CLIMATE RISK AND VULNERABILITY ASSESSMENT MANUAL FOR MMDAs

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List of Acronyms

Acronym	Full Meaning
AC	Adaptive Capacity
CCA	Climate Change Adaptation
CCMA	Cape Coast Metropolitan Assembly
CCRVA	Climate Change Risk and Vulnerability Assessment
CSIR	Council for Scientific and Industrial Research
DACF	District Assemblies Common Fund
DA	District Assembly
EPA	Environmental Protection Agency
GCM	Global Circulation Model
GHG	Greenhouse Gas
GMA	Ghana Meteorological Agency
GNHR	Ghana National Household Registry
GoG	Government of Ghana
IPCC	Intergovernmental Panel on Climate Change
IS	Indicator Score
IVT	Intermediate Village Tract
LDC	Least Developed Country
LUC	Local Urban Centre
LULC	Land Use and Land Cover
LVI	Livelihood Vulnerability Index
LVI-IPCC	Livelihood Vulnerability Index – Intergovernmental Panel on Climate Change
MDA	Ministries, Departments and Agencies
MMDAs	Metropolitan, Municipal, and District Assemblies
MTR	Mid-Term Review
NDPC	National Development Planning Commission
NDC	Nationally Determined Contribution
NAP	National Adaptation Plan
NGS	National Geospatial Services
NGO	Non-Governmental Organization
PRA	Participatory Rural Appraisal
SIDS	Small Island Developing States
SPEI	Standardised Precipitation Evapotranspiration Index
SVI	Social Vulnerability Index
UNFCCC	United Nations Framework Convention on Climate Change
VA	Vulnerability Assessment
WRC	Water Resources Commission

I. About this manual

What is the purpose of this manual?

This manual is developed to provide Metropolitan, Municipal, and District Assemblies (MMDAs) in Ghana with a standardized, practical guide for conducting Climate Risk and Vulnerability Assessments (CRVAs). It draws on Ghana's National Adaptation Plan (NAP) framework and builds on real-world experiences from assessments carried out in districts such as Cape Coast, Tamale, Keta, Kumbungu, and others. The manual is designed to guide MMDAs in Ghana to independently conduct Climate Risk and Vulnerability Assessments (CRVAs) and apply the findings to inform development planning and build local resilience. It provides a clear and practical step-by-step process that enables districts to:

- Identify and understand the specific climate risks and vulnerabilities affecting their communities, sectors, and infrastructure.
- Use evidence from assessments to support informed planning, prioritization, and decision-making;
- Integrate climate change considerations into Medium-Term Development Plans (MTDPs), budgeting, and routine service delivery.
- Institutionalize climate risk assessment as a core planning function at the district level;
- Build internal capacity and ownership for long-term climate adaptation and resilience-building efforts.

Ultimately, the manual empowers districts to mainstream climate change into their governance systems and development programmes, while enhancing their ability to manage present and future climate-related challenges effectively.

How was this manual developed?

This manual was developed through a synthesis of experiences, tools, and lessons from a series of district-level CRVAs conducted across Ghana. These assessments were carried out under the National Adaptation Plan (NAP) process, supported by the Environmental Protection Agency (EPA), the United Nations Environment Programme (UNEP), and other development partners. The manual draws specifically on the methodologies, frameworks, and participatory approaches applied in vulnerability assessments conducted in 27 MMDAs across 10 Regions and 5 Agroecological Zones in Ghana

Each of these assessments provided practical insights into how climate risks manifest locally, how communities and institutions respond, and what tools are most effective for identifying, analyzing, and addressing vulnerabilities. To ensure relevance and usability for MMDAs, the manual adapts internationally recognized frameworks such as the IPCC risk concept, CARE's Climate Vulnerability and Capacity Analysis (CVCA), and GIZ's Risk and Vulnerability Assessment methodology to the Ghanaian context. It also integrates guidance from national policies, including the National Climate Change Policy (NCCP), the NDCs, and the Medium-Term Development Planning Framework (MTDPF).

The development process was informed by a review of assessment reports, consultations with practitioners, and alignment with national planning processes to ensure that MMDAs can use the manual as a practical, self-guided tool to embed climate risk management into their operations.

Who are targeted audience?

This manual is intended for use by a wide range of actors within the Metropolitan, Municipal, and District Assemblies (MMDAs) who are directly or indirectly involved in development planning, environmental management, and service delivery. It is particularly targeted at local government officials and stakeholders who play a role in assessing, planning for, and responding to climate risks.

Key users include:

- **District Planning Officers and members of the Municipal Planning Coordinating Unit (MPCU):** To lead the integration of climate risk and vulnerability assessments into Medium-Term Development Plans (MTDPs) and budgets.
- **District Environmental and Climate Change Desk Officers:** To coordinate assessment processes and facilitate climate mainstreaming across departments.
- **NADMO Coordinators and Disaster Risk Management Officers:** To align disaster preparedness and response strategies with climate risk information.
- **Sector Heads and Technical Officers (e.g., Agric, Water, Health, Works, Education):** To identify climate risks affecting their sectors and design appropriate adaptation responses.
- **Statistical and Monitoring Officers:** To support data collection, analysis, and tracking of adaptation outcomes.
- **Presiding Members, Assembly Members, and Traditional Leaders:** To participate in decision-making and community-level validation of findings.
- **Local NGOs, CSOs, and Development Partners:** To support capacity-building, community engagement, and implementation of adaptation interventions.

The manual is written in accessible language and structured to allow both technical and non-technical users to follow the steps and tools, whether as implementers, facilitators, or supporters of the assessment process

II. Framework for climate change vulnerability assessment

2.1 Key terms and concepts

2.1.1 Basic terms

Understanding climate risk and vulnerability requires clarity on certain foundational terms. These concepts form the basis for assessing how climate change impacts people, places, and systems, and how well they are able to cope or adapt.

Weather	A condition of the atmosphere at a certain time and location described by meteorological variables such as temperature, precipitation, wind, humidity, atmospheric pressure, cloudiness.
Climate	The average characteristics of meteorological conditions, calculated over a long period (typically 30 years or more).
Climate variability	The variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate, attributed either to natural internal processes within the climate system, or to variations in natural or anthropogenic variables. In other words, climate variability refers to the annual fluctuation of the climate, above or below the long-term average.
Climate change	A shift in average climate parameters and/or in the magnitude of climate variability observed and persisting over long periods (typically decades or longer)[2]. To simplify, climate change suggests long-term continuous change of: (i) the average (typical) climate, e.g. average (typical) seasonal temperatures in the coastal zone of Ghana are getting higher; (ii) (variability of temperatures, precipitation, and other climate parameters, e.g. more frequent and severe rainfall and stronger winds are observed in some regions of Ghana.
Climate projections	Simulations of possible future state of Earth's climate (e.g. in 2050 and 2100) using climate models. The latest global and regional climate change projections are based upon scenarios for Representative Concentration Pathways (RCPs) under assumptions concerning socio-economic and technological developments that may or may not be realised.
Climate hazard	Any climate-related physical event (e.g. cyclone), trend (e.g. increasing temperatures in dry season) or impact (e.g. flood, sea level rise), which has the potential to cause loss of, and damage to, people, physical assets, provision of services, and ecosystems. Hazards (as well as climate change impacts) can be divided into slow onset (like drought and changes in

	temperatures and precipitations patterns), and rapid onset (like floods) events.
Exposure	Exposure entails the presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected.
Vulnerability	Vulnerability deals with the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt
Sensitivity	Sensitivity refers to the degree to which a system is affected by, or responsive to a hazard. In other words, sensitivity captures the potential of a system to be impacted by a hazard. Sometimes sensitivity is determined by the criticality of the service that the system provides. For example, a community uses a road located close to the low-lying area of the coast as its main access to a major hospital. In the past, this road has been inundated during a storm event making access to the hospital difficult. Because the hospital provides such an essential service, this community should be considered more sensitive to coastal inundation event.
Adaptation	Undertaking actions to adjust to already observed or expected climate and its effects with the objectives to: • protect natural and human systems against the actual and anticipated harmful effects of climate change; • exploit any opportunities they may generate; • ensure the sustainability of investment and development interventions despite of current climate risks and potentially increasingly difficult climatic conditions.
Climate change impacts	The effects of climate change (e.g. increasing temperatures and change in seasonal patterns) and extremes (e.g. heat waves, heavy rainfall, severe storms) on human systems and environment. The impacts of climate change include: • Physical impacts – floods, droughts and sea level rise; • Environmental – impacts on ecosystems such as loss of biodiversity, water scarcity, and land degradation; • Impacts on human systems – socio-economic effects (e.g. loss of life and livelihood, food insecurity), and infrastructural consequences.
Ecosystem	A system of living organisms, their environment (e.g. land, water) and the interactions within and between them.

Ecosystem services	Ecosystems provide people with numerous benefits called ecosystem services, which could be categorized as follows: • Provisioning services are all products obtained from ecosystems such as food, fresh water and raw materials. For instance, people depend on lakes and rivers for water and fish, while forests are vital source of wood and food for many communities. Nature also provides people with traditional and commercial medicinal plants/raw materials (e.g.) • Regulating services are related to the ability of ecosystems to regulate natural processes such as water, air and soil quality control, erosion prevention and moderation of extreme events. For example, trees in urban areas provide shade in hot days and improve the air quality, while mangroves can protect communities from hazards by reducing wind speed, flooding and coastal erosion. Forests remove carbon dioxide, prevent soil erosion and landslides, and reduce the flow of water during floods. Wetlands can filter waste water (e.g. human and animal waste) and absorb floodwater. • Cultural services refer to non-material benefits such as using the nature for tourism, ecotourism and sports, and cultural and spiritual activities. • Supporting services are those benefits related to natural processes that support and maintain all other services (e.g. soil formation, providing nutrition and habitat for species).
Gender	Socially ascribed roles, responsibilities, rights and opportunities associated with being a man or a woman, and the social relations between women and men. These are dynamic, change over time and are context-specific. Gender roles in society shape the gender division of labour, which is the allocation of the tasks and responsibilities of women and men at home, at work and in society. For example, often a division is made between: a) productive tasks (e.g. agriculture, fisheries/aquaculture, self-employment, workers in enterprises); b) reproductive tasks such as child care and household tasks; and c) community tasks (UN-Women, 2014).
Climate resilience	Adaptation to climate change aims at reducing vulnerability and building climate resilience. Climate resilience is the ability of a system to (i) absorb stress and cope with climate change and hazards, including maintaining its basic structure, functions and adaptive capacity, and (ii) recover, adapt and transform in ways that improve its sustainability, leaving it better prepared for future climate change impacts. In this context, climate-resilient development of districts of Ghana suggests development that ensures townships' ability to cope with current climate and its impact and to adapt to future climate change, by preserving development gains and minimising damages.

2.1 Framing risk of, and vulnerability to, climate change and hazards

The reason why countries get affect by climate change lies in the fact that the country is exposed and vulnerable to the impacts of climate change and climate–related hazards. The probability of experiencing negative impacts of climate change is called climate risk. Risk results from the interaction of climate change and hazards, exposure and vulnerability. Adaptation and mitigation actions can reduce the risk (Figure 1). According to the Intergovernmental Panel on Climate Change (IPCC), climate risk results from the interaction of hazard, exposure, and vulnerability. In the IPCC online glossary[1] the revised definition of **Risk** [used in the Special Report on Climate Change and Land and Special Report on the Ocean and Cryosphere in a Changing Climate – SRCCL (09/2019)] is the following, and is shown graphically in Figure 1 (from IPCC, 2014):

Climate Change Risk *is defined as the potential for adverse consequences for human or ecological systems, recognizing the diversity of values and objectives associated with such systems. In the context of climate change, risks can arise from potential impacts of climate change as well as human responses to climate change. Relevant adverse consequences include those on lives, livelihoods, health and wellbeing, economic, social and cultural assets and investments, infrastructure, services (including ecosystem services), ecosystems and species.*

- *In the context of climate change impacts,* ***risks*** *result from dynamic interactions between climate- related hazards with the exposure and vulnerability of the affected human or ecological system to the hazards.* ***Hazards, exposure,*** *and* ***vulnerability*** *may each be subject to uncertainty in terms of* ***magnitude*** *and* ***likelihood of occurrence****, and each may change over time and space due to* ***socio- economic changes*** *and* ***human decision-making****.*
- *In the context of climate change responses, risks result from the potential for such responses not achieving the intended objective(s), or from potential trade-offs with, or negative side-effects on, other societal objectives, such as the Sustainable Development Goals. Risks can arise for example from uncertainty in implementation, effectiveness or outcomes of climate policy, climate-related investments, technology development or adoption, and system transitions.*

Source: IPCC online glossary (https://apps.ipcc.ch/glossary/)

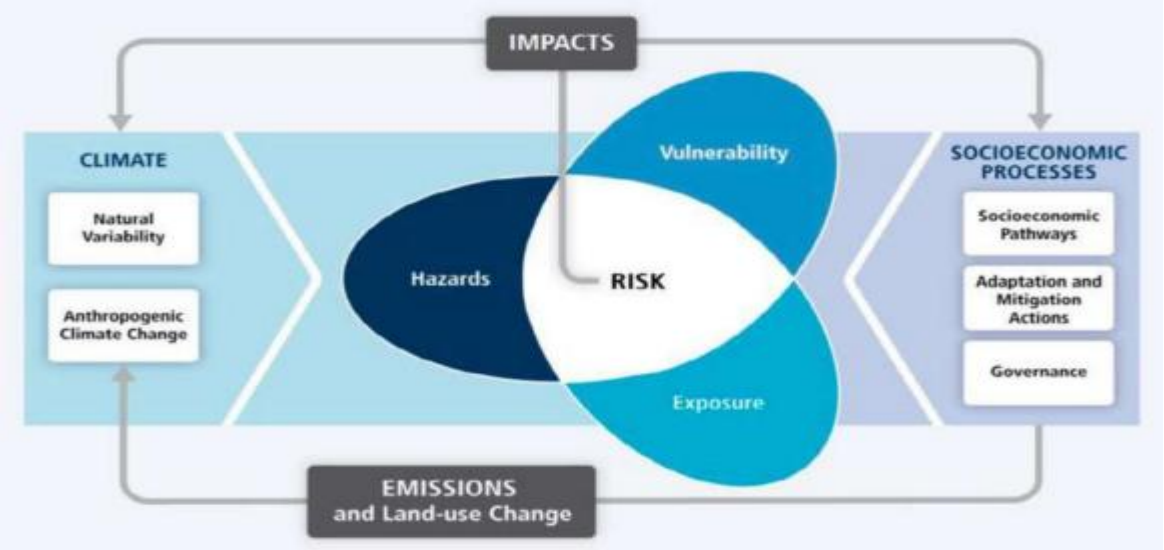


Figure 1. Figure 1 The concept of climate change risk (Source: IPCC, 2014)

[1] 1 https://apps.ipcc.ch/glossary/

The figure above presents the Intergovernmental Panel on Climate Change (IPCC) risk framework. This model provides a comprehensive and widely accepted structure for understanding how climate-related risks emerge and how they can be assessed at the district level. It is especially relevant for guiding vulnerability and risk assessments within Ghana's Metropolitan, Municipal, and District Assemblies (MMDAs).

Key Components of the Framework:

1. **Climate System (Left Side – Blue Box):**
   - Climate hazards are shaped by **natural variability** (e.g., seasonal weather patterns) and **anthropogenic climate change** (human-induced emissions and land-use changes).
   - These hazards include floods, droughts, heatwaves, sea-level rise, and others that districts in Ghana increasingly face.
2. **Hazards, Exposure, and Vulnerability (Center – Overlapping Ovals):**
   - The core of the framework shows that **risk** arises from the interaction of:
     - **Hazards:** The climate events or trends that can cause damage (e.g., heavy rains, drought).
     - **Exposure:** The presence of people, infrastructure, ecosystems, and assets in areas affected by these hazards.
     - **Vulnerability:** The degree to which these exposed systems are sensitive to harm and have the capacity to cope or adapt.
   - Where these three components overlap, climate risk is highest.
3. **Impacts (Top – Arrow):**
   - The intersection of hazard, exposure, and vulnerability leads to **impacts**—on livelihoods, infrastructure, health, agriculture, and ecosystems.
4. **Socioeconomic Processes (Right Side – Blue Box):**
   - These include:
     - **Socioeconomic pathways:** Such as poverty levels, urbanization, and population growth that influence exposure and vulnerability.
     - **Adaptation and mitigation actions:** That can reduce vulnerability and build resilience.
     - **Governance:** Which plays a central role in enabling or constraining effective responses.
5. **Feedback Loops:**
   - The system includes feedbacks between emissions, climate change, socioeconomic conditions, and the resulting risks. For example, poor governance can increase vulnerability, while strong institutions can enable adaptive planning and reduce risks.

Risk of climate-related impacts results from the interaction of climate-related hazards (including hazardous events and trends) with the vulnerability and exposure of human and natural systems. Changes in both the climate system (left) and socioeconomic processes including adaptation and mitigation (right) are drivers of hazards, exposure, and vulnerability.

Source: IPCC's Fifth Assessment Report (WGII AR5) (Field, et al., 2014)

Exposure refers to the extent to which people, ecosystems, infrastructure, and economic assets are situated in locations that are susceptible to climate-related hazards. It considers the physical presence of these systems in areas where they could be negatively impacted by climate events. Examples of exposure include populations living in flood-prone zones, agricultural land reliant on seasonal rainfall, houses near eroding coastlines, and essential services such as hospitals, schools, water, and power infrastructure located in hazard-prone areas.

Vulnerability describes how sensitive a system is to the impacts of climate change and its ability—or lack thereof—to withstand and recover from those impacts. It is shaped by a range of factors including socioeconomic conditions, physical infrastructure, and environmental degradation. For instance, communities heavily dependent on rain-fed agriculture with limited income sources, low levels of climate awareness, and poor access to basic services are typically more vulnerable. Environmentally, practices like deforestation or destruction of natural buffers such as mangroves increase vulnerability by weakening natural defenses against hazards like floods and coastal erosion.

Vulnerability also has a **physical dimension**, relating to the condition and robustness of buildings, roads, drainage systems, and other critical infrastructure. Poorly constructed housing in hazard-prone areas, for example, increases exposure and reduces resilience to extreme events.

A key factor influencing vulnerability is **adaptive capacity**, the ability of individuals, communities, and institutions to anticipate, respond to, and recover from climate impacts. This includes access to information, technology, financial resources, education, and institutions that support adaptation. Low adaptive capacity limits the potential to take advantage of climate-related opportunities, such as longer growing seasons, due to lack of know-how, tools, or supportive policies.

Adaptation to climate change involves taking deliberate actions to reduce vulnerability and enhance resilience. **Climate resilience** is the capacity of a system to absorb shocks from climate-related stressors, maintain essential functions, and evolve in a way that strengthens its ability to manage future risks. Resilient development, therefore, ensures that towns and communities can protect current development progress, minimize damage from future hazards, and adapt effectively to long-term changes in the climate.

Example: Climate Risk and Vulnerability Profile of Keta Municipality, Ghana

Climate Hazards

Keta Municipality, situated along Ghana's southeastern coastline, is one of the most climate-affected areas in the country. The municipality has historically suffered from severe coastal erosion, tidal flooding, and storm surges, with entire communities displaced or submerged. With future climatic changes, Keta faces increasing threats from:

- Rapid-onset hazards such as intense rainfall, flash floods, and coastal storms;
- Slow-onset processes including sea-level rise, salinization of freshwater and agricultural lands, prolonged dry periods, and land degradation.

These climate hazards are projected to intensify in both frequency and magnitude, exacerbating existing development challenges and threatening the municipality's ecological and socioeconomic stability.

Exposure

Keta's entire coastline and lagoon-adjacent communities lie in high-risk zones. Settlements such as Kedzi, Fuveme, and Dzita are directly exposed to recurrent tidal floods and rapid shoreline recession. The municipality's economy, largely reliant on climate-sensitive sectors like fisheries, salt production, and coastal farming, further heightens its exposure. Public infrastructure, including roads, schools, electricity poles, and water facilities, is also increasingly threatened by flooding and saline intrusion.

In recent years, infrastructure losses, housing collapses, and displacement of residents due to coastal erosion have become regular, severely affecting local productivity, social services, and livelihoods.

Vulnerability

Key drivers of vulnerability in Keta Municipality include:

- High dependency on climate-sensitive sectors, especially artisanal fishing and rainfed agriculture, for food and income security.
- Environmental degradation from sand mining, loss of mangrove buffers, and poor land management, which accelerate erosion and flood risk.
- Limited drainage systems and poor-quality housing, particularly in informal settlements, making them highly susceptible to water damage and collapse.
- Inadequate access to adaptation finance, climate information, and early warning systems, especially at the community level.
- Youth outmigration, unemployment, and poverty, which limit community capacity to invest in resilience and recovery efforts.

Keta's vulnerability is also exacerbated by institutional challenges, including low integration of climate risk into development planning, limited inter-agency coordination, and minimal enforcement of coastal protection measures.

2.2 Aim and principles of the vulnerability assessment

2.2.1 Purpose and objective of the vulnerability assessment

Before selecting and implementing appropriate climate change adaptation (CCA) actions, Metropolitan, Municipal, and District Assemblies (MMDAs) must first understand their specific climate risks and vulnerabilities. This includes identifying which communities, sectors, and assets are most at risk, and the underlying factors driving their vulnerability (Figure 2). Conducting a Climate Risk and Vulnerability Assessment (CRVA) allows districts to systematically identify, assess, and analyze climate-related hazards, exposure, and vulnerability.

Figure 2. Phases of local climate resilience action planning

The purpose of conducting a district-level vulnerability assessment is to provide relevant information for local and national authorities, development partners, and other stakeholders, including:

- Understanding the root causes of vulnerability—environmental, socio-economic, and infrastructural.
- Identifying the most vulnerable geographic areas, social groups, and sectors at present;
- Anticipating the potential impacts of climate change over short-, medium-, and long-term periods;
- Prioritizing sectors and populations that require immediate, medium-, or long-term adaptation responses to strengthen resilience at the local level.

This process helps MMDAs integrate climate considerations into development planning and implement targeted, context-specific adaptation actions aligned with Ghana's NDCs and National Adaptation Plan (NAP).

2.2.2 Guiding Principles

The proposed methodology for vulnerability assessment is based on the following overarching principles:

- **Simplicity** – The process is designed to be straightforward and easy to replicate across districts, regardless of their technical or financial capacity.
- **Measurability and Data Availability** – It prioritizes the use of readily available and updatable data to enable replication and progress monitoring.
- **Inclusiveness** – Ensures full participation of communities, especially vulnerable groups, throughout the assessment process.
- **Comprehensiveness** – Captures the ecological, social, and infrastructure dimensions of vulnerability and their interlinkages.
- **Spatial Relevance** – Aligns assessment findings with physical planning and location-specific interventions for adaptation.

Application of These Principles

To operationalize these principles, the assessment process should incorporate the following elements:

Accessible and Cost-Effective Tools

- Use of open-source software like QGIS, which facilitates mapping, analysis, and spatial planning without incurring software costs.
- Reliance on freely available national and subnational datasets, including those from the Ghana Statistical Service, EPA, NADMO, GMet and other government bodies.
- Avoidance of costly high-resolution imagery unless it is already available through institutional partnerships. However, use of such imagery is encouraged when accessible to enhance mapping and modelling accuracy.

Participatory and Inclusive Approach

- Employ participatory techniques such as district workshop, community surveys, focus group discussions, participatory mapping, and key informant interviews.
- Promote equal participation of gender groups (i.e. men and women, persons with disability, aged, etc) and use sex- and age-disaggregated data where possible to capture differentiated vulnerabilities.
- Engage district-level staff, traditional authorities, and local organizations throughout the process to enhance ownership and sustainability of the results.

System-Based and Spatially-Explicit Analysis

- Assess the three core systems of the district: ecological (e.g., wetlands, forests), socio-economic (e.g., livelihoods, health, education), and infrastructure (e.g., housing, roads, drainage).
- Understand how these systems interact and how climate impacts in one system may affect others.
- Analyze existing governance structures and institutional capacities at the district level to ensure feasibility and implementation of adaptation measures.
- Identify vulnerable population groups (e.g., women, youth, elderly, persons with disabilities) and recognize that different groups experience climate impacts in distinct ways.
- Consider the current and future spatial layout of the district to support forward-looking planning and ensure adaptation measures are appropriately targeted.

