Adapting Together, Thriving Tomorrow

Climate Change Rapid Risk Assessment and Adaptation Plan for Aowin Municipal Assembly

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

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Document Information

Title: Change Rapid Risk Assessment and Adaptation Plan for Aowin Municipal Assembly: Enhancing Multi-Sector Planning and Capacity for Effective Adaptation in Ghana

Prepared for: Government of Ghana with support from GCF and UNEP

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LIST OF ACRONYMS

Acronym	Full Form
CCRA	Climate Change Risk Assessment
GSS	Ghana Statistical Service
IPCC	Intergovernmental Panel on Climate Change
MTDP	Mid-Term Development Plan
NADMO	National Disaster Management Organization
NAP	National Adaptation Plan
NGO	Non-Governmental Organization
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
WHO	World Health Organization
NDC	Nationally Determined Contribution
CCV	Climate Change Vulnerability
FNC	Framework National Communication
CCRA	Climate Change Risk Assessment
MMDAs	Metropolitan, Municipal and Municipal Assemblies
CMIPs	Coupled Model Inter-comparison Projects
CHW	Community Health Workers
MoFA	Ministry of Food and Agriculture
SSP	Shared Socioeconomic Pathways

Executive Summary

Climate Change Rapid Risk Assessment

Understanding risks is the first step to mitigating them, and the Climate Change Rapid Risk Assessment (CCRA) for Aowin Municipal Assembly exemplifies this by providing a detailed evaluation of the municipality's climate vulnerabilities, risks, and adaptive capacity. Set against the backdrop of Ghana's Western North Region, the CCRA offers a granular analysis of the socio-economic and environmental challenges posed by climate change. Its findings underscore the urgent need for evidence-based planning to build resilience and reduce vulnerability in Aowin's communities.

The CCRA identifies key climate hazards impacting Aowin, including erratic rainfall, rising temperatures, and recurrent extreme weather events. These phenomena have severe implications for critical sectors such as agriculture, water resources, health, infrastructure, and biodiversity. The agricultural sector, which forms the economic backbone of Aowin, is severely affected by declining productivity due to irregular rainfall patterns, soil degradation, and heat stress. Water resources are increasingly under strain from mining activities, pollution, and evaporation, which contribute to scarcity and contamination, affecting both domestic and agricultural use.

The health sector faces significant challenges, with flooding and extreme heat exacerbating the prevalence of waterborne diseases and other climate-related illnesses. The municipality's infrastructure, including roads and housing, is particularly vulnerable, with frequent flooding disrupting transportation, economic activity, and access to essential services. Biodiversity and forest ecosystems are also at risk, with deforestation and illegal mining threatening the sustainability of Aowin's ecological resources. Importantly, the CCRA highlights the gendered nature of climate impacts, noting that women, youth, and differently abled individuals face disproportionate vulnerabilities due to socio-economic inequalities and cultural practices.

The assessment employed a robust methodology, combining desk reviews, stakeholder consultations, and local data analysis to paint a comprehensive picture of Aowin's vulnerabilities. Stakeholder engagement workshops were instrumental in validating findings, prioritizing risks, and incorporating community insights into the assessment process. The analysis utilized a climate risk framework that integrates hazard, exposure, and adaptive capacity to evaluate the municipality's resilience. Findings revealed that while Aowin has significant exposure to climate risks, its adaptive capacity remains constrained by socio-economic disparities, inadequate infrastructure, and limited institutional support.

The CCRA further examined observed climate trends and future projections for Aowin. Historical data shows a warming trend and increasingly erratic rainfall, with future scenarios predicting more frequent and intense climate extremes. These projections underscore the need for proactive and adaptive measures to mitigate the impacts of climate change. The report also emphasizes the interconnectedness of risks, illustrating how cascading impacts across sectors can amplify vulnerabilities and disrupt socio-economic stability.

The findings of the CCRA are not merely diagnostic but serve as a critical foundation for action. By identifying priority risks and vulnerabilities, the report lays the groundwork for targeted adaptation strategies. It calls

for integrated approaches that address the multi-dimensional nature of climate risks while promoting equity, sustainability, and resilience. In doing so, the CCRA equips Aowin Municipal Assembly with the knowledge and tools needed to confront the realities of climate change and build a future that is both adaptive and sustainable.

Adaptation Action Plan

It is often said that resilience is not built overnight but through deliberate and sustained effort. The Adaptation Action Plan (AAP) for Aowin Municipal Assembly exemplifies this principle by providing a comprehensive roadmap to address climate-related vulnerabilities and build long-term resilience. Building on the Climate Change Rapid Risk Assessment (CCRA), the AAP identifies actionable strategies that align with the municipality's specific climate risks, socio-economic context, and developmental priorities. Through a multi-sectoral approach, the plan ensures that interventions are not only sustainable but also inclusive, addressing the unique needs of vulnerable populations such as women, youth, and differently abled individuals.

The findings from the AAP highlight several critical areas requiring urgent attention. In agriculture, the backbone of Aowin's economy, climate-smart farming practices such as agroforestry, crop diversification, and sustainable soil management are prioritized to counteract the impacts of erratic rainfall and declining productivity. Water resource management is equally emphasized, with measures including rainwater harvesting, restoration of degraded water bodies, and improved sanitation systems to tackle water scarcity and contamination. The plan also underscores the importance of infrastructure resilience, proposing the rehabilitation of feeder roads, construction of flood-resistant housing, and upgrading of drainage systems to mitigate the effects of extreme weather events.

Biodiversity and forest conservation emerge as central themes in the plan, addressing the dual threats of deforestation and habitat loss due to illegal mining and logging. Strategies include reforestation programs, enforcement of sustainable land use policies, and community-driven conservation initiatives to preserve Aowin's rich ecological heritage. The health sector is another critical focus, with recommendations for enhanced disease surveillance, improved healthcare access, and public health campaigns to combat the increasing prevalence of climate-induced diseases such as malaria and waterborne illnesses. The AAP further emphasizes the integration of gender-responsive measures, ensuring that women, who are disproportionately impacted by climate change, are empowered through access to resources, capacity-building, and representation in decision-making processes.

Stakeholder engagement is a cornerstone of the AAP, reflecting the diverse perspectives of community leaders, local authorities, and development partners. This participatory approach has fostered a sense of ownership and commitment to the proposed adaptation measures, ensuring their relevance and effectiveness. The plan also identifies strategic funding opportunities, including leveraging international climate finance, fostering public-private partnerships, and exploring innovative financing mechanisms to support implementation.

To ensure sustained progress, the AAP incorporates a robust Monitoring, Evaluation, and Learning (MEL) framework. This framework provides the tools to track implementation, measure outcomes, and refine strategies in response to emerging challenges. By adopting this evidence-based and iterative approach, the AAP positions Aowin Municipal Assembly as a model for local climate adaptation in Ghana.

In sum, the Adaptation Action Plan is a transformative initiative that translates the findings of the CCRA into tangible actions. By addressing vulnerabilities across agriculture, water, health, infrastructure, and biodiversity, the plan offers a pragmatic yet visionary blueprint for safeguarding Aowin's people, economy, and ecosystems against the escalating impacts of climate change. It underscores the truism that building resilience is not just about surviving change but thriving despite it.

1 Introduction

1.1 Background

The far-reaching consequences of climate change have become a pressing global concern, as countries worldwide struggle to cope with its devastating impacts on development. 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). Gender inequalities further worsen the impact on women, youth, differently abled and other vulnerable groups. This could compromise the attainment of sustainable development goals and gender inclusive objectives in the country. The urgency for effective, localized adaptation strategies is paramount to mitigate these impacts and safeguard the progress towards sustainable development.

Climate change is increasingly permeating various economic sectors, including agriculture, fisheries, forestry, water resources, health, and others, thereby amplifying the scope and spread of associated risks and vulnerabilities. Consequently, it is essential to undertake deliberate and systematic efforts to investigate these risks and implement proactive adaptation measures that address both current and projected future impacts. The susceptibility of women and men to climate change risks and vulnerabilities differs significantly, primarily due to variations in their roles and responsibilities at the household, community, and municipal levels. Research indicates that women are disproportionately affected by climate change and possess limited adaptive capacity compared to men (Adzawla, Azumah, Anani, & Donkoh, 2019). As the impacts of climate change continue to unfold across Ghana, and as efforts to adapt to the complexities of climate change intensify, it has become imperative to make conscious efforts to comprehend the nature of impacts and how these impacts translate into risks and vulnerabilities. Effective climate adaptation in Ghana necessitates a systematic assessment of risks and vulnerabilities across sectors and regions, as well as the deliberate application of these insights to inform adaptation planning at both national and sub-national levels and in key climate-sensitive sectors (Mensah et al., 2022; Dapilah et al., 2021). This must include concerted efforts to mitigate the impacts on more vulnerable groups, such as women, children, and the elderly.

The complexities of climate change necessitate a multifaceted approach to adaptation planning, one that prioritizes a comprehensive understanding of the interplay between climate change impacts, risks, and vulnerabilities (Conway et al., 2019). Developing effective and proactive adaptation strategies requires a deliberate and systematic process of uncovering impacts and assessing associated risks and vulnerabilities. A critical component of this process is the ability to identify, assess, and appreciate the nature and distribution of climate risks, which is predicated on a thorough comprehension of 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 (Manteau et al, 2022). Furthermore, the development of adaptation strategies should incorporate emerging technologies and innovative approaches to enhance resilience and response capabilities. The design of effective adaptation strategies also necessitates a nuanced understanding of the diverse needs and experiences of various socioeconomic groups. In this context, the integration of a gender-responsive approach is crucial, as it acknowledges the unique challenges and opportunities faced by different groups, including women, children, and the elderly (Eriksen et al., 2021). This approach enables the development of adaptation strategies that address the specific needs and concerns of different groups, leading to more effective and equitable adaptation outcomes.

The foundation of effective adaptation planning and resilience building against climate change impacts lies in the development of a deeper understanding of climate impact manifestations and associated risks and vulnerabilities across diverse contexts and sectors (Owen, 2020; Eriksen et al., 2021). This understanding should serve as the basis for capacity-building processes aimed at fostering effective climate adaptation governance, which in turn enables the development of adaptive capacities in diverse sectors, communities, and at multiple levels (Yeleliere et al., 2023; Asibey et al., 2024). In response to these needs, Ghana has initiated its National Adaptation Planning (NAP) process, which seeks to mainstream climate adaptation imperatives in governance processes at various levels. The incorporation of community-based knowledge and indigenous practices into the NAP process has the potential to further enhance adaptation strategies, rendering them more effective and sustainable.

1.2 Study Aims and Objectives

The “Enhancing Multi-Sector Planning and Capacity for Effective Adaptation in Ghana” project aims to support the development of a comprehensive national adaptation plan and enhance the capacity of the Aowin Municipal Assembly staff to integrate adaptation considerations into their development plans. To achieve this, the project focuses on building the capacity of the Aowin Municipal Assembly to mainstream adaptation into their Mid-Term Development Plan (MTDP) policies and plans. The following specific objectives will guide this assessment:

- To conduct rapid climate risk assessments in the Aowin municipal Assembly.
- To develop cost adaptation plans for the Aowin municipal Assembly.

1.3 Document Purpose

This Climate Change Risk Assessment (CCRA) for the Aowin Municipal is a comprehensive evaluation designed to systematically identify, analyze, and prioritize climate-related risks. The primary objective of this document is to provide local experts and stakeholders with a structured framework for assessing the municipal’s vulnerability to climate change impacts. In accordance with the AR5 framework adopted from the Intergovernmental Panel on Climate Change (IPCC), this assessment emphasizes the integration of hazard, exposure, and vulnerability components. The specific aims of this assessment are:

1. **Provide a Comprehensive Overview of Climate Risks**: To capture a detailed picture of the climate hazards specific to Aowin Municipal, 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 municipal’s vulnerabilities, considering gender considerations and the multifaceted nature of climate risks that affect social, economic, and environmental dimensions.

3. **Enhance Understanding of the impact of climate change on gender inequality**: to capture the effects of climate change on socio-economic lives of the municipal as a basis for developing gender responsive adaptation strategies which improve the lives of vulnerable women, men, differently abled and youth groups.

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 Aowin municipal 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.

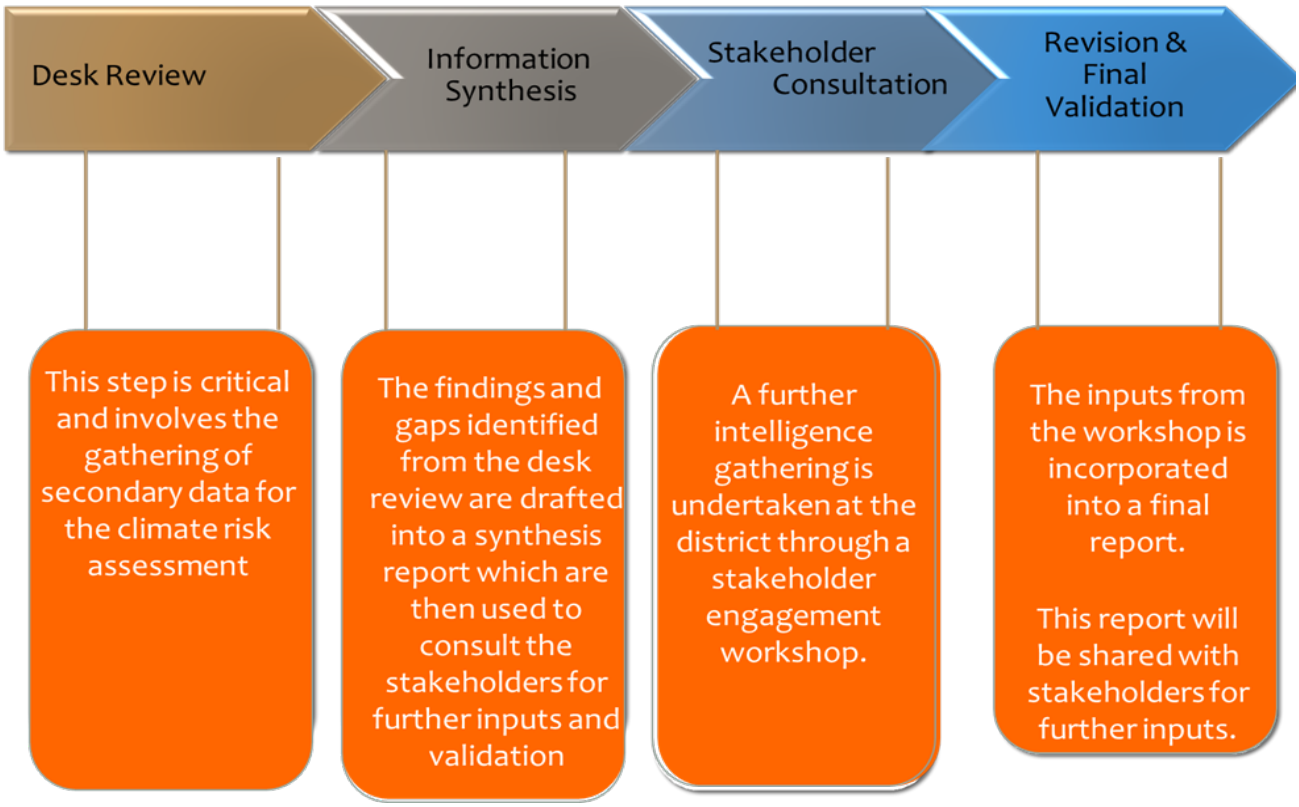
6. **Align with National and Regional Climate Change Frameworks**: To ensure that the findings and recommendations of the CCRA for Aowin municipal are consistent with national climate change strategies and action plans, contributing to the broader efforts to mitigate and adapt to climate change in Ghana.

2 Approach and Methodology

2.1 Approach

The methodology employed in this Climate Change Risk Assessment (CCRA) for the Aowin Municipal Assembly is characterized by a systematic, iterative process. This structured approach comprises several key steps, as illustrated in Figure 1, and is designed to ensure a comprehensive and rigorous evaluation of climate-related risks in the Aowin Municipal Assembly.

Figure 1: Overall work approach for the Climate Change Risk Assessment for the Aowin municipal Assembly.



- **Desk Review**: A comprehensive desk review was conducted to gather secondary data relevant to the climate risk assessment. This initial data collection phase involved compiling existing information from diverse sources to establish a foundational understanding of the intersections between gender, climate change vulnerability, and climate-related risks in the Aowin Municipal area.
- **Information Synthesis**: The findings and gaps identified during the desk review were consolidated into a comprehensive synthesis report. This report integrated the collected data, providing a clear and concise overview of the initial assessment. Serving as a foundational document, the synthesis report

informed subsequent consultations, summarized the current state of knowledge, and pinpointed areas requiring further investigation.

- **Stakeholder Consultation Workshops**: The next phase of the process involved conducting in-depth stakeholder engagement workshops within the Aowin Municipal. Two key workshops were held to assess the community's climate vulnerability. The initial workshop introduced the vulnerability assessment framework, aligning it with Ghana's National Adaptation Plan (NAP) process. It also presented preliminary findings from the desk survey, laying the groundwork for municipal-specific adaptation planning. The second workshop focused on validating the overall findings and refining proposed adaptation strategies. Employing a multi-criteria assessment, participants evaluated and prioritized adaptation options, emphasizing gender inclusivity to ensure equitable adaptation responses. These workshops played a vital role in gathering insights and experiences from diverse stakeholders. They provided an interactive platform for stakeholders to validate the findings of the desk review and information synthesis, and to contribute additional knowledge and perspectives that may have been overlooked in the secondary research.
- **Revision & Final Validation**: The final stage of this process involved consolidating the insights gathered during the stakeholder validation workshop into a comprehensive final report. This document distills the outcomes of the preceding stages, incorporating valuable contributions and validations from stakeholders of the Aowin Municipal Assembly, to provide a definitive and actionable assessment.

2.2 Methodology

The methodology for this Climate Change Risk Assessment is based on a structured three-stage approach, as shown in **Figure 2.** This framework, adapted from Norman et al. (2014), provides a clear and systematic process for assessing climate-related risks in the Aowin Municipal.

Stage 1: Risk Identification The assessment process began with a comprehensive desk review, which established the context and laid the foundation for identifying potential climate-related risks in the Aowin Municipal.

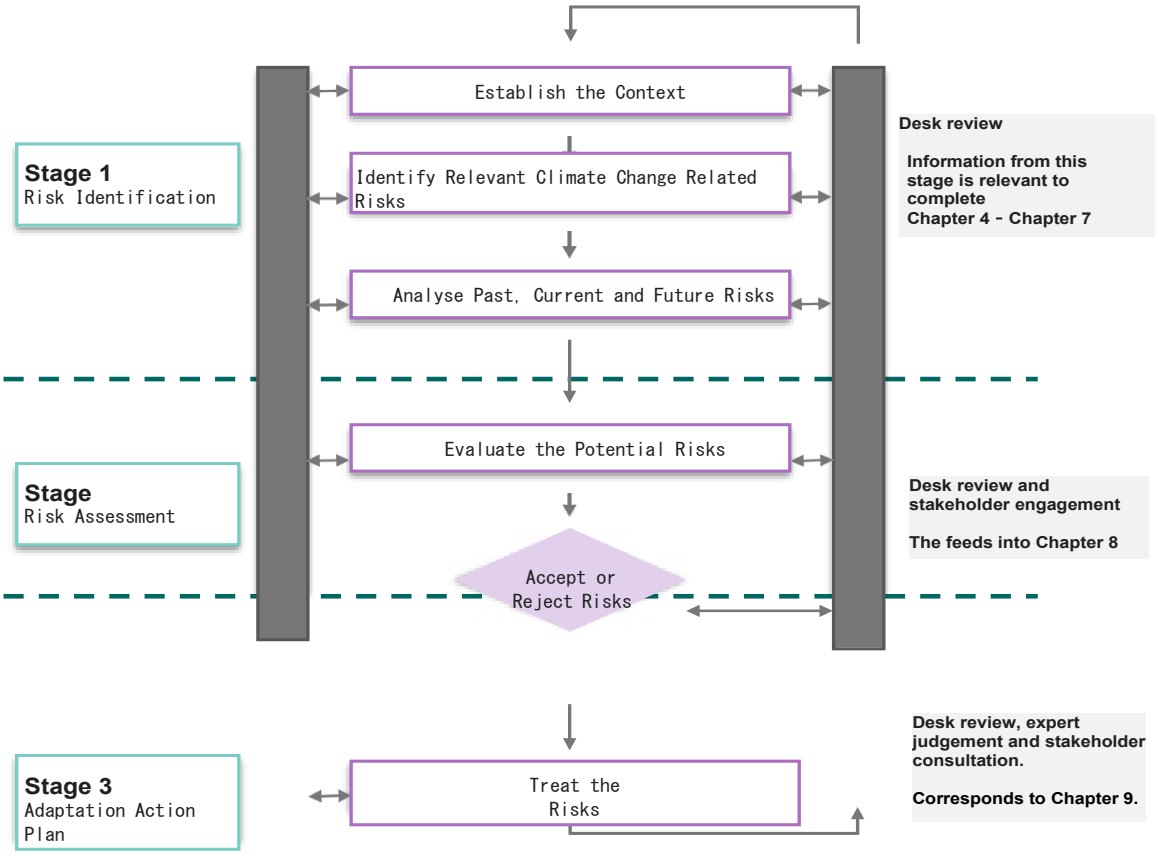
Stage 2: Risk Assessment This stage entailed a detailed analysis of the potential risks identified in the previous phase. The findings from the desk review were combined with insights gathered through stakeholder engagement, yielding a richer understanding of the potential risks. Stakeholder engagement proved instrumental in ensuring that the risk assessment was grounded in local perspectives and expertise. The results of this stage are presented in Chapter 8 of the Assessment, where each risk was carefully evaluated and prioritized based on its potential consequences and likelihood.

This evaluation led to a critical decision point, where each risk was either selected for further consideration or dismissed based on a set of established criteria. These criteria encompassed the potential severity of impacts, the vulnerability of affected populations, the financial implications of adaptation measures, and the Municipal's capacity to effectively manage risks. This informed decision-making process laid the foundation for developing a targeted and effective Municipal Adaptation Action Plan.

Stage 3: Adaptation Action Plan The final stage resulted in the development of a Municipal Adaptation Action Plan. This plan aimed to mitigate vulnerabilities and enhance the Aowin Municipal Assembly's resilience to climate change impacts, addressing the identified and accepted risks. The plan was formulated through a synthesis of desk review findings, expert judgment, and stakeholder consultation outcomes, as presented in Chapter 9 of the assessment. The plan outlines strategic and targeted responses to climate risks, comprising a range of actionable and strategic interventions. These interventions are designed to address key risks,

supporting the municipal's broader goals for climate change adaptation, while incorporating essential gender considerations to ensure inclusivity.

Figure 2: General overview of the risk assessment process.



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

The methodology emphasizes a collaborative approach, incorporating diverse perspectives and expertise to inform the assessment and action plan. This inclusive strategy is crucial for developing a tailored and effective climate change adaptation plan that addresses the unique needs and challenges of the Aowin Municipal Assembly.

3 Background and Context

3.1 Climate Change and Gender Policy Framework

3.1.1 Ghana National Climate Change Policy

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. The policy 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 effective adaptation, social development, and 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 integrates both mitigation and adaptation efforts, aligning with global climate agreements and national priorities. Key aspects of Ghana's climate change strategy include:

Nationally Determined Contribution (NDC): The Paris Agreement, adopted in 2015, serves as the foundation for Ghana's Nationally Determined Contribution (NDC). Ghana's NDC outlines efforts to reduce greenhouse gas emissions and adapt to climate change impacts, aiming to limit global temperature rise. Each country sets climate action goals based on national circumstances and development priorities through the NDC process. Ghana's NDC prioritizes sustainable development, focusing on key sectors like energy, agriculture, and forestry, while seeking international support for enhanced implementation. Ghana has committed to reducing greenhouse gas (GHG) emissions and adapting to climate change in several priority sectors under its NDC. These sectors include mass transit, infrastructure, land use and food production, energy, and forest and water resources management. Ghana aims to cut emissions by 64 million tons of CO2 equivalent by 2030 (UNDP, 2024), with certain actions conditional on international support.

National Adaptation Plan (NAP): Ghana is developing a National Adaptation Plan to address climate change challenges. The NAP process is grounded in the United Nations Framework Convention on Climate Change (UNFCCC) guidelines, established under the Cancun Adaptation Framework. Ghana's NAP process stems from its commitment to international climate agreements, such as the UNFCCC and the Paris Agreement. The process is driven by the need to meet global climate adaptation goals and national priorities, particularly in vulnerable sectors like agriculture, water, health, and infrastructure. Ghana initiated its NAP process by preparing vulnerability assessments across different regions and sectors, identifying areas with severe climate impacts. The Ministry of Environment, Science, Technology, and Innovation (MESTI) leads the process, collaborating with government agencies, development partners, and civil society. The NAP framework encompasses stakeholder engagements, capacity-building, and developing adaptation actions tailored to Ghana's unique geographical, social, and economic conditions. The plan builds on prior national adaptation efforts, including the National Climate Change Policy (NCCP), National Climate Change Adaptation Strategy (NCCAS), and sectoral adaptation plans.

3.1.1 Ghana National Gender Policy

The Ghana National Gender Policy, launched in 2015, serves as a foundational document aimed at integrating gender considerations into all aspects of Ghana's development process. This policy provides a comprehensive definition of gender, encompassing the socially constructed roles, relationships, and attributes assigned to individuals based on their sex. The policy specifically focuses on promoting gender equality and addressing the needs of vulnerable groups, including women, girls, children, persons with disabilities, and those with special needs. To achieve this, the policy establishes an institutional framework designed to bridge gender inequality gaps and promote inclusive development. Some key aspects of the Ghana National Gender Policy include:

- **Definition of Gender:** A comprehensive definition that encompasses socially constructed roles, relationships, and attributes assigned to individuals based on their sex.
- **Focus on Vulnerable Groups:** The policy specifically targets women, girls, children, persons with disabilities, and those with special needs.
- **Institutional Framework:** Establishes a framework to bridge gender inequality gaps and promote inclusive development.

Overall, the Ghana National Gender Policy provides a crucial foundation for promoting gender equality and addressing the unique needs of vulnerable groups in Ghana.

3.2 National Level Risk and Vulnerability Assessment

This section delves into 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 municipals, including Aowin Municipal.

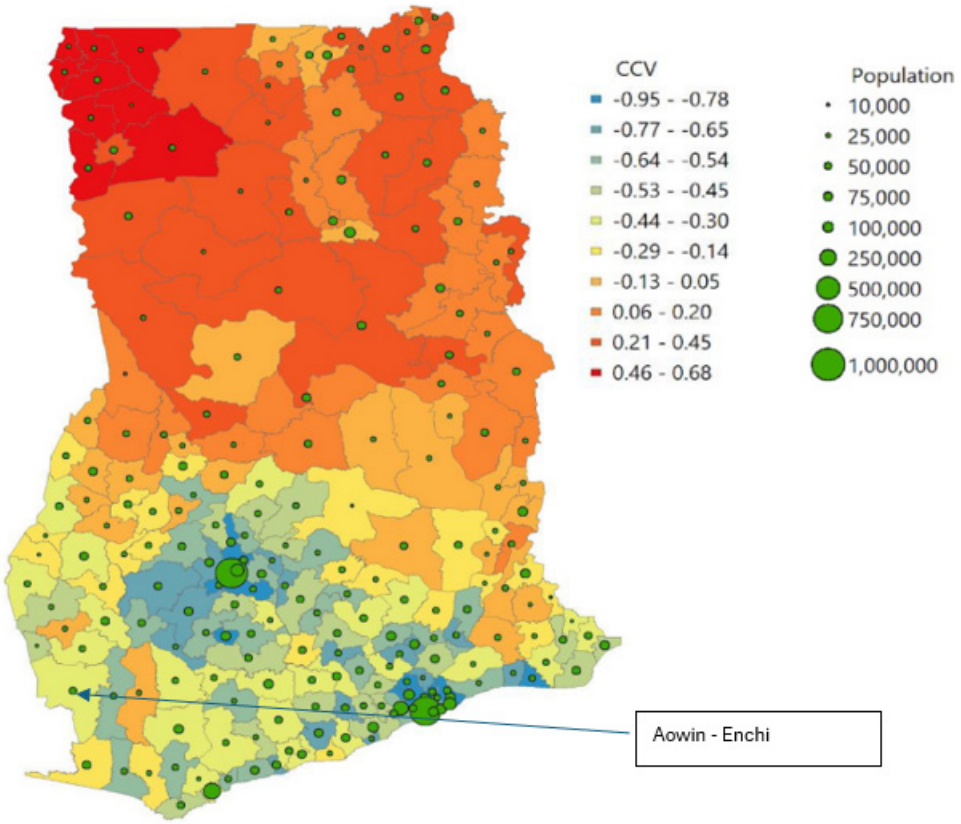
The national-level vulnerability assessment conducted for the Gh_NC4 utilized the definition of Climate Change Vulnerability (CCV) from the Fourth Assessment Report (AR4), which defines CCV as the product of Exposure and Sensitivity, subtracted by Adaptive Capacity. The data for this CCV was sourced 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 municipals according to their vulnerability to both current and anticipated climate changes.

The Gh_NC4 Assessment also examined the sensitivity of municipals to climate change, utilizing the percentage of the population employed in the agricultural sector as a primary indicator. Given the sector's dependence on climate conditions, those engaged in agriculture are considered highly sensitive to the impacts of climate variability, including temperature increases and fluctuating rainfall patterns. However, this sensitivity analysis is limited by the availability of current employment data at the regional level, resulting in a uniform sensitivity score being assigned to all municipals within each region due to the lack of municipal-specific employment data and future employment projections in agriculture.

The results from the Assessment **(Figure 3)** display Climate Change Vulnerability (CCV) scores for Ghana's 216 districts, represented by varying colours. Districts with higher vulnerability are indicated by red shades, while those with lower vulnerability are represented by green shades. The size of the dots reflects the population, with larger dots denoting more populous areas, highlighting regions where more people may be affected by climate-related issues. This visual representation facilitates the identification of regions and districts where resources and adaptation strategies should be prioritized.

Figure 3: Climate change vulnerability scores for Ghana's 216 districts, highlighting Aowin municipal



Source: (Pwamanng, Appah-Sampong, & Oppong-Boadi, 2020)

The Aowin Municipal Assembly has a sensitivity score of 0.45 and an exposure score of 0.30, coupled with an adaptive capacity of -0.60 (figure 3). These factors result in a Climate Change Vulnerability (CCV) score of -0.13 for the municipal. This negative CCV score signifies that, despite Aowin's moderate sensitivity and

exposure to climate change effects, its high adaptive capacity significantly mitigates its overall vulnerability. Consequently, Aowin is better positioned to manage and adapt to climate change impacts compared to districts with positive CCV scores. Here, sensitivity and exposure indicate the potential severity of climate impacts on the municipal, while adaptive capacity reflects its ability to cope with and adapt to these changes. Therefore, a negative CCV score like Aowin's suggests a relatively strong capacity to handle climate risks, whereas positive CCV scores point to greater vulnerability.

4 Overview Of Aowin Municipal Assembly

4.1 Geographical Description

4.1.1 Location and Size

The Aowin Municipal, formerly known as Aowin Suaman Municipal, is strategically situated in the Mid-western region of the Western North of Ghana. Positioned between latitude 5° 25' N and 6° 14' Nand longitude 2° 30'W and 3° 05'W (All Municipals, 2018), with Enchi as its capital. Currently designated as one of the 261 Metropolitan, Municipal and Municipal Assemblies (MMDAs) in Ghana, Aowin Municipal holds a distinctive position among the 9 MMDAs in the Western North Region, with Enchi serving as its administrative capital.

Spanning across a vast land area of 2,607.2 km^2, Aowin Municipal is characterized by a population density of 51 persons per square kilometer (figure 4). This expansive municipality shares its boundaries with the Wassa Amenfi West municipality to the East, Suaman Municipal to the Northwest, Jomoro Municipality to the South, Sefwi Akontombra Municipal, and Sefwi Wiawso Municipality to the Northeast. To the West, Aowin Municipal extends its borders to the Republic of La Cote D'Ivoire.

4.1.2 Topography and Climate

Aowin Municipal is characterized by its diverse topography and favourable climate, which play a crucial role in shaping the economic and ecological landscape of the region. The municipal area, covering approximately 2,610.301km^2, features a predominantly lowland terrain interspersed with a few hills, the highest points rising over 366 meters above sea level, particularly to the east of Enchi where they align from North-Northwest to South-Southwest.

The climate in Aowin is classified as Wet-Semi Equatorial, marked by high temperatures and substantial rainfall. The area hasan annual average temperature of about 26°C, with March and April typically being the hottest months. Aowin experiences a bimodal rainfall pattern, peaking in June and October, with annual precipitation ranging between 1,700mm and 2,100mm. This climate supports the cultivation of various crops such as cassava, plantain, rice, and maize, with farmers benefiting from the double rainfall seasons to boost crop production.

Aowin's rich geographical layout is complemented by numerous water bodies, including the Disue, Boin, Tano, Bia, and Susan rivers, alongside various streams. The Tano River notably serves as a natural boundary between Aowin Municipal and the Wassa Amenfi West Municipal. These rivers and streams are vital for domestic use in many communities and contribute significantly to the municipal's agricultural and forestry sectors.

The soil in Aowin is predominantly loamy, conducive for the cultivation of cocoa and other cash crops. The region's soil types—Acrisols, Ferralsols, and scattered Fluvisols—have evolved under the forest vegetation

and the climatic conditions of the area, making them rich in humus and ideal for agricultural activities. The municipal is positioned in the rainforest belt of Ghana, hosting eight forest reserves such as Tano Ehuro, Tano Anwia, and Boin Tano. These reserves are home to diverse tree species including wawa, odum, mahogany, and sapele, enhancing the municipal's capacity for forestry operations.

Figure 4: Map showing the Aowin municipal assembly coverage with major towns and geographical features

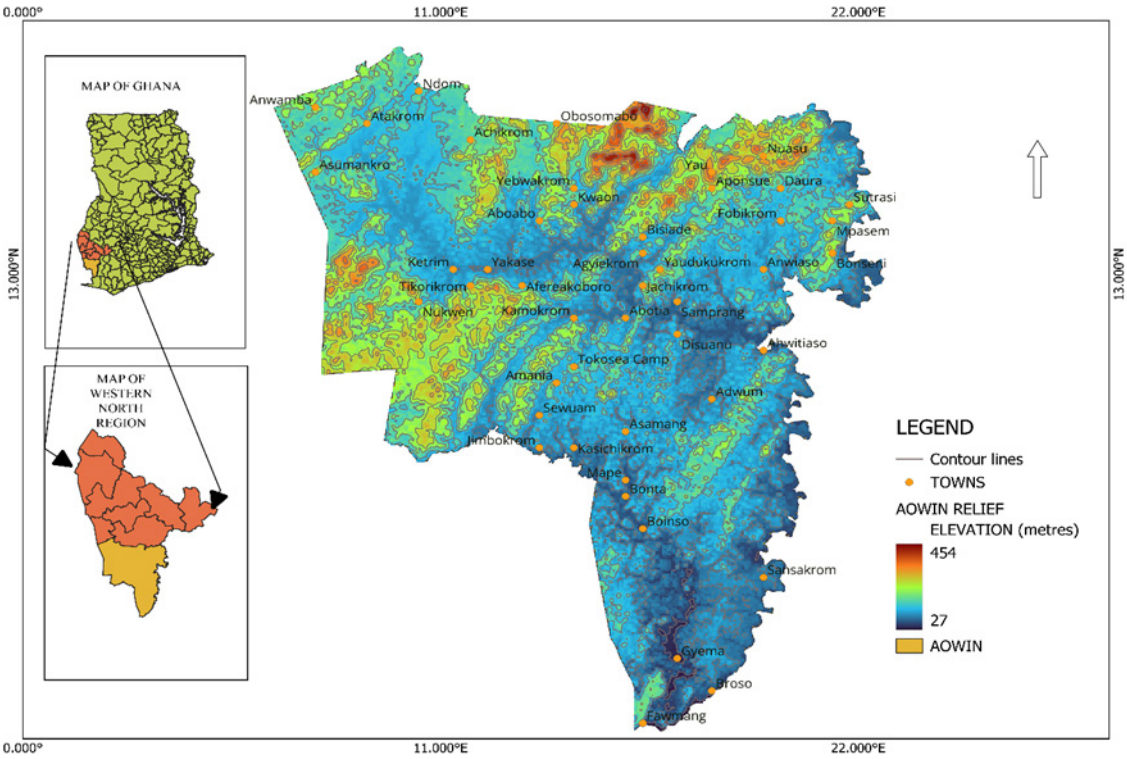


Table 1: Summary of geographic characteristics of the Aowin municipal

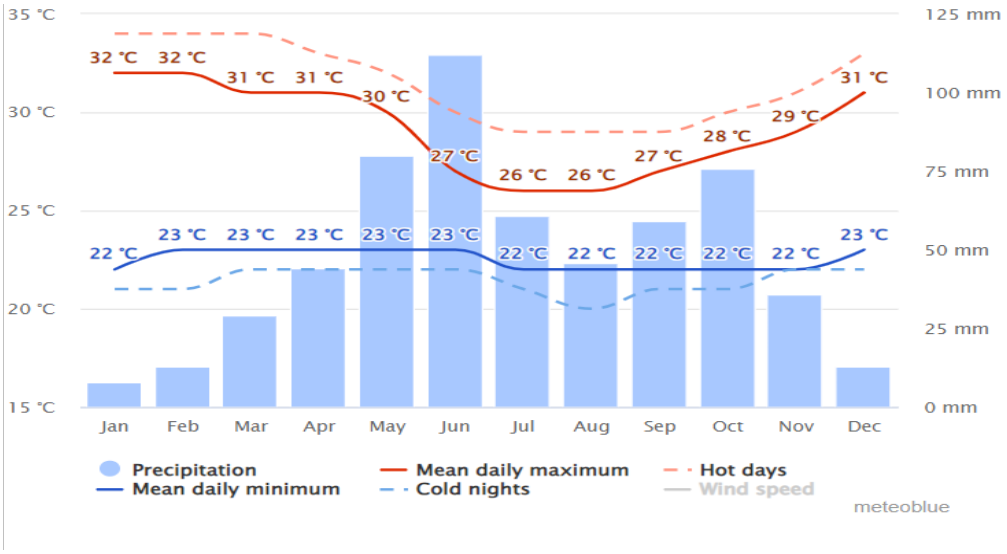
Theme	Details
Topography	Total area rising above 305 meters above sea level with the highest points over 366m above sea level.
Geology	Mainly Cambrian of the Birimian formation and Tarkwaian Sandstone-Association (Quartzite and Phylites). Rich in kaolin, silica, and gold.
Soil Composition	Acrisols and Ferralsols are the predominant soil types in the Municipality with appreciable dotted quantities of Fluvisols.
Agriculture	Prominent cultivation of cocoa, along with cassava, plantain, rice, and maize.
Climate	Wet-Semi Equatorial with significant annual rainfall (1700mm to 2100mm) and high humidity; double rainfall seasons.
Temperature	Average annual temperature around 26°C.
Humidity	High relative humidity, ranging from June holds the record for the highest relative humidity at 88.65%, while January experiences the least humidity at 76.36%.

