

Adapting Together, Thriving Tomorrow



Climate Change Rapid Risk Assessment and Adaptation Plan for Ellembele District Assembly, Ghana

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



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ACRONYMS

Acronym	Full Form
CCRA	Climate Change Risk Assessment
CHPS	Community-based Health Planning and Services
COCOBOD	Ghana Cocoa Board
EPA	Environmental Protection Agency
FCWC	Fisheries Committee for the West Central Gulf of Guinea
GDP	Gross Domestic Product
GSS	Ghana Statistical Service
IPCC	Intergovernmental Panel on Climate Change
LEAP	Livelihood Empowerment Against Poverty
MTDP	Mid-Term Development Plan
NADMO	National Disaster Management Organization
NAP	National Adaptation Plan
NGO	Non-Governmental Organization
NTFPs	Non-Timber Forest Products
PHC	Population and Housing Census
RCP	Representative Concentration Pathways
SSP	Shared Socioeconomic Pathways
UNEP	United Nations Environment Programme
UNFCC	United Nations Framework Convention on Climate Change



EXECUTIVE SUMMARY



Ellembella District Assembly

Climate Change Rapid Risk Assessment

This Climate Change Vulnerability Assessment (CCVA) provides a detailed evaluation of the Ellembelle District's exposure, sensitivity, and adaptive capacity to climate-related hazards. The district, located in Ghana's Western Region, faces significant challenges due to its coastal location, agricultural dependence, and socio-economic vulnerabilities. This report synthesizes data from climate projections, stakeholder engagements, and field observations to offer a comprehensive understanding of the district's risks and propose targeted adaptation strategies.

The Ellembelle District's geographical and economic features make it highly susceptible to the impacts of climate change. Key vulnerabilities stem from the district's reliance on climate-sensitive sectors such as agriculture and fisheries, the proximity of communities and infrastructure to the coastline, and gaps in resource management and planning. Observed climate trends — rising temperatures, erratic rainfall patterns, and sea-level rise — are already disrupting livelihoods and ecosystems. Projections suggest intensifying risks in the future, necessitating urgent and targeted action to build resilience. The report highlights the district's experience with coastal flooding, which frequently impacts low-lying areas such as Ankobra and Sanzule, causing damage to property, displacement, and erosion of coastal ecosystems. Inland flooding in towns like Esiam and Awiebo exacerbates agricultural losses and weakens critical infrastructure, including roads and drainage systems. Water scarcity, driven by deforestation, mining activities, and erratic rainfall, poses a significant challenge to both domestic water supply and agriculture. Additionally, heat stress threatens productivity, especially in outdoor sectors like farming and construction.

Gender-specific vulnerabilities are a critical dimension of this assessment. Women, often primary caregivers and key participants in farming and fishing activities, face increased burdens as climate change disrupts water availability, food security, and livelihood options. Youth face uncertain futures as traditional jobs in agriculture and fisheries become less viable due to changing climatic conditions. Differently-abled individuals experience heightened risks due to limited mobility and insufficiently inclusive disaster preparedness measures.

This assessment identifies a range of adaptation strategies tailored to Ellembelle's unique context. Climate-resilient construction practices, such as building elevated structures in flood-prone areas like Teleku Bokazo and Kikam, can mitigate damage from storms and floods. Enhanced flood management systems, including levees and drainage improvements, are critical for towns along the Ankobra River. Strategic land-use planning, which directs development away from high-risk zones and incorporates green buffers, can reduce vulnerability to landslides, erosion, and floods. Agroforestry practices, such as integrating shade trees into cocoa farms in Aiyinase, offer both environmental and economic benefits, reducing soil erosion while diversifying farmers' incomes. Water resource management strategies are essential to address the district's growing scarcity challenges. Community-based rainwater harvesting systems in Asasetre and Nkroful could provide reliable water sources during dry spells. Monitoring programs for water quality in areas affected by mining activities are necessary to protect public health and maintain ecological balance. Public health interventions, such as disease surveillance systems and enhanced sanitation facilities, are equally crucial to mitigate climate-related health risks such as malaria and cholera. Stakeholder participation has been a cornerstone of this assessment. Community members, government officials, and development partners contributed to identifying priority risks

and validating adaptation options. Workshops conducted in the district emphasized the importance of gender equity and inclusivity in climate resilience efforts. These engagements have fostered a sense of local ownership and commitment to implementing the proposed measures.

The report concludes with actionable recommendations to enhance Ellembelle's resilience to climate change. These include increasing investment in climate-smart infrastructure, enforcing environmental regulations to curb deforestation and mining-related degradation, and integrating climate considerations into district-level development planning. The importance of securing financial resources and strengthening institutional capacities cannot be overstated.

This Climate Change Vulnerability Assessment serves as both a roadmap and a call to action for the Ellembelle District. Through the identification and addressing of risks through targeted, inclusive, and sustainable measures, the district can safeguard its communities, ecosystems, and economy from the intensifying impacts of climate change, ensuring a resilient future for all.

Adaptation Action Plans

The adaptation action plans presented in this report aim to transform Ellembelle District into a resilient and sustainable community by addressing climate vulnerabilities through targeted, multi-sectoral strategies. These plans prioritize interventions in infrastructure, agriculture, water resources, ecosystems, and gender equity, guided by an inclusive and evidence-based approach.

In the infrastructure sector, climate-resilient construction techniques and flood management measures are highlighted as critical solutions. Raising structures in flood-prone areas, improving drainage systems, and strengthening transportation networks are key to mitigating the impacts of floods and ensuring accessibility during extreme weather events. Sustainable urban planning, incorporating zoning laws and green buffers, helps direct development away from high-risk areas, enhancing long-term resilience. For agriculture and food security, the plans emphasize climate-smart practices like agroforestry, drought-resistant crops, and efficient water use. These interventions not only improve productivity and reduce vulnerability but also promote sustainable resource management. The introduction of crop insurance and market access for diverse agricultural products further strengthens economic resilience among farmers. Water resource management is another priority, focusing on solutions such as rainwater harvesting systems, enhanced storage facilities, and robust water quality monitoring. These measures aim to ensure a reliable and safe water supply while addressing pollution issues linked to mining and deforestation. Community-led initiatives are central to fostering local ownership and ensuring the sustainability of these interventions.

The restoration and conservation of ecosystems, particularly mangroves and wetlands, are vital for buffering coastal areas against flooding and erosion. These actions also provide co-benefits such as carbon sequestration, biodiversity conservation, and sustainable livelihoods. Community involvement in ecosystem management is emphasized, ensuring that restoration efforts are inclusive and culturally appropriate. A strong focus on gender-responsive strategies ensures that women, youth, and differently abled individuals are active participants and beneficiaries of adaptation efforts. The plans support women-led initiatives in agriculture, fisheries, and conservation, while promoting gender-sensitive healthcare services and equitable water access. Empowering these groups not only enhances social equity but also strengthens the overall adaptive capacity of the district. Stakeholder engagement has been a cornerstone of the adaptation planning process. Community workshops, consultations with government agencies, and input from technical experts have ensured that the proposed strategies are inclusive, practical, and aligned with local needs. A robust monitoring and evaluation framework underpins the plans, providing mechanisms for tracking progress, measuring impact, and incorporating lessons learned into future interventions.

Overall, the adaptation action plans provide a roadmap for Ellembelle District to address climate risks comprehensively. Through sustainable infrastructure, innovative resource management, ecosystem restoration, and gender equity, these plans aim to build a resilient future that balances environmental preservation, economic growth, and social inclusion.



1



Introduction

1.1 Background

Climate change currently dominates international discussions as increasingly many countries around the world continue to experience its brutish impacts on development processes. This is particularly critical for sub-Saharan Africa countries whose economies depend heavily on climate sensitive sectors including agriculture (Intergovernmental Panel on Climate Change [IPCC], 2022). Ghana continues to experience is disruptive climate change impacts in key climate-sensitive sectors and sustainable development processes. The country has experienced increases in temperature, erratic rainfall, floods, and more extreme weather events, which all manifest in different ways in diverse places with worsening impacts (Asante and Amankwa-Mensah, 2015). This could compromise the attainment of sustainable development goals in the country. The urgency for effective, localized adaptation strategies is paramount to mitigate these impacts and safeguard the progress towards sustainable development.

As climate change impacts become even more pervasive in key economic sectors such as agriculture, fisheries, forestry, water resources, mining, health, and many others (Hernández-Delgado, 2015; Prakash, S., & Verma, 2022), the extent and spread of risks and vulnerabilities are also increasing. Consequently, the ongoing requires that intentional and purposeful steps are taken to explore such risks and to put in place adaptation measures that respond proactively to both current and projected future impacts. As awareness of impacts continues to grow across Ghana, and as efforts intensify to ensure adaptation to the complexities of climate change phenomenon, it has also become urgently important that conscious efforts are made to understand the nature of impacts and how such impacts translate into risks and vulnerabilities (Antwi-Agyei et al., 2021. Asante et al., 2021) Effective climate adaptation in Ghana will therefore mean an intentional assessment of risks and vulnerabilities across sectors and places and the deliberate use of such insights and understandings to drive adaptation planning at both national and sub-national levels and in key climate-sensitive sectors (Mensah et al., 2022; Dapilah et al., 2021), with concerted efforts to reduce the effect on more vulnerable groups.

Effective and proactive climate change adaptation planning is therefore a learning issue and one that requires a conscious process to uncover impacts and to assess associated risks and vulnerabilities (Conway et al., 2019). Central to identifying, assessing, and appreciating the nature and distribution of climate risks is the ability to understand the science and signs behind changing climatic conditions and the varying impacts of such changes on people, communities, and sectors. Such knowledge and understanding, once obtained, become the basis to address uncertainties as well as to make bold and evidence-based predictions about the future. It also becomes the premise for adaptation planning and actionable adaptation decision-making (Manteaw et al, 2022). Moreover, adaptation strategies should incorporate emerging technologies and innovative approaches to enhance resilience and response capabilities.

Effective adaptation also calls for a gender responsive approach to ensure that the needs of different socioeconomic groups including the most vulnerable in society such as women, children and the elderly are taken into consideration. This is especially so because different socioeconomic groups are impacted differently

by climate change risks. Ultimately, adaptation planning and resilience building against climate change impacts should be premised on knowledge development and deeper understanding of climate impact manifestations and associated risks and vulnerabilities in diverse places and sectors (Owen, 2020; Eriksen et al., 2021). Such knowledge should also form the basis of capacity building processes that ensure effective climate adaptation governance are aimed at building the requisite adaptive capacities in diverse sectors, communities and at multi levels. Ghana's National Adaptation Plan (NAP) process has been initiated to respond to these needs and to also ensure that climate adaptation imperatives are mainstreamed in governance processes at different levels (Yeleeire et al., 2023; Asibey et al., 2024). The inclusion of community-based knowledge and indigenous practices in the NAP process can further enrich adaptation strategies, making them more effective and sustainable.

1.2 Assessment Aims and Objectives

This assignment, titled: *“Enhancing multi-sector planning and capacity for effective adaptation in Ghana”* envisions the development of costed national adaptation plan and to build the capacity of the Ellembelle District Assembly staff to be able to mainstream adaptation consideration in their Mid-Term Development Plan (MTDP) policies and plans. To be able to accomplish this, this Assessment is guided by the following specific but interconnected objectives:

- To conduct rapid climate risk assessments in the Ellembelle District Assembly.
- To develop an adaptation action plan for the Ellembelle District Assembly

1.3 Document Purpose

This Climate Change Risk Assessment (CCRA) is designed to identify, analyze, and prioritize climate-related risks within the Ellembelle District. The primary purpose of this document is to guide local experts and stakeholders through a systematic evaluation of the district's vulnerability to climate change impacts, emphasizing the integration of hazard, exposure, and vulnerability components as per the AR5 framework adopted from the IPCC. Specifically, the document through this assessment aims to:

1. **Provide a Comprehensive Overview of Climate Risks:** To capture a detailed picture of the climate hazards specific to Ellembelle District, including their current and potential future impacts on people, livelihoods, and ecosystems. This entails a rapid but thorough collection of information that informs adaptation planning and decision-making processes.
2. **Enhance Understanding of Vulnerabilities:** To deepen the understanding of the district's vulnerabilities, considering gender considerations and the multifaceted nature of climate risks that affect social, economic, and environmental dimensions.
3. **Enhance Understanding of impact of climate change on gender inequality:** to capture the effects of climate change on socio-economic lives of the district as a basis for developing gender responsive adaptation strategies which improve the lives of vulnerable women, men, youth and others.
4. **Support Adaptation Planning:** To offer a foundational basis for developing targeted and effective adaptation strategies and measures that address the prioritized risks, thereby strengthening the resilience of the Ellembelle District to climate change.
5. **Promote Stakeholder Engagement and Collaboration:** To facilitate an inclusive process that engages a wide range of stakeholders, including government agencies, local communities, women and youth groups, NGOs, and private sector actors, ensuring that the CCRA process is grounded in local realities and benefits from diverse perspectives and expertise.

6. **Align with National and Regional Climate Change Frameworks:** To ensure that the findings and recommendations of the CCRA for Ellembelle District are consistent with national climate change strategies and action plans, contributing to the broader efforts to mitigate and adapt to climate change in Ghana.



2

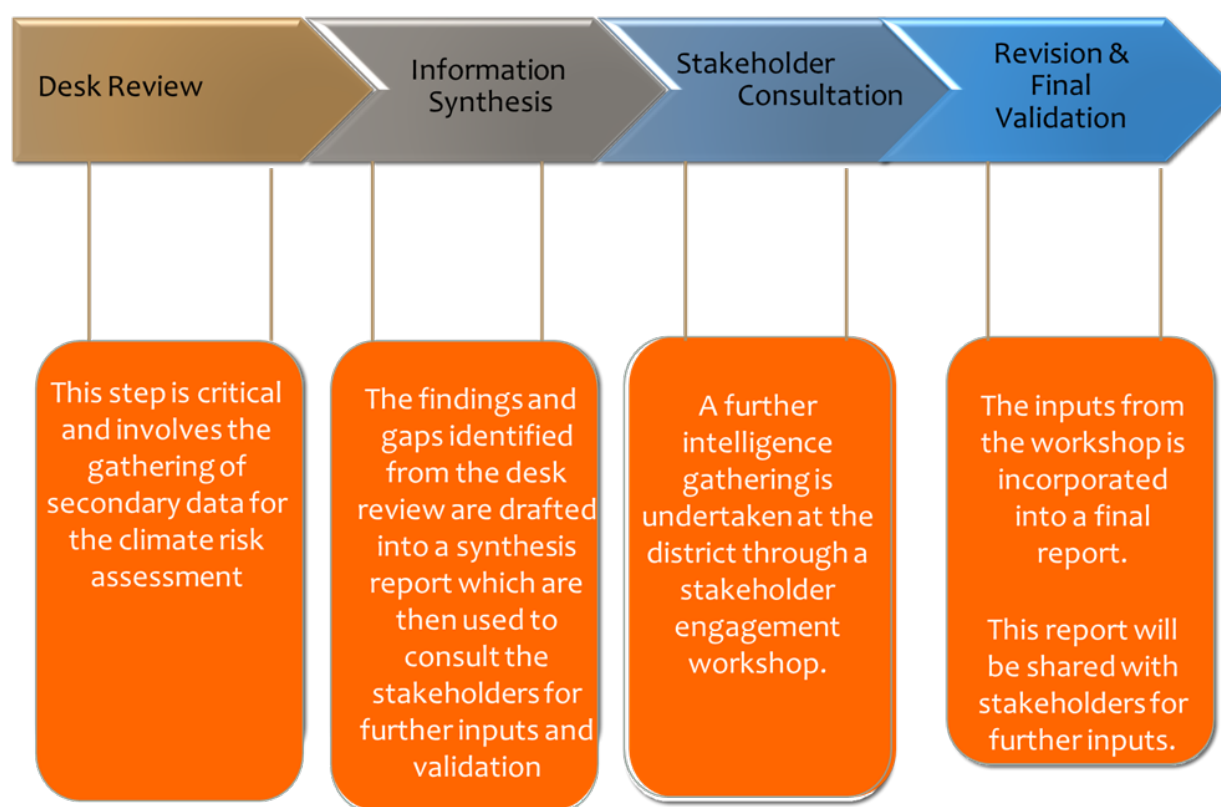


Approach and Methodology

2.1 Approach

The work approach for this CCRA for the Ellembelle District Assembly involves a structured, iterative process that encompasses the following steps (**Figure 1**):

Figure 1. Overall work approach for the Climate Change Risk Assessment for the Ellembelle District Assembly



- **Desk Review:** This foundational step was vital as it involved the collection of secondary data pertinent to climate risk assessment. This data gathering phase focused on accumulating existing information from various sources to construct a preliminary understanding of the gender and climate change vulnerability issues and the climate risks relevant to the Ellembelle District.
- **Information Synthesis:** Building upon the desk review, the findings and identified gaps were then compiled into a synthesis report. This document serves to integrate the data collected and provides a coherent overview of the initial assessment. This synthesis report was essential as it formed the basis

for subsequent consultations, encapsulating the current state of knowledge and highlighting areas requiring further exploration.

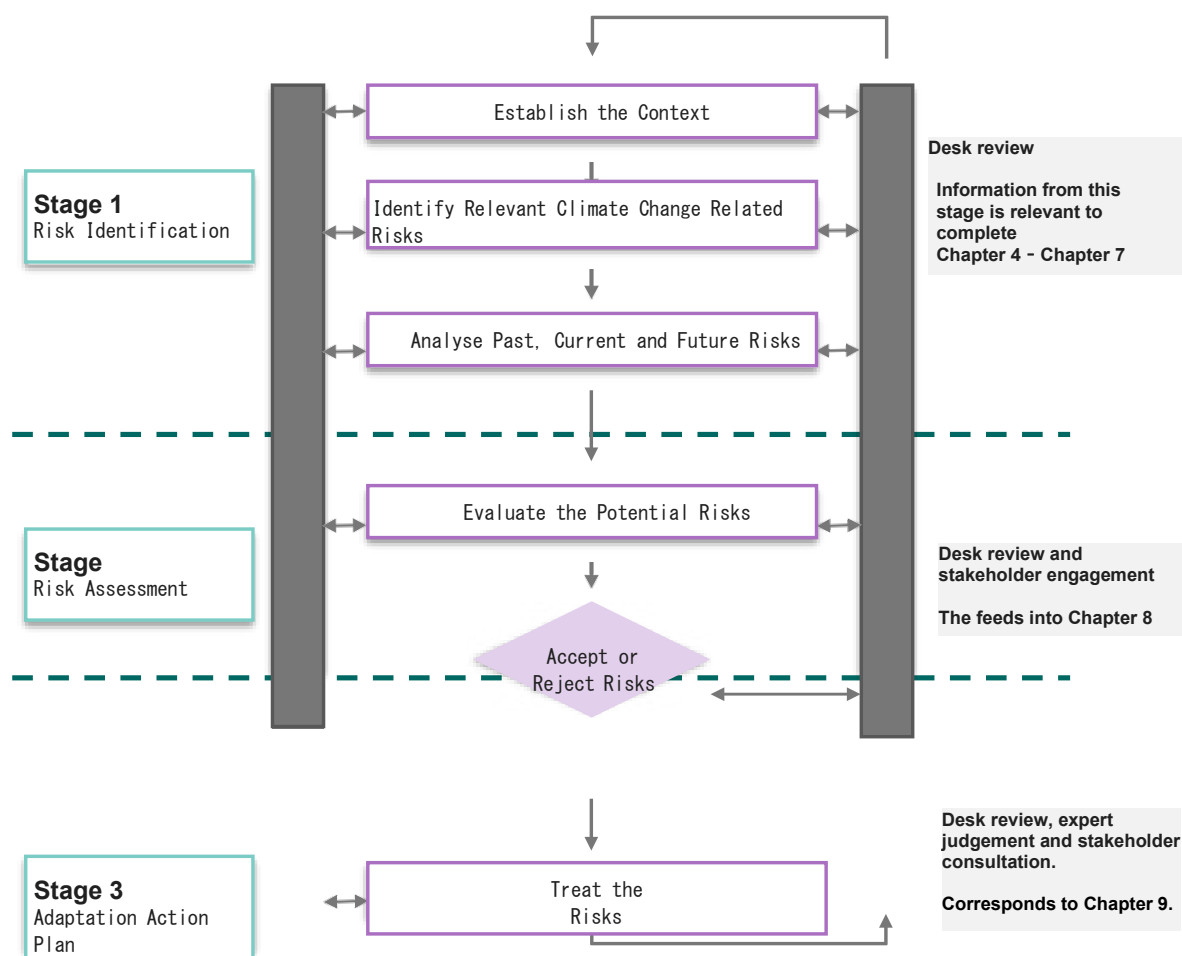
- **Stakeholder Consultation Workshops:** The process continued with in-depth stakeholder engagement workshops conducted within the district. In the Ellembelle District, two key workshops were conducted to assess the community's climate vulnerability. The first workshop conducted on introduced the broader vulnerability assessment, contextualizing it within Ghana's National Adaptation Plan (NAP) process. It also presented initial findings from a desk survey, laying the groundwork for district-specific adaptation planning. The second workshop focused on validating the overall findings and refining adaptation strategies proposed in the first session. Using a multi-criteria assessment, participants evaluated and prioritized these options with a strong emphasis on gender inclusivity to ensure equitable adaptation responses. These workshops were a critical intelligence-gathering exercise that involves various stakeholders, tapping into their insights and experiences. Both workshops served as interactive platforms for stakeholders to validate the findings of the desk review and information synthesis, and to contribute additional knowledge and perspectives that might not have been captured through secondary research.
- **Revision & Final Validation:** The culmination of this process was the integration of the insights gathered during the stakeholder validation workshop into a final report. This report is a comprehensive document that not only reflects the outcomes of the previous stages but also incorporates the practical contributions and validations from the Ellembelle district's stakeholders.

2.2 Methodology

The methodology for this Climate Change Risk Assessment for the Ellembelle District, adapted from Norman et al. (2014), is a structured approach divided into three primary stages, each with its specific focus and activities (**Figure 2**). The adapted approach integrates gender dimensions which will help the district reduce its climate change and gender vulnerabilities.

- **Stage 1: Risk Identification** In the initial phase, the context was established through an exhaustive desk review. This involved the collection of secondary data pertinent to climate risk assessment within the Ellembelle District as well as data on gender and climate change vulnerabilities. The gathered information was integral to the completion of chapters 4 to 7 of the assessment report, delineating the characteristics and extent of climate change risks. Within this established framework, the team identified relevant climate change-related risks by delving into the district's unique environmental and socio-economic attributes. They analyzed historical, present, and potential future risks, aiming to discern how climatic variations and changes had previously impacted the district and how they might continue to do so.

Figure 2. General overview of the risk assessment process



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

- Stage 2: Risk Assessment** The subsequent stage was dedicated to a thorough evaluation of the potential risks unearthed in the preceding phase. Insights from the desk review were complemented by the stakeholder engagement process, which provided a multi-faceted view of the potential risks. This engagement was pivotal as it ensured the risk assessment was well-informed by local stakeholders' insights and expertise. The outcomes from this stage were methodically documented in the Assessment, where risks were scrutinized and prioritized according to their potential impacts and probabilities, using the multi-criteria assessment framework. Following the comprehensive evaluation, a decisive juncture was reached where risks were either accepted for further action or rejected based on a set of predetermined criteria. These criteria typically included the severity of the impact, the effect on most vulnerable groups, the financial implications of adaptation, and the district's capacity to manage the risks effectively. This decision-making step was vital in shaping the direction and focus of the ensuing District Adaptation Action Plan.

- **Stage 3: Adaptation Action Plan** The final stage culminated in the formulation of a District Adaptation Action Plan. This plan was developed in response to the identified and accepted risks, aiming to mitigate vulnerabilities and strengthen the Ellembele District against the impacts of climate change. The plan was the product of a comprehensive synthesis of desk review findings, expert judgment, and stakeholder consultation outcomes. The plan set forth a suite of actionable and strategic interventions designed to address the key risks, thereby supporting the district's overarching goals for climate change adaptation and key gender considerations for inclusivity.

The methodology highlights a participatory approach, ensuring that the assessment and subsequent action plan are informed by a wide range of perspectives and expertise. This is essential for developing a robust and context-specific strategy for enhancing resilience to the impact of climate change in the Ellembele district.



3



Background and Context

3.1 Climate Change and Gender Policy Framework

3.1.1 Ghana National Climate Change Policy

Over the years, Ghana's approach to climate change policy encompasses various strategies and targets aimed at reducing greenhouse gas emissions and adapting to climate impacts. The country's National Climate Change Policy (NCCP) document published in 2013 outlines Ghana's comprehensive approach to addressing climate change. It highlights the challenges posed by climate change, including increasing temperatures, unpredictable rainfall, and sea-level rise. It also acknowledges the impact of climate change on women and other vulnerable groups and underscores the need to address gender issues to mitigate the effect of climate change on vulnerable groups. The policy emphasizes the importance of integrating gender equality and climate change into national development strategies and focuses on adaptation, social development, and mitigation. Ghana's National Climate Change Policy (NCCP) is built upon three core objectives namely (1) effective adaptation, (2) social development and (3) mitigation. The NCCP is designed to align with Ghana's broader sustainable development goals, recognizing that climate action is essential for the country's long-term prosperity and well-being. The five key focal areas in the NCCP include:

- Agriculture and food security
- Disaster preparedness and response
- Natural resource management
- Equitable social development
- Energy, industrial and infrastructural development

Ghana's climate change policy framework is driven by both mitigation and adaptation efforts, strategically aligned with global climate agreements and national priorities. Some of the key aspects of Ghana's climate change strategy include:

1. **Nationally Determined Contribution (NDC):** Ghana's Nationally Determined Contribution (NDC) originates from the Paris Agreement, adopted in 2015 during the UN Climate Change Conference (COP21). The NDC outlines Ghana's efforts to reduce greenhouse gas emissions and adapt to climate change impacts, aiming to limit global temperature rise. The NDC process involves each country voluntarily setting climate action goals based on national circumstances and development priorities. Ghana's NDC reflects its commitment to sustainable development, focusing on key sectors like energy, agriculture, and forestry, while also seeking international support for enhanced implementation. Ghana has committed under its NDC to reduce greenhouse gas (GHG) emissions and adapt to climate change in several priority sectors, including mass

transit, infrastructure, land use and food production, energy, and forest and water resources management. The country has set ambitious targets to cut emissions by 64 million tons of CO₂ equivalent by 2030 (UNDP, 2024), with certain actions being conditional on international support. To achieve the target, the NDCs highlight the need for gender equality strategies to be integrated. Therefore, in addition to gender being a crosscutting issue, it is also a thematic area. In addition to this, Ghana has developed a gender toolkit to guide the integration of the needs of vulnerable groups to ensure equitable approach to addressing climate change issues.

2. **National Adaptation Plan (NAP):** In response to the challenges posed by climate change, Ghana is developing a National Adaptation Plan. The NAP process is rooted in the United Nations Framework Convention on Climate Change (UNFCCC) guidelines, specifically established under the Cancun Adaptation Framework. The NAP process for Ghana originated from its long-standing commitment to international climate agreements, such as the UNFCCC and the Paris Agreement. It is driven by the need to meet both global climate adaptation goals and national priorities, especially in vulnerable sectors like agriculture, water, health, and infrastructure. Ghana initiated its NAP process with the preparation of vulnerability assessments across different regions and sectors, identifying areas where climate impacts are most severe. The process is led by the Ministry of Environment, Science, Technology, and Innovation (MESTI) in collaboration with other government agencies, development partners, and civil society. The NAP framework includes stakeholder engagements, capacity-building, and developing adaptation actions tailored to Ghana's unique geographical, social, and economic conditions. The plan builds prior national adaptation efforts, such as the National Climate Change Policy (NCCP), National Climate Change Adaptation Strategy (NCCAS), and sectoral adaptation plans. The NAP highlights the need for gender sensitivity and responsiveness as an integral part of building resilience to climate change
3. **Investment Requirements:** The implementation of Ghana's climate change measures, as outlined in the NDC, requires substantial investment. Estimates suggest that between US\$9.3 billion and US\$15.5 billion is needed from 2020 to 2030. Ghana expects a significant portion of this funding to come from international sources, highlighting the need for innovative financial solutions and partnerships with the private sector.
4. **Challenges in Implementation:** Despite these efforts, Ghana faces challenges in effectively enforcing climate change policies. There is a need for stronger political will, enhanced technical capacity including capacity to effectively address gender related climate change issues, and improved corporate compliance. The country currently lacks a strong climate change regulator, and the Ministry for Gender Children and Social Protection (MoGCSP) is limited in its ability to coordinate interagency activities on gender and climate change which is crucial for monitoring and enforcing these policies. Additionally, the technical capacity required for implementation could be outsourced to private entities under the supervision of a regulator
5. **Legislative Process:** The legislative process in Ghana involves multiple steps, including drafting by the Parliamentary Counsel and approval by various governmental bodies, before a bill becomes law. This process is essential for the enactment of comprehensive climate change laws and regulations.

3.1.2 Ghana National Gender Policy

The Ghana National Gender Policy (2015) is the overarching document for the inclusion of gender in all aspect of Ghana's development process. The policy defines gender as the "array of socially constructed roles and relationships, personality traits, attitudes, behaviours, values, relative power and influence that society ascribes to the two sexes on a differential basis". The Policy defines gender to include women, girls, children, people with special needs and persons with disability. It also provides the institutional framework for bridging the gender inequality gaps among the identified vulnerable groups.

3.2 National Level Risk and Vulnerability Assessment

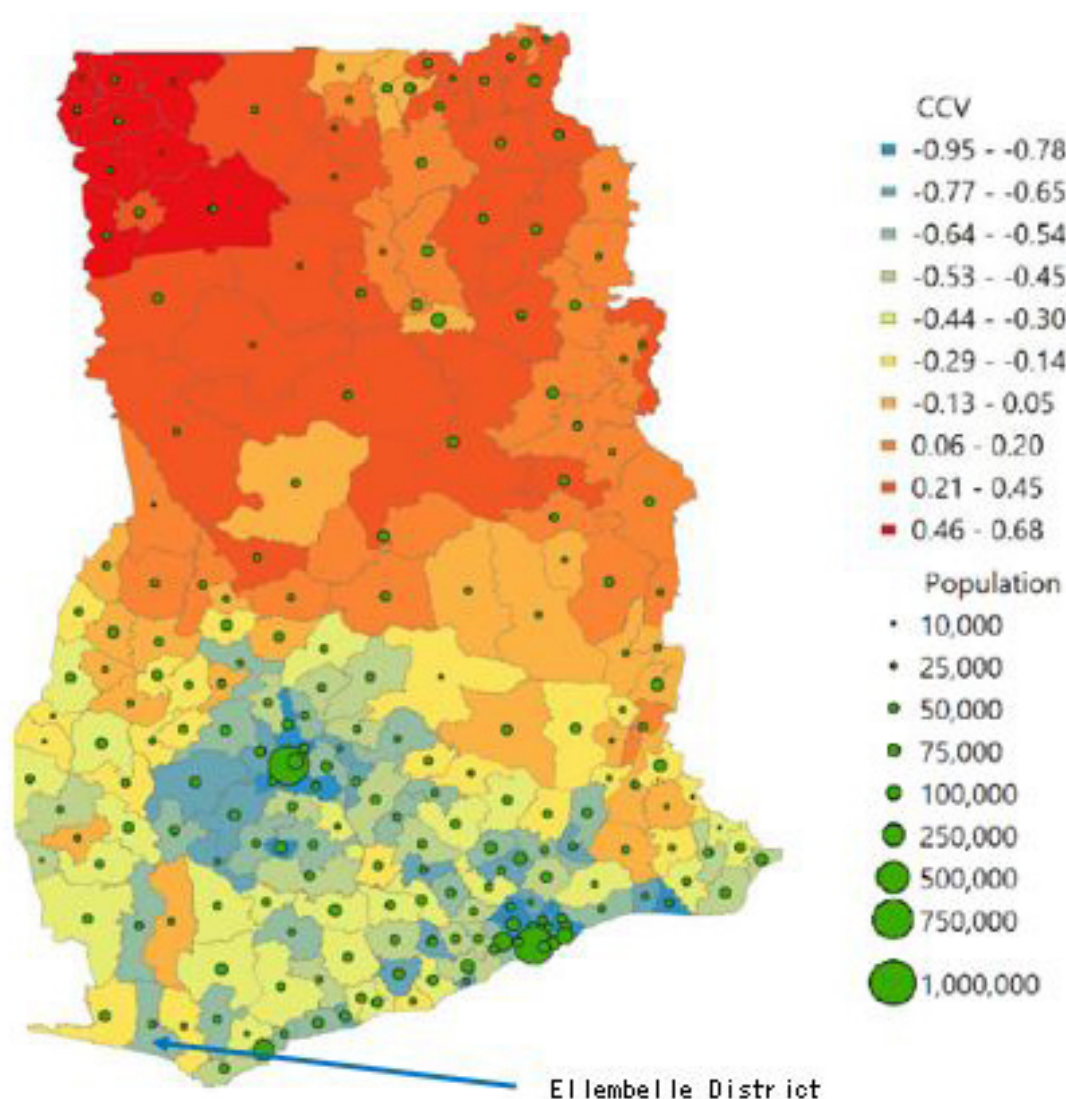
This section explores Ghana's risk profile and the critical vulnerabilities influencing national adaptation efforts. The assessment informs adaptation strategies, guiding the integration of climate risk management into national planning processes by evaluating the physical, socio-economic, and environmental vulnerabilities. Ghana's Fourth National Communication (Gh_NC4) to the UNFCCC report (https://unfccc.int/sites/default/files/resource/Gh_NC4.pdf) provides a comprehensive spatial climate change vulnerability (CCV) assessment report of Ghana's 216 districts including Ellembelle District (Figure 3). The national-level vulnerability assessment conducted for the Gh_NC4 utilized the definition of Climate Change Vulnerability (CCV) from the Fourth Assessment Report (AR4), which defines CCV as the product of Exposure and Sensitivity, subtracted by Adaptive Capacity. The data for this CCV was sourced from national institutions, literature, and intergovernmental bodies authorized to disseminate government data.

Exposure to climate change is dissected into two main categories: the current exposure to climate variability and change, and the anticipated future exposure, underpinned by predictive models. The current exposure was quantified using parameters based on observed shifts in temperature and rainfall patterns, whereas future exposure is assessed through a comprehensive set of nine rainfall and temperature parameters, further broken down into thirty-six sub-parameters. These parameters are designed to capture medium- to long-term projections (for the years 2060 and 2080) under two distinct climate change scenarios (RCP 2.6 and RCP 8.5), facilitating a detailed ranking of districts according to their vulnerability to both current and anticipated climate changes.

The Gh_NC4 Assessment also delved into the sensitivity of districts to climate change, using the percentage of the population employed in the agricultural sector as a primary indicator. Given the sector's dependency on climate conditions, those engaged in agriculture (most of whom are women and men small holder farmers) are deemed highly sensitive to the impacts of climate variability, including temperature increases and fluctuating rainfall patterns. This sensitivity analysis, however, is constrained to current employment data at the regional level, assigning a uniform sensitivity score to all districts within each region due to the absence of district-specific employment data and future employment projections in agriculture.

The results from the Assessment (**Figure 4**) shows CCV scores for Ghana's 216 districts, indicated by colour variation. Red shades represent higher vulnerability, while green shades indicate lower vulnerability. Dot sizes reflect population, with larger dots denoting more populous areas, indicating where more people may be affected by climate-related issues. This visual representation helps identify regions and districts where resources and adaptation strategies might be prioritized.

Figure 3: Climate change vulnerability scores for Ghana's 216 districts, highlighting the Ellembelle district.



For the Ellembelle District, with a sensitivity of 0.45, exposure of 0.30, and an adaptive capacity of 0.70, the CCV score is -0.57. This negative CCV indicates that despite its moderate sensitivity and exposure to climate change effects, Ellembelle's high adaptive capacity potentially mitigates its overall vulnerability, placing it in a better position to handle climate change impacts compared to districts with positive CCV scores. Sensitivity and exposure levels indicate potential impact, while adaptive capacity reflects the ability to cope with changes. Negative CCV scores, like Ellembelle's -0.57, suggest a district is relatively well-positioned to manage climate risks due to higher adaptive capacity. In contrast, positive CCV scores indicate greater vulnerability.



4

Overview Of Ellembelle District Assembly

Plate 1. Aerial view of Anokye town in the Ellembelle District



Source: <https://eiti.org/blog-post/engaging-communities-just-transition-ellembelle-ghana> (2024)

4.1 Geographical Description

4.1.1 Location and Size

The Ellembelle District is situated in the southern portion of Ghana's Western Region. The district spans a geographical area defined by longitudes 2° 05' W and 2° 35' W, and latitudes 4° 40' N and 5° 20' N. It is bordered by the Jomoro District to the west, the Wassa Amenfi West District to the north, the Nzema East Municipal to the southeast, and the Tarkwa-Nsuaem Municipal to the east. Additionally, the district boasts a 70-kilometer coastline along the Atlantic Ocean to the south (**Figure 4**).

This positioning not only gives it a unique geographical identity but also situates it as a nexus of various ecological zones. Geographically, the district is characterized by forest vegetation in its northern parts, while the southern region is defined by its extensive coastline. The district is made up of approximately 70 kilometres of uninterrupted sandy beach (Boye et al. 2022).

The district is dotted with major towns and cities that serve as economic and social hubs for the district. Aiyinase, Asasetre, Nkroful (the district capital), Awiebo, Esiama, Kikam, and Atuabo each have their

Figure 4 Geographical and hydrological map of the Ellembelle District with major towns



Climatically, Ellembele District lies within the semi-equatorial climate zone, typical of the West African sub-region. This zone is characterized by year-round rainfall, with the peak rainfall typically occurring in May and June. The district's mean annual rainfall fluctuates between 26.8 millimeters to 46.6 millimeters indicative of a generally humid and wet environment. The average temperature in the district hovers around 29.4°C. Throughout the year, there is a variation in mean monthly temperatures, usually ranging between 40°C to 50°C. The district also experiences high relative humidity levels, with figures ranging from 26.6% to 27.6% between May and June and slightly higher figures of 27.3% to 27.9% during the rest of the year. This high humidity and significant rainfall create a conducive environment for the district's lush vegetation and diverse agricultural activities.