2.3 Approach and Methodological framework

2.3.1 Overview of the Assessment Process

The proposed vulnerability assessment process consists of identification and analysis of socio-economic, physical and environmental factors, which determine the sensitivity/susceptibility of the district to the impact of climate change (e.g. increasing temperatures, change in seasonal patterns) and/or hazard (e.g. flood, drought), using a combination of qualitative and quantitative methods. More specifically, the proposed methodology involves district and community level technical meetings; local participatory workshops; surveys with household heads; a desk review of literature; use of secondary socio-economic and environmental data; and creation of datasets based on available geo-referenced data. The climate change vulnerability risk assessment process encompasses the five key activities:

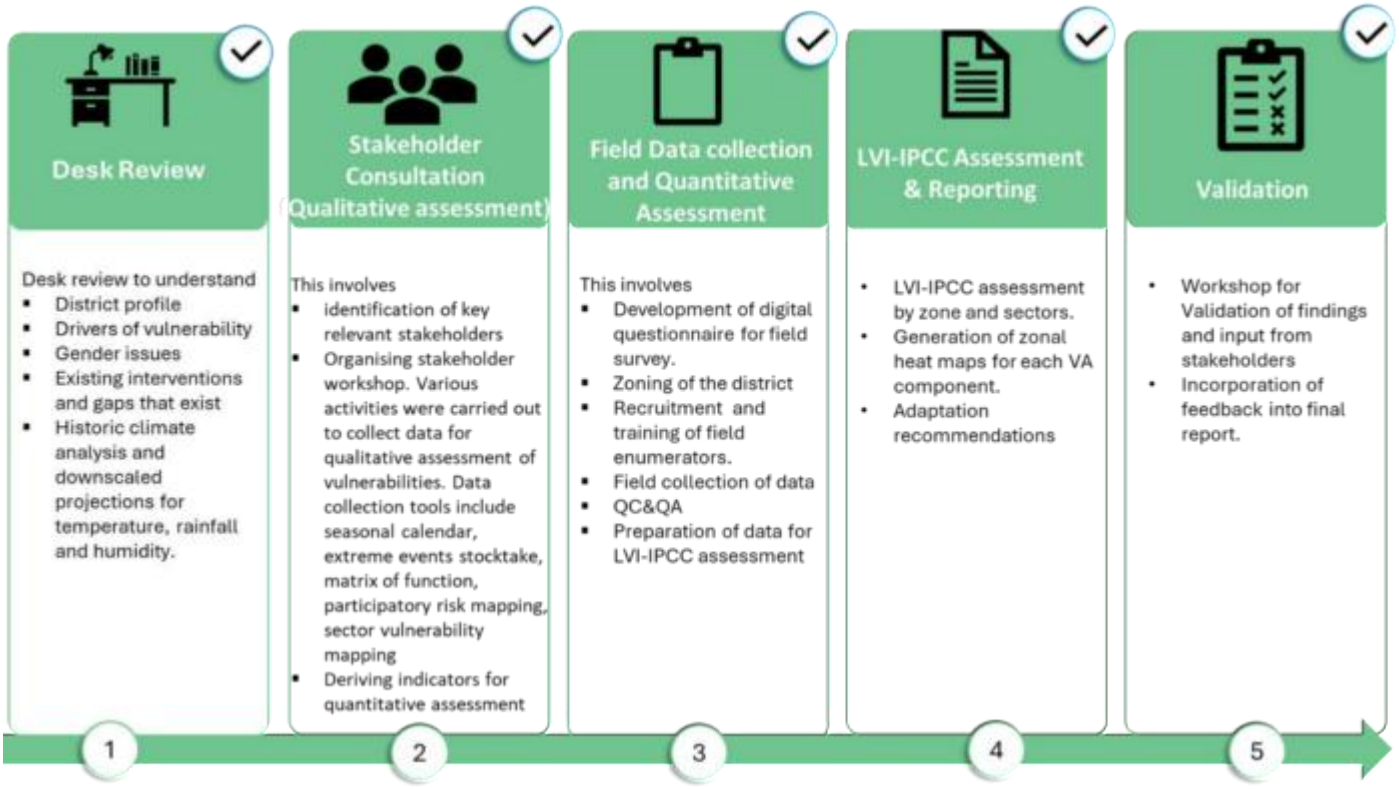


Figure 3 | ***Overall work approach for the Climate Change Risk Assessment***

2.4. Planning the vulnerability assessment

- Set clear objectives, aim, time-horizon (e.g. short-term year 2030, or long-term year 2050) and expected outcome of the vulnerability assessment.
- Define the available financial and human resources, and desired time-frame to conduct the vulnerability assessment. When resources and time are limited, districts officials can choose rapid vulnerability assessment (i.e. using tools and methods which do not require significant time, resources and expertise). Advanced (detailed) assessment, which contains spatial analysis, would require personnel with relevant technical skills in geographic information system (GIS) analysis, statistics, or climate risk modelling.
- Select a multi-disciplinary team of 3-5 members, and choose a Team Leader. It is essential to have at least one environmental specialist, one socio-economic development specialist and one urban/regional planner, architect or engineer (see Table 1). For advanced (spatial) vulnerability assessment, GIS specialist should also be appointed. Supportive role could have representatives from other sectors. Overall, specialists from the following departments could be considered for the assessment team:
    - Agriculture, fisheries and livestock departments
    - Forestry, environment and tourism departments
    - Water, energy and industry departments
    - Infrastructure and transport departments
    - District development planning department
    - Disaster risk management department
    - Education and health departments
- Using this manual, assessment teams should decide on the specific methods and tools that will be used (depending on the available resource and time). While this book provides guidance on various tools and methods for analysis, assessment teams should tailor their own approach suitable for the district of interest (e.g. develop a list of context-specific questions for district/community consultations and adapt the proposed survey form to the respective case study).
- Check data availability and request secondary data well in advance (e.g. Census data, or district level climate/weather data).
- Develop a plan for the vulnerability assessment and assign specific tasks to each group member. These should account for: a desk review of relevant documents/literature; collecting secondary and primary data (e.g. Census data; survey with assembly men); district and community level participatory workshops (see participatory tools and methods in **Section 3** and **Annex I**); data processing and analysis; and developing a final report.
- A vulnerability assessment process would require two (2) workshops.
    - A first stakeholder engagement workshop is focused on understanding the district dynamics and to collect qualitative data on prevailing climate change manifestations; drivers of vulnerability; vulnerable groups, locations, assets and sectors as well as impacts. It provides comprehensive

qualitative data on the dynamics of the components of climate risk and vulnerability (hazard, exposure, sensitivity and adaptative capacity) based on which indicators are derived to quantitatively assess these components and overall climate change vulnerability.

- A validation workshop is organized to verify findings of the vulnerability assessment process.

NB: Two is not standardized. The district could have other sub-group workshops/meetings if the need be and when time and financial resources allow that.

Table 1| Guide for selecting a district vulnerability assessment team

Role	Key Responsibilities	Suggested Profile / Institution
Team Leader / Coordinator	- Oversee the assessment process- Liaise with MMDA management and technical departments- Ensure integration into planning	Physical Planning Officer or Development Planning Officer at the MMDA
Climate Risk Analyst	- Identify climate hazards- Analyse exposure and sensitivity- Support risk mapping and projections	Officer from EPA, NADMO, or a consultant with experience in climate science
Socioeconomic & Gender Expert	- Lead community vulnerability profiling- Integrate gender and social inclusion- Disaggregate data by age, gender, and disability	Social Welfare Officer, Gender Desk Officer, NGO/CBO with gender expertise
Community Engagement Lead	- Mobilize community participation- Facilitate Focus Group Discussions, surveys, and participatory mapping	Representative from the Community Development Unit or local CSO
Data Collection & Analysis Officer	- Support household surveys- Manage data tools- Conduct statistical and LVI analyses	MMDA Statistics Officer or Planning Unit staff with data experience
GIS/Mapping Specialist	- Provide spatial analysis and mapping of risks and hotspots	Regional Spatial Planning Officer, Lands Commission, or consultant (QGIS skills)
Documentation & Reporting Lead	- Compile field reports- Draft synthesis report- Ensure documentation of process and outcomes	Development Planning Unit or local consultant/volunteer trained in report writing
Climate Modelling Expert	- Interpret downscaled climate projections - Provide trend analysis on temperature, rainfall, and sea-level rise	Officer from GMet, university climate centers, EPA, or technical partner institutions
Technical Advisor	- Provide guidance on methodology, validation, and alignment with national frameworks (NAP, NDCs, etc.)	Representative from EPA, academia, or development partner

III. Vulnerability assessment: process, methods and tools

The methodology outlined provides a foundation for assessing vulnerability by first establishing the local context, including key characteristics of the district's socio-economic systems, ecological landscape, infrastructure, and spatial layout. This contextual analysis helps to identify existing vulnerabilities and their underlying causes. A vulnerability index is also introduced as a practical tool for pinpointing areas within the district that are most at risk. The approach integrates spatial analysis to assess how projected changes in climate conditions—based on downscaled climate models—could impact populations, livelihoods, and physical assets. Additionally, the methodology incorporates gender-responsive considerations to ensure that the differentiated impacts of climate change are captured. Finally, it outlines possible future scenarios that could emerge in the absence of adaptation, which are then compared with resilient development pathways to guide local-level adaptation strategies. The subsequent sections provide step-by-step instructions for carrying out the assessment and preparing the final report.

3.1 Step 1: Developing a District profile

This step corresponds to developing the first section (chapter) of the vulnerability assessment report. In this chapter, assessment teams should provide the reader with a background information on key issues, which determine the vulnerability of the district of interest now and in future, including:

- ✓ Physical and environmental features (such as basic geography, local climate and exposure to climate-related hazards, natural resources)
- ✓ Demographic overview (e.g. density of the population, rural/urban ratio, migration trends)
- ✓ Administration and governance (e.g. description of the governance structure and capacities of the township, and the role of informal institutions)

What should be described in this section?

At first, township officials should develop a district profile, i.e. a basic description of physical and environmental characteristics, demographic trends, and governance structure. The following list provides guidance and recommendations on formulating a district profile.

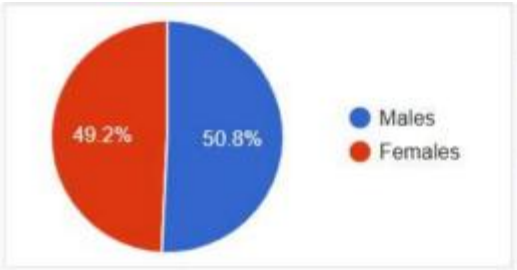
Table 2| Elements to be included in the district profile

Thematic Area	Data Requirements
Geographic Characteristics	- District boundaries and area size- Topography, elevation, landforms
Climate Characteristics	- Historical climate patterns (rainfall, temperature)- Seasonality and extremes
Demographic	- Socio-economic demographics: household type and size,

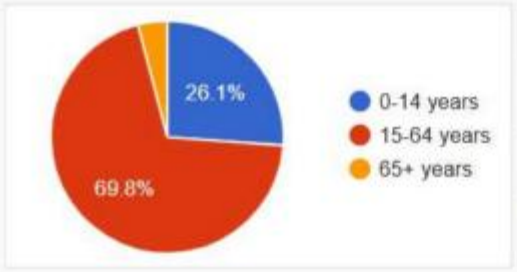
Data	per cent of female headed households, poverty levels, migration trends, child mortality, literacy rate/level of education, economically active/inactive population (out of which women), labour-force participation. If available, use sex and age disaggregated data. Pay attention that statistical data can be biased because women's work such as post-harvest processing and marketing of crops and fish, might not be considered as an 'economically active participation' in the existing statistical databases.
Natural Resource Base	- This section describes natural resources including their spatial distribution (location) and state (e.g. level of environmental degradation and resource depletion): marine and coastal ecosystems; coastal erosion and inundation water resources and hydrology; seasonal variation in water availability (e.g. rivers, groundwater); water quality forests and vegetation cover, and observed changes soils and soil nutrient status land use and drivers of change biodiversity (e.g. activities of galamseyers).
Infrastructure	- Roads, drainage, electricity, water supply, ICT, schools, and health facilities
Livelihoods and Economy	- Dominant livelihood activities (agriculture, fishing, trading, etc.)- Employment and income sources
Governance and Institutions	- Local governance structures- Presence of key departments and agencies
Hazard History	- Past disasters and climate-related events (floods, droughts, erosion, etc.)
Vulnerable Populations	- Settlements in hazard-prone areas- Marginalized or at-risk social groups

What methods and tools could be used to obtain, analyse and present information?

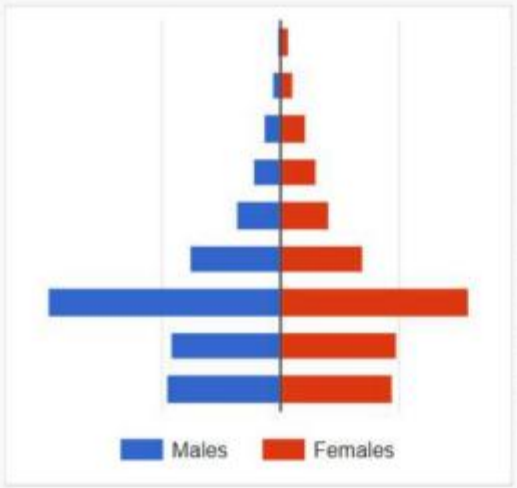
- **Review** of documents and published literature for the district.
- **Collection, analysis and graphic presentation of statistical data.** For example, Census data disaggregated at urban and rural level informs all aspects of the assessment (i.e. socio-economic and infrastructure information). In addition, a demographic chart, pie chart or column chart can be easily generated using the 2021 Census tables (Figure 5).



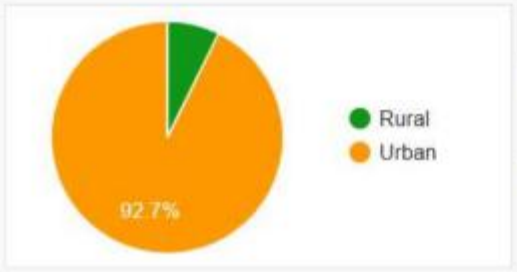
Gender (C 2021)	
Males	54,723
Females	53,075



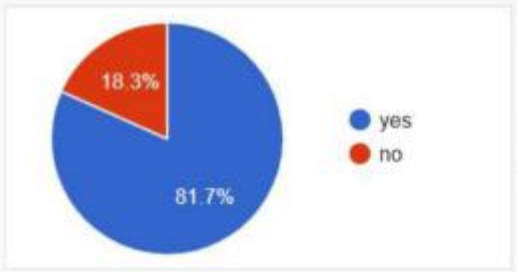
Age Groups (C 2021)	
0-14 years	28,164
15-64 years	75,229
65+ years	4,405



Age Distribution (C 2021)	
80+ years	1,023
70-79 years	1,799
60-69 years	3,734
50-59 years	5,260
40-49 years	7,770
30-39 years	14,701
20-29 years	35,428
10-19 years	19,022
0-9 years	19,061



Urbanization (C 2021)	
Rural	7,900
Urban	99,898



Literacy (A11+) (C 2021)	
yes	70,773
no	15,890

Figure 4 Example of a demographic chart: population pyramid for Effutu municipal (Source: City Population[2])

- **District mapping:** This step entails visually representing the major characteristics of the district in a spatial format. One practical approach is to use a large printed map of the district on which officials can

[2] https://www.citypopulation.de/en/ghana/admin/central/0207__effutu_municipal/

annotate relevant information, such as natural ecosystems, infrastructure, and socio-economic elements. This can be done either manually—by drawing or placing notes—or digitally using GIS tools. Where capacity allows, mapping these features in a Geographic Information System (GIS) platform provides enhanced analysis and can support integration with climate hazard data and future planning scenarios.

To learn more, see Annex I – C: Spatial analysis tools

- **Stakeholder Influence-Interest Matrix:** An Influence-Interest Matrix, which categorizes stakeholders based on their level of influence over decision-making processes and their interest in climate adaptation and development planning. This method helps to systematically identify key actors, including government agencies, traditional authorities, civil society organizations, and vulnerable groups such as women, youth, persons with disabilities, and low-income households. By mapping stakeholders into four quadrants—(1) high influence/high interest, (2) high influence/low interest, (3) low influence/high interest, and (4) low influence/low interest—MMDAs can better understand power dynamics, anticipate potential conflicts, and design inclusive engagement strategies. This analysis also supports the profiling of local governance structures and can be integrated into the Administration and Governance sub-section of the district profile. It ensures that no group is overlooked and that local institutions are effectively engaged in adaptation planning.

To learn more, see Annex I – Tool 1A

Data sources

District maps: District Planning Department/Unit or Google Maps.

Information on climate and environmental features (e.g. soil type, hydrology, crops and land use): information can be requested from respective district departments.

Census data: most of the necessary information for the development of district profile can be obtained from the 2021 Ghana Population and Housing Census.

3.2 Step 2: Assessing current vulnerability to climate change and hazards

Vulnerability can be assessed qualitatively and/or quantitatively. Qualitative assessment draws on local knowledge from communities and stakeholders, as well as statistical and geospatial data, to build a comprehensive picture of how climate change is currently affecting different sectors and social groups. It complements quantitative data by capturing insights, perceptions, and experiences of community members and stakeholders that cannot be fully reflected through numbers alone. The purpose of the quantitative assessment is to introduce a numerical framework that allows for the pragmatic comparison of vulnerability levels across different geographic areas, population groups, or components of the human environment within and across communities.

This step corresponds to developing the second section (chapter) of the vulnerability assessment report. In this chapter, assessment teams should describe the level of vulnerability of the district and corresponding underlying factors. More specifically, this chapter contains:

- ✓ Analysis of the observed climate changes including hazards
- ✓ Analysis of the factors of vulnerability to identify vulnerable sectors and groups:
  - Ecosystem conditions and impact of climate change on ecosystems
  - Socio-economic system conditions and socio-economic impacts of climate change
  - Infrastructure conditions and impact of climate change on infrastructure and human settlements
- ✓ Current disaster risk profile (risk map) to map the most vulnerable and at-risk locations
- ✓ Impacts of climate change on different sectors
- ✓ Quantitative assessment of vulnerabilities.

3.2.1 Identifying and analysing observed climate changes

What should be described in this section?

Assessment teams should obtain information on observed changes in local climate and its variability, as well as trends in frequency and magnitude of climate extremes (if possible for the last 30 years).

Key climate change indicators and observed trends across the country are:

- Increase in mean seasonal and annual temperatures
- Increase in daily maximum temperatures and number of hot days, more frequent heat waves
- Erratic rainfall patterns - increasing rainfall intensity (especially during the wet season) and decreasing number of rainy days
- Sea level rise
- Increase in frequency and magnitude of climate hazards:
  - increasing risk of coastal hazards (flooding, storm surges, strong winds)

- increasing risk of forest fires
- increasing risk of erosion and landslides
- more frequent occurrence of drought and flood events
- increasing intensity and frequency of cyclones

Key extreme or erratic events occurrence in the district:

- There is significant evidence of extreme climate events and hazards manifestation already affecting Ghana. This includes high temperatures, heatwaves, heavy rainfall, floods (inland and coastal), dry spells/ droughts, and windstorms which impacts natural and human systems. It is imperative to take stock of such occurrences in the district assembly to outline those areas or communities currently exposed to such hazards, and to support adaptation planning.

Table 3| Example of Disaster/hazard occurrences in the Cape Coast Municipal Assembly

Year	Occurrence	Climatic/non-climatic	Description of Damage	Affected Sector(s)	No. of Affected People	Estimated Cost	Source (e.g. Literature, survey, etc.)
15-Jun-22	Flood	Climatic	Major towns in the Cape Coast Metro were flooded following a heavy downpour	Agriculture, health, education, roads, transportation and infrastructure. (school submerged under water)	N/A	N/A	Stakeholders at workshop[3].
Oct - 01 - 2021	Flood	Climatic	Many schools, including the University of Cape Coast (UCC), had to suspend activities for the day, while most shops remained closed.	Metro wide sectors			Stakeholder at workshop.[4]
30-Oct-19	Flood	Climatic	Many residents were locked in their homes after about six hours of rainfall	Metro wide sectors	N/A	N/A	Stakeholders at workshop.[5]
June, 2016	Flood	Climatic	Flooding resulting from heavy rain which were accompanied by strong winds, thunderstorms and lightning.	Infrastructure	5 people have died in Cape Coast[6].	N/A	Stakeholders at workshop[7].
8-Jul-09	Flood	Climatic	Flood of homes and destruction of properties. Schools in affected areas suspended studies.	Infrastructure	15 people in 15 houses in five communities were rendered homeless	N/A	Stakeholders at workshop[8].

[3] Myjoyonline: https://www.myjoyonline.com /cape-coast-moree-abura-flooded-after-downpour/
[4] Graphic Online (https://www.graphic.com.gh/news/general-news/ghana-news-heavy-rains-flood-cape-coast.html)
[5] Graphic Online (https://www.graphic.com.gh/news/general-news/ghana-news-heavy-rains-flood-cape-coast.html)
[6] Three people died after a house collapsed. Other victims died after being electrocuted by power cables falling into flood water. The fifth victim is thought to have drowned in flood water.
[7] https://floodlist.com/africa/ghana-floods-central-region-june-2016
[8] Ghana Web: https://www.ghanaweb.com/GhanaHomePage/NewsArchive/Floods-destroy-properties-near-Cape-Coast-Elmina-165108

1994	Drought	Climatic	Another drought break out but didn't last like the one in 1992.	Water, agriculture, human health and sanitation	N/A	N/A	Stakeholders at workshop
1992	Drought	climatic	Long duration of drought that caused water shortage in the Metro.	Water, agriculture, human health and sanitation	N/A	N/A	Stakeholders at workshop

(Source: Cape Coast Municipal Assembly Assessment Report, 2023)

What methods and tools could be used to obtain, analyse and present information?

- **Time-series hydro-meteorological data analysis** (for observed trends at the national and sub- national levels see **Annex II**). For instance, the following variables could be analysed:
    - trends in average, minimum and maximum monthly and seasonal temperatures and precipitation
    - change in frequency and severity of extreme events.

  Obtaining time-series data at the district level could be challenging. In such case, a mix of regional level data analysis, and bottom-up approaches such as interview, workshop or survey could be applied.

- **Participatory methods** such as **seasonal calendar**: this approach involves facilitating a discussion on district perceptions and direct observations of changes in local climate. Older people often could provide valuable historical information. It is recommended that facilitators of this process guide the discussion through specific questions such as:
    - What are the major seasons in a calendar year?
    - What is the length of this seasons in the past 20 -30 years ago.
    - How are seasons changing? Is the rainy season getting shorter or longer compared to 20-30 years ago?
    - Do you think that temperatures are changing? Is it now cooler or warmer than before?
    - Is it raining when it is not supposed to rain nowadays?
    - Do you think that sea level is rising? Can you recall if the coastline was wider before?
    - Can you recall some major impacts experienced in your area as a result of these changes?

  Developing a **seasonal change calendar** together with communities is a useful tool to identify how recent climate changes affect district livelihood.

Season (Length)	Key events (Annual cycle)	Typical climate	Observed changes	Observed impacts
Dry season (Jan - Mar)	• Training to farmers on fire prevention; • Bushfires and domestic fires; • Mobilise community for health education on respiratory diseases; • Prepare forestland for plantation; • Local irrigation tech thrives around that time.	• No rains • Cool during day time • hot and dry temperatures during day • Very windy	It used to occur in Oct to March	• Inadequate rains affect crop production and yield • Increase in forest fires • Property and live loss • Increase in respiratory diseases • Decrease in water availability for distilling local drinks • Affects labour (construction work, farming) • Difficulty in harvesting cassava and leads to high prices • Difficult to get water for domestic use.
Major rainy season (April – July)	• Planting by farmers, Education and awareness campaigns,	• Frequent and heavy rains (sometimes daily) • Storms		• Malaria, worm infestation prevalence and Anemia; • Farmers not having time to feed wards; • High incidence of snake bites and farm accidents; • Timber operation becomes difficult because of the roads; • Disruption of bridges, disasters in schools, roof removal by winds; • Rains induces sleep and sexual desire; • High intensity rains affects roads (washes away surface gravel of roads); • Livestock diseases increases; • Destruction of crops by rivers overflowing their banks; • Abundance of leafy vegetables in markets; • General disruption of recreational activities, affects markets,
Minor rainy season (Aug – October ending)	• Cereals and grains production • Postharvest (storage, marketing, processing) issues from major season. • Harvesting	• Less frequent, less intense rains	Changed to August - December	• Less fire, more vehicular accidents • Changes in pest behaviour, attacking new hosts (FAW). • Prevalence of chorela and vectors

Figure 5| Seasonal calendar constructed during a VA stakeholder workshop in Bekwai. (Source: Bekwai VA Report, 2023)

To learn more, see Annex I – A: Tool 1/Tool 2/Tool 3

3.2.2 Qualitative Assessment of Vulnerability and Climate Risks

This step focuses on understanding the district's present-day vulnerability to climate-related risks. It involves evaluating how exposed the population, assets, and ecosystems are to climate hazards, the degree to which these elements are sensitive to such hazards, and the district's capacity to adapt or respond effectively. Together, these components form the basis for assessing vulnerability. The analysis includes qualitative data collection methods that draw on local knowledge from communities and stakeholders, as well as statistical and geospatial data, to build a comprehensive picture of how climate change is currently affecting different sectors and social groups. Qualitative analysis complements quantitative data by capturing insights, perceptions, and experiences of community members and stakeholders that cannot be fully reflected through numbers alone. It provides a deeper understanding of local vulnerability dynamics, decision-making processes, and socio-cultural factors influencing vulnerability.