4.1.3 Average temperatures and precipitation

In determining the average temperature and precipitation of the Aowin municipal, Using the Meteoblue, a meteorological service that combines cutting-edge science and technology to provide top-quality weather data, has diligently archived weather model data. Calculating weather models using historical data from 1985 onwards. Producing a continuous 30-year history with detailed hourly weather data. This extensive dataset serves as a valuable resource for various applications, from climate research to practical weather forecasts. Meteoblue commitment to precision and innovation ensures that users worldwide benefit from accurate and reliable weather information.

The “mean daily maximum” (solid red line) shows the maximum temperature of an average day for every month for Aowin. Likewise, “mean daily minimum” (solid blue line) shows the average minimum temperature. Hot days and cold nights (dashed red and blue lines) show the average of the hottest day and coldest night of each month of the last 30 years.

Figure 5: Average temperatures and precipitation of the Aowin municipal.



Source: Meteoblue

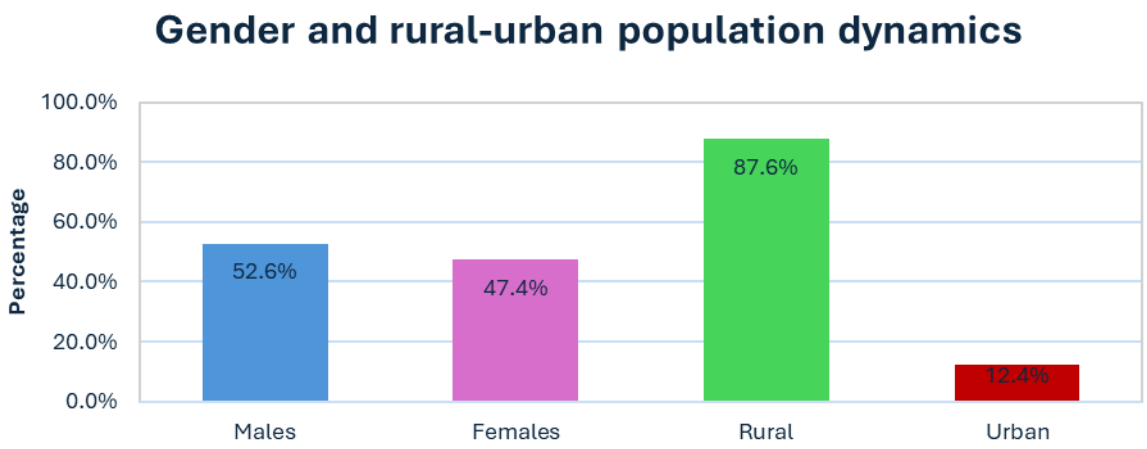
4.2 Demographics Characteristics

According to the 2021 Population and Housing Census (PHC), Aowin Municipality has a total population of 133,257. This comprises 70,131 males representing 52.6% and 63,126 females representing 47.4%. The majority (87.6%) of people in the Municipality live in rural areas. The projected population of the Municipality with the growth rate of 3.3%. Aowin Municipality has a youthful population with about 68.7% being between the ages of 15-39 years. The population distribution of the Municipality shows that majority are men, and the numbers keep increasing over the years.

Conversely, the age ranges of 20-29 years to 40-49 years represent a more adaptive and potentially resilient cohort. With a combined population of 39,977, individuals within this age range often exhibit higher levels of adaptability, resourcefulness, and capacity for climate-related challenges. Young adults and those in their prime working years contribute significantly to community resilience, as noted in studies such as the Intergovernmental Panel on Climate Change (IPCC) report on sustainable development and climate change. The elderly population, aged 50 years and above, comprising 22,325 individuals, also falls within the potentially vulnerable category. While the elderly may exhibit resilience through life experiences, they are often more susceptible to health issues exacerbated by climate-related factors. This aligns with findings from the National

Institute on Aging, emphasizing the increased vulnerability of older adults to extreme weather events and changing climatic conditions.

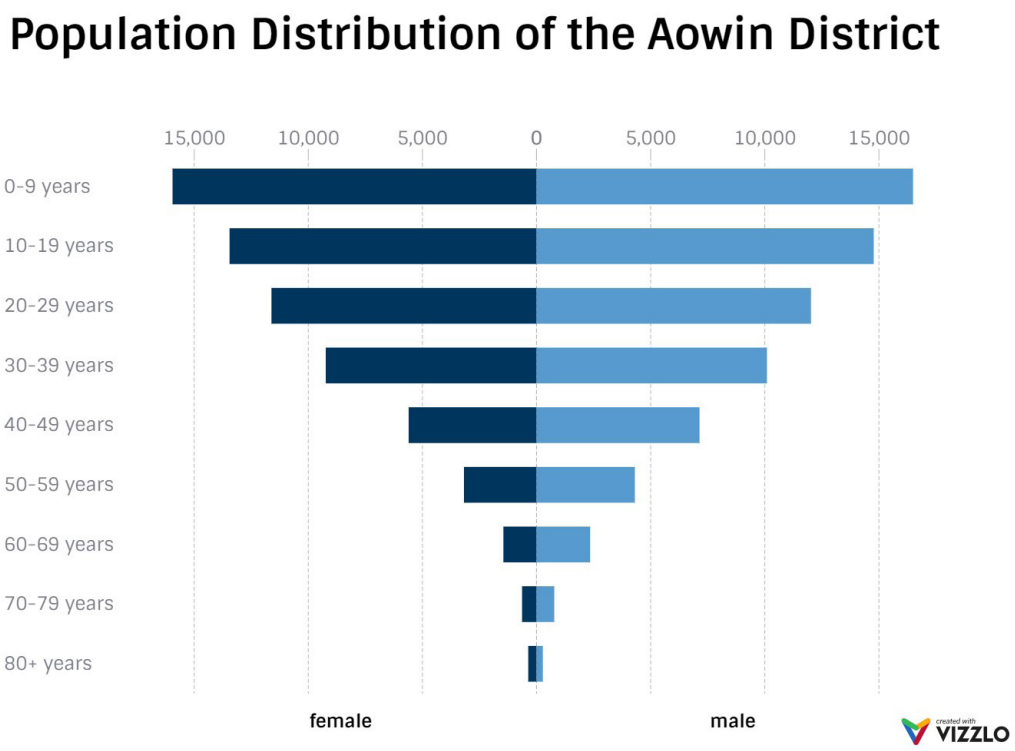
Figure 6: Gender and rural-urban population dynamics of the Aowin municipal



Source: Ghana Statistical Service, 2022.

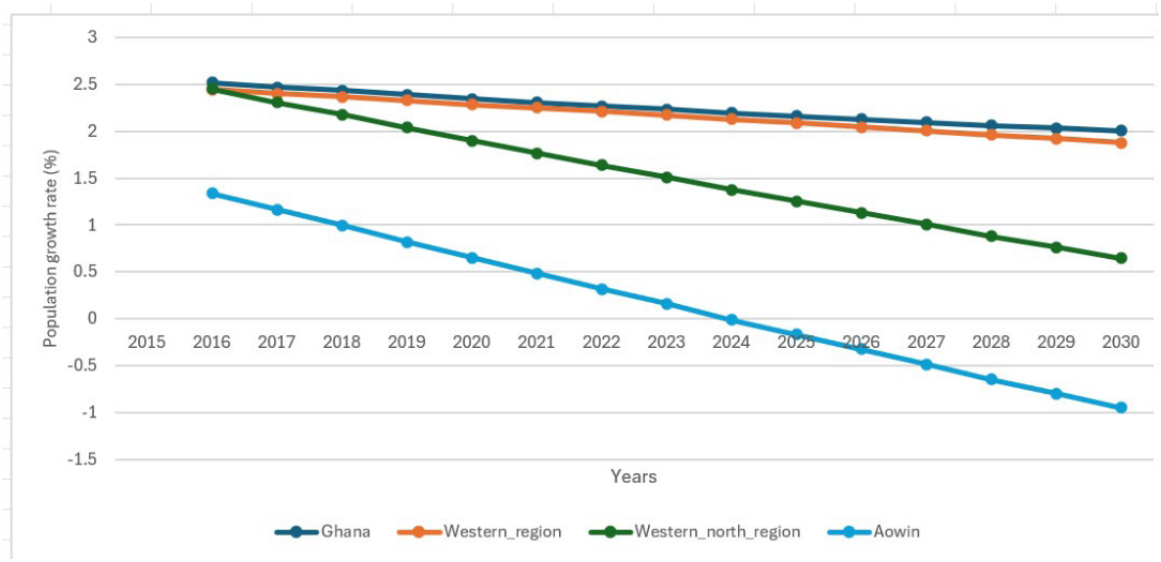
The demographic structure of Aowin municipal showcases distinct vulnerable and adaptive age groups. It is crucial for policymakers, local authorities, and development organizations to consider these dynamics when formulating strategies for climate resilience, healthcare provision, and social support systems in the region. Acknowledging these distinctions within the population can contribute to targeted and effective interventions that address the specific needs of each age and gender group, fostering a more sustainable and resilient community.

Figure 7: Population distribution of the Aowin municipal



Source GSS, 2022.

Figure 8: Projection of the annual growth rate between 2015 to 2030



Source: data retrieved from the United States Census Bureau

4.3. Key Economic Sectors

The economy of Aowin Municipal is deeply rooted in agriculture, with a strong focus on crop farming, particularly cocoa. This is due to the attractive profits from cocoa farming, which has become the most widespread agricultural activity in the municipality. As a result, a significant portion of the population, across various age groups, engages in agricultural activities. According to PHC 2021, 79.7% of the population aged 15 years and above are employed in skilled agricultural, forestry, and fishery jobs. This prevalence of farming is attributed to the high profits from cocoa farming, which has established itself as the primary cash crop in the region.

The services sector follows as the second-most prominent, with a small-scale industrial sector comprising mostly small-scale industries. Despite the potential for Agro processing to leverage the region's agricultural output, industrial development remains relatively underdeveloped, limiting the municipality's overall economic growth. Farmers in the area face numerous challenges, including pest infestations, disease impacts on crops, limited access to financial resources, poorly maintained farm roads, scarce agricultural extension services, high farming input costs, inadequate storage facilities, and a shortage of available land for agricultural expansion. Women's access to arable lands and farm inputs in these areas is further limited under customary land governance and state land title registration (Dugasseh, Aapengnuo, & Zandersen, 2021). These challenges hinder the full potential of the agricultural sector, which is crucial to the municipality's economic development (Botchway, 2019).

The municipality supports various livestock farming activities, with poultry farming being the most common. Poultry birds are the most widely reared, followed by turkeys and snails. Livestock rearing provides an additional income source, complementing earnings from cocoa and other activities. (Opoku, 2018; Agbefu, 2015). Forestry also contributes to the local economy, with eight forest reserves in Aowin rich in diverse timber species. Timber extraction is a key economic activity and employment source, although timber firms and sawmills are located outside the municipality. However, unregulated lumbering, illegal mining, and land encroachment threaten the sustainability of these forest reserves (Mawutor, 2020; Boakye & Larbi, 2022).

Tourism offers an untapped opportunity, with attractions like the largest tree in Apuja Yakasi, the Ablakanu Rocks, and the Sutreso Rapids. Despite this potential, these sites remain underdeveloped and underutilized. Investment and development could transform these sites into significant revenue sources for the Municipal

Assembly and help curb unemployment. Mining activities, including historical shafts and unexploited concessions, offer potential for growth in medium to large-scale ventures. However, illegal mining has raised security concerns and social challenges, including increased crime rates and food insecurity, as farmers opt for mining over traditional agriculture (Mantey et al., 2016).

Plate 1:Mining site

5 Climate Change Vulnerability of Aowin Municipal Assembly

5.1 Defining Climate Change Risk and Vulnerability

This section provides an in-depth examination of the definitions of climate risk and vulnerability as outlined by prominent organizations and institutions. It seeks to provide a comprehensive understanding of the complex interactions between climate hazards and socio-economic, environmental, and institutional vulnerabilities. To achieve this, the section analyzes the definitions provided by key entities such as the Intergovernmental Panel on Climate Change (IPCC), the United Nations Framework Convention on Climate Change (UNFCCC), and national-level frameworks. These definitions play a crucial role in shaping adaptation strategies, risk assessments, and resilience-building initiatives tailored to the specific needs of the Aowin Municipal Assembly.

5.1.1 Intergovernmental Panel on Climate Change (IPCC)

The IPCC offers a scientific perspective on climate risk and vulnerability, highlighting the complex interplay between climate hazards, exposure, and adaptive capacity. This interplay influences the susceptibility of both natural and human systems to climate impacts, as emphasized in the IPCC's definition. According to the IPCC, Climate Change Risk refers to the potential for adverse consequences or damage resulting from the interaction of climate-related hazards with the vulnerability and exposure of human and natural systems. This risk encompasses the likelihood and magnitude of harmful outcomes, taking into account 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).

In the context of climate change, vulnerability is understood as the propensity or predisposition to be adversely affected. This concept encompasses a range of factors, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt. Vulnerability is a complex, multi-dimensional concept that is influenced by various social, economic, environmental, and cultural factors. It reflects not only the potential impact of climate change but also the adaptive capacity of the system or community at risk.

5.1.2 United Nations Framework Convention on Climate Change (UNFCCC)

From a global governance perspective, the UNFCCC plays a crucial role in shaping the understanding of climate risk and vulnerability. The UNFCCC's approach prioritizes policy and equity considerations, highlighting the disproportionate impacts of climate change on vulnerable populations and regions. By emphasizing global cooperation and the protection of at-risk communities, the UNFCCC's definitions provide a framework for addressing climate change. According to the UNFCCC, climate change risk is characterized by the probability and severity of adverse effects of climate events on human and natural systems. The concept of vulnerability, as defined by the UNFCCC, encompasses the susceptibility of these systems to adverse effects, including their sensitivity and capacity to adapt to the character, magnitude, and rate of climate change (UNFCCC, 2007).

5.1.3 World Health Organization (WHO)

The World Health Organization's (WHO) perspective on climate risk and vulnerability is centered on the intersection of climate change and public health. The WHO highlights the ways in which climate change amplifies health risks, particularly for vulnerable populations, and stresses the importance of bolstering health systems to enhance resilience against these risks. Within the public health domain, the WHO defines climate change risk as the likelihood of adverse health consequences resulting from climate-related hazards, such as heatwaves, floods, or the proliferation of disease vectors. The WHO's concept of vulnerability focuses on the predisposition of populations to these health risks, which is influenced by a range of factors, including age, socioeconomic status, pre-existing health conditions, and access to healthcare (World Health Organization, 2021).

5.1.4 United Nations Office for Disaster Risk Reduction (UNDRR)

The UNDRR's definition of climate risk and vulnerability is rooted in the context of disaster risk reduction. This institution emphasizes the impact of climate-related disasters, such as floods and storms, on socio-economic vulnerabilities. To mitigate these risks, the UNDRR advocates for the implementation of early warning systems and risk-informed policies.

According to the UNDRR, climate change risk is a function of the frequency and intensity of climate hazards, combined with human exposure and vulnerability. The UNDRR's concept of vulnerability encompasses a broad range of physical, social, economic, and environmental factors that increase a community's susceptibility to climate-related hazards (UNDRR, 2022).

5.1.5 World Bank

The World Bank's economic and developmental lens shapes its definitions of climate risk and vulnerability. Highlighting the susceptibility of economies, infrastructure, and livelihoods to climate change, the World Bank emphasizes the importance of integrating climate risks into development planning and investments.

Climate change risk, as defined by the World Bank, encompasses both transition risks and physical risks. Transition risks refer to the economic adjustments required for a low-carbon transition, while physical risks arise directly from climatic changes. These risks have significant financial and socio-economic consequences. Furthermore, the World Bank views vulnerability through the lens of economic resilience, examining how susceptible an economy is to external shocks induced by climatic variability and change (World Bank Group, 2021).

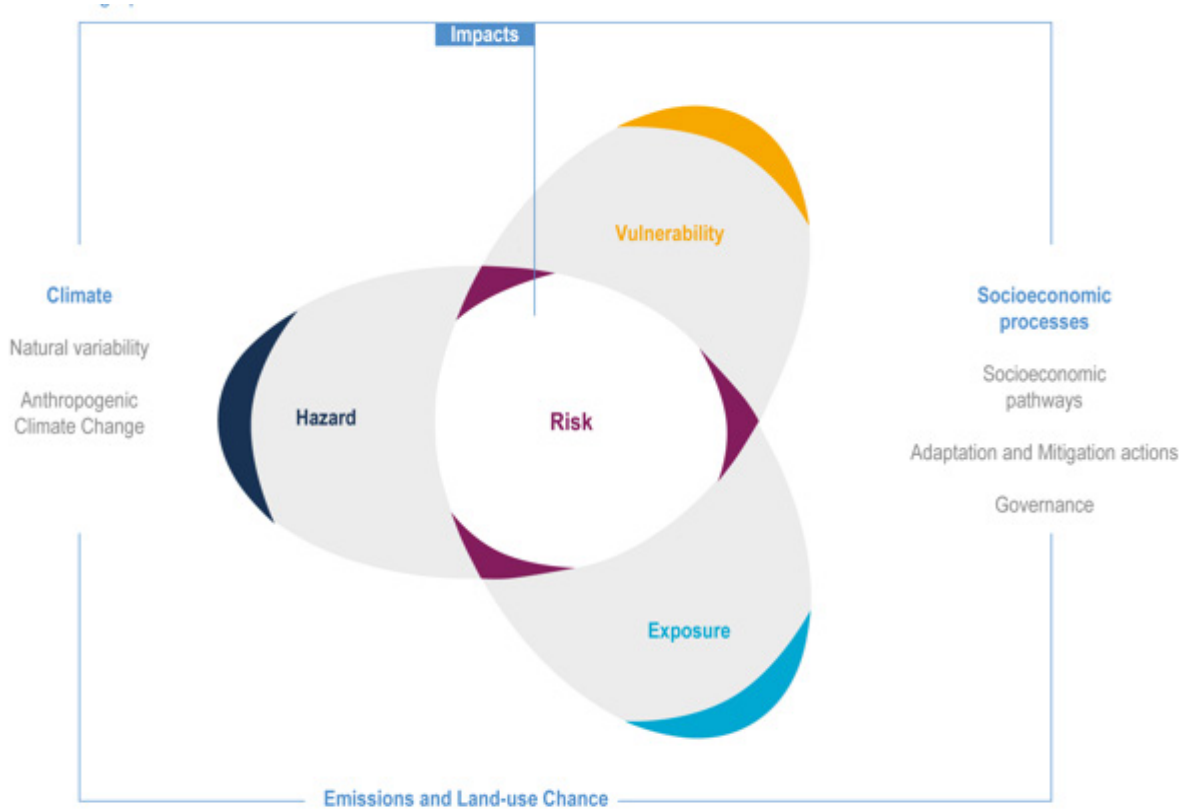
A comparative analysis of climate change risk and vulnerability definitions reveals that, despite variations in terminology, the core components of hazard, exposure, and vulnerability remain central to risk assessment. Across institutions, climate risk is consistently viewed as a combination of climate-related hazards, exposure, and a population's capacity to cope. The climate risk assessment framework **(Figure 3)** illustrates the interplay between climate drivers, socioeconomic processes, and vulnerability. This framework is essential for climate-vulnerable municipals like Aowin, as it integrates these variables to identify current and potential future risks.

In the context of the Aowin Municipal Assembly, the climate risk framework provides a comprehensive approach to understanding climate change impacts. As described 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, this framework offers a valuable tool for assessing climate-related risks and vulnerabilities **(Figure 3).**

The framework presented in Figure 9 provides a comprehensive structure for understanding climate risk and vulnerability. At its core, 'Climate' is defined as the foundational element, encompassing both natural variability

and the additional pressures of anthropogenic climate change. This, in turn, informs the types of 'Hazards' the municipal may encounter, which can range from extreme weather events to gradual climatic shifts. Within the Aowin municipal, the concept of 'Exposure' is critical, as it refers to the presence of communities, ecosystems, and infrastructural assets that are susceptible to the impacts of climate hazards. Furthermore, the municipality's 'Vulnerability' is influenced by a complex array of factors, including socio-economic status, public health, local environmental conditions, and the capacity of individuals and systems to adapt to climatic changes.

Figure 9: Risk assessment framework for evaluating climate change risks



Furthermore, the municipality's 'Vulnerability' is influenced by a complex array of factors, including socio-economic status, public health, local environmental conditions, and the capacity of individuals and systems to adapt to climatic changes.

Ultimately, the convergence of hazards, exposure, and vulnerability gives rise to 'Risk', which represents the likelihood of adverse consequences, such as threats to human life and well-being, damage to property and infrastructure, and environmental degradation. Climate change 'Impacts' are far-reaching, affecting both natural and human systems in the municipal. These impacts are shaped by the interplay between climate risk and socio-economic processes, including development pathways, adaptive practices, and governance structures.

In order to advance climate change adaptation strategies in the Aowin municipal Assembly, it is essential to recognize this interplay. Therefore, the municipal's adaptation efforts should be grounded in a nuanced understanding of local climate risks, informed by scientific knowledge and socio-economic dynamics, to foster resilience and sustainable development in the face of climate change.

5.2 Aowin Municipal's Current Vulnerability

The Aowin Municipal Assembly is characterized by a complex interplay of multiple dimensions of vulnerability, which collectively exacerbate the risks and impacts of climate change on local communities. Understanding these various dimensions of vulnerability is crucial for developing effective strategies to mitigate and adapt to the effects of climate change. ***Physically***, the municipality's natural environment and physical assets, including land, forests, water bodies, and critical infrastructure, are highly susceptible to climate-related hazards, such as river and inland flooding. These physical changes can result in significant damage to homes, farms, and ecosystems, thereby directly impacting the livelihoods of individuals and communities that depend on them. ***Socio-economically, the municipality's vulnerability*** is influenced by a range of factors, including poverty levels, employment opportunities, access to resources, and the resilience of livelihoods. These factors collectively affect the capacity of individuals and communities, particularly those reliant on climate-sensitive sectors such as agriculture, to cope with and recover from climate-related impacts. ***In terms of infrastructure,*** the municipality's-built environment, including roads, schools, bridges, and health facilities, is often poorly equipped to withstand extreme weather events. Poorly designed or located infrastructure in flood-prone areas is particularly vulnerable to damage, which can further exacerbate the municipality's vulnerability. Furthermore, climate change ***disproportionately affects men and women,*** particularly women who often bear a greater burden in terms of food and water provision, health, labor, and safety risks in climate-induced disasters.

5.2.1 Physical Vulnerabilities

The Aowin Municipal faces a range of existing vulnerabilities, with its geographical features playing a pivotal role in shaping the physical susceptibility of the region. The diverse topography, characterized by forests, rivers, and agricultural areas, exposes the municipal to a variety of environmental hazards. Low-lying regions are particularly at risk of flooding, while areas with steeper terrain face challenges such as soil erosion and landslides, especially during extreme weather events (Gyampoh et al., 2011; Abbey, 2016). Climate change compounds the vulnerability of Aowin, as the municipal experiences alterations in temperature, precipitation patterns, and the frequency of extreme weather events. These changes contribute to water scarcity, impacting both agricultural productivity and the availability of water resources for communities. The majority of the rural communities have no access to pipe-borne water inside their dwellings and still rely on streams, unprotected hand-dug wells, and rainwater for domestic purposes (Narasimhan, 2011).

In addition, the interconnectedness of climate variability and land use is evident, as deforestation and unsustainable land practices exacerbate soil degradation and diminish the Municipal's overall resilience to environmental stressors (Awuni, 2013; Agbefu, 2015). The Municipal's proximity to river systems introduces an additional layer of vulnerability, with the potential for flooding during heavy rainfall or as a consequence of upstream activities affecting river flow and encroachment of riverbanks. Illegal mining, disposal of liquid and solid waste into the river, and the use of chemicals for fishing further make Aowin vulnerable (Gyampoh et al., 2011; Abbey, 2016). Flood events pose a threat to infrastructure, agriculture, and community settlements. These impacts not only weaken the Municipal's ability to withstand environmental stress but also contribute to a cascade of adverse effects on the well-being of both natural and human systems (Yiran et al., 2015; Affram, 2021).

5.2.2 Socio-economic Vulnerabilities

The Aowin Municipal faces a range of socio-economic vulnerabilities significantly exacerbated by climate-related challenges. The region, known for its cocoa and crop farming, suffers from perennial rains that cause extensive damage to farmland and residences. Such intense weather events not only result in substantial economic losses by destroying agricultural produce but also displace communities, destroying homes and infrastructure (World Bank, 2019). For example, the heavy rains of 2007 vividly demonstrate the ongoing

susceptibility of these communities to severe climatic disruptions, reinforcing the critical need for robust adaptive measures (Narasimhan, 2011).

The socio-economic of Aowin is further complicated by the changing climate patterns that impact roads used by farmers, resulting in pooling water on footpaths, making access to farms difficult (Abbey, 2016; Afram, 2021). These disruptions extend beyond the immediate economic impacts, affecting the daily routines and overall quality of life for women, men and young persons. Additionally, altered rainfall patterns and extreme weather conditions have led to the migration of wildlife, such as elephants moving from the municipality to forests in Ivory Coast. This migration diminishes the area's tourism potential, which is crucial for economic growth, especially as Aowin is home to significant attractions like the Biggest Tree in the Western North Region (Selase et al., 2017; Abunyewah et al., 2023).

The broader implications of these climatic changes are profound, affecting various aspects of the local economy and exacerbating existing socio-economic challenges. The municipal's economy, which also relies on timber logging and mining, is under strain as these activities contribute to the degradation of the physical, natural, and built environment (Awuni, 2013; Agbefu, 2015). The resilience of the area's forest cover and ecosystems is threatened by illegal logging, mining, and other disruptive activities such as bushfires and poor environmental practices, which further compromise the municipal's development prospects (Mawutor & Hajjar, 2022; Yiran et al., 2015). Moreover, the socio-economic vulnerabilities are intensified by financial constraints that hinder the community's ability to recover and rebuild after disasters. Marginalized groups, including smallholder farmers, face compounded challenges of displacement, loss of livelihood, and limited access to resources necessary for adopting climate-resilient practices (Oduro et al., 2014; Oxfam, 2018). These groups are also disproportionately affected by a lack of infrastructure, which impedes effective recovery and perpetuates a cycle of vulnerability (Owusu-Acheampong, 2011; UNDP, 2020).

Infrastructure vulnerabilities in Aowin Municipality are closely intertwined with the impacts of climate change, particularly affecting the transportation network crucial for economic and social activities. According to the annual report from the Aowin Municipal Assembly, the municipality's road infrastructure, especially feeder roads crucial for agricultural transport, is severely compromised by weather conditions. These roads deteriorate rapidly under the strain of frequent heavy rainfall, impeding the efficient transport of essential commodities like cocoa and food crops to markets and causing significant economic losses (Sulemana, 2022; Bahal et al., 2018).

Women's mobility is in addition influenced by their domestic responsibilities requiring them to make more trips within a limited geographical area often using footpaths to reach the markets, send children to school, attend antenatal and related needs (Adom-Asamoah, Amoako, & Kwafo Adarkwa, 2020). The vulnerability of women and men in such instances vary as these transport routes are worsened during the rainy season when many roads, footpaths and farm tracks become impassable. In such instances, women and other vulnerable persons are forced to farm or look for jobs closer to their homes (World Bank, 2024). This situation necessitates continuous maintenance and the construction of culverts, footpaths and wooden footbridges to maintain connectivity. Delays in transportation during these periods not only lead to increased post-harvest losses but also raise the cost of farm produce, further straining the economic stability of local farmer (Agbefu, 2015; Asante, 2014).

The poor condition of the roads during the peak of the rainy season disrupts not only economic but also essential social activities. Feeder roads, serving as vital arteries to health centers, schools, and markets, require urgent and ongoing attention to ensure they are reliable year-round. The municipality has thus prioritized the rehabilitation and reshaping of these roads, along with building necessary drainage structures to mitigate the transportation challenges (Gyapong, 2015; Mantey et al., 2016).

Moreover, the lack of adequate drainage systems due to unplanned development and haphazard building arrangements poses significant public health risks. In settlements such as Old Yakasi, Enchi, Achimfo, and Omanpe, which are situated near rivers, the community experiences frequent and severe flooding. This flooding, intensified by increased rainfall, results in the loss of property and lives and disrupts daily life and economic activities for extended periods (Abbey, 2016; Sulemana, 2022).

Plate 2: Flooded and potholed road from Alubo to Enchi

Plate 3: Assessment team in mud pushing vehicle to pave way

In terms of sanitation, the situation remains alarming. Most of the communities within the Aowin municipality, with the exception of the capital, Enchi, lacks proper drainage, leading to unsanitary conditions and the proliferation of disease-carrying insects like mosquitoes. The increased rainfall exacerbates these conditions, creating

breeding grounds for mosquitoes and eroding infrastructure. Furthermore, the majority of the population lacks access to adequate and hygienic toilet facilities, compounding the challenges of sanitation management. This inadvertently affects school attendance of girls during days they need to manage their menstrual hygiene (Akanzum & Pienaah, 2023). The prevalent open dumping system for refuse disposal and the inadequate logistics for managing liquid waste highlight the urgent need for improved waste management systems to bolster public health and environmental quality in Aowin Municipality (Mantey et al., 2016; Attah-Tutu, 2011). Furthermore, according to reports, Aowin Municipality currently has only one well-developed waste disposal site, which is hampered by a non-functional septic emptier vehicle for liquid waste disposal. Additionally, the municipality has more than 20 skip containers for conveying waste, yet this infrastructure is insufficient to meet the needs effectively. This situation underscores the critical inadequacies in sanitation and logistics for waste management, particularly for liquid waste, necessitating urgent improvements to protect public health and the environment (Mantey et al., 2016; Adjarko et al., 2016).

5.2.3 Gendered Vulnerabilities

Gender-specific vulnerabilities in Aowin Municipal need to be assessed with a focus on agriculture, water resources, community health, forest and biodiversity, and infrastructure. Women, youth, and differently abled individuals often experience these vulnerabilities differently due to varying roles, responsibilities, and physical abilities within the society. Here's a brief outline of these vulnerabilities:

Agriculture: In Aowin Municipal Assembly, the majority of women are involved in subsistence farming. They experience heightened stress due to climate change, which affects crop yields, particularly cocoa, which is the main cash crop. Unpredictable rainfall and increased temperatures from climate change can lead to crop failures, directly impacting men and women's workload and their abilities to provide for their families. For instance, society expects men to meet the financial needs of their families so that decline harvest puts pressure on men to meet their obligations through other means (Bowen, Michael, Kodam, Odoi, & Anto-Ocrah, 2022). In another instance, during droughts or excessive rains, women may have to spend more time and labor on their farms, while still managing household responsibilities. In addition, Women, have only limited access to productive resources such as access to credit since financial institutions regard the subsistence agriculture as too risk prone. Also, most women engaged in agriculture have little access to improved technologies and are often not very open to their use. Hence, women are at risk of being marginalized by men whenever female dominated areas of work become more economically profitable (Adomako-Kwabia, 2021; Opoku, 2018).

Culture vulnerability: In Aowin, a unique cultural practice significantly impacts women, particularly those involved in market activities. Local traditions dictate that women are prohibited from crossing the Disue River on Wednesdays, which coincidentally aligns with a major market day in the community. Since the primary route to the market involves crossing this river, women face a logistical and economic challenge. To circumvent this restriction, many women are compelled to leave their homes on Tuesdays to secure accommodation closer to the market, where they stay overnight to ensure they can participate in market activities the following day. This not only adds additional expenses and logistical burdens but also results in lost income opportunities for those who cannot afford or manage the overnight stay. This cultural norm, therefore, poses a significant barrier to economic access and equity for women, who are predominantly farmers and rely heavily on market days to support their livelihoods (Adomako-Kwabia, 2021; Asante, 2014).

Water Resources: Women and girls are traditionally responsible for water collection, and water scarcity forces them to travel longer distances. This does not only pose health risks due to potential contamination but also limits the time available for other productive or educational activities. For example, in the dry season, women and girls may need to walk several kilometers to the nearest clean water source, which can be taxing and time-consuming.

Community Health: Women in Aowin Municipal typically serve as the primary healthcare givers in families, and with climate change exacerbating the prevalence of diseases like malaria and diarrhea, this role becomes even more burdensome. The youth, while physically active, may be exposed to health risks due to their engagement in outdoor activities. Differently abled individuals face significant barriers in accessing health care, particularly during health emergencies exacerbated by climate events.

Infrastructure: Infrastructure in Aowin, including roads, bridges, and buildings, is vulnerable to extreme weather conditions. Flooding, in particular, can damage or destroy critical infrastructure, disproportionately affecting women who may be responsible for securing the safety of their households during such events. Additionally, poorly designed or maintained infrastructure can pose significant challenges for differently abled individuals who might find it difficult to navigate or access safe areas during emergencies.

Table 2: Gender-Specific Vulnerabilities in Aowin Municipal with Community Examples

Sector	Vulnerability	Impact on Women	Impact on Youth	Impact on Differently abled	Specific Examples
Agriculture	Climate impact on crop yields	Increased workload, stress on dual roles	Uncertain job prospects, disrupted education	Accessibility barriers, need for adaptive technologies	In Enchi, erratic rainfall patterns are causing women to work longer hours to maintain cocoa yields, while youth face limited agricultural employment opportunities.
Water Resources	Water scarcity and contamination	Longer distances for water collection, health impacts	Diverted from education to water collection	Difficulty accessing clean water, heightened dependence	Women in Enchi have to farther walk to find uncontaminated water sources due to pollution from mining.
Community Health	Climate-induced health risks	Increased caretaker burden, health risks	Exposure to health risks, educational disruption	Exclusion from health services, increased vulnerability	Malaria and waterborne diseases and upper respiratory track infections due to the dusty nature of the roads, straining women's roles as caregivers and disrupting youth activities.

Forest and Biodiversity	Deforestation and biodiversity loss	Loss of livelihood, increased labor for forest resources	Loss of educational opportunities in environmental stewardship	Physical barriers to participating in conservation efforts	Women in communities like Kramokrom face longer journeys to collect firewood as nearby forests diminish, impacting local wildlife and reducing tourism potential.
Infrastructure	Poor resilience to extreme weather	Increased burden in securing family and community well-being	Limited engagement in recovery, lost development opportunities	Increased risk of injury, lack of accessible escape routes	Flood-damaged roads to Enchi which complicates evacuation and rebuilding efforts, disproportionately affecting women and the differently abled during emergencies.

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). However, initiatives to increase resilience, like those undertaken in Northern Ghana, involving agricultural diversification and investment in sustainable practices, could offer pathways for the Aowin Municipal to bolster its climate resilience.

The Aowin Municipal's unique 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 Observed Climate and Trends

6.0 Climate Trends and Impacts in Ghana

Ghana's tropical climate is characterized by two distinct seasons: the wet and the dry seasons. The country's southern regions receive significant rainfall, particularly during the June to August period. In contrast, the northern regions experience a single rainy season, spanning from April to October. The dry season, characterized by the Harmattan, brings dry and dusty conditions to the region. Climate trends in Ghana over the past century reveal a gradual increase in temperatures, aligning with global warming patterns. Historical climate data indicates that average maximum temperatures are highest during the MAM season, with recent decades reaching temperatures of up to 34.59°C.

This suggests a significant warming trend, particularly over the last thirty-year period from 1991-2020. The JJA season, despite being the coolest period, has seen an increase in rainfall, indicating a more intense rainy season. These observed climatic changes have important implications for Ghana's environmental and socio-economic landscapes. Rising temperatures and altered rainfall patterns necessitate adaptive strategies for agriculture, as crop viability may shift. The variability in water availability could also have repercussions for urban and rural water supply systems. Public health policy must adapt to potential changes in disease patterns with the evolving climate.

The trends underscore the necessity for Ghana to pursue sustainable development pathways that are resilient to climate variability and change. Figure 10 presents a climatology graph for Ghana, covering the period from 1991 to 2020. The graph illustrates the interplay between temperature and precipitation over the months. Temperature peaks occur 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. Precipitation is most significant around June, marking the height of the rainy season, with a secondary peak in September and October.

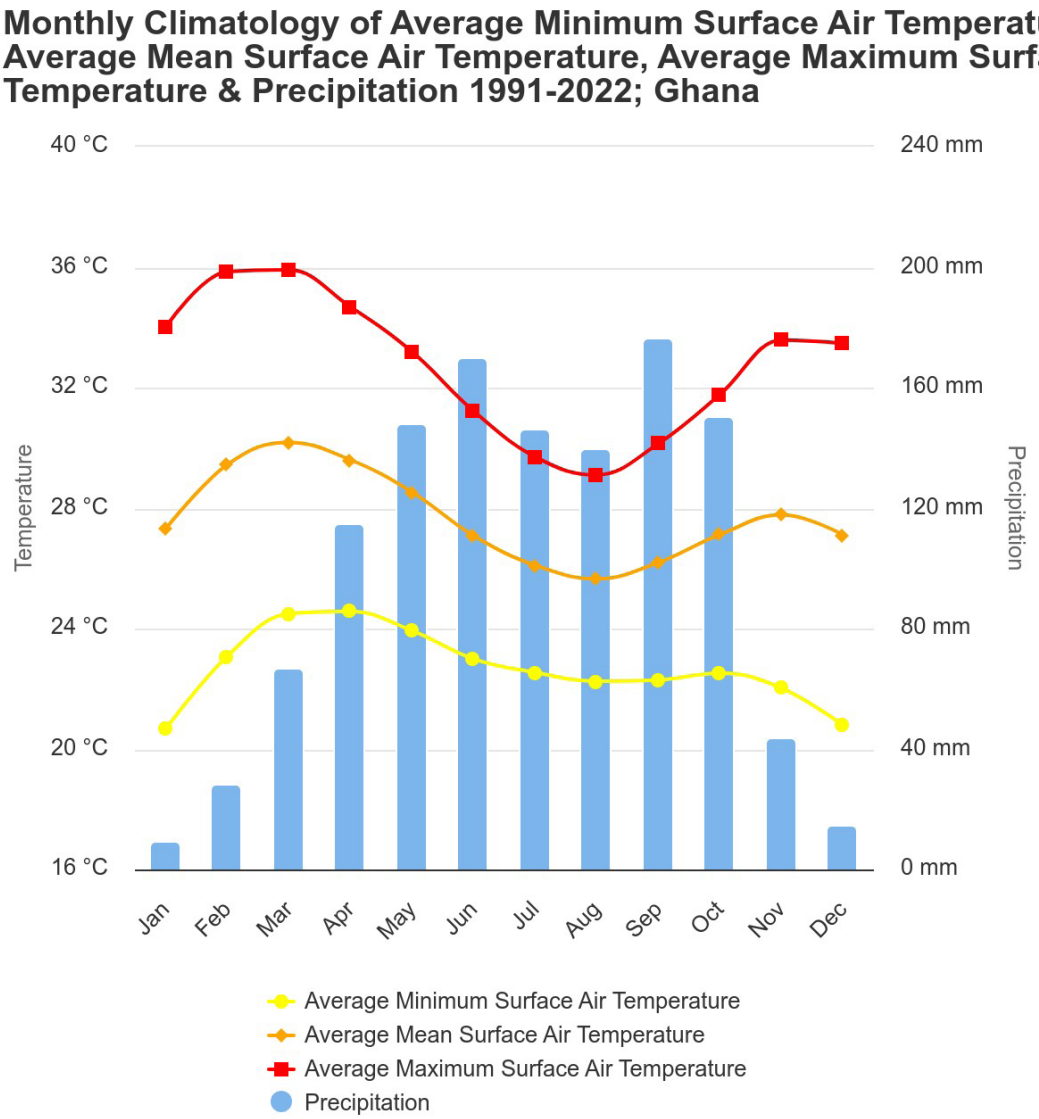
This pattern indicates a primary and secondary rainy season, typical of many tropical climates. The dry season, characterized by higher temperatures and lower rainfall, appears to fall in the early part of the year, particularly January through March. This climatic information is vital for various sectors, including agriculture, public health, and water resource management. The implications of these climate trends are far-reaching, with significant consequences for Ghana's economy, infrastructure, and human well-being. As such, it is essential that climate change mitigation and adaptation strategies are integrated into national development plans and policies.