The high rainfall and extended rainy seasons in the Ellembele District contribute significantly to the annual flow of major rivers such as the Ankobra, Amunzuri and Mufre. The Ankobra River, flowing through the district, serves as a pivotal economic and ecological resource. It originates in central Ghana (north of Wiawso) and discharges into the Gulf of Guinea at Ankobra (**Photo 4**). The Ankobra River historically played a key role in facilitating trade and transportation, with a particular emphasis on the gold industry. The Ankobra remains an important waterbody for local communities, supporting livelihoods through fishing and small-scale mining activities. However, the river is currently confronting significant pollution challenges, predominantly stemming from unauthorized mining activities, locally known as ‘galamsey’. Subsequently, various forms of heavy metals have been found in sections of the river (Asare-Donkor et al. 2016).

xxx. Estuary of the Ankobra River entering the Gulf of Guinea at Ankobra town



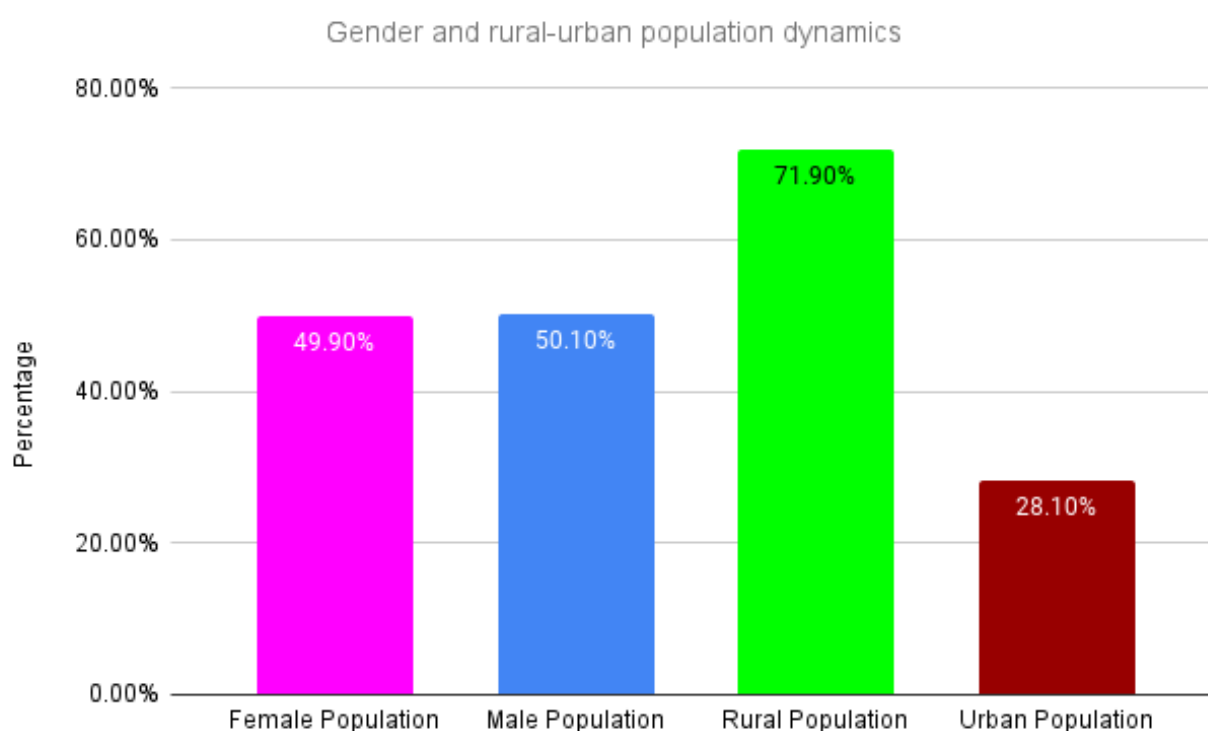
Table 1: Summary of geographic characteristics of the Ellembele District Assembly

Theme	Details
Topography	Generally undulating, highest point about 450ft above sea level.
Geology	Mainly Cambrian of the Birimian formation and Tarkwaian Sandstone-Association (Quartzite and Phylites). Rich in kaolin, silica, and gold.
Soil Composition	Predominantly ferric acrisols and dysric fluvisols. Ferric acrisols constitute about 98% of land.
Agriculture	Supports crops like cocoa, coffee, coconut, oil palm, plantain, cassava.
Climate	Lies within the semi-equatorial climatic zone. All-year-round rainfall with peak in May and June.
Temperature	Average temperature around 29.4°C. Mean monthly temperature ranges between 40°C to 50°C.
Humidity	High relative humidity, ranging from 26.6% to 27.6% between May and June and 27.3% to 27.9% rest of the year.

4.2 Demographics Characteristics

According to the 2021 Population and Housing Census (PHC), the Ellembelle district has a total population of 120,893, which accounts for 5.9% of the Western Region's entire population. Of this population, 60,307 are females, representing 49.9%, and 60,586 are males, constituting 50.1% (**Figure 5**). The district has a population density of approximately 124.3 individuals per square kilometer. In terms of settlement patterns, a significant majority of the district, 71.9%, is rural, while the remaining 28.1 percent of the population resides in urban areas (Ghana Statistical Service, 2022).

Figure 5. Gender and rural-urban population dynamics of the Ellembelle District



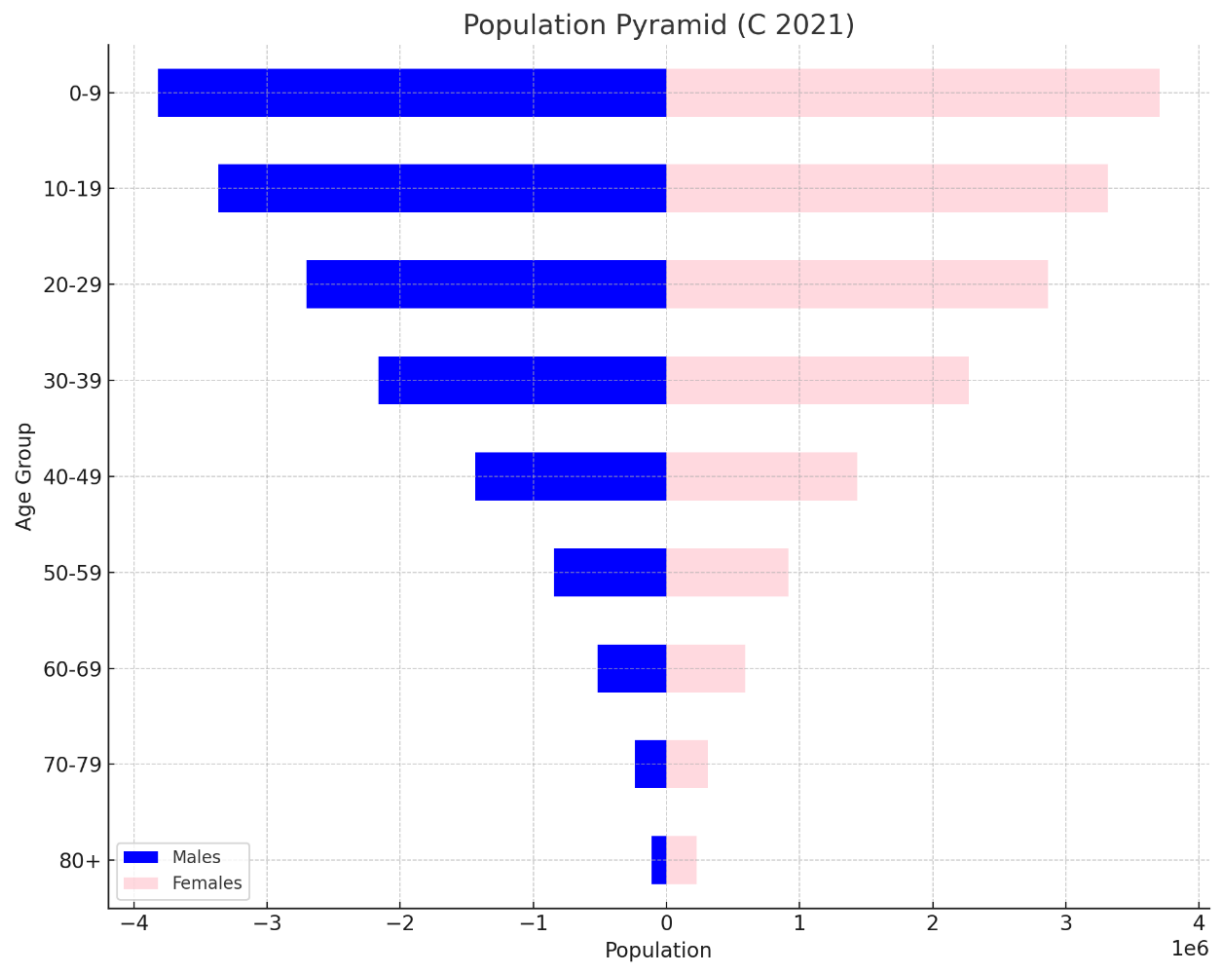
Source: Ghana Statistical Service, 2022

Based on data from the PHC 2021 census, the population pyramid for the Ellembelle district reveals a youthful demographic foundation with a pronounced youth bulge, particularly in the 10-29 age range, signifying a high birth rate and a considerable segment of the population approaching or within their working years (**Figure 6**). This structure indicates not only a increasing population but also future shifts towards an aging society, with the larger younger cohorts aging and the gender imbalance in the elderly suggesting higher female life expectancy. In the context of climate change vulnerability, this demographic dynamic plays a vital role. The youthful population suggests a potential for high adaptive capacity through innovation and labour for climate-resilient infrastructure, whereas the aging trend highlights a growing sensitivity, particularly among older individuals who are more vulnerable to climate change impacts. Gender disparities in aging also point to specific vulnerabilities, necessitating targeted adaptation strategies.

Moreover, the increasing population pressures natural resources, intensifying environmental degradation and elevating climate change risks. Therefore, addressing the district's climate change vulnerability effectively

requires a nuanced understanding of its demographic trends to bolster adaptive capacities, mitigate sensitivities, and leverage the demographic dividend for sustainable and resilient development.

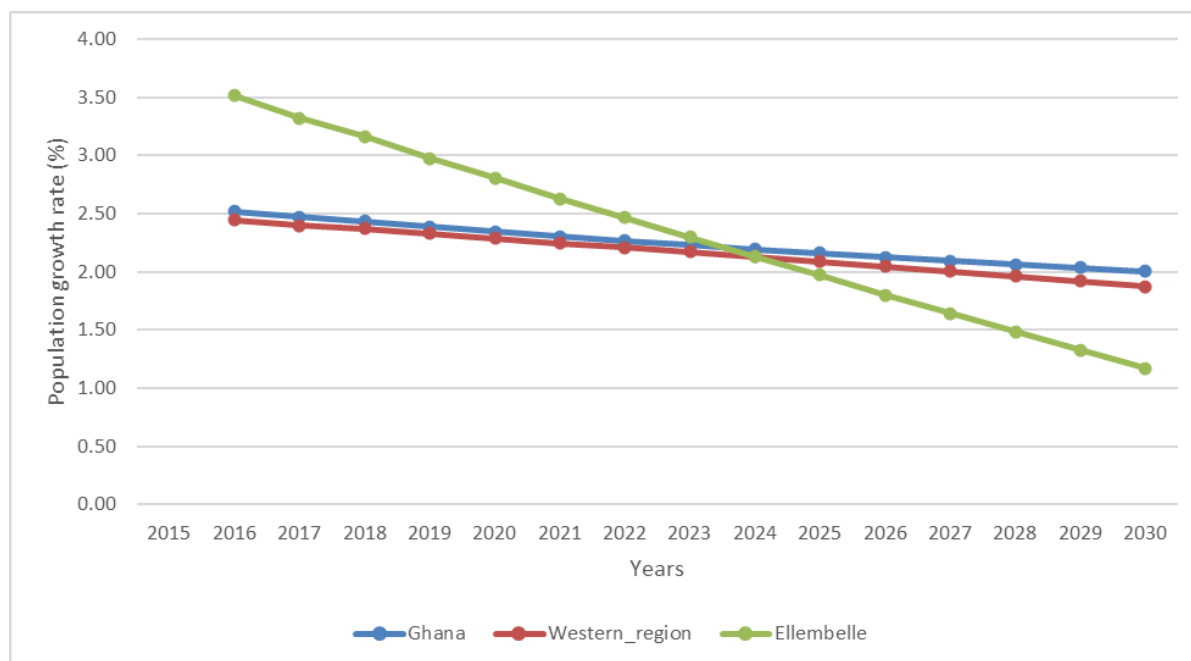
Figure 6. Population distribution of the Ellembelle district



Source: Ghana Statistical Service, 2021

Figure 7 depicts a declining trend in the annual population growth rates for Ghana, the Western region, and the Ellembelle district from 2015 to 2030. Ghana’s national growth rate is consistently higher than that of the Western region, which in turn is higher than the Ellembelle district. All three are converging towards a lower growth rate, with the district’s decrease appearing more linear and marked. This downward trend suggests that by 2030, population increases will be more subdued across these areas, potentially influencing socioeconomic planning and resource management.

Figure 7. Projection of the annual growth rate between 2015 to 2030.



4.3 Key Economic Sectors

The Ellembele District's economy is predominantly anchored in agriculture, (crop farming, livestock rearing), marine fishing, forestry, and small-scale mining.

4.3.1 Agriculture

Based on data from the 2021 Population and Housing Census (PHC), the agriculture sector accounts for 35.2% of the district's population (GSS, 2022). In the Ellembele district, agriculture is the foundation of the community's livelihood. It not only sustains the local economy but also contributes to the food supply at regional and national levels.

Over time, the agricultural landscape of Ellembele has undergone significant changes, particularly with the increasing dominance of cocoa cultivation. This shift was partly driven by the devastating effects of the lethal yellowing disease, also known as Cape Saint Paul's Wilt Disease (**Plate 2**), which decimated coconut crops in the district (NewsGhana, 2021; Philippe et al., 2009). The transition to cocoa was a strategic adaptation taking advantage of its economic value and its suitability to the local climate and soil conditions. In addition to cocoa farming (**Plate 3**), the district's crop farming sector is diverse and includes economically important tree crops such as oil palm, rubber, and citrus which are mostly cultivated by the men. These crops not only provide raw materials for various industries but also create employment opportunities for the residents of Ellembele, contributing to economic stability in the district.

Plate 2 Evidence of Cape Saint Paul Wilt Disease in the District



Source: NewsGhana, 2021

Plate 3. Cocoa farm in the Ellembele District.



Source: Bofo, 2023

The district's agricultural richness extends to food crops, with cassava, plantain, and rice being prominently cultivated. These crops are mostly cultivated by women to meet household nutritional needs and sale to markets for income. These staples are essential to the local communities and households' diet, ensuring food security and supporting culinary traditions. The cultivation of these crops is facilitated by the area's fertile lands and favorable climatic conditions, which allow for diverse agricultural activities. Furthermore, the Ellembelle district is known for its production of various vegetables, including garden eggs (eggplants) and tomatoes, as well as spices such as pepper. These crops play a crucial role in diversifying the community's diet and supporting small-scale agriculture engaged in by vulnerable women and men. The cultivation of vegetables and spices not only meets local consumption needs but also has the potential for market expansion, generating income for farmers.

Livestock farming is a significant agricultural activity in the district. The livestock raised consists of cattle, sheep, goats, pigs, and poultry, which make significant contributions to the local cuisine and economy. It is important to note that the rearing of goats is prohibited in some communities within the district. Poultry farming is a widely practiced occupation in the district, involving the rearing of chickens and other bird species. It serves as a major source of eggs and meat, which are essential components of the local population's daily diet.

4.3.2 Marine Fishing

Marine fishing is a vital part of the Ellembelle district's coastal economy. Fishing is deeply rooted in the culture and diet of the coastal communities in the district. With access to abundant fishing grounds, several communities and households rely on the industry as their main source of livelihood. This industry not only supports many livelihoods but also ensures food security and nutrition by providing a reliable source of protein essential for pregnant women and children. The marine waters in the district are noted for a variety of fish species, such as *tuna*, *sardines*, *mackerel*, and *anchovies*. These fish are essential to both the local diet and the export market. Traditional fish processing and fishing practices, passed down through generations, still prevail, with canoes and nets being the primary tools (**Photo 7**). This strong connection to the sea is reflected not only in the district's economic activities but also in its cultural traditions and celebrations that celebrate the ocean's abundance.

Plate 4.Typical fishing boats are used in the communities.



Source: Boafo, 2023

In recent years, efforts to diversify and enhance the sustainability of marine fishing have gained momentum in the Ellembelle district. Inspired by successful ventures in other parts of Ghana, such as the rise of catfish farming highlighted by the Fisheries Committee for the West Central Gulf of Guinea (FCWC), the fishing community in Ellembelle is exploring aquaculture as a complementary venture. Catfish farming presents a promising opportunity for economic diversification, offering a sustainable alternative to wild capture fisheries (Akegbejo-Samsons, 2022). This initiative aligns with broader efforts to ensure the long-term sustainability of fish stocks and reduce pressure on marine ecosystems.

The potential for aquaculture in Ellembelle, especially through the cultivation of species like catfish, known for their resilience and high market value, could represent a significant economic opportunity. The success of catfish farming in Ghana, where it has become a lucrative industry generating substantial income for farmers, demonstrates the viability of this approach (Mabe & Asase, 2020). The future of marine fishing and aquaculture in the Ellembelle district is intertwined with the community's commitment to sustainable practices, environmental stewardship, and economic resilience. Though fishing is the domain of men in coastal communities (Torell, Owusu, & Okyere-Nyako, 2015), fish farming offers an alternative for both men and women, and other vulnerable groups to earn income to build their resilience to the impact of climate change in the District.

4.3.3 Forestry

The forestry sector in Ellembelle district is a key contributor to the local economy, environmental sustainability, and the cultural heritage of the community. The Amanzule mangrove site in the district plays a crucial role beyond providing timber and non-timber forest products (Mensah, 2013). They function as essential ecosystems that promote biodiversity, regulate climate, and aid in soil and water conservation. The forests harbour a diverse array of plant and animal species, with some contributing to the economy and others playing a crucial role in the ecosystem. In the Ellembelle district, timber production plays a vital role in the local economy by offering employment to a section of residents and households. The district benefits economically from the forestry industry by exporting timber products to generate revenue and fulfil local demand. With gender disparities in knowledge, priorities and use of the forest and its products, the gains from export of the timber products will not equally inure to women and other vulnerable groups if they continue to be less involved in the governance and decisions related to the use of the forests (Wiafe, 2014).

In addition to timber resources, communities and households in the district derive value from the harvesting and trade of Non-Timber Forest Products (NTFPs) such as medicinal plants, fruits, nuts, honey, and materials for crafts. The products play a crucial role in supporting the well-being of numerous households, especially those residing in rural parts of the district. NTFPs provide an additional revenue stream that can enhance conventional agricultural, and fishing practices and has a greater impact on women's livelihood (Asamoah et al., 2023; Ahenkan and Boon, 2011). Forests are commonly viewed as areas of cultural significance, with specific regions safeguarded by traditional practices. Cultural beliefs play a significant role in promoting the preservation of forest areas and the diverse range of species they support. The forestry sector in Ellembelle is currently encountering various challenges such as deforestation, illegal logging, and land conversion for agricultural and developmental purposes (Ntim, 2021; Damnyag et al, 2023).

4.3.4 Small-scale (artisanal) mining

This form of mining involves the extraction of minerals such as gold, diamonds, and other precious metals through labour-intensive, low-tech methods. In the Ellembelle district, small-scale mining operations are

predominantly centred on the extraction of valuable minerals like gold. It serves as an income source for numerous families, allowing them to cover essential needs such as education and healthcare (Usman Kaku et al., 2021; Ainuson, 2023).

Small-scale mining in the district has resulted in extensive land degradation, deforestation, and water contamination (**Plates 5 and 6**). Hazardous substances like mercury and cyanide, commonly used in the extraction process, further pollute the environment (Owusu-Nimo et al., 2018). These practices not only disrupt Ellembele's ecological equilibrium and threaten the well-being of communities who rely on these resources, but also directly impact cocoa cultivation. Many cocoa farms are being mined, often forcing community members off their land and destroying their livelihoods. This destruction of valuable agricultural land undermines the economic stability of the region and jeopardizes the future of cocoa production in the district.

Plate 5. The Impact of Illegal Small-Scale Mining (altering of landscape) in the Ellembele district



Plate 6. The Price of Gold: Mining's Impact on Cocoa Farms in Ellembele district



Formalizing operation of small scale not only promotes environmentally responsible mining but also improve access of both women and men to enhanced occupational health and safety measures, reducing the vulnerabilities (Ofosu, Torbor, & Sarpong, 2022). With this, women's role in the mining process also shifts from secondary activities of separating ore, transporting mineral ore, providing water on mineralized sand and serving as forewomen to high positional roles (Arthur-Holmes & Abrefa Busia, 2021).



5

Climate Change Vulnerability of the Ellembelle District Assembly

5.1 Defining Climate Change Risk and Vulnerability

This section explores the definitions of climate risk and vulnerability as outlined by various organizations and institutions. It aims to provide a comprehensive understanding of how climate hazards interact with socio-economic, environmental, and institutional vulnerabilities by examining how entities like the Intergovernmental Panel on Climate Change (IPCC), the United Nations Framework Convention on Climate Change (UNFCCC), and national-level frameworks define these terms. These definitions help frame adaptation strategies, risk assessments, and resilience-building initiatives tailored to the Ellembelle District.

5.1.1 Intergovernmental Panel on Climate Change (IPCC)

The IPCC provides a scientific perspective on climate risk and vulnerability, focusing on the interaction between climate hazards, exposure, and the ability of systems to adapt. The IPCC's definition often emphasizes the interplay of these factors and how they influence the susceptibility of both natural and human systems to climate impacts.

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. Risk encompasses the likelihood and magnitude of harmful outcomes, considering the severity of the hazard, the conditions of vulnerability that could amplify or mitigate the hazard, and the level of exposure to the hazard (IPCC, 2014)

Vulnerability in the context of climate change is the propensity or predisposition to be adversely affected. It includes a variety of factors such as sensitivity or susceptibility to harm and lack of capacity to cope and adapt. Vulnerability is a multi-dimensional concept, often dependent on social, economic, environmental, and cultural factors. It reflects not just the potential impact of climate change, but also the adaptive capacity of the system or community at risk. The IPCC acknowledges gender as one of the socio-economic factors which influence one's adaptation ability (IPCC, 2007).

5.1.2 United Nations Framework Convention on Climate Change (UNFCCC)

The UNFCCC approaches climate risk and vulnerability from a policy and equity perspective, addressing the disproportionate impacts on vulnerable regions and populations. Its definitions emphasize global cooperation in adaptation efforts and the protection of at-risk communities in developing nations.

The UNFCCC articulates climate change risk as the probability and severity of adverse effects of climate events on human and natural systems. Vulnerability, according to the UNFCCC, is the degree to which these systems can be adversely affected, encompassing the character, magnitude, and rate of climate change they face, alongside their sensitivity and capacity to adapt (UNFCCC, 2007).

5.1.3 World Health Organization (WHO)

WHO's approach to climate risk and vulnerability centers around the impacts of climate change on public health. It focuses on the ways climate change exacerbates health risks, particularly for vulnerable populations, and emphasizes the importance of strengthening health systems to build resilience against these risks.

WHO contextualizes climate change risk within the public health domain, considering it as the likelihood of health consequences arising from climate-related hazards such as heatwaves, floods, or the proliferation of disease vectors. The WHO's notion of vulnerability zooms in on the predisposition of populations to these health risks, shaped by variables including age, economic conditions, existing health issues, and the availability of healthcare (World Health Organization, 2021).

5.1.4 United Nations Office for Disaster Risk Reduction (UNDRR)

The UNDRR defines climate risk and vulnerability within the context of disaster risk reduction. Its focus is on how climate-related disasters, such as floods and storms, exacerbate socio-economic vulnerabilities. This institution stresses the need for early warning systems and risk-informed policies to reduce vulnerability and improve resilience.

The UNDRR perceives climate change risk as a blend of the frequency and intensity of climate hazards coupled with human exposure and vulnerability. Vulnerability, from the UNDRR's standpoint, is determined by a range of physical, social, economic, and environmental factors that heighten a community's risk in the face of such hazards (UNDRR, 2022)

5.1.5 World Bank

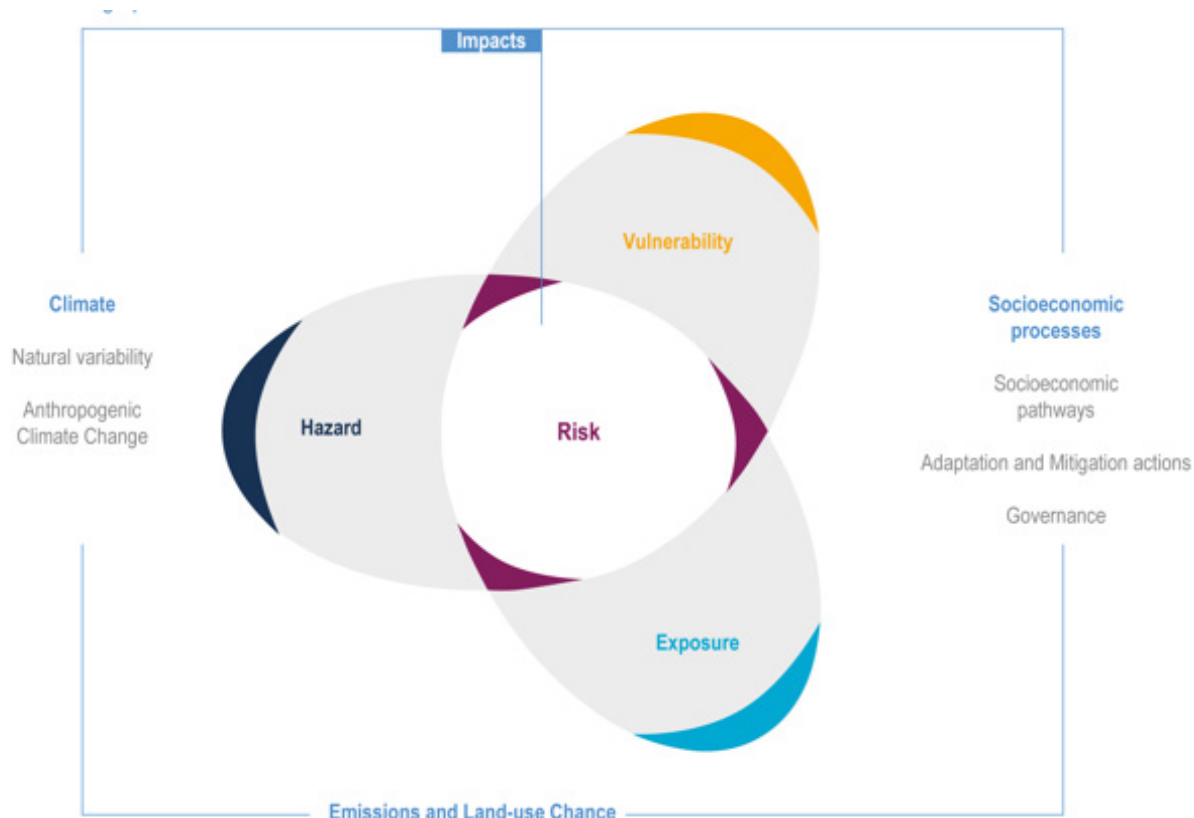
The World Bank defines climate risk and vulnerability through an economic and developmental lens. Its definitions highlight the susceptibility of economies, infrastructure, and livelihoods to climate change, and focus on the importance of integrating climate risks into development planning and investments to ensure sustainability and resilience in the long term.

The World Bank's take on climate change risk encompasses both transition risks, which refer to the economic adjustments required for a low-carbon transition, and physical risks directly stemming from climatic changes. These risks have tangible financial and socio-economic consequences. The World Bank also discusses vulnerability in terms of economic resilience, highlighting how susceptible an economy is to external shocks induced by climatic variability and change (World Bank Group, 2021).

In synthesizing various definitions of climate change risk and vulnerability, it becomes evident that while the terminology may vary across institutions, the core components—Hazard, Exposure, and Vulnerability—are central to assessing risk. Whether defined by the IPCC, UNFCCC, WHO, or other organizations, climate risk is viewed as a combination of climate-related hazards, the degree of exposure, and a population's capacity to cope. The exposure and vulnerability to climate change varies for the different sociocultural groups (including women, men, youth differently abled among others). Most often, women are significantly more vulnerable to climate change and have lower ability to adapt than men (Adzawla et al., 2019). This is a result of entrenched gender inequalities which often limit women's access to resources, knowledge and time which they need to adapt (FAO, 2007). Therefore, strategies which do not consider these factors tends to worsen the existing inequalities between women and men (Eastin, 2018).

The climate risk assessment framework (**Figure 8**) visualizes this relationship, emphasizing that effective evaluation must consider both climate drivers (natural variability and anthropogenic factors) and socioeconomic processes (governance, mitigation actions). This framework, vital for a climate-vulnerable district like Ellembele, integrates these variables to identify not only current risks but also potential future trajectories based on emissions and land-use changes.

Figure 8. Risk assessment framework for evaluating climate change risks.



In the context of the Ellembele District Assembly, the climate risk framework, as delineated by the IPCC Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX) and the Working Group II Fifth Assessment Report, provides a comprehensive approach to understanding the potential impacts of climate change on the district (**Figure 8**). The framework (**Figure 8**) considers ‘Climate’ as the foundational element, encompassing both the natural variability and the additional stresses from anthropogenic climate change, which in turn inform the types of ‘Hazards’ the district may face. These hazards could range from extreme weather events to gradual climatic shifts, each carrying the potential to disrupt the district’s socio-economic and environmental landscape.

Exposure within the Ellembele District is characterized by the presence of communities, ecosystems, and infrastructural assets that stand to be affected by climate hazards. The district’s ‘Vulnerability’—its susceptibility to harm from these hazards—is shaped by a variety of factors including socio-economic status, gender aspects, public health, local environmental conditions, and the capacity of individuals (particularly vulnerable women, men, youth and differently abled persons) and systems to adapt to climatic changes.

The '*Risk*' is then a product of these hazards coming into contact with the exposed and vulnerable systems within the district. It represents the likelihood of experiencing adverse consequences, which can range from threats to human life and well-being to damage to property and infrastructure, and degradation of the environment and biodiversity.

The '*Impacts*' of climate change are felt across the natural and human systems in the district. They are influenced by the intersection of climate risk with 'Socio-economic Processes' such as development pathways, adaptive practices, and the efficacy of governance structures in place to manage and respond to these risks.

The recognition of this interplay in the Ellembelle District is vital for advancing climate change adaptation strategies. The district's adaptation efforts must therefore be rooted in a deep understanding of local climate risks, informed by both scientific knowledge and socio-economic dynamics, to ensure resilience and sustainable development in the face of climate change.

5.2 Ellembelle District's Current Vulnerability

In the Ellembelle District, different dimensions of vulnerability play a significant role in understanding the risks and impacts faced by communities. **Physical vulnerability** refers to the susceptibility of the district's natural environment and physical assets—such as land, forests, water bodies, and critical infrastructure—to climate hazards like coastal erosion, sea-level rise, and flooding. These physical changes can damage homes, farms, and ecosystems, directly impacting the livelihoods dependent on them. **Socio-economic vulnerability** considers the capacity of individuals and communities, particularly those reliant on climate-sensitive sectors like agriculture and fisheries, to cope with and recover from climate impacts. It is influenced by poverty levels, employment, access to resources, and the resilience of livelihoods. **Infrastructure vulnerability** focuses on the ability of the district's built environment—roads, schools, bridges, and health facilities—to withstand extreme weather events. Poorly designed or located infrastructure in flood-prone areas is highly susceptible to damage, further exacerbating vulnerabilities. **Gender vulnerability** highlights the unequal impacts of climate change on men and women, particularly women, who are often responsible for food and water provision and may face additional health, labor, and safety risks in climate-induced disasters.

5.2.1 Physical Vulnerabilities

The Ellembelle district's physical vulnerability is significantly worsened by extensive deforestation and degradation of natural resources (Usman Kaku et al., 2021), primarily due to rampant logging by registered companies and illegal chainsaw operations, as well as unregulated agricultural practices (Damnyag et al., 2013). The prevalent slash-and-burn farming methods, along with indiscriminate bush burning during the harmattan season, further exacerbate the district's vulnerability to climate change (Bilson, 2018). These activities not only lead to the loss of biodiversity and forest cover but also contribute to soil nutrient depletion, undermining the district's agricultural productivity and increasing its susceptibility to climate-induced risks such as land degradation and reduced agricultural yields.

Additionally, artisanal small-scale mining, known locally as *galamsey*, is significantly contributing to the physical vulnerability of the Ellembelle District. The mining activities are destroying cocoa farms, rivers, and other water bodies, leading to widespread environmental degradation. The pollution from these operations threatens the district's agricultural base and water resources, which are critical for local livelihoods. In recent years, affected communities have staged protests to voice their concerns about the damage caused by *galamsey*, calling for more stringent regulation and enforcement to protect their lands and ecosystems.

According to the district's MTDP (2022), access to potable water has improved, the stark contrast in water availability between the southern and northern parts of the district highlights significant disparity. Most southern communities enjoy reliable water access, thanks to numerous small town water systems and boreholes. However, the northern part faces acute water scarcity, primarily due to poor road accessibility that limits the reach of drilling services. This geographical disparity in water access not only highlights the district's uneven vulnerability to water stress (**Figure 7**) but also points to potential challenges in adapting to future climate variability and change. In addition, the burden on accessing potable water for household related uses highlight the disparities in the gendered use of and access to water within these geographical areas. The high iron content in Nkroful's water further illustrates specific vulnerabilities related to water quality, impacting the health and well-being of local communities (Auwah et al., 2020; Ayeta et al., 2024).

Overall, the district's current state of environmental degradation and resource management challenges significantly amplifies its vulnerability to climate-induced risks, threatening the socio-economic stability and health of its populations.

5.2.2 Socio-economic Vulnerabilities

The Ellembele district faces complex socio-economic challenges that increase its vulnerability to various shocks, particularly those related to climate change. These challenges are intertwined with geographical, environmental, and social factors that hinder sustainable development and the ability to bounce back from setbacks.

The district's location in a wet semi-equatorial climate zone brings heavy rainfall. While this benefits agriculture, it also leads to flooding, which damages infrastructure and crops. Cocoa, a vital cash crop, is particularly affected, with heavy rains promoting diseases like black pod and hindering the drying process. Furthermore, the district's unpaved roads become nearly impassable during the rainy season, isolating communities and disrupting access to markets and essential services.

Plate 7. Cocoa seeds being dried in a community during the field visit.



As stated earlier, the district's economy heavily depends on agriculture, with most residents engaged in farming. However, the coastal communities that rely on fishing face challenges from overfishing, illegal

fishing practices, and declining fish stocks. While employment is high among the economically active population, a significant portion remains inactive, engaged in unpaid domestic activities or relying on informal work. Limited access to credit and financial services further restricts economic growth and the ability to withstand economic shocks..

The district has a large youth population, which presents both opportunities and challenges. While this “youth bulge” offers potential for a strong workforce, it also requires adequate services and opportunities to prevent future issues related to an aging population, especially in rural areas with limited access to resources. Furthermore, a gender imbalance among the elderly highlights the need for targeted support for older women who may face increased socio-economic difficulties.

Several groups within Ellembele are particularly vulnerable, including rural farmers, children facing hardship, people living with HIV/AIDS, communities displaced by mining, disadvantaged women, and people with disabilities. These vulnerabilities are worsened by malnutrition, limited access to education and healthcare, and the impacts of HIV/AIDS. Child labour is also a concern, with children often exploited and subjected to dangerous working conditions.

Households have developed coping strategies to deal with these challenges, such as selling assets or relying on informal insurance. However, the use of formal insurance remains low, indicating a need for greater access to these financial tools. The district has implemented programs to support vulnerable groups, including mass registration for the National Health Insurance Scheme, the Livelihood Empowerment Against Poverty (LEAP) program, and the formation of cooperative and welfare societies. These initiatives aim to reduce the impact of shocks and ensure that vulnerable groups are included in decision-making processes.

5.2.3 Infrastructure Vulnerabilities

The Ellembele District’s infrastructure exhibits vulnerabilities across several sectors, particularly in healthcare, education, transportation, and waste management, which can be significantly impacted by climate-related events and other factors.

- *Healthcare Infrastructure:* The district’s healthcare infrastructure is minimal, with only a few health training institutions and a limited number of health centers and Community-based Health Planning and Services (CHPS) compounds to serve its population. This limited healthcare infrastructure is further stressed by the presence of only one major hospital, St. Martin de Porres Catholic Hospital at Eikwe, and a National Health Insurance scheme in Nkroful. Such limitations pose a significant risk during health crises, especially those exacerbated by climate-induced diseases or events, as the existing facilities may not adequately meet the increased demand for healthcare services including antenatal, child welfare clinics.
- *Educational Infrastructure:* The educational sector is characterized by a high concentration of facilities in the southern part of the district, including a limited number of secondary and specialized schools. This geographical concentration increases the risk of disruption due to climate-induced events such as flooding, which can impede access to education and affect the long-term socioeconomic development of the district. The reliance on a few secondary institutions for the entire district’s educational needs further exacerbates this vulnerability.
- *Transportation Infrastructure:* The district’s transportation network, comprising 154 km of trunk roads with only a portion tarred, and 253 kilometers feeder roads, of which only about 150 km is motorable year-round, highlights significant vulnerability. Footpaths are also largely

used by women, children and other commuters but not much attention has been given to its development. The lack of maintenance and absence of essential infrastructure such as bridges and culverts render these roads particularly vulnerable to becoming impassable during the rainy season, isolating communities and hampering access to essential services and economic activities.

- **Waste Management:** The district's waste management system faces challenges due to the non-engineered nature of its disposal sites and insufficient resources, such as a limited number of skip containers and refuse trucks. This inadequacy in waste management infrastructure poses environmental and health risks, particularly in the absence of daily cover at dumpsites, leading to potential contamination of water sources and surrounding areas.