3.2.2.1 Assessment Drivers of Vulnerability

This part of the vulnerability analysis aims to explore and identify drivers of vulnerability. This should describe the underlying factors or conditions that exacerbate or lessen how much impact system experiences when it comes into contact with a hazard. These factors or conditions are grouped into 3: (i) Ecosystem and Biodiversity conditions: (ii) Socio-economic conditions (iii) Infrastructure and connectivity conditions. The analysis should be built upon in-depth understanding on those key characteristics of the district, which condition its vulnerability or resilience to climate change and hazards, as described below.

What should be described and analysed in this section?

Ecosystem and Biodiversity Systems: what should be described?

- Key ecosystem services:
    - Access to ecosystem services such as access to water for drinking and irrigation, productive land, or marine resources
    - Livelihood dependency on ecosystem services (forests, agriculture and fishing, marine ecosystems)
- Environmental issues such as erosion, deforestation, pollution of water resources (e.g. from agriculture), overfishing, unsustainable land use and agricultural practices.

Socio-economic Systems: what should be described?

- Economic profile:
    - Annual output per capita and key productive sectors (e.g. agriculture, fisheries, trade and service delivery, finance, etc.) as well as their contribution to the local economy (sectoral output and employment opportunities)

- Main agricultural output and level of economic dependency on a specific production (e.g. rice or certain type of fish); level of agricultural production diversification
- Dominant form of farming and entrepreneurship (small, medium or large farms/businesses)
- Access to resources such as land and financing

- Livelihood profile: main sources of livelihood and level of household income diversification; household food security; rural-urban differences

- Social issues:
  - Gender roles in community:
    - identification of the roles of men and women in family and community
    - analysis of gender equality: income generating opportunities for women/men, unpaid work women/men, daily wage women/men
    - access of women to resources (especially of women heads of households) such as land, assets (house), financing
  - Identification of socially and economically vulnerable groups such as minority groups and people with disabilities
- Health and sanitation issues: overall health status and key health risks in the township related to climatic conditions and hazards

Infrastructure and connectivity Systems: what should be described?

- Description of hard infrastructure such as road network, bridges, drainage system, energy and water infrastructure and facilities, water infrastructure for irrigation and livestock use
- Description of housing conditions (construction materials and techniques used) and access to basic services including:
  - Water and sanitation – main sources of and access to drinking water, household water storage and sanitation facilities
  - Energy - access to electricity and main sources of energy (e.g. hydropower energy, wood harvesting)
  - Telecommunications - access to radio, television and the Internet
- Transportation system: land and water transport systems
- Description of location, accessibility and safety of markets and public facilities:
  - Basic health and education coverage; areas/communities with low access to markets and public facilities (hospitals, schools).
  - Cyclones/emergency centres coverage
  - Disaster resilience of public buildings
  - Connectivity challenges during seasonal floods and most affected areas in the township
  - Access to early-warning systems.

What methods and tools could be used to obtain, analyse and present information?

- **Descriptive Analysis Based on Desk Review:** Descriptive analysis of drivers of vulnerability based upon desk review of literature. This approach entails a systematic review of publicly available and institutionally held data and reports to describe the current conditions that drive vulnerabilities. The analysis should be structured under the key thematic areas: ecosystems and biodiversity, socio-economic conditions, and infrastructure and connectivity.
    - Identify trends in land use, environmental degradation, and climate exposure (e.g., coastal erosion, deforestation, overfishing).
    - Understand district economic structures (e.g., reliance on rain-fed agriculture, fishing, informal trading).
    - Describe health, education, gender inequality, food security, and infrastructure conditions.
- **Participatory approaches (Stakeholder engagement workshop):** Participatory approaches are essential in complementing desk-based analyses by capturing community-level experiences and perceptions of vulnerability. These approaches enable the inclusion of local knowledge and ensure that the voices of all population segments are heard—particularly those most affected by climate hazards.

Information Presentation for the Drivers of Vulnerability Analysis

- Narrative summaries of each thematic vulnerability driver with maps or tables where applicable.

To learn more, see Annex I – A: Tool 1/Tool 2/Tool 3/Tool4/Tool5

3.2.2.2 Assessing Climate Change Impacts on Economic Sectors or Activities

This section examines how observed changes in climate — including variability and extreme events such as floods and droughts — are impacting key economic sectors, vulnerable population groups, and specific geographic areas within the district. The aim is to establish a clear linkage between climate variability, change, and hazards (as outlined in Section 2.1) and their direct and indirect effects on different sectors of the local economy. This step helps to create a chain of impact that illustrates how climatic disturbances translate into socio-economic and environmental consequences. The NAP sectors are:

- Agriculture (Crop, Fishery & Livestock)
- Forest (Biodiversity and Ecosystems)
- Water, Health, and Sanitation
- Infrastructure and Transportation
- Finance, Trade and Industry
- Gender (mostly considered crosscutting)

What should be analysed?

For each of the NAP sectors above, qualitatively analyse how they will be impacted by prevailing climate hazards.

To the extent possible, include a broad spectrum of issues such as observed or expected impacts on:

- Agriculture (Crop, Fishery & Livestock)
- Forest (Biodiversity and Ecosystems)
- Water, Health, and Sanitation
- Infrastructure and Transportation
- Finance, Trade and Industry
- Gender (mostly considered crosscutting)

- Which sectors, social groups and locations have been most impacted from recent climatic stress? Why, what makes these sectors, groups and communities vulnerable?
- What non-climatic factors have exacerbated the severity of climate change impacts? (e.g. galamsey, expansion of agricultural land)
- What coping or adapting practices/measures exist at community and household levels?

To identify gender-responsive Climate Change Adaptation actions and tailor local climate resilience action plans that addresses the needs of both men and women, the vulnerability analysis should be *gender-sensitive*.

Gender-sensitive approach to vulnerability assessment means to *understand and give consideration* of the different rights, roles and responsibilities of women and men in the community and the relationships between them in the context of vulnerability to climate change and hazards.

Gender-sensitive vulnerability analysis implies that:

- Both qualitative and quantitative data used in vulnerability assessment has been gathered and analysed disaggregated by sex (and age).
- Both men and women have been consulted, for example in focus group discussions, about their perception of climate change, hazards and livelihoods.

What makes women vulnerable to the impacts of climate change?

- Limited access to resources: in some cases, women have limited access to crucial resources such as land, livestock, tools, and credit. Even in cases where women may have access to land, they have limited control over it, as they do not own it and therefore cannot make decisions regarding its use.
- Dependence on natural resources most at risk from climate change such as water and tress.
- Higher level of poverty, especially of women heads of households, because of informal employment, lower salaries and less income-generating opportunities.
- Limited access to education, skills development and information. For example, girls often receive fewer years of education than boys. Climate change would affect the income of low-income families and this could further affect access to education. In turn, lower education level can affect girls' ability to: (i) understand and act on information concerning climate risks and adaptation measures; (ii) generate income.
- Limited participation in decision-making conditioned by traditional gender roles. As a result, women's needs and capacities are often neglected.
- Traditional women's occupations in community and family life, and responsibilities of caring for others increase the risks posed by climate change. For example, in case of a disaster women try to protect and save their relatives, which often hinder their timely escape, and access to shelter and health care. In addition, women are often socially restricted from leaving their communities (migrating) as a coping mechanism (used by men).

(UNDP, 2016; UNEP, 2016)

Example: Findings from Cape Coast Municipality

In the Central Coast Municipal Assembly (CCMA), the vulnerability assessment revealed that climate impacts disproportionately affect women due to their socioeconomic roles and livelihood dependencies. Women are predominantly engaged in fish processing, petty trading, farming, and other informal sector activities that are highly sensitive to climate hazards such as flooding, shoreline erosion, and declining fish stocks. Moreover, women often lack access to land, credit, and decision-making structures, which weakens their adaptive capacity. This gendered division of labor, coupled with existing inequalities, makes women and female-headed households particularly vulnerable to climate-induced livelihood disruptions. Tailored adaptation interventions that consider these dynamics are essential for equitable resilience-building.

- Vulnerability assessment report should clearly describes how observed/projected climate change affects/could potentially affect women and men differently.

What methods and tools could be used to obtain, analyse and present information?

- **Descriptive analysis** of impacts based upon national and regional level observations, and district level statistical data (if available). For instance, an analysis of historical climate data and agricultural output data can reveal the impact of climate variability and hazards on crops and livestock. Further, an analysis of climate data and output per capita can show if significant climate-related events have affected economic growth and poverty levels, and inform on the most vulnerable locations.

- **Participatory approaches** could complement the analysis by collecting data through:

    1. **Stakeholder consultation workshop:** Discussions should be tailored to capture:
        - Climate change impacts on economic sectors of the district (e.g. agriculture; water and
        - sanitation;);
        - Social aspects of vulnerability (e.g. ask workshop participants which social groups have been most affected from experienced hazards).
        - Gender vulnerabilities (e.g. a female facilitator could conduct a separate consultation with women and girls because some women may find it easier to express their problems, needs and views in a women-only group).

Presentation of Information on Associated Impacts of Climate Change, Variability and Hazards

- Narrative summaries of associated impacts of climate change, variability and hazards on each of the sectors, vulnerable groups and locations within the district.
- Use or construct illustrative schemas such as impact chains (Figure 7 and 8).

Impact chains provide a clear and logical way to visualize how climate hazards trigger cascading effects on exposed sectors, groups, and systems. By linking hazards to vulnerabilities and specific impacts, they help identify key drivers of risk and support prioritization of adaptation measures. Impact chains enhances understanding among both technical and non-technical stakeholders, improves cross-sectoral planning, and facilitates effective communication and decision-making. As demonstrated in Sekondi-Takoradi, impact chains also highlight where interventions are most needed, making them a valuable tool for representing MMDA-level identified pathway to climate change impacts.

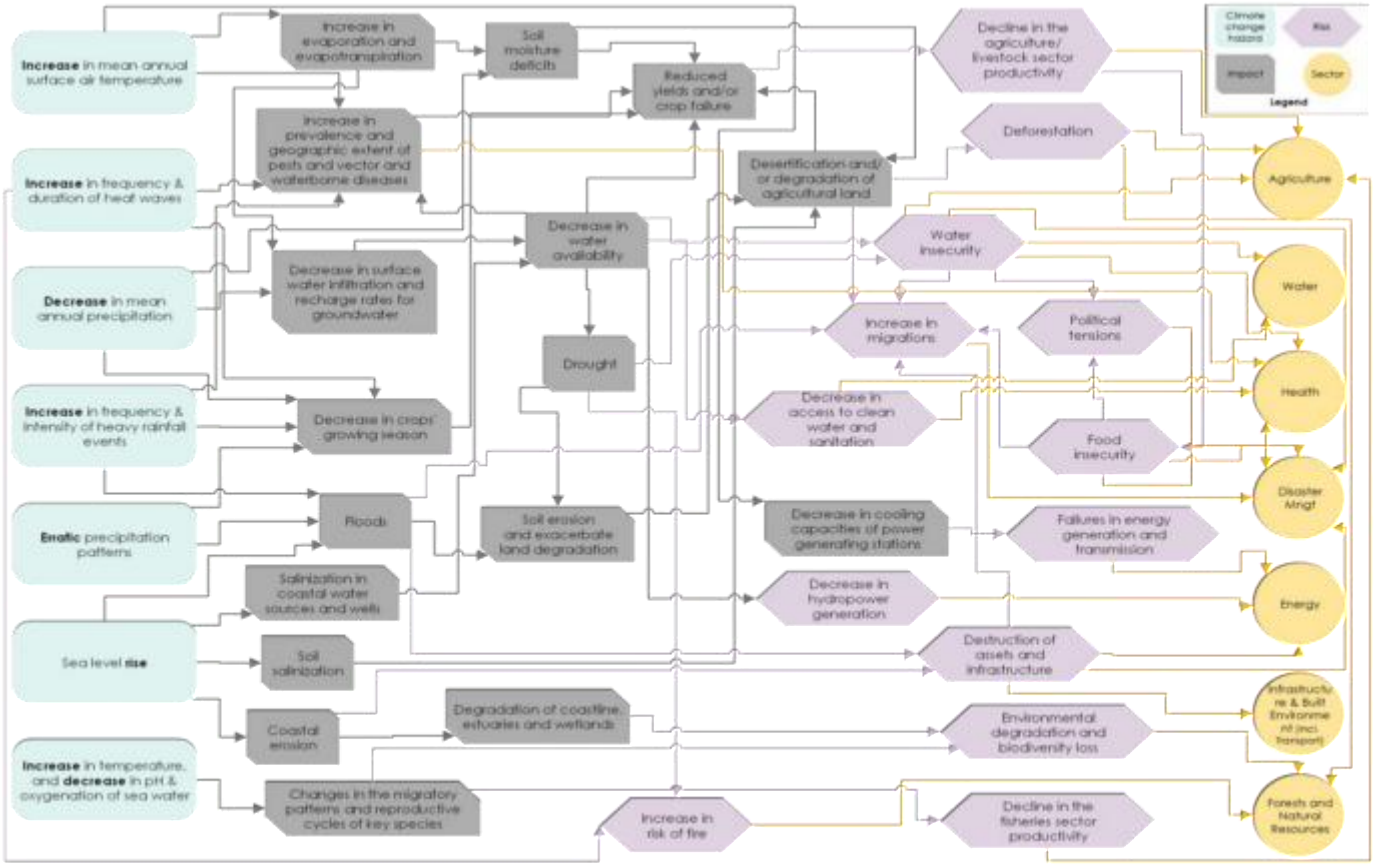


Figure 6. Generic schema of climate change hazards and their associated impacts (impact chain) on major economic activities. (Source: Climate Change Risk Assessment for Sekondi-Takoradi Metropolitan Assembly, 2023)

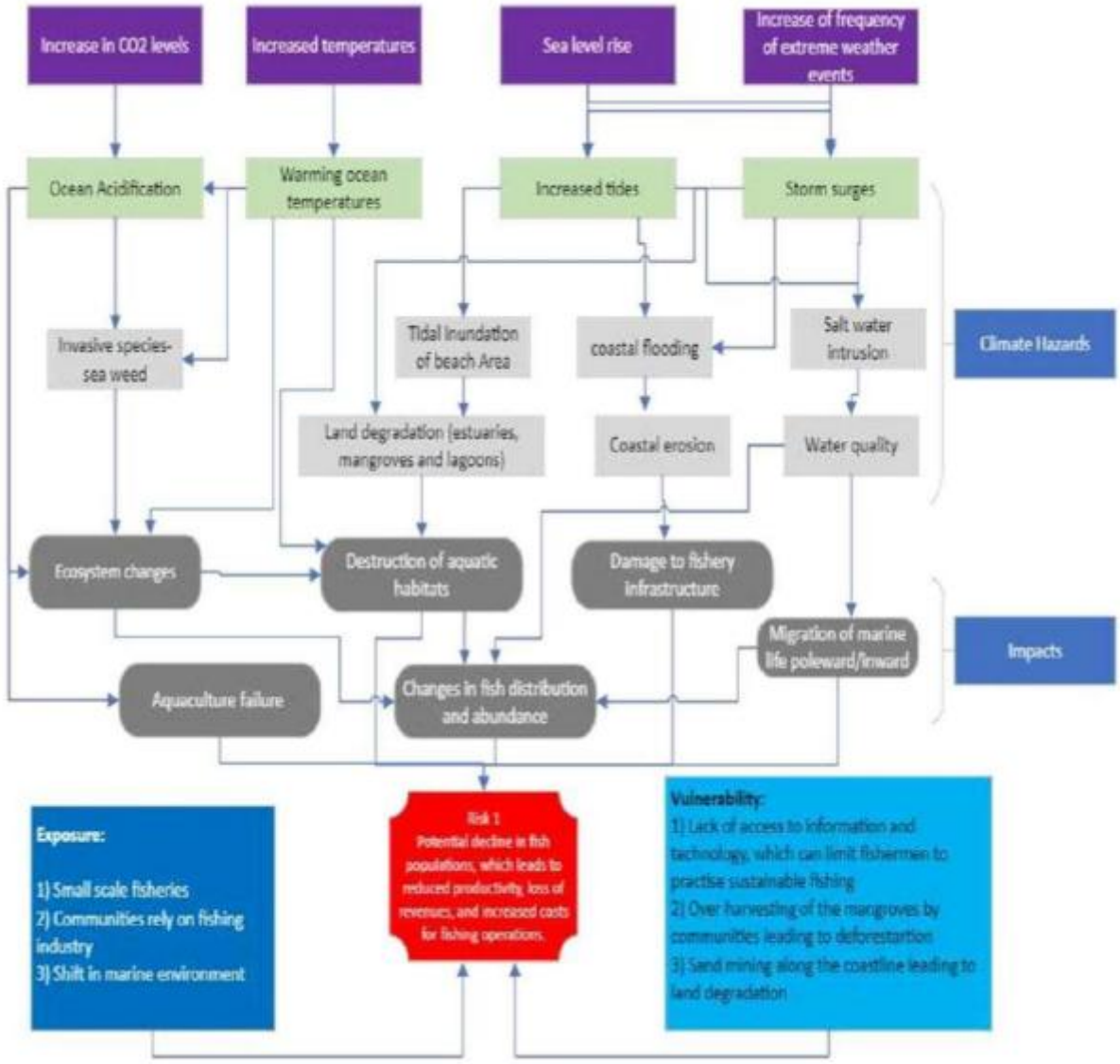


Figure 7| Fishery Impact Chain Diagram. (Source: Climate Change Risk Assessment for Sekondi-Takoradi Metropolitan Assembly, 2023)

2. **Economic Sector Ranking:** It is important to rank the vulnerability key sectors to enable prioritization both in quantitative vulnerability assessment and adaptation planning. The key NAP sectors are ranked. During the stakeholder engagement workshop, the participants ranked the sectors based on 4 criteria: certainty of impact, timing of impact, severity of impact, and importance of resource/sector. These were ranked on the scale of 1 to 5 with high = 5, medium-high = 4, medium = 3, medium - low=2 and low =1. The result is presented in Table as below.

Table 4| Template for sector ranking

Sector	Certainty of impact	Timing of impact	Severity of impact	Importance of resource	Weighted Average

Agriculture (Crop, Fishery & Livestock)	5	5	5	5	5
Forest (Biodiversity and Ecosystems)	5	4	5	5	4.75
Water, Health, and Sanitation	5	4	5	5	4.75
Infrastructure and Transportation	4	4	5	5	4.5
Finance, Trade and Industry	4	2	4	5	3.75

High = 5, medium-high = 4, medium = 3, medium-low = 2, low = 1 (Source: sector ranking for Bekwai)

- **Participatory risk mapping** through consultation with communities: involves mapping of the most exposed locations (of people, infrastructure and assets, crops and livestock) affected by hazards.

- **Spatial (GIS-based) analysis -** suggested methods/tools include:

- **Matrix of Functions** (MoF) is a useful method for conducting spatial and territorial analysis of current and future impacts of climate change, considering the linkages between urban and rural functionalities and climate hazards.

- **Infrastructure and connectivity system analysis using GIS** can provide a spatial analysis of the sensitivity of the built environment and connectivity to natural hazards and changing climatic

conditions. To conduct such spatial analysis, evaluation teams can use data obtained from local surveys, as well as census data. The analysis should provide a description of:

- the predominant construction design, techniques and materials, with the objective to understand the vulnerability of critical assets such as housing, schools, and health facilities to climate-related hazards (e.g. droughts, cyclones, and floods);
- the availability/access to basic services (water, sanitation, electricity) that could be affected by climate change and hazards such as types of sanitation facilities and water harvesting capacities of households and communities;
- the spatial distribution of district's transport network and communities' access to services and economic activities through roads and waterways with the objective of understanding how isolation and distance contribute to vulnerability, and how climate change exacerbates this.
- the distribution of, and access to key safety infrastructure: the analysis should highlight issues such as cyclone shelter availability and whether shelters are strategically located.

This analysis (Infrastructure and connectivity system analysis using GIS) has not been done in the district level CCRA so far due to unavailability of the data demands and sophisticated analysis and time required.

To learn more, see Annex I - A: Tool 1/Tool 2/Tool 3

3.2.3 Quantitative Assessment of Vulnerability and Climate Risks

This chapter presents the appropriate method (description of indicators derivation, data sources, data collection, data normalization, etc.) used to quantitatively assess vulnerability.

While not mandatory, it is advisable to complement the qualitative assessment described in Section 2.2.1 with a quantitative analysis. The purpose of this quantitative assessment is to introduce a numerical framework that allows for the pragmatic comparison of vulnerability levels across different geographic areas, population groups, or components of the human environment within and across communities.

The qualitative assessment in this manual is grounded in the IPCC framework of vulnerability, which encompasses three core concepts: **exposure**, **sensitivity**, and **adaptive capacity**.

- **Exposure** refers to the extent to which a system is subject to significant climate stressors. The first step in assessing exposure is to identify which climate-related hazards (e.g., temperature extremes or rainfall variability) may affect the geographic area, sector, or population in question. Mapping the spatial distribution of these hazards allows for a clearer understanding of which communities or assets are likely to be exposed. The approach used for climate downscaling—the indicators selected for temperature and rainfall exposure in district CRVA should be in line with the National Adaptation Plan (NAP) process.
- **Sensitivity** captures the degree to which a system or population is likely to be affected by climate stressors. A location or sector is considered highly sensitive if it has experienced past damage from such stressors, is under concurrent pressures from both climatic and non-climatic factors, or faces emerging new hazards.
- **Adaptive Capacity** reflects the ability of individuals, households, or institutions to cope with or adjust to climate risks. It is influenced by access to relevant information, availability of and access to financial and natural resources, the skills and capabilities of people and systems, and decision-making effectiveness. Assessing adaptive capacity can uncover disparities in resilience and inform targeted interventions to build long-term adaptive strength.

The indicators for each component should be informed by insights gathered during the qualitative assessment. Essentially, the qualitative assessment seeks to answer questions such as: What are the manifestations of climate change (climatic stressors)? Where do they occur? Who is vulnerable, and why? What impacts are being experienced? What coping mechanism exist? In contrast, the quantitative assessment focuses on answering the question of "how much"—providing measurable values to support comparison and prioritization. This ensures the measured risks and vulnerabilities reflects the context of the district.

Example: Inland District – *Ejura Sekyedumase*

In an inland farming district like Ejura Sekyedumase, qualitative consultations might reveal that **erratic rainfall** is leading to **declining maize yields**, particularly for smallholder farmers. Farmers may also report that **access to irrigation and credit** is limited, and **land tenure insecurity** hinders long-term investment in adaptive practices.

Based on these qualitative insights, **quantitative indicators** could be selected to reflect:

- Number of dry spells per year (Exposure)
- Proportion of households relying on rainfed agriculture (Sensitivity)
- Percentage of farmers with access to irrigation and credit (Adaptive Capacity)

These indicators, grounded in local realities, help measure and prioritize vulnerability in a way that reflects the **unique climate-agriculture-livelihood dynamics** of inland communities.

Example: Coastal District – *Keta Municipality*

In contrast, qualitative discussions in Keta may highlight **coastal erosion, tidal flooding**, and **salinization of freshwater sources** as dominant hazards. Vulnerable groups may include **fishing households, women-headed households**, and communities in low-lying areas. Informants may also reveal that **evacuation centres are inadequate**, and early warning systems do not reach all at-risk populations.