A warming trend has been evident in Ghana since the 1960s, characterized by increasing variability and several temperature peaks in the late 20th and early 21st centuries. The late 1970s marked the beginning of 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.

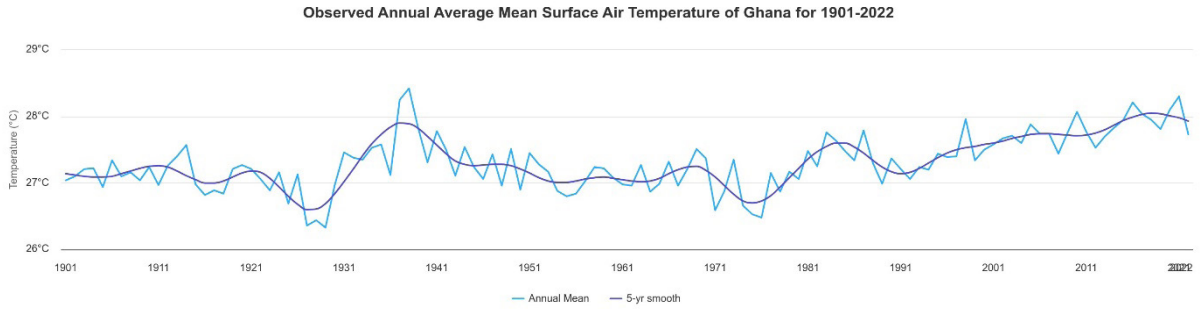
The rising temperatures in Ghana, particularly in areas like Aowin, have far-reaching consequences for farming, including reduced crop yields due to heat stress, decreased water availability, and increased pest and disease prevalence, ultimately threatening livelihoods and food security. Heat stress also affects livestock productivity, while overall economic stability is threatened as these sectors are primary income sources. Furthermore, the costs associated with adapting to these changes can be prohibitively expensive, potentially forcing rural populations to migrate to urban areas, thereby threatening food security and nutrition.

Figure 10: Monthly Climatology of Average Minimum, Maximum, and Mean Surface Air Temperature.



Source: Climate Change Knowledge Portal

Figure 11: Observed annual average mean surface air temperature of Ghana.

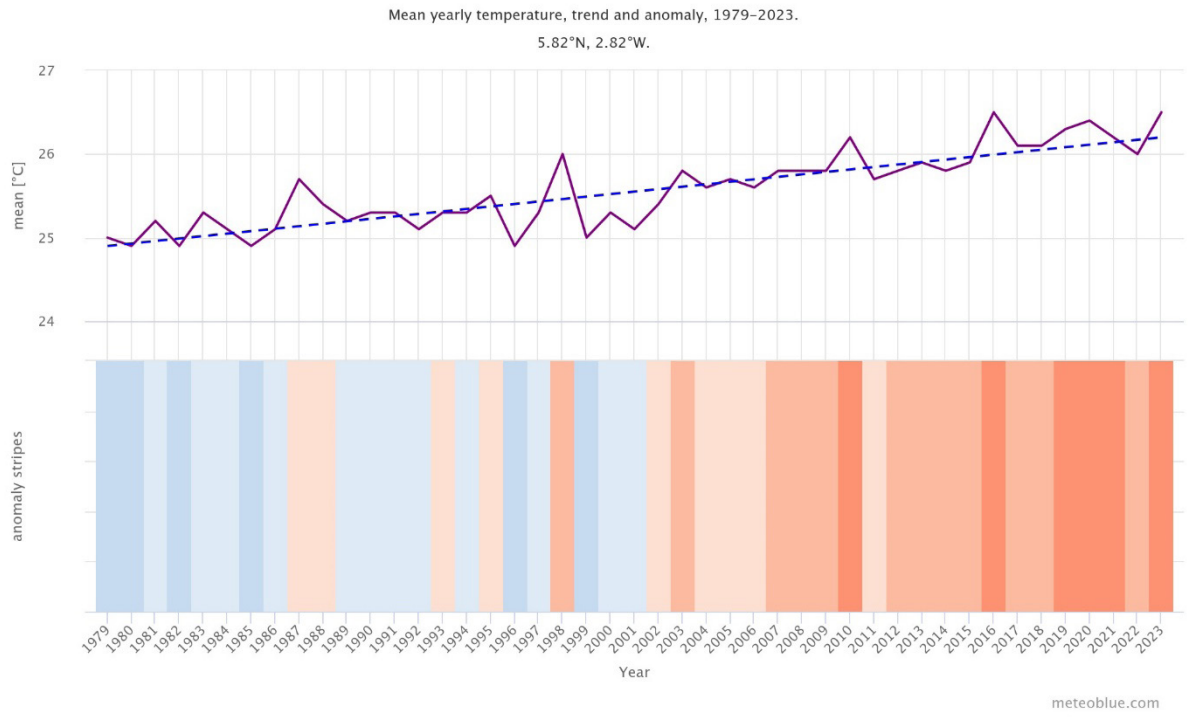


Source: Climate Change Knowledge Portal

6.1 Local Level Observed Climate and Trends

An analysis of the mean yearly temperature for the Aowin municipality, presented in Figure 12, reveals a distinct warming trend. The dashed trend line illustrates a steady increase in the mean yearly temperature over time. Notably, the temperature anomaly stripes transition from cooler shades of blue to warmer shades of red over the years, with a pronounced sequence of warmer years from 2015 to 2023. This observed warming trend is consistent with global climate change patterns, suggesting a rise in temperatures in recent times. Such an increase could have far-reaching consequences for the municipality, including alterations to agricultural cycles, increased energy demands for cooling, and heightened stress on water supplies.

Figure 12: Mean yearly temperature, trend, and anomaly in Aowin municipal.



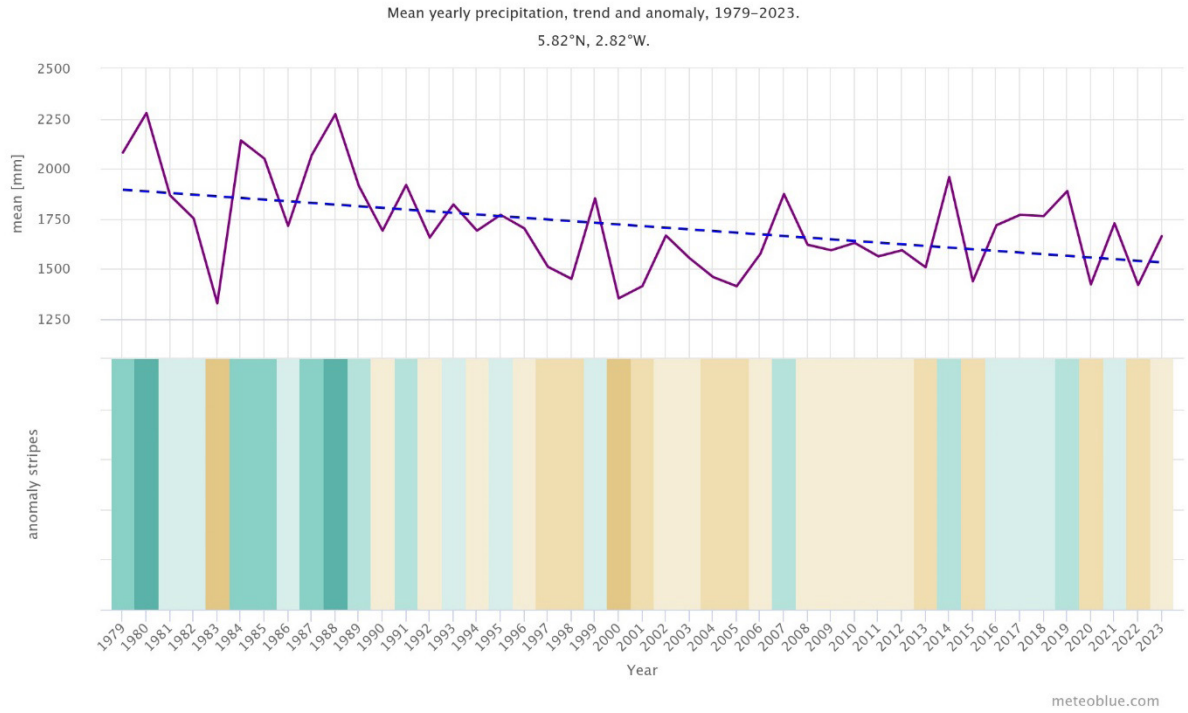
Source: Meteoblue.com, 2024.

Climate data for Aowin municipal over the past several decades reveals a complex scenario of increasing temperatures and fluctuating precipitation patterns. The municipal's rainfall, in particular, has not exhibited a definitive trend, instead oscillating between higher and lower than average yearly precipitation. This variability could potentially lead to alternating periods of flooding and drought. In contrast, temperature trends have

consistently risen, aligning with global warming trends and signaling potential challenges such as heat stress and altered agricultural conditions. Furthermore, monthly climate anomalies emphasize the municipal's susceptibility to variable and extreme weather events, underscoring an urgent need for integrated climate resilience. Figure 12 presents a long-term view of the mean yearly precipitation in the Aowin municipal from 1979 to 2023. This graph illustrates 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. Despite these yearly changes, there was no clear trend towards a consistent increase or decrease in annual rainfall amounts over the period observed.

The anomaly stripes at the bottom of the graph indicated years with above (teal) and below (beige) average rainfall, providing a visual representation of these deviations. Overall, the data suggested that Aowin Municipal experienced variable rainfall, which could have implications for water resource management and agricultural planning due to the potential for both flood and drought conditions.

Figure 13: mean yearly precipitation, trend and anomaly in Aowin municipal.



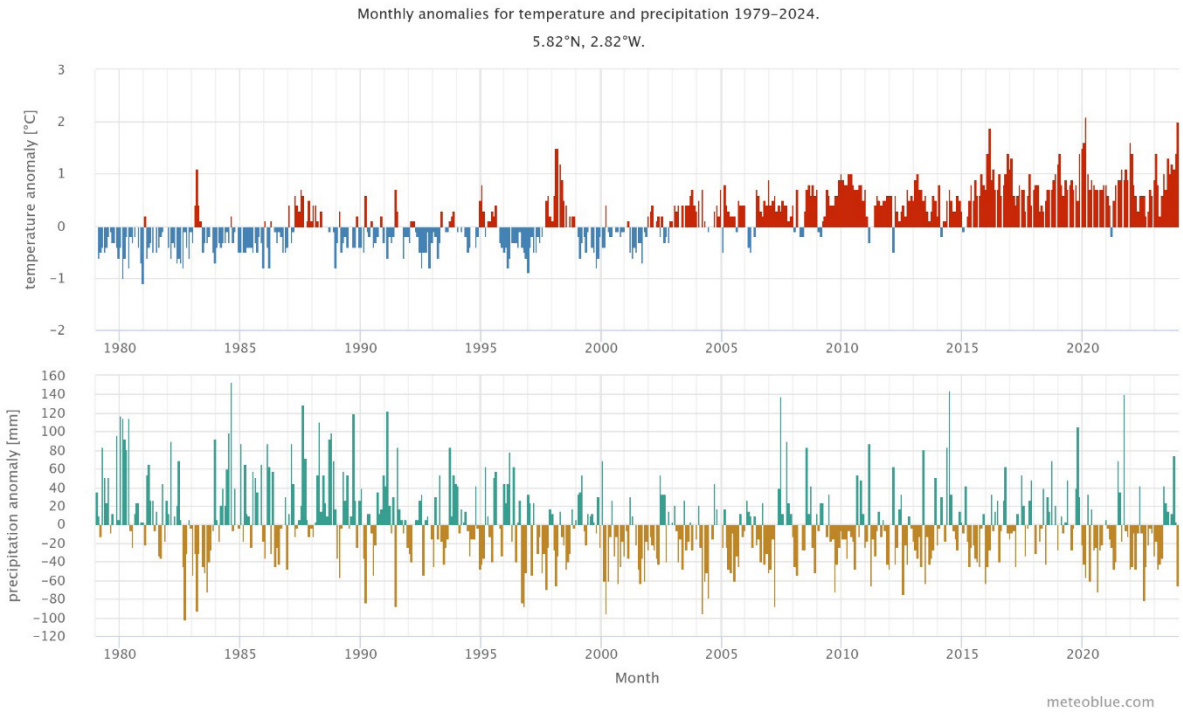
Source: meteoblue.com, 2024.

The temperature anomaly data presented in Figure 13 offers a comprehensive view of monthly temperature deviations from the 30-year climate mean of 1980-2010, spanning from 1979 to the present. The color-coded anomaly indicates warmer temperatures in red and colder temperatures in blue, relative to the established norm. A notable increase in warmer months is observable across most locations, consistent with the global warming associated with climate change. This upward trend in temperature anomalies underscores the significance of climate change in shaping local weather patterns. In addition to temperature anomalies, the lower graph in Figure 13 presents the precipitation anomaly for each month since 1979. This anomaly informs whether a month experienced more or less precipitation than the 30-year climate mean of 1980-2010. The color-coded representation denotes wetter conditions in green and drier conditions in brown, relative to the established norm.

This dual visual representation offers valuable insights into both temperature and precipitation variations over time, contributing to a comprehensive understanding of the climate trends in the specified period. By examining these anomalies, researchers and policymakers can better understand the implications of climate change for local communities and ecosystems.

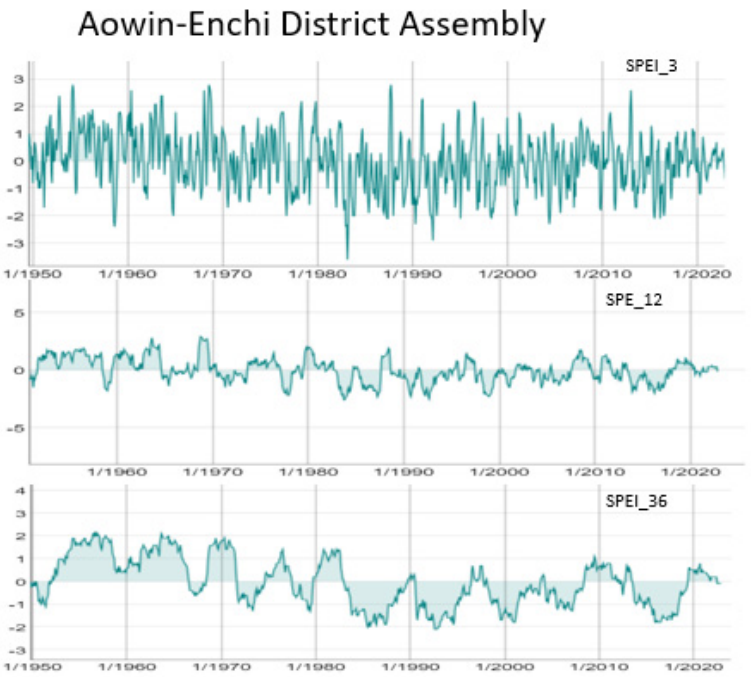
The Standardized Precipitation and Evapotranspiration Index (SPEI) is a preferred approach for analyzing drought conditions, as it effectively accounts for both precipitation and temperature variations in the context of global warming's impact on drought. By incorporating temperature-dependent evapotranspiration, the SPEI provides valuable insights into the changing pressure on water resources. As a metric for measuring water deficit, the SPEI assesses drought severity based on intensity and duration, pinpointing the commencement and conclusion of drought episodes (Beguería, Latorre, Reig, & Vicente-Serrano, 2022). The SPEI values are interpreted as follows: negative values denote dry conditions, signifying increased aridity, while positive values indicate periods of higher precipitation.

Figure 14: Monthly anomality's for temperature and precipitation Aowin municipal.



Source: meteoblue.com, 2024.

Figure 15: observed trends in SPEI



Source: meteoblue.com, 2024

Understanding the SPEI is crucial for the water sector, as it impacts both the quantity and quality of water supply for human consumption and agriculture, as well as for the energy sector, where reduced water availability affects river flow and hydropower generation capacities (The World Bank Group, 2021a). Figure 15 illustrates observed trends in drying (negative SPEI) and wetting (positive SPEI) over three different timescales (3, 12, and 36 months), serving as an indicator of current flood and drought trends. An analysis of the SPEI trends for the Aowin municipal reveals a notable trend towards increasing dry conditions over time, particularly in the past decade, with heightened annual variability. However, data from the past decade, since 2012, suggests a reduction in the drying trend, accompanied by an increase in wetting conditions.

6.2 Observed Natural Hazard and Extreme Events

Ghana's susceptibility to climate-induced hazards, particularly flooding, has become a pressing concern, necessitating a comprehensive understanding of the nation's vulnerability to extreme weather events. The frequency and severity of floods have increased over the years, especially in the northern regions (Atanga and Tankpa, 2021), which are prone to destructive flood events. These events 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. A notable example is the devastating floods of June 2015 in southern Ghana, where heavy thunderstorms led to significant rainfall and flooding in many areas, including Accra. According to Ghana's National Disaster Management Organisation (NADMO), numerous flood events occurred from 2015 to 2020, resulting in hundreds of deaths, injuries, and widespread destruction of property and farmland. 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.

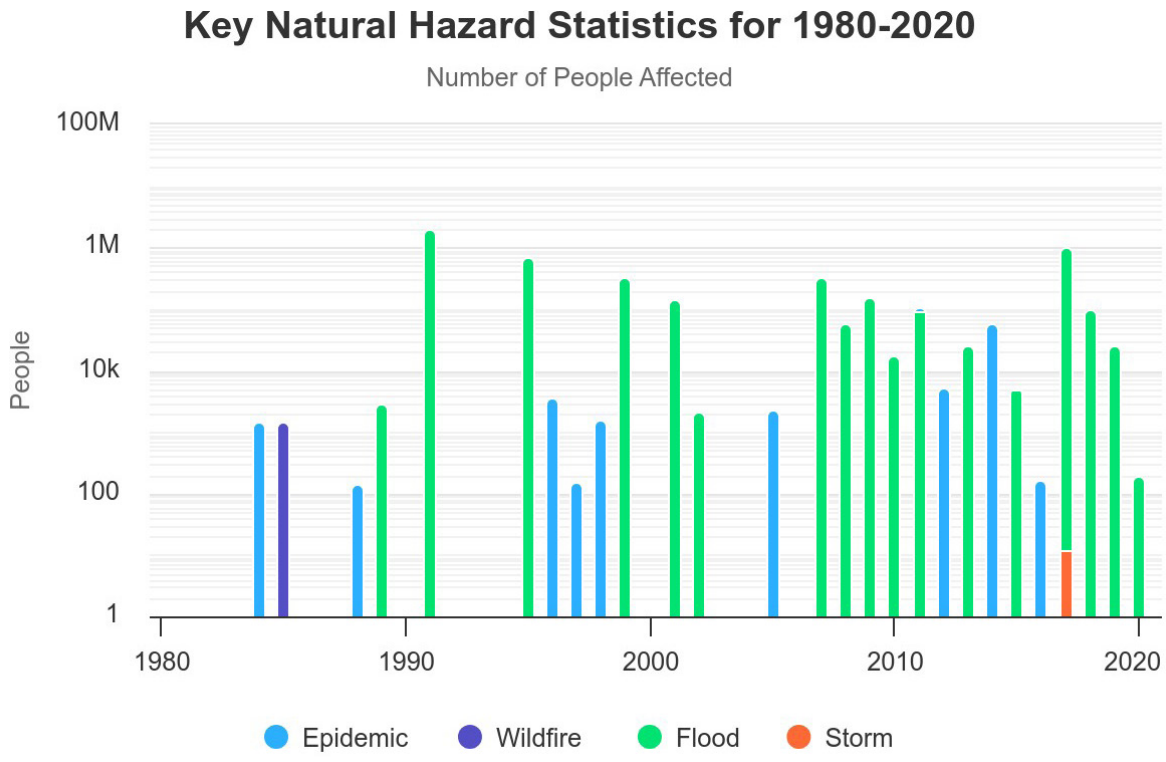
Estimates suggest that over the past 50 years, approximately four million people have been affected by floods in Ghana, resulting in economic damages exceeding $780 million (Ansah et al., 2020; Asumadu-Sarkodie,

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 16 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 municipality, 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. 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.

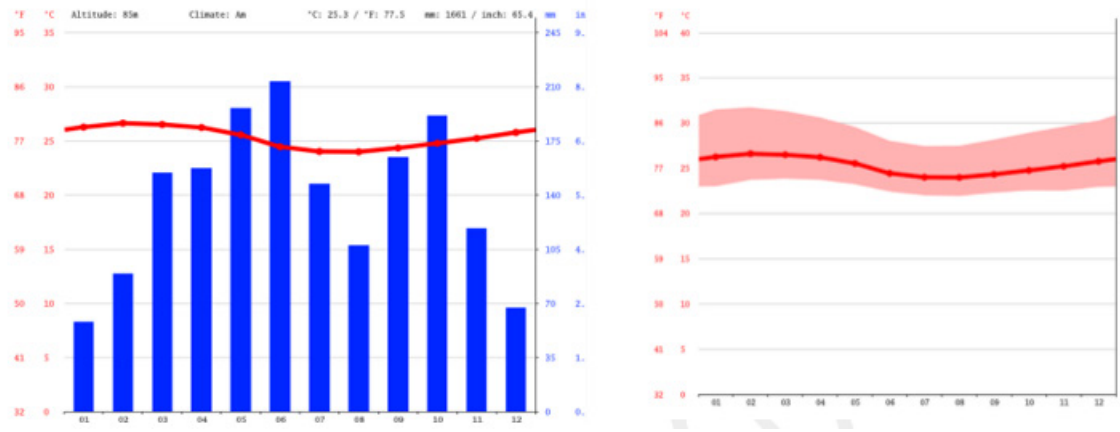
Ghana's climate is characterized by varied weather patterns, with Aowin exhibiting distinct monthly fluctuations. As shown in Figure 17, sourced from Climate-Data.org. January records the lowest rainfall, averaging 58 mm l 2.3 inches, whereas June receives the highest precipitation, peaking at 213 mm l 8.4 inches. Temperature-wise, February is the warmest month, with an average temperature of 26.6 °C l 79.9 °F, while August is the coldest, averaging 24.0 °C l 75.2 °F. The relative humidity also varies significantly, with June recording the highest relative humidity at 88.65%, and January experiencing the least humidity at 76.36%. An analysis of rainfall frequency reveals that October is the wettest month, with 27.33 days of rainfall, whereas January is the driest month, with only 12.63 days of rainfall. This data provides valuable insights into Aowin's climate patterns, which can inform decision-making and planning for climate resilience.

Figure 16: Summary of key Natural Hazard Events for Ghana



Source: WB Climate Change Knowledge Portal

Figure 17: Climate graph-weather and average temperature by month in Aowin 1991-2021.



Source: Climate-Data.org

The Aowin Municipal faces various climate-related hazards that significantly impact its vulnerability. Floods, a recurrent threat, bring about substantial challenges, including extensive displacement and the loss of life. The flooding of homes, destruction of physical infrastructure, and disruption of livelihoods contribute to the heightened vulnerability of the community. Wildfires, particularly domestic fire outbreaks, present another climate-related hazard, affecting both urban and rural areas. These incidents result in the displacement of residents, particularly women and children, and lead to the destruction of business properties, adversely affecting the economic fabric of the community.

Increased rainfall, contributing to flooding, poses a persistent risk to Aowin. This climatic phenomenon results in the pooling of water, causing damage to physical infrastructure such as buildings and homes, as well as farmlands. The consequences extend to the loss of livelihoods and, tragically, the loss of human lives. The vulnerability of the region is further accentuated by extreme heat events, which manifest in reduced food and cash crop production. This climate-induced reduction in agricultural productivity exacerbates food insecurity and economic challenges within Aowin Municipal.

Additionally, historical flood events have had severe implications for the community's resilience. The destruction of houses, crops, roads, and other public infrastructure underscores the region's susceptibility to climate-related hazards. The cumulative impact of these hazards emphasizes the urgent need for adaptive measures and sustainable strategies to enhance the climate resilience of Aowin Municipal.

Table 3: Historical catastrophic hazard events occurred in Aowin municipal and surrounding areas.

Date	Hazardous Event	Location	Impact	Reference
Aug-23	Flood	Bibiani Ahwiaso Bekwai and Aowin Municipality	One fatality, with a total of 3,962 displaced. The heavy rains led to significant flooding, causing displacement and loss of life.	Ghana News Agency, 2023
Nov-20	Wildfires-domestic fire outbreak	Enchi, nyakamam, boinso, new-yakasi	Affected 1,728 people, mainly women and children. Displacement of people, destruction of business properties, and adverse effects on livelihoods.	(NADMO, 2020)
2020	Floods: increased rainfall	Enchi-Accra station, Enchi kramakrom station, Enchi fitting shop, Kwaem business centre	Occurrence of pools of water, destruction of physical infrastructure including ripping off roofs of buildings and destroying homes and properties, farmlands destroyed, loss of livelihood, and human lives.	Ghana Guardian News, 2020
Oct-19	Flood	Enchi-adumline, nakaba, bionso, jema, yakese	Displacement and overflooding of the Disue Riverbanks. The heavy rains rendered hundreds homeless in Enchi, with about 300 persons displaced.	Ghana Web, 2019
Oct-19	River flood	Enchi Township	Three days of heavy rains resulted in the overflow of River Dosue, flooding many homes and farms.	Ghana Web, 2019
2016	Extreme heat	Aowin-Enchi	Reduction in food and cash crop production, increase in crop pests and diseases.	
Jul-10	Flood	Enchi	Approximately 5,000 victims, with Enchi town alone recording 951 victims. Large hectares of farms and houses destroyed, rendering people incapacitated.	Business Ghana, 2010
Oct-Nov 2007	Flood	Aowin-Enchi	Destruction of houses, crops, roads, and other public infrastructure.	Ghana Relief Web, 2007

Box 1: Flooding risk in Aowin Municipal

FLOODING RISK NARRATIVE FOR AOWIN MUNICIPAL

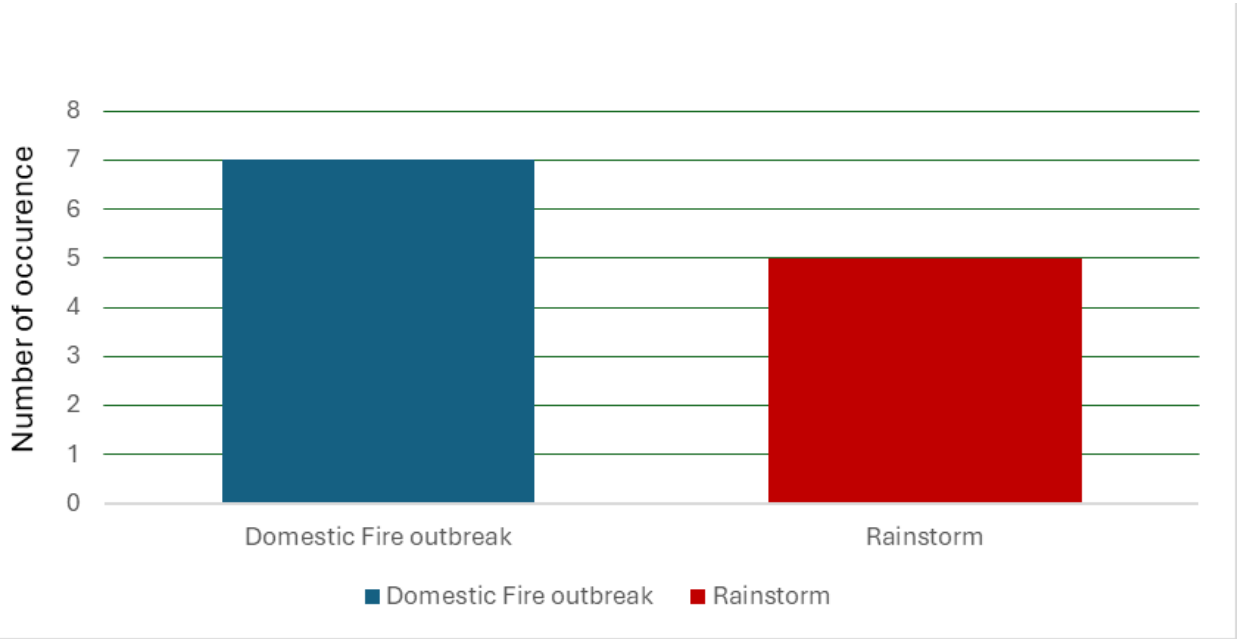
The Aowin Municipal Assembly has faced notable flood events that have significantly impacted its communities and infrastructure. The October to November 2007 floods were particularly the most destructive, causing extensive damage to houses, crops, roads, and other public infrastructure. The heavy rains rendered hundreds homeless in Enchi, with about 300 persons displaced. The river Disue overflowed its banks, further exacerbating the situation.

In recent years, the Aowin municipal has continued to experience climate-related incidents such as severe urban and river flooding, leading to the displacement of populations, property damage, and disruption of essential services. The floods result from increased rainfall, which causes pooling of water and subsequent damage to physical infrastructure and farmlands, further leading to loss of livelihoods and in some cases, loss of human lives. The community's resilience to these climate-related hazards has been tested, with vulnerable groups such as women and children being particularly affected. The distribution of relief items has been reported as inadequate, highlighting a need for more effective disaster response strategies.

The recurrence of such disasters, like the one in 2007, highlights the persistent vulnerability of the Aowin communities to climate-related events. The physical and socio-economic impacts are profound, as displaced victims lose personal belongings and agricultural produce, leading to significant economic setbacks. Moreover, the repeated flood events emphasize the urgent need for adaptive measures and sustainable strategies to enhance the climate resilience of the district.

Illustrated in Figure 18 is a comprehensive overview of the disaster landscape within Aowin Municipality throughout the year 2020. The municipality encountered a total of 12 recorded disasters during this period, highlighting the diverse challenges faced by its communities. The occurrences predominantly involved domestic fire outbreaks and rainstorms, with specific regions such as Enchi, Nyakoman, Boinso, New-Yakasi, and Seven-Miles being notably affected.

Figure 18: Frequencies of Disaster across Aowin Municipality.



Source: NADMO, 2020.

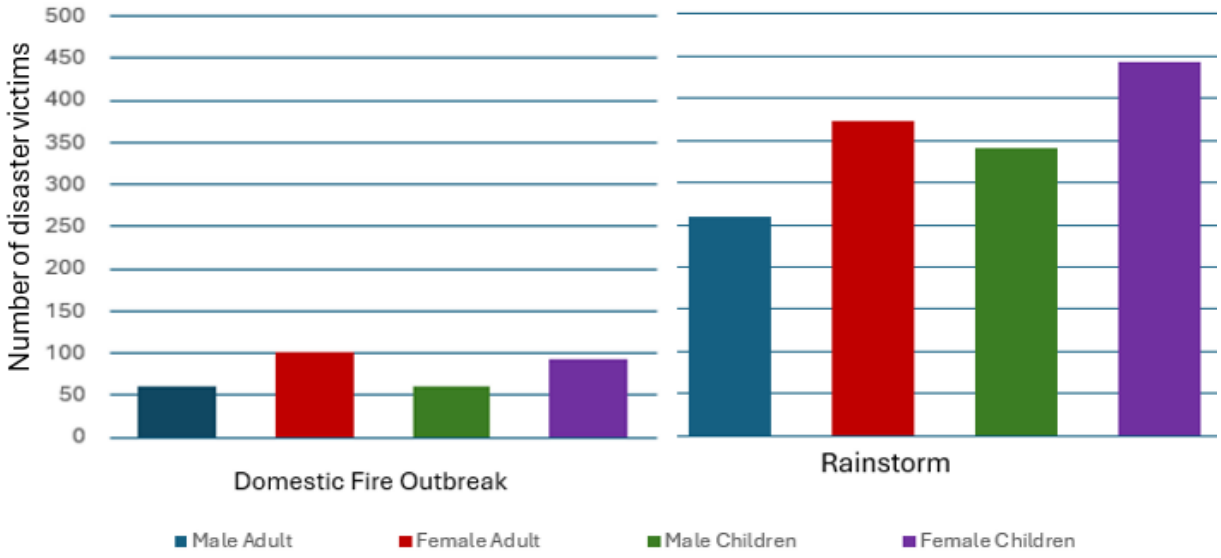
In Figure 19, a detailed breakdown is provided, focusing on the number of victims categorized by disaster type in Aowin Municipality for the year 2020. The first quarter was marked by rainstorms, leading to the tearing off of roofs and subsequent displacement of residents in communities like Boinso, and Nyakamam. Personal belongings were destroyed, emphasizing the need for relief assistance.

The third quarter witnessed a surge in domestic fire outbreaks, affecting communities such as Enchi, Aboagyenor, Motoso Jerusalem, and Seven Miles. These incidents resulted in the loss of personal properties and belongings. According to NADMO 2020, the disasters were particularly concentrated in the third quarter of the year. A significant impact was observed, with a total of 1,729 individuals suffering as victims. Female adults and children were reported to be the most affected demographic. However, the distribution of relief items was reported as inadequate, underscoring the urgency for effective disaster response strategies in the municipality.

Figure 19 is an indication of how floods have been a recurring challenge in Aowin Municipality over time. Photo

The overflow of river bodies such as the Disue in Enchi, triggered by continuous heavy rains, played a significant role in causing floods in various parts of the Municipality.

Figure 19: Number of victims by disaster type in Aowin Municipality.



Source: NADMO, 2020.

6.3. Future climate change projections

Climate modeling has become an essential tool for predicting future climate change scenarios. We can collectively provide a range of plausible climatic futures based on selected Shared Socioeconomic Pathways (SSP) by leveraging an ensemble of climate models. These models offer a diversified view of potential climate trajectories, accounting for uncertainties in climate forecasting. The climate projection data utilized here is based on the Coupled Model Inter-comparison Projects (CMIPs), coordinated by the World Climate Research Programme. Specifically, the data is drawn from the sixth phase of the CMIPs, known as CMIP6, which is the latest collection of global climate models contributing to the Intergovernmental Panel on Climate Change (IPCC) Assessment Reports. CMIP6 underpins the scientific findings of the IPCC's Sixth Assessment Report, offering the most up-to-date scenarios of climate change under various greenhouse gas concentration trajectories.

To ensure the data is both detailed and applicable for regional planning and decision-making, it is presented at a resolution of 0.25° x 0.25°, approximately 25km x 25km. This level of detail enables more localized climate projections, which is critical for municipals like Aowin Municipal Assembly in the Western-north Region of Ghana. Localized climate impacts can have significant implications for agriculture, water resources, infrastructure, and community resilience.

6.3.1 Future Climate Change Projections for Ghana

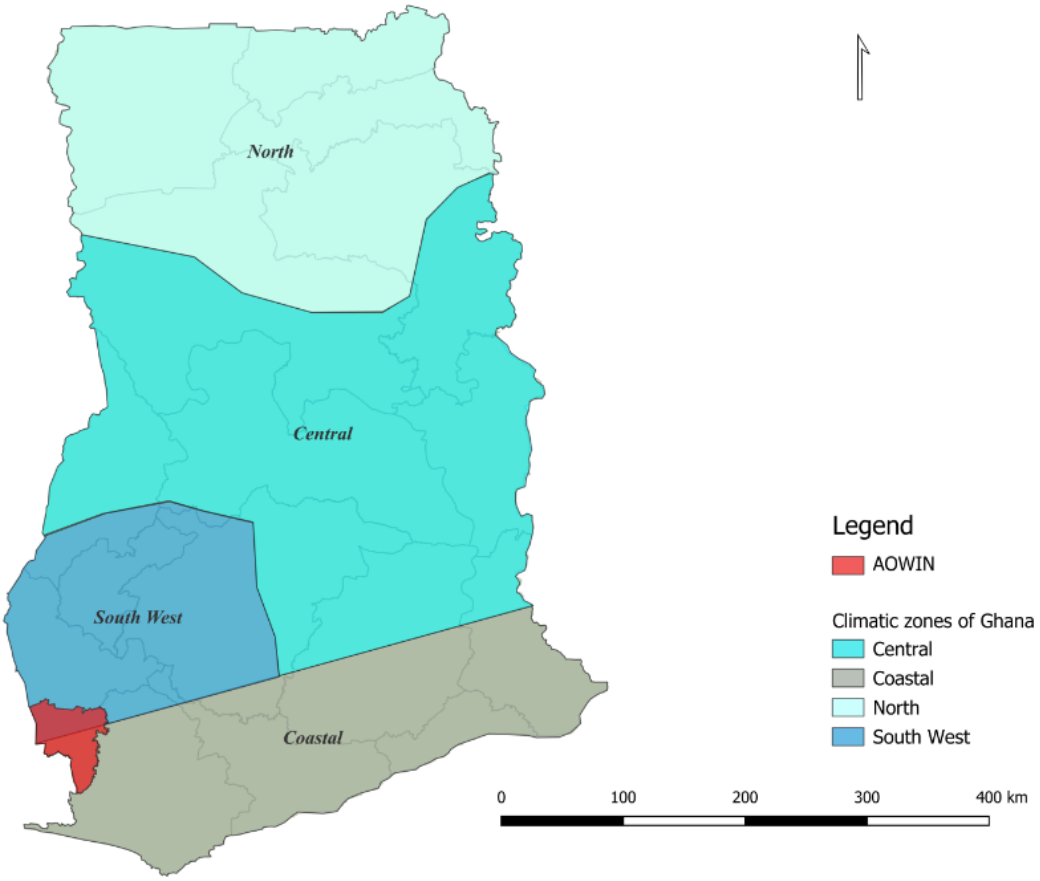
Ghana's future climate projections, as illustrated in Figure 21, provide valuable insights into the country's distinct climate zones. Key findings from these projections include:

- A unanimous consensus across all scenarios indicates that Ghana will experience a significant rise in air temperatures. This warming trend 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. These projections correspond to the RCP2.6/SSP1-2.6, RCP4.5/SSP2-4.5, and RCP8.5/SSP5-8.5 scenarios, respectively. Notably, this projected temperature increase is consistent across Ghana's four climatic zones: Central, Coastal, North, and South-west.

- In contrast, the confidence in projecting future precipitation trends is moderate to low. The projections suggest only minor changes in precipitation patterns, which may be marginally more significant than the historical variability observed in the past. This finding holds true across all emission scenarios. However, the uncertainty in these precipitation projections stems from discrepancies between observed historical rainfall data and the models' ability to simulate past rainfall trends accurately.

To facilitate the analysis of future climate change scenarios, Ghana was divided into four distinct climate zones, each characterized by relatively homogeneous climate conditions in terms of interannual variability **(Figure 20)**

Figure 20: The four climate zones, where it is possible to observe that the Aowin Municipal assembly is in the southwest zone.