5.2.4 Gendered Vulnerabilities

Studies have shown that women and differently abled people often bear disproportionate burdens during climate crises due to existing societal, economic, and political inequalities (Mujere, 2016; Denton, 2002; Alston et al. 2022). Thus, exploring gender-specific vulnerabilities to climate change in the Ellembelle District, where socio-economic roles and responsibilities are distinctly divided along gender lines is vital.

In this Assessment, the identification of gender-specific vulnerabilities in the Ellembelle District has been significantly enriched by data derived from multiple sources, including stakeholder workshops, the District Medium Development Plan (MTDP), and other secondary sources. These data sources have provided a detailed view of the unique challenges faced by different groups within the district, especially women and differently abled people (**Table 2**).

- **Agriculture:** Women in the district who rely on agriculture for livelihood face significant challenges due to climate change. The unpredictability of weather patterns can disrupt traditional farming schedules, which are crucial for the cultivation of staple crops such as cassava and plantain. As primary caregivers, women may need to balance increased agricultural labour with family responsibilities, exacerbating existing socioeconomic pressures. Youth in the district are particularly vulnerable to shifts in agricultural viability, which can thwart training opportunities and stable employment, essential for their socio-economic advancement. Differently abled individuals may find fewer opportunities in traditional farming due to physical barriers and a lack of adaptive technologies that facilitate participation.
- **Water Resources:** In the Ellembelle district, freshwater resources are critical but vulnerable to contamination from saline intrusion due to rising sea levels. Women and girls, who are primarily responsible for water collection, face increasing challenges to access safe drinking water, which impacts not only their physical health but also their ability to perform other community roles effectively. The task of fetching water, often relegated to women and youth, becomes more strenuous and time-consuming with environmental changes, directly impacting education and economic activities for young people. Differently abled people face severe accessibility issues that can lead to increased dependence on others for basic water needs, highlighting the need for inclusive water resource management strategies.
- **Fisheries:** The district's dependency on fisheries for economic activities means that changes in marine biodiversity can have stark impacts on women, particularly those involved in ancillary activities like fish processing and market vending. Reductions in fish stocks can

lead to reduced incomes and increased competition for available jobs, which may also lead to social and economic marginalization. The economic downturn in fisheries affects young workers by limiting job prospects in what is often a primary employment sector in coastal districts. Differently abled people encounter significant barriers in the fisheries sector, where physical demands and lack of accessible facilities reduce employment opportunities.

- **Health:** Women's health is particularly vulnerable to climate change impacts due to their roles in communities and families. Increased frequency of climate-related diseases such as malaria and cholera can impose additional burdens on women, both as patients and as primary caregivers in their families. Children and youth are particularly exposed to health risks associated with climate change due to their high mobility and involvement in physical activities. The differently abled people often face neglect in emergency health responses and climate change adaptation strategies, necessitating more inclusive health service planning.
- **Infrastructure:** Inadequate response to infrastructural needs during extreme weather events, such as floods, disproportionately affects women. The loss of housing or disruption of community services places additional burdens on women to secure the well-being of their families and to participate in recovery efforts. Women and children are most negatively impacted by displacements caused by infrastructural damage. The district infrastructure's inability to withstand extreme weather disproportionately affects the differently abled, who may not be able to evacuate or seek shelter independently. Youth involvement in rebuilding and resilience planning is essential yet often overlooked, which can hinder their development into prepared and resilient adults.

Table 2. Gender-specific vulnerabilities across priority sectors in the Ellembelle district.

Sector	Vulnerability	Impact on Women	Impact on Youth	Impact on Differently Abled	Specific Examples
Agriculture	Increased risk of crop failure due to erratic rainfall and extreme temperatures.	Women face increased food insecurity and workload.	Youth face employment instability in agricultural sectors, affecting future career prospects.	Limited mobility restricts access to modified agricultural roles, increasing dependency.	In towns like Aiyinase, women predominantly manage family farms and are critical in harvesting and selling crops like cassava, which is highly vulnerable to changing rainfall patterns.
Water Resources	Rising sea levels and increased salinity affecting freshwater supplies.	Increased burden on women to secure water impacts health and economic activities.	Educational disruptions as youth prioritize water collection over school.	Greater physical challenges in accessing safe water exacerbate health risks.	In coastal communities like Eikwe, Sanzule, saline intrusion into freshwater makes the daily task of collecting drinkable water even more challenging, especially for the elderly and differently abled.

Fisheries	Changes in marine ecosystems due to warming oceans and acidification.	Reduced fish catches affect women's income and job security.	Reduced entry-level job opportunities in fishing industries, impacting economic independence.	Access barriers to fishing and related activities due to lack of adaptive equipment or infrastructure.	The fish populations near the Ankobra River estuary are declining, impacting the local economy heavily reliant on fishing, affecting young workers' and women's livelihoods.
Health	Increased exposure to vector-borne diseases and waterborne illnesses.	Increased caregiving burdens impact women's well-being as well as drain of finances. It also reduces productivity at work.	Health risks from environmental exposure impact youth's long-term health, in addition to disruption in school attendance.	Health services may be less accessible or inadequate for specific needs, increasing health risks.	Outbreaks of malaria are common in the wetter months, placing a disproportionate burden on women who care for the sick in areas like Nkroful.
Infrastructure	Poor infrastructure resilience to extreme weather events.	Disproportionate impact on women in securing family safety and rebuilding communities.	Limited involvement in planning and recovery efforts reduces youth's influence on future resilience.	High susceptibility to injuries during disasters due to inadequate evacuation plans or facilities.	The frequent floods damage roads in Kikam, isolating communities and disrupting access to markets and health services, particularly challenging for those with disabilities.

Source: Stakeholder workshop, 2024

Across these scenarios, climate change poses risks to food security, as increased temperatures and variability in precipitation can disrupt agricultural productivity and access to food (Kotir, 2011; Kogo et al., 2021). The Ellembele District's unique coastal and forested ecosystems will require careful management to balance development with conservation, ensuring that the cultural and ecological heritage is preserved while adapting to and mitigating the impacts of climate change.



6



Ellembella District Assembly

Observed Climate Trends at Ellembelle District Assembly

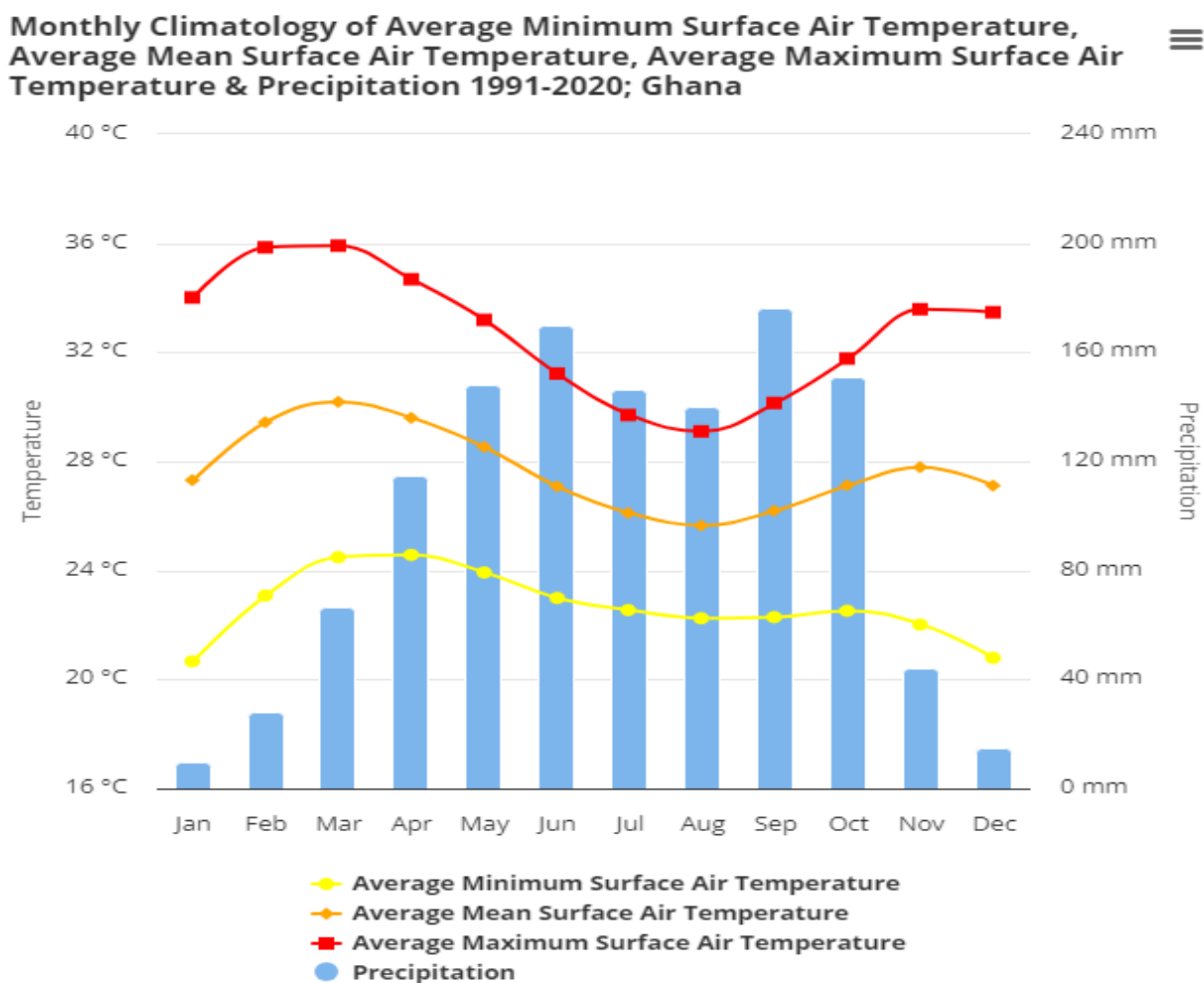
6.0 Climate Trends and Impacts in Ghana

Ghana's climate regime is predominantly tropical, characterized by two main seasons: the wet and the dry seasons. This equatorial country experiences significant rainfall, especially in the southern regions, with the wet season peaking during the June to August period. The northern parts of Ghana typically have a single rainy season, which starts in April and may last until October. The dry season is marked by the Harmattan, a dry and dusty northeasterly trade wind that blows from the Sahara Desert over West Africa into the Gulf of Guinea between the end of November and the middle of March.

The climate trends in Ghana over the last century show a gradual increase in temperatures, aligning with global warming patterns. Historical climatic data demonstrates that average maximum temperatures are generally highest during the March-April-May (MAM) season, with recent decades observing temperatures nearing 34.59°C. This suggests a significant warming trend, particularly in the last thirty-year period from 1991-2020. The June-July-August (JJA) season, despite being the coolest period, has seen an increase in rainfall, indicating a more intense rainy season, which is critical for the nation's agriculture and water resource management (World Bank, 2021). These observed climatic changes have important implications for Ghana's environmental and socio-economic landscapes. The increasing temperatures and altered rainfall patterns necessitate adaptive strategies for agriculture, as crop viability may shift. Additionally, the variability in water availability could have repercussions for both urban and rural water supply systems. Public health policy must also adapt to potential changes in disease patterns with the evolving climate.

Figure 9 is a climatology graph for Ghana, covering the period from 1991 to 2020. It illustrates the interplay between temperature and precipitation over the months. The graph depicts average minimum, mean, and maximum surface air temperatures, along with monthly precipitation rates. Notably, temperatures peak around February and March, then again in November, suggesting these periods may represent the hottest months of the year. Conversely, the coolest temperatures tend to occur in August, as indicated by the lowest average minimum temperatures.

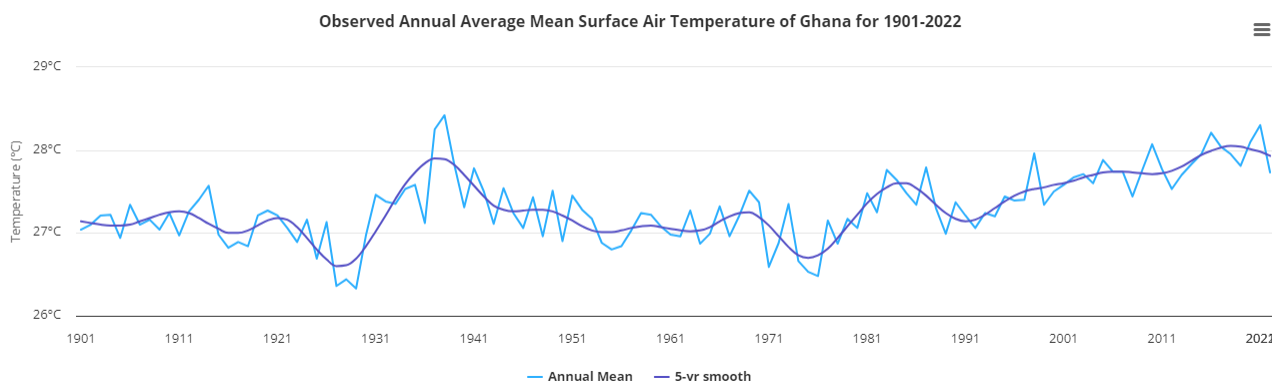
Figure 9. Interplay between temperature and precipitation over the months in Ghana from 1991-2020



From **Figure 9**, precipitation is most significant around June, marking the height of the rainy season, with a secondary, milder peak in the months of September and October. This pattern indicates a primary and secondary rainy season, typical of many tropical climates. The dry season, characterized by higher temperatures and lower rainfall, appears to fall in the early part of the year, particularly January through March. This climatic information is vital for various sectors, including agriculture, where it can guide planting and harvesting activities, and public health, where it can inform preparations for heat-related health issues or vector-borne diseases.

Figure 10 illustrates the observed annual average mean surface air temperature of Ghana from 1901 to 2022. The chart shows a clear long-term increase in temperature from about 27°C to nearly 28.5°C over the 121-year period. The annual mean temperatures, represented by the blue line, exhibit notable year-to-year fluctuations, while the 5-year moving average, shown by the purple line, highlights a more pronounced warming trend. Early 20th-century temperatures were relatively stable, but a significant spike occurred around the 1940s, followed by a slight cooling in the 1950s.

Figure 10: Observed annual average mean surface temperature of Ghana (1901-2022)



From the 1960s onwards, a gradual warming trend is evident, with increasing variability and several peaks in the late 20th and early 21st centuries. Recent years, particularly since the late 1970s, show a steeper rise in temperatures, with the highest levels recorded in the 2010s and early 2020s, reflecting the impact of global climate change. This trend has significant implications for local ecosystems, agriculture, water resources, and overall climate patterns in Ghana, emphasizing the need for effective mitigation and adaptation strategies.

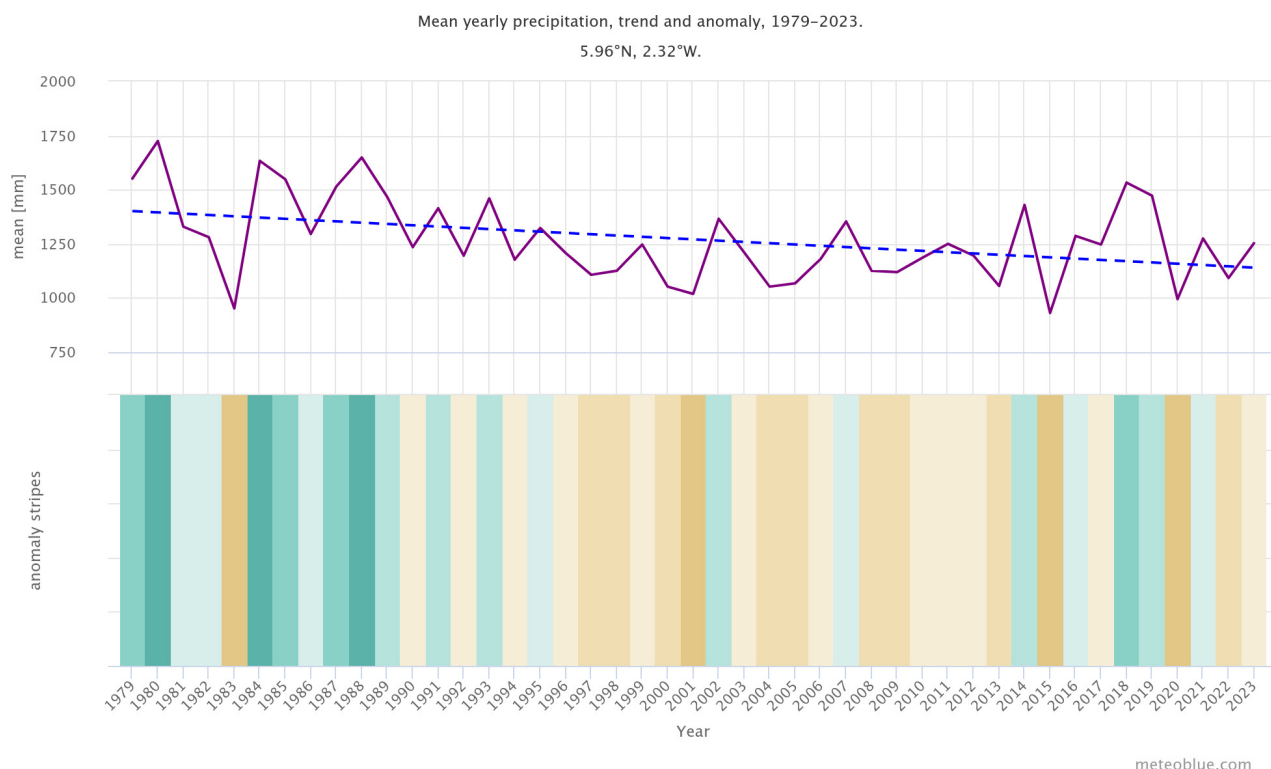
Rising temperatures in Ghana, particularly in districts like Ellembelle, have significant consequences for farming and fishing, reducing crop yields due to heat stress, decreasing water availability, and increasing pressure from pests and diseases, ultimately threatening livelihoods and food security. For fishing, warmer waters alter fish populations and distribution, affect breeding cycles, and degrade water quality, leading to higher fish mortality. Livestock productivity also declines due to heat stress, and overall economic stability is threatened as these sectors are primary income sources. Adaptation costs can be expensive, potentially forcing rural populations, mostly the youth, to migrate to urban areas. These changes threaten food security and nutrition.

6.1 Local Level Climate and Trends

Available climate data for the Western region and Ellembelle district over the past several decades reveals a scenario of increasing temperatures and fluctuating precipitation patterns. The district has not shown a definitive trend in rainfall, oscillating between higher and lower than average yearly precipitation, which could lead to alternating periods of flooding and drought. Temperature trends, however, have consistently risen, aligning with global warming trends, and signalling potential challenges such as heat stress and altered agricultural conditions.

Figure 11 shows a long-term view of the mean yearly precipitation in the Ellembelle district from 1979 to 2023. This graph showed annual fluctuations in precipitation levels, with certain years experiencing higher than average rainfall, resulting in peaks on the graph, and others with significantly less, reflected by the lower points.

Figure 11: Mean annual precipitation, trend, and anomaly in Ellembelle District, 1979-2023

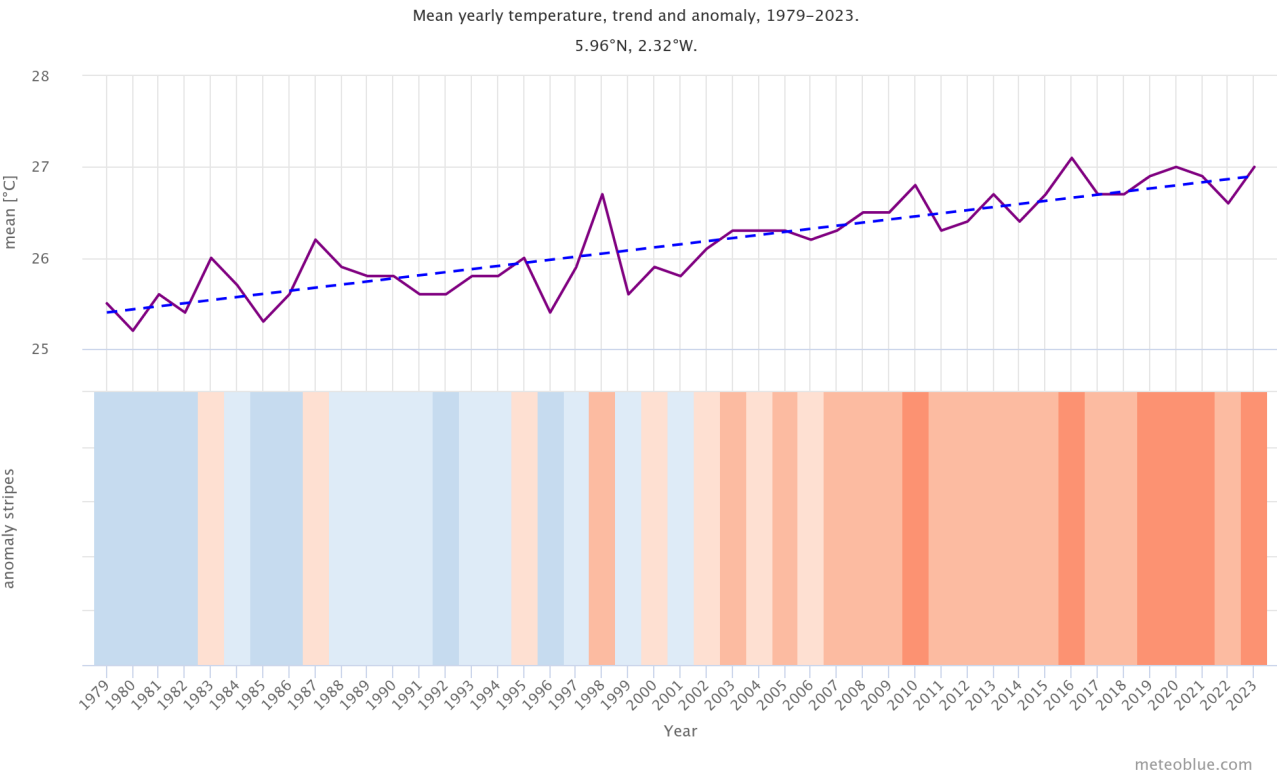


Source: meteoblue.com, 2024.

Despite these yearly changes, there was no clear trend towards a consistent increase or decrease in annual rainfall over the period observed. The anomaly stripes at the bottom indicated years with above (teal) and below (beige) average rainfall, providing a visual representation of these deviations. The data suggested that Ellembelle District experienced variable rainfall which could have implications for water resource management and agricultural planning and for residents, particularly women and young farmers directly involved in undertaking these activities due to the potential for both flood and drought conditions.

Figure 12 provides an analysis of the mean yearly temperature for the same Ellembelle district and period. It revealed a gradual warming trend with the dashed trend line showing an increase in the mean yearly temperature over time. The temperature anomaly stripes transitioned from cooler (blue) to warmer (red) over the years, particularly noting a sequence of warmer years from 2015 to 2023. This indicated a rise in temperatures in recent times, consistent with global warming trends. Such an increase could have various effects on the district, including shifts in agricultural cycles, increased energy demands for cooling, and greater stress on water supplies.

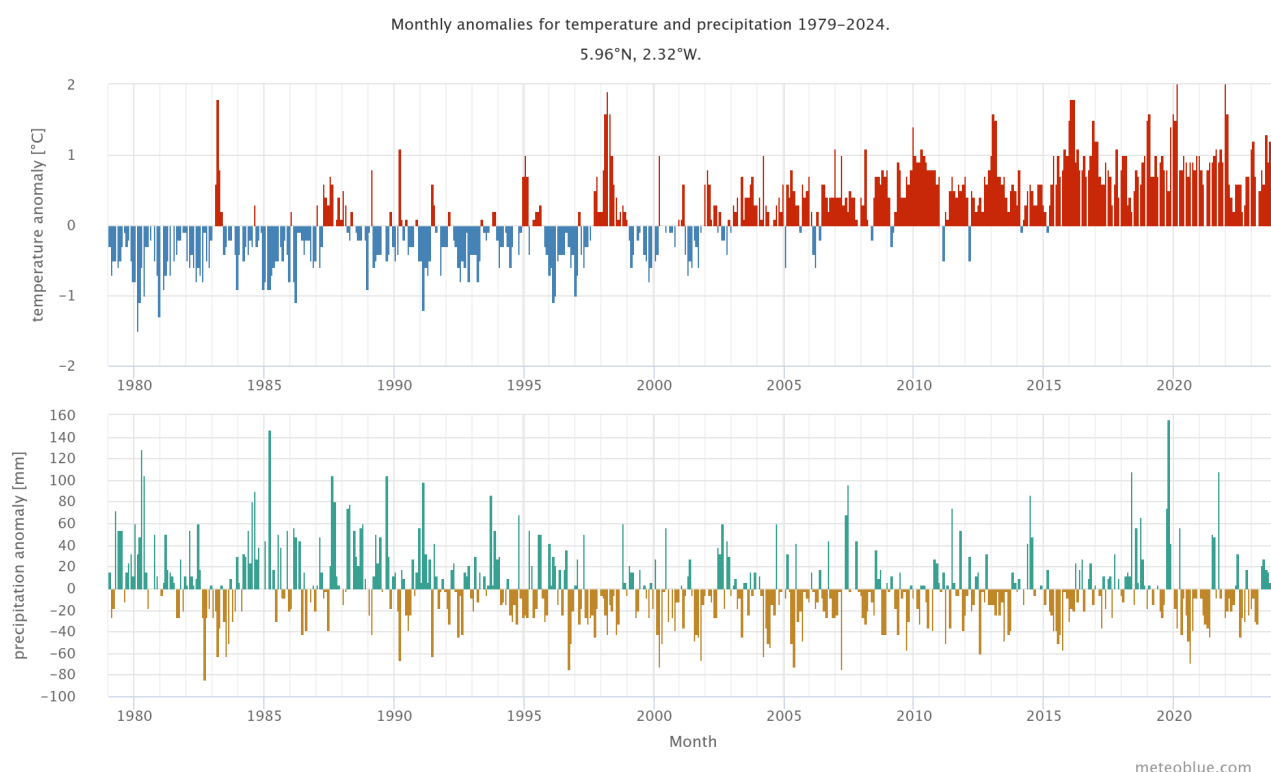
Figure 12: Mean annual temperature, trend, and anomaly in Ellembelle District, 1979-2023



Source: meteoblue.com, 2024

Figure 13 shows monthly anomalies for temperature and precipitation, highlighting the short-term variability within the district. Temperature anomalies were depicted with red bars for warmer-than-average months and blue bars for cooler-than-average months. In recent years, there was a visible increase in red bars, suggesting more frequent warm months. Precipitation anomalies were shown with green bars for wetter-than-average months and brown for drier-than-average months. This part of the graph illustrates the variability without a clear pattern, but with noticeable extreme wet and dry months, which could lead to periods of flooding or drought, respectively.

Figure 13 Monthly anomalies for temperature and precipitation in Ellembelle District



Source: meteoblue.com, 2024

6.2 Observed Hazard and Extreme Events

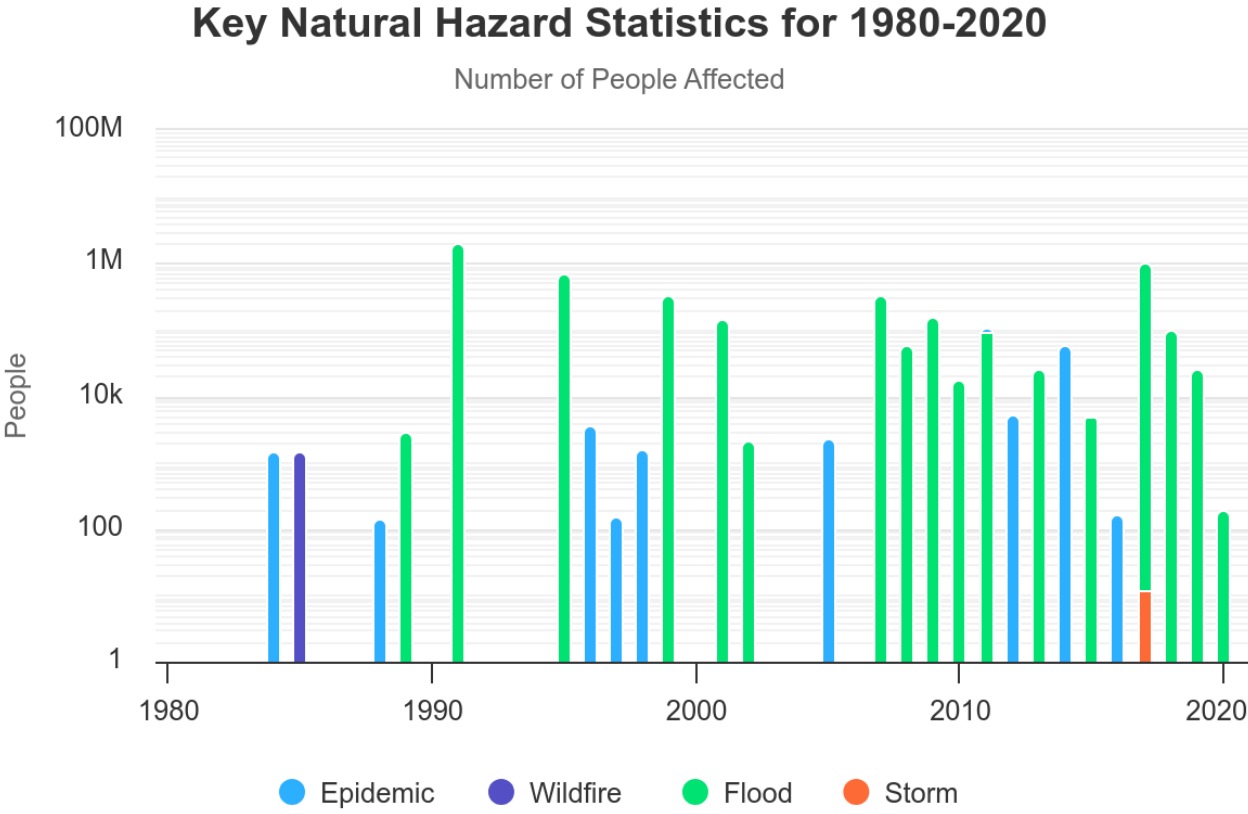
Ghana's vulnerability to climate-induced hazards, particularly flooding, is a significant and increasing concern. Over the years, the frequency and severity of floods have risen, especially in the northern regions (Atanga and Tankpa, 2021), which are prone to destructive flood events that have far-reaching effects on food production due to the area's reliance on rain-fed agriculture and limited response capacity to disasters. The impact of such events is compounded in urban areas like Accra and Kumasi, where seasonal rainfall, often exacerbated by poor urban planning and inadequate drainage, contributes to flooding (Abass, 2022). The devastating floods of June 2015 in southern Ghana (Ansah et al., 2020; Kayaga et al., 2021), where heavy thunderstorms led to significant rainfall and flooding in many areas including Accra, serve as a stark reminder of the nation's susceptibility to extreme weather events.

From 2015 to 2020, Ghana's National Disaster Management Organisation (NADMO) recorded numerous flood events, leading to hundreds of deaths, injuries, and widespread destruction of property and farmland (**Figure 14**). Despite substantial investments in flood protection structures, Ghana has not seen a reduction in flooding incidents, highlighting the inadequacy of reactive strategies and the urgent need for proactive flood risk management. It is estimated that over the past 50 years, about four million people have been affected by floods in Ghana, resulting in economic damages exceeding US\$780 million (Ansah et al., 2020; Asumadu-Sarkodie, et al., 2017).

Moreover, the increasing rainfall intensity, linked to higher temperatures expected with climate change, is predicted to intensify these challenges, particularly as heavy rainfall is projected to become more common between 2010 and 2050. The Government of Ghana's current coping strategies, including repairing infrastructure and clearing waterways post-flooding, are costly and fail to address the root causes of the floods or prevent future occurrences. **Figure 14** shows the number of people affected by different types of natural hazards and

extreme events in Ghana over a 40-year period. Floods are the most frequent natural hazard affecting people in the district, with the number of affected individuals often reaching into the tens of thousands. There appears to be a general increase in the frequency and/or the number of people affected by floods over time, particularly noticeable in the spikes in the 2000s and 2010s.

Figure 14: Summary of Key Natural Hazard Events for Ghana from 1980 to 2020



Source: World Bank Climate Change Knowledge Portal, 2023

Epidemics too have surged intermittently, striking with varying degrees of severity, and hinting at the possible proliferation of waterborne diseases post-flooding or other public health crises. Wildfires, while rarer and affecting fewer people when juxtaposed with floods and epidemics, pose a significant threat when they do flare up. Storm events have been minimal, with a singular occurrence marked in the dataset, possibly due to the region’s climatic dynamics being less conducive to such phenomena.

The Ellembele district’s proximity to the ocean increases the risk of flooding from storm surges, especially during the rainy season when the area is already prone to increased rainfall and associated flooding. The forested regions of the district are not immune to climate impacts either. They are at risk of wildfires, particularly in the dry season, when reduced humidity and drier conditions prevail. Deforestation and land-use changes for agriculture, galamsey or development can exacerbate this vulnerability by reducing the natural resilience provided by forest ecosystems. Additionally, the district’s climatic conditions can foster the spread of vector-borne diseases, leading to health epidemics.

The observed trends in the Ellembele district, reflecting a rise in the frequency and impact of natural hazards over the past decades, likely result from a mix of environmental change and socio-economic factors, including population growth and urbanization. The Ellembele district has faced a series of hazardous climatic-induced events over the past few years (**Table 3**). The data compiled herein is derived from various news sources

and reports, which have documented these occurrences, providing a lens into the tangible consequences of climate change faced by the communities and households of the Ellembelle district. It captures a range of events from severe downpours leading to widespread displacement to the destruction of properties and critical infrastructure.

The region and district have a history of perennial flooding. Flooding in the district often results in significant damage to homes and property, roads (**Plate 8**) displacement of thousands of residents, and in some cases, fatalities. Notable events include the flooding in Ankobra Town in April 2024, which destroyed over 100 houses, and the Western Region floods in July 2023, resulting in 2 deaths and affecting 2,300 people. Consistently, these events have led to significant property damage, displacement of thousands of residents, and disruption of daily activities, including education, as seen with the heavy rains in Nzema East in June 2014. The frequent and severe nature of these events highlights the vulnerability of the district to extreme weather patterns, likely exacerbated by climate change.

Table 3. Historical catastrophic hazard events occurred in Ellembelle District and surrounding areas.

Date	Hazardous Event	Location	Impact	Sources
April 2024	Ankobra Town Submerged After River Overflows Its Banks	Ankobra	destroyed over 100 houses and several properties, leaving residents displace	GhanaReport, 2024
June 2023	Deadly Floods Strike in Southern Regions	Southern Regions of Ghana	50 homes were damaged	Floodlist, 2023
July 2023	2 Dead, 2,300 Affected by Western Region Floods	Western Region	2 people dead and 2,300 people have been affected	Ghanaweb, 2023
24th June 2022	Heavy downpour renders several residents in Nzema Akropong homeless	Nzema Akropong	About 200 households were affected and over 1000 residents displaced	Daily Statesman, 2022
June 2022	Rain destroyed properties in parts of Western Region	Ankobra	200 households were affected and displacement of hundreds of people	Graphiconline, 2022
June 2022	DCE Calls for Relocation of Flood Victims in Ellembelle District	Adubiri and Akropong	1,000 displaced individua	Vaultnews, 2022
May 2020	Buildings Sink in Water as Parts of Nkroful Flood	Nkroful	Displaced hundreds of people and destroyed properties and personal belongings worth millions of cedis	Modern Ghana, 2020
3rd June 2014	Heavy rains affecting schools in Nzema East	Nzema East	Disrupted school activities as students could not come to school	GHHHeadlines, 2014

Plate 8. The road linking two communities in the Ellembelle District to the Apimanim-Elubo highway washed away after heavy rains and flooding in 2021.



6.3 Future Climate Change Projections

This section is predicated on an ensemble of climate models that collectively offer a spectrum of plausible climatic futures based on selected Shared Socioeconomic Pathways (SSP). These ensembles are essential as they provide a diversified view of the potential trajectories our climate could take, accounting for the inherent uncertainties in climate forecasting. Each model within the ensemble contributes unique insights that, when combined, allow us to delineate the boundaries of what we might expect in the coming years and decades.

The foundation of the climate projection data utilized here is the globally recognized Coupled Model Inter-comparison Projects (CMIPs), coordinated by the World Climate Research Programme. The data being presented is specifically drawn from the sixth phase of the CMIPs, known as CMIP6, which is the latest collection of global climate models contributing to the body of knowledge that informs the Intergovernmental Panel on Climate Change (IPCC) Assessment Reports. CMIP6 undergirds the scientific findings of the IPCC's Sixth Assessment Report, offering the most up-to-date scenarios of how the climate might change under various greenhouse gas concentration trajectories.