Here, the corresponding **quantitative indicators** could include:

- Rate of coastline retreat or number of flooding incidents per year (Exposure)
- Number of households relying on fisheries and salt-extractive livelihoods (Sensitivity)
- Coverage of flood warning systems and proximity to emergency shelters (Adaptive Capacity)

Such localized indicators enable planners to compare vulnerabilities across communities, **prioritize risk hotspots**, and design interventions that are **geographically and socially targeted**.

This approach ensures that the **quantitative assessment does not become a generic scoring exercise**, but rather one that is **grounded in lived experiences** and **tailored to the district's climate context and socio-economic realities**.

Example from Bekwai: Using Indicators to Understand Vulnerability to Flooding from the Odo River

In the case of Bekwai Municipality, vulnerability to flooding is significantly influenced by proximity to the Odo rivers, which overflow during intense rainfall events. To understand who most affected, qualitative assessments is first identified flood-prone communities (such as Kokotro, Dominase, and Senfi) through participatory mapping and community consultations.

From these insights, **quantitative indicators** were then derived to measure exposure and sensitivity. For example:

- **Exposure Indicator**: "Proportion of population or households located within a defined flood-risk buffer (e.g., within 500 meters) of the Oda or Odo rivers."
- **Sensitivity Indicator**: "Percentage of affected households using unreinforced housing materials" (as these homes are more likely to be damaged by floodwaters).
- **Adaptive Capacity Indicator**: "Access to early warning systems" in communities near the rivers.

What should be described and analysed in this section?

3.2.3.1 Overview of LVI and LVI–IPCC Framework

In this Manual the Sustainable Livelihood Framework (SLF) as used by Williams et al. (2019) is recommended to develop an indicator-based LVI to provide understanding of the contributions of factors such as social, demographic, and physical as a practical tool to identify areas for possible interventions. The LVI uses household-level data combined with secondary data on climate exposures to capture differences in community/district-level vulnerability. The LVI comprises eight major components, namely social networks, livelihood strategies, access to food, water, production and health, socio-demographic profile as well as climate variability and natural disaster risks. Further connected to the LVI is the LVI–IPCC method developed by (Hahn et al., 2009) which is also used for calculating climate vulnerability based on categorization of the main components of LVI framework into IPCC vulnerability framework: exposure, sensitivity, and adaptive capacity as illustrated in Figure 8.

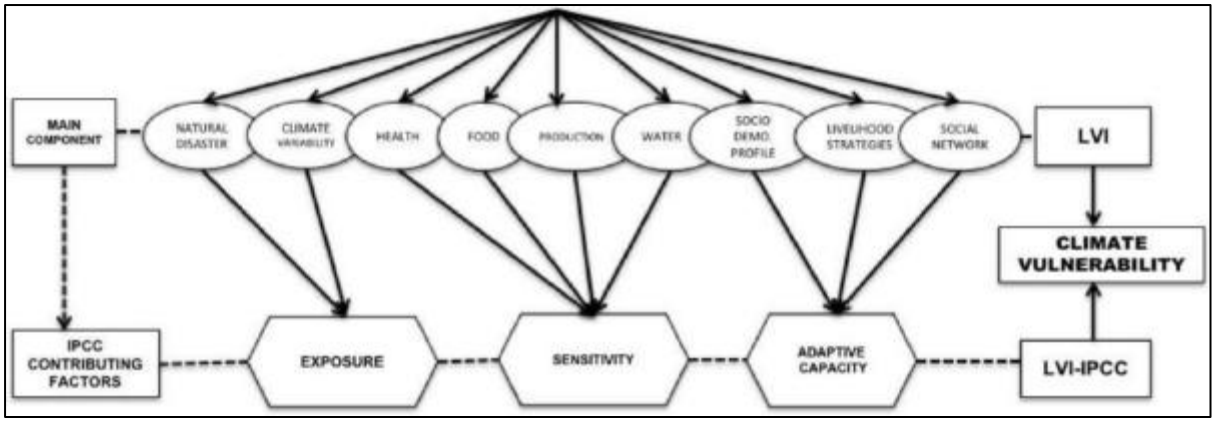


Figure 8: Grouping of major and subcomponents/indicators into LVI and LVI–IPCC

What methods and tools could be used to obtain, analyse and present information?

3.2.3.2 Field Data Collection for Quantitative Vulnerability Assessment

Purpose

Quantitative data collection provides measurable evidence to support vulnerability assessment by assigning numerical values to exposure, sensitivity, and adaptive capacity indicators. This enables comparison across locations and population groups, strengthens prioritization, and supports evidence-based planning.

Step 1. Preparing for Data Collection

a. Define Vulnerability Indicators

Indicators should be informed by the qualitative assessment (Section 2.2.1) and may include:

- **Exposure:** Distance from hazard zones (e.g., proximity to rivers or floodplains), frequency of hazard events.
- **Sensitivity:** Housing material types, income levels, livelihood dependence on climate-sensitive sectors.
- **Adaptive Capacity:** Education level, access to health services, participation in decision-making, asset ownership.

The CVRA team must reach consensus and select final set of vulnerability indicators. Based on these indicators, questionnaire is formulated and administered.

b. Translating Vulnerability Indicators into Questionnaire Questions

Purpose

Questionnaires convert the selected indicators—used to measure exposure, sensitivity, and adaptive capacity—into field-appropriate, respondent-friendly questions. This is essential for standardizing data collection and ensuring accurate responses that reflect local realities. Each indicator should be translated into **simple, clear, and culturally appropriate** questions. Below is a sample framework illustrating how to convert common indicators across the three vulnerability dimensions into questionnaire items.

Table 5| Sample Indicator-to-Question Conversion Table

Vulnerability Dimension	Indicator	Sample Questionnaire Question	Response Format
Exposure	Distance to flood-prone river	How far is your house from the nearest river or stream?	__ meters (GPS or self-estimate)
	Frequency of flooding	In the past 5 years, how many times has your home or farm been flooded?	__ number of times
Sensitivity	Housing material	What materials is your house mainly made of (walls, roof)?	Multiple choice (e.g., mud, wood, etc.)
	Dependence on climate-sensitive livelihoods	What is your primary source of income?	Multiple choice
	Income level	What is your average monthly household income?	Numeric entry / income bracket
	Crop loss due to climate events	Have you lost crops due to droughts or floods in the past 3 years?	Yes / No + follow-up (approx. % loss)
Adaptive Capacity	Education level of household head	What is the highest level of education attained by the household head?	None / Primary / JHS / SHS / Tertiary
	Access to early warning systems	How do you usually receive information about upcoming weather or disaster risks?	Radio / TV / Mobile / Community alert
	Membership in cooperative or social group	Are you a member of any community-based organization, cooperative or savings group?	Yes / No
	Access to health services	How far is the nearest health facility from your household?	__ minutes walking or driving
	Access to credit or savings	In the last 12 months, have you accessed any form of credit or had savings?	Yes / No

Tips for Writing Effective Questions

- **Use simple and local language:** Avoid technical jargon. Translate into local dialects where necessary.
- **Be specific:** Ask for exact figures (e.g., "what is your monthly income?") or clearly defined ranges.
- **Avoid leading questions:** Ensure neutrality to prevent bias.
- **Include skip logic:** If a respondent says "No" to having been affected by flood, skip further questions about flood impact.
- **Pilot the questionnaire:** Test with a small sample to ensure clarity and adjust based on feedback.

Format and Tools for Field Data Collection

Use digital platforms like:

- **KoboToolbox**, **DK Collect**, **Survey123**

These platforms allow for GPS integration, Skip logic, Multimedia (photos, audio), Offline data collection.

Geospatial Analysis

Where resource and expertise are available, integrate field data with base maps (Google Earth, OpenStreetMap, or drone imagery) to visualize spatial vulnerability. GIS software (e.g., QGIS, ArcGIS) can overlay:

- Flood zones
- Settlement patterns
- Distance to services
- Elevation and slope data

Step 2. Sampling Design

Selecting the appropriate sampling design is important for ensuring that the quantitative assessment accurately reflects the vulnerabilities across different geographic areas, social groups, and livelihood systems. Below are commonly used sampling strategies along with their advantages and disadvantages. Below is a table summarizing various **sampling designs** that can be used for quantitative vulnerability assessments, along with their **descriptions**, **advantages (pros)**, and **disadvantages (cons)**:

Table 6| Sampling Techniques

Sampling Design	Description	Pros (Advantages)	Cons (Disadvantages)

Stratified Sampling	Divides the population into distinct subgroups (strata) such as gender, income level, or location, and samples are drawn from each stratum.	- Ensures representation across key population groups- Facilitates comparison between strata- Reduces sampling error within homogenous groups	- Requires detailed knowledge of population structure- Can be complex to organize
Simple Random Sampling	Every individual or household has an equal chance of being selected.	- Easy to implement- Minimizes selection bias	- May miss smaller or vulnerable subgroups- May not reflect geographic or demographic diversity
Cluster Sampling	Divides the population into geographic clusters (e.g. communities), randomly selects some clusters, and surveys all or a sample within them.	- Cost-effective for widespread areas- Reduces logistical complexity during fieldwork	- Higher sampling error if clusters are too similar- Less precision compared to stratified sampling
Purposive Sampling	Targets specific individuals or groups known to be vulnerable or relevant to the study (e.g., flood victims, elderly, disabled).	- Focuses on key vulnerable groups- Useful when population data is limited	- Results not generalizable to whole population- High risk of selection bias
Systematic Sampling	Selects participants at regular intervals (e.g., every 5th household) from a list or route.	- Simple to execute in field- Less reliance on random number generation	- Can be biased if there is an underlying pattern in the list- Might skip certain population groups

Step 3. Recruitment and Training of Enumerators, and Data Verification

a. Enumerator Recruitment

To ensure high-quality data collection, enumerators must be carefully selected based on the following criteria:

- **Language Proficiency**: Fluency in local languages spoken in the target communities.
- **Educational Background**: At least a secondary school education, with preference for those with tertiary education in social sciences, geography, environment, or development studies.
- **Experience**: Previous field data collection experience using digital tools (e.g. KoboCollect, ODK, SurveyCTO) is preferred.
- **Familiarity with Local Context**: Enumerators who live in or are familiar with the local area have better contextual understanding and community trust.

Efforts should be made to ensure **gender balance** in recruitment, as this enables enumerators to engage more effectively across different population groups, especially in gender-sensitive interviews.

b. Enumerator Training

Before data collection begins, enumerators must undergo comprehensive training to ensure consistent, accurate, and ethical data gathering. The training should include:

- **Understanding the Assessment Objectives**: Overview of the climate vulnerability assessment and the role of field data.
- **Review of Indicators and Questionnaire**: Walkthrough of the indicators and purpose of each question to ensure clarity and avoid misinterpretation.
- **Use of Digital Tools**: Hands-on training on the digital data collection tool (e.g., KoboToolbox), including:
    - Downloading forms
    - Submitting responses
    - Troubleshooting issues in the field
- **Ethical Considerations**:
    - Informed consent
    - Data confidentiality
    - Respect for community norms
- **Mock Interviews & Roleplay**: Practical exercises with feedback to test understanding and improve communication.

c. Field Supervision

During data collection, field supervisors must:

- Conduct **daily debriefings** with enumerators to address challenges and clarify misunderstandings.
- Monitor data entries in real time using the dashboard of the data collection platform.

d. Data Quality Assurance and Verification

After data collection, a systematic verification process should be conducted:

- **Review for Completeness**: Check for skipped questions and submission errors.
- **Consistency Checks**: Use built-in logic checks and filters in the digital tool or spreadsheet analysis to detect outliers or inconsistent responses.
- **Geo-tagging and Time Stamps**: Ensure GPS coordinates and timestamps match enumerator field logs.

Step 4. Data Analysis for Quantitative Vulnerability Assessment

This section outlines a structured approach for analyzing quantitative data collected during the vulnerability assessment, with the objective of generating composite indices that can guide planning and prioritization of adaptation actions. The methodology applies the Livelihood Vulnerability Index (LVI) and the LVI–IPCC framework, allowing both internal comparison (between communities within the same district) and external comparison (with other districts across Ghana).

Objectives of the Analysis

- To quantify climate risk and vulnerability across geographic areas and population groups.
- To compare vulnerabilities among districts, communities, or socio-economic groups.
- To identify critical hotspots and priority groups needing adaptation interventions.
- To support visualization through maps and dashboards for better communication of findings.

Overview of LVI and LVI–IPCC Framework

Livelihood Vulnerability Index (LVI)

The LVI is a composite index that quantifies vulnerability through seven major components, each composed of multiple indicators:

1. **Socio-Demographic Profile (SDP)**
2. **Livelihood Strategies (LS)**
3. **Health (H)**
4. **Food (F)**
5. **Water (W)**
6. **Social Networks (SN)**
7. **Natural Disasters and Climate Variability (NDCV)**

Each indicator is standardized, averaged within its sub-component, and weighted equally to generate the LVI score ranging from 0 (least vulnerable) to 1 (most vulnerable).

LVI–IPCC Framework

This approach aligns with the IPCC's conceptual definition of vulnerability as a function of:

- **Exposure (E)**: Degree to which a system experiences hazards.
- **Sensitivity (S)**: Degree to which a system is affected.
- **Adaptive Capacity (AC)**: Ability to adjust or cope with impacts.

The major LVI components are grouped under these three IPCC contributing factors, and the LVI–IPCC value is computed as:

LVI–IPCC = (E – AC) × S ----------Equation 1

It is important to understand the structured hierarchy consisting of **Indicators, Subcomponents, and Main Components**. This structure allows for organized data collection, analysis, and interpretation. Each main component is broken down into subcomponents, and each subcomponent is measured using one or more indicators. Questionnaires are used to collect data for specific indicators, this is normalized and aggregated into sub components. The subcomponents are further aggregated into Main Components which are further aggregated into IPCC components. Table xx shows this relationship

Table 7| Relationship between indicators, subcomponents, main components and IPCC components

IPCC Component	Main Component	Subcomponent	Indicator(s)
Exposure (E)	Natural Disasters & Climate Variability	Frequency of floods, droughts	Number of flood events in the past 10 years
		Climate shocks	% of households affected by heatwaves or heavy rainfall
Sensitivity (S)	Health	Access to healthcare	% of households more than 30 minutes from a health facility
		Disease incidence	% of households with waterborne or vector-borne illnesses

	Livelihood Strategies	Dependence on agriculture	% of households whose primary income is from rainfed farming
	Food	Food insecurity	% of households reporting food shortage in the past 3 months
	Water	Water quality	% of households relying on unimproved water sources
		Water availability	% of households experiencing seasonal water shortages
Adaptive Capacity (AC)	Socio-demographic Profile	Dependency ratio	Ratio of dependent to working-age household members
		Literacy level	% of household heads with basic education
	Social Networks	External support during disaster	% of households receiving external help (e.g., remittances, NGOs)
		Community group membership	% of respondents participating in community-based organizations
	Livelihood Diversification	Alternate income sources	% of households with more than one income source
	Infrastructure & Services	Access to electricity	% of households connected to the national grid
		Road accessibility	% of communities accessible year-round by motorable road

Step 5. Data Standardization and Reversal

Step 1 - Identify Indicators for Reversal

Although Equation 1 is designed to calculate vulnerability using **Exposure (E)**, **Adaptive Capacity (AC)**, and **Sensitivity (S)**, it **assumes that all component scores move in the same direction**—meaning **higher scores indicate higher vulnerability**.

However, for some indicators (especially under Adaptive Capacity), **a higher raw value actually reflects *lower* vulnerability**. For example:

- Higher **access to clean water** or
- Higher **literacy rate** or
- Higher **ownership of radio for early warning**

… all **reduce** vulnerability. So if you don't reverse the scoring for these indicators, they will wrongly inflate the vulnerability score.

In the LVI–IPCC equation:

- **Exposure (E)** and **Sensitivity (S)** increase vulnerability → so their raw direction is fine.
- **Adaptive Capacity (AC)** *decreases* vulnerability → so it needs to be reversed *within its indicators*, such that **higher standardized values mean lower capacity**.

Create a column in your indicator list to flag reversed indicators, such as:

Table 8| Example of Indicator tagging for reverse normalisation

Indicator	Reversed Scoring?
% of households with access to piped water	No
% of households with a member in school	Yes
Number of income sources per household	Yes
Distance to nearest health facility (km)	No

Step 2 - Apply Standardization Formula

$$I_s = \frac{I_a - I_{min}}{I_{max} - I_{min}}$$ ----------Equation 2

For **reversed indicators** (where higher = more resilient):

$$I_s = \frac{I_{max} - I_a}{I_{max} - I_{min}}$$ ----------Equation 3

Where:

- I_s: Standardized value
- I_a: Actual value
- I_{min}, I_{max}: Min and max values across all communities

Step 3 - Grouping Indicators Under LVI Components

Group standardized indicators under the 7 major LVI components. For example:

- **Health**: Distance to health facility, % of ill family members, hospital availability
- **Water**: Primary water source, distance, frequency of shortages
- **Livelihood Strategies**: Income diversification, reliance on climate-sensitive jobs

Each indicator is equally weighted unless prior evidence justifies otherwise.

6.5 Calculating Major Component Scores

$$M_j = \frac{1}{n}\sum_{i=1}^{n} I_{ij}$$ ----------Equation 4

Where:

- M_j: Major component score
- I_{ij}: Standardized (and reversed if needed) value of the ith indicator in the jth component
- n: Number of indicators in component j

Step 4 - Calculating the Livelihood Vulnerability Index (LVI)

$$LVI = \frac{\sum_{j=1}^{m} W_j M_j}{\sum_{j=1}^{m} W_j}$$ ----------Equation 5

Where:

- W_j: Weight of each major component (equal unless specified)
- m: Number of major components (typically 7)

Step 5 - LVI–IPCC Analysis

Assign Components to IPCC Categories

Table 9 Categorisation of LVI components into IPCC Components

IPCC Dimension	LVI Components
Exposure (E)	Natural Disasters & Climate Variability
Sensitivity (S)	Health, Food, Water
Adaptive Capacity (AC)	Socio-Demographic Profile, Livelihood Strategies, Social Networks

Step 6 - Compute IPCC Scores

$$E, S, AC = \frac{\sum W_j M_j}{\sum W_j}$$ ----------Equation 7

Alternatively, same subcomponents used in the calculation of LVI are employed in the calculation of the LVI–IPCC with divergence in the combination of the major components. That is, rather than computing the LVI by combining the major components in the initial step, they are firstly merged according to the three main IPCC categorizations: exposure, sensitivity, and adaptive capacity. Comparison of the IPCC contributing factors and the major components of the LVI rather than the overall score is applied in this VA process.

Final Vulnerability Score

LVI–IPCC = (E − AC) × S

- Positive values = higher vulnerability
- Negative values = greater resilience

Considerations for Comparison and Mapping

- **Compare across communities** or districts using LVI or LVI–IPCC values.
- **Map spatial vulnerabilities** using GIS tools with scores as attribute data.
- **Use radar/spider charts** to show component contribution per location.
- **Bar/heatmaps** to compare specific components or indicators across areas.

Threshold Classification for Decision-Making

To support interpretation, vulnerability scores are grouped into ranges:

Table 10| Interpretation of vulnerability score

Vulnerability Score	Classification
0.00 – 0.30	Low Vulnerability
0.31 – 0.60	Medium Vulnerability
0.61 – 1.00	High Vulnerability

This categorization can guide resource allocation, project targeting, and risk communication.

Step 6. Visualization and Mapping

Use GIS software or platforms (e.g., ArcGIS, QGIS, Google Earth Engine) to generate:

- **Thematic maps** of Exposure, Sensitivity, Adaptive Capacity, and Vulnerability
- **Hotspot maps** showing high-risk communities
- **Dashboard visualizations** (e.g., bar charts, radar charts) for dissemination

Tools and Software

Recommended software/tools include:

Table 11| Software and Tools for Data Analysis

Purpose	Tools
Data Cleaning/Scoring	MS Excel, SPSS, Stata, R
Statistical Analysis	R, Python, SPSS
Mapping & Visualization	ArcGIS, QGIS, Power BI, Tableau

Dashboarding	Google Data Studio, Tableau, Excel Dashboards

Step 7. Documentation and Interpretation

- Present summary statistics (mean, median, standard deviation) for all indicators.
- Clearly describe assumptions, weighting (if any), and any deviations from standard methodology.
- Interpret findings in relation to the socio-ecological and infrastructural context of the district.

Step 8. Quality Assurance

- Ensure peer review of analysis procedures.
- Triangulate findings with qualitative insights and community feedback.
- Document limitations and uncertainties transparently.

📘 Illustrative Example: Computing LVI and LVI–IPCC with Reversed Scoring

Let's consider two fictional communities: **Riverdale** (a downstream community close to a river prone to flooding) and **Hilltop** (an upland community less exposed to flooding). We'll analyze the **"Water"** major component based on 3 indicators:

Indicator	Description	Type	Reversed Scoring?
I1	% of households with access to treated drinking water	Adaptive Capacity	✅ Yes
I2	Average time to collect water (minutes)	Sensitivity	❌ No
I3	Frequency of water shortages (days/month)	Sensitivity	❌ No

Step 1: Raw Data (Actual Values)

Community	I1 (% access)	I2 (min)	I3 (days/month)
Riverdale	30%	25	12
Hilltop	70%	10	4

Step 2: Apply Reversed and Direct Standardization

We standardize each indicator to a **0–1 scale** using min–max method. Assume:

- Min for I1 = 30%, Max = 70%
- Min for I2 = 10, Max = 25
- Min for I3 = 4, Max = 12

For Reversed Scoring (I1):

$$I1_s^{\text{Riverdale}} = \frac{70-30}{70-30} = 1.00 \quad \text{(higher = more vulnerable)}$$

$$I1_s^{\text{Hilltop}} = \frac{70-70}{70-30} = 0.00$$

For Direct Scoring (I2 and I3):

$$I2_s^{\text{Riverdale}} = \frac{25-10}{15} = 1.00, \quad I3_s = \frac{12-4}{8} = 1.00$$

$$I2_s^{\text{Hilltop}} = \frac{10-10}{15} = 0.00, \quad I3_s = \frac{4-4}{8} = 0.00$$

Step 3: Compute Major Component Score (Water)

$$M_{\text{Water}}^{\text{Riverdale}} = \frac{1.00+1.00+1.00}{3} = 1.00$$

$$M_{\text{Water}}^{\text{Hilltop}} = \frac{0.00+0.00+0.00}{3} = 0.00$$

Step 4: Assign to IPCC Dimensions

Let's say:

- I1 → Adaptive Capacity
- I2 and I3 → Sensitivity

Compute:

- **AC (Hilltop)** = 0.00
- **AC (Riverdale)** = 1.00
- **S (Hilltop)** = (0.00 + 0.00)/2 = 0.00
- **S (Riverdale)** = (1.00 + 1.00)/2 = 1.00

Assume Exposure (E) is 0.80 for Riverdale and 0.20 for Hilltop.

Step 5: Compute LVI–IPCC Score

$$\text{LVI-IPCC} = (E - AC) \times S$$

- **Riverdale** = (0.80 – 1.00) × 1.00 = –0.20 (resilient despite sensitivity due to good adaptation)
- **Hilltop** = (0.20 – 0.00) × 0.00 = 0.00 (low vulnerability)

3.3 Step 3: Assessing future climate change risk

This step corresponds to developing the third section (chapter) of the vulnerability assessment report. In this chapter, assessment teams should explain how projected changes in climate can affect the district in future under business-as-usual scenario.

- ✓ Summary of climate change projections
- ✓ Potential impacts and future climate change risk

3.3.1 Climate change projections

Understanding future climate conditions is fundamental to assessing long-term risks and vulnerabilities at the district level. Climate change projections offer insights into how key climate variables—such as temperature and precipitation—are expected to evolve under different emission scenarios. These projections enable Metropolitan, Municipal, and District Assemblies (MMDAs) to plan for both current and anticipated climate-related hazards that may impact populations, ecosystems, and infrastructure.

Purpose of Climate Projections in Vulnerability Assessment

Climate projections are used to:

- Anticipate the **magnitude and direction of change** in key climatic variables;
- Identify **geographic and sectoral exposure** to future hazards;
- Prioritize **adaptation strategies** based on the scale of expected change;
- Provide a **scientific basis** for policymaking and budget allocation.

What should be described in this section?

This sub-section should examine the future projections of temperatures, precipitation patterns, sea level rise, seasonal changes/shifts, and climate extremes (e.g. droughts, floods, cyclones).

What methods and tools could be used to obtain, analyse and present information?