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These zones - North, Central, Southwest, and Coastal - were identified through a comprehensive analysis of trends in observed climate data, as well as similarities in expected changes due to climate change. The identification of these homogeneous climate zones enables the prediction of similar responses to future climate change under various global emission scenarios. Consequently, the expected changes can be translated to the level of individual Metropolitan, Municipal, and Municipal Assemblies (MMDAs) or individual eco-regions, providing valuable insights for climate change mitigation and adaptation strategies

6.3.2 Future Climate Change Projections for Western North Region and Aowin municipal.

6.3.2.1 Temperature

The Western North Region of Ghana, including Aowin Municipal, is expected to experience significant temperature changes in the coming decades. Figures 21 (a, b, and c) provide a comprehensive overview of temperature projections for the region, illustrating mean, maximum, and minimum surface

air temperatures. The graphs offer valuable insights into potential future temperature deviations from historical patterns. The graphs feature lines representing different Shared Socioeconomic Pathways (SSP) scenarios, each corresponding to a distinct greenhouse gas emissions trajectory. The black line in each graph represents the historical reference period (1950-2014), providing a baseline for comparing future climate projections. The colored lines denote different SSP scenarios, which describe potential global societal, demographic, and economic developments over the 21st century, influencing greenhouse gas emissions and climate change. These scenarios include:

- **SSP1-2.6 (blue line):** Represents a low-emissions pathway, assuming aggressive reductions in greenhouse gas emissions, leading to a relatively modest temperature increase.
- **SSP2-4.5 (orange line):** Embodies a moderate-emissions scenario, where some efforts are made to curb emissions, resulting in moderate temperature rises.
- **SSP3-7.0 (red line):** Signifies a high-emissions pathway, marked by inadequate mitigation efforts, leading to more pronounced temperature increases.
- **SSP5-8.5 (pink line):** Depicts the highest-emissions scenario, assuming little to no climate action, resulting in the most substantial temperature increases and a significantly warmer future.

Projected mean Surface air temperatures

Figure 24a illustrates the projected mean surface air temperatures, revealing a relatively stable trend until the present day. Beyond 2014, the four SSP scenarios diverge, presenting distinct temperature pathways:

- The low-emission scenario (SSP1-2.6, blue line) predicts the smallest temperature increase, indicating successful global mitigation efforts and climate policies. This scenario suggests a gradual, moderate rise in temperatures.
- The middle-ground scenario (SSP2-4.5, orange line) anticipates some climate policy action, but with less urgency than SSP1-2.6. Temperature increases are more pronounced, indicating a warmer future within a manageable range.
- The high-emission scenario (SSP3-7.0, red line) assumes inadequate global climate action, resulting in steep temperature increases. This scenario suggests a world with more extreme heat and associated impacts.
- The highest emission scenario (SSP5-8.5, pink line) assumes unchecked global emissions, leading to the most substantial warming. This scenario predicts a severe temperature rise, far exceeding historical averages by the end of the century.

The shaded regions around each line represent uncertainty within each scenario, illustrating the range of possible outcomes influenced by factors such as technological advancements, socio-economic changes, and natural climate variability.

The projected warming trend for the Aowin Municipal underscores the urgency for enhanced preparedness and adaptation strategies. Key sectors, such as agriculture, infrastructure, public health, and natural resource management, which are highly vulnerable to rising temperatures, require immediate attention to mitigate the impending impacts of climate change.

Projected maximum surface air temperatures

Figure 21b displays the projected average maximum surface air temperature for the Western Region of Ghana, including the Aowin municipal, 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 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 Aowin municipal.

The uncertainty within each scenario is represented by the shaded regions surrounding each line, illustrating the range of possible outcomes influenced by various factors such as technological advancements, socio-economic shifts, and natural climate variability.

For the municipal, 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 Enchi, Nyakoman, Yakasi, susan, achimfo.

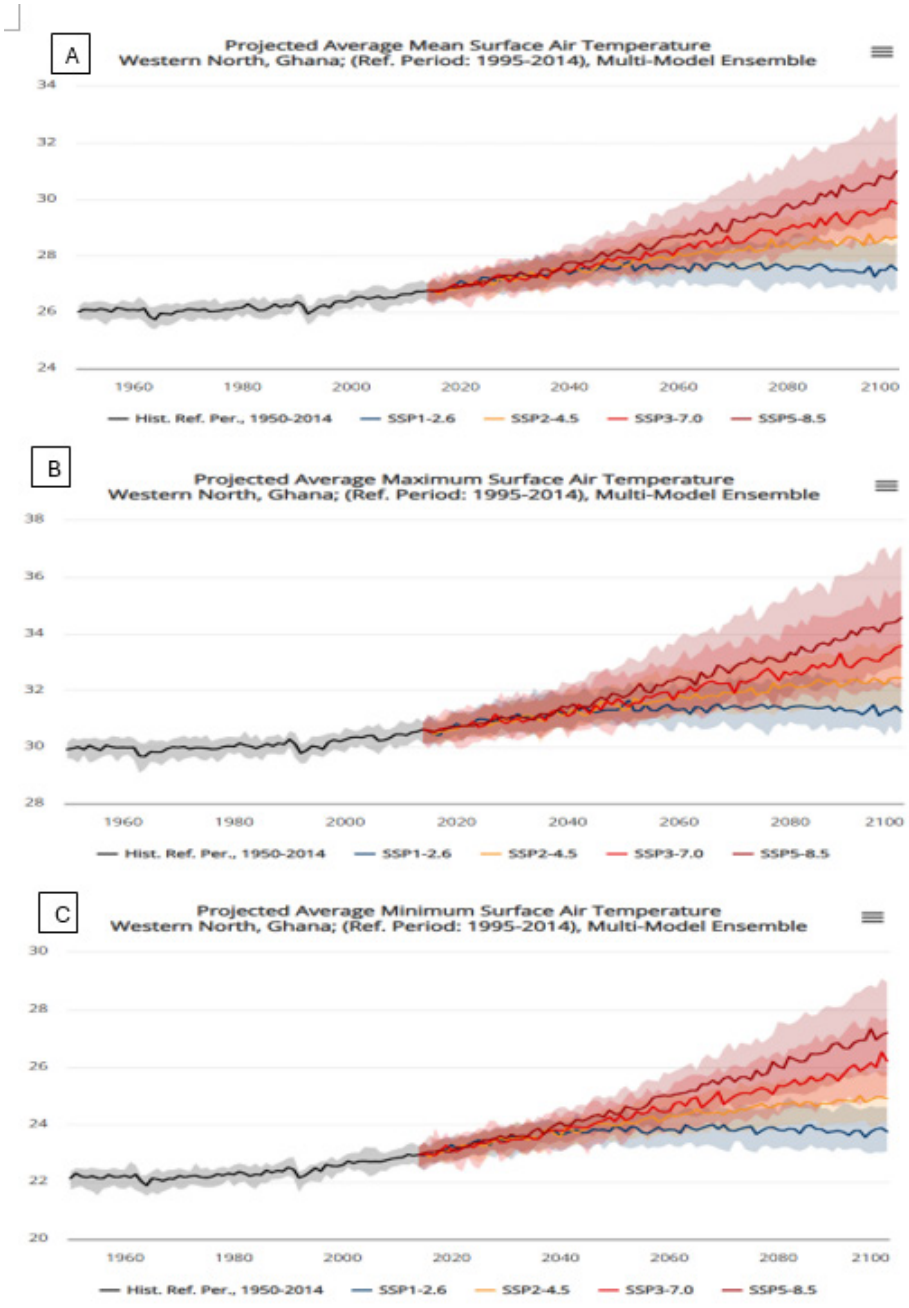
Projected minimum surface air temperatures

Figure 21c illustrates the projected minimum surface air temperatures for the Western North Region. The historical reference period (1950-2014) is depicted by the black line, showing the average minimum temperatures experienced historically. The future projections under the SSP scenarios are as follows:

- **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 on all aspects of life and necessitate urgent adaptation measures.

Climate projections for the Aowin Municipal are subject to uncertainties, which are represented by the shaded areas around each projection line. These uncertainties are inherent in climate modeling and highlight the range of possible minimum temperature changes within each scenario. Temperature increases in the Aowin Municipal are expected to range from 1.5/2.0 °C under RCP 2.6 to 3/4 °C under RCP 8.5, with RCP 4.5 indicating a midpoint of approximately 2/2.5 °C by the end of the century. RCP 8.5 signifies a notable escalation in temperature. Moreover, incorporating CMIP 6 into the plume plots suggests an additional temperature increase of at least 0.5 °C. The CMIP 6 projections also reveal a risk of significantly higher temperatures in the southwest zone, even under lower greenhouse gas concentration scenarios.

Figure 21: Future Climate Change Projections for Western North Region and Aowin municipal. (a) projected mean surface air temperatures (b). projected maximum surface air temperatures (c). projected minimum surface air temperatures



The uncertainty within each scenario is represented by the shaded regions surrounding each line, illustrating the range of possible outcomes influenced by various factors such as technological advancements, socio-economic shifts, and natural climate variability.

For the municipal, 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 Enchi, Nyakoman, Yakasi, susan, achimfo.

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- **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 on all aspects of life and necessitate urgent adaptation measures.

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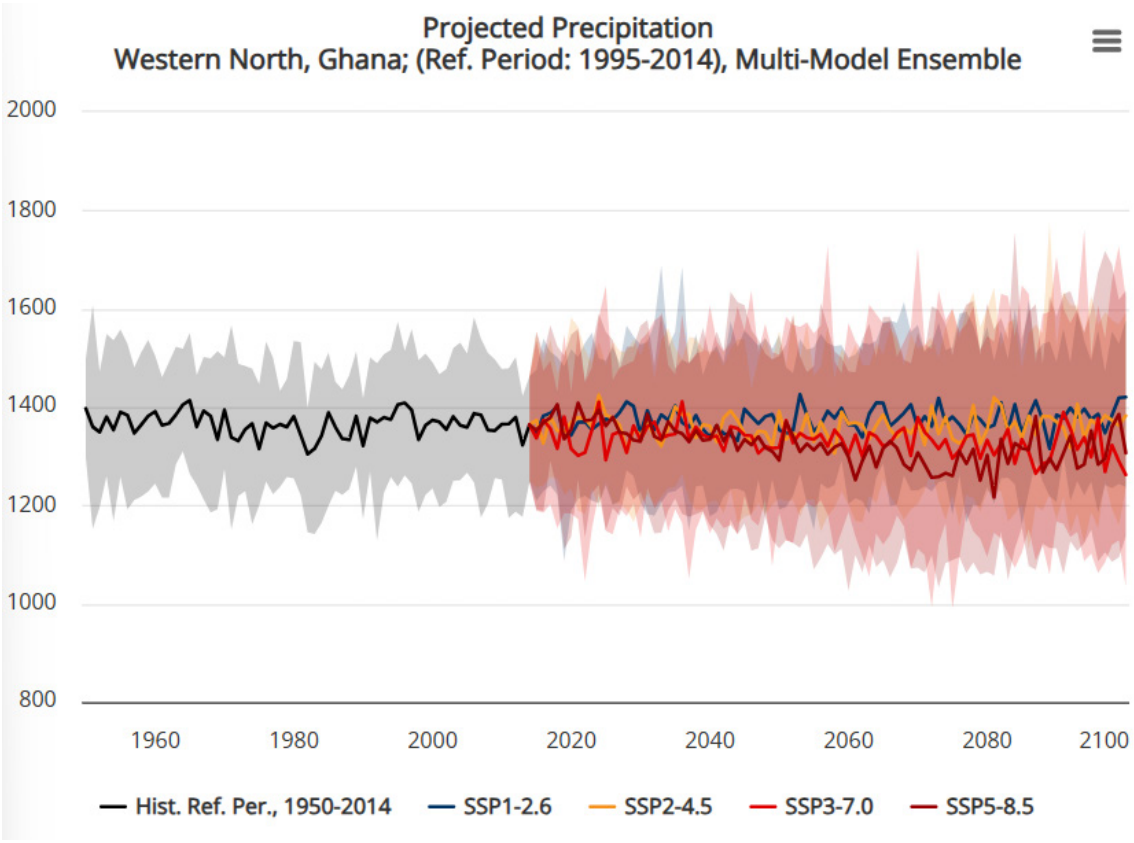
6.3.2.2 Precipitation

Figure 22 displays the historical precipitation levels, represented by the black line and grey area, which serve as a foundation for understanding future precipitation trends. Beyond 2014, the graph illustrates a divergence in projections across different SSP scenarios, highlighting distinct potential pathways for future precipitation patterns.

Figure 22: Projected precipitation patterns for the Western Region and Aowin municipal.



- **SSP1-2.6 (blue line):** This scenario suggests that robust climate policies could lead to relatively modest changes in precipitation patterns, with some variation but overall stability in rainfall rates.
- **SSP2-4.5 (orange line):** Under this moderate emissions scenario, some policy interventions are assumed, leading to increased variability in precipitation rates, with fluctuations above and below historical averages.
- **SSP3-7.0 (red line):** This higher emissions scenario, characterized by inadequate climate change mitigation efforts, is marked by a wider range of uncertainty, potentially leading to more frequent periods of excessive rainfall and significant droughts, impacting agriculture and water resource management in Aowin Municipal.
- **SSP5-8.5 (pink line):** Assuming the highest emissions without significant climate mitigation efforts, this scenario projects the largest variability and most extreme changes in precipitation patterns, implying a future with increased likelihood of severe weather events, including intense rainfall and prolonged dry periods.

Annual average precipitation projections reveal a nuanced outlook, with roughly equal chances of slight increases or decreases from the baseline period. Variations are generally expected to fall within a 10% increase or decrease range. However, more pronounced fluctuations are possible, with potential deviations reaching up to +/- 20%. The comparison between projected scenarios and observational data demonstrates satisfactory alignment, particularly at the Representative Concentration Pathway (RCP) 2.6 level. This suggests that scenarios at this level provide a credible reflection of anticipated variability in precipitation patterns. Conversely, projections at RCP 4.5 and RCP 8.5 indicate a greater likelihood of significant rainfall increases. Under these pathways, the region may experience rainfall amounts 20-30% higher than historical averages, emphasizing 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 essential for the Aowin Municipal, as they offer tailored climate projections that account for the municipal's unique geographical and socio-economic characteristics. The significance of these scenarios can be attributed to the following factors:

- ***Precision in Local Climate Projections:*** Downscaling global climate models allows for a finer spatial resolution, which can capture the local climate variations within the Aowin municipal. This is especially important given the diverse topography and microclimates within the municipal, 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 municipal 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. Downscale scenarios help to identify the areas within the municipal 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 municipal'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 municipal, community and household, they are more likely to engage in sustainable practices and support policy changes. Downscale scenarios facilitate community education and participatory adaptation processes.
- ***Economic Stability and Livelihoods:*** The Aowin municipal economy, particularly cash crop farming, is sensitive to climate variations. Downscale 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:*** In each of the downscaled scenarios, knowledge of the local gender vulnerabilities to climate change is useful as they provide a comprehensive understanding of the impact on the various gender groups as they persist in the local communities. This ensures 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

The Aowin municipal is expected to experience significant climate-related changes, which will have far-reaching implications for the municipal's agriculture, health, and overall well-being. The effects of global climatic trends on key climate variables in the municipality are discussed below:

6.4.2.1 Temperature

Temperature increases in the Aowin municipal area are projected to range from 0.5 to 4.5 °C, depending on the emissions scenario. This warming trend will have significant implications for agricultural cycles, disease prevalence, and human comfort in the municipality.

Rising temperatures are likely to alter crop phenology, potentially extending the growing season for some crops. The impact on cocoa production in the Aowin Municipal area is a critical concern, given the crop's sensitivity to climatic conditions. Cocoa trees thrive in a narrow temperature range of 18°C to 32°C. Projected temperature increases suggest that areas within Aowin could experience temperatures exceeding the optimal range for cocoa cultivation, leading to adverse effects such as:

1. **Heat Stress on Cocoa Trees**: Exceeding the upper threshold of the temperature range can lead to heat stress on cocoa trees. Heat stress can impair photosynthesis, stunt growth, and reduce the overall health of the trees, leading to decreased cocoa bean quality and yields.
2. **Increased Pests and Diseases**: Warmer temperatures might expand the range and increase the lifecycle speed of pests and pathogens that affect cocoa trees. For example, higher temperatures are favourable for the proliferation of the cocoa mirid, a significant pest, potentially leading to increased use of pesticides and associated costs.
3. **Water Stress**: Rising temperatures typically lead to higher evapotranspiration rates, which can exacerbate water stress during dry seasons. Cocoa trees are particularly susceptible to drought, and insufficient water availability can severely impact pod development and bean size, directly affecting crop yields.
4. **Alteration of Suitable Growing Areas**: Over time, the cumulative effect of increased temperatures may shift the geographical zones suitable for cocoa cultivation, potentially reducing the land area within Aowin suitable for cocoa farming.
5. **Economic Implications**: Given that cocoa is a major source of income for farmers in Aowin, any impact on cocoa production due to unfavourable temperature projections has direct economic implications, potentially reducing income and affecting livelihoods.

Higher temperatures can also facilitate the proliferation of vector-borne diseases such as malaria in the municipality. 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 municipal rich biodiversity, including its forest and species ecosystems, which usually attracts tourists 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 projected increase in average temperatures will lead to a rise in extreme heat days, pushing temperatures beyond historical peaks. This poses a multifaceted threat to the Aowin Municipal, where

communities' livelihoods are deeply connected to the land. Traditional livelihoods, such as farming, are typically outdoor activities that become increasingly hazardous under extreme heat conditions. As temperatures soar, crop productivity may decline, and some crops may not tolerate the higher temperatures. This could necessitate a shift to heat-tolerant varieties, potentially indigenous to other regions or developed through agricultural research.

Cocoa, a temperature-sensitive crop, may experience reduced yields, prompting farmers to explore alternative crops or farming methods. The resulting decrease in food crop yields could reduce household food availability, affecting nutrition, particularly for vulnerable groups such as pregnant women, children, and the elderly. Furthermore, the increased heat will lead to higher energy consumption as households and businesses rely more heavily on cooling systems, driving up electricity demand and associated costs.

6.4.2.3 Precipitation

The Aowin Municipal's semi-equatorial climate has historically provided a relatively predictable rainfall pattern, allowing farmers to schedule agricultural activities with confidence. However, climate change is projected to disrupt this predictability, with downscaled climate scenarios forecasting less reliable rainfall patterns. This shift poses significant challenges to the local agricultural sector, particularly for crops like cocoa, which is highly sensitive to changes in moisture availability. Traditional cocoa farming practices, such as timing planting to coincide with the onset of the rainy season, may no longer be effective. Instead, farmers face the risk of planting too early or too late, resulting in crop failure due to drought or root rot from excessive rainfall.

Furthermore, changing precipitation patterns may increase the prevalence of cocoa diseases, such as black pod, which thrive in wet conditions. This could impact yields and quality, exacerbating the challenges faced by cocoa farmers. Oil palm, another significant crop in the Aowin Municipal, also requires consistent rainfall throughout the year. Prolonged dry spells may decrease oil palm yields, affecting both large agribusinesses and smallholders who rely on this crop for income. Conversely, more frequent heavy rainfall events may lead to soil erosion and nutrient leaching on slopes where oil palms are grown, resulting in long-term declines in productivity.

6.4.2. 4 Extreme Rainfall.

Projected increases in extreme rainfall pose a significant threat to the Aowin Municipal. Heavy downpours are likely to result in severe flooding, with rivers such as the Bisue potentially overflowing and submerging nearby communities, as evidenced in recent events. These floods caused extensive damage to infrastructure, erode fertile topsoil critical for agricultural productivity, and disrupt daily life, as outlined in Table 4. Rural infrastructure, including road networks vital for transporting farm produce to markets and enabling access to schools, faces a heightened risk of destruction or becoming impassable, thereby cutting off essential socio-economic connections. Moreover, heavy rainfall degrades water quality by washing agrochemicals from farmland into water bodies, posing serious health risks to residents.

Table 4:Climate Change Mitigation and Vulnerability Analysis

Communities likely to be affected by disasters	Type of Risks	Population	Number of people likely to be affected	Key infrastructure likely to be affected	Water channels/ Rivers/ Streams
Omanpe	Flood	3,000	558	Farmlands/Houses	Ndoli streams

Communities likely to be affected by disasters	Type of Risks	Population	Number of people likely to be affected	Key infrastructure likely to be affected	Water channels/ Rivers/ Streams
Jema	Rainstorm	5,077	391	Houses	Pakyemogye stream
Amonie Nkwanta	Food	1,818	74	Farmlands/Houses	Kasolo stream
Nyankamam	Flood	2,707	81	Farms	Olou stream
Old Yakasi	Flood	1,682	803	Farmlands/Houses	Dosue River
Banaso	Flood/ Rainstorm	975	120	Farmlands/Houses	Yaw stream
Susan	Flood	680	68	Farmlands/Houses	Susan stream

Source: Source: MTDP, 2022

7 Potential Impacts for Priority Risk Domains

7.1 Initial Assessment of Critical Climate Related Hazard

In the Aowin Municipal Assembly, the assessment of various climate-related hazards have been conducted using data derived from the ThinkHazard! Tool (ThinkHazard!, 2023; **Table 1**). These hazard levels from the ThinkHazard! report was by the experiential accounts of local stakeholders participating in the municipal workshops and the study team's fieldwork observations of past and present hazards. Their observations and experiences provide valuable ground-truthing to the modelled data, highlighting the real-world implications of these climate-related hazards for the Aowin municipal.

The evaluation of these hazards provides insight into potential risks that may affect the communities and households in the Aowin Municipal Assembly **(Table 5).**

Table 5: Summary of critical climate related hazards for Aowin Municipal Assembly from ThinkHazard! Tool and stakeholder engagement

Hazard	River Flood	Urban flood	Water Scarcity	Extreme Heat	Wildfire
Level					

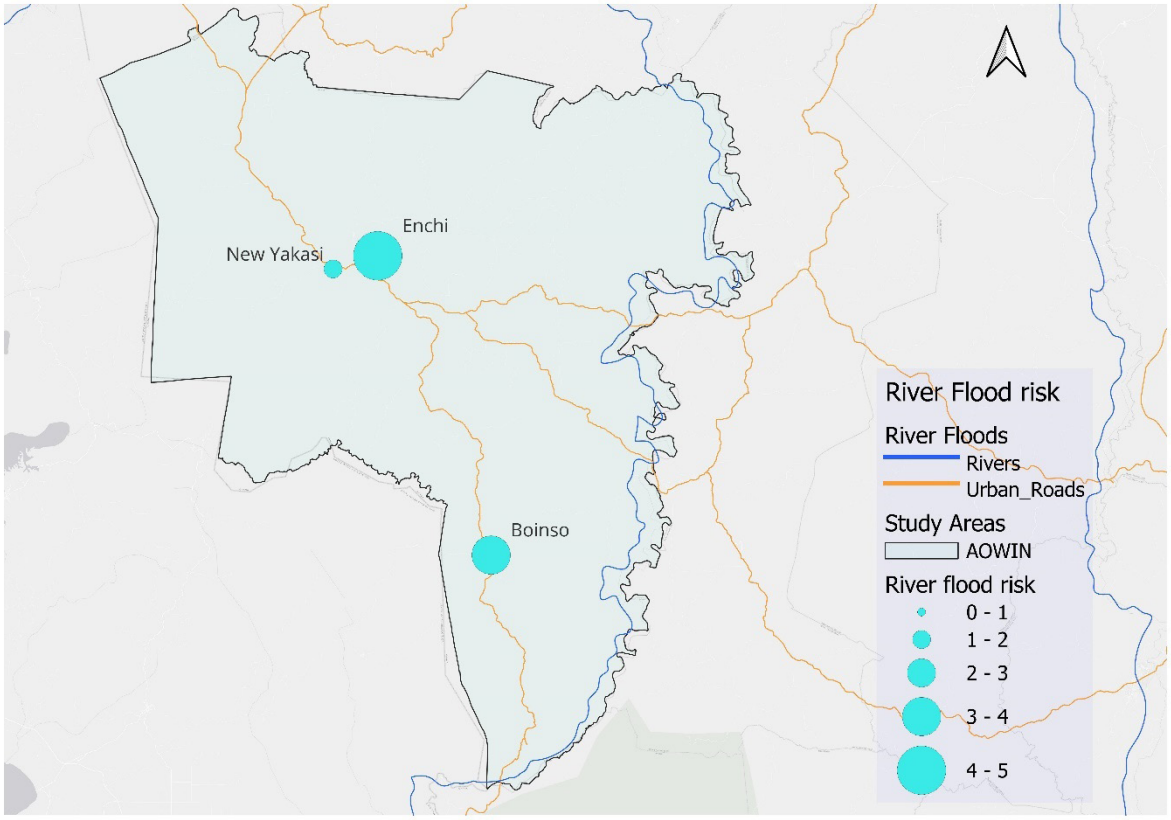
Interpretation	High	High	Medium	Medium	High

Source: ThinkHazard! (Global Facility for Disaster Reduction and Recovery (GFDRR), 2022).

7.1.1 River flood hazard

The risk of river flooding in Aowin Municipal Assembly is classified as high, indicating a significant likelihood of destructive and potentially life-threatening events. As shown in Figure 23, Enchi faces the highest risk (rated 5), followed by Boinso (4) and Aboagyenor (3). These communities have historically experienced severe flooding during the rainy season, resulting in the destruction of homes, displacement of residents, and disruption of livelihoods.

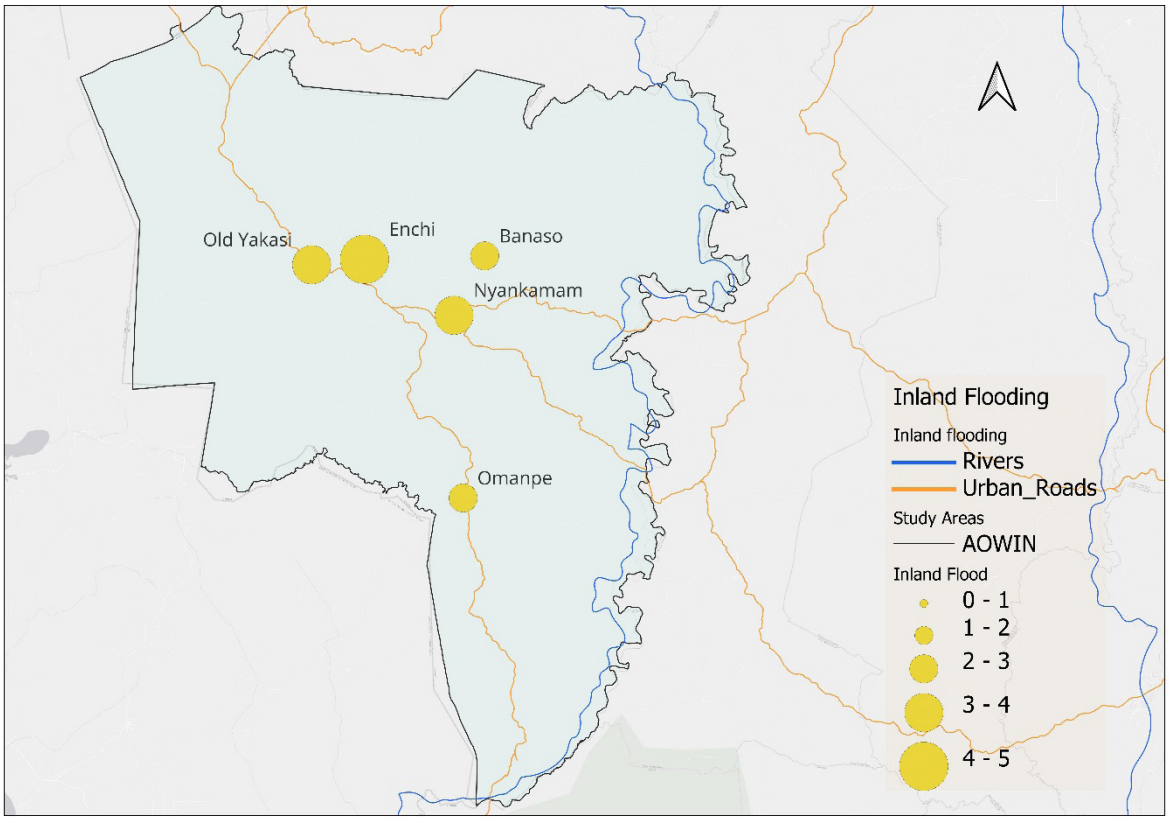
Figure 23. Severity and Frequency of River Floods in Aowin Municipal Assembly.



7.1.2 Urban flood hazard

Urban flooding in Aowin Municipal is also classified as high, suggesting that damaging floods are likely to occur within the next decade. Contributing factors include rapid urbanization, inadequate drainage systems, and unsustainable land-use practices. Figure 24 highlights Enchi (5) and Old Yakasi (4) as the most flood-prone areas.

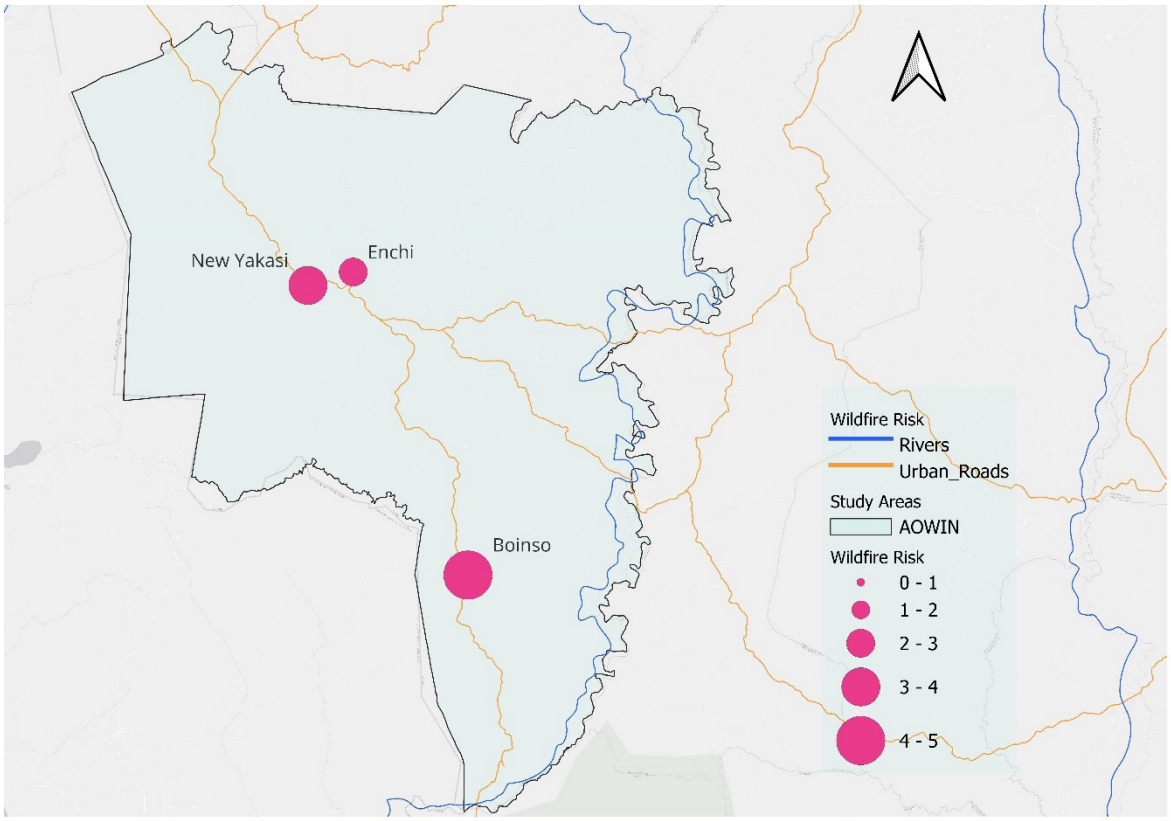
Figure 24. Severity and Frequency of Urban Floods in Aowin Municipal Assembly



7.1.3 Wildfire hazard

The wildfire hazard in Aowin Municipal is rated as high, with bushfires increasingly threatening farming communities and ecosystems. Figure 25 identifies Boinso (5) and New Yakasi (4) as the most vulnerable areas, while Enchi and Jerusalem (3) face moderate risk. These wildfires endanger lives, destroy property, and disrupt agricultural activities, emphasizing the urgent need for comprehensive wildfire management and mitigation strategies.

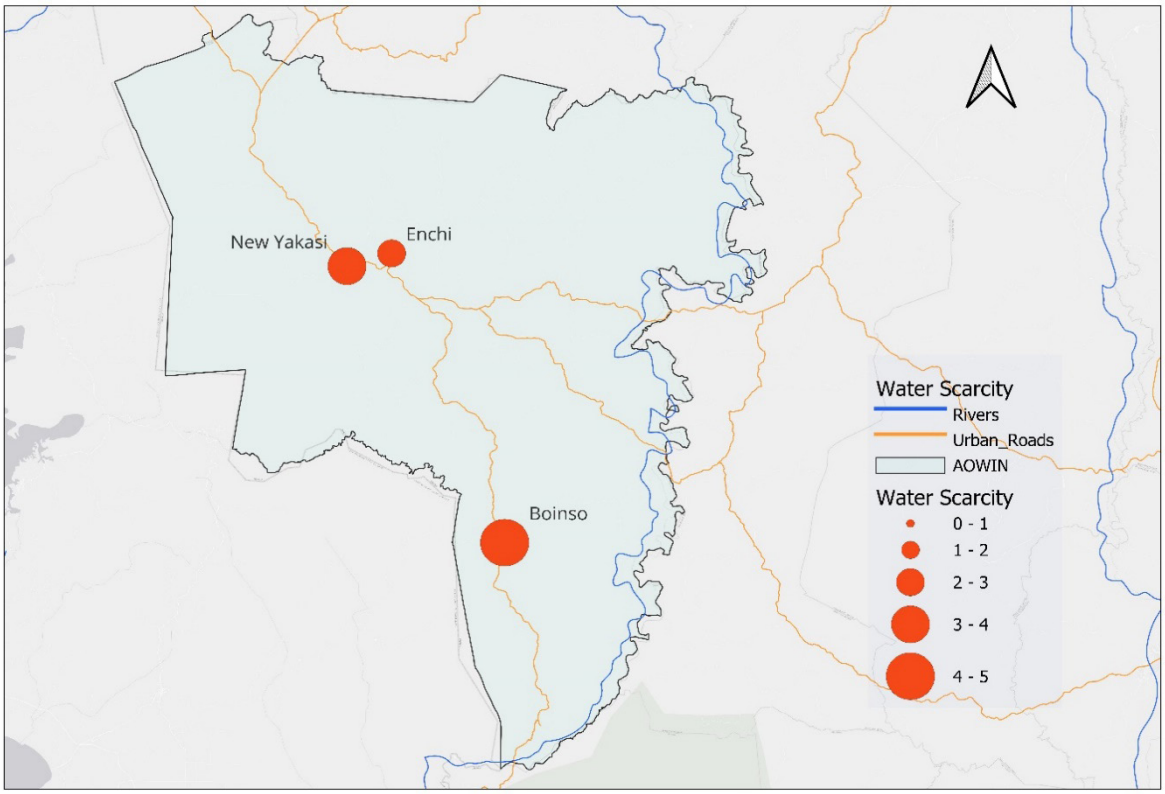
Figure 25: Severity and Frequency of Wildfires in Aowin Municipal Assembly



7.1.4 Water scarcity

Water scarcity in Aowin Municipal is classified as a medium hazard, reflecting challenges despite the municipal's significant rainfall. Deforestation, land degradation, and shifting rainfall patterns have contributed to localized water shortages. Figure 26 shows that Boinso (5) and Aboagyenor (4) are the most severely affected areas, with Enchi and Jerusalem (3) experiencing moderate vulnerability.

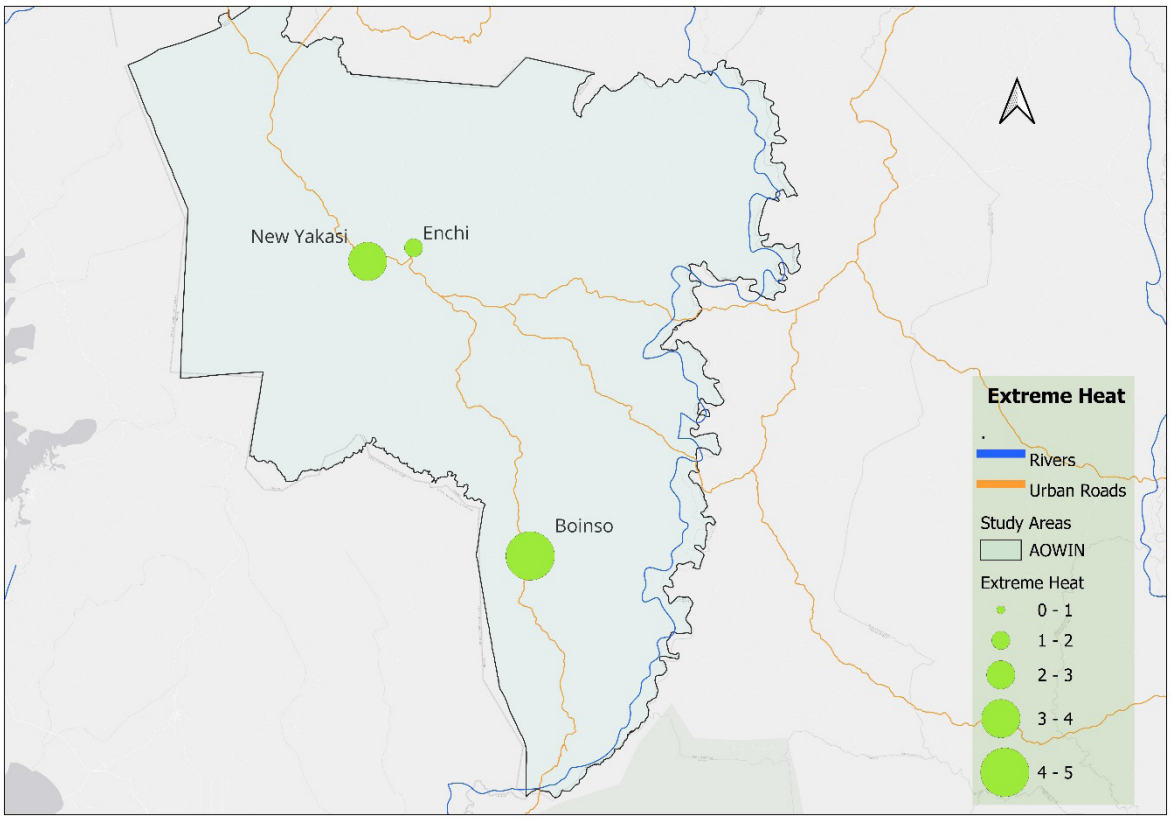
Figure 26: Severity and Frequency of Water Scarcity in Aowin Municipal Assembly



7.1.5 Extreme heat hazard

The hazard level for extreme heat in Aowin is rated as medium, with prolonged heatwaves expected to increase over the next five years. This trend may result in greater discomfort, higher water demand, and reduced agricultural productivity. Figure 27 indicates that Boinso (5) and New Yakasi (4) are the most affected areas, while Aboagyenor (3) and Enchi (2) experience moderate to low levels of heat stress.