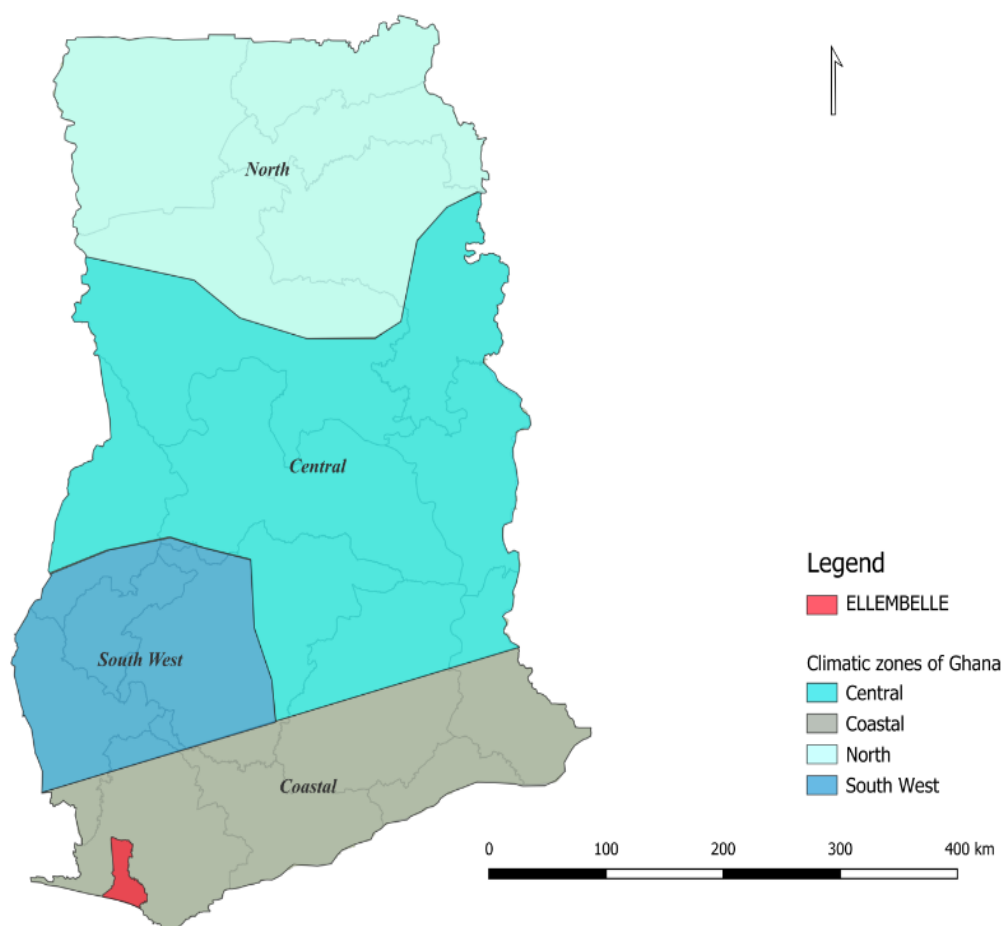
To ensure that the data is both granular and applicable on a scale that is relevant for regional planning and decision-making, it is presented at a resolution of $0.25^{\circ} \times 0.25^{\circ}$, approximately 25km x 25km. This level of detail allows for more localized climate projections, which is particularly critical for districts such as Ellembelle district in the Western Region of Ghana, where localized climate impacts can have profound implications for agriculture, water resources, infrastructure, and overall community resilience.

6.3.1 Future Climate Change Projections for Ghana

The future climate projections for Ghana (**Figure 15**) indicating its distinct climate zones, yield the following insights with varying degrees of certainty:

- There is strong consensus across all scenarios that Ghana will experience a rise in air temperatures. This warming is anticipated to range between 0.5 to 1.5 °C, 1.5 to 2.5 °C, and 2.5 to 4.5 °C above the historical average by the end of the 21st century, corresponding to the RCP2.6/SSP1-2.6, RCP4.5/SSP2-4.5, and RCP8.5/SSP5-8.5 scenarios, respectively. This projected increase is consistent throughout the four climatic zones identified in Ghana: Central, Coastal, North, and South-West.
- When it comes to precipitation, the confidence in projecting future trends is moderate to low. The projections suggest only minor changes, possibly marginally more significant than the historical variability observed in the past. This is true across all emission scenarios. The uncertainty in these precipitation projections stems from discrepancies between observed historical rainfall data and the models' ability to simulate past rainfall trends accurately.

Figure 15: Ghana's four climate zones, where it is possible to observe that the Ellembelle is in the southwest zone.



6.3.2 Future Climate Change Projections for Western Region and Ellembelle District

6.3.2.1 Temperature

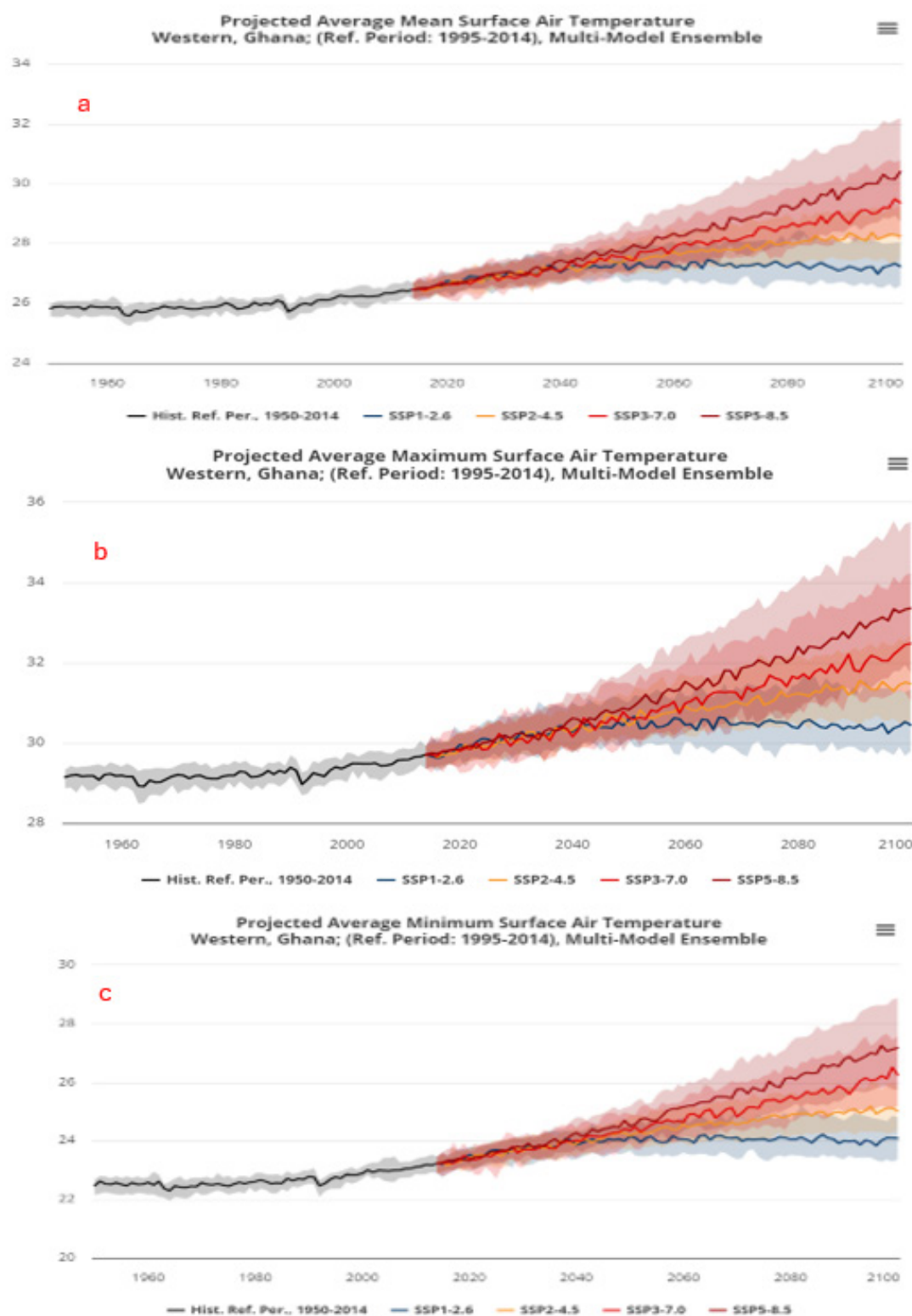
Figure 16 (a), (b), and (c) depict various aspects of temperature projections for the Western Region (proxy for Ellembelle district), including mean, maximum, and minimum surface air temperatures. The lines within these graphs represent different Shared Socioeconomic Pathways (SSP) scenarios, each illustrating how future temperatures might deviate from historical patterns based on a range of potential greenhouse gas emissions trajectories.

The black line in each graph shows the historical reference, providing a baseline of recorded temperatures from 1950 to 2014. This serves as the foundation for comparing future climate projections.

The coloured lines correspond to different SSP scenarios, which are pathways describing how global society, demographics, and economics might evolve over the 21st century, influencing greenhouse gas emissions and climate change:

- **SSP1-2.6 (blue line):** A sustainable pathway that assumes rapid and significant efforts to reduce greenhouse gas emissions, resulting in a lower rise in temperatures.
- **SSP2-4.5 (orange line):** A middle-of-the-road scenario where some efforts are made to mitigate emissions, leading to moderate temperature increases.
- **SSP3-7.0 (red line):** A pathway of higher emissions due to less ambitious mitigation efforts, resulting in greater temperature increases.
- **SSP5-8.5 (pink line):** The highest emission scenario without significant climate action, predicting the most substantial rise in temperatures, reflecting a much warmer future.

Figure 16: Future Climate Change Projections for Western Region and Ellembelle District (a) projected mean surface air temperatures (b). projected maximum surface air temperatures (c). projected minimum surface air temperatures



Projected mean surface air temperatures

This trend (**Figure 16a**) remains relatively stable until the current period. Post-2014, we see four divergent pathways represented by the SSP scenarios:

- This low-emission scenario [**SSP1-2.6 (blue line)**] predicts the least temperature increase, indicating proactive mitigation efforts and successful climate policies globally. This suggests a gradual, but relatively moderate, rise in temperatures.
- Reflecting a middle-ground scenario [**SSP2-4.5 (orange line)**], this path anticipates some policy action against climate change but not as aggressive as SSP1-2.6. The temperature increases here are more pronounced, indicating a warmer future that still remains within a potentially manageable range.
- This high-emission scenario [**SSP3-7.0 (red line)**]: is based on less effective global climate action, resulting in a steep increase in temperatures, significantly higher than the previous two scenarios. This suggests a world where regional climates, including that of the Ellembele District, could experience more extreme heat and its associated impacts.
- The highest emission scenario [**SSP5-8.5 (pink line)**] assumes unchecked global emissions, leading to the most substantial warming. The projection for this scenario predicts a severe rise in temperature, reaching levels far above historical averages by the end of the century.

The shaded areas around each line represent the range of uncertainty and variation within each scenario, highlighting the potential for both higher and lower temperature increases.

For the Ellembele District, these projections are a clarion call to prepare for a future with elevated temperatures. Adapting to these changes will require robust planning in agriculture, infrastructure, public health, and natural resource management to mitigate the impacts of the projected warming trend.

Projected maximum surface air temperatures

This graph (**Figure 16b**) displays the projected average maximum surface air temperature for the Western Region of Ghana, including the Ellembele District, from past recorded data (1950-2014) to future projections until 2100. The historical period, represented by the black line, provides a baseline showing the maximum temperatures that have been historically observed. Post-2014, projections diverge according to four SSP scenarios, each reflecting different levels of greenhouse gas emissions and global policy responses:

- **SSP1-2.6 (blue line)**: Represents a sustainable path that assumes significant measures to limit climate change, resulting in the lowest increase in maximum temperatures among the scenarios.
- **SSP2-4.5 (orange line)**: Suggests a moderate pathway with some efforts toward mitigation. Temperatures rise more than in SSP1-2.6, reflecting a warmer future that could stress ecosystems, water resources, and agricultural productivity.
- **SSP3-7.0 (red line)**: Indicates a scenario with fewer efforts to curb emissions, leading

to a higher increase in maximum temperatures. This scenario would likely exacerbate heat-related challenges, including heat stress, which can have severe impacts on human health, agricultural yields, fisheries catch and overall ecological balance.

- **SSP5-8.5 (pink line):** This high-emission pathway results in the steepest increase in maximum temperatures, suggesting a world with significantly more frequent and intense heat extremes, with profound implications for all aspects of life in the Ellembelle district.

The shaded regions around each line depict uncertainty within each scenario, illustrating the range of possible outcomes depending on various factors such as technological developments, socio-economic changes, and natural climate variability.

For the Ellembelle district, these projections signal a need for intensified preparation and adaptation measures, particularly in sectors sensitive to high temperatures like agriculture, health services, and urban planning in localities like Nkroful, Essiama, Aiyinase. Strategies may include developing heat-resistant crops, enhancing the capacity of healthcare systems to deal with heat-related illnesses, and designing infrastructure to cope with higher temperatures.

Projected minimum surface air temperatures

The historical reference period from 1950 to 2014 is depicted by the black line, showing the average minimum temperatures experienced historically in the Western region. From this baseline, the future projections under the SSP scenarios are as follows (**Figure 16c**):

- **SSP1-2.6 (blue line):** This scenario assumes strong mitigation measures leading to lower greenhouse gas emissions and a less severe increase in minimum temperatures. The rise is gradual, suggesting a relatively stable climate compared to other pathways.
- **SSP2-4.5 (orange line):** Portrays a middle-of-the-road scenario where some mitigation efforts are made. The predicted rise in minimum temperatures is more substantial than in SSP1-2.6, indicating warmer nights and early mornings that could affect ecosystems and human comfort.
- **SSP3-7.0 (red line):** Reflects a pathway with high emissions due to less ambitious mitigation efforts. The steep increase in minimum temperatures forecasted under this scenario points to significantly warmer conditions that could have adverse impacts on agriculture, human health, and natural ecosystems.
- **SSP5-8.5 (pink line):** Represents the highest emission scenario with no significant efforts to curb greenhouse gases, leading to the most extreme increase in minimum temperatures. Such drastic warming could exacerbate heat-related stress in all aspects of life and necessitate urgent adaptation measures.

The shaded areas around each projection line show the range of possible minimum temperature changes within each scenario, highlighting the uncertainties inherent in climate modeling. These projections are crucial for anticipating potential impacts on agricultural practices, public health planning, and managing natural resources in the Ellembelle District.

Generally, the Ellembelle district's coastal climate zone will see temperature increases from between 1.5 °C under RCP 2.6 to 3 to 4.5 °C under RCP 8.5 with RCP 4.5 suggesting a mid-point of about 2.0 °C. As usual RCP 8.5 represents a step change in temperature. However, the plume

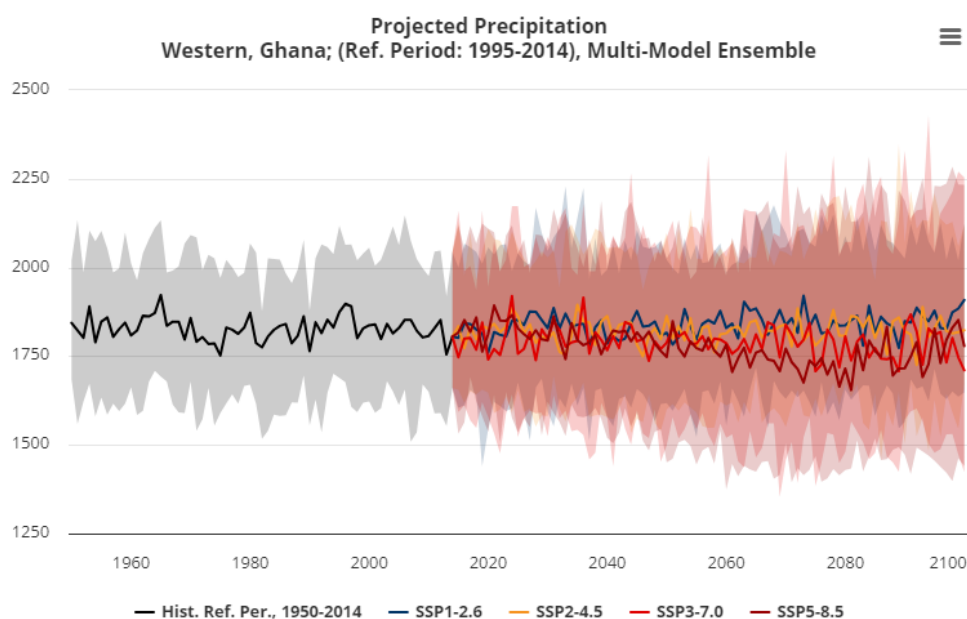
plots particularly when incorporating CMIP 6 suggest an even greater increase in temperature of at least another 0.5 °C. In short there is a risk of significantly higher temperatures in the North even at lower GHG concentration scenarios.

6.3.2.2 Precipitation

The historical precipitation levels, represented by the black line and gray area, provide the context from which future trends are extrapolated (**Figure 17**). Post-2014, the graph reveals a divergence in projections under different SSP scenarios:

- **SSP1-2.6 (blue line):** Illustrates a scenario where stringent climate policies could lead to modest changes in precipitation. The trend under this scenario indicates some variation but stays closer to the historical average, suggesting a potential stabilization of rainfall patterns.
- **SSP2-4.5 (orange line):** Indicates a moderate emissions scenario with some policy interventions to address climate change. Projections under this pathway show an increase in variability, with precipitation rates potentially fluctuating above and below historical averages.
- **SSP3-7.0 (red line):** Under this higher emissions scenario with fewer climate change mitigation efforts, there is a much wider range of uncertainty. This suggests a future where periods of both excessive rainfall and significant droughts may become more common, affecting everything from agriculture to water resource management in Ellembele district.
- **SSP5-8.5 (pink line):** This scenario assumes the highest emissions without significant climate mitigation efforts. The projections indicate the largest variability and the most extreme changes in precipitation patterns, implying a future with a higher likelihood of severe weather events, including intense rainfall and prolonged dry periods.

Figure 17: Projected precipitation patterns for the Western Region and Ellembele District



The analysis of annual average precipitation projections indicates that there is an approximately equal likelihood of marginal increases or decreases relative to the baseline period. On average, variations are projected to be within the range of a 10% increase or decrease. However, the projections also allow for the possibility of more pronounced fluctuations, with potential deviations reaching up to +/- 20%.

The comparison between the projected scenarios and observational data demonstrates a satisfactory alignment, particularly at the Representative Concentration Pathway (RCP) level 2.6. This suggests that the scenarios at this level provide a credible reflection of the anticipated variability in precipitation patterns. Conversely, the projections at RCP 4.5 and RCP 8.5 indicate a greater likelihood of significant increases in rainfall. Under these pathways, the region could experience rainfall amounts that are 20-30% higher than the historical averages, underscoring the need for robust adaptive strategies to manage potential hydrological changes.

6.4 Downscaled Climate Change Scenarios

6.4.1 Significance of Downscaling global climate Models

Downscaled Climate Change Scenarios are critical for the Ellembelle District because they provide localized climate projections that are more relevant and applicable to the district's specific geographical and socio-economic contexts. Below are reasons why these scenarios are vital:

- **Precision in Local Climate Projections:** Downscaling global climate models allows for a finer spatial resolution, which can capture the local climate variations within the Ellembelle District. This is especially important given the diverse topography and microclimates within the district, which can significantly affect local weather patterns.
- **Informed Adaptation and Mitigation Strategies:** Accurate local climate projections enable decision-makers to develop targeted adaptation strategies that address specific climate risks the district may face, such as increased temperatures and uncertain precipitation patterns. For example, in agriculture, knowing the expected temperature and rainfall changes can inform crop selection, irrigation scheduling, and pest management practices.
- **Risk Management and Planning:** Understanding the potential intensity and frequency of extreme weather events such as heatwaves, heavy rainfall, or droughts is crucial for emergency planning and risk management. Downscaled scenarios help to identify the areas within the district most at risk and prioritize interventions.
- **Infrastructure Development:** Infrastructure design and development can be optimized with detailed climate projections. This includes the construction of buildings, roads, and bridges that are resilient to future climatic conditions, as well as planning for adequate drainage to prevent flood damage.
- **Protection of Natural Resources and Ecosystems:** Local climate projections are essential for conserving and managing natural resources and ecosystems. As climate change may alter the district's biodiversity, water resources, and coastal zones, downscaled scenarios enable more precise conservation actions.
- **Community Engagement and Education:** When local communities understand the specific climate risks to districts, community and household, they are more likely to engage in

sustainable practices and support policy changes. Downscaled scenarios facilitate community education and participatory adaptation processes.

- **Economic Stability and Livelihoods:** The Ellembelle District's economy, particularly fisheries and agriculture, is sensitive to climate variations. Downscaled scenarios can help predict climate-related impacts on these sectors and assist in developing economic policies to ensure stability and sustainable livelihoods.
- **Health Implications:** Local climate scenarios can forecast the potential spread of climate-sensitive diseases, allowing for proactive public health interventions.
- **Gender Inclusive:** Downscale scenarios by their specific and targeted nature lead to identifying gender related climate challenges which ensure that relief or adaptation measures build the resilience of women and other vulnerable groups in the local community and not make their situation worse. This will lead to the design of effective, context relevant, inclusive, and sustainable climate change adaptation strategies (Acheampong, et al., 2023).

6.4.2 Implications of Projections on Key Climate Variables

Global climatic trends might manifest can influence various climate parameters and phenomena in the Ellembelle district as discussed below.

6.4.2.1 Temperature

Temperature projections for the Ellembelle district, which suggest increases ranging from 0.5 to 4.5 °C depending on the emissions scenario, have significant implications for the district's agricultural cycles, disease prevalence, and overall human comfort. With warmer conditions, crop phenology may shift, potentially extending the growing season for some crops. For instance, crops like maize may experience faster growth rates, leading to earlier harvests. However, increased temperatures can also stress plants, necessitating the adoption of crop varieties that are more resilient to heat, such as drought-tolerant maize or heat-resistant rice varieties which have been developed through agricultural research. Higher temperatures can facilitate the proliferation of vector-borne diseases such as malaria in the district. In warmer conditions, mosquitoes that transmit malaria (e.g., *Anopheles species*) have faster life cycles, potentially leading to higher transmission rates. Public health systems may need to adapt by enhancing vector control and surveillance systems, as seen in other West African contexts where interventions have been scaled up in response to similar risks. The district's rich biodiversity, including its forest and coastal ecosystems, may also be affected. Warmer temperatures can alter the habitats of various species, potentially leading to shifts in species distributions.

6.4.2.2 Extreme Heat

The anticipated rise in average temperatures directly correlates with an increase in extreme heat days, pushing temperatures beyond historical peaks. In the Ellembelle district, where communities and households' livelihoods are intrinsically tied to the land and the sea, the rise in extreme heat events poses a multifaceted threat. Traditional and primary livelihoods, such as farming and fishing, are typically outdoor activities that become strenuous and potentially hazardous under extreme heat conditions. For example, during peak fishing seasons, fishermen may face increased risk of heat exhaustion, which could lead to a decrease in the time they can safely spend at sea, impacting their catch and income. Fishmongers may have to deal with the stress of processing fish (smoking, frying, drying) in heat in the midst of extreme heat.

The increasing heat could also affect the productivity of crops, as some might not tolerate higher temperatures, leading to a need for shifting to heat-tolerant varieties, possibly indigenous to other regions or developed through agricultural research. For instance, traditional crops like cocoa, which is sensitive to temperature changes, could suffer from reduced yields, pushing farmers to explore alternative crops or farming methods. On the domestic front, increased heat leads to higher energy consumption as households and businesses use fans or air conditioning units more frequently to cool down, thus raising electricity demand and associated costs. Babies, children and pregnant women may not be able to cope with heat stress as it may be fatal to their health.

6.4.2.3 Precipitation

In the Ellembelle district, with its semi-equatorial climate, the population has historically relied on a relatively predictable rainfall pattern to schedule agricultural activities, from planting to harvesting. As the district grapples with the implications of climate change, including the possibility of less predictable rainfall patterns forecasted by downscaled climate scenarios, the local agricultural sector could face several significant shifts. For instance, cocoa, a mainstay of the Ellembelle District's economy, is sensitive to changes in moisture availability. Cocoa farmers have traditionally timed the planting of their crops to coincide with the onset of the rainy season. However, with changing precipitation patterns, the risk of planting too early or too late could result in crop failure due to drought or root rot from excessive rainfall.

Additionally, the prevalence of cocoa diseases, such as black pod, which thrives in wet conditions, may increase with more frequent heavy rainfall events, thereby impacting yield and quality. Another crop that could be impacted on is oil palm, which requires consistent rainfall throughout the year. If dry spells become more prolonged, oil palm yields may decrease, affecting both large agribusinesses and smallholders who rely on this crop for income. Conversely, if heavy rain becomes more common, the risk of soil erosion and nutrient leaching on slopes where oil palms are grown could lead to long-term declines in productivity.

6.4.2. 4 Extreme Rainfall.

The potential for increased extreme rainfall, as suggested by climate projections, presents a pressing concern for the district. Intense downpours can lead to catastrophic flooding, causing rivers like the Ankobra to overflow their banks and inundate communities. Flooding not only damages infrastructure but also washes away fertile topsoil, essential for agriculture, and disrupts the lives of residents. The district's infrastructure, particularly in rural areas, is at risk from these deluges. Road networks, essential for connecting farmers to markets and children to schools, may be destroyed or rendered impassable, severing vital socio-economic links. For example, heavy rainfall in the past has damaged the Menzizor Bridge connecting Aiyinase and Menzizor, a critical artery for the transportation of goods and people within the district.

Additionally, the quality of water sources is compromised when heavy rains wash agrochemicals from farms into water bodies, impacting both human health and aquatic life. In settlements like Sanzule and Asanta, this contamination has previously resulted in cholera outbreaks, highlighting the need for robust water management systems. Women may be forced to use more resources (time, money, energy to undertake previously less demanding domestic and economic tasks). Ellembelle's coastal communities, such as those around Salman and Atuabo, are susceptible to storm surges exacerbated by extreme rainfall, which can lead to coastal erosion and loss

of property. As climate change progresses, the traditional buffer provided by mangroves and wetlands is under threat, necessitating concerted conservation and restoration efforts.

6.4.2.5 Sea-Level Rise

The impending threat of sea-level rise looms large over the coastal areas of the Ellembelle District, where the intertwining of community, commerce, and culture with the sea is a way of life. As global temperatures climb (Muruganandam et al., 2023) melting polar ice and expanding seawaters (Barua et al., 2022) threaten to redraw the boundaries of the district's coast, submerging lands and possibly leading to the displacement of entire communities. Essential infrastructure along the coast, such as roads, bridges, and buildings, is also at risk of damage or complete loss, posing a severe challenge to economic stability and growth. Such emergencies affect women, children, differently abled more than their men counterparts because they sometimes lack the skills and energy to seek early redemption.

Saltwater intrusion into freshwater aquifers and estuarine ecosystems presents another critical concern, potentially rendering water sources undrinkable and disrupting the delicate balance that supports both agricultural productivity and marine life. This intrusion, if unaddressed, could significantly affect Ellembelle's agriculture, which depends on the availability of fresh water for crops like oil palm, and food staples.

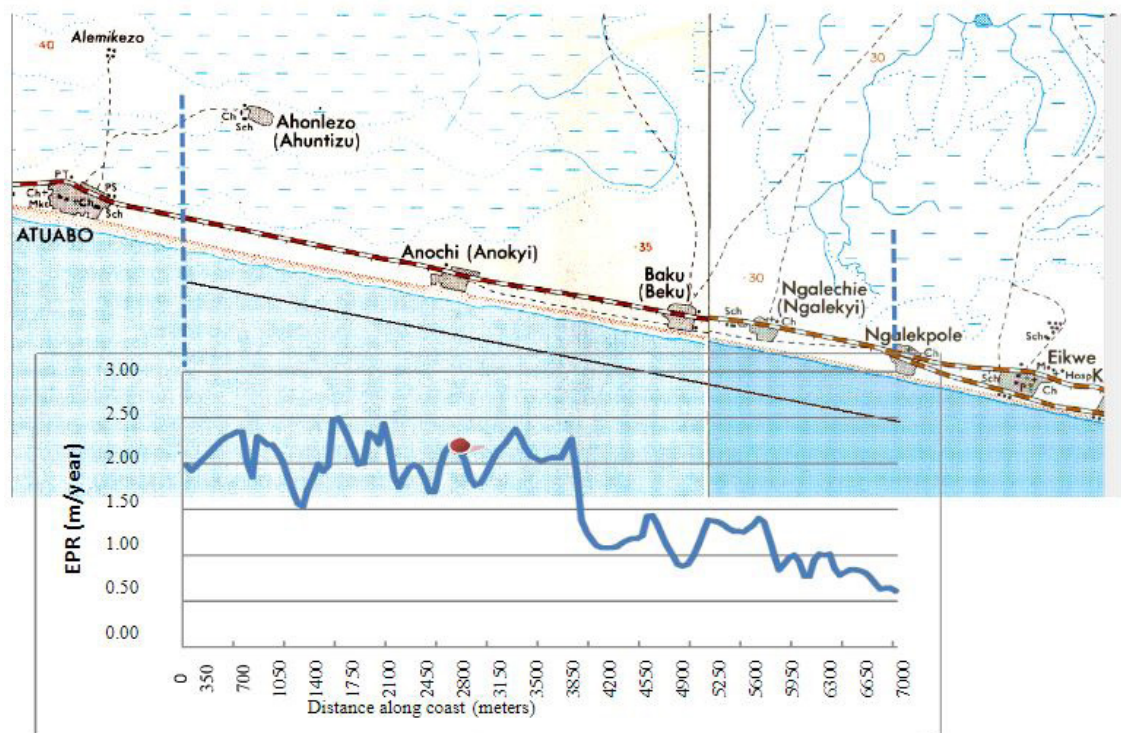
6.4.2.6 Coastal Erosion

Coastal erosion presents an urgent challenge for the Ellembelle District, a socio-ecological system already facing the compounded pressures of sea-level rise. The continuous wearing away of the shoreline not only leads to the loss of land but also destabilizes the foundations of local communities, their economies, and ecosystems (**Figure 18**). Critical areas like Sanzule and Old Bakanta are witnessing the slow disappearance of their beaches and land into the sea, threatening homes, livelihoods, and the natural beauty that draws visitors to the area. The benefits of coast and beaches to the businesses of fishmongers can be affected by such erosions.

The natural coastal defenses that have long protected Ellembelle, such as the extensive Amanzule mangrove forests, are in peril (Ajonina et al., 2014). The Greater Amanzule wetlands and its associated ecosystems are invaluable, not only for their role in preventing erosion but also as habitats for a diverse range of marine species that sustain the local fishing industry (**Figure 19**). As the Amanzule mangroves diminish, the risk of land loss accelerates, and the protective nursery grounds for fish dwindle, striking a blow to both ecological diversity and the economic welfare of those who depend on the sea for their living (Nunoo, & Agyekumhene, 2022).

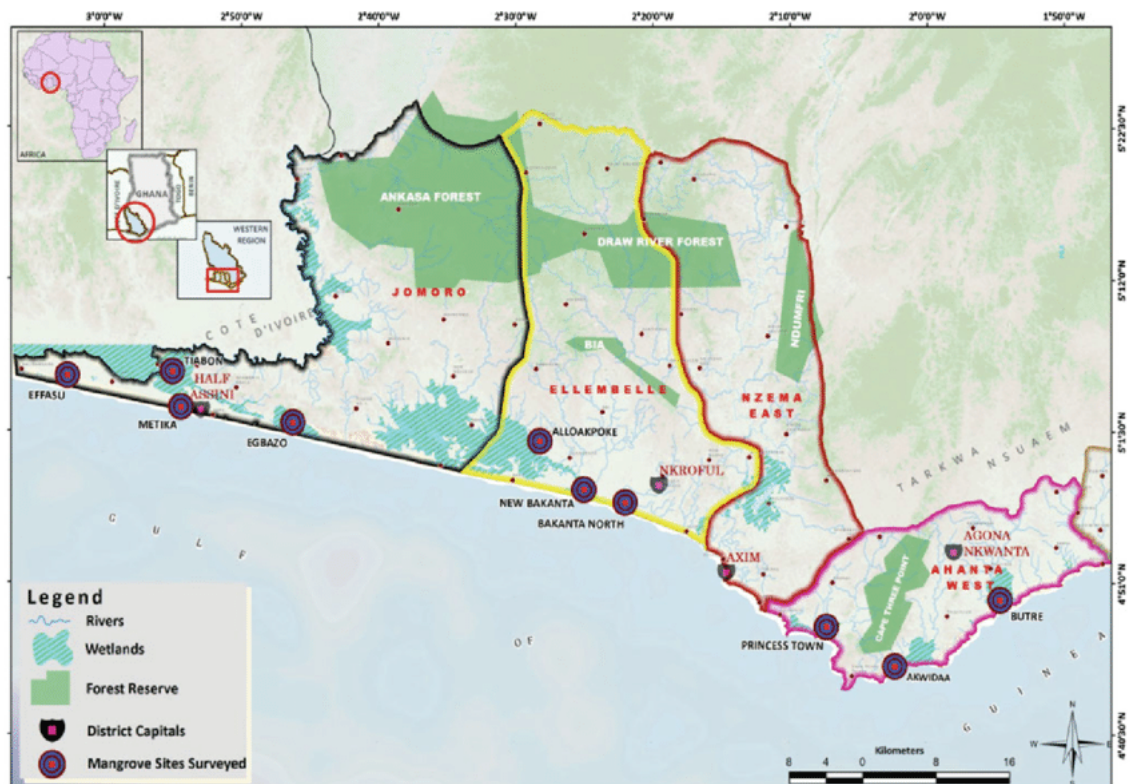
Tourism, which capitalizes on the district's picturesque coastline and unique cultural heritage, is also at risk. Attractions like the birthplace of Dr. Kwame Nkrumah in Nkroful draw visitors, but as coastal erosion advances, the preservation of these historical sites is under threat. The gradual loss of beaches and coastal landscapes could deter tourism, a key economic driver for the district.

Figure 18: Annual erosion rates for a 7 km stretch of shoreline in Ellembelle District



Source: Wiafe (2012)

Figure 19: Map of wetlands distribution in Western Region (Greater Amanzule covers wetlands from Ivory Coast border to Ankobra River)



Source: Ajonina et al. 2014



7



Potential Impacts for Priority Risk Domains

7.1 Initial Assessment of Ellembelle District Critical Climate Related Hazards

The preliminary assessment of various climate-related hazards was conducted using data derived from the [ThinkHazard!](#) Tool (ThinkHazard!, 2023; **Table 4**). These hazard levels from the ThinkHazard! report was corroborated by the experiential accounts of district planning officers, gender focal persons and other local stakeholders who participated in the district workshops and the study team's fieldwork observations of past and present hazards. Their observations and experiences provide valuable ground-truthing to the modeled data, highlighting the real-world implications of these climate-related hazards for the Ellembelle District. The evaluation of these hazards provided insight into potential risks that may affect the communities and households in the Ellembelle District (**Table 4**).

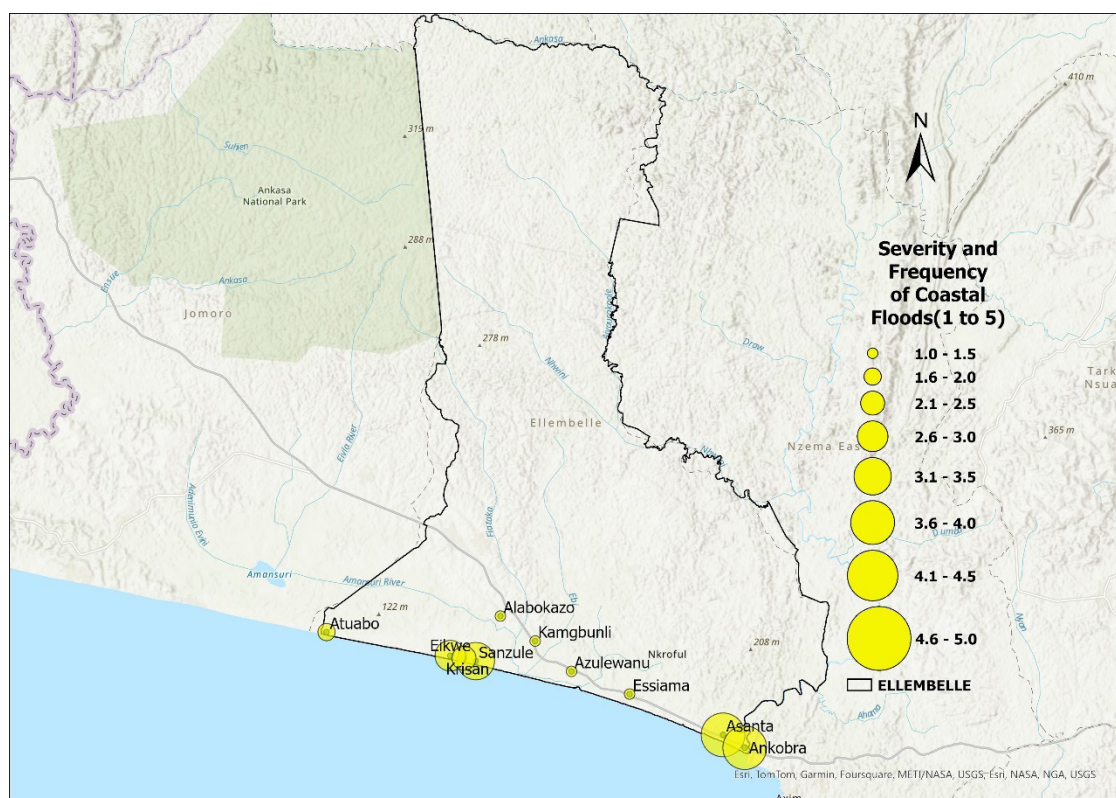
Table 4: Summary of critical climate related hazards for Ellembelle district from ThinkHazard! Tool and stakeholder engagement

Hazard	Coastal Floods	Inland Floods	Water Scarcity	Extreme Heat	Wildfire	Coastal Erosion	Sea Level Rise
Level	High	Low	Medium	Medium	Low	High	High
Interpretation	High	Low	Medium	Medium	Low	High	High

7.1.1 Coastal Floods

The level of risk of coastal flooding in the Ellembelle District is interpreted as high. This suggests that there is a significant likelihood of coastal floods occurring, with potentially damaging and life-threatening consequences. This is consistent with the district's geographic proximity to the coastline, making it susceptible to tidal surges and sea level rise. Based on the field survey and stakeholders' reports, the study team mapped Ellembelle District varying levels of flood risk (past and present) along the coast (**Figure 20**). Coastal towns such as Atuabo, Eikwe, and Ankobra show high flood frequency and severity, represented by larger circles (rating 4.6 to 5.0). These areas are particularly exposed to tidal surges and sea level rise due to their proximity to the Atlantic Ocean. Towns with lower vulnerability like Kamgbunli and Alabokazo experience less frequent flooding.