MMDAs are encouraged to use **nationally endorsed climate models** and downscaled data aligned with the Ghana National Adaptation Plan (NAP) process. Key sources include:

- Ghana Meteorological Agency (GMet)
- CORDEX Africa downscaled datasets
- CSIR and University of Ghana model outputs
- IPCC's CMIP6 datasets (for context and comparative analysis)

Projections are typically made using **Representative Concentration Pathways (RCPs)** or **Shared Socioeconomic Pathways (SSPs)** such as:

- RCP4.5 (intermediate emissions scenario)
- RCP8.5 (high emissions scenario)
- SSP2-4.5 or SSP5-8.5 under CMIP6

Key Climate Variables to Assess

- **Temperature:** Mean annual temperature, frequency of heatwaves, diurnal temperature range.
- **Rainfall:** Mean annual precipitation, rainfall intensity, frequency of extreme rainfall events, number of dry days.
- **Hydroclimatic Stressors:** Changes in river flow, water table levels, flood risk, and drought duration.

Time Horizons for Projection

To ensure actionable planning, three future time horizons may be adopted:

- **Near-term (2021–2040):** Inform short-term adaptation and infrastructure development.
- **Mid-century (2041–2060):** Guide medium-term planning and investments.
- **End-century (2081–2100):** Useful for long-term strategic and spatial development decisions.

Interpreting and Using Projections

District-level users should:

- **Compare baseline climate data** (e.g. 1981–2010) with future projections to identify shifts in climatic patterns;
- Identify **trends and thresholds** that may exceed current coping capacities;
- Use visualizations (e.g. climate graphs, heat maps) to communicate findings;
- Incorporate projected changes into **exposure analysis**, feeding into the Livelihood Vulnerability Index (LVI) or LVI-IPCC framework.

> **Practical Example**
> In coastal districts like **Keta**, projections may show an increase in sea-level rise and storm surge frequency by 2050, compounding flood risk and salinization. In inland districts like **Bekwai**, projections may show an increase in rainfall variability and extreme rainfall events by 2040, which may aggravate riverine flooding and impact cocoa productivity.

Annex II contains summary of:

the latest climate change projections at the national and regional levels;

> This section of the assessment report should contain tables and figures of projected changes for key climate indicators such as temperatures, precipitations, seasonal patterns, sea level rise

3.3.2 Identifying potential impacts of climate change and assessing future risk

This section guides MMDAs in translating projected climate trends into tangible impacts on communities, sectors, and ecosystems, and in evaluating the likelihood and consequences of those

impacts. The aim is to move from *what is projected to change* (climate variables) to *what this means for people, infrastructure, and livelihoods*.

What should be described in this section?

This step of the vulnerability analysis aims to explore potential climate change impacts and develop future risk profile of the township of interest. The analysis builds upon the findings of the previous steps of the assessment, and possible future scenarios for socio-economic, environmental and infrastructure developments. The findings will show the future climate risk profile of the district under business-as-usual scenario (i.e. no adaptation action).

Difference between a scenario and forecast:

- A forecast suggests one pathway to the future (Figure 4 (a)). For example, using technology we can forecast when a storm or cyclone will reach Ghana.
- Scenario is a possible future state of climate, environment and socio-economic characteristics of township. Therefore, scenario planning involves considering how multiple variables (e.g. climate, ecosystems, infrastructure, and socio-economic variables) could change and lead to multiple futures (e.g. high climate change impacts, or medium climate change impacts) (Figure 4 (b)). Scenario planning is considered a more effective way for governments to plan so-called 'no- regret' actions.

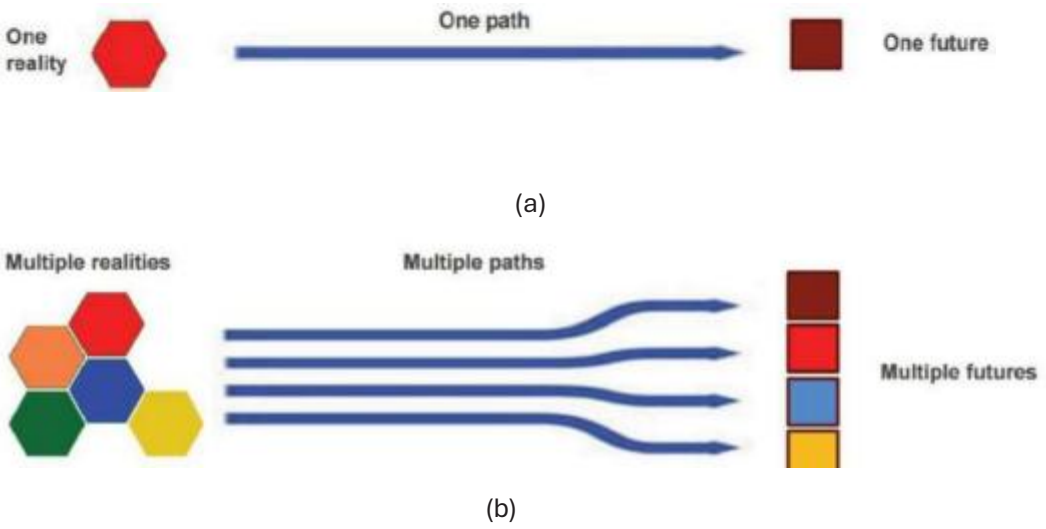


Figure 4 Graphic representation of forecast (a) and scenario (b)[9]

[9] Graphics taken from Economist Intelligence Unit (2016)

Main issues to be addressed in this sub-section:

- How would expected (projected) changes in climate (including climate variability and hazards) likely affect the district considering environmental, socio-economic and infrastructure aspects? To the extent possible, include a broad spectrum of issues such as potential impacts on:
    - Agriculture, natural resources and ecosystem services
    - Human settlements, industry and infrastructure
    - Human health, well-being and security

  Summary figure of potential impacts of climate change and hazards on sectors in Ghana in illustrated in Figure 7 and could be used to guide the analysis.

- Which sectors, social groups and locations could potentially be most impacted from expected climatic stress? Why, what makes these sectors, groups and communities vulnerable?
- What non-climatic factors could exacerbate the severity of the identified potential climate change impacts? (e.g. rapid urbanization, deforestation, expansion of agricultural land)

What methods and tools could be used to obtain, analyse and present information?

- **Literature review** on potential impacts or **working with experts to develop sectoral impact Assessment** for the district. The second option involves the use of simulation models (most often sector-specific), which requires significant data input and technical expertise.

- **Potential impact pathways graph** is a visual presentation of the complex relationship between projected climate changes, potential hazards and multiple primary and secondary impacts. The graph could be developed through a review of national and sub-national level studies on potential impacts, analysis of secondary data at the township level, and consultation with communities. The latter, which is a participatory method, allows for reflecting local (e.g. community level) vulnerabilities.

☐ **Spatial (GIS-based) analysis:**

- **Assessing potential impacts of rapid and slow onset climate hazards:** key features of the ecological, socio-economic and infrastructure systems are linked with the projected climatic changes for the district, and illustrated in a GIS environment. For instance, a coefficient for climate change for each projected change is assigned and multiplied against a given feature, such as crops.

- **Analysis of Matrix of Function for 2050** could be used to explore the impact of climate change on the socio-economic and infrastructure development across the district (if MoF is used as a tool for current vulnerability analysis).

3.4 Step 4: Summarizing findings

This step corresponds to developing the fourth section (chapter) of the vulnerability assessment report. In this chapter, assessment teams summarize the overall findings of the assessment and propose a long list of potential adaptation options.

What should be described in this section?

The vulnerability assessment findings could be summarized in a table and key messages highlighted. Emphasis should be on current vulnerabilities and potential future impacts on ecosystems, socio-economic systems and the built environment. Results should show the most vulnerable sectors, social groups and locations in the selected township to current and future climate pressures.

IV. Adaptation Recommendations

At the last stage of the vulnerability assessment process, CVRA Team could develop a long list of adaptation options through consultations with communities and relevant stakeholders. The findings could serve as a starting point for identification of adaptation priorities and specific actions.

Tool:

District assemblies are encouraged to adopt the Assessing Climate Change Adaptation Framework (ACCAF) as a practical tool for conducting adaptation assessments and guiding climate-resilient planning. Developed by the World Resources Institute (WRI) with UNCDF for the LoCAL programme, ACCAF is a step-by-step monitoring and evaluation framework that helps local governments systematically track, analyse and improve the adaptation elements of their climate initiatives. Using ACCAF will enable districts to better assess whether their planned and implemented measures are truly delivering the intended adaptation benefits and to strengthen future CCA planning and investment decisions.

Annexes

Annex I. Tools for vulnerability assessment

A. Participatory tools:

Participatory tools allow for the collection of data relevant for the vulnerability and risk assessment in open dialogue with members of the district or communities and specific sector or marginal groups.

Tool 1A: Stakeholder Identification and Mapping

We define a stakeholder as organizations or individuals and organizations who is impacted by climate change, will be actively involved in the VA, or whose interests may be positively or negatively affected because of climate change or adaptation measures implementation.

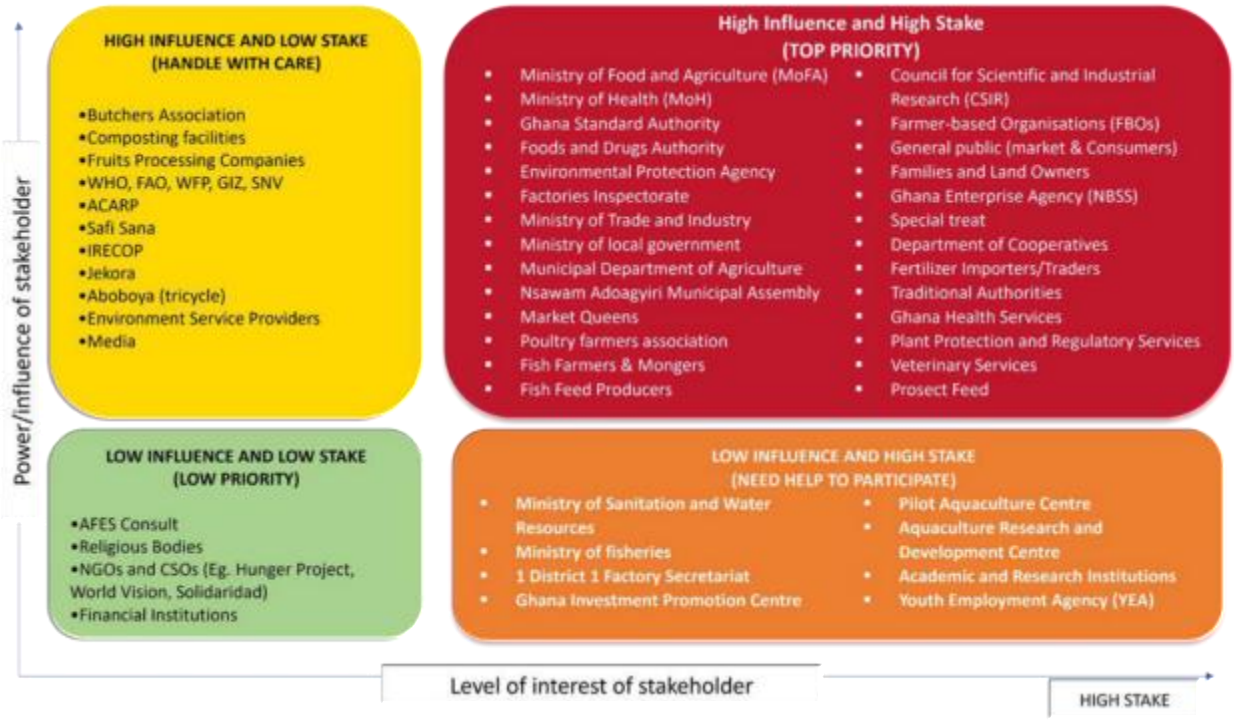
Steps to Stakeholder Identification and Mapping

1. Identify stakeholder and analyse their institutional relations with climate change (impacts and actions): - List of stakeholders and a map of their roles and institutional arrangement. See template form below:

Name of the stakeholders	Main Activity/Roles	Interest/relation with the district development and climate action	Contact details

2. Identify Stakeholders Interest/Influence: Identify each stakeholder's interest, influence, knowledge about climate change and level of support needed (awareness, capacity building, financial, collaboration, etc). **This can be achieved through a quick survey.**

3. Prioritize/Categorize the stakeholders: map out the stakeholders, and classify them according to their power over and their interest in it climate change (i.e. impacts and action), on a Power/Interest Grid. See an example of a **Stakeholder Influence-Interest Matrix**



4. Identify effective engagement strategies for each group: proposed strategies to be considered by the VA team to ensure effective communication and maximum coordination

Tool 1B: Semi-structured interview and Stakeholder Workshops with district/community members

What is a semi-structured interview?

Semi-structured interview is a discussion in an informal way using open questions. Group interviews and focus group discussions are types of semi-structured interviews.

- **Group interview** is a type of semi-structured interview, which aims at obtaining community level information.
- **Focus group discussion** is a type of semi-structured interview, which aims at discussing a specific topic in detail with a small group of persons who are well familiar with the topic of interest.

How to facilitate group interviews and focus group discussion?

- Prepare a list of key issues in advance and select one person from your group to lead the interview (nevertheless, the other group members can also ask questions)
- Use open-ended questions such as 'what', 'why', 'who', 'when' and ask for concrete examples; if you have questions arising from the given answers, ask new questions
- Try to involve everyone from the focus group to express opinion and share information
- Thoroughly record the answers
- Present results to community and facilitate discussion on the findings.

What is a stakeholder workshop?

A stakeholder workshop is a structured participatory session that brings together individuals, groups, or institutions with an interest or stake in a particular issue—in this case, climate risk and vulnerability—to collaboratively share knowledge, validate findings, identify priorities, and build consensus for action. It is a key component of inclusive climate risk assessments.

- **District-level stakeholder workshop**: A session convened at the municipal or district level involving representatives from relevant government departments, traditional authorities, community-based organizations, NGOs, women's groups, youth groups, and the private sector, community members.

How to facilitate a stakeholder workshop?

- **Identify and invite diverse stakeholders**: Ensure representation across gender, age, occupation, and community structures to capture varied perspectives.
- **Set clear objectives**: Define the goal of the workshop (e.g., Data collection, validation of climate vulnerability and risk assessment report, prioritization of vulnerable groups, co-development of adaptation actions).
- **Use participatory tools**: Apply tools such as seasonal calendars, hazard maps, and vulnerability ranking matrices to promote active involvement and local insight.
- **Encourage inclusive dialogue**: Create a safe space for all voices, especially marginalized groups, to be heard. Use local languages or translators as needed.
- **Record and validate inputs**: Document discussions systematically and validate them with

participants before concluding the session.

- **Present findings and next steps**: Summarize key outputs at the end of the workshop and outline how the inputs will influence ongoing assessments or planning.

Stakeholder workshop is recommended because it provides a cost-effective platform for collaboratively gathering diverse insights in a single setting, reducing the need for multiple field visits and interviews while ensuring efficient resource use and broad local ownership of climate vulnerability assessments.

Tool 1 (a): Stakeholder Engagement Workshop

Focus on ecosystems profile, observed climate changes and impacts on ecosystems and agriculture

What issues should be explored during the workshop?

The objective of the discussion is to obtain information for developing the ecosystems component of the vulnerability analysis including ecosystems profile and impact of observed climate changes on ecosystems. Specific questions are suggested below.

Ecosystems profile	What are the main natural assets available in your community? What is the state of these natural assets (level of environmental degradation and resource depletion)? Depending on the case study, the following natural resources should be explored: ○ marine and coastal ecosystems; coastal erosion and inundation ○ water resources and hydrology; seasonal variation in water availability (e.g. rivers, groundwater); water quality ○ forests and vegetation cover, and observed changes ○ soils and soil nutrient status ○ land use and drivers of change ○ biodiversity Additional questions could be: ○ What is the access of the community to water for drinking and irrigation, productive land (e.g. for agriculture and livestock), or marine resources? ○ To what extent the community depends on natural resources for livelihood? ○ Are there any environmental issues in this community such as erosion, deforestation, pollution of water resources (e.g. from agriculture), illegal fishing, expansion of agricultural land, 'slash-and-burn' practices?

Observed changes in local climate	Explore people's perception for changes in local climate. Some examples: ○ Do you think that temperatures are changing? Is it now cooler or warmer than before? ○ How are seasons changing? Is the rainy season getting shorter or longer compared to 20-30 years ago? Is it raining when it is not supposed to rain nowadays? ○ Do you think that sea level is rising? Can you recall if the coastline was wider before? How does this affect your livelihood? ○ Can you recall some major hazards experienced in your area (e.g. floods, droughts, cyclones, heat waves)?
Impact of observed climate change on ecosystems	For each of the observed changes/hazards, ask how this has affected the environment and ecosystems including: ○ crops production, fisheries and livestock ○ soil and land productivity (short- and long-term effects) ○ water quality and availability, overall access to water for drinking and irrigation ○ forests and biodiversity ○ marine and coastal ecosystems Afterwards, try to find out what does the community do in response to the observed changes and hazards.
Focus on socio-economic profile and impacts of observed climate changes on livelihood	
What issues should be explored during the workshop? The objective of the discussion is to obtain information for developing the socio-economic component of the vulnerability analysis including socio-economic profile and impact of observed climate changes on community livelihood.	
Socio-economic profile	Main productive sectors (agriculture, fisheries, business/industries) Level of household income diversification and overall food security of the community Agriculture sector profile information such as: ○ dominant form of farming (small, medium or large farms) ○ mainagricultural production and level of crops diversification ○ economic dependency on specific production (e.g. rice or certain type of fish) • Financial capacity such as access to credit, loans and insurance. • Social issues such as access to education and health care, migration

Impact of observed climate change on livelihood and productive sectors	For each of the observed changes/hazards, ask how this has affected the social and economic life of the community including: ○ income generation and food security, poverty levels and migration ○ the productive sectors (e.g. agricultural production loss in a short- and long-term) ○ the health of the population ○ the access to education • Afterwards, try to find out what does the community do in response to the observed changes and hazards. Finally, ask who are the most vulnerable people in the community such as minority groups and people with disabilities, or those living in a flood-prone area.
Focus on infrastructure profile and impacts of observed climate changes on infrastructure	
What issues should be explored during the workshop? The objective of the discussion is to obtain information for developing the infrastructure component of the vulnerability analysis including infrastructure profile and impact of observed climate changes on community infrastructure and connectivity.	
Infrastructure profile	Explore the community infrastructure, including what infrastructure, housing and public facilities are available, how they are maintained and are they resilient to climate hazards such as floods and droughts. Consider the following categories: ○ Housing including building materials, design and retrofitting status ○ Households access to water, sanitation and electricity, e.g. availability of drinking water infiltration wells, hand/motor pumps, tap water, roof-top harvesting systems, sanitation facilities ○ Main sources of energy and electrification status ○ Water infrastructure and facilities such as dams, canals, farm ponds, irrigation and drainage systems of agricultural fields ○ Road infrastructure and accessibility ○ Flood control/protection infrastructure such as drainage systems, sea defense walls, dykes, elevated evacuation routes ○ Disaster-resilient infrastructure for storage of food and seeds/grains, and shelters for livestock ○ Access to, and availability and condition of hospitals and public health centres ○ Schools and other community buildings and multipurpose shelters (e.g. cyclone shelters). Explore whether these facilities are available particularly for vulnerable

	group like children, women, disabled and elderly persons.
Impact of observed climate change on infrastructure	For each of the observed changes/hazards, ask how this has affected the housing, infrastructure, public facilities and connectivity of the community. For example: were there many destroyed houses and roads? was the access to hospitals and schools affected? did you have access to water and electricity? Afterwards, try to find out what does the community do in response to the observed changes and hazards. Finally, ask who are the most vulnerable people in the community such as minority groups and people with disabilities, or those living in a flood-prone area.
Focus on women and girls to explore gender roles and vulnerabilities	
What issues should be explored during the workshop? The objective of the discussion is to understand gender roles in the community and identify vulnerabilities and needs of both men and women.	
Understanding livelihood to create community profile	• What are the main labour-related activities in your community? What kind of work men do? Is it paid? How much? • What do women do, and are they paid? How much? The following aspects could be considered: o Productive roles: paid work (e.g. agriculture, employment and other income-generating activities), subsistence production o Reproductive roles: domestic work (water, fuel, cooking, market), childcare and care of the sick and elderly o Community-related activities/duties • What are the main livelihood assets available in your community? • Who has access to these resources – both men and women? How and why? The following aspects could be considered: o Human assets: such as health services, education, skills/training o Natural assets: land, water, forest, fish, ecosystem service o Social assets: e.g. social networks, voluntary groups o Physical assets: housing and basic infrastructure (e.g. water, energy), transportation, communications o Financial assets: e.g. credit, loans, insurance Who takes important decisions in your community? Are women involved in community decision-making? If 'no', why? If 'yes' in what way? (e.g. decision on the management of resources

	and community planning process)
Assessing current vulnerability	• What happens when there is flood/drought? How is the community affected? • How are men affected? How are women, elderly and children affected? • What men usually do in such case? What about women? What are • their roles?
Assessing future vulnerability	• What would happen in future when the local climate is getting warmer, and rainfall is changing (and sea level is rising)? • How would this affect men? What about women? Why?
Identifying needs	• Given the expected climate change, what are the needs of your community? What would help you to reduce the impact of climate change? • What do women need? What do men need? The following aspects could be considered: • Women's and men's needs to perform their productive (labour and income-related) and reproductive (family care) roles under the challenges of climate change • Long-term strategic perspective related to transformation of gender roles in family and community such as increased access to decision-making and resources

Tool 2: Participatory community and risk mapping

What is participatory mapping?

Participatory mapping is a process of drawing a village/community map based upon information and knowledge shared by local people. It is recommended that women, men, and children from different social groups participate in this process.

- Participatory mapping could be used to develop community and hazard/risk maps: Community mapping is used to indicate the spatial location of natural resources (main ecosystem services), land-use types (e.g. forest area, agricultural fields and residential areas), important community assets and infrastructure (e.g. roads, bridges, energy grid, water infrastructure and utilities), and other features.
- Hazard/risk mapping illustrates the hazard-prone locations, as well as people, ecosystems and assets most at risk of hazards such as floods. Other information that could be mapped include: safe areas/route to safe areas, and local capacities such as rescue posts.

Steps in participatory risk mapping:

- Decide what kind of information is needed and prepare a list of questions. Bring necessary materials for the mapping (e.g. printed map of the area, flip chart, markers and

pencils, paper/transparent paper, colour paper/sticky notes, etc.).

- Find and gather community members who know the area and are willing to share their knowledge.
- Put the community members or stakeholders into groups around each map and provide them with what information to map.

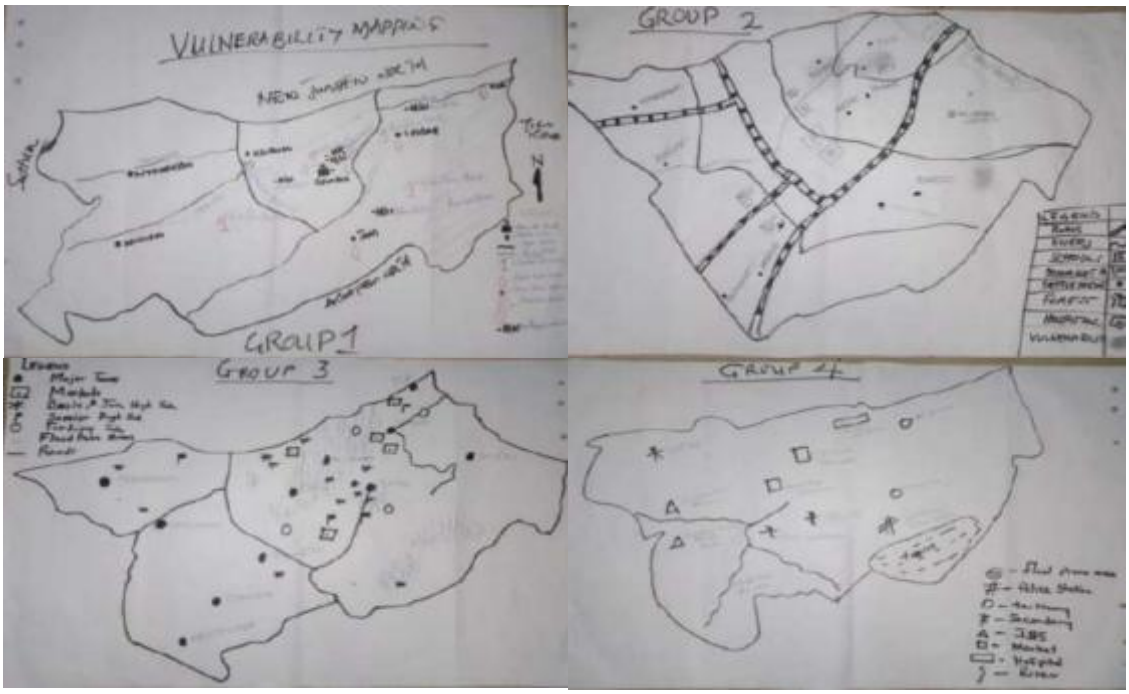
What issues should be explored through the mapping exercise?