Figure 27: Severity and Frequency of Extreme Heat in Aowin Municipal Assembly



7.2 Stakeholder Engagement

The climate change risk assessment for Aowin Municipal was a collaborative and inclusive process designed to incorporate the perspectives, concerns, and expertise of all interested and affected parties (I&APs). This approach recognized the critical contributions of various stakeholders, including diverse community members, women, youth, and other potentially vulnerable groups. Stakeholder participation was central to ensuring a comprehensive and participatory risk assessment, aligned with the objectives of the National Adaptation Plan (NAP) project. A stakeholder engagement workshop was held on March 19, 2024, at the Aowin Municipal Assembly Hall. The workshop brought together key municipal and local stakeholders to facilitate meaningful dialogue and foster collaboration. This engagement provided the Assessment team with an invaluable platform to achieve several objectives:

(a) Introducing the NAP project framework to stakeholders and outlining the collaborative process.

(b) Educating stakeholders about climate change, its potential impacts, and the various factors influencing the risk assessment process.

(c) Sharing initial down-scaled climate projections for temperature and precipitation specific to Aowin context.

(d) Validating these climate change projections with empirical evidence and local expertise to ensure accuracy and relevance.

(e) Conducting gender-specific discussions to address the implications of climate change on different demographic groups.

(f) Identify critical climate-related risks and collecting both quantitative data and qualitative insights to deepen the understanding of these risks, their impacts, and the community's adaptive capacity.

A total of 30 participants attended the stakeholder engagement workshop for the Aowin Municipal Assembly (Appendix A). The participant list reflected a diverse and inclusive representation, critical for ensuring comprehensive community involvement in climate resilience planning. Attendees included representatives from national and local government bodies, such as the National Disaster Management Organization (NADMO) and Aowin Municipal Assembly, alongside professionals from environmental and water management agencies, such as the Community Water and Sanitation Agency. Additionally, local media personnel and representatives from the education sector participated, providing valuable perspectives. Community representation was a key highlight of the workshop, with women's groups, local farmers, and other grassroots stakeholders actively contributing to the discussions. This broad engagement strategy ensured that a variety of perspectives, expertise, and lived experiences were brought to the table. The first session of the workshop was pivotal in setting the stage and providing a framework for the discussions. It introduced participants to the objectives of the workshop, contextualized the importance of climate resilience for the Aowin Municipal, and encouraged active participation throughout the event.

Plate 4: Participants listening to a presentation by Dr. Boafo

The workshop began with a series of presentations delivered by the lead consultant, followed by an interactive question-and-answer session. This initial segment addressed climate variability and change at the global, national, regional, municipal, and local levels, laying the groundwork for participants to contextualize Aowin's specific climate challenges. The second session shifted to participatory activities involving sector-specific groups. These activities focused on hands-on exercises, including physical/resource and hazard mapping, which engaged participants in identifying the most vulnerable and at-risk locations within the Municipal. This exercise not only pinpointed geographic areas prone to climate impacts but also highlighted critical resources and infrastructure at risk from these hazards. The main sectors represented in these activities were:

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

Additionally, participants collaborated on identifying climate hazards, to visually map the timing and intensity of climate hazards and disasters. This exercise provided a shared understanding of Aowin's climate patterns and anomalies, fostering a holistic perspective on the vulnerabilities faced by the Municipal. Through these interactive activities, stakeholders were able to collectively assess risks, identify priorities, and build a foundation for effective climate resilience planning.

Plate 5: Participants participating in sector-specific group exercises.

During the second phase of the workshop, the sector groups focused on creating a sector-specific vulnerability and adaptation matrix. Participants systematically assessed and prioritized identified vulnerabilities by evaluating their severity and likelihood of occurrence. This structured approach enabled stakeholders to quantify relative risks and develop targeted strategies to address the most critical climate challenges facing the Municipal.

In addition, the workshop incorporated gender-focused discussions to examine the differentiated impacts of climate change on men, women, and other vulnerable groups. These discussions highlighted the unique challenges experienced by various gender groups and emphasized the importance of integrating gender-specific needs into climate adaptation planning.

Plate 6: Photo call after the workshop in the Aowin municipal.

A validation workshop was held at the Aowin Municipal Assembly on September 16, 2024, with the primary objective of presenting a range of potential climate adaptation options to key stakeholders. This workshop aimed to facilitate the validation and prioritization of these options, ensuring their alignment with the Municipal's unique vulnerabilities and development objectives. A full list of workshop participants can be found in Appendix A2.

Workshop Focus: The workshop was structured as a participatory process, encouraging stakeholders to critically assess pre-identified climate adaptation strategies and collaboratively prioritize them. The emphasis was on fostering local ownership and ensuring that the selected adaptation measures reflect the Municipal's specific needs and align with its broader developmental goals.

Workshop Highlights: The event commenced with an opening address by the Municipal Regional Director of Aowin, who underscored the urgency of addressing climate change vulnerabilities. He highlighted the critical role of stakeholders in validating and prioritizing adaptation strategies and emphasized the importance of active and collaborative participation to ensure the local relevance and effectiveness of the measures. Dr. Yaw Agyeman Boafo, the Lead Consultant, delivered a detailed presentation on potential climate adaptation options tailored to Aowin's unique needs. The strategies spanned several critical sectors, including agriculture, water resources, community health, biodiversity, infrastructure, and human settlements. Dr. Boafo highlighted the importance of integrating gender-sensitive and inclusive approaches to protect the municipal's most vulnerable populations. Participants were organized into sectoral groups based on their expertise in areas such as Agriculture, Water Resources, Community Health, Infrastructure, and Biodiversity. Guided by Miss Doreen Lartey, these groups utilized the Multiple Criteria Analysis (MCA) framework to evaluate and rank the proposed adaptation measures. This rigorous evaluation process considered factors such as the effectiveness, affordability, environmental benefits, gender responsiveness, and long-term sustainability of each adaptation option, ensuring a comprehensive and equitable prioritization process.

Plate 7:. Validation workshop participants listening to the main presentation

Each sectoral group engaged in detailed discussions to critically evaluate and validate the proposed climate adaptation options. The discussions focused on assessing the relevance of the options to Aowin's specific context and their potential socio-economic and environmental impacts. The groups considered local priorities, resource availability, and the feasibility of implementation to ensure a practical and effective prioritization process. Following these evaluations, each group ranked their sector-specific adaptation options, identifying those requiring immediate attention and action. The prioritized options were then presented to all workshop participants, promoting a shared understanding of the Municipal's most pressing needs and enabling consensus on the strategies deemed most critical. The workshop achieved its goal of validating and prioritizing key climate adaptation measures for the Aowin Municipal Assembly. This participatory approach ensured that the selected strategies are not only locally relevant but also well-aligned with the Municipal's broader development objectives.

Plate 8:Participants engaging in the prioritization of the adaptation options using the MCA approach

7.3 Priority Risk Domains Finalization

The climate change vulnerability assessment of Aowin Municipal underscores the importance of identifying and prioritizing risk domains to strengthen resilience and foster effective adaptation strategies. This process highlights the socio-economic, environmental, and infrastructural challenges faced by the municipality, ensuring that resources and efforts are directed toward the most critical areas. A deeper understanding of these domains and their gender-specific implications provides a foundation for tailored and inclusive solutions:

- Empowering Risk Management: Analyzing how climate change impacts key sectors like agriculture and water supply, the municipal can develop targeted interventions to safeguard livelihoods, food security, and critical infrastructure. Anticipating these challenges enables proactive responses, reducing long-term vulnerabilities.
- Strategic Resource Allocation: Prioritizing risk domains facilitates equitable and efficient use of resources, ensuring that adaptation measures are both practical and impactful. For example, focusing on infrastructure resilience and sustainable water management promotes climate-proof development while addressing urgent community needs.
- Gender Integration in Planning: Incorporating an understanding of gendered vulnerabilities helps design interventions that address the unique needs of women, youth, and marginalized groups. This approach not only reduces inequities but also enhances the overall effectiveness of adaptation measures by fostering inclusive participation and ownership.

Based on this assessment, the priority risk domains for climate change impacts in Aowin Municipal include:

I. Agriculture and Food Security

II. Water Supply and Security

III.Health

IV.Forestry and Biodiversity Conservation

V. Infrastructure and Human Settlements

These domains were selected based on their vulnerability to climate risks, their socio-economic significance, and their potential for effective intervention. Addressing these areas through evidence-based and gender-sensitive strategies will enable Aowin Municipal to build resilience, protect livelihoods, and ensure sustainable development in the face of climate change.

Table 6:Criteria for prioritizing climate change impact risk domains in Aowin Municipal

Criteria	Explanation
Economic Significance	Agriculture is the backbone of the Aowin Municipal economy, with a significant portion of the population engaged in farming activities. Predominantly, cocoa farming. The municipality'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	Illegal mining is a critical concern in Aowin Municipal, given its extensive distractions to soil fertility, farmland, water bodies etc. An example of environmental sensitivity impacting communities dependent on rivers is the encroachment of riverbanks and illegal mining polluting river boin, and disue. Also, settlememnts such old yakasi, Enchi, Achimfo located close to the rivers often come under heavy floods threatens homes and livelihoods, highlighting the need for targeted conservation and adaptation measures.
Community Dependence	In Aowin Municipal, the majority of the rural populations depend on rivers as their source of water. During extreme rainfall, the water resources such as Boin, Butuye, Angunzu and Disue are polluted and hence not good for consumption and emphasizing the need for equitable water management solutions.
Infrastructure Vulnerability	The municipal'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 in 2007 that caused a lot of erosion and making major roads inaccessible 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 municipal'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 municipal are exemplified by the challenges faced by farming communities due to decline in cocoa yields and the heavily dependent on cocoa farming which limits economic stability. Also, cultural norms and economic structures in Aowin often limit women's participation in profitable economic activities and decision-making.

7.3.1 Agriculture and Food Security

The agricultural sector in Aowin Municipal faces significant challenges from the impacts of climate change, which manifest through various environmental and climatic shifts. These impacts are intricately linked to the sustainability and productivity of farming, particularly cocoa, which forms the economic backbone of the region. Erratic rainfall patterns have become increasingly common in Aowin, disrupting the agricultural calendar and complicating water management for farming. This irregularity not only affects the timing of planting and harvesting but also increases the vulnerability of crops to diseases and pests. Prolonged droughts further exacerbate these challenges, leading to frequent fire outbreaks on cocoa farms, which damage crops and reduce yields significantly (Abbey, 2016; Selase et al., 2017).

Increased rainfall intensity which results in flooding can devastate agricultural lands, washing away freshly planted seeds, eroding topsoil, and drowning young plants. The impact of these floods is catastrophic for farmers, leading to significant losses in crop production and, consequently, income. Environmental degradation due to deforestation and small-scale mining activities compounds these climatic challenges. This deforestation is often driven by the expansion of agricultural lands and the encroachment of illegal mining operations, which also pollute water bodies with chemicals that degrade soil quality, rendering it infertile and unsuitable for crop cultivation (Gyampoh et al., 2011; Konlan, 2012).

Climate change and agricultural output in Aowin is further evidenced by research, such as studies by Codjoe et al. (2013) and Agbongiarhuoyi et al. (2013), which highlight how sensitive cocoa crops are to climatic and environmental conditions. These studies note that changes in temperature, humidity, and rainfall can significantly alter pest and pathogen dynamics, negatively impacting cocoa production. The erratic precipitation patterns, exacerbated by climate change, pose severe threats to Aowin's agriculture. With limited irrigation infrastructure — only 2 percent of the agricultural land is irrigated — the reliance on rainfed cultivation makes crops highly susceptible to the changing weather patterns. This lack of irrigation facilities leaves staple crops like cassava, yams, plantains, maize, and rice vulnerable to reduced yields due to increased temperatures and altered rainfall regimes (Affram, 2021; McKinley et al., 2015).

This presents a dire threat to the livelihoods of those dependent on agriculture, particularly women and youth small holder farmers, further stressing the importance of integrating climate-resilient strategies into the farming practices of the region. Cocoa production, a vital component of Ghana's economy, faces unique challenges under the changing climate. The suitable area for cocoa cultivation are shrinking due to rising temperatures, and increased flooding. As rainfall becomes more variable and the growing seasons shift, cocoa yields are expected to suffer more severe losses, impacting the economic stability of Aowin and its contribution to national agricultural output (Oppong & Attuah, 2016; Gyampoh et al., 2011).

7.3.2 Water security and supply

In Aowin Municipal, anticipated climate change impacts pose a critical threat to water resources, reflecting a broader challenge that is prevalent throughout Ghana. As climate change advances, it is expected to

exacerbate existing vulnerabilities within the region, particularly due to the low water storage capacity and the unreliability of rainfall patterns.

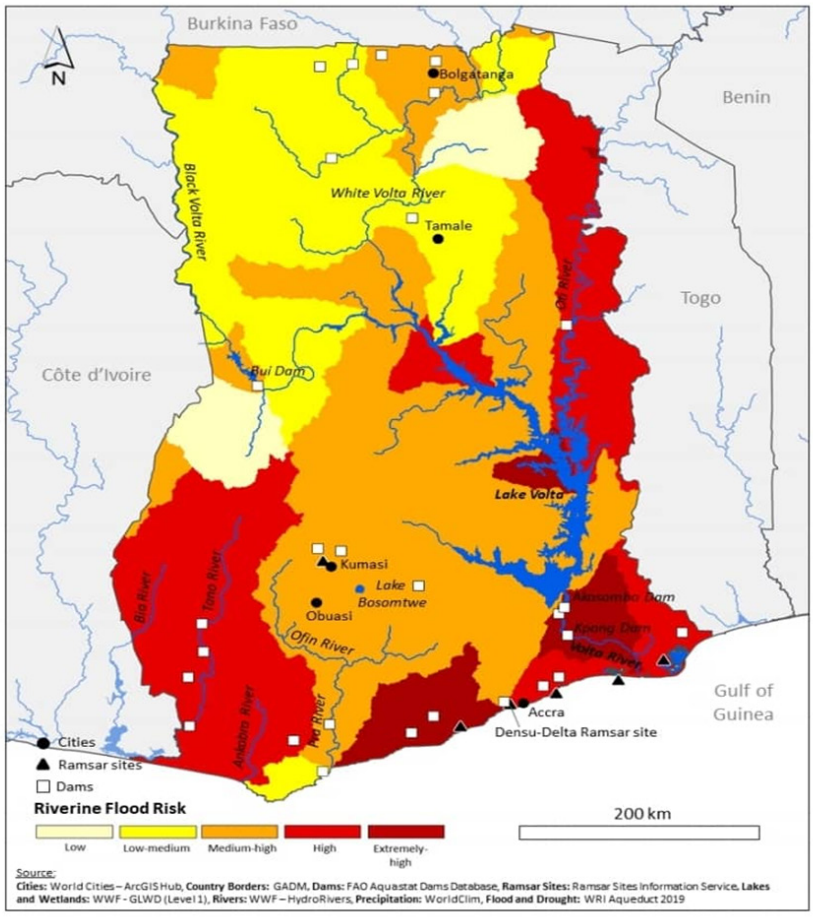
7.3.3 Climate-Driven Variability in Rainfall and Temperature

Climate change significantly alters rainfall and temperature patterns in Aowin Municipal, leading to both drought conditions and excessive rainfall. This variability is especially problematic given the municipal's limited water storage capacity and dependence on river bodies. During droughts, critical water sources such as rivers and wells become depleted, drastically reducing water availability for agricultural and domestic use. Conversely, during periods of heavy rainfall, the area experiences flooding which not only damages infrastructure but also leads to the contamination of existing water supplies with pollutants from runoff, further complicating water quality and availability (Abbam et al., 2018; Asare, 2013).

7.3.4 River Flooding and Water Security

Aowin Municipal faces significant threats from both urban and river flooding. Urban flooding, exacerbated by inadequate drainage systems and rapid unplanned urbanization, frequently results in the overflow of sewage systems, contaminating local water bodies. River flooding, triggered by erratic and intense rainfall, causes rivers to overflow their banks. These spill-over effects are severe, overburdening agricultural lands and settlements and washing pollutants from various sources, including agricultural lands and illegal mining sites, into the water supply (Selase et al., 2017; Narasimhan, 2011). As shown in **Figure 28,** increase in precipitation is expected to result in river flood with a high-level indication in Aowin municipal affecting major rivers such as the Tano river.

Figure 28: Ghana Water Resources Profile: Drought Risk



Source: USAID, 2021

7.3.5 Pollution from Spill-over Effects and Impact on Water Quality

The spill-over effects from flooding introduce a wide range of pollutants into the water system, significantly degrading water quality. Chemicals from farming and toxic residues from mining activities mix with floodwater, causing long-term contamination of water sources. This pollution presents serious health risks and affects the availability of clean water for drinking and irrigation, further stressing the municipal water supply system (Abbam et al., 2018; Foli, 2020) and placing further domestic burdens on women and girls who often walk long distances in search of potable water.

7.3.6 Challenges Posed by Illegal Small-scale Mining

Illegal mining activities in the Aowin Municipal exacerbate the environmental challenges linked to climate change. These activities release toxic chemicals into rivers and streams, which not only degrade water quality but also disrupt the ecological balance of these water bodies. The mining pollutants compromise the soil's fertility and the integrity of water bodies, making it difficult to use the water for agricultural or domestic purposes without risking health (Mantey et al., 2016; Afriyie et al., 2023).

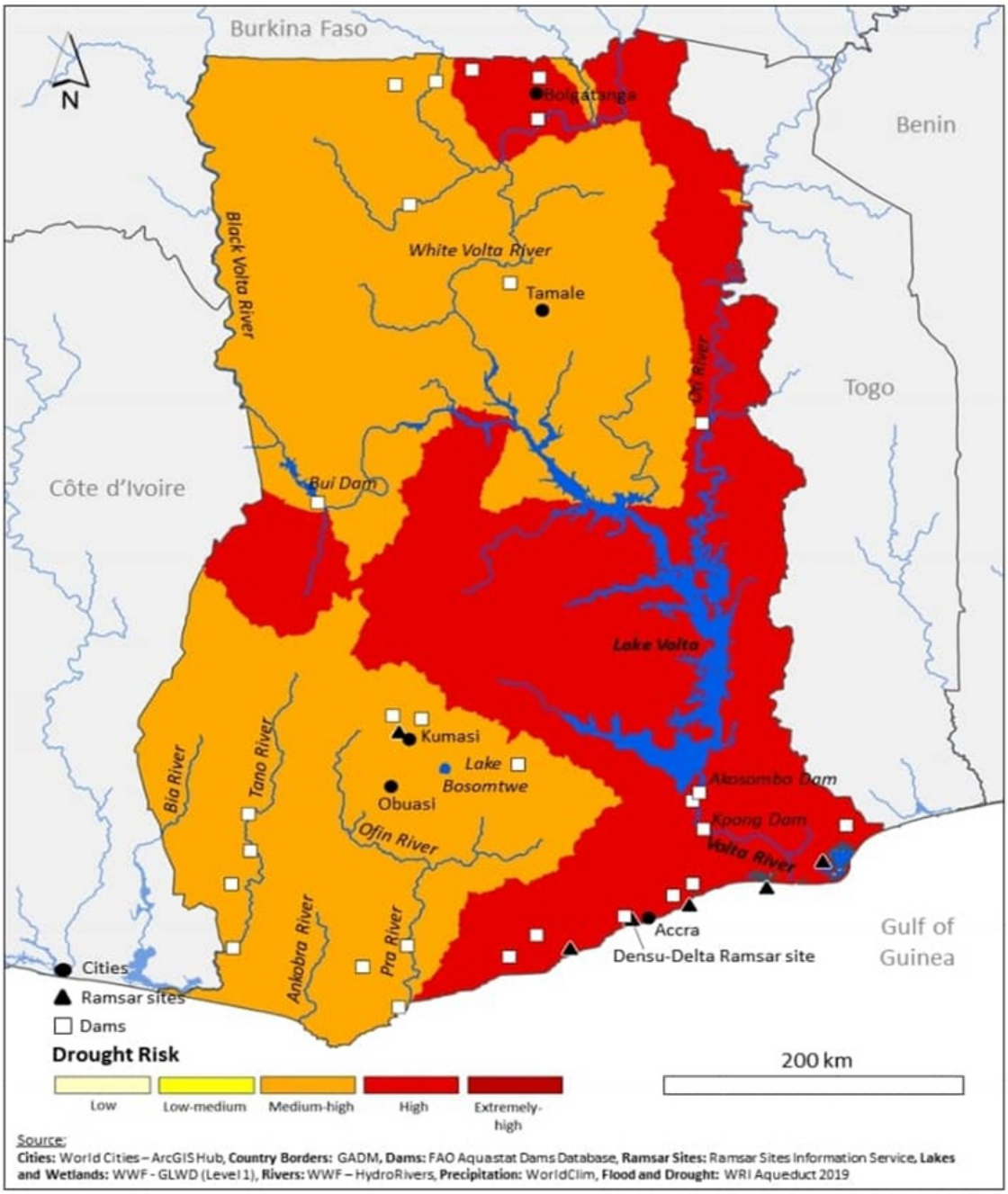
7.3.7 Water Scarcity and Supply Challenges

The combination of reduced rainfall, increased evaporation due to higher temperatures, and pollution from floods contributes to water scarcity in the Aowin Municipal. This scarcity is compounded by the area's inadequate water storage and management capacity, making it challenging to secure sufficient water supplies during periods of drought. As water bodies become polluted and depleted, the community faces significant challenges in accessing clean, safe water, impacting everything from daily living needs to agricultural productivity and food security (Abbam et al., 2018; Narasimhan, 2011).

7.3.8 Projection of Future Water Scarcity

Long-term climate projections suggest that the Aowin Municipal may experience heightened dry conditions and significant water scarcity by the mid to late century as climate change is expected to raise average temperatures by 1.7-3.5-degree Celsius, increasing evaporation and cause water losses as indicated in **Figure 28** showing a medium high level. These conditions are likely to be worsened by a predicted decrease in the flow of the Tano river, a vital water source for the municipal. Such scenarios threaten the sustainability of water resources necessary for human consumption, agriculture, and energy production, demanding proactive measures to mitigate impending water crises.

Figure 29: Ghana Water Resources Profile: Drought Risk



Source: USAID, 2021

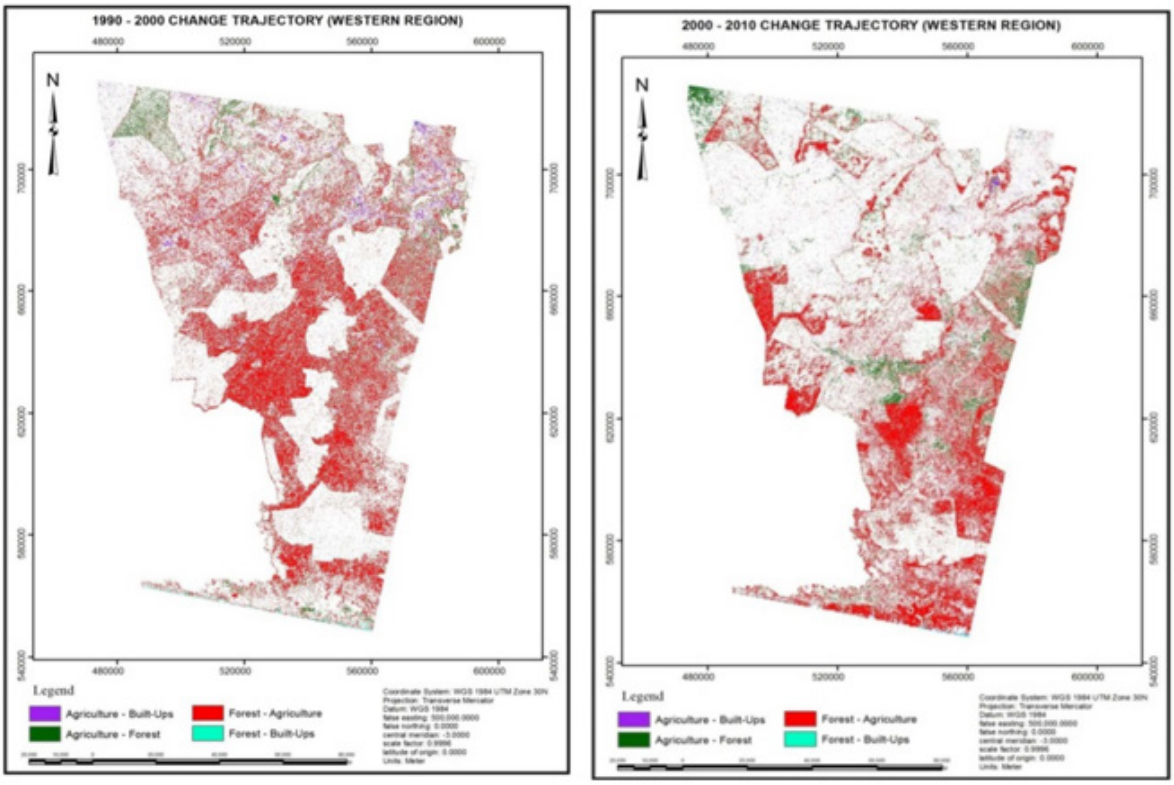
7.4 Forest and loss of biodiversity

The Aowin Municipal is witnessing substantial ecological shifts due to the combined effects of climate change and human activities, resulting in significant reductions in forest cover and biodiversity. These ecological changes are intertwined with socioeconomic repercussions that impact the local communities, affecting their livelihoods and the sustainability of local ecosystems.

7.4.1. Land Use Changes and Biodiversity Impacts

According to Koranteng et al. (2016), and as seen in figure 30 on the detailed land use analysis spanning two decades, from 1990 to 2010, reveals a concerning trend where large areas of forest land have been converted to agricultural use. This transformation is primarily driven by the local population's increasing demand for arable land to support agricultural expansion. The conversion of forests to farmland is detrimental, leading to the loss of vital wildlife habitats and plant diversity. These habitats are crucial for maintaining ecological balance, and their degradation results in the loss of species that are essential for pollination, seed dispersal, and maintaining the structural integrity of the forest ecosystem.

Figure 30: Land use change in Western region



Source: (Koranteng et al., 2016)

7.4.2 Climate Drivers of Forest Degradation

Climate change exacerbates forest degradation through altered rainfall patterns and increased temperatures. These climatic changes induce stress on forest ecosystems, making them susceptible to fires, pests, and diseases. Additionally, warmer and drier conditions accelerate the decomposition of organic matter, reducing soil fertility and increasing vulnerability to erosion. The altered climate conditions also facilitate increased human encroachment into forested areas for agriculture and infrastructure development, further straining these ecosystems.

7.4.3 Deforestation Dynamics

The dynamics of deforestation in Aowin are complex and are influenced by both climatic and human activities factors. Within and outside protected areas, forests are being depleted at an alarming rate. Activities such as illegal logging and mining not only strip the forest of its natural resources but also disrupt wildlife and pollute water sources. These practices diminish the forest's resilience to climate impacts, degrade the quality of land, and reduce the capacity of these areas to act as carbon sinks, which is crucial for mitigating the broader impacts of global warming.

7.4.4 Impact on Ecosystem Services

The ongoing deforestation and degradation have a profound impact on the ecosystem services that forests provide. These services include regulation of water cycles, purification of air and water, and provision of fertile soil for agriculture. As forest cover diminishes, so does the ability of the ecosystem to support agricultural activities, which are the backbone of the local economy. Furthermore, the loss of biodiversity leads to a decrease in ecosystem resilience, reducing its ability to recover from environmental stresses and climatic changes.

7.4.5 Projections and Future Risks

Future climate projections for Aowin suggest an exacerbation of current trends, with an increase in temperatures and changes in precipitation patterns expected to drive the region towards even greater ecological fragility. The likelihood of more frequent and severe droughts, coupled with intense rainfall events, threatens to amplify the cycles of flooding and drought. These extreme weather events will further challenge the already stressed ecosystems and could lead to irreversible damage, impacting biodiversity and human livelihoods.

7.5 Human health

The Aowin Municipal Assembly is increasingly vulnerable to climate-induced health risks, which exacerbate existing challenges in water and sanitation infrastructure. The region's health dynamics are closely linked to its environmental conditions, which are being altered significantly due to climate change. The climate-induced health risks of children and pregnant women affects the optimal growth of fetus and babies (Damptey, 2007). As primary carers, women are further burdened with taking of the sick in the household.

7.5.1 Waterborne Diseases and Sanitation Issues

During flood events, critical water sources such as streams, rivers, and wells become polluted with contaminants washed down from elevated areas. This situation is aggravated by the inadequate supply of pipe-borne water infrastructure, leading to increased reliance on these compromised water sources. The heavy reliance on surface water for daily needs makes the community particularly vulnerable to waterborne diseases. Additionally, a significant portion of the population lacks access to adequate and hygienic toilet facilities, which further deteriorates the sanitation conditions. Inadequate drainage systems not only fail to manage stormwater but also contribute to soil erosion, undermining building structures and facilitating the proliferation of disease vectors (Aidoo, 2013; Fiati, 2020).

7.5.2 Climate Change and Its Direct Impacts on Health

The changing climate enhances the risks associated with vector-borne and waterborne diseases, particularly in urban areas where the density of the population and inadequate sanitation infrastructure create ripe conditions for disease outbreaks. The increase in both temperature and frequency of severe flooding events escalates the incidence of diseases such as cholera, malaria, and dengue fever, especially impacting vulnerable populations

like children. For instance, recent cholera outbreaks have highlighted the critical need for comprehensive public health strategies that address these emergent challenges (D'Agnes & Johnson, 2010; Amo, 2007).

7.5.3 Pollution and Health Complications from Illegal Mining

Pollution in Aowin is primarily driven by illegal mining activities, which not only degrade the environment but also pose direct threats to public health. The removal of topsoil and vegetation for mining operations exposes bare soil, leading to severe erosion and the formation of hazardous pits that endanger the community. The chemicals used in mining operations contaminate local water sources, leading to outbreaks of diseases such as typhoid and polio, compounded by the region's limited capability to manage such environmental and health crises effectively (Matthew et al., 2013; Konlan, 2012).

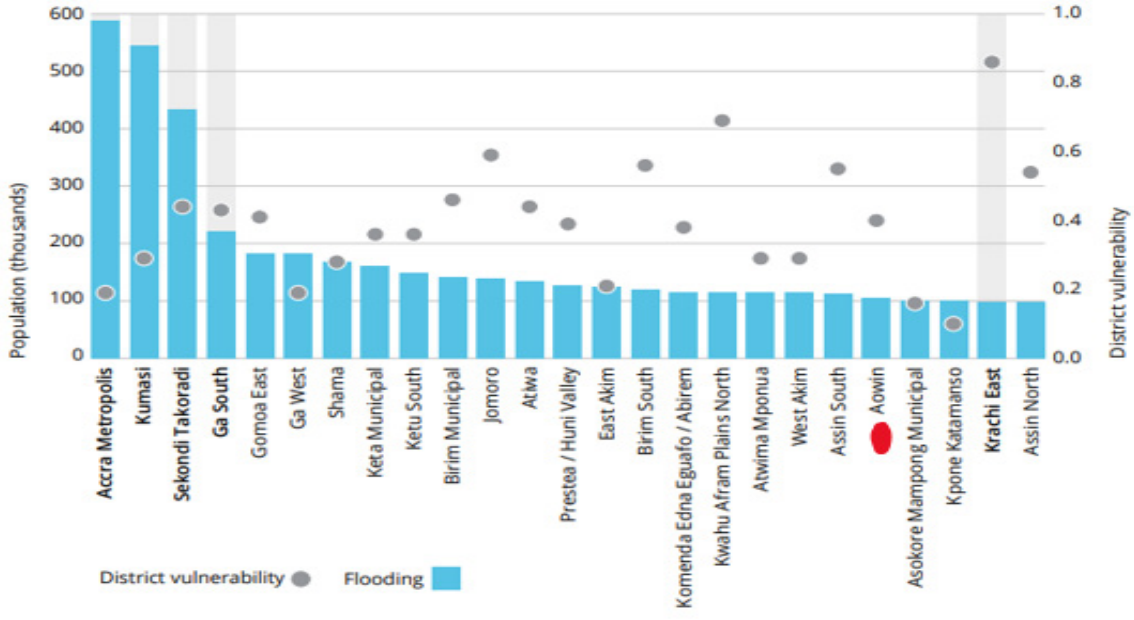
7.5.4 Effects of Flooding on Community Health

Flooding in Aowin leads to multiple health risks, including the spread of infectious diseases such as diarrhea due to overcrowding in temporary shelters. Stagnant water from floods serves as breeding grounds for disease vectors like mosquitoes, increasing the risk of vector-borne diseases. Additionally, the disruption of local food and water supplies due to floods affects the nutritional status of the population, making them more susceptible to illness and disease (Gyapong, 2015; Osei, 2012).

7.6 Infrastructure

In Aowin Municipal, the robustness of infrastructure, particularly transport systems like roads, is critically undermined by the effects of climate change. Extreme weather events, driven by climate change, pose severe threats to infrastructure integrity, impacting vital societal functions and economic stability. High temperatures and intense rainfall are major contributors to infrastructure deterioration within the Aowin municipal, washing out road bases and creating potholes, severely impairing road usability and safety. This degradation not only increases maintenance costs but also disrupts everyday activities, hindering access to essential services such as trade, healthcare, and education, especially in more remote and rural areas (Asafo-Adjei & Buabeng, 2016; Awuni, 2013).

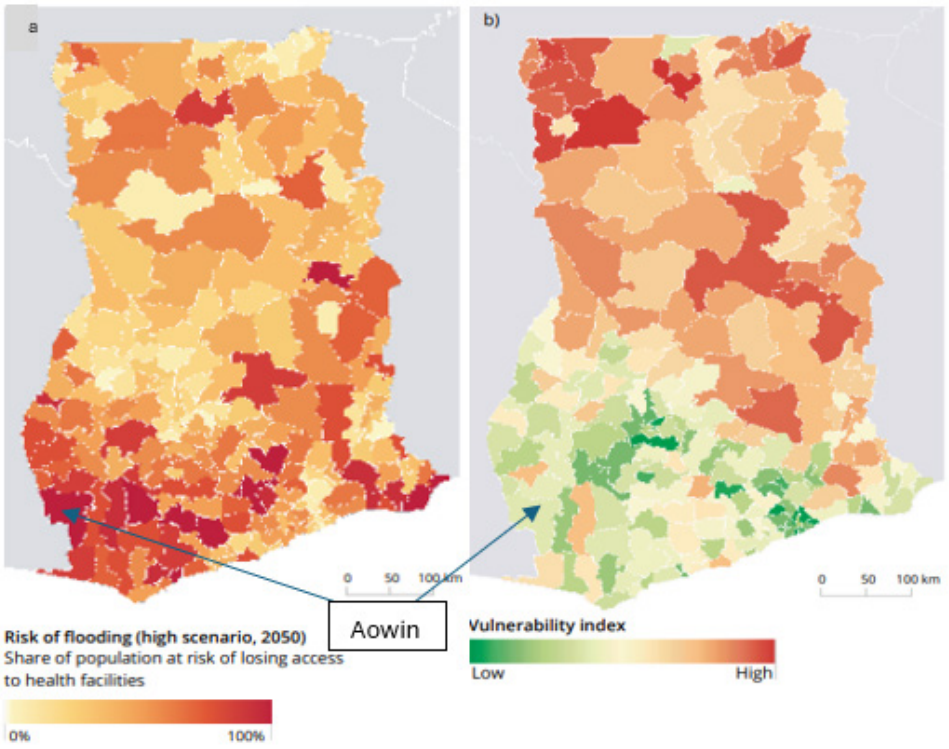
Figure 31: Municipals exposed to flood hazards on roads under the high 2050 scenario.



Source: Ghana Roadmap for Resilient Infrastructure – UNOPS, 2022

According to UNOP, (2022), in figure 31 projections for 2050 under a high hazard scenario, municipals like Aowin are expected to experience increased incidences of road flooding, posing substantial risks to the population's access to healthcare and other critical services, highlights areas at high risk, using models that intersect flood data with road networks and routes to healthcare facilities.

Figure 32: Risk of flooding (high scenario, 2050) and Vulnerability Index



Source: Ghana Roadmap for Resilient Infrastructure – UNOPS, 2022

The Aowin Municipality as represented in Figure 32 is at a high risk under the scenario of population at risk of losing access to health facilities although the vulnerability index of Aowin is on the average. The potential isolation of communities due to flooded infrastructure could lead to significant delays in emergency response times and general healthcare access, exacerbating health outcomes during disaster events.

The analysis combines the population share per municipal at risk of losing access to healthcare facilities due to flooded road networks, using flood and road data intersection with routing to healthcare facilities. Aowin, as depicted in **Figure 27** emerges as at high risk of losing access to health facilities under the 2050 high scenario, with approximately 105,760 populations facing this risk. These findings underscore the urgency of addressing infrastructure vulnerabilities to ensure continued access to essential services, particularly healthcare, in the face of climate change impacts.

8 Climate Change Risk Assessment

8.1 Identify Critical Climate Related Hazards

The participatory and bottom-up approach adopted for the Climate Change Risk Assessment (CCRA) in Aowin Municipal focused on collaboratively identifying and understanding the diverse climate-related hazards threatening the municipal's ecological stability, economic growth, and community well-being. Through two stakeholder workshops, participants engaged in dynamic discussions to explore how the evolving climate has introduced unprecedented risks to the municipal, emphasizing the need for informed, proactive measures to safeguard livelihoods and ecosystems. Grounded in local knowledge, scientific research, and practical experiences, these workshops facilitated the identification and validation of the most pressing climate hazards confronting Aowin Municipal. A wide range of stakeholders contributed to these discussions, including local government officials, community leaders, environmental NGOs, farmers, youth, and women's groups, as well as representatives from the health, water, and infrastructure sectors (see Appendix for list of participants). This diverse representation ensured that the hazards identified reflected a comprehensive understanding of the municipal's vulnerabilities and priorities.

The workshops offered an essential platform for exchanging perspectives and insights, anchored in the current climate realities faced by Aowin Municipal. Recent extreme weather events and their cascading effects on the municipal communities and ecosystems formed the foundation of these discussions. By focusing on these tangible impacts, participants were able to pinpoint hazards that not only directly affect local livelihoods but also have broader socio-economic and public health implications. This section synthesizes the outcomes of these participatory workshops, presenting the critical climate-related hazards identified by stakeholders. The findings, summarized in Table 7, highlight the key climate risks, their potential impacts on systems and assets within the municipal, and the cascading consequences on public health, infrastructure, and economic vitality. These insights provide a roadmap for targeted interventions aimed at building resilience and reducing vulnerability across Aowin Municipal.