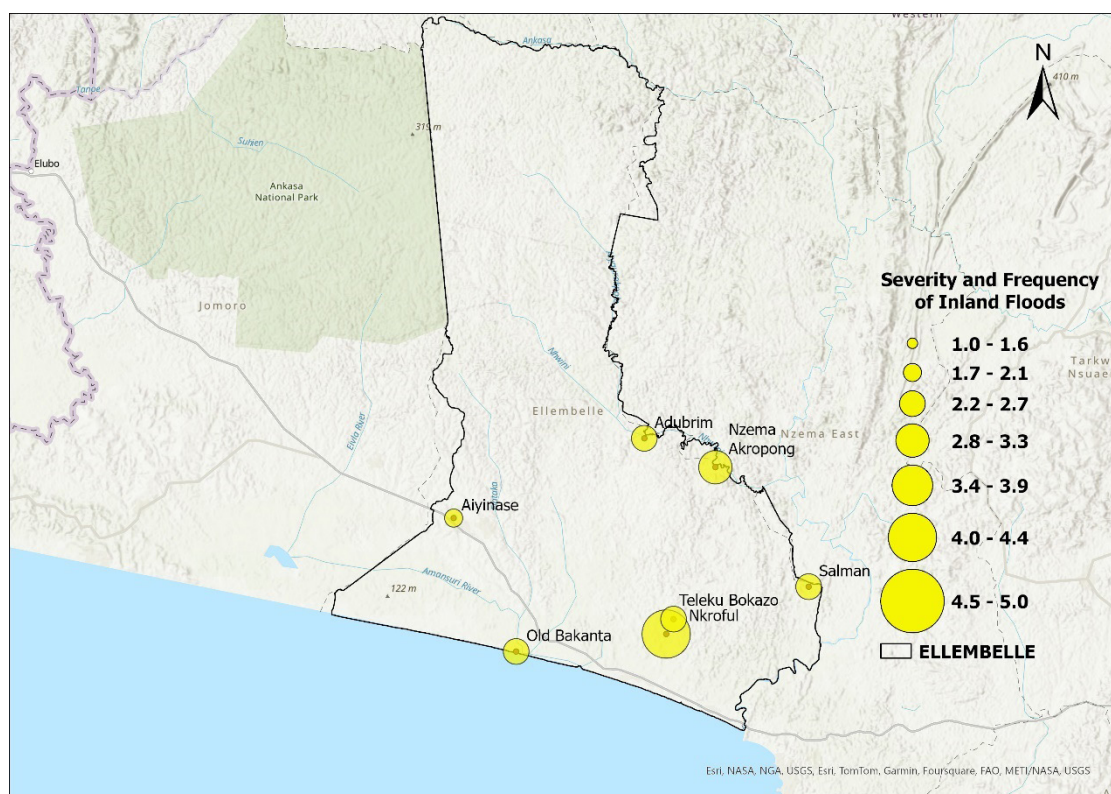
Figure 20. Severity and Frequency of Coastal Floods in Ellembelle District



7.1.2 Inland Flood

In contrast, the hazard level for inland flooding is classified as low, indicating that, based on the current models and data, the probability of damaging river floods within the next decade is relatively minimal, akin to a return period of approximately 1 in 1000 years. **Figure 21** illustrates the areas in Ellembelle District that experience regular inland flooding, typically on an annual basis. High flood-prone zones include settlements like Teleku Bokazo, Nkroful, Adubrim, and Akropong, with flood severity and frequency ranging between 3.4 and 5.0. These areas face frequent inland flooding during the rainy season, leading to potential disruption of livelihoods, damage to infrastructure, and displacement of communities.

Figure 21. Severity and Frequency of Inlands Floods in Ellembelle District



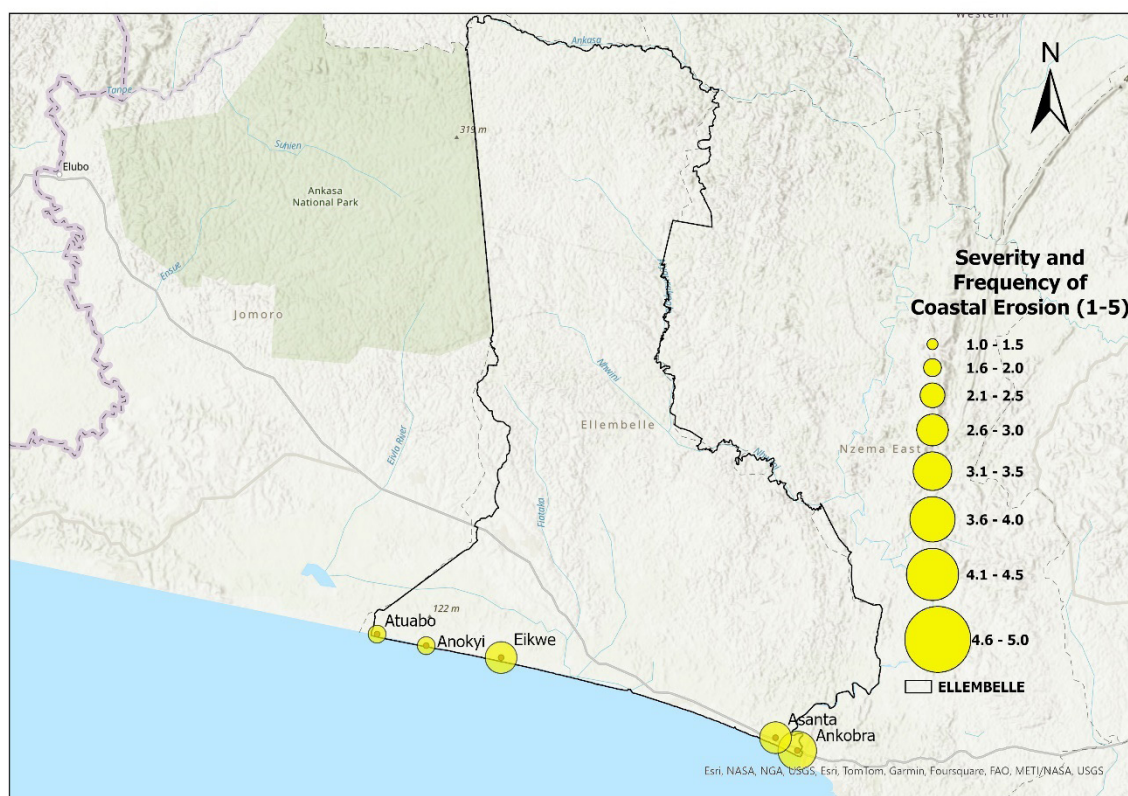
7.1.3 Water Scarcity

The district faces a medium-level hazard for water scarcity. While the area does experience significant rainfall, variability in rainfall patterns, combined with factors such as deforestation and land degradation, contribute to concerns over the long-term availability and management of water resources. **Figure 21** reports water scarcity levels across the Ellembelle District, with some areas experiencing severe shortages. Kwesikrom, for instance, shows the highest frequency and severity of water scarcity, scoring between 4.5 to 5 on the severity scale. Other areas, like Adubrim and Kokum, also face considerable water stress, though to a slightly lesser degree.

[illegible]

Coastal erosion presents a high hazard level, exacerbated by sea level rise and human activities such as sand mining. This poses a direct threat to coastal habitats and infrastructure, potentially leading to loss of property and biodiversity, as well as displacement of coastal communities. Figure 23 illustrates the severity and frequency of coastal erosion along Ellembelle's coastline, highlighting areas at significant risk. Communities such as Ankobra and Asanta exhibit the highest vulnerability (4.6-5.0 on the scale), underscoring the impact of natural forces such as rising sea levels, tidal surges, and anthropogenic activities like sand mining. This erosion directly threatens coastal infrastructure, livelihoods, particularly fisheries, and habitats. Other areas, like Atoabo and Eikwe, also face notable risk, though to a lesser extent.

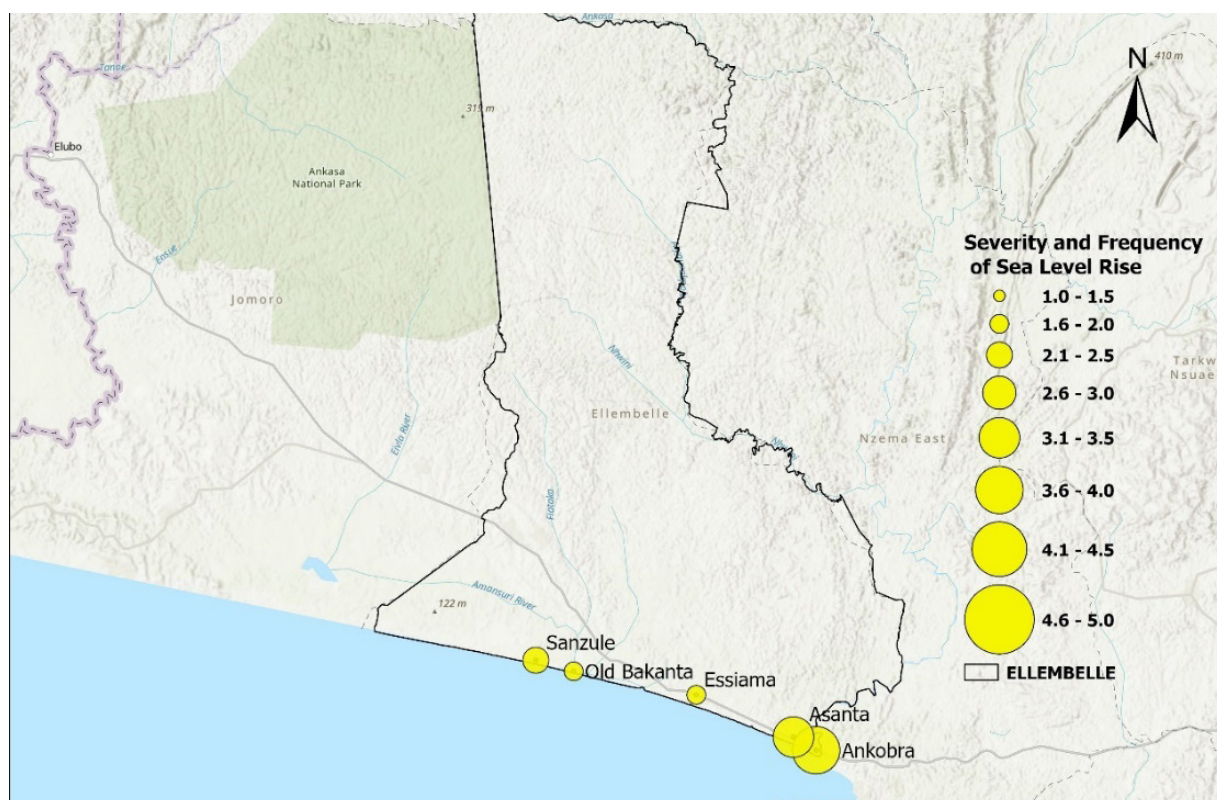
Figure 23. Severity and Frequency of Coastal Erosion in Ellembelle District



7.1.5 Sea Level Rise

The district is also highly vulnerable to the hazards of sea level rise, which is expected to contribute to more frequent coastal flooding and erosion, leading to significant ecological and socio-economic impacts, particularly for communities and industries along the coast. **Figure 24.** illustrates the severity and frequency of sea-level rise in the Ellembelle District, with communities such as Ankobra, Asanta, and Sanzule being particularly vulnerable. The coastal towns experience a high risk of rising sea levels, represented by larger yellow circles on the map. This risk is influenced by climate change-induced factors, including tidal surges and changes in sea level.

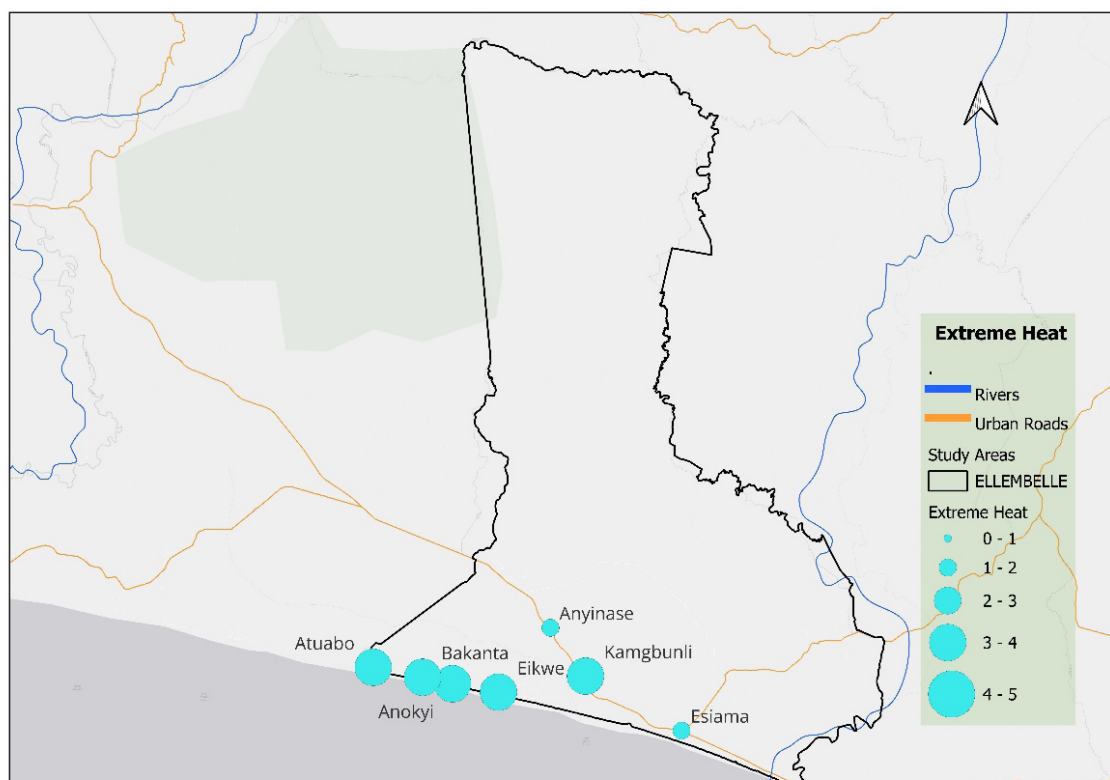
Figure 24: Severity and Frequency of Sea-Level Rise in Ellembelle District



7.1.6 Extreme Heat:

For extreme heat, the hazard level is also set at medium. The data suggests that the district is likely to experience higher temperatures, which may not be immediately life-threatening but could impact human comfort, agricultural productivity, and increase the demand for water and energy. Workshop participants from Ellembele district reported an increase in extreme heat, particularly in towns situated near the Ghana Gas plant. This observation aligns with the spatial distribution of extreme heat illustrated in **Figure 25**, where Atuabo and Bakanta, both in close proximity to the plant, are identified as experiencing some of the highest levels of extreme heat. Other communities like Eikwe and Kamgbunli also report experiencing moderate levels of extreme heat, while Anyinase reports lower levels.

Figure 25. Reported areas of extreme heat in the Ellembelle District

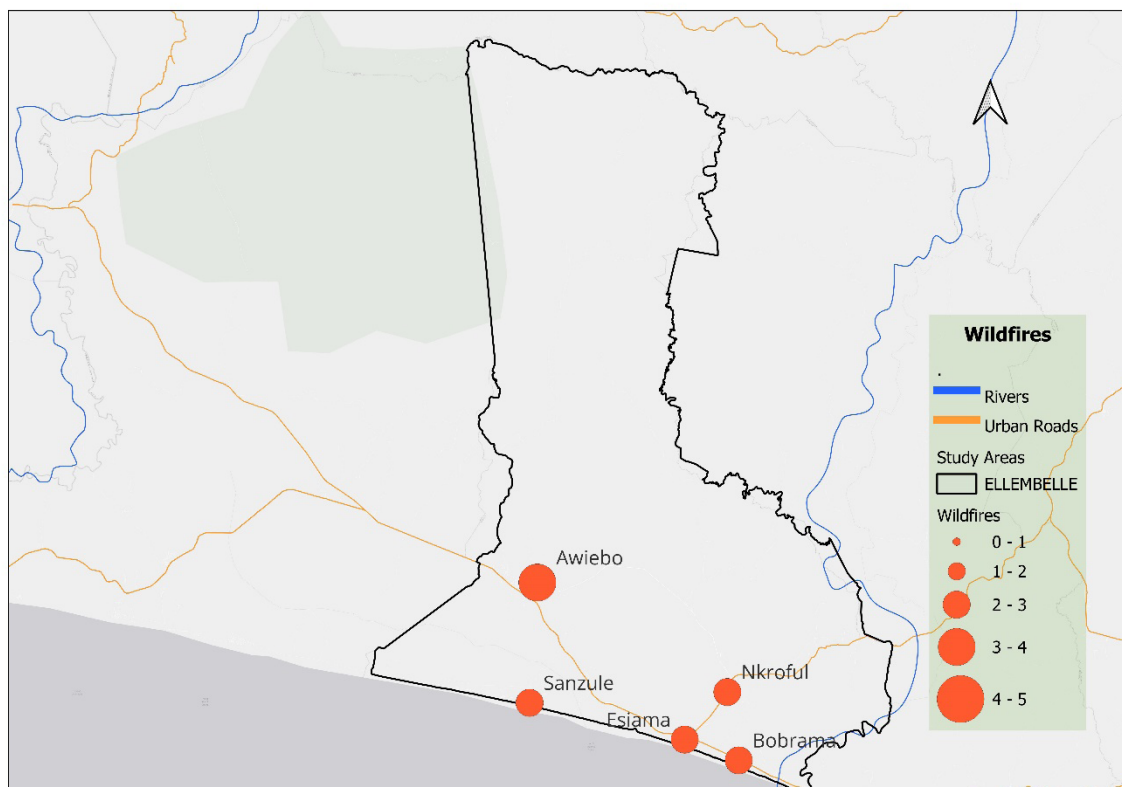


7.1.7 Wildfires

The risk of wildfires in the Ellembelle district is considered low. Although wildfires can occur, the frequency and extent to which they pose a risk to life and property are not as significant when compared to other areas with more dry and arid climates.

From the participatory map exercise (**Figure 26**), highlights areas in Ellembelle district with a history of wildfire occurrences. Esiama and Bobrama, in the south, stand out with the most frequent and intense wildfires reported. Awiebo, in the north, also shows a significant history of wildfire activity. Nkroful and Sanzule display moderate to lower levels of reported wildfires, respectively.

Figure 26 Report areas of wildfires in the Ellembelle District



7.2 Stakeholder Engagement Workshops

A climate change risk assessment is a collaborative and inclusive process designed to integrate the concerns and insights of all interested and affected parties (I&APs), acknowledging the vital contributions of relevant stakeholders including diverse community members, including women, youth, and potentially vulnerable groups. To ensure comprehensive and participatory risk assessment, stakeholders from various sectors of the Ellembelle district were engaged throughout the process, aligning with the goals of the National Adaptation Plan (NAP) project.

The first stakeholder engagement workshop for the Ellembelle District was held on 21st March 2024 at the Aya Community Centre, Esiama (**Plate 9**). The workshop provided the Assessment team with the opportunity to:

- Introduce the NAP project framework to stakeholders and outline the collaborative process.
- Educate stakeholders about climate change, its potential impacts, and the various factors to be considered in the risk assessment.
- Share the initial down-scaled climate projections for temperature and precipitation.
- Validate these climate change projections with empirical evidence and local expertise.
- Undertake gender discussions on gender implications of climate change.
- Identify critical climate-related risks and gather both quantitative data and qualitative accounts to deepen the understanding of these risks, their consequences, and the community's adaptive capacity.

The engagement was limited to a workshop of selected key district and local stakeholders. Overall, 31 participants took part in the workshop (**Appendix A**). The participants list included representatives from national and local government bodies such as the National Disaster Management Organization (NADMO) and Ellembelle District Assembly, professionals from environmental and agricultural agencies like the EPA and COCOBOD, as well as local media and education sectors. Community voices are also well-represented, with youth activists, women and men local farmers, and community radio personnel participating.

Plate 9. Participants listening to a presentation of the NAP process



The first part of the workshop was the presentations by the lead consultant, followed by questions and answers on the global, national, regional, district and local level climate and variability issues. The second session focused on activities with participants. During this period, sector groups engaged in participatory activities that included physical/resource and hazard mapping. The main sectors for the activities were:

- i. Agriculture
- ii. Water Resources
- iii. Fisheries
- iv. Health
- v. Infrastructure
- vi. Gender

Workshop participants identified the most vulnerable and at-risk locations within the district, an exercise that not only pinpointed the geographical areas prone to climate impacts but also highlighted the critical resources that could be affected by these hazards. Simultaneously, another set of sector group activities revolved around climate hazards identification (**Plate 10**). Here, participants constructed a seasonal change calendar, which provided a visual representation of the timing and intensity of various climate hazards and disasters that the community has experienced or may face. This facilitated a shared understanding of the district's climate patterns and anomalies.

Plate 10. Participants participating in sector-specific group exercises.



Building on this, the sector groups diligently worked on creating a sector-specific vulnerability and adaptation matrix. They scored and prioritized each identified vulnerability, considering both the severity of impact and the probability of occurrence. This methodical approach helped in quantifying the relative risks and framing targeted adaptation responses. Additionally, gendered discussions on climate impacts and adaptation were conducted, ensuring that the workshop addressed the differentiated impacts of climate change on men and women. These conversations brought to light unique challenges faced by various gender groups and fostered inclusive strategies that recognize and integrate gender-specific needs and perspectives.

Plate 11. Photocall after the first workshop in the Ellembelle District.



This second workshop (findings validation) was conducted in the Ellembelle district on 18th September 2024. The primary aim of this workshop was to share a range of potential climate adaptation options with key stakeholders, enabling them to validate these options and prioritize their implementation within the district.

Workshop Focus:

This workshop was designed to facilitate a participatory process where stakeholders could critically assess pre-identified climate adaptation strategies and determine their suitability and priority for Ellembelle. The emphasis was on local ownership and collaborative decision-making to ensure that the chosen adaptation measures align with the district's specific needs and development goals.

Workshop Highlights

The District Coordinating Director of Ellembelle opened the workshop, highlighting the urgency of addressing climate change vulnerabilities and highlighting the vital role of stakeholders in validating and prioritizing adaptation options for the district. He encouraged active participation and collaborative discussions to ensure that the selected strategies are effective and locally relevant.

Dr. Yaw Agyeman Boafo, the Lead Consultant, presented a comprehensive overview of potential climate adaptation options tailored to the specific needs and vulnerabilities of Ellembelle. He highlighted strategies across various sectors, including coastal ecosystems and fisheries, agriculture, water resources, infrastructure, and health, emphasizing the importance of gender-sensitive and inclusive approaches to protect vulnerable populations.

Plate 12. Validation workshop participants listening to the main presentation



Participants were divided into sectoral groups representing diverse areas of expertise, including Agriculture, Water Resources, Community Health, Coastal Ecosystems & Fisheries, Biodiversity, Infrastructure, and Human Settlements (**Plate 12**). Facilitated by Miss Doreen Lartey, these groups utilized the Multiple Criteria Analysis (MCA) framework to rigorously evaluate and prioritize the presented adaptation options. They considered factors such as effectiveness, affordability, environmental benefits, gender responsiveness, and sustainability.

Each group engaged in in-depth discussions to validate the proposed adaptation options, considering their relevance to the district's context and potential impact. They then prioritized these options based on local priorities, resource availability, and feasibility of implementation. The prioritized options were presented to all participants, fostering a shared understanding of the most urgent needs and the strategies that require immediate action.

The workshop successfully enabled stakeholders to validate and prioritize critical climate adaptation measures for the Ellembelle District (**Plate 13**). This participatory approach ensured that the selected strategies are locally relevant and aligned with the district's development priorities.

Plate 13. Participants engaging in the prioritization of the adaptation options using the MCA approach



7.3 Priority Risk Domains

Based on the detailed understanding of Ellembelle District's climate change vulnerability, including its socio-economic conditions, environmental challenges, and infrastructural limitations, it is essential to identify and focus on priority risk domains to enhance resilience and adaptation efforts. An understanding of the potential climate change and gender impact on selected priority areas is vital for several reasons:

- First, it makes tailored risk assessment and management possible, empowering communities and decision-makers to anticipate and lessen certain dangers. For example, understanding how climate change could affect rainfall patterns, sea levels, and temperature regimes is crucial for preserving livelihoods and food security in a district like the Ellembelle district, where agriculture, fishing, and coastal ecosystems are critical to the local economy and way of life.
- Second, having this insight helps with strategic planning and well-informed decision-making. Resources can be distributed more equitably, and adaptation efforts can be made both realistic and successful by identifying the most vulnerable groups, communities and sectors. It encourages the creation of resilient infrastructure, environmentally friendly farming methods, and conservation initiatives that are adapted to the expected changes to maximise their efficacy.
- Third, understanding the effect of these risks on the various gender groups helps communities and the district to integrate the existing gender and climate change issues to district plans to help improve lives of the more vulnerable groups thus reducing gender inequities in the communities.

From this Assessment, the priority risk domains for climate change impacts in the Ellembelle District can be identified as follows:

- Agriculture and Food Security
- Water Resources
- Coastal Ecosystems and Fisheries
- Forestry
- Infrastructure and Human Settlements

The selection of the priority risk domains for climate change impacts in the Ellembelle district was based on several key criteria designed to ensure detailed coverage of the most vulnerable and impactful areas (**Table 4**).

Table 5. Criteria for prioritizing climate change impact risk domains in Ellembelle district

Criteria	Explanation
Economic Significance	Agriculture is the backbone of the Ellembelle economy, with a significant portion of the population engaged in farming activities such as cocoa and oil palm cultivation. The district's economic vulnerability was highlighted when changes in rainfall patterns and increased incidence of diseases, like the black pod disease affecting cocoa crops, directly impacted agricultural productivity and, consequently, the local economy.
Environmental Sensitivity	Coastal erosion and sea level rise are critical concerns in the Ellembelle district, given its extensive coastal ecosystem and coastline. An example of environmental sensitivity impacting the district is the erosion near coastal communities like Asanta and Alabokazo, where land loss threatens homes and livelihoods, highlighting the need for targeted conservation and adaptation measures.

Community Dependence	Water scarcity in the northern part of district, contrasted with relatively better access in the southern regions, shows the community's dependence on natural resources. During dry seasons, communities like <i>Kamgbunli</i> face acute water shortages, affecting domestic use and agriculture, and emphasizing the need for equitable water management solutions.
Infrastructure Vulnerability	The district's road network, particularly untarred roads in rural areas, becomes nearly impassable during heavy rains, isolating communities and hindering access to markets, healthcare, and education. The flooding event that washed away the bridge linking <i>Esiama</i> to <i>Nkroful</i> serves as a stark example of how climate-induced events can disrupt critical infrastructure and services.
Adaptive Capacity	Limited adaptive capacity is evident in the district's struggle to cope with and recover from flooding events due to inadequate drainage systems and lack of early warning mechanisms. The widespread displacement and damage to properties during the 2019 floods highlighted the need for strengthening local capacities to manage disaster risks and implement effective adaptation strategies.
Socio-economic Disparities	The socio-economic disparities within the district are exemplified by the challenges faced by fishing communities due to declining fish stocks from overfishing and illegal unreported and unregulated (IUU) fishing practices. Communities like <i>Azuleloanu</i> experience reduced catches, affecting livelihoods and food security, pointing to the necessity of sustainable fisheries management and livelihood diversification efforts.

7.3.1 Agriculture and Food Security

Climate change presents significant challenges to agriculture and food security in the Ellembelle district, with implications spanning crop yields, livestock productivity, pest management, and water resources. Projected temperature increases ranging from 0.5 to 4.5°C, depending on the emission scenario, could lead to varied impacts. For instance, higher temperatures might accelerate the maturation of crops such as maize, reducing their growing period and potentially decreasing yields. This effect was observed in studies across sub-Saharan Africa, where yields of maize and other staple crops decreased with rising temperatures due to shortened growth cycles (Lizaso et al., 2018; Chen et al., 2018). Additionally, livestock productivity could decline as animals experience heat stress, impacting fertility and increasing vulnerability to diseases.

The alteration in precipitation patterns and the increased likelihood of extreme rainfall events compound these challenges. For example, changes in the timing and distribution of rainfall could disrupt traditional planting and harvesting schedules, critical for crops like cocoa, which rely on specific moisture conditions. Furthermore, extreme rainfall can lead to significant soil erosion, especially in Ellembelle's sloped agricultural areas, depleting soil fertility and leading to nutrient loss.

Coastal agriculture faces unique threats from sea-level rise and coastal erosion. Rising sea levels enhance saltwater intrusion into freshwater systems and agricultural lands, jeopardizing freshwater availability and arable land. Rice paddies in coastal areas, for example, could experience increased salinity that hinders growth and reduces yields, a situation already documented in coastal regions of Southeast Asia (Wassmann, et al., 2009; Loc et al., 2021). Moreover, coastal erosion from heightened storm surges and higher sea levels could physically reduce the amount of land available for farming, exacerbating land scarcity issues. These environmental changes directly threaten food security in Ellembelle district, impacting food availability through reduced crop yields and the loss of arable land.

Access to food could also be compromised as food prices rise due to lower production and higher cultivation costs. Additionally, the nutritional quality of food could decline if farmers shift to crop varieties that are more resistant to climate change but potentially less nutritious. The stability of food supply may become more unpredictable with increased climate variability, leading to periodic food shortages and price spikes, thereby affecting the economic stability of households reliant on agriculture for their livelihoods.

7.3.2 Water Resources

Climate change is poised to significantly impact water resources in the Ellembelle district, affecting both the availability and quality of water which are essential for human consumption, agriculture, industry, and ecosystem sustainability. Studies indicate that climate change is likely to exacerbate water scarcity in regions already facing water access issues, affecting both quality and quantity of available water (Taylor et al., 2013).

Central to the findings are the detrimental effects of water pollution, flooding, and deforestation on the district's water bodies, which serve as the lifeline for its communities. Water pollution emerges as a critical concern, contaminating water with both organic and inorganic materials, thus rendering it unsafe for human consumption and disrupting aquatic ecosystems. This contamination is largely attributed to the release of harmful chemicals and waste into waterways from small-scale mining and agriculture, significantly degrading water quality.

7.3.2.1 Variability in Precipitation

Changes in rainfall patterns are perhaps the most direct climate-related impact on water resources. Ellembelle District might experience shifts in the timing and intensity of rainfall due to climate change. This could mean longer dry spells interspersed with periods of heavy rainfall. Such variability can lead to challenges in water storage and management, as water supply systems that are designed for consistent and gradual rainfall might not cope effectively with sudden and intense downpours. Moreover, prolonged dry periods could strain existing water supplies, impacting agricultural activities that depend on regular water availability, and affecting the recharge of local aquifers.

7.3.2.2 Increase in Water Demand

As temperatures rise, evaporation rates are likely to increase, which can reduce the amount of surface water and groundwater available for use. Higher temperatures also lead to increased water demand for agriculture, industry, and domestic use, compounding the stress on water resources. For instance, crops might require more frequent irrigation to combat the stress of higher temperatures, and residents may consume more water for cooling and hydration purposes.

7.3.2.3 Impact on Water Quality

Extreme rainfall events can lead to runoff that carries pollutants, sediments, and other contaminants into water bodies. This runoff can degrade the quality of surface water, making it unsafe for drinking and harmful to aquatic life. In the Ellembelle district, where small-scale mining and agricultural chemicals are prevalent, heavy rains could increase the risk of water pollution if runoff sweeps these substances into rivers and streams. Additionally, flooding, which might become more common, can introduce waterborne pathogens to the water supply, posing health risks to the population. Health risks are a major concern, with waterborne diseases such as cholera and

malaria posing significant threats to public health, as evidenced by past outbreaks like the cholera incidents in Asanda, Esiama, and Nkroful in 2012.

7.3.2.4 Sea-Level Rise and Saltwater Intrusion

For coastal areas of the Ellembelle district, rising sea levels pose a unique challenge by enabling seawater to encroach into freshwater aquifers. Saltwater intrusion compromises the quality of groundwater, making it unsuitable for drinking and irrigation without costly desalination treatments. This not only affects human populations but also the freshwater ecosystems that are sensitive to changes in salinity.

7.3.2.5 Ecosystems Impact

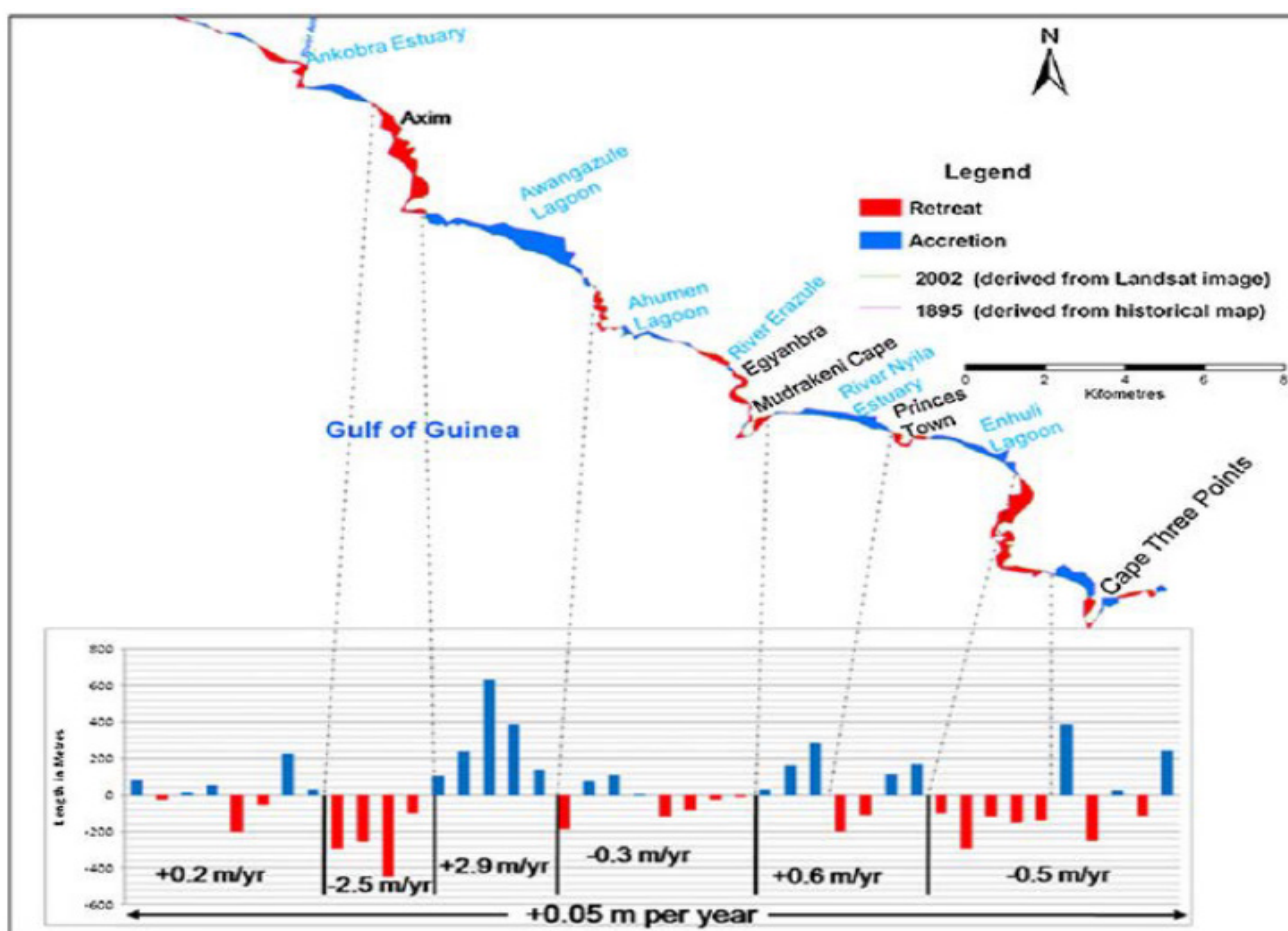
Water bodies in the Ellembelle district support a variety of aquatic and terrestrial ecosystems. Changes in the flow and availability of water can alter these ecosystems, impacting biodiversity and the services they provide. For instance, wetlands, which are critical for biodiversity, water purification, and flood regulation, might dry up or become inundated, depending on the changes in precipitation and temperature.

7.3.3. Coastal Ecosystems and Fisheries

7.3.3.1. Rising Sea Levels and Coastal Erosion

Rising sea levels threaten to submerge low-lying coastal areas in the Ellembelle district, leading to the loss of critical habitats such as mangroves and wetlands. These ecosystems serve as vital nurseries for fish and act as natural barriers against coastal erosion and storm surges. The loss of mangroves and other coastal vegetation exacerbates coastal erosion, reducing the land available for habitation and economic activities, including tourism and fishing (**Figure 27**). For instance, mangrove degradation diminishes fish stocks by removing essential breeding and feeding grounds, directly impacting the fisheries that rely on these habitats (Alongi, 2008; Mentaschi et al., 2018).

Figure 27. Coastline change in the Western Region's southwest facing shore.



Source: Boateng (2012)

7.3.3.2 Increased Sea Surface Temperatures

Warmer waters can lead to shifts in fish distribution and abundance, affecting the types and quantities of fish available for local fishermen. Species that are sensitive to temperature changes may migrate to cooler areas, leaving behind a changed ecological community that could support fewer commercially valuable fish species. This shift can disrupt traditional fishing practices and may lead to reduced catches, affecting food security and income for local communities (Poloczanska et al., 2016). In such instances, fishermen more easily migrate to neighbouring communities and countries to fish leaving the women who take up additional role of household heads (Torell, Owusu, & Okyere-Nyako, 2015). Additionally, increased temperatures are conducive to harmful algal blooms, which can poison fish stocks and contaminate water used for swimming and other recreational activities.

7.3.3.3 Ocean Acidification

The increased absorption of CO_2 by the ocean leads to ocean acidification, a significant threat to marine life, particularly shellfish and corals. This process affects shell formation in marine organisms and can lead to the collapse of coral reefs, which are vital for biodiversity and as barriers protecting the coastline against wave action. The degradation of coral reefs further affects fish species diversity and abundance, impacting artisanal fisheries and the ecotourism sector (Gattuso et al., 2015).