The objective of this exercise is to create a spatial profile of the community, including to illustrate the exposure of people, ecosystems, assets, and infrastructure to hazards and climate change impacts (e.g. flood, sea level rise, etc.). The following specific issues could be drawn on the map. If they are provided on printed base map, they will need to locate or indicate them on the map. In some instances, both will apply:

- spatial location of natural resources and main ecosystem services
- land-use types (e.g. forest area, agricultural fields and residential areas)
- important community assets and infrastructure (e.g. roads, bridges, energy grid, water infrastructure and utilities)
- location of/access to cyclones/emergency centres
- other features: location of/access to markets, schools, health facilities
- most at risk locations, assets and people, based upon community's experience from past disasters.

How to present the key findings to community?

Map by four groups showing vulnerable Locations in New Juaben South Municipal Assembly



(Source: New Juaben South Municipal Assembly VA Report, 2023)

Tool 3: Developing community seasonal change calendar to identify observed climate changes and impacts on livelihood

What is a community seasonal change calendar?

Developing a seasonal calendar together with district stakeholders is a useful tool to identify how recent climate changes affect district livelihood. The calendar could be developed by drawing a simple table on a large piece of paper/flip chart or projecting on a screen during the workshop and completing together.

Season and Length	Key Events	Typical Climate	Observed Change in the Local Climate	Observed Impacts
Dry Season				
Major Rainy Season				
Minor Rainy Season				

How to facilitate the process of developing community seasonal calendar and what issues should be explored?

Draw or project from a digital projector, the above table and ask workshop participants to list:

- Typical Seasons and length (column one) in the annual cycle of the district. While districts in southern Ghana have 3 seasons, districts in the north may experience only 2 seasons. Ask the participants to list the seasons in the annual calendar and when they used to occur.

- Key events (column two), which relate to any significant for the life of a community event during a year such as planting and harvesting, start of school year or seasonal income generating opportunities. Ask what do men and women do, as well as children and elderly, throughout community's annual cycle.

- Climate indicators (columns three and four) could be temperatures, timing and intensity of rainfall, wind patterns, and types and occurrence of hazards. For example, to explore this you can ask the following questions:
  - Typical Climate (column three: What are the main climatic condition during this season in the past 20 -30 years? This refers to temperature (cool or warm), rainfall (rain or no rains), windy conditions (very windy, storms, etc.)

  - Observed Changes: Ask participants
    - Do you think that temperatures are changing? Is it now cooler or warmer compared to 20-30 years ago?
    - How are seasons changing? Is the rainy season getting shorter or longer compared to 20-30 years ago? Is it raining when it is not supposed to rain nowadays?
    - Do you think that sea level is rising? Can you recall if the coastline was wider before?
    - Can you recall some major hazards experienced in your area (e.g. floods, droughts, cyclones, heat waves)?

- Observed impacts (column five) relate to any hardship or loss experienced by communities due to observed changes such as disruption of the annual events cycle. For example, a shift/change in seasonal patterns could affect the growing period, while annual floods may disrupt access to school and affect small-scale producers. Ask about impacts on:
  - Impact on ecosystems (e.g. forest, soil, water resources)
  - Productive sectors (e.g. agriculture, fisheries, livestock, local production)
  - Transportation and connectivity (e.g. access to markets, schools, health services)
  - Access to water and energy
  - Health and social impacts (e.g. impacts on the poorest households, on women and children)

Remember:

The objective is to identify how recent climate changes affect community livelihood

Ask people to provide examples as much as possible

While filling the calendar during the workshop, write down in detail what people say

because this information will be used in the vulnerability assessment.

How to present the key findings to community?

Season (Length)	Key events (Annual cycle)	Typical climate	Observed changes	Observed impacts
Dry season (Jan - Mar)	• Training to farmers on fire prevention; • Bushfires and domestic fires; • Mobilise community for health education on respiratory diseases; • Prepare forestland for plantation; • Local irrigation tech thrives around that time.	• No rains • Cool during day time • hot and dry temperatures during day • Very windy	It used to occur in Oct to March	• Inadequate rains affect crop production and yield • Increase in forest fires • Property and live loss • Increase in respiratory diseases • Decrease in water availability for distilling local drinks • Affects labour (construction work, farming) • Difficulty in harvesting cassava and leads to high prices • Difficult to get water for domestic use.
Major rainy season (April – July)	• Planting by farmers, Education and awareness campaigns,	• Frequent and heavy rains (sometimes daily) • Storms		• Malaria, worm infestation prevalence and Anemia; • Farmers not having time to feed wards; • High incidence of snake bites and farm accidents; • Timber operation becomes difficult because of the roads; • Disruption of bridges, disasters in schools, roof removal by winds; • Rains induces sleep and sexual desire; • High intensity rains affects roads (washes away surface gravel of roads); • Livestock diseases increases; • Destruction of crops by rivers overflowing their banks; • Abundance of leafy vegetables in markets; • General disruption of recreational activities, affects markets,
Minor rainy season (Aug – October ending)	• Cereals and grains production • Postharvest (storage, marketing, processing) issues from major season. • Harvesting	• Less frequent, less intense rains	Changed to August - December	• Less fire, more vehicular accidents • Changes in pest behaviour, attacking new hosts (FAW). • Prevalence of chorela and vectors

Tool 4: Developing a Potential Impact Pathways graph

What is a Potential Impact Pathways graph?

Potential Impact Pathways graph is a visual presentation of the complex relationship between projected climate changes, potential hazards and multiple primary and secondary impacts (see the example provided below).

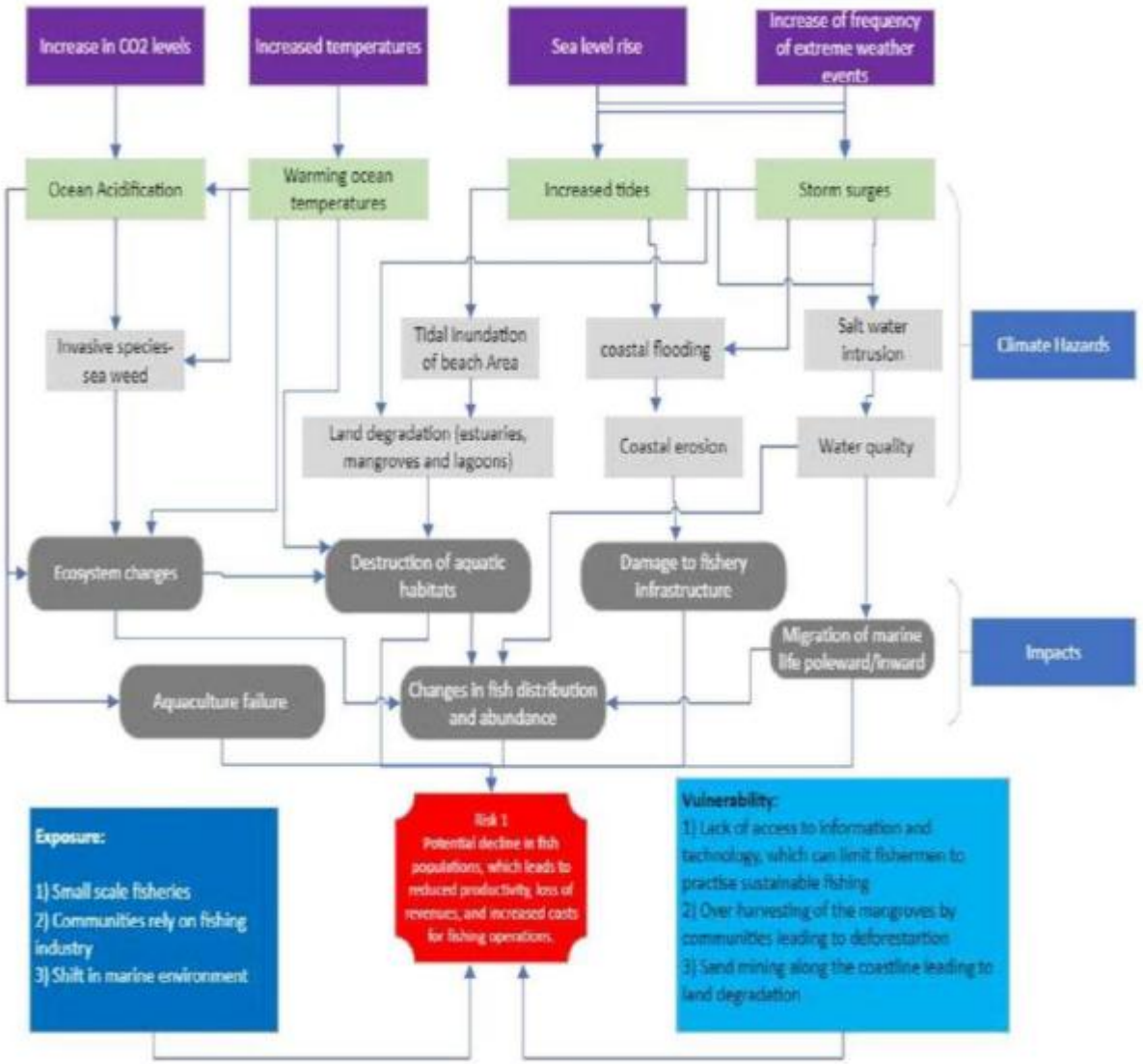
How to facilitate the process?

Working in small groups, stimulate discussion using open-ended questions such as these suggested below.

- What would happen in future when the local climate is getting warmer, and rainfall is changing (and sea level is rising)?
- How would this affect:
  - environment and natural resources such as land/soil, water, forests, fish, etc.
  - agriculture and food security
  - local production, income and migration
  - access to water and energy, and other services such as transportation and education
  - health of people
- How would this affect men? How would this affect women? How would this affect elderly and children?

Example: *Fishery Impact Chain Diagram. (Source: Climate Change Risk Assessment for*

Sekondi-Takoradi Metropolitan Assembly, 2023)



Tool 5: Matrix of Functions

What is a Matrix of Functions?

MoF is a spatial planning tool which describes (i) which services and functions are available in each village/town of the district; (ii) what is the hierarchy and importance of these settlements one to another; (iii) where functions are missing; and (iv) how balanced the spatial development of the district is. Applied to climate change, it increases the understanding of how the current spatial structure of the district enables or inhibits the resilience of the area to the changes in climate. MoF is developed by collecting data with a simple questionnaire to determine where services are available. The information collected through the survey enables planners and policymakers to analyse the district's level of physical and socio–economic development which characterizes it vulnerability to climate change.

The assumption in this assessment method, is that those communities where fewer functions are present are more vulnerable, and their vulnerability would be reduced by providing the services that are largely missing. At the district level, the method allows for visualising the linkages between villages such as the degree of dependency in terms of health or education services.

How to develop MoF?

Step1: Filling the questionnaire

The analysis is based on the data collected at community level through the distribution of a questionnaire filled by community representatives for inventorying the presence or absence of functions- as exhaustively as possible - existing services, activities, equipment and infrastructure - with an economic, administrative, social or cultural function - for each Village Tract and Ward (see the sample below).

Sample: Questionnaire for inventorying the functions in each community

Name: Towns/Village/City -
Is this a Towns/Village/City -
Total population of village/town?city /

Category	Name of function	Presence (Yes/No)
1. Public utilities and facilities.	1.1. Access or connectivity (cellular network and internet	
	1.2. Access to radio/TV connectivity	
	1.4. Rainwater harvest.	
	1.5. Usable wells	
	1.6. Pipe borne water).	
	1.7. Irrigation system for farming.	
	1.8. Private solar panel electricity supply.	
	1.9. Public Electricity Network On Grid .	
	1.10. Sewerage drainage system/gutters.	
	1.11. Storm water drainage system/big gutters.	
	2.1. Paved/tarred roads.	

2. Road Connection and Transportation Infrastructure	2.2. Unpaved/untarred roads.	
	2.3. public transportation daily basis.	
3. Markets	3.1. Local Market	

Category	Name of function	Presence
4. Industries and Commercial Establishments	4.1. Small basic needs stall	
	4.3. Big retail shop	
	4.4. Restaurant/chopbar	
	4.8. Factory	
	4.10. Aquaculture	
	4.11. Banks, western union, Momo access	
5. Provisioning eco-systems services	5.1. Rice farms.	
	5.3. Groundnuts.	
	5.4. Maize.	
	5.5. Beans.	
	5.6. Flowers.	
	5.7. Tobacco.	
	5.8. Vegetables.	
	5.9. Livestock.	
	5.10. Wood for charcoal.	
	5.11. Oil extraction.	
	5.12. Herbal/Natural medicines.	
6. Health Facilities	6.1. CHIP Compound.	
	6.2. Public Hospital.	
	6.3. Clinic.	
7. Specialized	7.1 Midwife (government/traditional).	

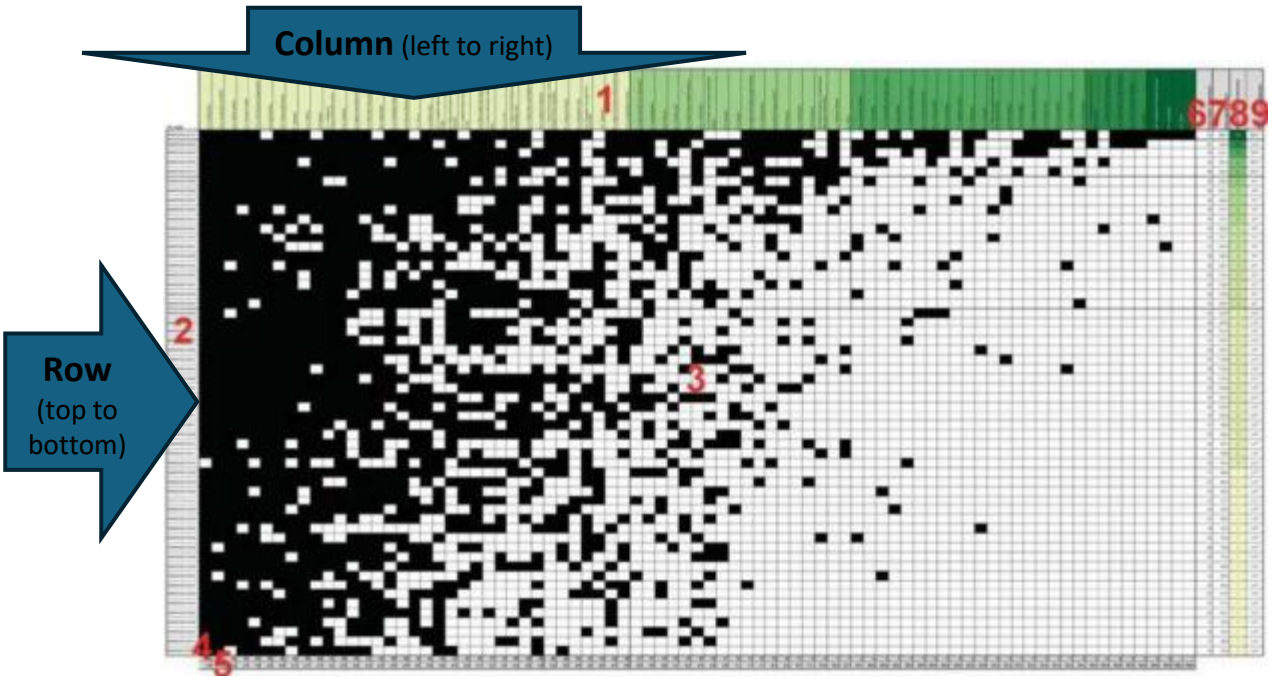
Health Staff and Services	7.2 Dentist	
	7.3 Eye specialist.	
	7.4. Pharmacy.	

Category	**Name of function**	**Presence**
8. **Educational Institutions**	8.1. Kindergarten.	
	8.2. Basic Education Primary Schools.	
	8.3. Basic Junior High Schools.	
	8.4. Senior High Schools.	
	8.6. Vocational/Technical Training Schools.	
	8.7. University/Colleges of Education.	
9. Public recreational and Cultural Facilities	91. Cultural Centre.	
	9.2. Museum.	
	9.3. Library.	
10. Security Services	10.1. Disaster management organisation .	
	10.4. Fire Station .	
	10.5 Disaster evacuation point	
11. Community Organizations and NGOs	11.1. Churches/Mosques	
	11.2. Civil Society Organisation	
	11.3. Cooperative Union	
	11.4. NGOs	
12. Own account worker	12.1. Fishermen	
	12.2. Street sellers	
	12.3. Carpenters	
	12.4. Weaving sewing	
	12.5. Lawyers	
	12.6. Accountants	
	12.7. Licensed Electricians	

	12.8. Plumbers .	

Step 2: Matrix of functions production

The information collected through the survey enables planners and policy-makers to analyse the district's level of physical and socio-economic development.



Organization of the Matrix of Functions

The data collected should be fed into an ordered matrix (e.g. Excel table) (Figure C1), where:

- The first column shows the "functions", ordered from left to right according to its frequency of presence;
- The first row shows the name of community (Human Settlements), ordered from top to bottom as per the highest presence of functions in it;
- In the table (or matrix) itself, a black cell indicates the presence of the function (NB: not how many times the function is present, just if it is present or not), while a white cell indicates its absence in the community concerned;
- The second-to-last row (**4**) shows the "functions' frequency", i.e. the number of times that a given function is present in all the community;
- The last row (**5**) shows the "functions' weighted value", calculated by dividing 100 (the conventional total value of each function) with the frequency: thus, functions are assigned a weight in inverse proportion to the frequency with which they occur.
- The first column following the matrix (**6**) itself (i.e. the black and white cells) shows the total number of existing functions for each community;

- The third-to-last column (**7**) shows the "total centrality score" calculated by adding the "weighted values" of the functions in as far as present in the row of the given Community;

- The second-to-last column (**8**) shows the "condensed level of hierarchy" obtained by fixing a level whenever a big gap appears between one value of the centrality score and the next value;
- The last column shows the grouping and classification of the Village Tracts according to the following 6 typologies: Main Rural Settlements (MRS), Intermediate Rural Settlements (IRS), Local Rural Settlements (LRS), Metropolitan and Municipal Capitals (MMC), District Capitals or Secondary Towns (DC), Small Urban Settlements or Peri-Urban Areas (PUA)

Settlement hierarchy and administrative planning units	**Description**
Main Rural Settlements (MRS)	Larger rural communities with significant population density and public services (e.g., CHPS compounds, basic schools, markets). Often serve as sub-district or electoral area hubs.
Intermediate Rural Settlements (IRS)	Mid-sized rural communities with moderate population and services. May be accessible but with fewer facilities than MRS.
Local Rural Settlements (LRS)	Smaller rural communities or hamlets with limited access to services and infrastructure. Often remote and more vulnerable.
Metropolitan and Municipal Capitals	Large urban centres like Accra, Kumasi, or Cape Coast, which are regional or district capitals with advanced services and infrastructure.
District Capitals or Secondary Towns	Urban towns with growing populations and services that act as economic or administrative nodes within districts.
Small Urban Settlements or Peri-Urban Areas	Minor towns or peri-urban communities, often on the edge of larger towns, showing early signs of urbanization.

How to develop an ordered matrix?

Sum the number of times a function occurs, which is the **function frequency**, and by convention divides by 100 to obtain the **function weight**. Hence, basic functions which occur often, obtain a low weight and rare central functions obtain a high weight. Therefore, each black square in the matrix (Figure C1) represents a present function and has an associated weight. When the weights of all functions present in each

administrative unit are summed, the **"centrality score"** emerges for each settlement. Then, after sorting by function weight and centrality score the **"ordered matrix"** is established. This ordered matrix is then interpreted to group basic, intermediate, and central settlements and determine a "set of functions" that should be covered considering the highest presence of a function for each category in the context of the region.

Considering *basic settlements* as the lowest level, an implicit assumption is that in a "*regular/standard distribution*" any higher hierarchical level should contain the number of functions of the precedent level(s) plus their own specific functions, hence the matrix allows to identifying settlements where functions are "missing" and whether functions of higher levels are present.

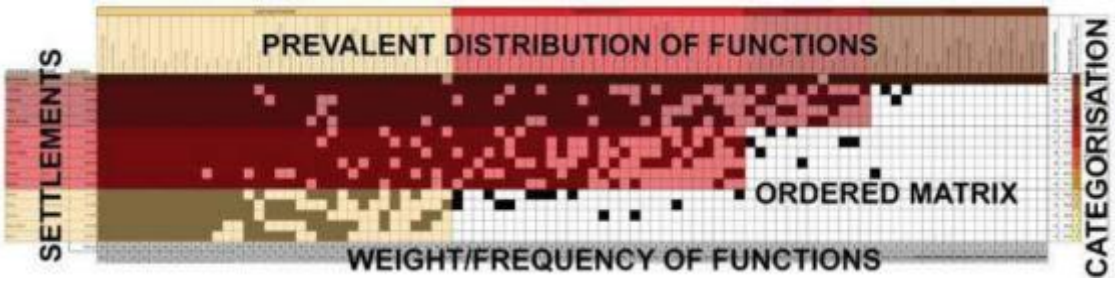


Figure C2 Example of a fictional ordered Matrix of Functions with four levels (colors) of centrality

In addition, a GIS mapping of the different typologies of settlements helps visualizing how balanced the spatial development of the region is, which, from the perspective of improving the urban settlements gives already some clear indications in terms of prioritization for preliminary needed investments in each community.

See the Matric of function for Cape Coast Metropolitan Assembly: CLICK HERE

Annex II. Current Climate Analysis and Future Projections

:This annex provides guidance to the Climate Change Risk and Vulnerability Assessment (CCRVA) Team on how to obtain and utilize relevant climate data—both historical and projected—to support informed, evidence-based assessments of exposure and risk across Ghana's Metropolitan, Municipal, and District Assemblies (MMDAs).