Table 7: Outcomes of Stakeholder engagement

Systems and Assets Exposed to Hazard	Climate Hazard	Climate Risk and Potential Impacts
Water Resources	Water Pollution	In Aowin, illegal mining activities, particularly 'galamsey', have caused severe water pollution, resulting in increased water temperatures and subsequently lower crop yields. Communities such as Enchi and surrounding areas have been forced to rely on capital-intensive water treatment methods to secure safe water for domestic use.
	Deforestation	Deforestation due to illegal chainsaw operations and farming methods has led to the drying up of important water bodies like the Boin and Sui rivers, causing a rise in local temperatures. This not only affects the climate but also hinders agricultural activities in communities like Nyakamam and Boinso.
	Irregular Rainfall	Irregular rainfall patterns have resulted in inconsistent agricultural output, contributing to hunger in the municipal. This has been notably observed in areas such as Omampe and Nseakyi, where lack of rain disrupts the planting season and reduces potable drinking water availability.
Community Health	Flooding	The 2007 floods left Enchi township, including areas such as Achimfo and Old Yakasi, submerged, leading to widespread displacement and outbreaks of diseases like diarrhea due to overcrowded living conditions.
	Water Pollution	The contamination of water bodies from mining has affected water quality, resulting in waterborne diseases in communities engaged in small-scale mining, including the use of harmful chemicals that lead to health issues like typhoid.
	Irregular Rainfall	The municipal's reliance on rain-fed agriculture means that irregular rainfall can cause widespread plant and animal dehydration, with significant implications for the local food supply and ecosystem balance, particularly in agricultural communities.
Infrastructure and Human Settlement	Flooding	The Aowin area has seen critical infrastructural damage due to floods, which has destroyed roads and bridges, such as the incident in 2007 that affected Enchi and Nyakamam, disrupting the lives and livelihoods of the residents.
	Water Pollution	Poor water quality due to pollution has led to an outbreak of waterborne diseases such as cholera and dysentery, with significant health implications for the population reliant on natural water sources for consumption.
	Land Degradation	Illegal mining and improper land use have led to land degradation, affecting the landscape and infrastructure such as roads and buildings, which was observed in areas like Boinso and Nyakamam where roads were cut off during floods in 2023.

Agriculture and Food Security	Irregular Rainfall	The unpredictability of rainfall has led to difficulty in timing the planting season, causing poor yields and increased food insecurity in farming communities such as Enchi and Yakasi.
	Land Degradation	Land degradation due to practices like 'galamsey' has led to significant soil erosion and a reduction in soil fertility, increasing production costs and impacting areas once fertile for agriculture, now turned into degraded fields.
	Deforestation	The widespread deforestation for agriculture and mining has led to higher local temperatures and irregular rainfall, impacting crops' growth and reducing agricultural productivity, as seen in the major cocoa-producing areas of Aowin.

8.2 Impact Story Lines for Critical Assets and Risk Domain

To deepen the understanding of climate-related hazards, vulnerabilities, and exposures affecting critical assets within Aowin Municipality, detailed impact storylines were developed. Using stakeholder input and local data, these storylines mapped the cascading effects of hazards such as erratic rainfall, flooding, and extreme heat on agriculture, water resources, health, infrastructure, and biodiversity. 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 municipality.

1. **Risk of Water Scarcity and Insecurity**: The proliferation of 'galamsey' operations in Aowin is severely affecting the region's water bodies, leading to a critical shortage of clean water. The consequent water scarcity not only hampers the community's daily needs but also threatens the irrigation systems that sustain local agriculture, ultimately endangering food security and livelihoods.
2. **Risk of Decline in Agricultural Viability**: As Aowin contends with erratic weather patterns and the encroachment of pests, cocoa, the crop that forms the economic backbone of the area, suffers. Declining yields translate directly to reduced income for farmers and may lead to increased poverty rates within the community.
3. **Risk of Health Hazards from Water Pollution**: The chemicals and waste released by illegal mining activities are contaminating rivers and streams, sources of water for many. This contamination carries the risk of a surge in waterborne diseases, placing an additional strain on the already challenged healthcare system of the municipality.
4. **Risk of Infrastructural Instability from Environmental Degradation**: The environmental impact of illegal mining is profound, with increased flood risks due to deforestation and land erosion. This not only damages roads and bridges but also disrupts transport, education, and trade, which are vital for Aowin's economic health.
5. **Risk of Loss of Biodiversity**: The rich flora and fauna of Aowin are being rapidly depleted as mining and farming encroach on previously undisturbed lands. The loss of biodiversity has far-reaching effects, impacting not only the region's ecological balance but also its potential for eco-tourism and the traditional knowledge systems dependent on indigenous species.
6. **Risk of Socioeconomic Disruption**: The allure of quick profits from 'galamsey' is drawing the youth away from traditional and sustainable forms of employment, such as agriculture and education. This trend risks eroding the fabric of society, with long-term implications for economic stability and growth as the shift away from stable, generational occupations continues to take hold.

BOX 2: Socio-economic shift and environmental crisis in Aowin Municipal

FROM COCOA TO GALAMSEY: THE SOCIO-ECONOMIC SHIFT AND ENVIRONMENTAL CRISIS IN AOWIN MUNICIPAL.

"Illegal mining, known as 'galamsey', has severely impacted Aowin Municipal, causing environmental and social damage. This practice has destroyed the natural beauty and resources of the land, and has also led many people, especially youth, to abandon their traditional jobs, such as cocoa farming, in pursuit of quick money. This has resulted in a loss of education and long-term economic stability, as people are lured into the dangerous and unstable world of mining."

The turn from agriculture to mining is indicative of the broader challenges facing Aowin. Cocoa farming, once a symbol of prosperity and the main source of income for many households, is now plagued by persistent pests, diseases, and the lack of reliable roads for transport to markets. These challenges have diminished the appeal of farming cocoa, once the pride of Aowin, pushing people towards the more lucrative but environmentally damaging practice of 'galamsey'.

The adverse effects of this transition are manifold. The immediate health implications for those working in the mines and living nearby are significant, with polluted water bodies leading to waterborne diseases, a serious concern for public health. Furthermore, the environmental impact is profound; the land scarred by mining pits and chemicals is a stark departure from the once fertile grounds used for cocoa cultivation.

Children, the most vulnerable demographic, are often the most impacted. Their participation in mining signifies a loss of potential and a direct hit to the fabric of the community, which has long valued education as a pathway to progress. The decline in cocoa farming and the rise in mining also signal a deeper economic shift, with significant implications for Aowin's future.

This critical junction calls for a collective effort to address the immediate economic allure of 'galamsey' and to find sustainable solutions that can rejuvenate the traditional practices like cocoa farming. In doing so, the community of Aowin can work towards restoring the environmental integrity and ensuring a healthier, more stable economy for future generations.

8.2.1 Risk 1: Risk of Water Scarcity and Insecurity

The risk of water scarcity and insecurity in Aowin Municipal, intensified by illegal mining activities and climate change, poses serious challenges across multiple dimensions.

During the dry season, the reduced rainfall expected from climate projections can lead to the critical rivers—Boin, Sui, and Tano—drying up. These rivers are essential sources of water for the community, and their depletion drastically reduces water availability, concentrating pollutants in the remaining water. This situation poses severe health risks as the community relies on these contaminated sources for drinking, cooking, and bathing. The high concentration of pollutants from mining runoff, agricultural chemicals, and domestic waste further compromises water quality, increasing the prevalence of waterborne diseases.

Conversely, climate projections also predict more intense rainy seasons, which heightens the risk of severe flooding. Floods can cause spillovers that introduce additional pollutants into water bodies, further contaminating the already vulnerable water sources. These floodwaters, laden with toxins from 'galamsey' sites and other contaminants, can spread to previously unaffected areas, broadening the scope of water insecurity and health risks.

The environmental degradation from these mining activities and the extreme weather conditions due to climate change also impact agriculture. With the rivers serving as vital irrigation sources, their pollution or depletion directly affects agricultural productivity and food security. The seasonal extremes—prolonged dry spells and heavy floods—disrupt traditional farming cycles, leading to crop failures and economic instability for farmers reliant on agriculture.

Children and women, who often bear the burden of collecting water, face increased hardships. They may need to travel greater distances to find clean water sources, which impacts education and economic activities, deepening the social and economic rifts within the community.

8.2.2 Risk 2: Risk of Decline in Agricultural Viability

The risk of decline in agricultural viability in Aowin Municipal is a significant concern, driven by a combination of environmental, economic, and social factors. This decline threatens the backbone of the region's economy, which has traditionally been reliant on cocoa farming, a major source of income for many households.

Environmental Challenges: Climate change poses a severe threat to agriculture in Aowin. Increasing temperatures and changing rainfall patterns are leading to more frequent and severe droughts and floods, which directly affect crop yields. Pests and diseases are becoming more rampant and destructive, exacerbated by the warmer and more humid conditions. Cocoa plants are particularly susceptible to pests like the cocoa pod borer and diseases such as black pod disease, which thrive under these changed climatic conditions.

Economic Impacts: The decline in agricultural output due to environmental stressors directly impacts the local economy. As cocoa yields decrease, farmers face reduced incomes, which affect their ability to invest in farm improvements or diversify their crops, creating a cycle of diminishing returns. This decline also affects the broader community since agriculture employs a significant portion of the population, either directly or through related industries such as processing and transport.

Land Degradation: Illegal mining activities, or 'galamsey', further exacerbate the situation by degrading the land used for agriculture. The chemical runoff from these mining operations contaminates soil and water sources, making them unfit for agricultural use. The physical disruption of landscapes for mining creates craters and diverts water courses, which leads to soil erosion and loss of fertile topsoil essential for cocoa cultivation.

Socioeconomic Consequences: The reduction in viable agricultural land and the decrease in productivity force many farmers to abandon agriculture, seeking alternative livelihoods, often in the same illegal mining

that is partly responsible for the degradation of their farming land. This shift has profound implications for food security and the socio-economic stability of the region. Moreover, the loss of traditional agricultural knowledge and a decrease in the farming population can have long-term consequences for agricultural recovery and sustainability.

8.2.3 Risk 3: Risk of Health Hazards from Water Pollution

The risk of health hazards from water pollution in Aowin Municipal presents a critical public health concern. This issue stems predominantly from the contamination of local water bodies due to illegal mining activities and inadequate waste management systems, impacting the quality of drinking water and general sanitation.

Pollution: Illegal mining, or 'galamsey', is a major contributor to water pollution in Aowin. The use of heavy metals such as mercury and cyanide in the mining process results in these toxic substances leaching into rivers and streams. Additionally, the mechanical disruption of riverbeds increases sedimentation and turbidity, further degrading water quality. Agricultural runoff, containing pesticides and fertilizers, also plays a significant role, adding nitrates and phosphates into the water bodies, which can lead to eutrophication and harmful algal blooms.

Direct Health Impacts: The consumption of or exposure to contaminated water leads to a range of health issues among the local population. These include acute problems such as gastrointestinal infections from pathogens and chronic conditions like mercury poisoning, which can affect neurological development and reproductive health. Children and pregnant women are particularly vulnerable to these health effects, as the developing bodies of children and fetus are more susceptible to the toxins found in polluted water.

Indirect Health Impacts: The indirect effects of water pollution on health can be just as severe. Waterborne diseases require medical treatment and hospitalization, which strains the local healthcare systems and diverts resources from other medical needs. The economic burden of illness due to water pollution reduces family incomes and can contribute to a cycle of poverty, especially when wage earners are affected by disease. Women as primary care givers bear extra burden when their relatives fall sick.

Community and Social Impact: The pervasive issue of water pollution affects not just individual health but also community welfare. Safe, clean water is a fundamental need for hygiene and sanitation. When water sources are contaminated, the entire community faces increased risks of outbreaks of diseases, which can lead to school closures, reduction in workforce productivity, and a general decrease in the quality of life.

Mitigation and Prevention Strategies: To address the risk of health hazards from water pollution, it is essential to implement comprehensive water management and purification strategies. These might include establishing more stringent regulations and enforcement against pollution from mining and agriculture, investing in advanced water treatment facilities, and promoting community-based water purification systems. Education plays a critical role in prevention, as raising awareness about the dangers of polluted water and the importance of sanitation can empower communities to take action.

Moreover, restoring and preserving natural waterways can help improve water quality over time, providing a sustainable solution to the problem. Efforts to reclaim and rehabilitate environments damaged by mining and industrial activities are crucial for the long-term health and resilience of Aowin's water resources.

8.2.4 Risk 4: Risk of Infrastructural Instability from Environmental Degradation

The risk of infrastructural instability from environmental degradation in Aowin Municipal is a pressing concern, primarily due to the extensive impact of illegal mining and deforestation. These activities compromise the structural integrity of the land and significantly affect the durability of built infrastructure.

Environmental Degradation: Illegal mining, particularly 'galamsey', involves the excavation of earth, often using heavy machinery that disrupts the soil structure and undermines the foundation of nearby structures. The

diversion of water courses and the creation of artificial ponds further exacerbate soil erosion and saturation, increasing the likelihood of land and mudslides that can damage roads, bridges, and buildings. Additionally, deforestation for mining or agricultural expansion strips the land of trees that would normally help stabilize the soil and manage water flow, leading to further erosion and increased vulnerability to natural disasters.

Direct Impacts on Infrastructure: The physical damage to infrastructure due to environmental degradation can be severe. Roads may become impassable due to erosion or the collapse of surfaces, isolating communities and disrupting the flow of goods and services. Bridges can be weakened or destroyed by the increased water flow and sediment load in rivers, posing serious safety risks. Buildings and homes, especially those built near mining sites, are at risk of structural failures due to the unstable ground.

Indirect Economic and Social Impacts: The degradation of infrastructure not only requires costly repairs and replacements but also affects the economic activities that depend on reliable transport and communications networks. For instance, the disruption in transportation can lead to delays in the supply chain, affecting local businesses and farmers who rely on these routes to market and sell their products. Socially, the instability can lead to a reduction in access to essential services such as healthcare and education, as roads and transportation are crucial for reaching hospitals, schools, and other community services.

8.2.5 Risk 5: Risk of Loss of Biodiversity

The risk of loss of biodiversity in Aowin Municipal is a critical environmental concern, largely fueled by the destructive practices of illegal mining and deforestation. These activities not only disrupt local ecosystems but also threaten the survival of numerous species that depend on these habitats.

Drivers of Biodiversity Loss: Illegal mining operations, known locally as 'galamsey', often involve the clearing of large areas of forest land, directly leading to habitat destruction. The toxic chemicals used in mining, such as mercury and cyanide, contaminate the soil and waterways, adversely affecting both terrestrial and aquatic life. Deforestation for agricultural expansion or timber extraction further diminishes the natural habitat, leading to a decrease in species diversity and an imbalance in the ecological network.

Direct Impacts on Wildlife and Plants: The immediate consequence of habitat loss is a reduction in wildlife populations. Species that depend on forest cover for shelter, breeding, and food sources are left vulnerable and may face extinction if their habitats are continually degraded. Areas such as Tano Anwia, a forest reserve which offers tourism is under poaching (MTDP, 2022).

Indirect Effects on Ecosystem Services: Biodiversity loss has profound indirect effects on ecosystem services that are essential for human survival and well-being. These services include pollination of crops, regulation of climate, control of pests and diseases, and maintenance of water quality. As biodiversity declines, these natural systems become less effective, potentially leading to crop failures, increased pestilence, and greater vulnerability to climate extremes.

Socioeconomic Implications: The loss of biodiversity can also have significant socioeconomic impacts. Many communities in Aowin depend on the natural environment for their livelihoods, whether through agriculture or ecotourism. As species disappear and ecosystems degrade, these sources of income become unsustainable, which can lead to economic decline and increased poverty rates.

8.2.6 Risk 6: Risk of Socioeconomic Disruption

The risk of socioeconomic disruption in Aowin Municipal is a significant concern, stemming primarily from environmental degradation, shifts in employment from traditional agriculture to illegal mining, and the broader impacts of global market changes on local economies.

Economic Shifts from Agriculture to Mining: The allure of quick financial returns from illegal mining ('galamsey') has drawn a significant portion of the Labor force away from traditional agriculture, particularly cocoa farming, which has been the backbone of Aowin's economy. This shift not only affects individual farmers and their families but also disrupts the entire agricultural supply chain, from production to distribution. As more individuals engage in mining, the agricultural sector experiences a drain of skilled labor, leading to decreased productivity and increased food insecurity.

Environmental Impact and Economic Vulnerability: The environmental damage caused by mining — including deforestation, soil erosion, and water contamination — further exacerbates economic instability. These environmental issues lead to reduced agricultural yields and increase the vulnerability of the community to natural disasters, such as floods, which can destroy homes, farms, and critical infrastructure, creating cycles of economic hardship and recovery that strain local resources.

Social Implications: The socioeconomic disruption has profound social consequences. The migration of young people towards mining areas can lead to demographic imbalances, weakening community ties and traditional social structures. Education levels may decline as children and teenagers forego schooling to work in mines, impacting the community's long-term socioeconomic development. Additionally, the influx of workers into mining areas can strain local services and infrastructure, such as healthcare, housing, and sanitation, leading to deteriorated living conditions.

Dependency on Fluctuating Global Markets: Dependence on commodities like cocoa, whose prices are subject to global market fluctuations, adds another layer of economic uncertainty. When prices fall, or when international demand shifts, Aowin's economy can suffer quickly, leaving little room for the community to adapt without significant hardship.

8.3. Gender-specific vulnerability assessment

The gender-specific vulnerability assessment in the Aowin Municipal highlights the unequal impacts of climate change across different demographic groups, emphasizing the need for targeted, equitable adaptation strategies (Thomas et al., 2019). Women, who are often responsible for food production, resource management, and caregiving, face heightened challenges due to erratic rainfall, increasing temperatures, and water scarcity. These climate stressors significantly disrupt their roles in food and water provision and undermine their economic activities. Combined with limited access to resources and decision-making processes, these factors elevate women's overall vulnerability. Youth in the municipality are moderately exposed and sensitive to climate risks, particularly extreme weather events and economic instability in agriculture. However, their relatively higher adaptive capacity, driven by access to education and innovation potential, positions them as key agents of change in resilience-building initiatives. Differently-abled individuals face extreme vulnerabilities due to high exposure and sensitivity to climate impacts like flooding and extreme heat. Barriers to physical mobility and the lack of inclusive disaster planning further diminish their adaptive capacity, leaving them at significant risk during climate events.

Table 8: Assessment of Current Gender-Specific Climate Change Risks in Aowin Municipal

Group	Hazard Description	Exposure	Sensitivity	Adaptive Capacity	Overall Vulnerability	Comments/Impacts
Women	Increased temperatures and variability in rainfall	High	High	Low	Very High	In Aowin, women who are primarily responsible for water collection and subsistence farming face acute challenges during periods of drought and unpredictable rainfall, severely impacting their ability to provide for households and manage agricultural responsibilities.
Youth	Economic instability due to climate impacts on agriculture	High	Medium	Medium	High	Youth in Aowin, who are often involved in the agricultural sector, face uncertain economic futures as changing climate patterns affect crop yields and disrupt traditional farming schedules.
Differently-abled Individuals	Reduced accessibility during extreme weather events	High	Very High	Low	Very High	Differently abled individuals in Aowin struggle with mobility and access to emergency services during floods and storms, exacerbating their isolation and vulnerability.
Children	Prone to climate induced sicknesses. Flood affects access to school.	High	High	Low	Very High	Malaria and other climate induced sickness affect the physical cognitive development of children. Flooded undeveloped footpaths affects school attendance.

The assessment of future climate change risks in the Aowin Municipal reveals significant disparities in how different groups are impacted, highlighting the need for targeted adaptation strategies (Table 8). Women are at very high risk due to increased heat and drought, which severely affect water resources, agriculture, and health. These stressors threaten their critical roles in ensuring household sustenance and providing healthcare, intensifying the burden on their already constrained resources and capacities. Youth face high risks stemming from climate-driven shifts in the job market, particularly within agriculture. As a sector highly sensitive to climatic variability, agriculture's instability poses significant threats to their employment opportunities and economic future. This emphasizes the need for adaptive solutions that provide alternative livelihoods and skill development to build resilience among this group. Differently-abled individuals are particularly vulnerable, facing high risks due to accessibility challenges during extreme weather events and an increased likelihood of health complications. These risks are compounded by inadequate infrastructure and the lack of inclusive planning, underscoring the urgency for tailored strategies that ensure their safety, mobility, and access to essential resources during climate emergencies.

Table 9: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	H	VH	M	VH	VH	VH	Women, critical in water and food provision, face heightened labour and health risks due to increased temperatures and water scarcity.
Youth	Job market shifts due to climate impacts on agriculture.	H	H	H	M	M	H	H	Youth employment in agriculture is unstable as climate changes disrupt traditional livelihoods, posing economic uncertainties.
Differently Abled	Limited accessibility and higher health risks during extreme weather	VH	H	VH	L	VH	VH	VH	Differently abled individuals face significant barriers in mobility and access to resources, exacerbated by severe weather events.
Children	Stress on health facilities and health outreach programmes reduce access to preventative and curative healthcare. Limited accessibility during flood.	VH	H	VH	L	VH	VH	VH	Open mining trenches continue to breed mosquitoes, flood increases the prevalence of cholera and continuous exposure to hazardous chemicals will continue to impede optimal growth. Children access schools using footpaths. Floods restrict their access.

The future residual risk assessment after implementing adaptation measures in the Aowin municipal shows a moderate to high level of risk across different groups, reflecting varied levels of vulnerability and adaptive capacity (Table 9).

- **Women** face a **medium residual risk** due to their central roles in resource management and food provision, which are highly sensitive to climate variability. Despite improved water management, challenges remain due to their high exposure to climate impacts.
- **Youth** also encounter a **medium residual risk**, benefiting from high adaptive capacity through education and technology. However, irregular weather patterns continue to threaten their employment prospects in agriculture and related sectors.
- **Differently-abled individuals** experience the **highest residual risk**, with limited adaptive capacity and high exposure to events like flooding. Specific, inclusive strategies are needed to enhance their safety and accessibility during such crises.
- Children face high residual risks with limited adaptative capacity and high exposure to events of flooding exacerbated by exposure to hazardous chemicals from illegal mining.

9 Conclusion and Recommendations

9.1 Future Climate Change Scenarios for Aowin Municipal

Projections for the Aowin Municipal indicate significant environmental challenges shaped by climate change. By the end of the century, temperatures are expected to increase between 1.5°C and 4°C, depending on emission scenarios. This warming trend is anticipated to heighten heat stress, potentially reducing agricultural productivity, straining water resources, and exacerbating health vulnerabilities. Rainfall patterns are projected to fluctuate, with potential variations of approximately 10% from historical averages. Intense rainfall events are more likely, which could exacerbate flooding risks in both urban and rural areas. These floods threaten to damage critical infrastructure, disrupt livelihoods, and compromise agricultural lands.

9.2 Priority Climate Related Hazards and Risks

The climate risk assessment for Aowin Municipal has identified several critical risk domains that are particularly sensitive to the impacts of climate change:

- **Water Resources**: Threats to water availability due to erratic rainfall and increased evaporation.
- **Agricultural Systems**: Vulnerability of crop production to changing temperature and precipitation patterns.
- **Forest and Biodiversity**: Risks to forest cover from increased temperatures and changing rainfall regimes.
- **Community Health**: Challenges related to waterborne and vector-borne diseases exacerbated by climate change.
- **Infrastructure**: Increased susceptibility to damage from flooding and land degradation.

Key climate hazards for Aowin include extreme heat, altered rainfall patterns, and both riverine and flash flooding. These conditions threaten the municipal's agricultural base, water resources, forest biodiversity, and the overall health of the community.

Engagement with stakeholders in Aowin has been crucial for understanding the impacts of climate hazards. This interaction has helped in identifying the levels of current and future risks based on the Municipal's hazard exposure and adaptive capacity. It has also helped to understand the impact of the climate risks to the various gender groups. Some of the most pressing risks identified include:

- **Agricultural production** is under threat from unpredictable weather patterns and temperature variations, potentially reducing crop yields and affecting food security.
- **Water resources** are at risk from reduced rainfall and increased evaporation, leading to water scarcity and affecting both drinking water supplies and agricultural irrigation.
- **Community health** could deteriorate due to an increase in waterborne diseases from flooding and mining and inadequate water quality, and from vector-borne diseases due to warmer climates.

9.3 Climate Change Risk Assessment Results

In Aowin Municipal, understanding the vulnerability to climate change involves an examination of how the region's unique characteristics intersect with a range of potential climate hazards. Vulnerability, as emphasized by the Intergovernmental Panel on Climate Change (IPCC), is not solely about geographic exposure but also encompasses socio-economic, cultural, institutional, and infrastructural factors that influence the community's capacity to respond to and recover from climate impacts.

Geographically, Aowin's landscape, with its low-lying areas prone to flooding and its surrounding hills at risk of erosion, is inherently vulnerable to the increasing variability of weather patterns. This vulnerability is compounded by socio-economic factors such as high dependency on climate-sensitive sectors like agriculture, particularly cocoa farming, which is susceptible to shifts in temperature and precipitation patterns. The economic reliance on such a sector makes the community's income and food security highly sensitive to climate variability.

The climate risk assessment for the Aowin Municipal Assembly has highlighted significant vulnerabilities across various sectors, reflecting the municipality's exposure to hazards such as irregular rainfall, flooding, and extreme weather events. These risks are driven by both natural and anthropogenic factors, with unique impacts on gender roles, socio-economic structures, and critical infrastructure. Below are the detailed results for each major sector, grounded in the specific context of Aowin

9.3.1 Gender Vulnerability

Women in Aowin Municipal face heightened vulnerability due to their roles in subsistence farming, caregiving, and water collection. Seasonal water scarcity, worsened by erratic rainfall, increases the time and physical effort required for water collection, disproportionately impacting women and girls. Cultural practices, such as prohibiting women from crossing the Disue River on specific days, further limit their economic opportunities and access to markets. Additionally, women's limited access to land ownership, credit, and advanced farming technologies exacerbates their vulnerability, especially in the face of declining agricultural productivity due to climate stressors.

9.3.2 Community Health Sector

Climate-induced health risks are significant in Aowin. The prevalence of diseases such as malaria, diarrhea, and typhoid has increased due to flooding, stagnant water, and poor sanitation infrastructure. These challenges are compounded by limited access to healthcare services, particularly for rural communities. Children and the elderly are especially vulnerable to heat-related illnesses, while women bear a disproportionate burden as caregivers during health crises. The lack of proper drainage systems and the proliferation of mosquitoes further elevate the health risks in communities across the municipality.

9.3.3 Agriculture and Food Security

Agriculture, the backbone of Aowin's economy, is highly sensitive to climate variability. Cocoa, the main cash crop, faces declining yields due to unpredictable rainfall patterns, pest infestations, and soil degradation. Food crop farmers are also affected, with prolonged dry spells and unseasonal heavy rains disrupting planting and harvesting cycles. Access to markets is hindered by poor road conditions, especially during the rainy season, leading to increased post-harvest losses and economic instability. Smallholder farmers, particularly women, face challenges in adopting climate-smart agricultural practices due to limited resources and institutional support.

9.3.4 Infrastructure and Human Settlement

Critical infrastructure in Aowin, including roads, bridges, and public buildings, is severely affected by climate hazards. Flooding and heavy rains cause recurrent damage, making many roads impassable and isolating rural communities. This has a cascading impact on economic activities, particularly the transportation of cocoa and other agricultural products. Settlements along riverbanks, such as Enchi and Old Yakasi, are frequently affected by flooding, leading to property damage and displacement. The municipality's infrastructure requires significant investment in climate-resilient construction and regular maintenance.

9.3.5 Water Supply and Security

Water scarcity and quality degradation are critical challenges in Aowin. Irregular rainfall patterns, combined with pollution from illegal mining activities, have led to the contamination of rivers and streams, the primary water sources for many communities. Drought conditions exacerbate these issues, with salinity intrusion and reduced water availability impacting both domestic use and agricultural productivity. Women and girls, who are primarily responsible for water collection, bear the brunt of these challenges, often traveling long distances to access clean water.

9.3.6 Forest and Biodiversity

Aowin's forest reserves are under threat from illegal logging, mining, and unsustainable agricultural practices. These activities have led to deforestation, soil erosion, and loss of biodiversity, weakening the natural resilience of the ecosystem. The destruction of forest cover has reduced the municipality's capacity to buffer against climate impacts such as flooding and extreme heat. The loss of biodiversity also threatens livelihoods that depend on forest resources, such as timber and non-timber forest products.

9.4 Recommendations

The Aowin Municipal Assembly's climate change adaptation strategies should emphasize localized, inclusive, and sustainable approaches, addressing the municipal's distinct vulnerabilities, socio-economic dynamics, and environmental challenges. The recommendations outlined below are based on the findings of this assessment and provide a roadmap for building resilience and fostering sustainable development:

9.4.1 Water Resources Management

- ***Rainwater Harvesting and Storage:*** Install rainwater harvesting systems in Old Yakasi and Achimfo and enhance water storage facilities in Boinso and Adonikrom to address seasonal water shortages.
- ***Water Quality Monitoring and Regulation:*** Enforce strict regulations on mining activities near critical water bodies like the Disue River to prevent contamination. Establish robust monitoring systems and empower communities, including women, to report illegal activities.
- ***Water-Efficient Practices:*** Promote drip irrigation and educate farmers on water-efficient agricultural techniques to minimize wastage.

9.4.2 Infrastructure and Human Settlements

- ***Climate-Resilient Infrastructure:*** Build flood-resistant roads and bridges, especially in Enchi and Nankaba, and retrofit public buildings to withstand extreme weather events.
- ***Flood Management Systems:*** Develop levees and drainage systems in flood-prone areas such as Achimfo to mitigate flooding risks.

- ***Reforestation and Green Buffers:*** Establish green buffers along water bodies and in degraded areas to prevent soil erosion and improve flood resilience.

9.4.4 Agriculture and Food Security

- ***Climate-Smart Agriculture:*** Introduce drought-resistant crops and diversify farming systems with agroforestry practices in Nyankaman and Omanpe.
- ***Soil Conservation Measures:*** Encourage contour ploughing and terracing to prevent soil erosion, particularly in cocoa-growing areas.
- ***Weather Forecasting Services:*** Provide localized weather information to farmers to guide planting and harvesting decisions.

9.4.5 Community Health

- ***Improved Sanitation and Water Access:*** Upgrade water and sanitation infrastructure in areas like Boin and Butuye to reduce disease outbreaks, particularly those linked to mining pollution.
- ***Disease Surveillance and Public Awareness:*** Strengthen health monitoring systems and launch community campaigns on hygiene and disease prevention.
- ***Flood-Resilient Health Centers:*** Elevate and secure health facilities in high-risk areas to maintain functionality during extreme weather events.

9.4.6 Forest, Mining, and Biodiversity Conservation

- ***Reforestation and Sustainable Forest Management:*** Implement community-led tree-planting programs and regulate logging activities to restore degraded lands and conserve biodiversity.
- ***Mitigating Mining Impacts:***
  - Enforce stricter environmental regulations on artisanal and illegal mining operations to prevent deforestation and water pollution.
  - Rehabilitate degraded mining sites through reforestation and soil restoration initiatives.
- ***Ecosystem Restoration:*** Restore wetlands and create wildlife corridors to improve biodiversity and natural defenses against climate impacts.

9.4.7 Governance and Capacity Building

- ***Capacity Building:*** Train local officials and communities on climate adaptation planning, including strategies for managing mining-related environmental impacts.
- ***Resource Mobilization:*** Collaborate with development partners, NGOs, and the private sector to secure funding for adaptation projects.
- ***Monitoring and Evaluation:*** Establish systems to track the progress and impact of adaptation initiatives for continual improvement.

ADAPTATION ACTION PLAN FOR THE AOWIN MUNICIPAL ASSEMBLY

10

Adaptation Action Plan for the Aowin Municipal Assembly

10.1 Introduction

The Adaptation Action Plan (AAP) for the Aowin Municipal Assembly provides a strategic, targeted, and actionable framework to address the pressing challenges posed by climate change. Situated in Ghana's Western North Region, Aowin's economy is deeply rooted in agriculture, forestry, and small-scale mining, sectors that are increasingly vulnerable to climate variability and extreme weather events. With these challenges come risks to livelihoods, infrastructure, and the environment, underscoring the urgent need for a coordinated response.

This plan seeks to enhance Aowin's resilience by integrating adaptation strategies into the municipal's development agenda. By aligning with Ghana's National Adaptation Plan (NAP) framework, the AAP not only ensures sustainability but also provides a foundation for securing financial support from government, international donors, and private investors. It is designed to prioritize and implement actions that mitigate risks, optimize resources, and build a sustainable and climate-resilient future for the municipality and its people.

The Aowin Adaptation Action Plan emphasizes practical and impactful interventions tailored to the municipal's unique context. It prioritizes inclusivity, ensuring that local communities, traditional authorities, and stakeholders are actively involved in developing and executing climate solutions. This approach guarantees that adaptation measures are both effective and reflective of the municipal's realities.

The AAP for Aowin focuses on the following critical areas:

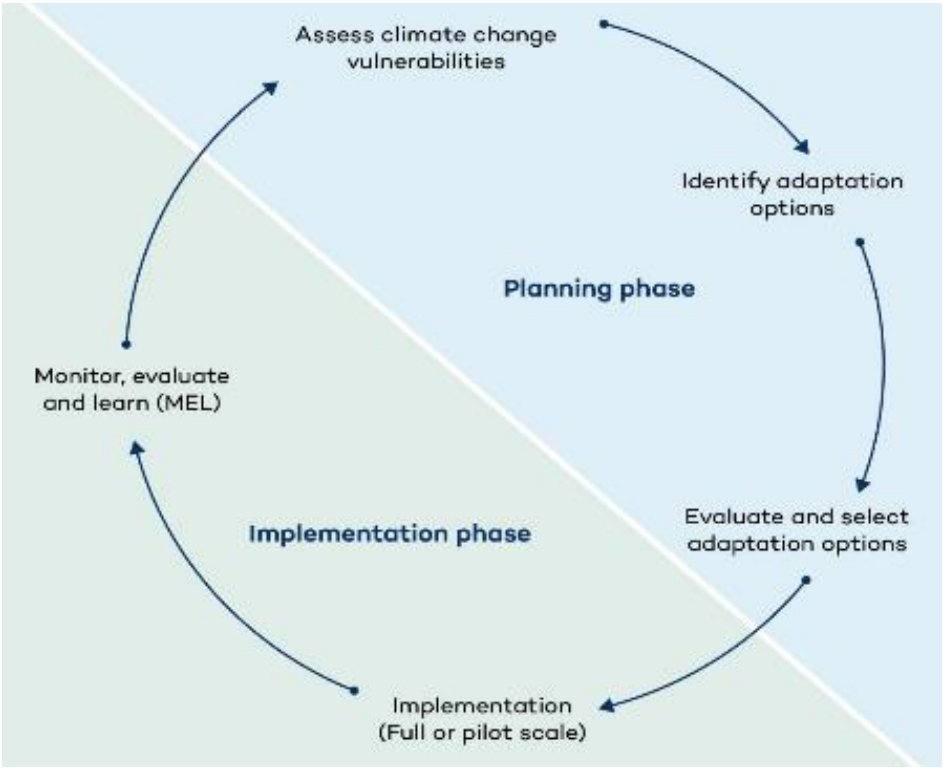
1. **Risk Assessment and Vulnerability Analysis:** Identifying the most critical climate risks and vulnerabilities in sectors such as agriculture, water resources, and infrastructure. This analysis informs targeted interventions to reduce exposure and enhance adaptive capacity.

2. **Stakeholder Engagement:** Actively involving local communities, government agencies, traditional leaders, and private sector actors in designing and implementing adaptation strategies. This inclusive approach ensures widespread support and maximizes the effectiveness of proposed measures.

3. **Implementation of Adaptation Measures:** Executing practical interventions to address climate risks. These include reforestation programs, sustainable agricultural practices, improved water management systems, and enhanced infrastructure to withstand extreme weather events.

4. **Monitoring and Evaluation:** Establishing a dynamic monitoring and evaluation framework to track progress, assess impacts, and refine strategies as needed. This ensures the plan's long-term sustainability and adaptability in the face of evolving climate conditions.

Figure 33: Approach to Aowin Municipal Assembly Adaptation Planning



10.2 Identification and Compilation of Sector-Specific Adaptation Actions

The Adaptation Action Plan for the Aowin Municipal Assembly is a detailed and targeted framework designed to address the municipal's unique challenges and vulnerabilities to climate change. This process involved the meticulous identification and integration of specific adaptation strategies, ensuring their relevance to the socio-economic, environmental, and infrastructural realities of the municipal. These actions are aimed at building resilience, reducing vulnerabilities, and safeguarding the livelihoods of Aowin's communities.

The methodologies and techniques employed to identify these adaptation measures are summarized in Table 10 and Figure 34. These tools ensured the plan's inclusivity, evidence-based foundation, and alignment with both national and local priorities. The Action Plan prioritizes the following six critical sectors:

- Agriculture and Food Security
- Water Resources
- Community Health
- Forestry and Biodiversity
- Infrastructure and Human Settlements
- Gender responsiveness

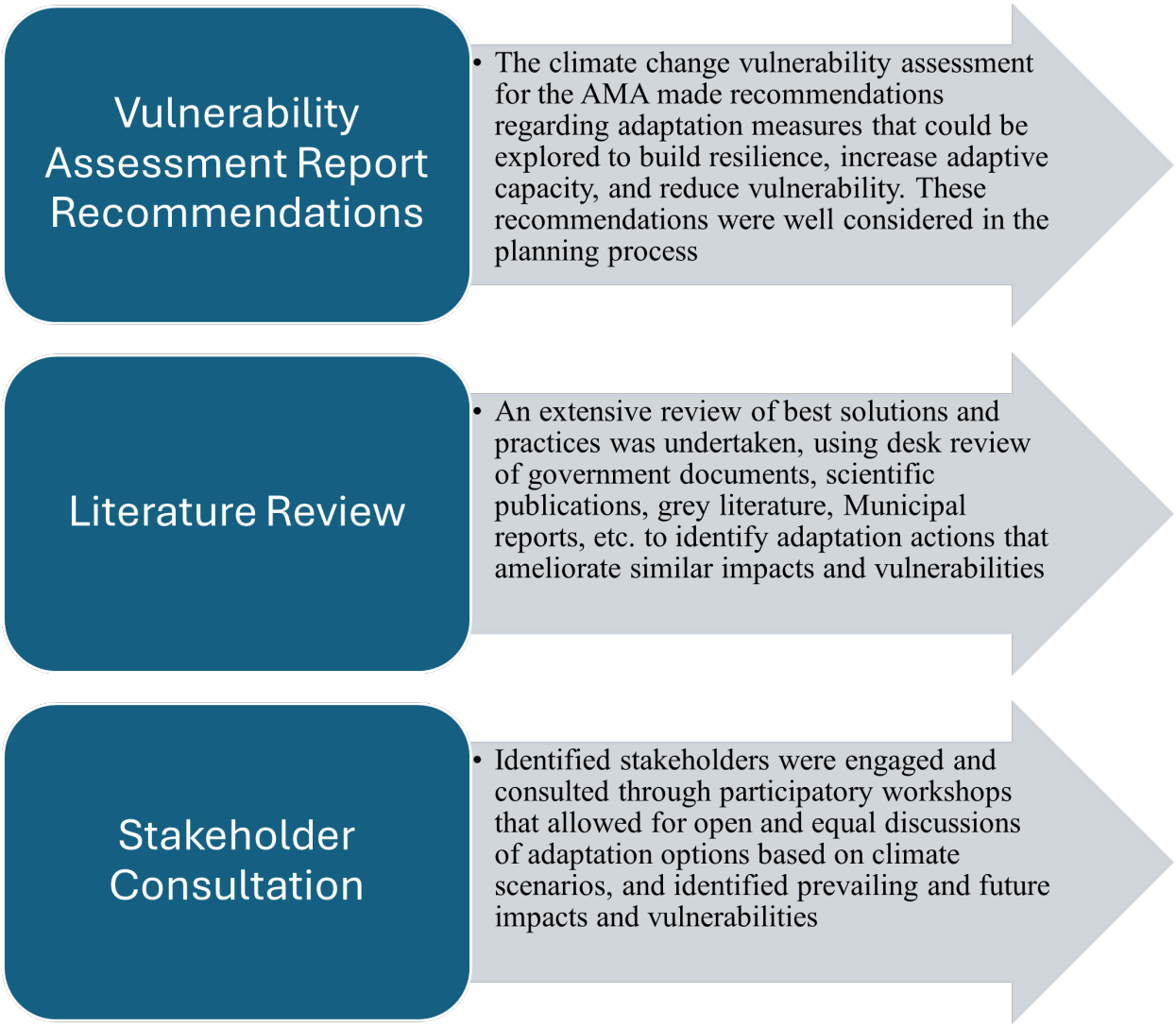
The planning process relied on three core methodologies as seen in figure xx

Vulnerability Assessment Recommendations: The Climate Vulnerability Assessment for Aowin provided the foundation for identifying adaptation measures. It highlighted specific climate risks affecting key sectors such as agriculture, water resources, health, and infrastructure. These recommendations were central to the planning process, ensuring that identified actions directly addressed the municipal's most pressing challenges.