7.3.3.4 Changes in Precipitation Patterns

Alterations in rainfall patterns can influence coastal ecosystems by changing the amount of freshwater flowing into the sea. Excessive runoff can lead to higher sedimentation rates, which can smother coral reefs and affect the clarity and quality of coastal waters, further stressing marine life. Additionally, runoff can carry pollutants, such as pesticides and fertilizers from agricultural land, into coastal waters, exacerbating the eutrophication that leads to dead zones where fish cannot survive (Nicholls et al., 2018).

7.3.4 Forestry

The Ellembelle district, with its significant forest cover, faces a range of impacts from climate change that could transform its forestry sector. The implications for forestry are diverse, affecting biodiversity, forest productivity, and the socio-economic fabric of communities reliant on these ecosystems.

7.3.4.1. Changes in Forest Composition and Health:

Climate change could lead to shifts in the ranges of various tree species, altering forest composition over time. Rising temperatures and changes in precipitation patterns may favour some species while disadvantaging others. For instance, species that are less tolerant to drought may decline, whereas those adapted to warmer conditions might proliferate. This shift could affect biodiversity and the structure of the forest ecosystem. Studies, such as those by Zolkos et al. (2015), who examined eastern United States forests, suggest that such shifts can lead to decreased resilience against pests, diseases, and fire. A similar trend could be expected in Ellembelle, where changes in species composition might affect the ecological balance and forest health.

7.3.4.2. Forest Productivity and Growth Rates:

Increased carbon dioxide (CO₂) levels can initially enhance plant growth through the CO₂ fertilization effect. However, this benefit is often offset by other limiting factors such as nutrient availability, water stress, and temperature extremes. As noted by Mina et al. (2022) in their synthesis on forest responses to elevated CO₂, the productivity of forest ecosystems is highly contingent on how these multiple stressors interact, which could lead to complex outcomes in Ellembelle's forests.

7.3.4.3. Vulnerability to Pests and Diseases

Rising temperatures can also expand the range and activity of forest pests and pathogens. Warmer conditions may enable pests and diseases to survive winter months more easily and expand into new areas previously unattainable due to cold temperatures. For instance, a study by Simler-Williamson, et al., (2019) highlighted how climate change is altering the distribution of forest insects on a global scale. Ellembelle's forests might see similar trends, potentially leading to higher tree mortality rates and reduced forest health.

7.3.4.4. Increased Risk of Bush and Wildfires

Changes in rainfall patterns and increased temperatures are likely to enhance the risk of wildfire. Drier conditions and more frequent heatwaves can create environments more prone to fires, which can be devastating for forests, wildlife, and human communities. Research by Tong et al. (2019) has linked increased fire activity with climate-induced aridity in Sub-Saharan Africa countries forests, a phenomenon that could similarly affect inland forests in the Ellembelle district.

7.3.4.5 Impacts on Non-Timber Forest Products (NTFPs)

Many communities in Ellembelle rely on NTFPs for medicinal, culinary, and economic purposes (Tannor et al., 2022; Osei-Tutu, 2020). Climate change poses significant threats to the availability of these resources through alterations in ecosystem health and species distribution. For instance, medicinal plants like *Prunus africana*, which require specific ecological conditions, may become scarce, disrupting local healthcare practices. Edible plants such as wild mushrooms and bush mangoes may decline due to changing temperature and rainfall patterns, affecting local diets and food security. For example, the availability of medicinal plants that require specific ecological conditions could decrease, affecting local traditions and economies.

This can affect the food security and dietary diversity of female headed households more than male headed households (Batame, 2024). Economically, products like rattan from the Amanzule wetland, essential for local crafts and trade, could see reduced yields, impacting household incomes, most especially the incomes of women who mainly undertake such craft. Additionally, climate-induced shifts in species distribution may lead to the loss of biodiversity, further limiting NTFP availability. The overall health of forest ecosystems could also deteriorate due to altered precipitation and increased frequency of extreme weather events, reducing the viability of NTFP resources.

7.3.5 Infrastructure and Human Settlements

Climate change has significant implications for infrastructure and human settlements in the Ellembelle District, affecting everything from housing and road networks to public utilities and community resilience. The impacts are driven by a range of factors including rising temperatures, increased frequency of extreme weather events, sea-level rise, and shifting precipitation patterns.

7.3.5.1 Impact on Built Infrastructure:

There is enough evidence pointing to the fact that increased temperatures and changes in precipitation are likely to stress the built infrastructure in Ellembelle. For example, roads and bridges might be subjected to more frequent and severe flooding, leading to faster degradation and higher maintenance costs. This may limit the mobility of women, children, aged and differently abled persons. The study by Dawson et al. (2018) discusses how climate change increases risks to transportation infrastructure due to thermal expansion of materials and damage from storm surges and flooding. Buildings, particularly those not constructed to withstand higher temperatures, may require significant modifications to ensure comfort and safety. This could include enhancing ventilation, upgrading insulation, and using heat-reflective materials to mitigate the impacts of increased heat.

7.3.5.2 Water and Sanitation Systems

As noted in research by Howard et al. (2016), climate change can severely impact water supply and sanitation infrastructure. In Ellembelle, changes in rainfall patterns could strain existing water supply systems, necessitating the expansion or enhancement of water storage facilities to manage periods of drought or excessive rainfall. Additionally, flooding can contaminate water supplies, posing significant health risks and requiring immediate and costly interventions. Women and girls' access to quality water for homes will be impacted.

7.3.5.3 Vulnerability to Flooding

Human settlements, especially those in low-lying coastal areas or near rivers, are increasingly vulnerable to floods. In Ellembelle, communities like Asanta, Aiyinase, and Nkroful have experienced flooding incidents that damage homes and disrupt lives. A study by Jongman et al. (2012) highlights how urban expansion in flood-prone areas increases vulnerability, suggesting the need for strategic urban planning to avoid high-risk zones and the implementation of flood defenses.

7.3.5.4. Impact on Energy Infrastructure:

The reliability of energy infrastructure is also at risk. Increased demand for cooling due to higher temperatures could overload local electricity networks, particularly during peak times. Additionally, energy production facilities, including any renewable energy installations like the **Nzema solar farms**, may be affected by changing weather patterns, requiring adaptive strategies to ensure stability and efficiency. The Nzema Solar Power Station is a large photovoltaic (PV) power plant in Ghana. Located near the village of *Aiwiaso* in the Ellembelle district. It is one of the largest solar power projects in Africa. The plant has a capacity of 155 MW and can produce approximately 240,000 MWh of electricity annually, sufficient to power about 100,000 homes. The project contributes significantly to Ghana's renewable energy goals and economic development, creating jobs and providing a sustainable energy source.

7.3.5.5. Sea-Level Rise and Coastal Erosion:

Rising sea levels and increased coastal erosion present significant risks to coastal infrastructure in the Ellembelle District. This can result in the loss of land, property, and vital infrastructure. For example, communities such as Nkroful, Ankobra, Kikam and Axim are particularly vulnerable, with observed instances of flooding and land degradation impacting homes and public spaces. To mitigate these effects, protective measures like constructing sea walls and elevating structures are crucial. Additionally, restoring mangrove buffers in coastal zones, such as those in the Ankobra River area, can provide natural protection against storm surges and erosion. Mangroves not only act as physical barriers but also offer ecological benefits by supporting biodiversity and improving water quality.



8



Climate Change Risk Assessment for Ellembelle District Assembly

8.1 Identification of Critical Climate Related Hazards

In line with the participatory and bottom-up approach adopted for the CCRA the two stakeholder participatory workshops in the Ellembelle district aimed at understanding the climate-related hazards that threaten the district's ecological balance, economic vitality, and community well-being. These workshop activities were grounded in the recognition that the evolving climate poses unprecedented risks, necessitating a proactive and informed response to safeguard the livelihoods and habitats within the district. Drawing upon a rich wealth of local knowledge, scientific research, and firsthand experiences, workshop participants across various sectors collaboratively identified and validated the most pressing climate hazards confronting the Ellembelle district.

These workshops aimed to identify and validate climate-related hazards and their associated risks, leveraging both local knowledge and scientific insights. Drawing from initial desk-based research and vulnerability assessments, the first workshop introduced the broader climate change context within Ghana's National Adaptation Plan (NAP) framework. During this session, participants collaboratively refined the focus areas by identifying systems, assets, and communities most vulnerable to climate change impacts.

The second workshop expanded on these findings, utilizing multi-criteria assessment tools to prioritize adaptation options. The questions served as structured guides during breakout discussions, ensuring a comprehensive exploration of vulnerabilities across sectors such as water, agriculture, health, forestry, and fisheries. This participatory approach enabled stakeholders—ranging from local government officials, farmers, and fishers to representatives of environmental NGOs, women's groups, and youth organizations—to contribute valuable insights. The outputs provided a robust foundation for the district's climate risk assessment, detailing critical impacts and shaping actionable adaptation strategies. The questions are listed below:

- What key systems and assets in Ellembelle are most exposed to climate hazards such as sea level rise, flooding, and drought?
- How do irregular rainfall patterns and water pollution impact fisheries, agriculture, and water supply in the district?
- What are the socioeconomic consequences of coastal erosion and habitat loss for communities reliant on fisheries and tourism?
- How do water pollution and flooding affect public health, particularly concerning access to clean water and the spread of waterborne diseases?
- In what ways does deforestation exacerbate the risks of flooding and drought, and how does this affect water availability and quality?
- How are agricultural activities in Ellembelle impacted by flooding, irregular rainfall, and soil degradation?

- What are the health implications of air and water pollution caused by bushfires, mining, and agricultural runoff in the district?
- How do climate hazards disrupt community livelihoods, particularly in sectors like fishing, farming, and forestry?
- What strategies have communities employed to cope with the impacts of climate-related hazards, and what additional support is needed?
- Which adaptation measures should be prioritized to mitigate the impacts of identified climate risks on critical sectors such as water resources, agriculture, and health?

8.2 Risk Assessment Results

These key climate risks and potential impacts (**Table 6**) from the stakeholder engagement workshops provide a comprehensive understanding of the Ellembelle district's vulnerabilities and risks to climate change. Participants across diverse sectors, including local government, agriculture, fisheries, health, and community groups, collaboratively identify key climate hazards, their impacts, and priority areas for intervention. The findings highlight the interconnected nature of climate risks across ecosystems, livelihoods, and infrastructure, providing a clear foundation for targeted and inclusive adaptation strategies

Table 6. Workshop participants Assessment of Climate Hazards, Risks, and Potential Impacts on Systems and Assets in the Ellembelle District

Systems and Assets Exposed to Hazard	Climate Hazard	Climate Risk and Potential Impacts
Coastal Ecosystem and Fisheries	Sea Level Rise	Sea level rise can lead to the inundation of coastal zones, including mangrove forests and beaches, crucial for the district's ecology and fisheries, potentially displacing communities and disrupting marine habitats. Loss of coastal areas can also impinge on tourism, a vital economic contributor, and lead to the erosion of lands that are essential for the sustenance of local fisheries and livelihoods. Loss of coastal habitats, including mangroves and beaches, directly affects biodiversity and disrupts the lifecycles of marine species crucial for fishing industries. Erosion also threatens infrastructure and settlements along the coast, including key economic areas in towns like Essiama, Asanta and Sanzule. The economic livelihoods of communities reliant on tourism and fisheries are jeopardized, leading to increased poverty and displacement of populations.

	Irregular Rainfall Patterns	Altered rainfall can disrupt the traditional fishing patterns, with shifts leading to uncertainty in fish populations and affecting the timing and success of breeding seasons. Increased rainfall can cause freshwater dilution and sedimentation in coastal waters, leading to reduced salinity, which affects species composition and fishery productivity. Alterations in freshwater inflow into coastal ecosystems can lead to changes in salinity levels, adversely affecting fish breeding grounds and aquatic biodiversity. Pollution from agricultural runoff and illegal mining activities compounds these effects, degrading water quality and marine habitats. Reduced fish stocks and biodiversity loss lead to decreased incomes for fishermen and increased food insecurity. Water pollution exacerbates health risks for communities, impacting public health systems.
	Water Pollution	Pollution from chemicals used in fishing, as well as run-off from land-based sources due to mining and agriculture, can degrade water quality. This leads to the contamination of aquatic life, impacting the health of fisheries and the communities that depend on them. Accumulation of toxins in the water can also have direct public health implications and on women and girls who are mostly exposed during the processing of fishes.
Water Supply	Extreme Rainfall, Flooding	Heavy rains and subsequent flooding can overwhelm drainage systems, resulting in the contamination of freshwater sources and the destruction of water supply infrastructure, leading to shortages and public health crises.
	Drought	Prolonged periods of drought may decrease river and groundwater levels, impacting water availability for domestic use, agriculture, and other critical sectors. Reduced water availability can also lead to overreliance on limited sources, which may not be sustainable.
	Deforestation	The removal of forest cover can exacerbate the impact of both floods and droughts on water supply. Forests play a critical role in the water cycle by regulating the flow and purification of water. Deforestation can therefore lead to decreased water quality and increased vulnerability to water scarcity.
Agriculture	Flooding	Flooding can lead to the submersion and destruction of crops, resulting in the loss of yield and income for farmers. Flooding can also cause soil erosion and nutrient loss, making land less arable and reducing agricultural productivity over time.
	Irregular Rainfall	Variability in rainfall can cause periods of drought and excessive rain, both of which are detrimental to crop yields. Drought can lead to crop failure and water scarcity for irrigation, while excessive rainfall can cause waterlogging and facilitate the spread of plant diseases.
	Water Pollution	The runoff from agricultural lands can contribute to the pollution of water bodies, affecting both the quality of the water for irrigation and the health of the ecosystems within. Pollution from agrochemicals can lead to the bioaccumulation of harmful substances in the food chain.

Forestry	Bushfires	Bushfires can destroy large swaths of forest, degrading biodiversity and the forest's ability to sequester carbon, which is vital for climate regulation. The destruction also affects the soil quality and the forest's role in the hydrological cycle.
	Deforestation and Land Degradation	Clearing forest lands for agricultural expansion or mining activities can lead to loss of biodiversity, reduced carbon sequestration capacity, and increased soil erosion. Land degradation can also make areas more prone to the impacts of climate change, such as floods and droughts, which further affect the viability of agricultural and forestry sectors.
Community Health	Air and Water Pollution	Contaminated air from bushfires and mining activities can lead to respiratory illnesses, while water pollution can increase the prevalence of waterborne diseases. These health hazards strain the healthcare system and can lead to greater economic burden on the communities.
	Flooding	Flooding can lead to the spread of waterborne diseases such as cholera and typhoid, and also damage health infrastructure, reducing access.

Plate 14: Workshop participants perception of the impact of Atuabo Gas Plant on extreme heat in the Ellembelle district

PERCEIVED IMPACT OF ATUABO GAS PLANT ON EXTREME HEAT GENERATION IN ELLEMBELLE DISTRICT	
During the stakeholder participatory work, the establishment of the Atuabo Gas Plant has become a topic of intense discussion among the local communities. Notably, several of the workshop participants, mostly community members, voiced a rising concern, one that resonates with the changing environment they interact with daily — an increase in local temperatures, a change they perceive to be linked to the gas plant's operations. These community members, whose lives are intricately woven with the natural fabric of Ellembelle, have noted that since the Gas Plant became operational, the once cool climate has taken a turn towards persistent extreme heat. Fishermen spoke of warmer days that disturb their time-honoured routines, while farmers discussed the heat that seems to grip the air, affecting both their crops and their comfort. The anecdotal evidence is compelling, painting a vivid picture of a community grappling with unexpected climatic changes. This narrative aligns with global conversations about the environmental impacts of industrial development. The phenomenon, potentially akin to the 'thermal pollution' observed near industrial sites (Ma et al., 2017), suggests that the heat generated by the gas plant's processes could be contributing to local warming. This speculation is supported by studies (Portela et al., 2020) that show industrial facilities can indeed elevate local temperatures through direct heat emissions and landscape alterations that reduce the earth's reflectivity — a low-tech reflection of the high-stakes issue of climate change. Again, the local observations in Ellembelle District echo broader environmental principles, such as the urban heat island effect, where man-made structures contribute to higher temperatures in their immediate surroundings (Yang et al., 2016). It's a story replicated in different settings across the globe where industrialization infringes upon natural landscapes. The community's perceptions in Ellembelle are a call to action, prompting a need for dedicated research to unravel the empirical truth behind their lived experiences. They highlight the urgency of environmental monitoring and impact assessment that can inform sustainable industrial practices. It's not just about understanding the 'what' and the 'why' but also about exploring 'how' to mitigate these impacts. The participants called on the management of the Ghana Gas Plant to provide support to communities and households to adapt to the ongoing problem.	

8.3 Impact Story Lines for Critical Assets and Risk Domains

To enhance our understanding of the climate-related hazards, vulnerabilities, and exposure impacting critical assets in Ellembelle District, individual impact chains were developed. These chains were constructed using

data and insights provided by stakeholders, focusing on priority risks identified during the engagement sessions. This approach allowed for a detailed assessment of how specific climate threats interact with local systems and infrastructure, enabling more targeted and effective adaptation strategies for the district.

- **Risk 1: Risk of Diminished Fishery Yields:** Due to sea temperature changes and acidification, there is a significant risk that fish populations will alter unfavourably, impacting the livelihoods of fishermen, fish processors and the local economy dependent on fisheries. The increase in alien species further threatens local marine biodiversity and the balance of the ecosystem.
- **Risk 2: Degradation of Coastal Habitats from Sea Level Rise:** The continuous rise in sea levels poses a risk of loss of critical coastal habitats, including mangroves and wetlands, which are vital for fish breeding and protection against erosion. This also threatens the displacement of coastal communities and damages tourism, which is integral to the district's economy.
- **Risk 3: Infrastructure Damage Due to Extreme Weather Events:** The district's infrastructure is at risk from extreme climate events like storms and floods, which can damage roads, bridges, and essential services. The potential exposure of the Ghana gas pipeline and other key assets to such events could have far-reaching implications for safety and economic stability.
- **Risk 4: Water Scarcity and Contamination:** Variable rainfall and extreme weather events pose a dual risk of drought leading to water scarcity and flooding leading to water contamination. These conditions put a strain on water supply systems, contribute to deplete energy and time resources of women and children, affect the health of the population, and hinder economic activities, particularly in agriculture.
- **Risk 5: Agricultural Productivity Loss:** The agriculture sector faces significant risks from irregular rainfall patterns, flooding, and extreme temperatures, all of which can lead to crop failure, soil degradation, and ultimately food insecurity. This is compounded by the potential for increased pest and disease prevalence due to warmer and wetter conditions.
- **Risk 6: Public Health Crises:** Changes in temperature and precipitation patterns contribute to a higher prevalence of vector-borne diseases like malaria, and waterborne diseases following flooding events. Flooding and contaminated water supplies can also lead to outbreaks of diseases such as cholera and typhoid, straining the healthcare system and affecting the well-being of the children, aged and other district's residents.

8.3.1 Risk 1: Risk of Diminished Fishery Yields

In the Ellembele District, the coming together of climatic and environmental stressors presents a significant risk to the fisheries industry, upon which the local economy and many coastal livelihoods depend. The increasing changes in sea temperatures and acidification, primarily driven by global climate change, are altering marine ecosystems in ways that can significantly disrupt fish populations. Warmer sea temperatures can shift the habitat ranges of certain fish species, affecting breeding and feeding patterns, while ocean acidification can impair the ability of shellfish and corals to maintain their shells and structures, disrupting the marine food chain (Henson et al., 2017; Brander, 2010). The Ellembele district, with its intricate coastline and dependence on traditional fishing methods, finds its fishery yields threatened not just by global trends but also by local factors such as the proliferation of alien species that can outcompete native ones and further unbalance the ecosystem. This shift poses a direct threat to the artisanal fishing practices that have sustained communities for generations.

Furthermore, the rise in sea levels associated with climate change threatens to inundate coastal areas, erode shorelines, and destroy breeding grounds and nurseries for fish, compounding the stress on fish

stocks. These changes do not occur in isolation but are part of a broader spectrum of climate-related impacts, including increased frequency and intensity of storms and irregular rainfall patterns, all of which have the potential to severely impact on the fishing industry and the wider community that it supports. In addition to environmental changes, the district faces socio-economic challenges such as sand winning and deforestation, which further exacerbate the vulnerability of the coastal ecosystem. These activities not only impact the immediate coastal areas but also have cascading effects on the hinterland ecosystems, affecting freshwater inflows and sedimentation rates, which are vital for maintaining productive estuarine and coastal fisheries.

8.3.2. Risk 2: Degradation of Coastal Habitats from Sea Level Rise

Mangroves and wetlands serve as critical nurseries for a multitude of fish species and act as natural buffers that absorb the energy of storm surges and reduce coastal erosion. The degradation of the Amanzule wetlands and mangroves from sea level rise, identified through stakeholder engagement in Ellembelle and studies (Ofori et al., 2023), could disrupt the intricate life cycles of various marine organisms. The literature supports these observations, with studies indicating that increased inundation and salinity intrusion from rising seas detrimentally affect the growth and survival of mangrove species (Alongi, 2008; Gilman et al., 2008).

The gradual submersion and erosion of coastal lands and Greater Amanzule peatland (Amoakoh et al., 21) also pose a direct threat to the livelihoods of fishermen and fishmongers who rely on these ecosystems' health for their catch. With the diminishing of mangroves, fish breeding grounds shrink, leading to reduced fish populations and catches, as indicated by the local fishermen's observations during the workshops.

The district's economy, which benefits from tourism attracted by its picturesque coastline and rich cultural heritage, stands to suffer. Coastal resorts, beaches, and other tourism-related infrastructure are at risk from the relentless advance of the sea, a concern echoed in the findings of the Intergovernmental Panel on Climate Change (IPCC), which warns of the adverse effects of sea level rise on tourism in small islands and coastal regions (IPCC, 2022).

The human cost of sea level rise is palpable in the potential displacement of the coastal communities in Ellembelle District. As the sea encroaches on land, homes, and public infrastructure become increasingly vulnerable to flooding and eventual destruction, forcing residents to relocate. This is not just a future projection but a current reality for some communities within the Ellembelle District, as reflected in workshop testimonies where instances of high-tide floods have become more frequent and severe.

8.3.3. Risk 3: Infrastructure Damage Due to Extreme Weather Events

The Ellembelle District, with its growing infrastructure pivotal to Ghana's economic growth, faces significant risks from the wrath of extreme weather events exacerbated by climate change. The infrastructure, which includes critical assets such as roads, bridges, and the Ghana gas pipeline, serves as the lifeline for the district's economy and the safety of its people.

During the workshop deliberations, stakeholders voiced concerns over the vulnerability of these infrastructures to the increasing frequency and intensity of storms and floods. Roads that once connected communities now lie at the mercy of raging floodwaters, which often wash away sections of pavement, isolate populations and minority groups, and paralyze the flow of goods and services. Bridges, too, are at risk of collapse under the force of floodwaters, as witnessed in historical incidents within the district,

where crucial links have failed, causing not only immediate disruption but also long-term economic impacts.

In the Ellembelle District, several critical energy infrastructure components are at heightened risk of damage from extreme weather events, exacerbated by climate change. These include the offshore gas export pipeline, a 12-inch diameter, 58 km long subsea pipeline that transports dense-phase Jubilee gas and TEN gas to the Gas Processing Plant (GPP) at Atuabo. Close to the GPP, approximately 2.5 km away near Anokyi, is the Liquefied Petroleum Gas (LPG) truck-loading gantry. The GPP itself, located at Atuabo in the Western Region, boasts a design capacity of 150 MMScfd and normally operates at 120 MMScfd. Additionally, there is a main onshore 20-inch diameter 110 km gas pipeline system that includes the Atuabo Initial Station (AIS), Esiama Distribution Station (EDS), and the Takoradi Distribution Station (TDS). The Ghana gas pipeline, an asset of national importance, threads through the district, and its exposure to extreme climate events is a matter of national concern. Damage to such critical installation from wildfires, flooding or storm-induced erosion could lead to substantial economic losses and pose severe safety hazards. The disruption of energy supplies could ripple through the economy, affecting industries and households alike.

8.3.4. Risk 4: Water Scarcity and Contamination

In the Ellembelle District, the dual threats of water scarcity and contamination stand at the forefront of climate-related challenges. The district, characterized by its variable rainfall patterns, experiences periods of intense droughts interrupted by extreme weather events such as floods. During stakeholder workshop discussions, community level participants including farmers and fisherfolks repeatedly expressed concerns over the increasing unpredictability of rain, which once followed more reliable seasonal patterns essential for agriculture, the backbone of the local economy.

Drought conditions have been shown to severely impact water levels in rivers and streams, critical sources for the community's water needs. This scarcity not only affects households and sanitation facilities but also has a detrimental impact on agricultural productivity. Crops suffer without adequate irrigation, and in turn, this leads to a reduction in agricultural output and income for farmers—a pattern of impact corroborated by climate vulnerability research (IPCC, 2021).

Conversely, when floods do occur, they overwhelm the existing water supply infrastructure, often leading to the contamination of freshwater sources with pollutants and pathogens. The workshop findings revealed instances where such contamination has led to outbreaks of waterborne diseases, echoing academic literature that links flooding to increased prevalence of diseases like cholera and diarrheal illnesses (Suhr & Steinert, 2022; Huda et al., 2022) with more severe effect on children and pregnant women.

The contamination is expected to be further exacerbated by land practices such as deforestation and illegal mining, which increase sediment and chemical loads in the water, compromising quality and biodiversity. These issues highlight the critical need for effective water resource management in the district.

8.3.5. Risk 5: Agricultural Productivity Loss

The Ellembelle district, with fertile lands that support diverse crop cultivation, stands at a critical crossroad as climate change threatens to undermine its agricultural foundations. Cocoa is the predominant of the tree crops now grown because of the devastation of the coconut crop by the deadly lethal yellowing disease (Cape Saint Paul's wilt Disease) other tree crops of economic importance include oil palm,

robber, and citrus. Major food crops are cassava, plantain, rice, vegetables such as garden eggs, pepper, and tomato.

The agricultural stakeholders including Ministry of Food and Agriculture within the district have reported, through workshops and engagements, the increasing challenge of irregular rainfall patterns which oscillate between excessive downpours leading to flooding and prolonged dry spells resulting in droughts. Both extremes present a formidable risk to crop viability, soil health, and the district's overall food security.

Flooding, as experienced in recent years across several farming communities including *Adubrim, Nzema Akropong, Nkroful*, has not only waterlogged fields, damaging crops beyond recovery but also washed away the rich topsoil, crucial for agricultural productivity. The erosion of topsoil is a loss that is not easily or quickly remedied, as it represents the culmination of centuries of natural processes. This has been further corroborated by research indicating that soil degradation poses a significant threat to agricultural productivity (Hossain et al., 2020; Ehui & Pender, 2005).

Complicating matters further are the extreme temperatures which are becoming more common. These high temperatures can stress crops, sometimes beyond their threshold for survival, particularly in districts like Ellembelle where traditional farming methods may not be equipped to manage such extremes. Local farmers' accounts, as discussed in the workshops, underscore the need for adapting farming practices to the evolving climate reality.

The climate change scenario in the Ellembelle district also sets the stage for increased prevalence and distribution of pests and diseases. Warmer and more humid conditions are conducive to the proliferation of pests and the spread of plant diseases, which can devastate crops and reduce yields. The local evidence from Ellembelle mirrors the broader trends suggested in the literature, where climate change is a driver for shifting patterns of pests and diseases, impacting agricultural systems (Donatelli et al., 2017; Skendžić, et al. 2021).

8.3.6 Risk 6: Public Health Crises

In the Ellembelle District, the changes in temperature and precipitation not only shape the natural environment but also the epidemiological landscape. During the recent workshops and interviews, healthcare providers and community leaders have raised alarms over the rise in climate-sensitive diseases, particularly vector-borne diseases like malaria, which thrive in the warmer and wetter conditions increasingly characteristic of the district.

Malaria, already a significant health concern across Ghana (Fenny & Akuffo-Henaku, 2020), finds a more conducive breeding ground for its mosquito vectors in the stagnant waters left by flooding, a situation that is poised to escalate with climate change. The World Health Organization (WHO) has noted that even small variations in temperature can have a dramatic effect on the transmission potential of diseases like malaria (WHO, 2022). Local healthcare systems, already stretched thin, face the possibility of being overwhelmed by surges in such diseases.

Flooding events, growing more frequent and intense in the Ellembelle district, not only damage infrastructure but also compromise water quality, leading to the spread of waterborne diseases such as cholera and typhoid fever. The contamination of water supplies with sewage and pathogens creates a public health emergency, as seen in various instances documented by the workshop participants. The aftermath of floods often leaves a legacy of increased diarrheal diseases, which can be devastating, particularly for the most vulnerable populations like children and the elderly.

The strain on the healthcare system in such scenarios is multifaceted. There's an immediate increase in demand for medical services and disease surveillance. Long-term, there's a need for recovery and rehabilitation of water and sanitation infrastructure to prevent future outbreaks. Furthermore, the psychological impact of these events and the diseases they bring cannot be understated, contributing to a rise in mental health issues within affected communities. Changes in temperature and precipitation patterns contribute to a higher prevalence of vector-borne diseases like malaria, and waterborne diseases following flooding events. Flooding and contaminated water supplies can also lead to outbreaks of diseases such as cholera and typhoid, straining the healthcare system and affecting the well-being of the district's residents.

8.4. Gender-specific vulnerability assessment

Assessing gender-specific vulnerabilities in the Ellembelle District is essential as climate change impacts do not affect all community members equally (Thomas et al., 2019). Women, often central to the cultivation of food crops, resource management and caregiving, can face disproportionate challenges during climate crises. Understanding these gendered dimensions is crucial for creating equitable, targeted interventions that ensure effective adaptation and resilience-building.

The assessment of current gender-specific climate change risks in the Ellembelle District highlights significant vulnerabilities across different groups (**Table 7**). Women face high exposure and sensitivity to erratic rainfall, sea-level rise, and increased temperatures, which severely impact their roles in water and food provision, stressing their adaptive capacities and elevating their overall vulnerability. Youth experience medium exposure and sensitivity to extreme weather and job market instability, yet they possess a high adaptive capacity due to their potential for innovation. The differently abled individuals are extremely vulnerable, with high exposure and very high sensitivity to accessibility issues during extreme weather, compounded by low adaptive capacity due to physical barriers and inadequate inclusive planning.

Table 7. Assessment of current gender-specific climate change risks

Group	Hazard Description	Exposure	Sensitivity	Adaptive Capacity	Overall Vulnerability	Comments/Impacts
Women	Erratic rainfall, sea-level rise, increased temperatures	High	High	Medium	High	Women, typically responsible for water and food provision, face increased burdens due to resource scarcity and extreme weather events.
Youth	Extreme weather events, job market instability	Medium	Medium	High	Medium	Youth employment and education opportunities are disrupted, but their potential for innovation offers a higher adaptive capacity.
Differently-abled Individuals	Accessibility issues during extreme weather	High	Very High	Low	Very High	Physical barriers and lack of inclusive planning result in heightened vulnerability and lower adaptive capacity.

The assessment of future climate change risks in the Ellembelle District indicates that different groups will face unique challenges due to evolving environmental conditions (**Table 8**). Women are at very high risk from increased heat and droughts impacting water resources, agriculture, and health, which could significantly strain their roles in sustenance and healthcare provision. Youth will experience high risks from shifts in the job market,

particularly in agriculture and fisheries, threatening their employment stability and economic future. Differently-abled individuals face particularly high risks due to limited accessibility and increased health challenges during extreme weather events, underscoring the urgency for targeted adaptive strategies to ensure their safety and access to necessary resource.

Table 8. Assessment of future climate change risks among different groups

Group	Hazard Description	HS	ES	H×E	AC	S	V	CCR	Comment-Impacts
Women	Increased heat and droughts could affect water supply, agriculture, and health	VH	VH	VH	M	H	VH	H	Women, who often lead in water and food collection, may face more labour and health risks.
Youth	Job market shifts due to climate impacts on agriculture and fisheries	H	H	H	M	M	H	H	Youth face uncertain job prospects as traditional livelihoods are disrupted.
Differently Abled	Limited accessibility and higher health risks during extreme weather	VH	M	H	L	VH	VH	H	Those with disabilities may have limited mobility and access to resources during disasters.



9



Conclusion and Recommendations

9.1 Future Climate Change Scenarios for Ellembelle District

Future climate projections indicate significant risks for the Ellembelle District, with forecasts predicting substantial increases in temperatures. Depending on the emission scenario, temperature rises could range from 1.5 to over 4°C by the century's end, with the most severe scenarios suggesting even higher peaks. Although projections for precipitation are less certain, they show potential variations around a 10% increase or decrease relative to historical averages. Notably, scenarios such as RCP 4.5 and RCP 8.5 suggest increased likelihoods of heavy precipitation events, which could exacerbate flooding risks across the district.

9.2 Priority Climate Related Hazards and Risks

The Ellembelle District's climate risk assessment identified the following priority risk domains based on the locale's specific vulnerabilities:

- Water Resources
- Coastal Flooding
- Erosion and Sedimentation
- Agricultural Systems
- Fisheries
- Community Health

Key climate hazards identified include extreme heat, sea-level rise, and both riverine and urban flooding. The district's coastal areas are particularly at risk, with rising sea levels expected to increase coastal flooding, erosion, and damage to infrastructure. Agricultural productivity is threatened by variable precipitation and increasing temperatures, which may also escalate pest and disease prevalence. Moreover, the health sector may face challenges from vector-borne diseases like malaria due to changing climatic conditions.

9.3 Climate Change Risk Assessment Results

The climate risk assessment for the Ellembelle District has revealed significant vulnerabilities across various sectors, underscoring the district's exposure to climate hazards such as coastal erosion, extreme weather events, and changing precipitation patterns. These risks are influenced by both natural and anthropogenic factors, with varying degrees of impact on gender, socio-economic structures, and critical infrastructures. Below are the detailed results for each major sector:

9.3.1 Gender Vulnerability

Women in Ellembelle District bear a disproportionate share of climate impacts, largely due to their roles in food production, water collection, and caregiving. Erratic rainfall patterns increase water scarcity,

compounding the burden on women. Additionally, the effects of heatwaves and malnutrition due to reduced agricultural productivity heighten risks for pregnant women and children. These challenges are exacerbated during climate events like floods, which increase competition for resources and the potential for gender-based violence.

9.3.2 Health Sector

The health system faces heightened risks from climate-induced factors. Flooding and inadequate sanitation are projected to escalate incidences of waterborne diseases such as cholera and typhoid. Rising temperatures increase risks of heatstroke, dehydration, and vector-borne diseases like malaria. Vulnerable populations, including children and the elderly, are particularly affected by these health challenges, necessitating enhanced public health surveillance and infrastructure resilience.

9.3.3 Agriculture

Agriculture in Ellembelle is highly sensitive to climate variability. Changes in rainfall patterns and temperature extremes threaten crop yields, while droughts and floods exacerbate soil degradation and pest outbreaks. These impacts undermine food security and livelihoods, requiring targeted interventions such as climate-smart agricultural practices and pest-resistant crop varieties.

9.3.4 Infrastructure

Critical infrastructure in Ellembelle is vulnerable to climate extremes, particularly flooding and coastal erosion. Roads, bridges, and utilities are often damaged during storms, affecting accessibility and economic activities. The Ghana Gas pipeline and other strategic assets face exposure to extreme weather events, necessitating resilient design and maintenance strategies.

9.3.5 Water Resources

Erratic rainfall and extreme weather variability contribute to both water scarcity and water quality degradation. Floods contaminate water sources with pollutants, while droughts lead to salinity intrusion in groundwater. These dynamics strain water supply systems, impacting households, agriculture, and industrial activities.

9.3.6 Coastal Ecosystems and Fisheries

Coastal ecosystems, critical to fisheries and biodiversity, are increasingly under threat from sea-level rise and warming oceans. These changes disrupt marine habitats, affecting fish populations and the livelihoods of fishing communities. The degradation of mangrove ecosystems further weakens natural coastal defenses against storm surges and erosion.

9.4 Recommendations

The Ellembelle District's climate change adaptation strategies should focus on localized, inclusive, and sustainable approaches tailored to the district's unique vulnerabilities and socioeconomic structure. Below are targeted recommendations based on findings from this Assessment:

9.4.1. Enhancing Coastal and Fisheries Resilience

- *Coastal Flood and Erosion Management:* Construct levees and flood barriers to safeguard communities like Atuabo and Eikwe. Protect fishing livelihoods by creating resilient landing sites and processing areas.
- *Mangrove Restoration:* Establish and sustain mangrove plantations, particularly around the Ankobra River estuary, to provide natural flood protection and biodiversity benefits.
- *Sustainable Fisheries Practices:* Train fisherfolk on alternative livelihoods like aquaculture and improve access to modern fishing equipment for enhanced sustainability.

9.4.2 Agriculture and Food Security

- *Agroforestry Systems:* Promote the integration of fruit and timber trees with crops like cassava and cocoa to protect soils and improve yields. Focus areas include Asasetre and Kamgbunli.
- *Irrigation and Water Management:* Develop irrigation schemes and rainwater harvesting systems to mitigate water scarcity and improve agricultural productivity.
- *Crop Diversification:* Introduce drought-resistant crops to enhance resilience to unpredictable rainfall patterns.

9.4.3 Infrastructure and Human Settlements

- *Climate-Resilient Construction:* Retrofit roads and bridges in flood-prone areas like Nkroful and Teleku Bokazo using durable materials. Public infrastructure like schools and health facilities should incorporate flood-resistant designs.
- *Urban Planning:* Implement stringent zoning laws to prevent construction in high-risk areas prone to flooding and erosion.
- *Green Infrastructure:* Install permeable pavements and rain gardens in urban areas to manage stormwater effectively.

9.4.4 Water Resources Management

- *Rainwater Harvesting:* Establish community-based rainwater collection systems in towns like Esiama and Alabokazo to address water scarcity.
- *Water Quality Monitoring:* Regularly assess the Ankobra River and other water bodies for contamination from mining and agricultural runoff.
- *Conservation Practices:* Promote water-efficient usage in households and irrigation practices to reduce overall demand.

9.4.5 Health and Gender-Inclusive Planning

- *Climate-Resilient Health Systems:* Strengthen healthcare infrastructure to handle climate-induced diseases, with a focus on flood-prone areas like Nkroful.
- *Gender-Sensitive Programs:* Empower women through access to clean water, credit facilities, and training in sustainable agriculture and fisheries.
- *Public Awareness Campaigns:* Educate communities about the health impacts of climate change and encourage proactive adaptation behaviors.