Tool / Source	Type	Data Provided	Strengths	Limitations	Access
Ghana Meteorological Agency (GMet)	National (Official)	Long-term observed weather data (rainfall, temperature, humidity, etc.)	High accuracy; local station-based data	May involve bureaucratic request process	Formal letter request (see Annex IV)
Meteoblue	Global/Simulated Historical	Simulated historical weather data; weather maps; trends	Easy access; user-friendly visualizations	Modelled data—not always validated by local stations	meteoblue.com
Global SPEI Database	Global	Drought index (Standardized Precipitation-Evapotranspiration Index)	Useful for analyzing drought risks over time	Does not provide full climatic variables like temperature	spei.csic.es
World Bank Climate Knowledge Portal	Global/Regional	Historic climate trends; sector impact profiles; projections under RCP scenarios	Sector-specific risks; interactive and easy to interpret	Generalized data; lower spatial resolution	climateknowledgeportal.worldbank.org
ThinkHazard! (GFDRR)	Global	Hazard exposure levels (flood, drought, cyclone, etc.)	District-level risk summary; hazard prioritization	Does not provide time-series data; qualitative only	thinkhazard.org

CORDEX-Africa (via WCRP)	Regional Downscaled	Climate projections (temperature and rainfall) under multiple emission scenarios (RCPs)	High-resolution data for Africa; supports district-level projections	Technical data format (requires GIS or model tools to use)	cordex.org
Climate Change Knowledge Portal – Ghana	Global/Regional	Projected changes in climate variables under RCPs (temperature, rainfall)	Provides downloadable datasets; scenario comparison available	Does not allow for local calibration	climateknowledgeportal.worldbank.org
IPCC Data Distribution Centre (DDC)	Global	GCM outputs and scenario datasets used in IPCC reports	Authoritative source; useful for referencing IPCC-based scenarios	Requires technical understanding to use	ipcc-data.org

Note on Limited Resources for District-Level Climate Analysis

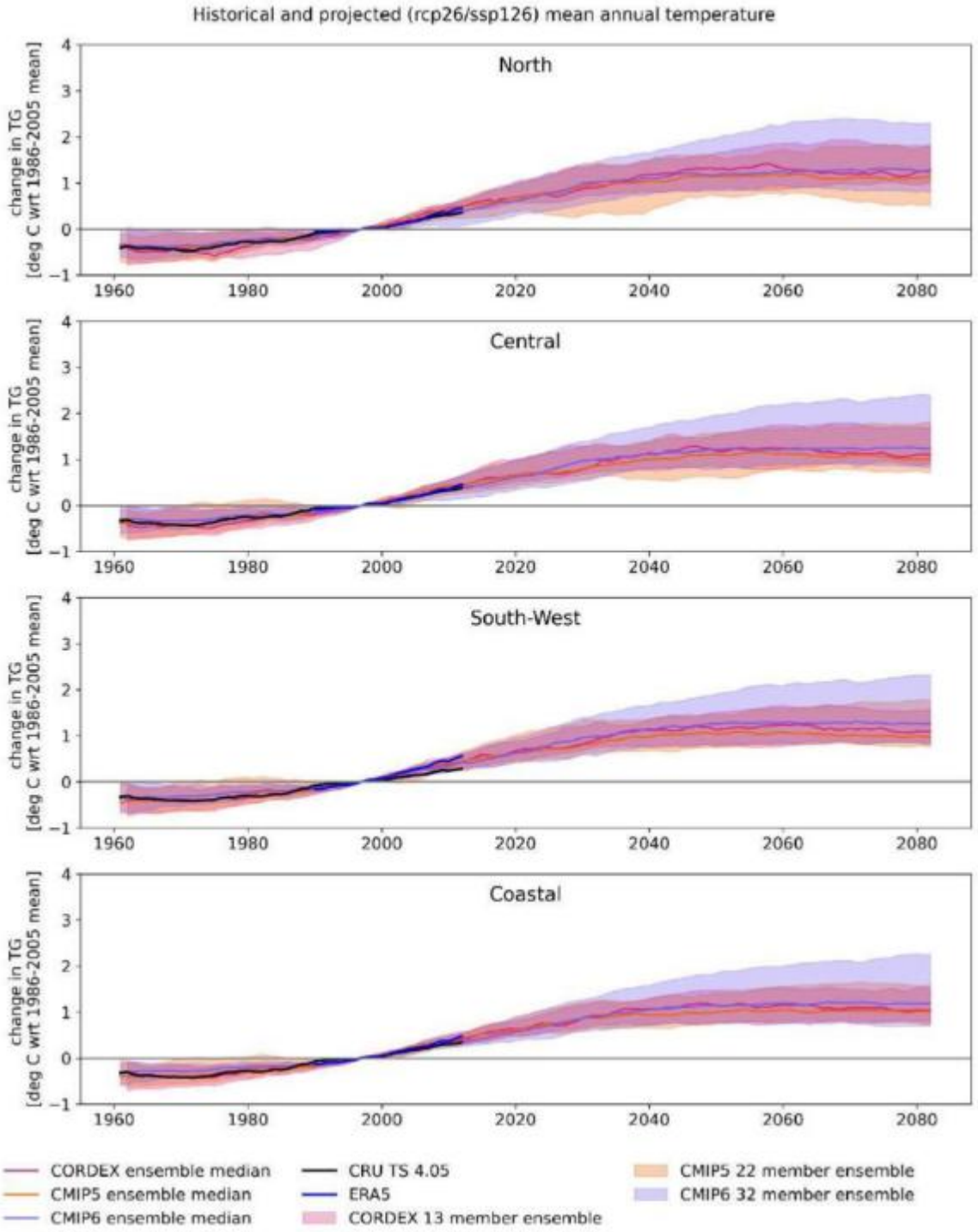
In cases where the MMDAs are unable to engage external technical experts due to resource constraints, national and regional climate assessments can serve as a reliable alternative. These assessments—such as those conducted under Ghana's National Adaptation Plan (NAP)—provide downscaled projections and risk profiles that can be referenced to support district-level planning.

While local data remains ideal for precision, these national analyses offer credible, validated climate information that reflects general trends in temperature, rainfall, and extreme event probabilities. Districts may adapt these insights to suit their context using participatory methods and locally available evidence.

a. key indicators/parameter options for downscaling

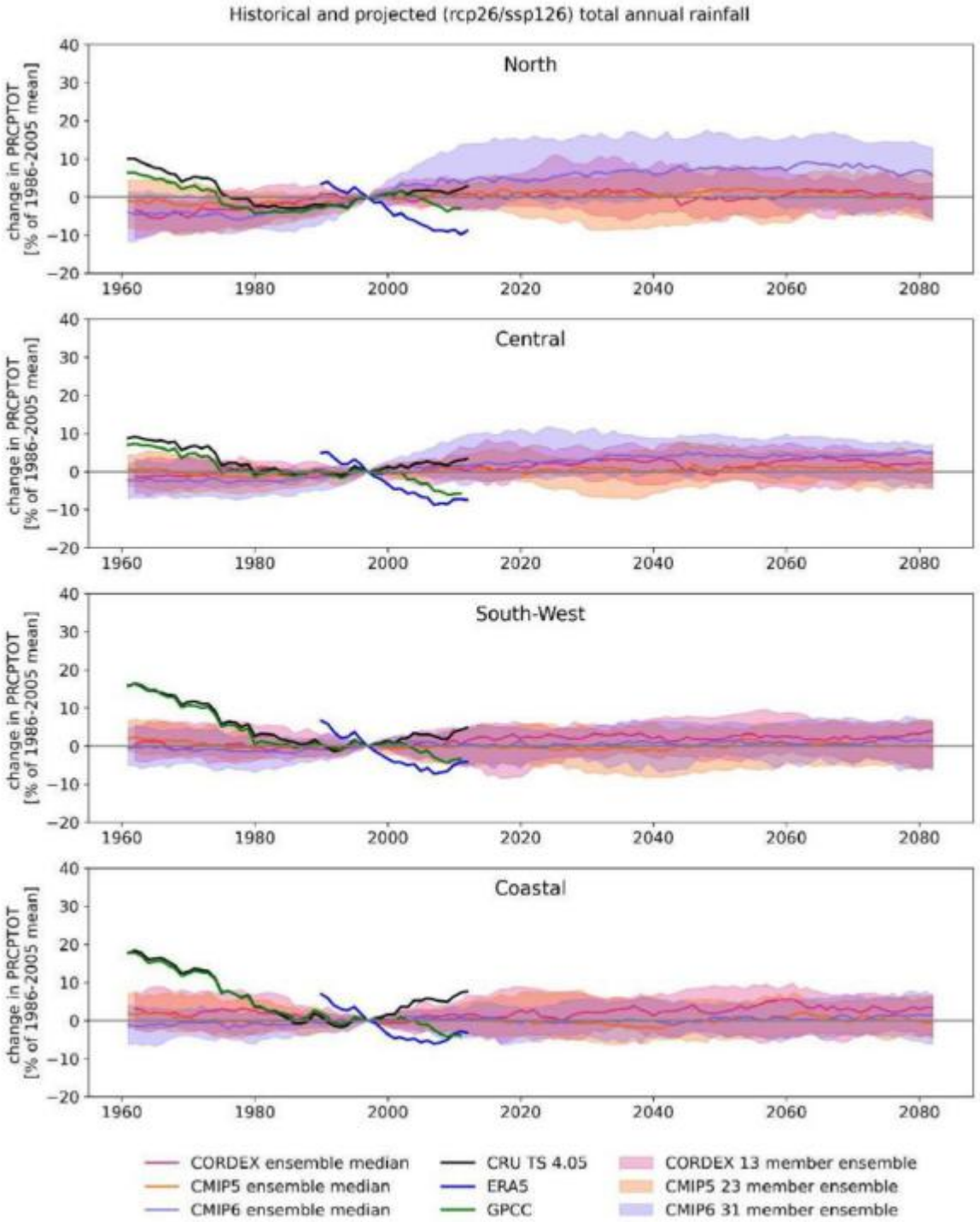
Variables	Temperature			Rainfall				Relative Humidity and Moisture				Wind			Radiation	
Basic variables	Daily Mean	Daily Max	Daily Min	Daily Total	Seasonal Total	Annual Total	Daily Maximum Rate	Daily Average	Actual Daily Evaporation	Daily Surface Runoff	Total Soil Moisture	Daily Average	Maximum Daily	Maximum Daily Gust	Daily Sunshine Duration	Upwards & Downwards Daily Radiation
Derived variables	Time series for seasons/years; Changes in warm days/nights; Changes in diurnal temperature variation; Changes in length of hot spells			Time series for seasons/years; Changes in mean daily rainfall intensity; Changes in lengths of wet and dry spells; Drought Indices				Drought Indices; Flood Risk?								
FIRST ORDER RISKS																
Water Resources	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Water Quality	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Floods				✓	✓	✓	✓			✓	✓					
Droughts	✓	✓	✓	✓	✓	✓	✓			✓	✓					
Erosion/Sedimentation				✓	✓	✓	✓			✓	✓	✓	✓	✓		
Land Use Capability	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Coastal flooding	This requires further consideration. Coastal flooding can originate from any of pluvial, fluvial or inundation: pluvial can be considered using rainfall variables, and fluvial perhaps with surface runoff variables; inundation needs consideration of sea level rise plus windstorms															
Fire risk	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Ecosystems	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SECOND ORDER RISKS																
Water Security	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓					
Energy Security	✓	✓	✓	✓	✓	✓	✓		✓	✓					✓	✓
Transport Systems	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓		
Crop Productivity	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Livestock Productivity	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Health	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓		
Built Environment	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Mining	Further details are required of needs. Mine flooding might be treated with the rainfall variables, but other impacts need further consideration															
Manufacturing	Further details are required here; it is likely each manufacturing process has its own impacts from climate change															
Fisheries	This cannot be treated directly via the downscaling but would require a desk review of available literature															

b. observed trends and future projections



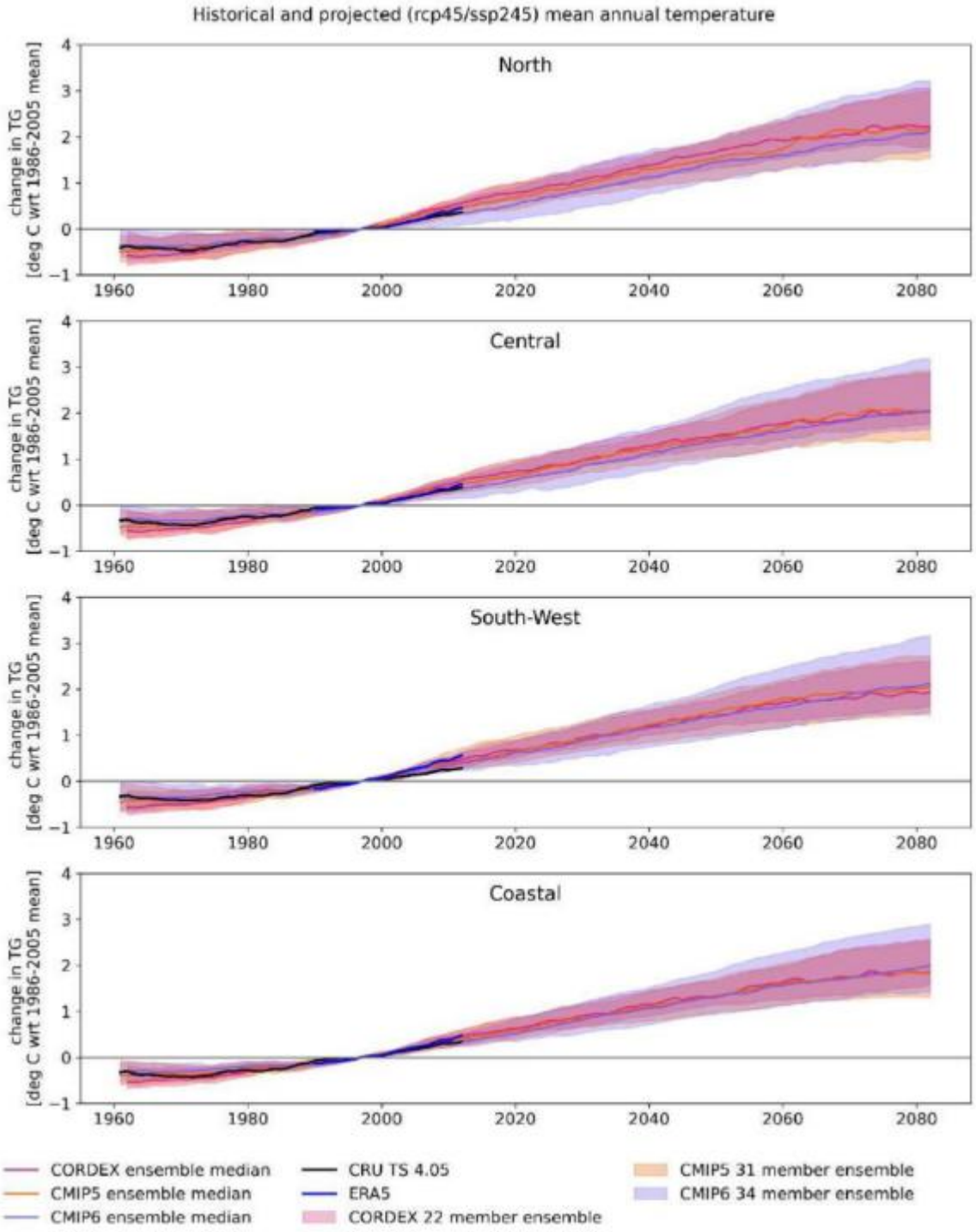
All lines represent 20-year running averages calculated on annual values. Shaded areas show the range 10th to 90th%.

Figure 9 | Plume plots illustrating the evolution of mean annual temperature in Ghana homogeneous climate zones in simulations of historical and future climate under rcp26/ssp126 scenarios.



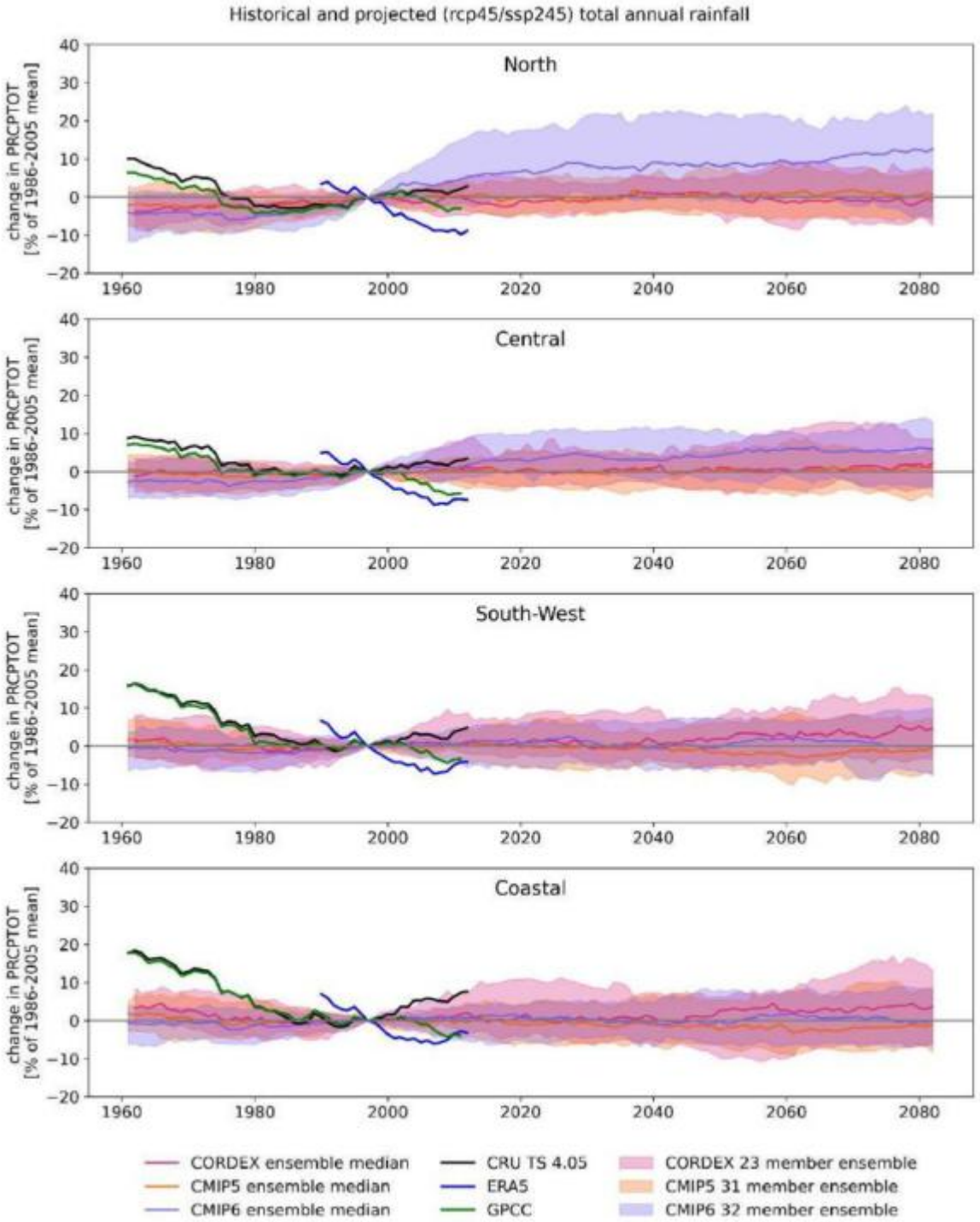
All lines represent 20-year running averages calculated on annual values. Shaded areas show the range 10th to 90th%.

Figure 10 | Plume plots illustrating the evolution of total annual rainfall in Ghana homogeneous climate zones in simulations of historical and future climate under rcp2.6/ssp126 scenarios.



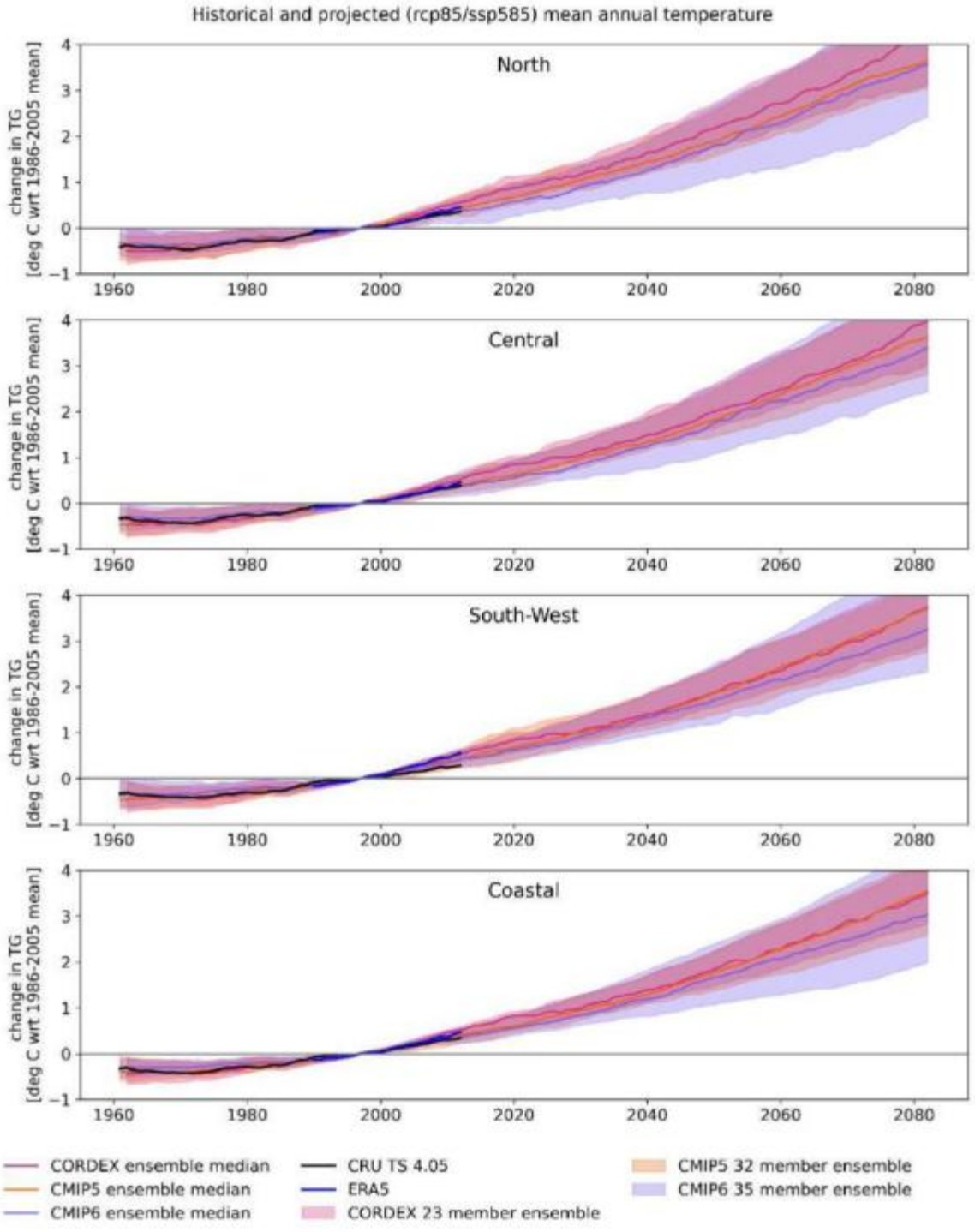
All lines represent 20-year running averages calculated on annual values. Shaded areas show the range 10th to 90th%.

Figure 11 | Plume plots illustrating the evolution of mean annual temperature in Ghana homogeneous climate zones in simulations of historical and future climate under RCP 4.5/SSP2 4.5 scenarios.



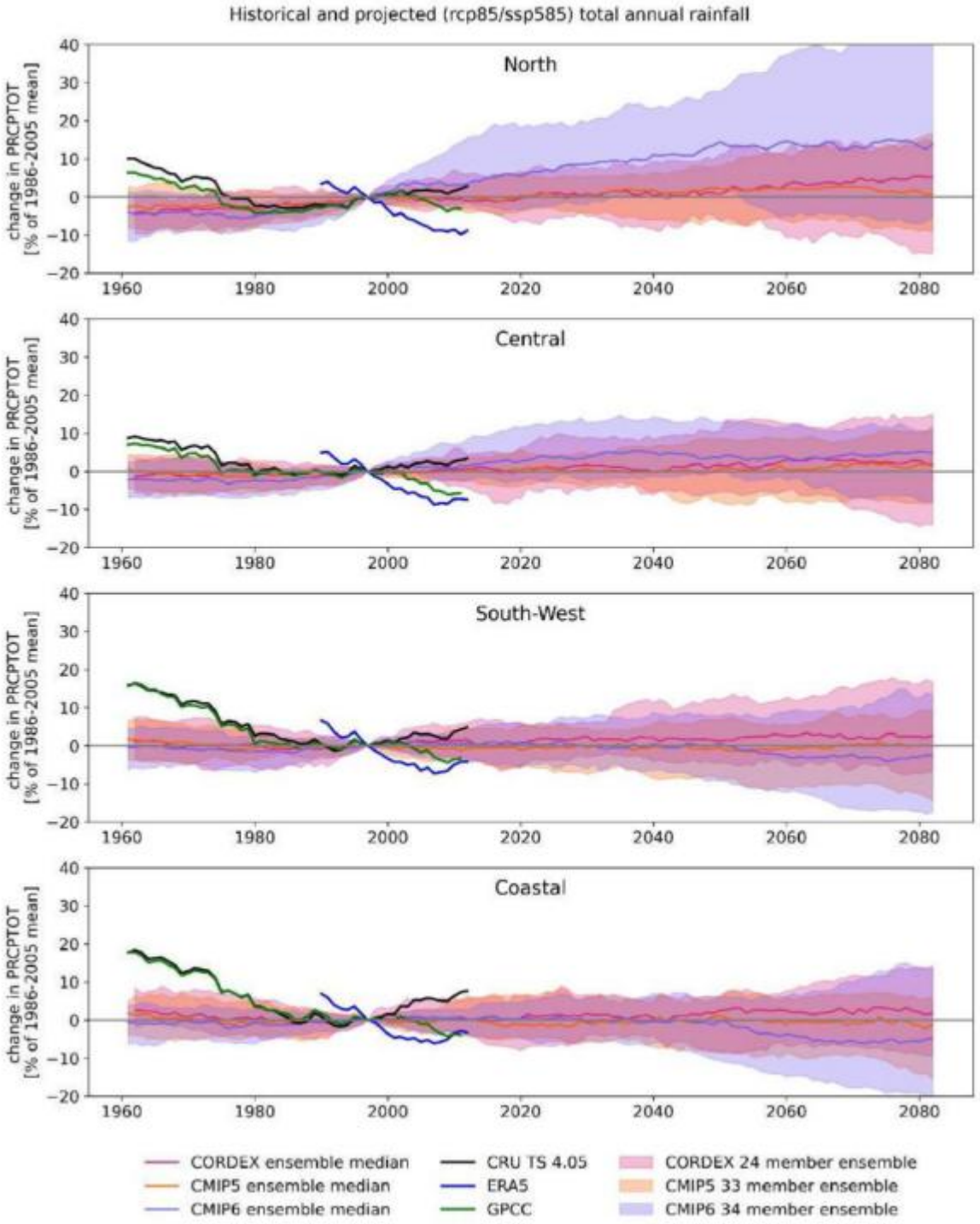
All lines represent 20-year running averages calculated on annual values. Shaded areas show the range 10th to 90th%.