Literature Review: A detailed review of relevant documents, including government policies, municipal reports, scientific publications, and grey literature, was conducted. This step focused on identifying best practices and adaptation strategies that have proven effective in addressing similar climate impacts elsewhere. The literature review provided critical insights to shape innovative and practical solutions for Aowin.

Stakeholder Consultation: Stakeholder engagement was integral to the process, ensuring inclusivity and local relevance. Representatives from local communities, traditional authorities, government agencies, NGOs, and private sector actors participated in participatory workshops. These consultations facilitated open discussions on adaptation options, validated findings, and prioritized actions based on feasibility and impact.

Figure 34: Methodology to identify adaptation options



In total, **31 adaptation options** were identified across the six sectors. Table 10 illustrates the distribution of these actions, with **community health and infrastructure and human settlements** ranking the highest in terms of proposed actions. These priorities reflect the critical vulnerabilities identified during the vulnerability assessment and stakeholder consultations.

Table 10: Distribution of Adaptation Actions by Sector

Sector	Number of Adaptation Actions	Rank
Agriculture and Food Security	6	4
Water Supply and Security	5	5
Community Health	8	1
Forestry and Biodiversity	5	5
Infrastructure and Human Settlements	7	2

10.3 Methodological Approach for Ranking Adaptation Options

Based on the key vulnerabilities and climate risks identified in the Aowin Municipal Assembly, a comprehensive list of potential adaptation options was developed through a detailed desk review, literature search, and interactions with key stakeholders. These options were then validated and refined during participatory stakeholder workshops, ensuring their alignment with local priorities and realities.

During the workshops, participants were grouped according to their expertise and interest areas, representing critical sectors such as agriculture, forestry and biodiversity, water and sanitation, health, infrastructure, and disaster risk reduction. This grouping allowed for focused discussions and evaluations of adaptation options. The stakeholders were tasked with assessing the suitability of the proposed measures for the Aowin context, their potential to enhance resilience, reduce vulnerabilities, and support sustainable development.

This prioritization process aimed to ensure that decisions were informed, effective, and avoided the risks of maladaptation. Relevant actors, including municipal officials, traditional leaders, community representatives, and technical experts, were actively involved in the assessment to guarantee the appropriateness of the selected options. Careful attention was given to avoiding measures that could unintentionally exacerbate vulnerabilities or create new challenges.

To evaluate and rank the adaptation options, the Multicriteria Decision-Making (MCDM) analysis was employed. This systematic approach allowed stakeholders to assess each adaptation measure against multiple criteria, ensuring balanced and well-informed decisions. The MCDM approach was particularly important as it acknowledged that different adaptation measures might perform variably across criteria and could involve trade-offs. The MCDM methodology involves defining relevant criteria, assigning weights to each criterion based on their significance, and then scoring the adaptation options accordingly. This method enabled the evaluation of complex options, incorporating input from diverse stakeholders to balance competing objectives

The criteria for the evaluation of the climate change adaptation strategies are defined in Table 11

Plate 9 : Consultation with the sector stakeholders for the ranking and prioritization exercise

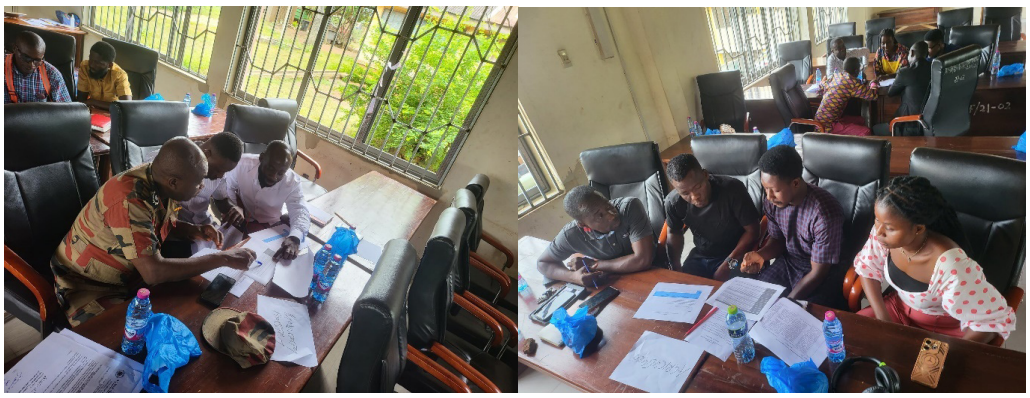


Table 11: Criteria for the assessment of the climate change adaptation options

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** **Alignment with municipal and/or national priorities**	Institutional feasibility refers to institutional and legal capacity. The preferred adaptation option aligns with laws, regulations, and institutional structures. The extent to which does this measure supports other development priorities of the municipal 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/ Economic/ Institutional/ Environmental or social**	**Barriers to implmentation**	This identifies potential institutional, economic, technological, and social barriers to the implementation of the adaptation option.

Source: Adapted from Dixit & McGray (2013)

After ranking the different indicators, it was essential to assign appropriate weights to them. An unequal weighting system, reflecting the relative importance of each indicator, was used (Zobeidi et al., 2024; Antwi-Agyei et al., 2013; UNFCCC, 2011). Therefore, a five-point Likert scale (Table 11) was utilized, where climate change experts, as well as agricultural and food experts, ranked the indicators based on their perceived importance, similar to the method used by Antwi-Agyei et al. (2013). The frequency with which each indicator was cited was used to develop the weighting system (Zobeidi et al., 2024; Antwi-Agyei et al., 2013; UNFCCC, 2011).

Table 12: 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.**

Following the scoring and weighting process, the adaptation options were ranked according to their overall performance. This ranking allowed stakeholders to identify which options should be prioritized for implementation. The prioritization process was carried out in collaboration with local stakeholders to ensure that the selected options were not only technically and economically feasible but also socially acceptable and aligned with the local governance framework.

- **Sector-Based Prioritization:** Each sector (agriculture, water, health, etc.) generated a list of prioritized adaptation options. These sector-based lists were then integrated into a comprehensive municipal-wide adaptation plan, which balanced the needs and priorities of all sectors.
- **Transparent Decision-Making:** The MCDA approach promoted transparency in decision-making, ensuring that stakeholders understood how the ranking of adaptation options was derived. This transparency fostered local ownership of the decisions and improved the likelihood of successful implementation.

Once the prioritization process was completed, the results were reviewed with stakeholders to validate the findings. This review process allowed for any necessary adjustments to be made and ensured that the final list of prioritized adaptation options reflected the needs and priorities of all sectors within Aowin Municipal.

10.4 Adaptation options

The adaptation options for the Aowin Municipal Assembly represent a carefully curated set of measures aimed at addressing the municipal's most pressing climate risks and vulnerabilities. These options were identified through a structured process that included desk reviews, vulnerability assessments, and participatory stakeholder workshops.

Focusing on five critical sectors—agriculture and food security, water resources, community health, forestry and biodiversity, and infrastructure and human settlements—these measures are designed to enhance resilience and foster sustainable development. Each option reflects the local context and aligns with the municipality's priorities, ensuring that the interventions are both practical and impactful.

10.4.1 Agriculture and Food Security

Agriculture is a cornerstone of the economy and livelihoods in the Aowin Municipal Assembly, with the majority of residents relying on farming for sustenance and income. However, the sector faces significant challenges due to climate change, including erratic rainfall patterns, prolonged droughts, and rising temperatures. These impacts threaten crop yields, soil health, and the livelihoods of smallholder farmers in communities like Enchi, Dadieso, and Boinso, many of whom depend on rain-fed agriculture.

To address these vulnerabilities, the Aowin Municipal Assembly has identified and ranked several adaptation options to enhance the resilience of the agricultural sector. Capacity-building workshops, ranked first, are central to equipping farmers with the knowledge and skills needed to adopt climate-smart agricultural practices. These workshops, conducted in collaboration with NGOs and farmer-based organizations, focus on sustainable techniques such as crop rotation, composting, and efficient water use. Farmers trained in towns like Kwawu and Achimfo have already begun integrating these practices to improve productivity and reduce environmental impacts.

Agroforestry, ranked second, is another key intervention, promoting the integration of trees into farmlands to improve soil fertility, reduce erosion, and provide additional income streams through timber and non-timber forest products. Communities in Akontombra and Nyankamam are adopting this approach to rehabilitate degraded lands and create more sustainable farming systems.

Ranked third, diversified cropping systems aim to reduce reliance on single crops and enhance resilience to climatic variability. Planting a variety of crops, farmers in Enchi and Dadieso are better equipped to withstand unpredictable weather patterns and mitigate the risks of crop failure. This measure also improves food security by ensuring a more stable supply of agricultural products.

Table 13: Ranking of adaptation options for the agriculture sector

Adaptation option	Final score from stakeholders	Rank
Diversified Cropping Systems	39	3rd
Agroforestry	41	2nd
Soil Conservation Measures	32	5TH
Advanced Weather Forecasting Tools	37	4th
Capacity Building Workshops	48	1st
Irrigation and atmospheric water	24	6th

The fourth-ranked measure, advanced weather forecasting tools, supports farmers in planning their agricultural activities more effectively. Providing timely and accurate weather information, these tools enable farmers to optimize planting and harvesting schedules, reducing losses due to unexpected climatic events. Farmers in areas like Boinso and Achimfo are increasingly using these tools to improve decision-making and productivity.

Soil conservation measures, ranked fifth, address critical issues of land degradation and erosion. Techniques such as terracing, contour plowing, and mulching are being implemented to improve soil health and ensure long-term agricultural sustainability. These practices are particularly important in Nyankamam and surrounding areas, where degraded soils pose a major challenge to farming.

Finally, irrigation and atmospheric water harvesting, ranked sixth, are being introduced to address water scarcity, particularly during prolonged dry spells. Small-scale irrigation systems and innovative atmospheric water collection methods are being piloted in communities like Kwawu and Dadieso to ensure a consistent water supply for agriculture. While this measure is still in its early stages, it has the potential to significantly enhance resilience against drought.

10.4.2 Community Health

The Aowin Municipal Assembly faces significant public health challenges as a result of climate change, including the spread of vector-borne diseases, waterborne illnesses, and inadequate sanitation. Communities such as Enchi, Boinso, and Dadieso are particularly vulnerable due to limited access to clean water, poor sanitation infrastructure, and insufficient public health resources. Erratic rainfall, prolonged dry spells, and flooding events further exacerbate these challenges, threatening the well-being of residents and straining local healthcare systems.

To address these vulnerabilities, several high-priority adaptation measures have been identified. **Watershed restoration**, ranked first by stakeholders, is critical for protecting and rehabilitating water sources in the municipal. Restoring degraded watersheds, particularly around the Tano River, ensures a sustainable supply of clean water for domestic and agricultural use. This initiative also mitigates the risks of waterborne diseases by reducing contamination from runoff and other pollutants. **Vector control technologies**, also ranked first, aim to reduce the prevalence of diseases such as malaria and dengue. The distribution of insecticide-treated nets, coupled with targeted community spraying programs, has been prioritized in high-risk areas like Boinso and Akontombra. These measures are essential for breaking the transmission cycle of vector-borne diseases, particularly in areas experiencing increasing temperatures and prolonged wet seasons.

Equally prioritized are **public health regulations**, which play a key role in improving resilience to climate-induced health risks. These regulations focus on ensuring clean water supply, managing waste effectively, and controlling pollution from mining and agricultural activities. Complementing these efforts are **community education and awareness programs**, which empower residents with knowledge about climate-related health risks and adaptive behaviors. Workshops and outreach campaigns in towns like Dadieso and Kwawu have been instrumental in promoting healthier practices and reducing preventable diseases.

Table 14: Summary of Adaptation Options for Agriculture and Food Security in Aowin

Adaptation Actions	Objectives	Indicators of Success	Time Frame	Resources (Finance, Human, Technology)	Implementing Partners	Estimated Cost (GH₵)
Capacity-Building Workshops	To equip farmers in communities like Enchi, Kwawu, and Dadieso with knowledge and skills to adopt climate-smart agricultural practices, increase resilience to climate impacts, and improve productivity.	• Number of workshops conducted. • Percentage of farmers adopting climate-smart practices. • Increased crop yields and improved resource management.	Short Term	• Funding for training sessions. • Skilled facilitators. • Training materials and tools.	Aowin Municipal Assembly (Lead), NGOs, Farmer-Based Organizations	
Agroforestry Practices	To enhance soil fertility, control erosion, and provide additional income streams in areas like Akontombra and Nyankamam while supporting biodiversity conservation.	• Hectares of land under agroforestry. • Improved soil fertility metrics • Increased farmer incomes from agroforestry products • Reduced soil erosion rates.	Medium Term	• Tree seedlings • Planting equipment • Extension services and monitoring tools.	Forestry Commission (Lead), Traditional Authorities, Local NGOs	
Diversified Cropping Systems	To reduce dependence on monoculture farming, enhance resilience to climatic variability, and improve food security in towns like Dadieso and Achimfo.	• Increased diversity of crops grown. • Improved farmer income levels. • Reduced risks of crop failure due to weather variability.	Short to Medium Term	• Supply of diverse crop seeds. • Demonstration plots. • Farmer extension services.	Ministry of Food and Agriculture (MoFA) (Lead), Local NGOs	

Advanced Weather Forecasting Tools	To provide farmers in Boinso and Nyankamam with timely and accurate weather information to plan agricultural activities and mitigate risks from climatic variability.	• Number of farmers using weather tools. • Reduced crop losses due to extreme weather. • Improved planning of planting and harvesting activities.	Medium Term	• Digital forecasting tools. • ICT infrastructure and mobile networks. • Training programs for farmers.	Ghana Meteorological Agency (Lead), MoFA, Telecommunications Companies	
Soil Conservation Measures	To prevent land degradation, enhance soil health, and ensure long-term agricultural productivity in degraded areas such as Achimfo and Kwawu.	• Reduction in soil erosion rates. • Increased adoption of soil conservation techniques. • Improved crop yields in targeted areas.	Short to Medium Term	• Funds for land restoration activities. • Technical expertise. • Equipment for mulching, terracing, and contour plowing.	Aowin Municipal Assembly (Lead), Local Farmer Groups	
Irrigation and Atmospheric Water Harvesting	To ensure water availability for agriculture, particularly during dry spells in Dadieso and Kwawu, and reduce reliance on rain-fed systems.	• Increased number of farms with irrigation systems. • Improved water use efficiency in farming. • Reduction in crop losses during dry periods.	Medium to Long Term	• Irrigation infrastructure (pipes, pumps, water storage facilities). • Technical support for system installation.	Aowin Municipal Assembly (Lead), Water Resources Commission, Private Contractors	

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

Adaptation option	Final score from stakeholders	Rank
Watershed management	**40**	8th
Watershed restoration	**45**	**1st**
Water treatment systems	43	6th
Flood mitigation infrastructure	**43**	**6th**
Improved sanitation infrastructure	44	5th
Vector control technologies	45	1st
Public health regulations	45	1st
Community education and awareness	45	1st

Improved sanitation infrastructure, ranked fifth, addresses critical gaps in hygiene and sanitation facilities across the municipal. New sanitation systems are being constructed in vulnerable communities, while education campaigns ensure their effective use. These measures are expected to significantly reduce the incidence of diseases such as cholera and diarrhea. **Flood mitigation infrastructure**, ranked sixth, is vital for protecting public health facilities and minimizing health risks associated with flooding. Reinforcing health centers in flood-prone areas like Enchi and Boinso ensures they remain functional and accessible during extreme weather events. These measures also help safeguard critical medical supplies and improve emergency response capacity.

Water treatment systems, also ranked sixth, focus on enhancing water quality in areas where untreated water is commonly used. Advanced filtration and purification technologies are being introduced, particularly in Enchi and Akontombra, to reduce waterborne diseases and improve overall community health. Finally, **watershed management,** ranked eighth, complements restoration efforts by ensuring the long-term sustainability of rehabilitated water sources. Community-led initiatives to monitor and manage watersheds are fostering local stewardship and improving water use practices in towns like Achimfo and Nyankamam.

Table 16: Summary of Adaptation Options for Community Health in Aowin

Adaptation Actions	Objectives	Indicators of Success	Time Frame	Resources (Finance, Human, Technology)	Implementing Partners	Estimated Cost (GH₵)
Watershed Restoration	To protect and rehabilitate critical watersheds like those near the **Tano River**, ensuring sustainable water supply and improved public health.	• Number of restored watersheds. • Improved water quality metrics. • Reduced prevalence of waterborne diseases in affected communities.	Medium Term	• Funds for watershed restoration projects. • Community participation. • Tools for catchment management.	Aowin Municipal Assembly (Lead), NGOs, Ministry of Water Resources	
Vector Control Technologies	To reduce the prevalence of vector-borne diseases such as malaria in high-risk communities like **Enchi, Dadieso, and Akontombra**.	• Reduced incidence of malaria and related diseases. • Increased community adoption of vector control technologies. • Improved health outcomes.	Short Term	• Insecticide-treated nets • Community spraying programs • Educational materials for malaria prevention.	Ghana Health Service (Lead), Local NGOs, WHO	
Public Health Regulations	To strengthen policies in areas like **Boinso and Nyankamam**, ensuring clean water access and proper waste management.	• Number of health regulations enforced. • Reduced contamination of water sources. • Improved community health indicators.	Short to Medium Term	• Legislative support. • Health enforcement teams. • Monitoring tools for compliance.	Ministry of Health (Lead), Aowin Municipal Assembly	

Community Education and Awareness Programs	To raise awareness about climate-induced health risks and adaptive behaviours in communities like **Kwawu and Achimfo.**	• Number of education campaigns conducted. • Increased adoption of healthier practices. • Reduction in preventable health conditions.	Short Term	• Public education materials. • Training for community leaders. • Outreach platforms for information sharing.	Local NGOs (Lead), Community Leaders, Ghana Health Service	
Improved Sanitation Infrastructure	To enhance access to sanitation facilities and reduce disease outbreaks in vulnerable communities like **Enchi and Boinso.**	• Number of new sanitation facilities constructed. • Increased sanitation coverage. • Reduced incidence of sanitation-related diseases.	Medium to Long Term	• Construction materials • Sanitation engineers. • Behavioral change campaigns for communities.	Ministry of Sanitation (Lead), Local NGOs, Aowin Municipal Assembly	
Water Treatment Systems	To ensure clean drinking water in communities such as **Enchi and Dadieso**, reducing waterborne diseases through advanced treatment technologies.	• Number of communities with functional water treatment systems. • Reduced waterborne disease prevalence. • Improved water quality.	Medium Term	• Water filtration technologies. • Technical expertise for installation. • Maintenance funding.	Ministry of Water Resources (Lead), Local NGOs, Private Sector	
Flood Mitigation Infrastructure	To protect health facilities in flood-prone areas such as **Enchi and Boinso**, ensuring functionality during climate events.	• Number of health facilities retrofitted against flooding. • Improved emergency response capacity. • Secure storage of medical supplies.	Long Term	• Engineering tools. • Retrofitting designs. • Skilled labor for implementation.	NADMO (Lead), Ministry of Health, NGOs	
Community Health Networks	To expand access to healthcare services in remote areas like **Nyankamam and Dadieso** by training community health workers (CHWs).	• Number of CHWs trained and deployed. • Increased health service coverage in underserved areas. • Improved community health outcomes.	Short Term	• Training resources for CHWs. • Transportation for remote areas. • Health kits and medical supplies.	Ghana Health Service (Lead), Local NGOs, Community Health Committees	

10.4.3 Infrastructure and Human Settlement

Infrastructure and human settlements in the Aowin Municipal Assembly are highly vulnerable to the impacts of climate change, including flooding, extreme weather events, and gradual environmental degradation. Communities such as Enchi and Boinso face significant challenges due to poor drainage systems, unplanned urban growth, and aging infrastructure that cannot withstand the increasing frequency and intensity of climate-related hazards. These vulnerabilities not only threaten public safety but also disrupt economic activities and access to essential services.

To address these challenges, a range of adaptation measures has been prioritized based on stakeholder input. Ranked first, **community engagement and awareness programs** are essential for promoting climate-resilient infrastructure practices. These initiatives involve training community members in sustainable building practices, maintenance techniques, and disaster preparedness. Workshops held in Dadieso and Nyankamam have been instrumental in increasing awareness and fostering community-led actions to protect local infrastructure.

Green infrastructure, ranked second, focuses on integrating eco-friendly solutions into urban and rural planning. This includes creating green spaces, using permeable materials for roads and pavements, and promoting urban vegetation to mitigate heat and manage stormwater. In towns like Enchi and Akontombra, green infrastructure projects are helping to reduce the urban heat island effect and improve resilience to flooding. Ranked third, **flood-resilient urban planning** involves redesigning urban areas to minimize flood risks and enhance drainage efficiency. These efforts include the construction of improved drainage systems, zoning regulations to prevent settlement in flood-prone areas, and the incorporation of flood management designs in new developments. Communities such as Kwawu and Dadieso are benefiting from these initiatives, which aim to protect lives and property from extreme weather events.

Table 17: Ranking of Adaptation Options for the Infrastructure and Human Settlement

Adaptation option	Final score from stakeholders	Rank
Green Infrastructure	**39**	2nd
Flood-Resilient Urban Planning: Redesign of Urban Areas	**35**	3rd
Infrastructure Audit and Reinforcement:	**30**	5th
Upgrading and Reinforcing Infrastructure	**30**	5th
Regular Maintenance and Retrofitting	35	3rd
Retrofitting Existing Structures	33	4th
Community Engagement and Awareness Programs	40	1st

Also ranked third is **regular maintenance and retrofitting**, which ensures the longevity and functionality of critical infrastructure. Routine inspections, repairs, and retrofitting of roads, bridges, and public buildings are essential to withstand changing climate conditions. This measure is particularly important in areas like

Nyankamam, where aging infrastructure is more susceptible to damage. Ranked fourth, **retrofitting existing structures** is focused on strengthening vulnerable buildings to better resist extreme weather events. In flood-prone areas such as Boinso, public buildings and health facilities are being retrofitted to improve their resilience, ensuring that critical services remain operational during emergencies.

Infrastructure audits and reinforcement, ranked fifth, involve assessing the structural integrity of key infrastructure and identifying areas for improvement. By prioritizing repairs and upgrades, this measure reduces the risks of catastrophic failures, particularly in high-traffic areas and critical service points like schools and health centers. Finally, also ranked fifth, **upgrading and reinforcing infrastructure** focuses on modernizing outdated systems to meet current and future climate challenges. Investments in robust construction materials, advanced designs, and skilled labor ensure that new and existing infrastructure can withstand the impacts of extreme weather. Upgrades in areas like Enchi and Dadieso are enhancing the municipal's overall resilience.

Table 18: Summary of Adaptation Options for Infrastructure and Human Settlements in Aowin

Adaptation Actions	Objectives	Indicators of Success	Time Frame	Resources (Finance, Human, Technology)	Implementing Partners	Estimated Cost (GH₵)
Community Engagement and Awareness Programs	To raise awareness about climate-resilient infrastructure practices among residents in communities like Enchi and Boinso.	• Number of workshops conducted. • Improved understanding of climate-resilient practices. • Reduction in community-driven infrastructure damage.	Short Term	• Training materials • Facilitators and logistics for community workshops. • Communication tools.	Aowin Municipal Assembly (Lead), Local NGOs	
Green Infrastructure Development	To integrate eco-friendly infrastructure solutions into urban planning in areas like Dadieso and Nyankamam to mitigate extreme weather impacts.	• Number of green infrastructure projects completed. • Reduced urban heat island effects. • Improved stormwater management.	Medium to Long Term	• Funds for green materials • Technical expertise for design and implementation • Maintenance tools.	Ministry of Works and Housing (Lead), NGOs, Local Contractors	
Flood-Resilient Urban Planning	To redesign urban areas in flood-prone communities such as Kwawu and Akontombra to minimize flood risks and improve drainage systems.	• Number of flood-prone areas redesigned. • Improved drainage efficiency • Reduction in flood-related damages.	Medium Term	• Urban planning experts. • GIS tools • Funds for drainage system improvement.	Urban Planning Departments (Lead), Aowin Municipal Assembly	

Retrofitting Existing Structures	To strengthen critical public infrastructure in areas like Achimfo and Dadieso to withstand extreme weather events.	• Number of retrofitted public buildings. • Improved resilience of critical infrastructure. • Enhanced safety during disasters.	Medium to Long Term	• Retrofitting equipment • Technical expertise • Building materials for reinforcement.	Ministry of Works and Housing (Lead), NGOs, Local Contractors	
Regular Maintenance and Infrastructure Audits	To ensure the functionality and resilience of key infrastructure through regular assessments and repairs in communities like Nyankamam and Enchi.	• Number of audits conducted • Improved maintenance schedules. • Reduced infrastructure failure rates.	Short to Medium Term	• Audit tools. • Repair materials • Skilled labor for infrastructure maintenance.	Aowin Municipal Assembly (Lead), Ministry of Works and Housing	
Infrastructure Upgrades and Reinforcement	To modernize and strengthen aging infrastructure in areas like Kwawu and Dadieso to meet current and future climate challenges.	• Number of upgraded infrastructure projects • Enhanced resilience of upgraded systems. • Improved service delivery.	Medium Term	• Funds for modern construction materials • Technical expertise • Skilled labor for implementation.	Aowin Municipal Assembly (Lead), Ministry of Works and Housing	
Disaster Preparedness Training for Communities	To train residents in disaster-prone areas like Enchi and Boinso to safeguard infrastructure and respond effectively during climate events.	• Number of community members trained. • Improved disaster response times. • Reduction in infrastructure damage during disasters.	Short Term	• • Training modules • Facilitators and engagement materials • Community resources for practical drills.	NADMO (Lead), Local NGOs, Aowin Municipal Assembly	

10.4.4 Forestry and Biodiversity

Forestry and biodiversity in the Aowin Municipal Assembly are critical to the municipal's ecological and economic well-being. Forests in the area provide essential ecosystem services such as carbon sequestration, water regulation, and soil conservation, while also serving as a source of livelihood for communities reliant on timber, non-timber forest products, and eco-tourism. However, these resources are increasingly threatened by deforestation, unsustainable logging, and climate change. Communities such as Enchi, Akontombra, and Nyankamam face significant risks due to forest degradation, which exacerbates soil erosion, reduces biodiversity, and undermines the local economy.

To address these challenges, several adaptation measures have been identified and prioritized. Ranked first, **sustainable forest management software** is being introduced to improve monitoring and management of forest resources. This software enables real-time tracking of logging activities, deforestation rates, and biodiversity health. By equipping stakeholders with accurate data, this measure ensures informed decision-making and strengthens enforcement against illegal logging. Areas like Boinso and Dadieso are already benefiting from these innovative tools, which enhance the efficiency and transparency of forest management.

Afforestation and forest degradation reduction, ranked second, focuses on restoring degraded lands and increasing tree cover through targeted tree-planting initiatives. These programs are being implemented in deforested areas around Akontombra and Achimfo, where community-led efforts are helping to rehabilitate forests and improve soil and water conservation. By involving local residents, this measure also creates economic opportunities through the cultivation of timber and non-timber forest products.

Table 19: Ranking of Adaptation Options for the Forestry and Biodiversity Sector

Adaptation option	Final score from stakeholders	Rank
Afforestation and Forest Degradation Reduction	38	2nd
Sustainable Forest Management Software	39	1st
Controlled Logging Practices	37	3rd
Community Engagement and Education	35	4th
Sustainable Tourism Development	31	5th

Ranked third, **controlled logging practices** aim to regulate timber extraction to ensure the sustainable use of forest resources. This includes the enforcement of strict logging quotas, monitoring of logging concessions, and promotion of alternative income-generating activities to reduce reliance on unsustainable practices. Controlled logging is particularly important in Enchi and Kwawu, where overexploitation of forest resources has been a major concern.

Community engagement and education, ranked fourth, emphasizes the active involvement of local residents in forest conservation efforts. Awareness campaigns and capacity-building workshops in communities like Nyankamam and Achimfo are fostering a sense of stewardship among residents. These programs highlight

the importance of forests for local livelihoods and climate resilience, encouraging behaviors that support sustainable forest use.

Finally, **sustainable tourism development**, ranked fifth, focuses on promoting eco-tourism as a strategy for conserving biodiversity while generating income for local communities. Efforts are underway to develop eco-tourism sites and train community members as guides and entrepreneurs. This initiative not only reduces pressure on forest resources but also raises awareness about the value of biodiversity. Enchi and surrounding areas with rich biodiversity are key targets for this measure, which aims to integrate conservation with economic development.

Table 20:Summary of Adaptation Options for Forestry and Biodiversity in Aowin

Adaptation Actions	Objectives	Indicators of Success	Time Frame	Resources (Finance, Human, Technology)	Implementing Partners	Estimated Cost (GH₵)
Sustainable Forest Management Software	To improve the monitoring and management of forest resources in areas such as **Akontombra and Dadieso,** reducing illegal logging and forest degradation.	• Number of forest areas monitored using the software. • Reduced illegal logging activities. • Improved biodiversity metrics.	Medium Term	• Software development and deployment. • Training for Forestry Officers. • Monitoring equipment and tools.	Forestry Commission (Lead), NGOs, IT Companies, Aowin Assembly	
Afforestation and Forest Degradation Reduction	To restore degraded forests and promote tree planting in communities such as **Boinso and Kwawu**, enhancing biodiversity and ecosystem resilience.	• Hectares of land reforested. • Increased tree survival rates. • Improved soil and water conservation in target areas.	Medium Term	• Tree seedlings • Funding for community-led tree planting initiatives • Tools for site preparation and maintenance.	Forestry Commission (Lead), Local NGOs, Community Leaders	
Controlled Logging Practices	To ensure sustainable forest resource use through regulated logging in areas such as **Enchi and Nyankamam**, reducing overexploitation.	• Reduced logging beyond quotas. • Increased compliance with forest management regulations. • Improved forest regeneration rates.	Medium to Long Term	• Policy enforcement frameworks. • Monitoring tools • Community education on alternative livelihoods.	Ministry of Lands and Natural Resources (Lead), Forestry Commission	

Community Engagement and Education	To involve local communities in biodiversity conservation and forest protection in areas such as **Achimfo and Dadieso**, fostering stewardship and awareness.	• Increased participation of local communities in forest conservation projects. • Improved knowledge about forest protection benefits.	Short Term	• Public education materials. • Community workshops and facilitators. • Communication tools for outreach.	Local NGOs (Lead), Forestry Commission, Traditional Authorities	
Sustainable Tourism Development	To promote eco-tourism in biodiversity-rich areas like **Enchi and Akontombra**, providing economic opportunities while supporting conservation efforts.	• Development of eco-tourism sites. • Increased revenue from tourism. • Improved community livelihoods linked to conservation.	Medium to Long Term	• Funding for eco-tourism infrastructure. • Training programs for guides. • Marketing and promotion resources.	Tourism Board (Lead), Local NGOs, Aowin Municipal Assembly	

10.4.5 Water Supply and Security

Water supply and security in the Aowin Municipal Assembly face significant challenges due to the impacts of climate change and human activities. Erratic rainfall patterns, prolonged dry spells, and contamination of water sources threaten the availability of clean and reliable water for communities such as Enchi, Dadieso, and Boinso. These challenges not only compromise public health but also disrupt agriculture and other water-dependent activities, making water resource management a critical priority for the municipal.

To address these challenges, the Aowin Municipal Assembly has prioritized several adaptation measures. Ranked first, **increasing access to potable water supply and sanitation services** is a foundational step toward improving water security. Projects such as the installation of boreholes, solar-powered water systems, and improved sanitation facilities in towns like Enchi and Akontombra aim to ensure reliable access to clean water for households and public facilities. These efforts are essential for reducing waterborne diseases and improving overall community health.

Ranked second, **community-based rainwater harvesting systems** focus on enhancing water availability in areas like Kwawu and Nyankamam, which face acute water shortages during dry spells. These systems are designed to capture and store rainwater for domestic and agricultural use, reducing dependence on overused rivers and boreholes. By supporting both household and agricultural needs, rainwater harvesting ensures water availability even during prolonged dry periods.

Table 21:Ranking of Adaptation Options for Water supply and security

Adaptation option	Final score from stakeholders	Rank
Community-Based Rainwater Harvesting Systems	39	2nd
Enhanced Water Purification and Safety Programs	3rd	3rd
Increase Access to Potable Water Supply and Sanitation Services	1st	1st
Ensure Environmentally Sustainable Mining Activities	5th	5th
Gender-Sensitive Water Management Training	4th	4th

Enhanced water purification and safety programs, ranked third, target improvements in water quality in areas such as Enchi and Boinso. These programs introduce advanced filtration systems and water treatment facilities to ensure that drinking water is safe and free from contaminants. Public education campaigns are also being implemented to encourage households to adopt water purification practices, reducing the prevalence of waterborne diseases.

Ranked fourth, **gender-sensitive water management training** is being implemented to empower women and vulnerable groups to participate actively in water resource management. Training programs in communities like Nyankamam and Achimfo focus on building the capacity of women to adopt sustainable water use practices and contribute to decision-making processes. These efforts promote inclusivity and equity in water resource management, ensuring that the needs of all community members are addressed.

Finally, **ensuring environmentally sustainable mining activities**, ranked fifth, aims to mitigate the negative impacts of mining on water resources. In mining-affected areas such as Boinso, regulations are being strengthened to reduce water contamination from mining operations. This includes the adoption of sustainable mining techniques and stricter enforcement of environmental policies to protect vital water bodies like the Tano River.

Table 22:Summary of Adaptation Options for Water Supply and Security in Aowin

Adaptation Actions	Objectives	Indicators of Success	Time Frame	Resources (Finance, Human, Technology)	Implementing Partners	Cost (GH₵)
Increase Access to Potable Water Supply	To provide reliable access to safe drinking water for communities, reducing waterborne diseases.	• Increased number of households with access to potable water. • Reduction in waterborne disease incidence.	Short to Medium Term	Funds for infrastructure, technical expertise, and sanitation training.	Aowin Municipal Assembly, NGOs, Ministry of Water Resources	
Community-Based Rainwater Harvesting Systems	To enhance water availability in rural areas by harvesting and storing rainwater.	• Number of operational rainwater harvesting systems. • Increased water availability during dry seasons. • Reduced dependence on unsafe water sources.	Medium Term	Rainwater storage tanks, community training programs, and installation tools.	Local NGOs, Community-Based Organizations, MoFA	
Enhanced Water Purification and Safety Programs	To improve water quality and reduce contamination risks in water supply systems.	• Improved water quality metrics. • Reduced prevalence of waterborne diseases • Increased adoption of water purification methods by households.	Short Term	Filtration systems, purification chemicals, and education materials.	Ministry of Sanitation and Water Resources, NGOs	

Gender-Sensitive Water Management Training	To involve women and vulnerable groups in water management decisions and practices.	• Increased participation of women in water resource management. • Improved equity in access to water resources. • Enhanced capacity of women in decision-making.	Short Term	Training resources, facilitators, and community engagement tools.	Aowin Municipal Assembly, Local Women's Groups, NGOs	
Ensure Environmentally Sustainable Mining Activities	To protect water resources from contamination due to mining activities.	• Reduced levels of water contamination from mining activities. • Adoption of sustainable mining practices • Implementation of water monitoring systems.	Long Term	Monitoring tools, regulatory frameworks, and environmental education.	Environmental Protection Agency, Mining Companies	

10.4.6 Gender Responsiveness in Adaptation Options

Gender responsiveness is central to the adaptation planning process for the Aowin Municipal Assembly, ensuring that climate interventions are inclusive and equitable. The assessment of adaptation measures prioritized actions that directly addressed gender-specific needs, empowered women and youth, and promoted the participation of marginalized groups in decision-making processes.

Community Health emerged as the highest-ranking sector. This ranking reflects the sector's comprehensive adaptation approaches to addressing gender-specific vulnerabilities, particularly through gender-sensitive healthcare and WASH (Water, Sanitation, and Hygiene) services. The provision of mobile health clinics and targeted campaigns addressing maternal health and hygiene ensures that women and other vulnerable groups have access to equitable healthcare. These measures reduce the health burdens faced by women, enabling them to participate more actively in economic and social activities.

Infrastructure and Human Settlements ranked second, tied with Forestry and Biodiversity. The infrastructure sector focuses on empowering women and differently-abled individuals through training in climate-resilient construction and urban planning. Disaster preparedness and flood risk management programs include gender-specific measures, such as involving women in planning and decision-making processes. These actions not only build community resilience but also provide women with the skills and opportunities to engage in traditionally male-dominated fields, promoting long-term gender equity.

Table 23:Ranking of Adaptation Options for Gender in Aowin

Adaptation Option	Key Gender-Specific Benefits	Final Score from Stakeholders	Rank
Community Health	• Ensures equitable access to gender-sensitive healthcare and WASH facilities. • Targets maternal health through tailored campaigns and mobile clinics in remote areas. • Promotes hygiene education and awareness to reduce women's health burdens.	32	1st
Infrastructure and Human Settlements	• Trains women in climate-resilient construction techniques and urban planning. • Involves women and differently-abled individuals in disaster preparedness and flood management initiatives to strengthen community resilience.	18	2nd
Forestry and Biodiversity	• Empowers women through active participation in reforestation, mangrove restoration, and conservation projects. • Creates income-generation opportunities through women-led sustainable eco-tourism initiatives and community engagement.	18	2nd

Agriculture and Food Security	- Provides women with access to drought-resistant crops, financial resources, and agribusiness opportunities. - Builds capacity for women and youth in sustainable farming practices and improves their ability to adapt to climate variability.	17	4th
Water Supply and Security	- Promotes gender-sensitive water management training and equitable resource governance. - Reduces the burden on women through community-based rainwater harvesting systems, improving water availability and accessibility.	15	5th

Forestry and Biodiversity also emphasizes the inclusion of women in conservation and eco-tourism initiatives. Adaptation measures in this sector, such as reforestation provide ecological and economic benefits while addressing gender disparities. Women-led eco-tourism initiatives create alternative income sources, empowering women to contribute to biodiversity conservation and benefit from sustainable resource management. These actions underscore the intersection of environmental sustainability and gender equity, particularly in rural communities reliant on forest resources.