9.4.6 Governance and Financial Mobilization

- *Capacity Building:* Train district officials and stakeholders in climate adaptation planning and implementation.
- *Resource Mobilization:* Partner with international donors, NGOs, and the private sector to secure funding for adaptation projects.
- *Monitoring and Evaluation:* Establish a robust framework for tracking the progress of implemented measures and adapting them based on outcomes.

ADAPTATION ACTION PLAN FOR THE ELLEMBELLE DISTRICT ASSEMBLY





10

Adaptation Action Plan for the Ellembelle District Assembly

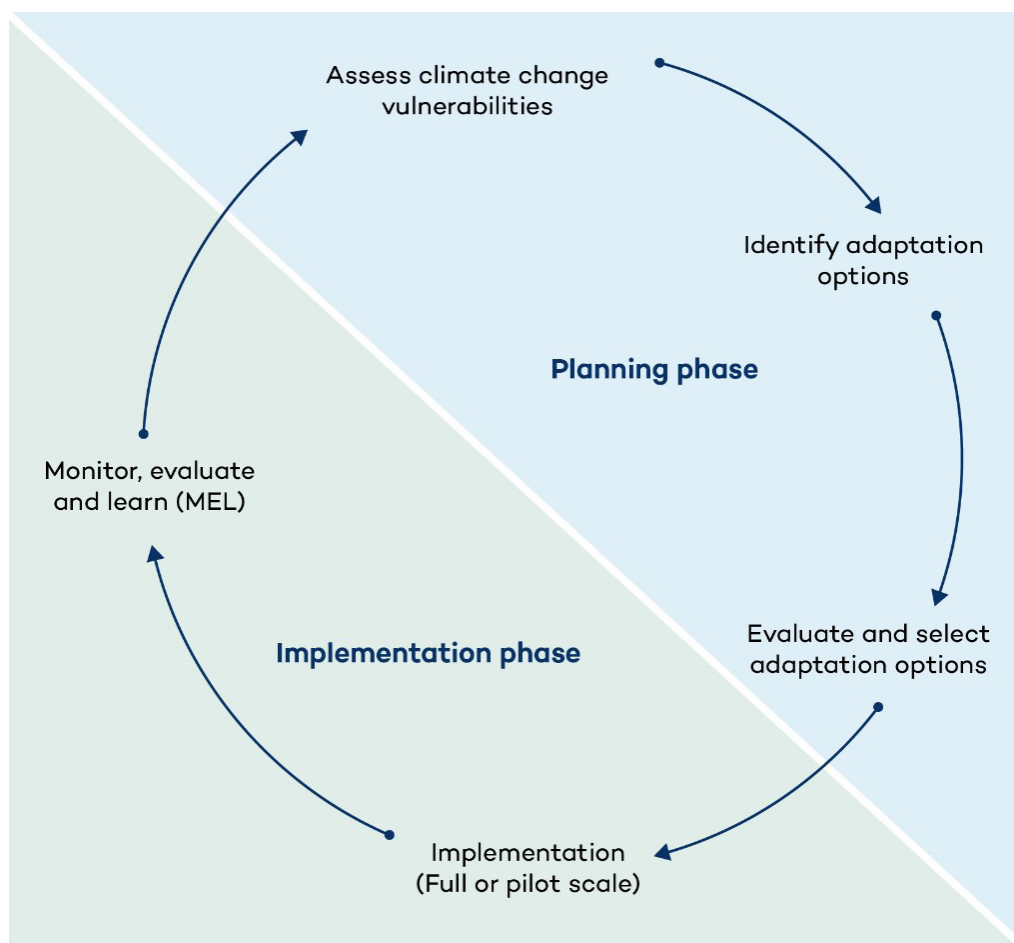
10.1 Introduction

The development of an adaptation action plan is essential for the Ellembelle District, as it provides a strategic and financially accountable framework to address the challenges posed by climate change and other environmental risks. The district is characterized by its diverse ecosystems and economically dependent on agriculture, fisheries, and tourism. This makes it particularly vulnerable to climate-related phenomena such as flooding, erosion, and unpredictable weather patterns. Thus, a comprehensive adaptation plan not only maps out the necessary interventions across various sectors but also allocates financial resources efficiently to ensure that these measures are both sustainable and effective. The district can better attract and justify funding from government bodies, international donors, and private sector investments. Moreover, this plan facilitates the prioritization of actions based on urgency and impact, leading to more resilient infrastructure, enhanced public health, and sustainable community livelihoods. This proposed plan is there essential for guiding Ellembelle District toward a resilient future, safeguarding its environment, economy, and the well-being of its communities against the looming challenges of climate change

The Adaptation Action Plan is designed to address the pressing climate challenges identified through comprehensive risk assessments and stakeholder engagement. This plan prioritizes four key areas to ensure a holistic and effective approach to climate resilience:

- **Risk Assessment and Vulnerability Analysis:** Focused on pinpointing the most critical climate risks and identifying sectors and communities most vulnerable to these challenges.
- **Stakeholder Engagement:** Emphasizing inclusivity, the plan involves local communities, government agencies, and relevant stakeholders to co-develop tailored and actionable adaptation strategies.
- **Implementation of Adaptation Measures:** Encompassing practical interventions such as upgrading drainage systems, expanding green infrastructure, and encouraging sustainable land use to mitigate identified risks.
- **Monitoring and Evaluation:** Introducing robust frameworks to regularly track the success and impact of implemented measures, facilitating necessary adjustments to enhance outcomes over time.

Figure 28: Approach to Ellembelle District Assembly Adaptation Planning



10.2 Identification and Compilation of Sector-Specific Adaptation Actions

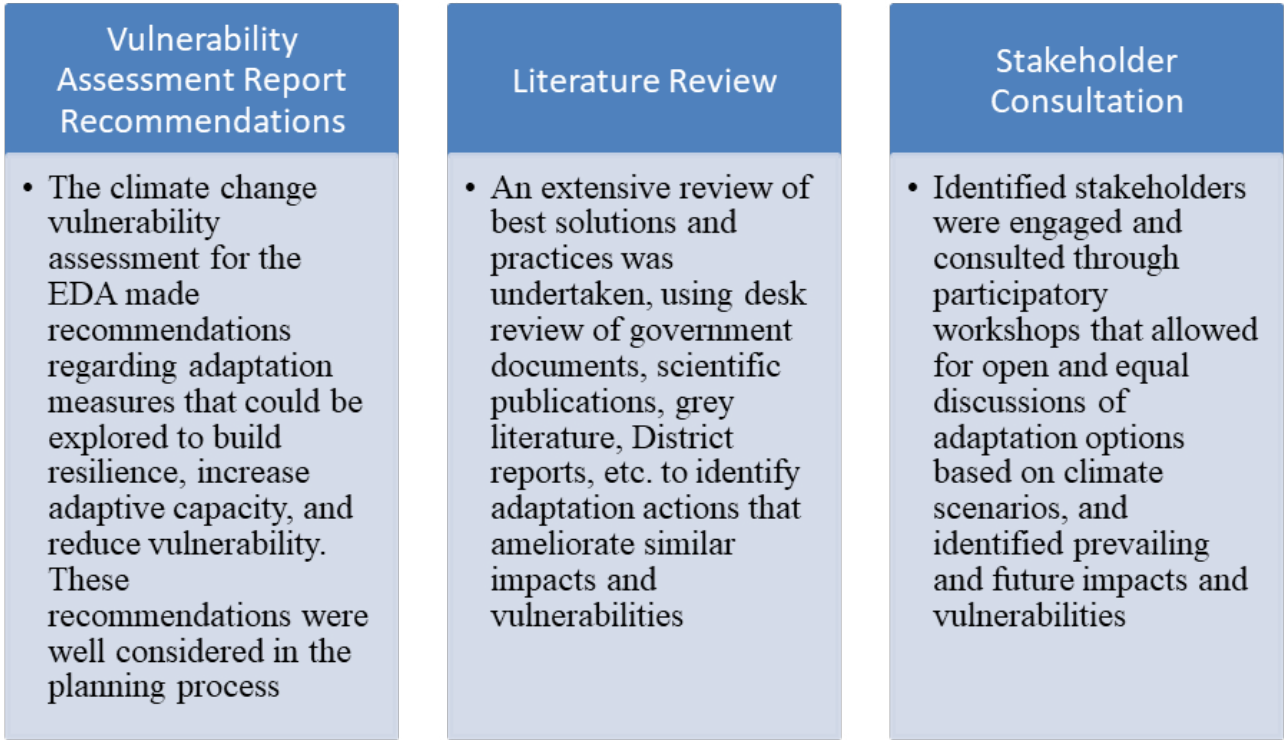
The Adaptation Action Plan for the Ellembelle District identifies and integrates specific adaptation strategies tailored to the unique challenges and vulnerabilities of the district. **Figure 29** outlines the techniques and methodologies employed to develop these adaptation actions, which are designed to build resilience and safeguard the district's socio-economic and environmental well-being. The Ellembelle District's adaptation plan targets six critical sectors including:

- Coastal Ecosystems and Fisheries
- Agriculture and Food Security
- Community Health
- Water Resources
- Gender
- Infrastructure and Human Settlement

The process began with the Vulnerability Assessment Report Recommendations, which identified specific adaptation measures to enhance resilience, build adaptive capacity, and reduce vulnerabilities based on a detailed analysis of climate risks. This was complemented by an extensive Literature Review, leveraging

government documents, scientific publications, district reports, and grey literature to identify best practices and adaptation actions that address similar impacts in comparable contexts. Finally, Stakeholder Consultation ensured inclusivity by engaging local communities, government officials, and other stakeholders through participatory workshops. These consultations enabled open discussions of adaptation options based on climate scenarios, ensuring the plan addressed both current and future challenges. Together, these methodologies ensured that the action plan was evidence-based, context-specific, and inclusive

Figure 29: Methodology to identify adaptation options



10.3 Methodological Approach for Ranking Adaptation Options

The key vulnerabilities and climate risks identified through comprehensive assessments of the Ellembelle District Assembly informed the development of a list of potential adaptation options. These options were compiled from an extensive desk review of literature, consultations with stakeholders, and recommendations from previous vulnerability assessments. Subsequently, the options were validated during stakeholder workshops (**Plate 15**), where participants engaged in collaborative discussions to refine and contextualize the proposed measures.

To ensure effective prioritization, participants were grouped based on their expertise and interests, representing key sectors such as agriculture, water and sanitation, fisheries, community health, infrastructure, and gender. Using a Multicriteria Decision-Making (MCDM) Analysis (**Table xxxx**), participants evaluated and ranked the proposed adaptation options against established criteria. This systematic process allowed for an assessment of the suitability of each option in addressing the specific vulnerabilities highlighted in the Ellembelle climate change vulnerability assessment, while also considering their potential to enhance resilience and foster sustainable development in the district.

Plate 15: Stakeholders Validating and Prioritizing Climate Adaptation Options in Ellembelle District



Table 9: Criteria for the assessment of the climate change adaptation options

S/N	Dimension	Indicators	Description
1	Technological	Effectiveness	Effectiveness of importance describes how well effective an adaptation option can mitigate climate damage. In essence, an effective option yields considerable benefits in terms of avoided consequences, albeit potentially at a high cost.
2	Economic	Affordability (cost efficiency)	This refers to the cost of implementing the adaptation option
3	Institutional	Institutional feasibility	Institutional feasibility refers to institutional and legal capacity. The preferred adaptation option aligns with laws, regulations, and institutional structures.
		Alignment with district and/or national priorities	The extent to which does this measure supports other development priorities of the district or the country?
4	Technological	Technical feasibility	Technical feasibility focuses on evaluating the technological expertise and the availability of necessary human, financial, and administrative resources for a specific option.

5	Social	Traditional acceptance of adaptation	Traditional acceptance refers to the degree of acceptability of an adaptation strategy aligning with the context of traditional values.
6	Social	Social co-benefits	This entails evaluating whether the proposed adaptation aligns with existing social practices and customs and whether it is likely to be embraced by the affected community or population.
7	Environmental	Flexibility	Flexibility refers to the ability to change behavior in response to changing conditions.
8	Environmental	Environmental considerations	This evaluates the potential of the intervention to improve GHG emissions, biodiversity, human health, soil quality, water quality, air quality, climate, and landscape.
9	Social	Gender responsiveness	This evaluates the extent to which the adaptation options address gender-related issues.
10	Social	Equity	The extent to which the adaptation option will benefit vulnerable groups and communities.
11	Technological	Replicability or scalability	This defines the ability or possibility of the intervention to be replicated elsewhere in the country or scaled up.
12	Technological/ Economics/ Institutional /Environmental or social	Barriers to implementation	This identifies potential institutional, economic, technological, and social barriers to the implementation of the adaptation option.

Source: Adapted from Dixit & McGray (2013)

The prioritization exercise was critical to selecting actionable and context-specific measures while avoiding maladaptation. Stakeholders representing government agencies, community groups, environmental organizations, and local leaders contributed to the process, ensuring that the adaptation options were inclusive, equitable, and relevant. The MCDM approach was particularly valuable in weighing trade-offs, as adaptation measures often perform differently across various criteria. The methodology involved assigning weights to indicators based on their perceived importance and scoring each adaptation option accordingly.

A five-point Likert scale, similar to the methods applied by Antwi-Agyei et al. (2013), Zobeidi et al. (2024), and UNFCCC (2011), was utilized to rank the indicators (**Table 10**). This approach allowed climate experts, agricultural professionals, and other stakeholders to systematically evaluate adaptation measures, ensuring balanced decisions that address the district's diverse needs. Unequal weighting was applied to reflect the varying significance of indicators, based on stakeholder feedback and the frequency with which each criterion was emphasized. This participatory and evidence-based prioritization process underscores the importance of integrating local knowledge and scientific research in shaping climate adaptation strategies for Ellembelle.

Table 10. Ranking of adaptation options based

Number	Interpretation
1	Low
2	Neutral
3	Medium
4	High
(....)	Enclose a number in a bracket to show high uncertainty .

10.4 Adaptation Options

This section presents a detailed exploration of sectoral adaptation measures tailored to address the unique climate vulnerabilities of the Ellembelle District. Each adaptation option is aligned with specific objectives to enhance resilience, mitigate risks, and safeguard livelihoods. The discussion highlights the justification for each measure, emphasizing its relevance to local contexts and the critical considerations for successful implementation.

10.4.1 Coastal Ecosystems and Fisheries

From the Assessment, coastal ecosystems and fisheries were identified as highly vulnerable to climate change impacts. Out of the multiple adaptation options evaluated through the MCDM Analysis, five were selected and prioritized for their potential to safeguard the district's coastal resources and the livelihoods dependent on them. **Table 11** presents the prioritization of adaptation options for the Coastal Ecosystems and Fisheries sector in Ellembelle District, reflecting stakeholder evaluations based on criteria such as effectiveness, feasibility, and social acceptance. **Table 12** provides a detailed breakdown of prioritized adaptation options for the Coastal Ecosystems and Fisheries sector in Ellembelle District. It elaborates on the specific objectives, indicators of success, time frames, required resources, implementing partners, and associated costs for each adaptation action.

Table 11: Ranking of Adaptation Options for the Coastal Ecosystems and Fisheries Sector

Adaptation Option	Final Score from Stakeholders	Rank
Mangrove Restoration and Nature-Based Solutions	44	1st
Local Knowledge Workshops	43	2nd
Aquaculture Development	43	2nd
Women's Sustainable Livelihood Programs	42	4th
Enhance Enforcement and Compliance	39	5th

Mangrove Restoration and Nature-Based Solutions ranked highest, underscoring their critical role in mitigating coastal erosion, enhancing biodiversity, and supporting livelihoods. For instance, implementing closed fishing seasons and enforcing no-fishing days are essential strategies to allow fish populations to regenerate during critical reproductive periods. This approach supports sustainable fisheries management, ensuring long-term benefits for both the environment and local communities reliant on fishing for their livelihoods (Hen Mpoano, 2024). Mangrove reforestation in areas like the Amanzule Wetland was also prioritized due to its critical role in carbon sequestration, shoreline stabilization, and providing nursery habitats for marine species, which sustain local fisheries and reduce vulnerability to coastal flooding and erosion (Global Mangrove Alliance, 2023).

Local Knowledge Workshops and Aquaculture Development tied for second place, highlighting the integration of traditional practices and sustainable aquaculture as pivotal strategies. Such approaches bolster resilience by fostering alternative livelihoods and reducing pressure on wild fish stocks. Women's Sustainable Livelihood Programs ranked fourth, underscoring the importance of gender-responsive initiatives that empower women in fisheries through activities like shellcraft and community-based conservation.

The fifth-ranked option, Enhance Enforcement and Compliance, emphasizes the need for robust institutional frameworks to regulate fishing practices. Measures such as closed fishing seasons and no-fishing days allow fish populations to regenerate during critical reproductive periods, ensuring sustainable fisheries management (Hen Mpoano, 2024). Complementing these efforts are community

sensitization programs, which empower fishers through education on sustainable practices and the ecological significance of marine habitats, fostering conservation-friendly behaviors (FAO, 2024).

Finally, broader strategies such as Integrated Coastal Zone Management (ICZM) harmonize development with conservation, promoting alternative livelihoods like ecotourism. Disaster preparedness training further equips coastal communities to respond effectively to flooding and storms, safeguarding both human lives and economic stability (NADMO, 2024). Together, these prioritized adaptation options form a comprehensive framework to protect coastal ecosystems and fisheries while enhancing community resilience.

Table 12: Summary of Adaptation Options for Coastal Ecosystems and Fisheries Sector

Adaptation Actions	Objectives	Indicators of Success	Time Frame (Short, Medium, or Long Term)	Resources (Finance, Human, Technology)	Implementing Partners	Cost
Implementation of Closed Seasons and Enforcement of No Fishing Days	To enhance fish stock sustainability and support the economic stability of fishing communities by implementing district-wide closed seasons and no-fishing days.	- Improved fish stock regeneration rates. - Increased compliance among fishers. - Improved economic stability in fishing communities.	Medium-Term	- Finance (grants), - Human resources (local leaders, Fisheries Commission staff), - Technology (monitoring tools).	Fisheries Commission, Local Government, Hen Mpoano, Research Institutions.	
Mangrove Reforestation Plan	To restore and expand mangrove forests to enhance ecological resilience, support community livelihoods, and mitigate the impacts of climate change.	- Increased mangrove cover in Amanzule Wetland; - Improved biodiversity; - Reduced coastal erosion; Increased community participation in restoration efforts.	Medium-Term	- Finance (government and donor grants) - Human resources (community workers, NGOs), - Technology (remote sensing tools for monitoring).	Hen Mpoano, Universities, Global Mangrove Alliance, Local NGOs.	
Community Sensitization Programs	To educate and empower communities in sustainable practices, fostering collective action for sustainable resource management and climate resilience.	- Increased awareness of climate change impacts and sustainable practices. - Active participation of all demographic groups - Reduced unsustainable activities (e.g., illegal logging, overfishing).	Short-Term	- Finance (for training materials), - Human resources (educators, facilitators), - Technology (media platforms, apps).	Local Government, Community Groups, Schools, NGOs.	

Integrated Coastal Zone Management (ICZM)	To sustainably manage and protect the district's coastal resources, ensuring environmental integrity, economic stability, and community resilience.	• Reduced coastal erosion. • Improved stakeholder collaboration. • Enhanced governance of coastal resources.	Long-Term	• Finance (PPP, international grants) • Human resources (coastal management teams, local leaders), • Technology (GIS for mapping and monitoring).	Ministry of Environment, Local Government, Environmental NGOs, Community Groups.	
Sustainable Fisheries Management Program	To ensure the sustainability and health of marine ecosystems while safeguarding livelihoods through co-management, aquaculture promotion, and education on sustainable fishing practices.	• Increased adoption of sustainable fishing practices. • Reduction in illegal fishing activities. • Growth in aquaculture initiatives. • Enhanced fish stock levels.	Medium-Term	• Finance (grants, private investments) • Human resources (fishers, trainers, NGOs), • Technology (tracking tools, aquaculture systems).	Fisheries Commission, Local Communities, NGOs, International Conservation Bodies.	
Disaster Preparedness and Response Training	To enhance the district's capacity to prepare for and respond to natural disasters, reducing vulnerability and protecting human lives, infrastructure, and livelihoods.	• Formation of local response teams • Successful implementation of simulation drills • Increased awareness and readiness among residents.	Short-Term	• Finance (disaster management budgets), • Human resources (trainers, volunteers) • Technology (early warning systems, mobile communication tools).	NADMO, Local Government, International Organizations (e.g., Red Cross, UNICEF).	
Promotion of Sustainable Agroforestry	To integrate trees into farming systems, enhance soil health, and improve resilience to climate impacts.	• Increased adoption of agroforestry practices • Improved soil quality and crop yields. • Diversified income sources from timber and non-timber forest products.	Medium-Term	• Finance (agricultural support grants), • Human resources (agriculture extension officers, farmers) • Technology (modern agroforestry tools and systems).	Ministry of Agriculture, FAO, Farmers' Cooperatives, Research Institutions.	

Infrastructure Maintenance and Retrofitting	To improve the resilience of critical infrastructure to climate impacts, ensuring continuous accessibility and functionality during extreme weather events.	- Reinforced bridges and roads in flood-prone areas - Reduced instances of infrastructure failures during floods and storms - Improved disaster response capacity.	Long-Term	- Finance (government budgets, climate funds) - Human resources (engineers, technicians), - Technology (flood-resistant construction materials).	Ministry of Roads, Local Government, Engineering Firms.	
Flood Management Measures	To reduce the risk of urban and riverine flooding by improving drainage systems, constructing levees, and promoting green infrastructure.	- Reduced frequency and impact of urban flooding - Increased community satisfaction with flood control measures. - Improved functionality of drainage systems during heavy rainfall.	Medium-Term	- Finance (development funds, donor support) - Human resources (urban planners, engineers) - Technology (flood modeling tools, green infrastructure systems).	Ministry of Water Resources, Local Authorities, NGOs, Community Groups.	

10.4.2 Agriculture and Food Security

Agriculture and food security in Ellembelle District face significant risks from climate change, such as irregular rainfall, soil degradation, and the increasing frequency of extreme weather events. Key adaptation measures were proposed to address these challenges and enhance the sector's resilience.

Table 13 illustrates the prioritization of adaptation options for the Agriculture and Food Security sector in Ellembelle District based on stakeholder evaluations. The ranking reflects the options' effectiveness in addressing climate risks while enhancing agricultural resilience and ensuring food security.

Conservation Agriculture Practices secured the highest rank with a score of 46, underscoring its critical role in improving soil health, conserving water, and enhancing crop yields through sustainable farming techniques. Soil Conservation ranked second, highlighting the importance of erosion control and fertility management in maintaining long-term agricultural productivity. Agricultural Extension Services achieved third place, emphasizing the value of disseminating knowledge, training farmers, and introducing innovative techniques to enhance resilience.

Table 13: Ranking of Adaptation Options for the Agriculture and Food Security Sector

Adaptation Option	Final Score from Stakeholders	Rank
Conservation Agriculture Practices	46	1st
Soil Conservation	42	2nd
Agricultural Extension Services	40	3rd
Efficient Water Management Systems	37	4th
Enhanced Weather Forecasting	37	4th
Climate-Resilient Agricultural Practices	30	5th

Efficient Water Management Systems and Enhanced Weather Forecasting shared the fourth position, indicating their complementary roles in optimizing water use and providing timely climate information for informed decision-making in farming practices. Climate-Resilient Agricultural Practices ranked fifth, reflecting the potential challenges of scaling these practices due to resource or institutional constraints. However, its inclusion in the list reinforces the need to adapt traditional methods to mitigate the impacts of changing climatic conditions. Collectively, these prioritized actions represent a strategic approach to strengthening the district's agricultural sector against climate vulnerabilities while supporting livelihoods and food security.

Table 14 provides a detailed breakdown of the prioritized adaptation options for the Agriculture and Food Security sector in Ellembelle District. Each action is aligned with specific objectives, success indicators, time frames, and resource requirements, highlighting the collaborative efforts needed for successful implementation.

Table 14: Summary of Adaptation Options for the Agriculture and Food Security Sector

Adaptation Actions	Objectives	Indicators of Success	Time Frame	Resources (Finance, Human, Technology)	Implementing Partners	Cost
Implementation of Climate-Smart Agriculture (CSA)	To bolster the resilience and sustainability of the Ellembele District's agricultural sector through CSA practices, such as adopting drought-resistant crop varieties, improving irrigation systems, and encouraging crop diversification.	• Increased adoption of drought-resistant crops. • Improved irrigation efficiency. • Greater diversity of crops and income sources. • Enhanced participation of women farmers.	Medium-Term	• Finance (credit facilities, subsidies). • Human resources (agricultural extension agents). • Technology (irrigation systems, seed development).	Ministry of Food and Agriculture, Local Government, NGOs, Farmer Associations.	
Soil Conservation Measures	To prevent soil erosion, maintain soil fertility, and ensure sustainable agricultural productivity through techniques like contour ploughing, terracing, mulching, and cover cropping.	• Reduced rates of soil erosion. • Increased soil organic matter and water retention. • Higher crop yields. • Participation of women in soil conservation initiatives.	Short-Term	• Materials for terracing and mulching. • Human resources (trainers, extension officers). • Financial resources for erosion control programs.	Ministry of Agriculture, Research Institutions, Community Groups.	
Agroforestry	To integrate trees and shrubs into farming systems to enhance biodiversity, improve soil health, and provide additional income streams through fruits, timber, and non-timber forest products.	• Increased adoption of agroforestry systems. • Enhanced biodiversity on farms. • Improved soil fertility and water infiltration. • Increased income from diversified products.	Medium-Term	• Finance (grants, microcredit for farmers). • Human resources (forestry experts, trainers). • Technology (nurseries, planting tools).	Forestry Commission, NGOs, Ministry of Agriculture, Farmer Cooperatives.	
Enhanced Weather Forecasting	To provide accurate meteorological data for informed decision-making in agriculture, fisheries, and disaster preparedness.	• Increased use of weather forecasts for agricultural planning. • Reduced losses due to weather-related events. • Improved disaster preparedness among communities.	Medium-Term	• Finance (investment in weather stations). • Technology (mobile apps, SMS systems). • Human resources (meteorologists, trainers).	Ghana Meteorological Agency, Local Government, Farmer Associations.	

10.4.3 Community Health

The community health sector in the Ellembelle District is highly susceptible to climate change, particularly in areas like waterborne and vector-borne diseases. To address these challenges, several adaptation strategies have been collaboratively proposed to ensure the resilience of the district's health systems.

Table 15 ranks the proposed interventions based on their effectiveness, feasibility, and alignment with community needs. Capacity Building for Health Workers and Community-Based Health Education are tied as the top priorities with a score of 48. These measures recognize the critical importance of empowering healthcare professionals and equipping communities with knowledge to manage and mitigate health risks effectively. Skilled health workers are vital for responding to climate-induced health challenges, while informed communities are better prepared to adopt preventive measures and access healthcare services.

Table 15: Ranking of Adaptation Options for the Community Health sector

Adaptation Option	Score	Rank
Capacity Building for Health Workers	48	1st
Community-Based Health Education	48	1st
Targeted Disease Surveillance and Control	47	3rd
Vector Control Programmes	44	4th
Enhanced Water and Sanitation Infrastructure	44	4th

Targeted Disease Surveillance and Control, ranked third with a score of 47, emphasizes the need for robust monitoring and response systems. By tracking climate-sensitive diseases like malaria and cholera, the district can act proactively to prevent outbreaks and minimize health impacts. Vector Control Programs and Enhanced Water and Sanitation Infrastructure tied for fourth place, each scoring 44. Vector control is essential for managing the prevalence of diseases spread by mosquitoes and other vectors, which are exacerbated by changing environmental conditions. Simultaneously, improving water and sanitation systems is critical to reducing waterborne diseases, particularly during flooding events. Table 16 provides a detailed breakdown of the prioritized adaptation options for the Community Health sector in Ellembelle District. Each adaptation action is aligned with specific objectives, measurable indicators of success, and time frames, ensuring a structured approach to enhancing health resilience.

Table 16: Summary of Adaptation Options for Community Health Sector

Adaptation Actions	Objectives	Indicators of Success	Time Frame	Resources (Finance, Human, Technology)	Implementing Partners	Cost
Enhanced Water and Sanitation Infrastructure	To provide reliable access to safe drinking water and improve sanitation in communities like Esiama and Nkroful, reducing waterborne diseases and ensuring public health during climate impacts like flooding.	• Increased access to safe drinking water. • Reduction in waterborne diseases. • Improved sanitation coverage in targeted areas. • Community participation in health monitoring.	Medium-Term	• Construction materials for sanitation systems. • Solar-powered purification units. • Community training programs.	Local Government, Ministry of Sanitation and Water Resources, NGOs, Research Institutions.	
Public Health Campaigns	To enhance community health literacy by educating on hygiene, disease prevention, and climate change health impacts.	• Increased public awareness of hygiene and climate-related health risks. • Adoption of better hygiene practices. • Reduced disease outbreaks.	Short-Term	• Health education materials. • Digital outreach platforms. • Partnerships with local health departments.	Ghana Health Service, Local NGOs, Community Leaders, International Health Organizations.	
Infrastructure Resilience Against Flooding	To safeguard health facilities, particularly in flood-prone areas like Nkroful, ensuring they remain functional and accessible during floods.	• Functional health facilities during floods. • Improved emergency response capacity. • Secure storage of medical supplies.	Medium-Term	• Funds for retrofitting health facilities. • Emergency equipment and storage. • Technical expertise.	NADMO, Ministry of Health, Construction Firms, Local Government Units.	

Innovative Health Monitoring Technologies	To integrate advanced health monitoring tools, such as mobile apps and remote sensors, for real-time disease surveillance and emergency response.	• Increased use of health monitoring technologies. • Improved disease surveillance and reporting. • Quicker emergency response times.	Medium-Term	• Mobile health apps and GIS tracking systems. • Training programs for health workers. • Financial support for technology maintenance.	Ministry of Health, Local IT Developers, International Donors, NGOs.	
Strengthening Community Health Networks	To enhance health service delivery by developing a robust network of community health workers (CHWs), especially in remote and underserved areas of Ellembelle District.	• Expanded CHW network. • Increased health coverage in underserved areas. • Improved community health outcomes.	Short-Term	• Comprehensive training resources. • Transportation and communication tools. • Funds for salary and logistical support.	Ghana Health Service, Local NGOs, Community Health Committees, International Donors.	

10.4.4 Water Resources

The water resources sector in Ellembelle District faces significant challenges from climate variability, including water scarcity, pollution, and irregular rainfall patterns. To address these issues, a series of targeted adaptation actions have been proposed to enhance water resource management and build resilience. The prioritization of adaptation options for the Water Resources sector reflects the need to address water security and climate resilience comprehensively in Ellembelle District (**Table 17**). Water Purification Installations ranked first, underscoring the critical importance of ensuring access to safe drinking water as a cornerstone of public health and resilience, particularly in communities impacted by waterborne diseases. Community Engagement and Education follows in second place, emphasizing the value of empowering residents with knowledge and tools for sustainable water management practices, fostering local stewardship, and improving overall water resource efficiency.

Table 17: Ranking of Adaptation Options for the Water Resource Sector

Adaptation Option	Final Score from Stakeholders	Rank
Water Purification Installations	46	1st
Community Engagement and Education	45	2nd
Enhanced Water Storage Facilities	42	3rd
Flood Barriers and Watershed Management (NBS)	39	4th
Regulations and Enforcement	38	5th
Watershed Management Plans	38	5th
Community-Based Rainwater Harvesting Systems	35	7th
Water Recycling in Urban and Industrial Sectors	32	8th

Enhanced Water Storage Facilities ranks third, highlighting the importance of securing consistent water supplies for domestic and agricultural use, especially during droughts. An example of Enhanced Water Storage Facilities includes the installation of solar-powered water systems in communities like Nkroful and Esiam (Plate 16). These systems utilize solar energy to pump, purify, and store water, ensuring a consistent and reliable supply even in remote areas or during power outages. Solar-powered water systems are particularly important for addressing the water scarcity challenges posed by climate variability, as they provide a sustainable, low-carbon solution that aligns with the district's goals of promoting renewable energy and environmental conservation. The importance of these systems lies in their ability to operate efficiently in areas with abundant sunlight, reducing dependence on fossil fuels and lowering operational costs over time. Furthermore, solar-powered systems ensure water access during prolonged dry spells or droughts, supporting both domestic and agricultural needs.

Barriers and Watershed Management placed fourth, pointing to the necessity of mitigating flood risks while safeguarding ecosystems through nature-based solutions. Both Regulations and Enforcement and Watershed Management Plans shared fifth place, reflecting their roles in creating a governance framework for sustainable water use and pollution control.



Plate 16: Example of solar-powered water system

Table 18 provides comprehensive details of the prioritized adaptation measures aimed at enhancing water security and sustainability in the Ellembelle District. Table 18: Summary of Adaptation Options for Water Resources Sector provides comprehensive details of the prioritized adaptation measures aimed at enhancing water security and sustainability in the Ellembelle District.

Table 18: Summary of Adaptation Options for Water Resources Sector

Adaptation Actions	Objectives	Indicators of Success	Time Frame	Resources (Finance, Human, Technology)	Implementing Partners	Cost
Community-Based Rainwater Harvesting	To reduce dependency on variable river flows and groundwater by implementing community-led rainwater harvesting systems in towns like Akanko, Edwapkole, Menzozor, and New-Adiembra, ensuring a reliable water supply for agriculture and domestic use during dry periods.	• Increased use of harvested rainwater for agriculture and domestic purposes. • Improved community involvement in water system maintenance. • Reduction in water scarcity during dry seasons.	Medium-Term	• Tanks, gutters, pipes, filtration systems. • Engineers and technicians. • Community education programs.	Local Government, NGOs, Community Groups, Water and Sanitation Committees.	
Enhanced Water Storage Facilities	To construct and upgrade large-scale community water storage systems in towns like Nkroful and Esiama, ensuring consistent water supply for domestic and agricultural needs, particularly during droughts.	• Increased water storage capacity. • Reduction in reliance on rain-dependent sources. • Improved water availability during droughts.	Medium-Term	• High-quality construction materials. • Technical expertise for design and supervision. • Training programs for community-based management.	Local Government, Ministry of Sanitation and Water Resources, NGOs.	
Robust Water Quality Monitoring Programs	To establish comprehensive monitoring systems for water bodies like the Ankobra River, ensuring safety and health for communities and ecosystems by detecting and mitigating pollution sources.	• Improved water quality in monitored water bodies. • Reduced pollution incidents. • Increased community involvement in water quality monitoring.	Medium-Term	• Laboratory equipment for water quality tests. • Skilled technicians and scientists. • Educational tools for community involvement.	Ministry of Environment, Research Institutions, Local Government.	
Community Engagement in Water Monitoring	To empower local communities to participate in water quality monitoring efforts, fostering awareness and promoting collective action for sustainable water management.	• Formation of community-based monitoring teams. • Increased community awareness of water quality issues. • Timely reporting and mitigation of pollution incidents.	Short-Term	• Water testing kits and educational materials. • Technical support from water quality experts. • Communication tools for reporting results.	Local NGOs, Community-Based Organizations, Water Agencies.	

Water-Efficient Agricultural Practices	To promote sustainable agricultural techniques such as drip irrigation and mulching, improving water use efficiency and reducing wastage in farming across Ellembele District.	• Increased adoption of water-efficient practices by farmers. • Reduction in water use per unit of crop yield. • Improved soil health and reduced erosion.	Medium-Term	• Drip irrigation systems and mulching materials. • Educational materials for farmers. • Agricultural extension services.	Ministry of Agriculture, Local Farmer Associations, NGOs.	
Water Recycling in Urban and Industrial Sectors	To implement water recycling and reuse systems in urban and industrial areas like Atuabo, reducing reliance on freshwater resources and enhancing water efficiency.	• Increased use of recycled water in urban and industrial processes. • Reduction in freshwater demand. • Public awareness and adoption of water recycling practices.	Long-Term	• Infrastructure for recycling systems. • Educational materials for awareness campaigns. • Support for legal and administrative policy enforcement.	Local Industries, Ministry of Environment, NGOs, Urban Authorities.	

10.4.5 Infrastructure and Human Settlement

The Infrastructure and Human Settlements sector in Ellembelle District requires targeted adaptation measures to address the increasing impacts of climate change, including flooding, erosion, and rising temperatures. The prioritization table for the Infrastructure and Human Settlement Sector highlights key adaptation options ranked by stakeholders based on their potential to enhance resilience and sustainability in the Ellembelle District (**Table 19**)

Table 19: Ranking of Adaptation Options for the Infrastructure and Human Settlement Sector

Adaptation Option	Final Score from Stakeholders	Rank
Reforestation and Green Buffers	43	1st
Enforce Zoning Laws	43	1st
Climate-Resilient Construction	40	3rd
Promote Climate-Resilient Housing Models	35	4th
Strengthen Infrastructure Resilience	31	5th
Encourage Relocation from High-Risk Areas	30	6th

Reforestation and Green Buffers and Enforce Zoning Laws share the top rank (43 points), reflecting their critical role in mitigating climate impacts such as flooding and erosion while preserving ecological stability and guiding sustainable development. Climate-Resilient Construction ranks third (40 points), emphasizing the importance of incorporating durable materials and energy-efficient designs to safeguard buildings against climate-related hazards. Promotion of climate-resilient housing models follows in fourth place (35 points), underlining the need to design homes that can withstand environmental stresses while ensuring comfort and safety. Lower-ranked options, such as Strengthening Infrastructure Resilience (31 points) and Encourage Relocation from High-Risk Areas (30 points), highlight the need for targeted investments in retrofitting infrastructure and strategic planning to reduce vulnerability in high-risk zones.

Table 20 provides a detailed overview of the prioritized adaptation actions for the Infrastructure and Human Settlements sector in Ellembelle District. These actions aim to enhance resilience and sustainability by addressing climate-related challenges such as flooding, infrastructure vulnerability, and environmental degradation. The table outlines specific objectives, indicators of success, time frames, required resources, implementing partners, and estimated costs, offering a comprehensive framework for targeted and effective adaptation interventions in this critical sector.