Figure 12 | Plume plots illustrating the evolution of total annual rainfall in Ghana homogeneous climate zones in simulations of historical and future climate in under RCP 4.5/SSP2 4.5 scenarios.



All lines represent 20-year running averages calculated on annual values. Shaded areas show the range 10th to 90th%.

Figure 1 | Plume plots illustrating the evolution of mean annual temperature in Ghana homogeneous climate zones in simulations of historical and future climate under RCP 8.5/SSP5-85 scenarios.



All lines represent 20-year running averages calculated on annual values. Shaded areas show the range 10th to 90th%.

Figure 2 | Plume plots illustrating the evolution of total annual rainfall in Ghana homogeneous climate zones in simulations of historical and future climate under RCP 8.5/SSP5-85 scenarios.

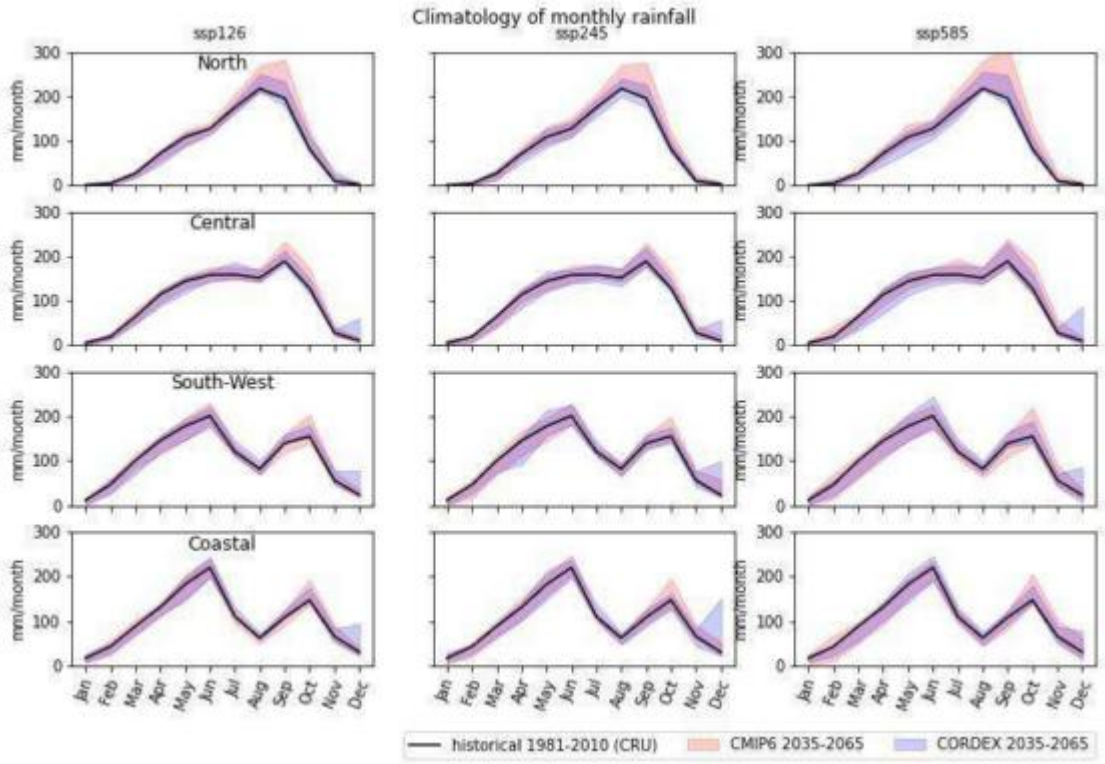


Figure 4 | Projected change in mean monthly precipitation by mid-century for the climate zones.

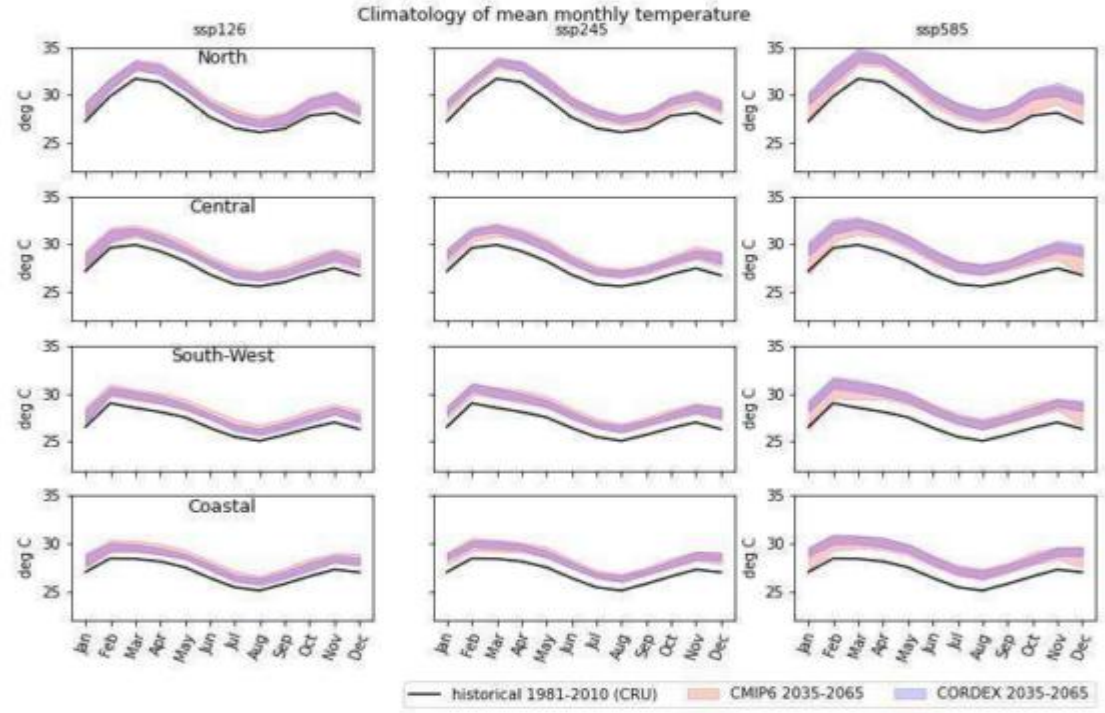


Figure 5 | Projected change in mean monthly temperature by mid-century for the climate zones.

Annex III – Sample Questionnaire for Vulnerability Assessment at the Local Level

Date: ..... Operational area: ..... Community/Town/Village: .....

Latitude: ..... Longitude: .....

Questionnaire ID: ..... Enumerator: .....

A. Respondents Profile

A1. Name of respondent (HH Head): ..... Contact phone No: .....

A2. Age of respondent: .....Years

A3. Gender of respondent: [ ] 1=Female 2=Male

A4. Marital status of respondent: [ ] 1 = Single 2 = Married 3 = Divorced/Separated 4 = Widowed

A5. Highest level of formal education of respondent: [ ] 1 = None 2 = Basic (Primary/Middle/JHS) 3 = Secondary (Secondary/vocational) 4 = Tertiary (Training college/Polytechnic/University)

A6. Period of stay in community/town/village: .....Years

A7. Origin of respondent: [ ] 1 = Native 2 = Settler/Migrant 3 = Other (specify).....

A8. What is the total number of your dependents: .....

A9. Is anyone in this household a returnee from abroad or internal migration? [ ] Yes [ ] No

A10. Has anyone left this household in the past 5 years due to climate or environmental changes? [ ] Yes [ ] No

If yes, reason: _____

B. Livelihood and Socio-economic status

B1. Primary occupation of respondent (HH Head) [ ] 1 = Agriculture 2 = Civil service 3 = Private sector (businessman/woman) 4 = Fishing, 5= Mining and quarrying, 6= Unemployed 5 = Other (specify) .....

B2. Are you engaged in other income generating activities? [ ] 1 = Yes 2 = No

B3. If yes, which other income generating activities are you engaged in? [ ] 1 = Agriculture 2 = Civil service 3 = Private sector (businessman/woman) 4 = Fishing 5= Mining and quarrying, Other (specify) .....

B4. (a). Average monthly income from second activity: _____ GHS

Do you have seasonal variations in income? [ ] Yes [ ] No

If yes, which months are hardest? _____

B5. Does any member of your household work outside this community? [ ] 1 = Yes 2 = No

B6. Do you have access to credit for your livelihood activities? 1 = Yes 2 = No

C. Assessment of assets

C1. Which of these assets does your household own? [ ]/ [ ]/ [ ]/ [ ]/ [ ]/ [ ]/ [ ]/ [ ]

1= Radio 2 = T.V 3 = Mobile phone 4= Bicycle 5= Tricycle 6= Motorbike 7= Car

8= Others (specify).....

C2. How often do you use the communication gadgets to access information on weather/production methods and activities [ ]

1 = Very often 2 = Not often 3 = Sometimes 4 = Not at all

C3. Do you have access to good road network? [ ] 1 = Yes 2 = No

C4. What material is your house made of? 1 = Cement 2 = Bricks 3 = Mud 4 = Cement/Brick/Mud 5 = Other (specify)

C5. Is your house in a flood prone area? [ ] 1 = Yes 2 = No

C6. Has any part (or all) of your house collapsed as a result of heavy rainfall/flooding? [ ] 1 = Yes 2 = No

C7. Do you have access to internet connectivity? [ ] 1 = Yes 2 = No

C8. Do you have a health facility in this community? [ ] 1 = Yes 2 = No

C9. How long (minutes) does it take to get to a health facility? .....minutes

C10. Are you on the National Health Insurance Scheme? [ ] 1 = Yes 2 = No

C11. Do you have access to ready market in this community? [ ] 1 = Yes 2 = No

C12. If yes, how long (minutes) do you have to travel to the market? .....minutes

C13. Has water availability been a problem? [ ] 1 = Yes 2 = No

C14. What is the main source of water for drinking and for household chores? [ ] 1=Stand pipe 2= Bore hole 3=Tube well

4=River, sea, lake, lagoon, spring 5 = dam 6 = traditional well 7 = Sachet water 8 =Bottled water 7= Other (specify) .....

C15. How long (minutes) does it take to get to the water source? .....minute

D. Social network

D1. Are you a member of any social organisation? [ ] 1 = Yes 2 = No

D2. Are you aware of any active gender related organisations and associations in the community? [ ] 1 = Yes 2 = No

D3. Are there any gender related government social interventions (e.g., LEAP, subsidy, land tenure arrangement) in the community [ ] 1 = Yes 2 = No

D4. Have you ever received support from any Research and Development Institution (s) [ ] 1 = Yes 2 = No

D5. Have you ever received support from any governmental organisation(s)? [ ] 1 = Yes 2 = No

D6. Have you ever received support from any non-governmental organisation(s)? [ ] 1 = Yes 2 = No

D7. If you have received support from any of the organisations/institutions above, did you recive support in coping with climate- related issues? [ ] 1 = Yes 2 = No

D8. Do you receive information on weather forecasts for your livelihood activities or in the community? [ ] 1 = Yes 2 = No

D9. If yes, what are your main sources of information? [ ]/ [ ]/ [ ]/ [ ]/ [ ]/ [ ]/ [ ]/ [ ]

 1 = GMet 2 = Newspaper/ Television/ Radio/Phone alert 3 = Friends/family 4 = Agricultural Extension

Agent (AEA) 5 = Personal Observation/Indigenous knowledge 6 = Community radio 7 = Other (*Specify*).....

E. Availability and access to credit

E1. Do you have access to credit for your economic activities? [ ] 1 = Yes 2 = No

E2. If yes, from which source? [ ]/ [ ]/ [ ]/ [ ]/ [ ]/ [ ]/ [ ]/ [ ]/ [ ]

1 = Family/friend support 2 = Trade credit 3 = Susu 4 = Local money lenders 5 = Reinvestment

6 = Personal savings 7 = Bank loan 8= NGOs/Church 9=Other (specify).....

E3. Has your household received remittances/assistance from family or friends within the past 12 months? [ ]

1 = Yes 2 = No.

E4. Do you have access to any subsidies ? [ ] 1 = Yes 2 = No

F. CLIMATE EXPOSURE

F1. How many extreme drought/dry spells have occurred in this community since 2012 (10 years ago)

F2. How many extreme flood(s) have occurred in this community since 2012 (10 years ago)

F3. Did you receive any warning about a flood or drought event before it happened? [ ] 1 = Yes 2 = No

F4. Comparing your experiences now with about ten (10) years ago, what kinds of changes have you observed about the following parameters in this community?

	Large increase	**Moderate increase**	**Constant**	**Moderate decrease**	**Large decrease**
a. Rainfall i. Quantity ii. Duration					
b. Wind storm i. Frequency ii. Force (violent)					
c. Water Sources i. Number ii. Abundance iii. Quality					
d. Temperature					
e. Drought					
f. Flood i. Volume ii. Damage to infrastructure					
g. Seasonal calendar					
h. Bush fires					

F5. To what extent are you exposed to the changes above? [ ] Rate from 1 (low) to 5 (high)

F6. Select a sector most applicable to you: [ ] 1 = Agriculture 2 = Forestry (Ecosystems and Biodiversity) 3 = Water

4 = Human Health and Sanitation 5 = Infrastructure (Roads and Buildings, Transport) 6 = Service Sector (Finance, Trade and Industry, Tourism)

G. AGRICULTURE DEPENDENT SECTOR

G1. What is the total size of your farm? (Average since 5 years ago): .....acres

G2. How did you acquire land for farming? [ ] 1 = Inherited 2 = Bought 3 = Lease 4 = Own 5 = Sharecropping 6 =Hiring 7= Other **(**specify**)**.....

G3.1 What are your three main crops? (list in order of importance) 1. _____ 2. _____ 3. _____

G3.2. Have you observed a change in when or how you grow these crops over the last 10 years? [ ] Yes [ ] No → If yes, what kind of change?

G3.3. Do you experience crop loss due to any of the following? (✓ all that apply) [ ] Drought [ ] Flood [ ] Pest attack [ ] Delayed rainfall [ ] Other: __

G3.4. What percentage of your harvest is lost after harvest (approximate)? _____%

G5. Do you have livestock/poultry? [ ] 1 = Yes 2 = No

G6. Do you have irrigation system on your farm? [ ] 1 = Yes 2 = No

G7. If yes, what type of irrigation system? [ ] 1= Manual 2 = Mechanised

G8. If yes, what percentage of your farm land is under irrigation (Estimate)?.....

G9. Do you have access to water for dry season farming? [ ] 1 = Yes, every year 2 = Yes, some years 3 = No

G10. Are you a member of a Farmer Based Association (FBO)? [ ] 1 = Yes 2 = No

G11. Do you have access to/contact with Agricultural Extension Agents (AEA) [ ] 1 = Yes 2 = No

G12. If yes how often? [ ] a) Weekly b) Monthly c) Quarterly d) Every six months e) Annually

G13. Do you get information on improved production methods and systems? [ ] 1 = Yes 2 = No

G14. Is your farm in a flood prone area? [ ] 1 = Yes 2 = No

G15. What percentage of your total output do you lose as a result of post-harvest losses?.....

G16. Do you know about agricultural insurance? [ ] 1 = Yes 2 = No

G17. If yes, have you subscribed to any insurance product? [ ] 1 = Yes 2 = No 3 = Interested but no money

H. HEALTH DEPENDENT SECTOR

H1. What is the level of prevalence of climate-sensitive diseases in the community [ ] (very low = 1; low = 2; somewhat low = 3; high = 4; very high = 5)(*eg. Cholera; Typhoid, Bacillary dysentery, Infectious, hepatitis, Giardiasis, Scabies, Lice, Trachoma, Dysenteries, Ascariasis, schistosomiasis, Bilharziasis, Threadworm, Yellow fever, Dengue fever, and Malaria*)

H2. Do you have access to safe sanitation facilities? [ ] 1 = Yes 2 = No

H3. Do you have access to health care? [ ] 1 = Yes 2 = No

H4. How many health facilities do you have in this community/town?.....

H5. How many public toilet facilities do you have in this community/town .....

- Has anyone in your household become sick after a flood or drought in the past 5 years? [ ] Yes [ ] No

- Were you able to access health care during that time? [ ] Yes [ ] No [ ] Facility was closed/inaccessible

- Has your nearest clinic/hospital ever been affected by: [ ] Flooding [ ] Storm damage [ ] Drought-related water shortage [ ] Not affected

H6. Have you had any training/sensitization on climate related diseases like malnutrition and diarrhea, respiratory diseases, waterborne diseases etc. [ ] 1 = Yes 2 = No

I. **WATER DEPENDENT SECTOR**

I1. What is the average cost of water per month? ..... (GHS)

- In the past year, have you experienced any water shortages for: • Drinking? [ ] Yes [ ] No • Household chores? [ ] Yes [ ] No
- During which months is water availability worst? _____
- Has there been any conflict or tension over water in your community? [ ] Yes [ ] No
  → If yes, between whom? _____

I2. What is the level of NGOs and CSOs activity (Collective action - e.g., NGOs and CSOs investing in water) in the community (very low = 1; low = 2; somewhat low = 3; high = 4; very high = 5)

I3. Do you have access to potable water? [ ] 1 = Yes 2 = No

I4. Do you have access to useable wells/rain harvesting structure [ ] 1 = Yes 2 = No

I5. In the past, have you heard about any conflicts over water or climate related threats to water based on past events in this community? [ ] 1 = Yes 2 = No

I6. Are you aware of any water management regulations (conservation, watershed management) protects our water resources [ ] 1 = Yes 2 = No

I7. If yes, what is the level of enforcement of water management policy or regulations [ ] (Scale of 1 - 5) 1 = strict 2 = rather strict 3 = rather weak 4 = weak 5 = no enforcement

J. FORESTRY (BIODIVERSITY AND ECOSYSTEMS) DEPENDENT SECTOR

- J1. Do you depend on any of the following from nearby forests/wetlands? (✓ all that apply) [ ] Firewood [ ] Herbal medicine [ ] Poles/thatch [ ] Hunting/fishing [ ] None
- Have forested or wetland areas in or around your community decreased in the last 10 years? [ ] Yes [ ] No
  → If yes, what do you think caused it? _____

How many forest pest and disease outbreaks have occurred in this community since 10 years ago .....

J2. How many forest fire s have occurred in this community since 10 years ago .....

J3. What is the level of forest cover in this area [ ] (very low = 1; low = 2; somewhat low = 3; high = 4; very high = 5)

J4. Do you depend on ecosystem services (eg.) from the forest? [ ] 1 = Yes 2 = No

J5. What is your level accessibility to biodiversity [ ] Scale of 1(low) to 5(high)

J6. Do you obtain income from engagement with the forestry? [ ] 1 = Yes 2 = No

J7. What average distance (km) do you have to travel from the community to the forest? .....km

J8. Are you aware of any government policies, regulations and laws on land management and regulations (e.g. insect control policy, wildfire control policy) [ ] 1 = Yes 2 = No

J9. If yes, what is the level of enforcement [ ] (Scale of 1 - 5) 1 = strict; 2 = rather strict ; 3 = rather weak 4 = weak; 5 = no enforcement

K. SERVICE DEPENDENT SECTOR

K1. Is your business in a flood prone area? [ ] 1 = Yes 2 = No

K2. Do you depend on agriculture for raw materials in your business activities? [ ] 1 = Yes 2 = No

K3. Have you insured your business? [ ] 1 = Yes 2 = No

K4. Are you a member of any business cooperative? [ ] 1 = Yes 2 = No

K5. Are you aware of any government intervention, strict enforcement of regulations and laws (e.g., education policy, credit for businesses) [ ] 1 = Yes 2 = No

K6. If yes, what is the level of enforcement [ ] (Scale of 1 - 5) 1 = strict; 2 = rather strict ; 3 = rather weak 4 = weak; 5 = no enforcement

L. SETTLEMENT AND INFRASTRUCTURE DEPENDENT SECTOR

What is your house built with?
[ ] Mud [ ] Brick [ ] Cement [ ] Mixed [ ] Other: _____

Has your house been damaged by flood, erosion, or strong winds in the past 5 years? [ ] Yes [ ] No → If yes, what happened? _____

Are roads to your community often blocked or unusable during heavy rains? [ ] Yes [ ] No

L1. Have you insured any of your properties (buildings, cars, etc)? [ ] 1 = Yes 2 = No

L2. Do you have disaster resilient infrastructures? [ ] 1 = Yes 2 = No

L3. Are you aware of any climate driven risk based on past threats? [ ] 1 = Yes 2 = No

L4. Are you aware of any government policies, regulations and laws regarding building permit [ ] 1 = Yes 2 = No

L5. If yes, what is the level of enforcement [ ] (Scale of 1 - 5) 1 = strict 2 = rather strict 3 = rather weak 4 = weak 5 = no enforcement

M. **COASTAL ZONE CLIMATE RISKS (ONLY FOR COASTAL HOUSEHOLDS)**

M1. Distance to shoreline: [ ] <100m [ ] 100–500m [ ] 500m–1km [ ] >1km

M2. Have you observed shoreline change? [ ] Yes [ ] No

M3 . If yes indicate: [ ] Erosion [ ] Accretion [ ] Both

M4. Has your household experienced tidal flooding? [ ] Yes [ ] No

M5. If yes, indicate the frequency: [ ] Every year [ ] Seasonally [ ] Rarely

M6. Saltwater intrusion has affected: [ ] Farmland [ ] Drinking water [ ] Livelihoods [ ] Not applicable

M7. Main livelihood from coastal resources (✓): [ ] Fishing [ ] Fish processing [ ] Salt production [ ] Tourism [ ] Other: __

M8. . Changes in fish catch over past 10 years: [ ] Significant decline [ ] Slight decline [ ] No change [ ] Increase

M9.. Presence of mangroves/wetlands? [ ] Yes [ ] No

M10. If yes, used for: [ ] Firewood [ ] Spawning habitat [ ] Flood protection [ ] Other

M11. Access to coastal storm early warnings? [ ] Yes [ ] No

M12. Existing adaptation measures in the community (✓): [ ] Sea defense wall [ ] Mangrove restoration [ ] Elevated housing [ ]Planned relocation [ ] None

Has your household ever considered relocating due to sea-related risks? [ ] Yes [ ] No

M13. What coastal measures would you like to see? (✓): [ ] Early warnings [ ] Livelihood training [ ] Infrastructure defenses [ ] Relocation support [ ] Wetland protection [ ]Other

N. GENDER ROLES & HOUSEHOLD DECISION-MAKING

N1. Decision-Making:

i. Who decides in your household?Finances: [ ] Male [ ] Female [ ] Joint

ii.Farming: [ ] Male [ ] Female [ ] Joint

iii Children's education: [ ] Male [ ] Female [ ] Joint

N2. Task Distribution (✓ one per row):

i. Farming: [ ] Male [ ] Female [ ] Shared

ii.Fetching water: [ ] Male [ ] Female [ ] Shared

iii. Childcare: [ ] Male [ ] Female [ ] Shared

N3. . Are women involved in household climate-related decision-making? [ ] Yes [ ] No

N4. . Do women have equal access to:

i. Land: [ ] Yes [ ] No Credit: [ ] Yes [ ] No

ii.Information: [ ] Yes [ ] No

N5. . Are there any groups/organizations supporting women in climate adaptation? [ ] Yes [ ] No

N6 If yes, what type of support: _____

The end: Thank you for your cooperation

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