Agriculture and Food Security followed with a score of 17, reflecting its targeted efforts to enhance gender inclusivity in farming practices. Capacity-building workshops equip women with climate-smart agricultural techniques, while access to drought-resistant crops and financial support ensures that women farmers can adapt to climate variability. Despite these significant contributions, the sector's measures focus more on practical solutions rather than addressing systemic gender barriers, which explains its lower ranking. Nevertheless, the inclusion of agri-business training for youth and women highlights progress in promoting gender-responsive approaches within the agricultural sector.

Water Supply and Security ranked fifth with a total score of 15. This sector addresses immediate practical needs, such as reducing the burden of water collection through community-based rainwater harvesting systems and promoting gender-sensitive water management training. While these measures contribute to equitable access and burden-sharing, they have a limited focus on addressing systemic inequities or empowering women in decision-making roles. Consequently, the sector ranks lower in terms of overall gender responsiveness.

Table 24:Gender-Responsive Adaptation Options in Aowin (Ranked)

Adaptation Actions	Objectives	Indicators of Success	Time Frame	Resources (Finance, Human, Technology)	Implementing Partners	Cost
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 at women's issues, such as maternal care. • Participation of women in community-led health initiatives.	Short to Medium Term	• Infrastructure for flood-resistant water and sanitation systems. • Mobile clinics and medical equipment. • Educational materials for campaigns.	Local Health Departments, NGOs, International Health Organizations, Community Leaders	
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. • Representation of women and youth in flood planning and implementation.	Medium to Long Term	• 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	

Forestry and Biodiversity	Enhance biodiversity and support conservation through gender-inclusive strategies, fostering sustainable eco-tourism and local livelihoods.	• Proportion of reforestation and conservation projects led by women. • Increased representation of women in eco-tourism ventures. • Proportion of community education programs targeting women's participation in conservation efforts.	Medium Term	• Tree seedlings and tools for conservation. • Funds for eco-tourism infrastructure. • Experts in biodiversity and conservation management.	Forestry Commission, Local NGOs, Traditional Authorities	
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 Term	• Funding for agripreneurship and training • Experts in sustainable farming and inclusive education • Agricultural technologies and tools.	Ministry of Agriculture, NGOs, Research Institutions, Community Groups	

Water Supply and Security	Improve water security and resilience through eco-friendly 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	

11

Strategic Funding and Investment Framework

11.0 Introduction

The implementation of climate adaptation measures in the Aowin Municipal Assembly necessitates a robust and strategic approach to funding. This section highlights two core objectives: identifying diverse funding streams and establishing clear, actionable criteria for allocating financial resources. These efforts aim to ensure that Aowin not only secures the necessary funding but also uses it efficiently to address the municipal's specific climate vulnerabilities while fostering long-term sustainability.

Aowin's financial strategy emphasizes the importance of tapping into a variety of funding sources, including government budgets, international climate funds, private sector investments, and community contributions. This multi-faceted approach is designed to enhance resilience in financial planning, ensuring that adaptation projects remain viable even amid economic fluctuations or changing policy environments.

Equally essential is the development of prioritization criteria to guide resource allocation. The municipal seeks to maximize the impact of its investments by channelling funds to projects that offer significant community benefits, align with Aowin's development goals, and address the most pressing climate risks. Factors such as the scale of impact, inclusivity, gender equity, and long-term sustainability will serve as key considerations in this process.

This framework provides the foundation for Aowin to secure and manage the financial resources needed to transform its adaptation plan into action. Aligning funding mechanisms with local priorities and global best practices, the assembly aims to build a resilient, inclusive, and sustainable future for all its residents.

11.1 Potential Funding Sources

11.1.1 Government Funding (National and Local)

Government funding forms a foundational pillar for financing climate adaptation initiatives in the Aowin Municipal Assembly. Leveraging national and local government resources, Aowin can address climate risks across critical sectors such as infrastructure, health, agriculture, water, and biodiversity conservation. These funds are vital in ensuring that adaptation measures are not only implemented but are also aligned with national climate strategies and local development priorities. In Aowin, government funding will support key projects such as:

- **Flood-Resilient Infrastructure:** Building roads, bridges, and housing designed to withstand extreme weather events, particularly in vulnerable areas like Boinso and Kwawu.
- **Climate-Sensitive Public Health Facilities**: Upgrading community health centres to address climate-related health issues and equipping them with sustainable water and energy systems.

- **Agriculture and Food Security:** Introducing climate-smart farming techniques, such as drought-resistant crops and irrigation systems, to boost resilience among women farmers and youth.
- **Water Security:** Developing community-led rainwater harvesting systems and sustainable water treatment facilities in underserved areas like Nyankamam.
- **Conservation and Reforestation:** Supporting afforestation projects and biodiversity conservation efforts that empower local communities and create alternative livelihoods.

Key funding sources and mechanisms include:

- **Ministry of Finance:** Allocates resources for national environmental sustainability and climate resilience projects, including disaster risk reduction and adaptive infrastructure.
- **Ministry of Environment, Science, Technology, and Innovation (MESTI):** Provides funding for innovative environmental projects, particularly those involving new technologies and nature-based solutions.
- **Ghana Climate Change Fund (GCCF):** Managed under MESTI, this fund offers dedicated support for projects that mitigate and adapt to climate change, with a focus on vulnerable communities.
- **Municipal Assemblies Common Fund (DACF)**: Ensures financial resources are available for local assemblies like Aowin to implement grassroots adaptation projects, such as community training programs and small-scale conservation initiatives.
- **Ministry of Food and Agriculture:** Offers sector-specific funding for climate-smart agriculture and food security programs, particularly those that prioritize women and youth.

11.1.2. International Aid and Grants

International sources of funding play a critical role in supporting climate adaptation initiatives, especially in vulnerable regions like the Aowin Municipal Assembly. These funding sources are essential for addressing the financial gaps that local and national resources alone cannot bridge. International climate finance is typically allocated through multilateral institutions, bilateral agreements, development agencies, and global philanthropic initiatives. Below are key international funding sources that Aowin can explore to support its climate adaptation strategies:

- **Green Climate Fund (GCF):** The Green Climate Fund is one of the largest international climate finance mechanisms, established under the United Nations Framework Convention on Climate Change (UNFCCC). It provides funding to developing countries for both mitigation and adaptation projects. Aowin could access GCF funding for initiatives such as flood management systems, community-based water harvesting projects, or agroforestry programs. To secure funding, the municipal must develop comprehensive project proposals aligned with GCF objectives and demonstrate measurable climate impacts.
- **Global Environment Facility (GEF)**: The GEF offers grants to developing countries to address global environmental issues, including climate change adaptation. This fund prioritizes projects that focus on biodiversity conservation, land degradation, and sustainable natural resource management. Aowin could tap into the GEF to support biodiversity restoration programs, sustainable agriculture practices, and community-driven conservation projects.

- **Adaptation Fund**: The Adaptation Fund finances concrete adaptation projects that aim to reduce vulnerability and enhance resilience to climate change. This funding mechanism is especially suitable for localized and community-based adaptation initiatives, such as improving water resource management or developing climate-resilient infrastructure in flood-prone areas. Aowin can leverage this fund to support rural infrastructure projects or health interventions targeting climate-related risks.
- **Climate Investment Funds (CIF):** The CIF provides funding through programs like the Pilot Program for Climate Resilience (PPCR), which focuses on integrating climate resilience into development planning. Aowin could apply for PPCR funding to strengthen its municipal-level adaptation planning and integrate climate considerations into key policies, such as the Medium-Term Development Plan (MTDP).
- **Bilateral Development Partners:** Many developed countries provide bilateral climate finance to support adaptation efforts in developing countries. For instance, organizations like USAID, the German Development Agency (GIZ), and the UK's Foreign, Commonwealth & Development Office (FCDO) often fund projects related to climate resilience, water resource management, and sustainable livelihoods. Partnerships with these agencies could unlock funding for Aowin's priority sectors, such as agriculture and water supply.
- **United Nations Development Programme (UNDP):** UNDP offers technical and financial support to governments for integrating climate resilience into development planning. Aowin could collaborate with UNDP to secure funding and technical expertise for implementing inclusive and sustainable adaptation strategies, particularly those addressing gender-specific vulnerabilities.
- **Philanthropic Organizations:** Global philanthropic foundations, such as the Rockefeller Foundation and the Bill & Melinda Gates Foundation, provide funding for innovative solutions to climate challenges. These organizations often support projects focused on building community resilience, promoting technological innovation, and addressing health-related impacts of climate change. Aowin could explore partnerships with these foundations to fund initiatives such as mobile health clinics or community-based composting programs.
- **Multilateral Development Banks (MDBs):**:Institutions like the World Bank and the African Development Bank (AfDB) are significant contributors to climate adaptation financing. These banks often offer concessional loans, grants, and technical assistance for large-scale infrastructure projects, such as flood-resilient housing, improved drainage systems, and renewable energy initiatives. Aowin could partner with these banks to secure funding for transformational adaptation projects.
- **Global Adaptation Network (GAN):** The GAN provides capacity-building support and funding for climate adaptation projects that emphasize knowledge sharing and community empowerment. Aowin can engage with GAN to access resources for education and training programs on climate-smart practices and technologies.
- **Private Sector Climate Finance**: International corporations and private investors are increasingly contributing to climate adaptation efforts through Corporate Social Responsibility (CSR) initiatives and green investments. Aowin could attract private sector financing by showcasing projects with potential for economic returns, such as renewable energy installations or eco-tourism initiatives.

11.1.3 Public-Private Partnerships (PPPs)

Public-Private Partnerships (PPPs) are a pivotal funding mechanism for addressing climate adaptation and infrastructure needs in the Aowin Municipal Assembly. Combining the strategic oversight and public

accountability of government bodies with the financial resources, technological expertise, and operational efficiency of private enterprises, PPPs offer a unique opportunity to tackle large-scale, high-impact projects that are critical for building resilience to climate change. In the context of Aowin, PPPs provide an avenue to mobilize private sector investments for essential adaptation measures, such as renewable energy projects, flood-resilient infrastructure, sustainable agriculture, and waste management solutions. These partnerships are particularly valuable for initiatives that require significant upfront capital and technical expertise, as well as for projects where operational efficiencies can reduce costs and improve outcomes.

The success of PPPs lies in their ability to align the interests of both public and private stakeholders. For Aowin, this means ensuring that projects not only deliver public value, such as improved livelihoods and environmental sustainability, but also generate sufficient returns to attract and retain private sector partners. This dual focus creates a win-win scenario, fostering long-term collaboration and innovation in addressing climate challenges. PPPs are also instrumental in fostering economic development and creating employment opportunities within the municipal. Engaging local private entities alongside multinational corporations, Aowin can ensure that adaptation projects are tailored to local needs while benefiting from global expertise. Moreover, these partnerships can unlock additional resources, such as grants or technical support, from international development organizations that prioritize public-private collaboration.

11.1.4 Community and Local Fundraising

Community and local fundraising are vital components of Aowin's overall strategy for financing climate adaptation. These approaches leverage the collective strength, commitment, and resources of local communities to support projects that address their most pressing vulnerabilities. Empowering communities to play an active role in raising funds and implementing adaptation measures, Aowin can foster a sense of ownership, accountability, and sustainability. Additionally, local fundraising efforts can serve as a foundation to attract co-funding from national and international sources by demonstrating local commitment and involvement.

The need for community and local fundraising is particularly significant in Aowin, where diverse socio-economic activities such as small-scale farming, trading, and artisanal work are integral to daily life. These activities can be harnessed as a resource base for adaptation efforts, integrating contributions—both monetary and non-monetary—into the broader framework of climate resilience. Furthermore, leveraging traditional leadership structures and cultural practices provides a unique opportunity to mobilize resources effectively while maintaining alignment with local norms and values.

Key Mechanisms for Community and Local Fundraising

1. Community Savings and Cooperative Contributions

- *Savings Groups and Cooperatives:* Women's groups, farmers' associations, and youth cooperatives can pool resources to fund small-scale initiatives such as the purchase of drought-resistant seeds, construction of rainwater harvesting systems, or soil conservation projects.
- *Micro-Donations:* Households can contribute small amounts regularly to a communal fund designated for specific adaptation projects, ensuring inclusivity even for low-income families.
- *Targeted Donor Drives:* Traditional leaders, local businesses, and philanthropic individuals can be approached to sponsor specific projects such as the installation of solar-powered water pumps or flood barriers in vulnerable areas.

2. In-Kind Contributions

- *Provision of Materials:* Communities can contribute materials like sand, stones, and timber for infrastructure projects, such as constructing flood barriers or retaining walls in flood-prone areas.
- *Labor Contributions:* Community members can volunteer their time and skills for activities such as planting trees for reforestation, maintaining rainwater harvesting systems, or repairing community roads impacted by flooding.

3. Leveraging Traditional Leadership and Cultural Practices

- *Traditional Authorities' Involvement:* Chiefs and elders can mobilize resources by encouraging their communities to contribute to adaptation initiatives. Their influence ensures broad participation and cultural alignment.
- *Integration with Cultural Festivals:* Fundraising activities can be incorporated into traditional festivals, such as organizing tree-planting drives or environmental clean-up campaigns as part of festivities.

5. Partnerships with Local Businesses

- *Small Business Sponsorships:* Engage local business owners to sponsor community projects such as water storage systems or public green spaces. Businesses can also offer discounts or services in exchange for recognition as contributors to climate resilience.
- *Corporate Social Responsibility (CSR):* Partner with local enterprises to integrate adaptation projects into their CSR initiatives, such as sponsoring reforestation efforts or supporting educational campaigns on waste management.

11.1.5 Innovative Financing Mechanisms

Innovative financing mechanisms offer transformative opportunities for securing financial resources to implement climate adaptation projects in Aowin. These mechanisms go beyond traditional funding sources by integrating market-based tools, incentive-driven approaches, and sustainable financial practices to support large-scale and impactful initiatives. Given Aowin's unique challenges—such as deforestation, water scarcity, and flood risks—these financing mechanisms can unlock resources to address these vulnerabilities effectively while fostering local economic growth and environmental sustainability.

1. **Green Bonds:** Green bonds are debt instruments specifically issued to finance climate-friendly and sustainable projects. For Aowin, green bonds provide an opportunity to fund infrastructure projects that promote resilience and environmental conservation. For instance, funds raised through green bonds could be used to construct flood-resilient infrastructure, such as drainage systems and levees in flood-prone areas like Boinso and Enchi, which are critical to protecting lives and property. Similarly, green bonds can support renewable energy projects, such as biomass energy facilities that utilize agricultural waste, addressing both waste management and energy needs in rural communities. Issuing green bonds requires careful planning, including the preparation of detailed environmental impact assessments and securing certifications to validate the sustainability of proposed projects.
2. **Climate Funds:** Climate funds are specialized financial resources dedicated to supporting efforts that mitigate the impacts of climate change and promote resilience. Global mechanisms such as the Green Climate Fund (GCF) and the Adaptation Fund are key sources of financial support for countries and communities like Aowin that are disproportionately affected by climate variability. These funds provide

grants and concessional loans for projects that align with global climate goals and deliver measurable outcomes. In Aowin, climate funds could be instrumental in financing reforestation programs to restore degraded landscapes, such as those near Akontombra. They could also support the establishment of climate-smart farming hubs that train farmers in sustainable practices, enhancing food security and reducing reliance on traditional, less-resilient farming methods. To access these funds, Aowin must develop high-quality project proposals that demonstrate clear objectives, long-term sustainability, and measurable impacts.

3. **Payments for Ecosystem Services (PES):** PES is a financing mechanism that links beneficiaries of ecosystem services with the communities or individuals who manage and protect those ecosystems. This approach is particularly relevant for Aowin, where forested areas and watersheds provide vital services such as water purification, flood regulation, and carbon sequestration. For example, industries and downstream water users could compensate upstream communities for maintaining forest cover, which stabilizes water flow and improves water quality. Similarly, PES schemes could incentivize farmers to adopt agroforestry practices, integrating trees into their agricultural systems to improve soil health, enhance biodiversity, and sequester carbon. Implementing PES in Aowin would require identifying key ecosystem services, conducting ecological and economic assessments, and establishing agreements between beneficiaries and providers.

4. **Blended Finance:** Blended finance is an approach that combines public and private capital to reduce investment risks and attract private sector participation in climate adaptation projects. For Aowin, this mechanism can be particularly useful in large-scale projects requiring significant upfront capital, such as renewable energy installations or flood management infrastructure. Public funds or concessional loans can be used to de-risk investments, making them more attractive to private investors. For instance, a flood-resilient housing project in Boinso could be financed through a mix of public grants and private sector contributions, with the latter incentivized by reduced financial risk and shared project benefits. Blended finance enables the alignment of public and private interests, fostering partnerships that deliver both social and financial returns.

5. **Impact Investment:** Impact investment is a financing mechanism where investors seek both financial returns and measurable environmental or social benefits. This approach is well-suited to Aowin's adaptation projects, which often deliver significant social outcomes alongside environmental gains. For example, investors could support the development of green urban spaces in towns like Enchi, which not only mitigate urban heat and improve air quality but also enhance the quality of life for residents. Similarly, impact investments could fund waste management initiatives, such as composting facilities or recycling plants, which create jobs, reduce pollution, and support agriculture. To attract impact investors, Aowin must highlight the social and environmental benefits of its projects, demonstrating how these align with investor priorities.

6. **Carbon Markets:** Carbon markets provide a mechanism for monetizing reductions in greenhouse gas emissions, creating an economic incentive for climate mitigation efforts. Aowin could participate in carbon offset programs by implementing reforestation projects or transitioning to energy-efficient technologies in key sectors. Communities engaging in afforestation and forest conservation could sell carbon credits to industries seeking to offset their emissions, generating revenue while contributing to global climate goals.

11.2 Criteria for Allocation and Prioritization of Funds

The allocation and prioritization of funds for climate adaptation projects in Aowin must follow a transparent, inclusive, and well-structured framework to maximize their effectiveness and sustainability. Given the municipal's specific vulnerabilities and resource constraints, this framework must integrate global best practices while addressing local needs. The following enhanced criteria are proposed to guide the allocation process, ensuring that resources are directed toward impactful, equitable, and innovative projects.

1. **Project Impact and Urgency:** Priority will be given to projects that demonstrate significant potential to deliver ecological, social, and economic benefits, especially those addressing urgent risks. Projects such as flood management systems in **Boinso** or reforestation in **Nyankamam** can mitigate immediate threats to livelihoods, ecosystems, and infrastructure. High-impact projects that target critical issues such as water scarcity, soil erosion, or food insecurity will be fast-tracked to prevent severe consequences for the community and environment.

2. **Community Engagement and Co-Benefits:** Projects that actively involve local communities in their design, implementation, and monitoring will receive higher priority. Community engagement fosters ownership, enhances sustainability, and aligns projects with the specific needs of residents. For instance, rainwater harvesting systems designed with community input not only address water shortages but also empower local stakeholders through skill development. Co-benefits, such as job creation in eco-tourism or sustainable farming, further increase the value of these projects.

3. **Sustainability and Longevity:** Funds will be allocated to projects that promise long-term sustainability and incorporate mechanisms for ongoing maintenance and self-sufficiency. For example, climate-smart agricultural hubs paired with training programs ensure continuous benefits by equipping farmers with the skills to adapt to changing conditions. Similarly, perennial crop systems and agroforestry initiatives promote soil health, biodiversity, and sustained agricultural productivity over time.

4. **Alignment with Strategic Goals:** Projects must align with Aowin's overarching climate adaptation and development objectives, such as improving water security, enhancing food production, protecting biodiversity, and building community resilience. This ensures that funded initiatives contribute cohesively to municipal-wide adaptation goals, creating a unified and impactful strategy.

5. **Cost-Effectiveness:** Aowin's limited resources must be utilized efficiently, with priority given to projects that offer high returns on investment. Cost-effective initiatives maximize impact per unit of funding, ensuring that resources are stretched to cover more ground. For instance, low-cost, high-impact projects such as community composting facilities can improve waste management while supporting sustainable farming practices.

6. **Climate Justice and Equity:** Special emphasis will be placed on addressing disparities in vulnerability, ensuring that marginalized communities and groups—such as women, youth, and differently-abled individuals—benefit equitably from adaptation projects. Initiatives that directly involve these groups in decision-making, such as women-led rainwater harvesting projects or agroforestry programs targeting youth employment, will be prioritized to ensure fair distribution of resources and opportunities.

7. **Innovation and Scalability:** Projects that introduce innovative approaches or technologies and have the potential to be scaled up across the municipal will be highly valued. For example, mobile-based weather forecasting tools for farmers represent an innovative solution that can be expanded to cover more communities. This criterion ensures that Aowin's adaptation measures are future-ready and capable of broader impacts.

8. **Leverage and Matching Opportunities:** Priority will be given to projects that can attract additional resources or complement other investments. For instance, projects co-financed through international grants, private sector contributions, or public-private partnerships (PPPs) multiply the value of municipal funds and allow for larger-scale implementation. Such leveraging opportunities are vital for enhancing the municipal's financial capacity to execute transformative projects.

9. **Measurable Outcomes and Accountability:** Projects with clear, measurable outcomes and well-defined mechanisms for monitoring, evaluation, and reporting will be favoured. Transparent metrics for success, such as the number of households benefiting from water purification systems or reductions in flood-related damage, allow for evidence-based assessments of project performance. This ensures accountability and informs future decision-making.

10. **Scientific and Technical Viability:** Priority will be given to projects that are supported by robust scientific research and technical feasibility. For example, reforestation initiatives based on proven methodologies for carbon sequestration and soil stabilization are more likely to succeed than untested approaches. This ensures that investments are backed by credible evidence and deliver tangible results.

12

Framework for Adaptation Monitoring, Evaluation, and Learning

12.0 Introduction

The success of climate adaptation efforts in the Aowin Municipal hinges on a comprehensive and adaptable Monitoring, Evaluation, and Learning (MEL) framework. This framework is critical for tracking the implementation and outcomes of adaptation initiatives, ensuring that they address the most pressing vulnerabilities while remaining adaptable to changing conditions. As climate impacts intensify, a well-structured MEL framework enables stakeholders to assess progress, extract lessons, and make data-driven decisions that refine and enhance future interventions. The MEL framework serves several critical purposes:

- **Ensure Accountability:** The framework tracks project implementation against planned objectives and budgets, ensuring efficient and transparent resource utilization. This builds stakeholder confidence in the adaptation process.
- **Measure Impact:** Evaluating the effectiveness of adaptation actions, such as reducing exposure to flooding or improving agricultural productivity, the MEL framework validates successful strategies and identifies areas for improvement.
- **Facilitate Adaptive Management:** Real-time monitoring and feedback enable project teams to modify interventions based on emerging data and evolving conditions, ensuring their continued relevance and effectiveness.
- **Promote Stakeholder Engagement:** Inclusive reporting and feedback loops actively involve local communities, government agencies, and other key stakeholders. This ensures diverse perspectives are integrated into decision-making and foster a sense of ownership among participants.
- **Enhance Learning and Knowledge Sharing:** Documenting successes, challenges, and lessons learned, the MEL framework provides valuable insights that inform future adaptation strategies and contribute to broader knowledge on climate resilience.

12.1 Objectives of the MEL Framework for Aowin Municipal Assembly

The Monitoring, Evaluation, and Learning (MEL) framework for Aowin Municipal Assembly is designed to address the municipal's distinct climate vulnerabilities, which include increasing rainfall variability, heightened risks of flooding, and deforestation. The framework ensures that climate adaptation strategies are not only effective but also sustainable and inclusive, fostering resilience across all segments of the community. The objectives of the MEL framework are to:

- **Tailor Monitoring and Evaluation Processes:** Adapt the MEL processes to reflect the specific environmental, social, and economic priorities of Aowin, ensuring that adaptation strategies effectively address the most critical local needs.
- **Enhance Local Capacity:** Develop the capabilities of local stakeholders, including municipal authorities, NGOs, and community representatives, to independently conduct and manage MEL activities, ensuring long-term sustainability beyond individual projects.
- **Provide Evidence-Based Insights:** Generate actionable data and lessons to inform local and national climate adaptation policies, ensuring that strategies are aligned with evolving climate risks and best practices.
- **Encourage Innovation and Technology Integration:** Promote the use of innovative approaches, such as Geographic Information Systems (GIS) and mobile-based data collection, to enhance the quality and efficiency of MEL activities.
- **Foster Equity and Inclusion:** Specifically evaluate the impacts of adaptation measures on vulnerable groups, including women, youth, and differently abled individuals, to ensure that climate resilience efforts are equitable and address the needs of all community segments.

12.2 MEL Design for Aowin Municipal Assembly

The MEL framework for Aowin integrates monitoring, evaluation, and learning as interconnected components that provide continuous feedback loops, fostering adaptive management and improved decision-making.

12.2.1 Monitoring Framework

Monitoring involves systematic tracking and documentation of adaptation activities to assess progress and address emerging challenges. It provides stakeholders with real-time data to ensure that projects stay on track and remain aligned with their objectives.

12.2.2 Objectives of the Monitoring Framework

1. Track Timelines and Resource Use: Ensure that project implementation adheres to planned schedules and budgets.
2. Identify Deviations and Enable Corrections: Detect challenges or delays early and implement timely corrective actions to maintain progress.
3. Support Data-Driven Decisions: Provide reliable information to guide decision-making and respond effectively to changing climate impacts.
4. Foster Accountability: Ensure transparency by documenting and reporting progress to stakeholders, including funders, government agencies, and communities.

12.2.3 Indicators and Metrics for Aowin

To effectively measure progress, the MEL framework for Aowin employs tailored indicators and metrics that align with the municipal's unique climate risks and socio-economic priorities.

Key Indicators and Metrics:

1. **Reduction in Vulnerability Indices**

- Measures the extent to which households, ecosystems, and infrastructure are protected from climate hazards like flooding and drought.
- Example: Assessing the effectiveness of flood barriers in reducing damage during extreme rainfall in Boinso.

2. **Community Participation Rates**
   - Tracks the proportion of community members actively engaged in adaptation initiatives, such as tree planting or rainwater harvesting systems.
   - Example: Monitoring participation in agroforestry training programs in Nyankamam.
3. **Infrastructure Resilience Metrics**
   - Evaluates the structural integrity and performance of newly built or retrofitted infrastructure.
   - Example: Assessing the durability and effectiveness of flood-resistant housing in Enchi during heavy rains.
4. **Economic and Environmental Impacts**
   - Measures the tangible benefits of adaptation actions, such as increased crop yields, improved biodiversity, and strengthened economic stability.
   - Example: Tracking income growth from sustainable farming practices or reduced soil erosion through agroforestry projects.
5. **Equity and Inclusion Metrics**
   - Evaluates the extent to which adaptation measures benefit vulnerable groups, ensuring that women, youth, and marginalized communities are active participants and beneficiaries.
   - Example: Assessing the number of women-led initiatives in water management systems or agroforestry practices.

Data Collection Methods

To ensure the Monitoring, Evaluation, and Learning (MEL) framework for Aowin Municipal Assembly is robust and actionable, a combination of traditional, innovative, and locally tailored data collection methods will be employed. These methods are designed to ensure inclusivity, reliability, and responsiveness to the municipal's socio-economic and environmental conditions.

1. **Remote Sensing** Satellite imagery and aerial photography will be used to monitor land use changes, vegetation cover, and infrastructure development. For instance, remote sensing can help track reforestation efforts in Nyankamam and assess urban expansion in Enchi, offering spatial data critical for decision-making.
2. **Community-Based Reporting** Local communities will play a vital role in collecting and reporting climate-related data. Using mobile technology, farmers and residents can share real-time information on rainfall patterns, crop health, and water resource challenges. This approach not only enhances data accuracy but also fosters local ownership of adaptation projects. Insights from

traditional knowledge systems, such as rainfall predictions based on indigenous observations, will be integrated to provide context-specific data.

3. **Surveys and Interviews** Structured surveys and interviews will capture qualitative and quantitative feedback from beneficiaries. For example, farmers involved in agroforestry programs can provide data on soil health improvements, while women engaged in water resource management projects can share insights into social and economic benefits.

4. **Environmental Sensors** Sensors will be deployed to measure critical environmental parameters, such as rainfall, water levels, and soil moisture. These tools will provide real-time data for adaptation projects like flood mitigation in Boinso, ensuring timely and evidence-based interventions.

5. **School and Youth Engagement** Schools and youth groups will be actively involved in data collection activities. For instance, students can participate in tree-planting programs and monitor their growth, while youth groups can assist in tracking water quality or monitoring infrastructure resilience. This approach fosters environmental awareness and builds the next generation of climate adaptation advocates.

Roles and Responsibilities

The successful implementation of the MEL framework requires coordinated efforts across various stakeholders:

1. **Local Government** The Aowin Municipal Assembly will oversee the coordination of monitoring activities and ensure the integration of findings into municipal-level planning, such as the Medium-Term Development Plan (MTDP). For instance, lessons from flood-resilient infrastructure projects will guide similar initiatives in other vulnerable communities.

2. **Community Groups** Community-based organizations, women's groups, and youth associations will actively collect data and provide feedback on adaptation measures. Traditional leaders will also play a crucial role in contextualizing findings based on local knowledge.

3. **External Partners** NGOs, academic institutions, and international agencies will provide technical expertise, independent evaluations, and capacity-building support.

4. **Project Teams** Project implementation teams will be responsible for day-to-day data collection and compliance with project goals. Engineers working on water management systems can conduct regular inspections and compile detailed progress reports.

5. **Conflict Resolution Mechanisms** Mechanisms to resolve conflicts arising from MEL activities will be established. For instance, disputes regarding resource allocation or interpretation of data will be addressed through participatory dialogues facilitated by neutral parties.

12.3 Evaluation Framework

The evaluation component assesses the outcomes and overall impact of adaptation projects, offering actionable insights for improvement.

Key Types of Evaluations:

1. Formative Evaluation: Conducted during implementation to address emerging challenges and ensure alignment with project objectives.

2. Summative Evaluation: Conducted after project completion to measure overall success and inform future initiatives.

Evaluation Criteria and Benchmarks:

- Effectiveness: Degree to which projects reduce vulnerabilities and enhance resilience.
- Efficiency: Cost-effectiveness of achieving project goals.
- Equity: Fair distribution of benefits among community segments, including women, youth, and marginalized groups.
- Sustainability: Long-term viability of adaptation measures and their maintenance mechanisms.

Methods and Approaches:

- Qualitative: Focus groups, interviews, and observations to capture community perceptions.
- Quantitative: Statistical analysis and surveys to measure measurable changes, such as increased water availability or reduced flood damage.

12.4 Learning Framework

The learning component ensures that insights from monitoring and evaluation shape future adaptation efforts.

Key Activities:

- Document and share lessons learned from successful and unsuccessful projects.
- Revise adaptation strategies based on evaluation findings and stakeholder feedback.
- Promote capacity-building workshops to incorporate lessons learned into future projects.
- Align lessons with municipal and national development goals to ensure coherence.

Knowledge Sharing and Communication:

- Reports, policy briefs, and community outreach initiatives will disseminate MEL findings.
- Online and offline platforms will share case studies and success stories to inspire replication of best practices.

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**
    - Document successes and failures, implementing corrective measures.
    - Align adaptations with the MTDP and broader development goals.
4. **Communicating Outcomes**
    - Share progress, effectiveness, and learnings through reports and community outreach.

12.6 Sustainability of the MEL Framework

Ensuring the long-term sustainability of the MEL framework involves:

- **Community Ownership:** Involving residents at every stage of MEL activities fosters local accountability and continuity.
- **Capacity Building:** Continuous training for municipal staff, community members, and project teams to maintain MEL processes.
- **Integration with Municipal Plans:** Embedding MEL findings into the municipal's MTDP and other policy frameworks ensures that learnings are institutionalized.
- **Technological Innovation:** Leveraging advanced tools, for land monitoring and mobile platforms for real-time data collection, enhances efficiency and scalability.
- **Securing Long-Term Funding:** Partnering with donors and exploring innovative financing mechanisms will sustain MEL activities beyond individual project cycles.

13 Conclusion and Recommendations

13.0 Introduction

Aowin Municipal Assembly's Adaptation Action Plan presents a well-rounded and forward-looking strategy to combat the adverse effects of climate change. Focusing on critical sectors such as agriculture, water supply, health, infrastructure, and biodiversity, the plan prioritizes building resilience, securing livelihoods, and fostering sustainable development tailored to the municipal's unique context. Drawing on comprehensive vulnerability assessments, participatory stakeholder consultations, and a meticulous prioritization process, the plan identifies actionable measures to mitigate climate risks. Interventions such as flood-resilient infrastructure, climate-smart agricultural practices, water management systems, and gender-responsive health initiatives are designed to address the municipal's current challenges while laying the groundwork for equitable and long-term sustainability.

13.1 Recommendations

The following recommendations provide a roadmap for transformative climate adaptation in Aowin, focusing on strengthening institutional capacity, securing sustainable financing, enhancing stakeholder engagement, and promoting technological innovation, among other key areas.

- **Strengthening Institutional Capacity:** To effectively implement and manage adaptation actions in Aowin, institutional capacity must be significantly enhanced. Local government authorities, traditional leaders, community-based organizations, and implementing agencies require tailored training in areas such as resource mobilization, project management, and the integration of sustainable practices. Programs that build expertise in data-driven decision-making, participatory governance, and the adoption of innovative technologies will empower stakeholders to oversee and coordinate adaptation initiatives effectively. Institutional frameworks must be strengthened to ensure that roles and responsibilities are clearly defined, enabling efficient collaboration and accountability across sectors.

- **Securing Sustainable Financing:** Achieving long-term climate resilience in Aowin requires a diversified and transparent financing strategy. The municipal assembly should actively seek funding from national budget allocations, international climate funds such as the Green Climate Fund, private sector investments, and community contributions. Innovative financing mechanisms, including green bonds and payments for ecosystem services, should be explored to bridge funding gaps. Transparent allocation criteria based on measurable impacts and project urgency will ensure efficient resource use. Regular reporting on fund utilization will build stakeholder trust, fostering continued financial support.

- **Enhancing Stakeholder Engagement:** Inclusive stakeholder engagement is fundamental to the success of climate adaptation efforts in Aowin. Diverse groups, including women, youth, and differently-abled individuals, must be actively involved in planning and implementation processes. Tools such as participatory workshops, community forums, and resource mapping exercises can facilitate inclusive

dialogue. Partnerships with NGOs, local businesses, traditional authorities, and private sector actors will enhance collaboration and shared accountability. Continuous communication and feedback loops will ensure ongoing stakeholder commitment and foster local ownership of adaptation measures.

- **Integrating Adaptation into Policy Frameworks:** To achieve long-term impact, climate adaptation strategies must be embedded into existing municipal and national development plans. Aowin's adaptation goals should align with the Medium-Term Development Plan (MTDP) and other policy instruments to mainstream climate resilience into socio-economic planning. For example, zoning regulations should incorporate climate risks to guide land use planning, while agricultural policies should promote climate-smart practices. Urban planning frameworks should prioritize resilient infrastructure and green spaces, ensuring resource efficiency and coherence across adaptation efforts.

- **Establishing a Robust MEL Framework:** Aowin municipality must adopt a comprehensive Monitoring, Evaluation, and Learning (MEL) framework to track and enhance adaptation initiatives. This framework should include clear performance indicators, timelines, and feedback mechanisms to evaluate the effectiveness of strategies. Regular evaluations will inform necessary adjustments and ensure continuous improvement. Active involvement of local communities in MEL activities will promote transparency, accountability, and ownership, fostering long-term commitment to adaptation goals.

- **Promoting Technological Innovation:** Harnessing modern technologies can amplify the impact and efficiency of adaptation initiatives in Aowin. For instance, GIS tools can be employed to monitor forest cover and assess flood risks, while mobile applications can support real-time data collection on water quality. Solar-powered water purification units can address water security challenges, particularly in off-grid areas. Encouraging the adoption of affordable, context-specific technologies will reduce reliance on external resources and enhance the sustainability of adaptation efforts.

- **Scaling Up Successful Initiatives:** Scaling up proven pilot projects to other parts of Aowin can maximize their impact and attract additional support. Successful agroforestry programs that enhance soil fertility and biodiversity or flood-resilient housing designs that protect vulnerable communities should be replicated municipal-wide. Establishing knowledge-sharing platforms and demonstration sites will facilitate the adoption of best practices across different communities, ensuring broader and more equitable benefits.

- **Advancing Gender-Responsive Approaches:** Inclusive and gender-responsive adaptation strategies are essential to fostering social cohesion and resilience in Aowin. Programs that empower women, such as sustainable farming training or leadership roles in water management, can drive equitable development. Youth engagement in technology-driven sectors like aquaculture or renewable energy can harness their innovative potential. Additionally, designing infrastructure and services to meet the needs of differently-abled individuals will ensure inclusivity and accessibility, leaving no group behind in the pursuit of climate resilience.

13.2 Conclusion

The Adaptation Action Plan for Aowin Municipal Assembly represents a significant step toward addressing the municipal's vulnerabilities to climate change while fostering resilience and sustainable development. Through targeted interventions across agriculture, water supply, health, infrastructure, and biodiversity, the plan aligns with Aowin's unique socio-economic and environmental realities. Integrating evidence-based strategies, robust stakeholder engagement, and innovative financing mechanisms, this plan offers a roadmap for transformative climate adaptation that benefits both current and future generations.

The plan's emphasis on equity, inclusivity, and sustainability ensures that all segments of the community, particularly women, youth, and marginalized groups, are active participants and beneficiaries of adaptation efforts. Moreover, the Monitoring, Evaluation, and Learning (MEL) framework embedded within the plan ensures accountability, continuous improvement, and the ability to respond effectively to evolving climate challenges.

As Aowin implements this comprehensive plan, it is vital to prioritize capacity building, secure diversified and sustainable financing, and foster partnerships at all levels. Scaling successful initiatives and integrating adaptation strategies into broader development policies will amplify the plan's impact, ensuring that adaptation measures are resilient, equitable, and impactful.

This plan not only addresses Aowin's immediate vulnerabilities but also positions the municipal as a model for locally tailored, community-driven climate adaptation. Committing to this adaptive and inclusive approach, Aowin can build a future that is not only resilient to climate change but also reflective of the municipal's aspirations for sustainable growth and development.

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Table 25: Top 35 municipals vulnerability and population losing access to healthcare.

ble A11: Roads (top 35 districts)

District name	Population losing access to healthcare	District vulnerabi
Accra Metropolis	588,528	
Kumasi	545,259	
Sekondi Takoradi	432,837	
Ga South	220,319	
Gomoa East	182,917	
Ga West	182,445	
Shama	168,029	
Keta Municipal	161,062	
Ketu South	148,007	
Birim Municipal	141,747	
Jomoro	139,819	
Atiwa	134,765	
Prestea / Huni Valley	127,846	
East Akim	125,077	
Birim South	119,250	
Komenda Edna Eguafo / Abirem	115,822	
Kwahu Afram Plains North	115,570	
Atwima Mponua	115,239	
West Akim	113,750	
Assin South	111,886	
Aowin	105,760	
Asokore Mampong Municipal	99,385	
Kpone Katamanso	99,297	
Krachi East	98,208	
Assin North	96,643	
Asikuma / Odoben / Brakwa	93,710	
Ga Central Municipal	93,019	
Tema Metropolis	92,157	
Asunafo North	90,109	
South Tongu	89,652	
Kpandai	87,528	
La Dade Kotopon	87,519	
West Mamprusi	86,575	
Twifo Atti-Morkwa	86,218	
Nkwanta South	86,051	