Table 20: Summary of Adaptation Actions for Infrastructure and Human Settlements

Adaptation Actions	Objectives	Indicators of Success	Time Frame	Resources (Finance, Human, Technology)	Implementing Partners	Cost
Climate-Resilient Construction	To enhance the structural durability and functionality of buildings and infrastructure in Ellembele District to withstand climate-related hazards.	• Increased use of flood-resistant and durable materials. • Improved structural resilience to climate hazards. • Integration of energy-efficient designs.	Medium-Term	• Technical expertise (engineers, architects). • High-quality, locally sourced materials. • Financial investment for resilient construction practices.	Local Government, Construction Firms, NGOs, Urban Planners.	
Flood Management Measures	To mitigate flood risks in riverine and urban areas by strengthening flood defenses such as levees, drainage systems, and green infrastructure.	• Reduction in flood events in vulnerable areas. • Effective operation of flood management infrastructure. • Increased community awareness of flood measures.	Medium to Long	• Skilled engineers and planners. • Construction materials for barriers and drainage systems. • Monitoring tools for flood performance evaluation.	Ministry of Works and Housing, Environmental NGOs, Local Communities.	
Land Use Planning	To guide development away from high-risk areas, promoting sustainable practices that enhance resilience to climate impacts.	• Reduced development in flood-prone areas. • Improved resilience of infrastructure to climate hazards. • Increased preservation of natural buffers.	Long-Term	• Geographical and environmental data. • Skilled urban planners and scientists. • Community education programs.	Local Government, Land Use Planning Committees, Urban Development Authorities.	
Reforestation and Green Buffers	To reduce climate vulnerability and improve ecological stability by implementing reforestation and green buffers in Ellembele District.	• Increased forest cover in vulnerable areas. • Enhanced soil stability and reduced flood risks. • Improved biodiversity and ecosystem services.	Medium-Term	• Nurseries for native tree cultivation. • Forestry and environmental experts. • Community engagement materials.	Forestry Commission, NGOs, Community Groups, Research Institutions.	
Infrastructure Maintenance and Retrofitting	To strengthen and extend the lifespan of existing infrastructure to withstand extreme weather events and climatic stresses.	• Reduced infrastructure failures during extreme weather events. • Prolonged lifespan of critical infrastructure. • Increased community resilience.	Short to Medium	• Skilled engineers and construction workers. • Financial resources for retrofitting. • Sustainable materials for repairs.	Local Government, Engineering Firms, Infrastructure Development Authorities.	

10.4.6 Gender Responsiveness in Adaptation Options

Gender-responsive adaptation in Ellembelle District emphasizes the equitable participation of women, youth, and differently-abled individuals in strategies across sectors.

The prioritization table highlights gender-responsive adaptation options ranked by their ability to promote inclusivity and resilience across diverse groups, including women, youth, and differently abled individuals (**Table 21**). Coastal Ecosystems and Fisheries ranks highest (1st) due to its emphasis on sustainable livelihoods like mangrove restoration and shellcraft, actively empowering women and youth while fostering environmental conservation. Agriculture and Food Security follows (2nd), recognizing its role in providing women access to resources and engaging youth in agribusiness innovation. Community Health (3rd) prioritizes gender-sensitive WASH infrastructure and targeted health campaigns, addressing the specific needs of women and remote populations. Water Resources (4th) emphasizes women-led rainwater harvesting systems and accessible water facilities for differently abled individuals. Lastly, Infrastructure and Human Settlements (5th) highlights eco-friendly construction and disaster resilience projects, ensuring women's and differently abled individuals' involvement in planning and execution.

Table 21: Ranking of Adaptation Options for Gender

Adaptation Option	Key Gender-Specific Benefits	Final Score from Stakeholders	Rank
Coastal Ecosystems and Fisheries	- Empowers women and youth through livelihoods like mangrove restoration and shellcraft. - Enhances inclusion of differently-abled individuals in conservation initiatives.	45	1st
Agriculture and Food Security	- Improves access for women to drought-resistant crops and financial support. - Engages youth in agripreneurship through technology and training.	44	2nd
Community Health	- Provides gender-sensitive healthcare and WASH infrastructure. - Targets women's health through specific campaigns and mobile clinics for remote areas.	43	3rd
Water Resources	- Promotes women-led rainwater harvesting systems. - Ensures equitable water access for differently-abled individuals.	42	4th
Infrastructure and Human Settlements	- Trains women in climate-resilient construction. - Involves women and differently-abled persons in flood management planning and land use strategies.	41	5th

Table 22: Summary of Gender-Responsive Adaptation Options

Adaptation Actions	Objectives	Indicators of Success	Time Frame	Resources (Finance, Human, Technology)	Implementing Partners	Cost
Coastal Ecosystems and Fisheries	Enhance resilience of coastal ecosystems and fisheries through gender-responsive strategies, promoting diversified livelihoods and conservation.	• Active participation by women, youth, and differently-abled individuals in ecotourism and conservation projects. • Percentage increase in women-led mangrove nurseries and shellcraft initiatives. • Representation of women in decision-making processes related to conservation.	Medium-Term	• Funding for training and infrastructure. • Experts in gender studies and conservation. • Materials for mangrove nurseries and conservation activities.	Local Government, NGOs, Fisheries Commission, Gender Advocacy Organizations.	Estimated
Agriculture and Food Security	Strengthen agricultural resilience with gender-sensitive approaches addressing the specific needs of women, youth, differently-abled, and elderly farmers.	• Number of women and youth trained in sustainable agriculture techniques. • Proportion of women accessing agricultural inputs and credit schemes. • Percentage increase in female and youth agripreneurs supported through capacity-building initiatives.	Medium to Long	• Funding for agripreneurship and training. • Experts in sustainable farming and inclusive education. • Agricultural technologies and tools.	Ministry of Agriculture, NGOs, Research Institutions, Community Groups.	Estimated
Community Health	Strengthen community health resilience through equitable healthcare services and preventive measures tailored to diverse needs, including women and the elderly.	• Increased number of gender-sensitive WASH facilities accessible to women and differently-abled individuals. • Proportion of health campaigns targeted specifically at women's health issues, including maternal care. • Percentage increase in women's participation in community-led health initiatives.	Short to Medium	• Infrastructure for flood-resistant water and sanitation systems. • Mobile clinics and medical equipment. • Educational materials for health campaigns.	Local Health Departments, NGOs, International Health Organizations, Community Leaders.	Estimated

Water Resources	Improve water security and sustainability through gender-responsive strategies like rainwater harvesting and accessible water facilities.	• Number of rainwater harvesting systems managed by women-led community groups. • Proportion of water facilities designed for differently-abled users. • Representation of women and youth in water resource planning committees.	Medium-Term	• Investment in rainwater harvesting systems. • Comprehensive educational programs. • Technical expertise in water management.	Water Resource Management Authorities, NGOs, Local Communities, Research Institutes.	Estimated
Infrastructure and Human Settlements	Build resilient infrastructure and settlements through eco-friendly construction, flood resilience projects, and inclusive land use planning.	• Percentage of women trained and employed in climate-resilient construction projects. • Proportion of housing projects incorporating safe spaces for women and differently-abled individuals. • Number of flood resilience projects involving women in planning and implementation phases.	Medium to Long	• Sustainable construction materials. • Specialized training modules for women and differently-abled individuals. • Experts in eco-construction and flood management.	Urban Planners, Local Government, NGOs, Environmental Experts.	Estimated



11



Strategic Funding and Investment Framework

11.0 Introduction

In light of the pressing need for robust climate change adaptation options in the Ellembelle District, this section focuses on two main areas: identifying potential funding sources and establishing criteria for the allocation and prioritization of funds. This ensures that the necessary financial resources are not only secured but are also distributed effectively to maximize the impact of each adaptation project.

Understanding potential funding sources allows the district to tap into a diverse pool of financial support, ranging from government allocations and international aid to private investments and community contributions. This diversity is vital in building a resilient funding strategy that can withstand economic fluctuations and varying budget allocations from different sources. Equally important is the establishment of clear criteria for fund allocation. This ensures that the limited resources are used efficiently and are directed towards projects that offer the highest potential for community impact and sustainability. A prioritization criterion will typically consider factors such as the urgency of the need, the number of people benefited, the long-term sustainability of the project, and the project's ability to leverage additional funds or resources.

11.1 Potential Funding Sources

11.1.1. Government Funding (National and Local)

Government funding in Ghana includes allocations from both national and local government bodies, specifically designed to support climate adaptation and sustainable development initiatives. This type of funding primarily targets public entities such as municipal and district assemblies, and non-governmental organizations (NGOs) that collaborate with governmental agencies to implement projects directly benefiting the public and environment.

Key areas of focus for this funding include infrastructure improvements, such as the construction of climate-resilient roads and bridges; public health enhancements, aiming to better community health facilities to withstand climate-related challenges; agriculture, with a special emphasis on introducing climate-smart agricultural practices; water resource management, such as the development of sustainable water supply systems; and community-based adaptation projects, which may include reforestation or community training programs on climate resilience.

The sources of government funding are diverse:

- **Ministry of Finance:** Allocates national budget for climate and environmental initiatives.
- **Ministry of Environment, Science, Technology, and Innovation (MESTI):** Focuses on funding projects that promote technological innovations in tackling environmental challenges.
- **Ghana Climate Change Fund (GCCF):** Established under MESTI, the fund supports projects that mitigate and adapt to climate change.

- **District Assemblies Common Fund:** A portion of this fund, managed by local district assemblies, is allocated towards local sustainable development projects, including those addressing climate adaptation.

11.1.2. International Aid and Grants

International aid for climate adaptation in Ellembelle District is accessible through various global organizations, including financial institutions and development agencies that support large-scale and impactful projects. This type of funding plays a crucial role in addressing the diverse needs of climate adaptation, from infrastructure development to community empowerment and ecological conservation.

Organizations like the World Bank provide significant financial support for projects that improve infrastructure resilience, enhance agricultural practices, and manage water resources effectively to withstand climate variability. The United Nations Development Programme (UNDP) focuses on projects that integrate climate change adaptation into development planning and policies, emphasizing sustainable community-led initiatives. Additionally, numerous international NGOs participate in funding efforts that promote resilience building and technological integration to aid climate adaptation. Examples include Conservation International and the Global Environment Facility (GEF), which offer grants for biodiversity conservation and environmental restoration projects that mitigate climate impact.

For departments and agencies in the Ellembelle District Assembly looking to access international aid and grants, it is essential to closely monitor these organizations' grant cycles and prepare proposals that meticulously meet the criteria outlined in the call for applications. It is also advisable to establish partnerships with international bodies and other local stakeholders to strengthen proposal submissions and increase the chances of securing funding.

11.1.3 Public-Private Partnerships

Public-Private Partnerships (PPPs) offer a strategic avenue for funding climate adaptation and infrastructure development projects in the Ellembelle District. These partnerships bring together the public sector's strategic oversight and the efficiency and innovation of private enterprises, creating synergies that can tackle large-scale projects crucial for climate resilience. PPPs are particularly suitable for implementing substantial infrastructure projects such as the construction of resilient road networks, water management systems, and renewable energy facilities. These projects often require technological expertise, operational efficiencies, and capital investment that private firms can provide. The Ellembelle District can leverage private investment to enhance public service delivery in areas critical to adapting to climate change, such as sustainable urban development and energy transition by partnering with private companies.

To participate in a PPP, projects need to demonstrate not only sustainability from an environmental standpoint but also the potential for economic returns that make them attractive to private investors. The focus is on creating value for money for the public while ensuring that the private entities can achieve a reasonable return on their investment. This dual focus helps ensure that the projects are financially viable and environmentally sustainable. In the Ellembelle District, several areas could benefit from Public-Private Partnerships (PPPs), especially those that align with the district's needs for climate resilience and sustainable development. Here are some potential examples:

1. Renewable Energy Projects:

- **Solar Power Farms:** Partnering with private firms to develop solar energy facilities that can provide clean, sustainable energy to the district. This could involve the installation of

solar panels on public buildings and lands, reducing the carbon footprint and electricity costs associated with public services.

- **Biomass Energy:** The use of agricultural waste to generate energy through partnerships with companies specializing in bioenergy. This not only helps manage waste but also generates energy, promoting circular economy principles.
- **Potential Private Sector Organizations and Firms:** Eni Ghana, Bboxx Ghana,

2. Water Management Infrastructure:

- **Rainwater Harvesting Systems:** ED can collaborate with private companies to install sophisticated rainwater harvesting and storage systems in public and community buildings. This can help address water scarcity during dry seasons and reduce dependence on traditional water sources.
- **Flood Resilience Infrastructure:** Developing advanced flood management systems, such as reinforced levees and stormwater management facilities, through PPPs to protect the district from the increasing instances of flooding due to climate change.
- **Potential Private Sector Organizations and Firms:** Bosch Rexroth Ghana.

3. Sustainable Agriculture:

- **Climate-Smart Agricultural Facilities:** Establishing state-of-the-art agricultural facilities that use modern technology for irrigation, crop monitoring, and pest management. These facilities could serve as demonstration and training centers for local farmers, improving agricultural productivity and sustainability.
- **Potential Private Sector Organizations and Firms:** Yara International

4. Waste Management Solutions:

- **Waste-to-Energy Plants:** Partnering with private entities to create facilities that convert municipal waste into energy. This not only helps manage waste efficiently but also contributes to energy production.
- **Recycling Plants:** Establishing recycling facilities to handle the district's waste, reducing landfill use and promoting recycling industries.
- **Potential Private Sector Organizations and Firms:** Zoomlion Ghana Limited

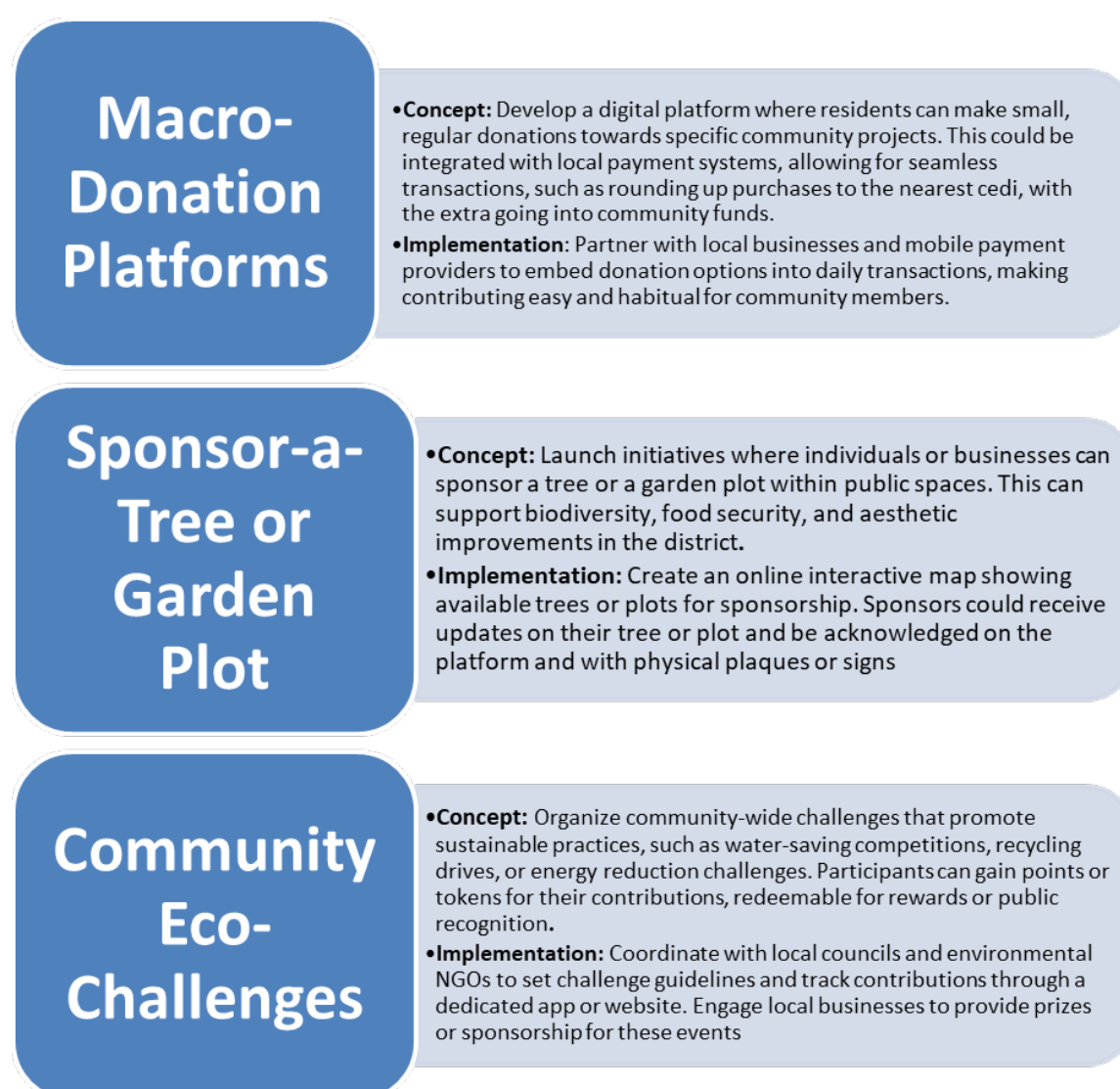
11.1.4 Community Contributions and Local Fundraising

Community contributions and local fundraising represent a grassroots approach to financing adaptation and development projects within the Ellembelle District. This method capitalizes on the direct financial involvement and vested interest of local residents, community groups, and small businesses in seeing tangible improvements within their environments. Such contributions often support projects with immediate local impacts, such as establishing community gardens, enhancing local water conservation systems, or small-scale health facilities that cater to immediate community needs.

This type of funding is especially effective for projects that do not require large capital outlays but are crucial for the daily lives of the community members. For instance, setting up rainwater harvesting systems in individual homes or neighbourhoods, creating community-led waste recycling initiatives,

or developing local healthcare outreach programs that provide basic medical services and health education. The engagement of the community not only provides funding but also ensures a high level of commitment from participants to the project's success and sustainability. The process typically involves local NGOs or community leaders who organize and lead fundraising activities, such as local events, donation drives, or small-scale crowdfunding initiatives. These efforts are often supported by awareness campaigns to educate the community on the benefits of the projects and the importance of their financial and participatory contributions. Moreover, such community-driven funding efforts can be supplemented by matching funds from local authorities or businesses, which can double the financial inputs and thereby enhance the project's scope or sustainability. This synergy between community contributions, local business involvement, and governmental support can significantly enhance the capacity of local systems to adapt to and manage climate impacts more effectively. Some innovative ideas for raising such funds are listed below.

Figure 30: Some Innovative ideas for raising funds



11.1.5 Innovative Financing Mechanisms

Innovative financing mechanisms offer a dynamic approach to funding environmental and sustainability projects by leveraging market-based tools to generate necessary capital. These mechanisms are particularly valuable for addressing large-scale projects in areas like the Ellembele District, where

traditional funding streams may not fully meet the needs for ambitious climate adaptation and sustainable development efforts.

1. **Green Bonds:** Green bonds are debt securities issued by corporations, financial institutions, or governments specifically to raise money for climate and environmental projects. These bonds provide investors with regular returns, while the funds raised are earmarked for projects that have a positive environmental impact, such as renewable energy installations and energy-efficient building projects. The proceeds from green bonds can be used to finance new or existing projects that are environmentally beneficial. Eligibility criteria often require comprehensive environmental impact assessments to ensure the projects funded provide tangible environmental benefits. The funding amounts for green bonds can vary significantly, often reaching into the millions or billions, depending on the issuer and the scale of the projects. Issuers need to prepare detailed project proposals and undergo rigorous environmental certification processes to qualify. The issuing process aligns with financial markets' regulatory frameworks, with specific timelines for issuance and maturity.
2. **Climate Funds:** These are specialized funds dedicated to supporting global and regional efforts to mitigate climate change impacts. This includes funds like the Green Climate Fund (GCF), which allocates money to projects that reduce carbon emissions and enhance resilience against climate change. Climate funds typically support projects ranging from large-scale infrastructure to smaller community-based initiatives that can demonstrate significant climate impact potential. These projects must align with the fund's objectives and demonstrate capacity for sustainable impact. Similar to green bonds, the amounts can be substantial, providing significant financial resources necessary to implement comprehensive climate resilience projects. Accessing these funds usually requires detailed project proposals, clear outcomes, and strong governmental or NGO backing. Calls for proposals are often announced annually, with detailed submission guidelines:
3. **Payments for Ecosystem Services (PES):** PES is a financial incentive-based system where beneficiaries of ecosystem services pay the stewards of those ecosystems. For example, downstream water users might pay upstream communities to maintain forest cover that stabilizes the watershed. The scope includes a wide range of ecosystem services, such as water purification, carbon sequestration, and biodiversity conservation. Projects must clearly define the service being enhanced or protected and have measurable outcomes. Payments are typically ongoing and proportional to the service provided, often calculated based on the costs of conservation and the value of the ecosystem service to beneficiaries. Establishing a PES scheme requires careful ecological and economic assessment to define the parameters of the service and set up agreements between stakeholders. It involves complex negotiations and legal frameworks to ensure compliance and fair compensation. A potential Payments for Ecosystem Services (PES) programme in the Ellembele District could focus on mangrove restoration and conservation, given the critical role these ecosystems play in coastal protection, biodiversity conservation, and carbon sequestration.

11.2 Criteria for Allocation and Prioritization of Funds

The allocation and prioritization of funds for climate adaptation in the Ellembele District are crucial for ensuring effective and sustainable outcomes. Given the region's vulnerability to climate impacts and the diverse needs of its communities, a structured and transparent approach to funding allocation is essential. The following criteria are proposed to guide this process:

1. **Project Impact and Urgency:** Projects that demonstrate a high potential for significant ecological, economic, and social benefits will receive priority. This includes initiatives like mangrove restoration or flood management systems that can drastically reduce vulnerability to natural disasters. Projects addressing urgent risks, such as those preventing immediate soil erosion or water scarcity, will also be prioritized to mitigate potential immediate and severe impacts on the community and environment.
2. **Community Engagement and Co-Benefits:** Preference will be given to projects that incorporate active community participation, ensuring that the initiatives are grounded in local needs and capabilities. For example, rainwater harvesting systems designed and managed with community input not only solve water issues but also enhance community ownership and skills development. Projects offering significant co-benefits, such as job creation in sustainable tourism or ecological monitoring, will be favoured.
3. **Sustainability and Longevity:** Funds will be allocated to projects that promise long-term sustainability and have established mechanisms for maintenance and continuity post-implementation. Projects like the establishment of climate-smart agricultural practices that include training for ongoing self-sufficiency, or the introduction of perennial crop systems designed for long-term productivity and soil health improvement are examples of initiatives with high sustainability and longevity.
4. **Alignment with Strategic Goals:** Projects that align with the broader strategic goals of the Ellembelle District, such as increasing resilience to climate change, enhancing food security, and improving water resource management, will be prioritized. This ensures that all funded initiatives contribute cohesively to the district's overarching climate adaptation and resilience-building goals.
5. **Leverage and Matching Opportunities:** Projects capable of leveraging additional funds or matching other investment sources, such as international aid or private sector contributions, will be prioritized. This approach maximizes the impact of each dollar spent and attracts more comprehensive support for larger-scale projects.
6. **Gender and Social Inclusion:** Special consideration will be given to projects that promote gender equality and social inclusion. This includes initiatives that ensure women and marginalized groups are not only beneficiaries but also active participants in project planning and execution. For instance, projects that focus on enhancing women's access to climate-resilient agricultural resources or involve differently-abled individuals in adaptive technology development will receive higher priority.
7. **Measurable Outcomes and Accountability:** Preference will be given to projects with clear, measurable outcomes and established mechanisms for monitoring, evaluation, and reporting. This ensures accountability and the ability to assess the effectiveness of each project, adjusting strategies as necessary based on performance data.
8. **Scientific and Technical Viability:** Projects that are supported by solid scientific research and proven technical feasibility will be prioritized. This ensures that the adaptations implemented are based on the best available knowledge and are likely to succeed. For example, integrating scientifically vetted water purification technologies in community water systems will be a priority.



12



Framework for Adaptation Monitoring, Evaluation, and Learning

12.0 Introduction

The importance of a robust Monitoring, Evaluation, and Learning (MEL) framework in the context of climate adaptation projects cannot be overstated. This framework serves as the backbone for assessing the efficacy and impact of climate adaptation strategies, ensuring that they meet their intended goals and are responsive to the needs of the community. In the face of escalating climate challenges, a systematic approach to MEL enables stakeholders to track progress, learn from outcomes, and make informed decisions to enhance future interventions. MEL are critical components that provide continuous oversight and assessment of adaptation projects. These processes allow project managers, funders, and stakeholders to:

- **Ensure Accountability:** By tracking the implementation of projects against planned targets and budgets, MEL frameworks help ensure that resources are used efficiently and transparently.
- **Measure Impact:** Evaluation processes assess the effectiveness of adaptation actions in mitigating climate impacts, thereby validating the approaches used and guiding future funding and efforts.
- **Facilitate Adaptive Management:** Monitoring and learning mechanisms enable project teams to adapt strategies in real-time based on performance data and changing conditions, ensuring that adaptation measures remain relevant and effective.
- **Promote Stakeholder Engagement:** Through regular reporting and feedback loops, all stakeholders, including local communities, are kept informed and involved in the adaptation process, fostering greater engagement and ownership.

12.1 Objectives of The MEL Framework for Ellembelle District Assembly

In the Ellembelle District, where the effects of climate change manifest in various forms such as increased flooding, erratic rainfall patterns, and changing coastal dynamics, the MEL framework aims to:

- Tailor the monitoring and evaluation processes to reflect the specific environmental, economic, and social priorities of the Ellembelle District, ensuring that adaptation strategies are directly addressing the most pressing local needs.
- Develop local capabilities to conduct and manage MEL activities, ensuring sustainability beyond the lifespan of individual projects.
- Generate evidence-based insights and data to inform and shape local and national climate adaptation policies, enhancing the overall resilience of the district.
- Encourage the incorporation of new technologies and innovative approaches within adaptation strategies, assessed through advanced MEL techniques.

- Specifically monitor and evaluate the impact of adaptation measures on different community segments, including women, youth, and differently-abled individuals, to promote equitable climate resilience.

12.2 MEL Design for Ellembelle District

The MEL framework incorporates monitoring, evaluation, and learning as interlinked components, ensuring continuous feedback loops for adaptive management.

12.2.1 Monitoring Framework

Monitoring in this case refers to the systematic observation and documentation of adaptation activities, enabling real-time tracking of progress and identifying issues early.

12.2.2 Objectives

1. Track implementation timelines and resource consumption.
2. Identify deviations from plans and enable timely corrective actions.
3. Provide data to support decision-making and responsiveness to climate impacts.
4. Foster transparency and accountability in adaptation efforts.

12.2.3 Indicators and Metrics

To effectively monitor and measure progress in climate adaptation initiatives, Ellembelle District employs specific indicators and metrics tailored to its unique climate vulnerabilities and socio-economic dynamics. These metrics are designed to provide actionable insights into the success and challenges of adaptation actions, enabling informed decision-making and continuous improvement.

Key Indicators and Metrics

1. Reduction in Vulnerability Indices

Tracking changes in the district's exposure to climate risks is crucial. Vulnerability indices measure the extent to which households, infrastructure, and ecosystems are protected against hazards like flooding, droughts, and coastal erosion.

2. Community Engagement Rate

This indicator tracks the percentage of residents actively participating in adaptation projects. In Ellembelle, community involvement is vital for projects like mangrove restoration in coastal areas and the promotion of agroforestry practices in inland farming communities.

3. Infrastructure Resilience Metrics

This metric assesses the structural durability of newly constructed or retrofitted infrastructure. For example, flood-resistant water storage facilities in Nkroful and Esiama can be evaluated for their ability to withstand extreme weather events. Metrics such as the longevity of materials used, maintenance costs, and performance during adverse conditions provide valuable insights into their resilience.

4. **Economic and Environmental Impact**

This indicator evaluates the tangible benefits of adaptation measures, including increased agricultural yields, enhanced biodiversity, and improved economic stability.

Data Collection Methods

To generate reliable and actionable data, there is the need to employ a combination of traditional and innovative data collection methods tailored to local conditions and priorities.

1. **Remote Sensing**

Satellite imagery and aerial photography can be used to monitor land use changes, vegetation cover, and infrastructure development.

2. **Community-Based Reporting**

Local residents can play an active role in reporting observations on climate impacts and project performance. In Ellembelle, mobile technology can be leveraged to enable farmers and fisherfolk to share real-time data on rainfall patterns, crop health, and fish stocks.

3. **Surveys and Interviews**

Structured surveys and interviews are conducted with beneficiaries to capture qualitative and quantitative feedback. For example, farmers participating in soil conservation training can be surveyed to assess how these practices have improved soil health and crop yields. Similarly, interviews with women in mangrove restoration projects can help highlight their experiences and the socio-economic benefits of their involvement.

4. **Environmental Sensors**

Sensors measuring rainfall, water levels, and soil moisture can be deployed to collect real-time environmental data.

Roles and Responsibilities

The success of the MEL framework relies on the coordinated efforts of various stakeholders, each playing a distinct role in data collection, analysis, and reporting.

1. **Local Government**

The Ellembelle District Assembly oversees the coordination of monitoring activities and integrates findings into development plans, such as the Medium-Term Development Plan (MTDP). For example, the assembly ensures that lessons from water resource management projects in Nkroful inform the design of similar initiatives in other communities.

2. **Community Groups**

Local groups actively collect data and provide feedback on adaptation actions. For instance, youth groups in Menzessor are trained to monitor the growth and health of mangroves in restored areas. Their involvement ensures that data collection is continuous and reflective of on-the-ground realities.

3. External Partners

NGOs, research institutions, and development agencies provide technical expertise and independent reviews. For example, Hen Mpoano, a non-governmental organization, supports the district in assessing the ecological impact of coastal reforestation projects and provides training on sustainable fishing practices.

4. Project Teams

Teams responsible for implementing adaptation projects oversee daily data collection, ensure compliance with project goals, and respond to findings. For example, engineers working on flood-resistant infrastructure in Esiama conduct regular inspections and compile progress reports to guide future actions.

12.3 Evaluation Framework

Evaluation assesses the outcomes and overall impact of adaptation projects, providing insights into their effectiveness and areas for improvement.

Types of Evaluations

1. **Formative Evaluation:** Conducted during implementation to identify and address emerging challenges.
2. **Summative Evaluation:** Conducted after project completion to measure overall success and inform future interventions.

Criteria and Benchmarks

Evaluation criteria align with Ellembelle's adaptation priorities:

- **Effectiveness:** Degree to which projects reduce vulnerabilities and enhance resilience.
- **Efficiency:** Cost-effectiveness in achieving desired outcomes.
- **Equity:** Fair distribution of resources and benefits across community segments.

Benchmarks are derived from local data and comparisons with similar projects globally.

Methods and Approaches

- **Qualitative Methods:** Focus groups, interviews, and observations capture community perceptions.
- **Quantitative Methods:** Statistical analysis and structured surveys measure objective changes.

Stakeholder Involvement

- **Local Government:** Ensures evaluations align with policy objectives.
- **Community Members:** Provides firsthand insights into project impacts.
- **External Experts:** Brings methodological rigor and third-party objectivity.
- **Funding Agencies:** Ensures alignment with donor expectations.

12.4 Learning Framework

The learning component ensures that lessons from monitoring and evaluation inform future adaptation efforts.

Key Activities

1. Document and disseminate lessons from successful and unsuccessful initiatives.
2. Revise adaptation activities based on evaluation insights.
3. Promote continuous improvement through training and workshops.
4. Align learnings with broader district and national goals.

Communication and Knowledge Sharing

- Adaptation documents and reports are shared widely through the KMA annual report and community platforms.
- Learning products are tailored for diverse audiences, including policymakers, community members, and external partners.

12.5 Steps in Implementing the MEL Framework

The MEL framework follows a four-step approach:

1. **Monitoring Adaptation Actions**
 - o Identify activities to monitor and define performance metrics.
 - o Collect qualitative and quantitative data to track progress.
2. **Evaluating Adaptation Processes**
 - o Assess effectiveness, identify gaps, and revise strategies based on findings.
 - o Incorporate insights from studies and stakeholder feedback.
3. **Learning and Updating**
 - o Document successes and failures, implementing corrective measures.
 - o Align adaptations with the MTDP and broader development goals.
4. **Communicating Outcomes**
 - o Share progress, effectiveness, and learnings through reports and community outreach.

12.6 Sustainability of the MEL Framework

To ensure long-term success, the MEL framework emphasizes:

- **Community Ownership:** Engaging residents in all MEL activities to promote participation and accountability.
- **Capacity Building:** Training local staff and stakeholders to sustain MEL processes.

- **Integration with District Plans:** Embedding MEL findings into development policies for continuity.
- **Technological Innovation:** Leveraging advanced tools like GIS and mobile platforms for efficiency.



13



Conclusion and Recommendations

13.0 Introduction

The Adaptation Action Plan for the Ellembelle District Assembly provides a well-structured response to the escalating impacts of climate change. Through targeted interventions across key sectors, this plan promotes resilience, secures livelihoods, and ensures sustainable development. Grounded in vulnerability assessments, stakeholder input, and multi-criteria prioritization, the plan aligns with the district's unique socio-economic and environmental realities. Adaptation measures, such as mangrove restoration, climate-smart agricultural practices, enhanced water infrastructure, and gender-sensitive health initiatives, address immediate vulnerabilities while supporting long-term sustainability and equity.

13.1 Recommendations

The recommendations outlined in this section provide strategic guidance for enhancing Ellembelle District's climate resilience. These actions focus on strengthening institutional capacity, securing sustainable financing, promoting stakeholder engagement, and integrating climate adaptation into policy frameworks. Emphasis is placed on leveraging modern technologies, establishing a robust Monitoring, Evaluation, and Learning (MEL) framework, scaling successful initiatives, and advancing gender-responsive approaches to ensure inclusive and sustainable adaptation efforts across the district.

- **Strengthening Institutional Capacity:** Institutional capacity must be enhanced to effectively implement and manage adaptation actions. Local government authorities, community leaders, and implementing agencies require ongoing training to build expertise in areas such as resource mobilization, project management, and the integration of sustainable practices. Programs focused on equipping stakeholders with knowledge in data-driven decision-making, technological innovation, and participatory governance can greatly improve project efficiency. Strengthening institutional frameworks will ensure that the district can successfully oversee and coordinate diverse adaptation initiatives.
- **Securing Sustainable Financing:** A diversified approach to financing adaptation projects is critical to achieving long-term resilience. Ellembelle District must actively seek funding from multiple sources, including national budgetary allocations, international climate funds, private sector investments, and community contributions. Innovative financing mechanisms, such as green bonds and payments for ecosystem services, can be explored to bridge funding gaps. Establishing clear, impact-based criteria for fund allocation will ensure resources are channeled into high-priority, high-impact projects. Transparency in the use of funds will also help attract ongoing financial support from donors and stakeholders.
- **Enhancing Stakeholder Engagement:** Stakeholder involvement should be expanded and deepened throughout the planning and implementation phases. Effective engagement requires mechanisms to involve diverse groups, including women, youth, and differently-abled individuals, in decision-making processes. Workshops, participatory mapping, and community forums can create platforms for inclusive dialogue and collaboration. Strengthening partnerships with NGOs, traditional authorities, and

local businesses will not only enrich the planning process but also ensure a shared commitment to the success of adaptation measures.

- **Integrating Adaptation into Policy Frameworks:** Climate adaptation strategies should be embedded into existing district and national development policies, such as the Medium-Term Development Plan (MTDP). This alignment ensures that adaptation efforts are mainstreamed into broader socio-economic planning and that resources are distributed effectively. Incorporating climate adaptation objectives into zoning regulations, agricultural policies, and urban planning guidelines will reinforce the district's resilience and ensure policy coherence across sectors.
- **Establishing a Robust MEL Framework:** A robust Monitoring, Evaluation, and Learning (MEL) framework is essential to track the progress and outcomes of adaptation actions. The framework should define clear performance metrics, timelines, and feedback mechanisms for assessing the effectiveness of implemented strategies. Regular evaluations will allow the district to refine its approaches, address emerging challenges, and build on successful initiatives. Active involvement of local communities in MEL activities will foster accountability and transparency while enhancing their ownership of adaptation efforts.
- **Promoting Technological Innovation:** Investing in modern technologies can significantly enhance the efficiency and impact of adaptation measures. Tools such as remote sensing, mobile applications, and advanced irrigation systems provide reliable data for monitoring environmental changes and improving project implementation. For instance, using GIS for water resource management or deploying solar-powered purification units for water supply can address critical challenges while promoting sustainability. Encouraging local innovation and technological solutions will also reduce reliance on external expertise and resources.
- **Scaling Up Successful Initiatives:** Scaling successful pilot projects to other areas of the district can maximize their impact. For example, agroforestry programs and mangrove restoration efforts, which have proven effective in building resilience and providing sustainable livelihoods, should be expanded to benefit a larger population. Knowledge-sharing platforms and demonstration sites can facilitate the replication of these projects, enabling communities to adopt best practices tailored to their local conditions.
- **Advancing Gender-Responsive Approaches:** Ensuring that adaptation measures are inclusive and gender-responsive will strengthen the district's social cohesion and resilience. Programs that empower women, such as training in sustainable farming techniques or leadership roles in community water management, contribute to equitable development. Similarly, initiatives targeting youth involvement in technology-driven projects, such as aquaculture or renewable energy, can harness their potential as agents of change. Incorporating the needs of differently-abled individuals in infrastructure and service design will ensure that no group is left behind in the pursuit of resilience.

13.2 Conclusion

The Adaptation Action Plan sets the Ellembele District on a path toward climate resilience and sustainable development. The district can safeguard its ecosystems, infrastructure, and livelihoods against the growing impacts of climate change by addressing immediate vulnerabilities and building long-term capacity. The successful implementation of this plan depends on inclusive governance, adequate financing, and continuous learning. With strong leadership, effective stakeholder collaboration, and innovative approaches, the Ellembele District can become a model of climate adaptation for other districts in Ghana and beyond.

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