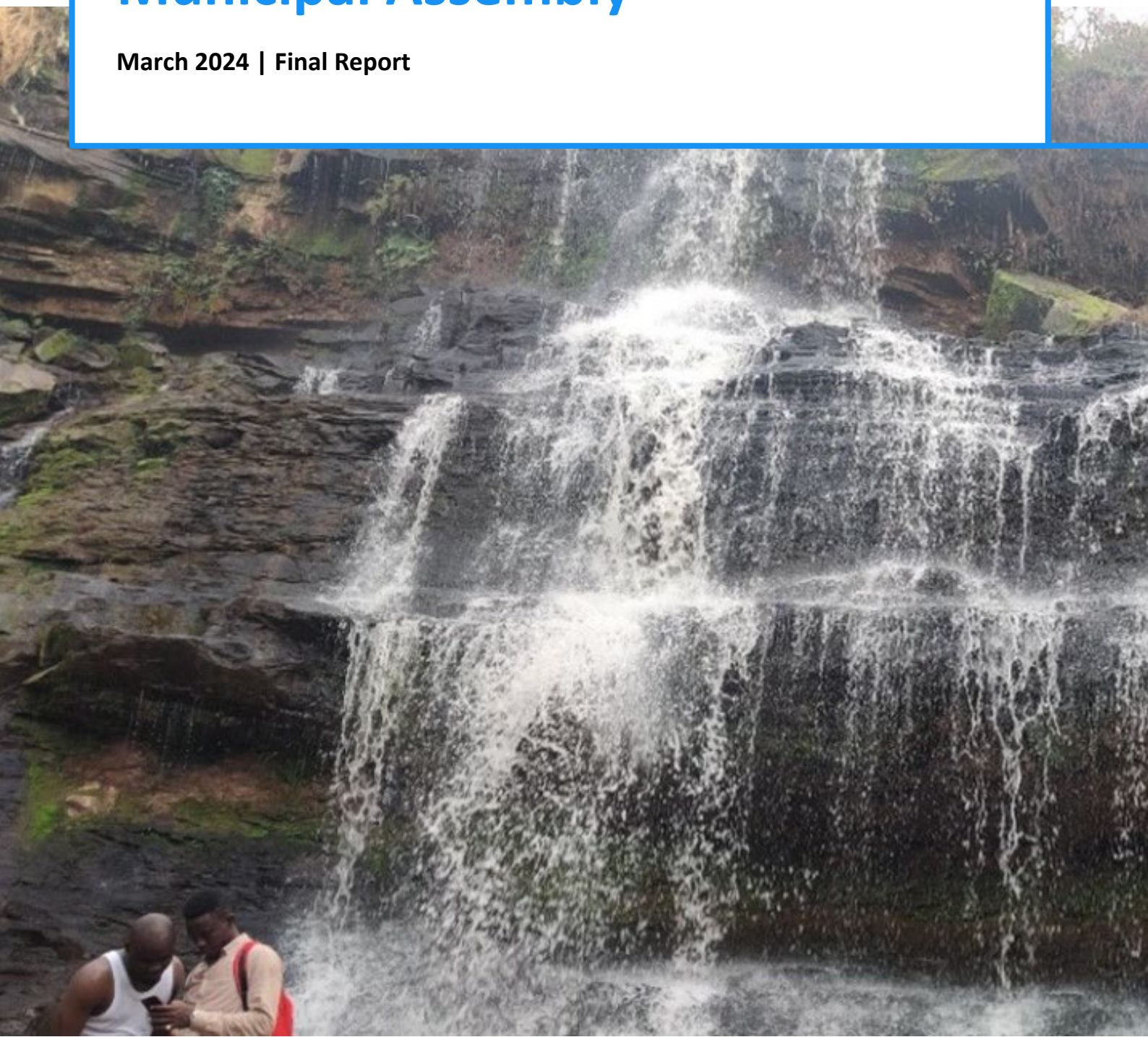
# Climate Change Vulnerability Assessment for the Kintampo Municipal Assembly

**March 2024 | Final Report**



**Climate Change Vulnerability Assessment for the Kintampo Municipal Assembly**

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Photo credit: EPA

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# Foreword

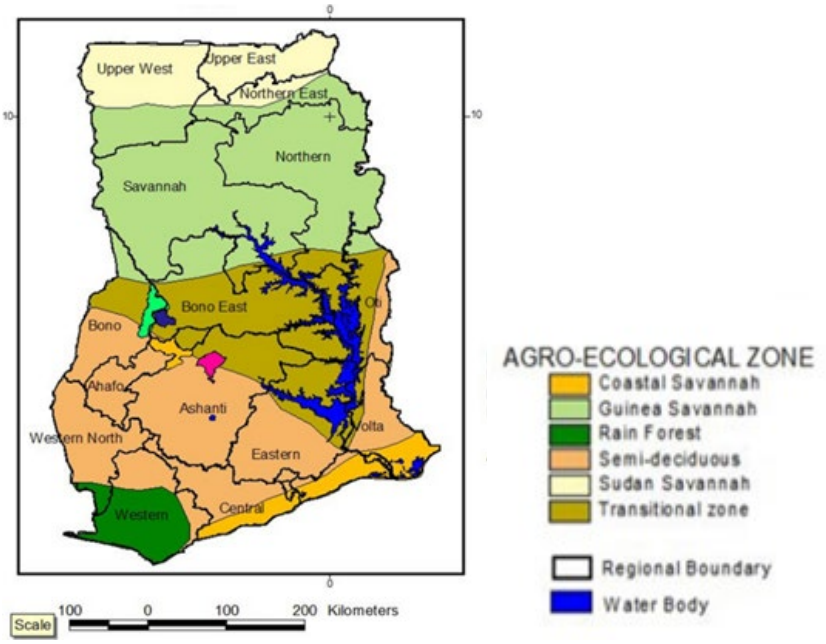
The Government of Ghana prepared six district-level climate vulnerability assessments, each for a municipal assembly located in one of the country's agroecological zones as part of the National Adaptation Planning (NAP) process. These vulnerability assessments aimed to improve the national and subnational governments' understanding of climate hazards, vulnerabilities, and risks both now and in the future to generate a knowledge base to guide adaptation planning and the identification of priority adaptation actions. They were also to provide a baseline against which progress in adaptation could be monitored and evaluated.

Vulnerability assessments were prepared for the following municipalities drawn from Ghana's six specific agroecological zones:

- Bekwai: Semi-Deciduous Forest
- Bibani-Anhwiaso-Bekwai: Rain Forest
- Cape Coast: Coastal Savannah
- Kassena Nankana: Sudan Savannah
- Kintampo: Transitional
- New Juaben South: Semi-Deciduous Forest

This vulnerability assessment was prepared for the Kintampo Municipal Assembly and is representative of a district located in the transitional agroecological zone (see Figure F1).

**Figure F1. Regional and agroecological map of Ghana**




Source: Hashmiu, I., Agbenyega, O., & Dawoe, E. (2022). Cash crops and food security: evidence from small holder cocoa and cashew farmers in Ghana. *Agriculture & Food Security 11:12*, Page 7 of 21.

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# Abbreviations

| | |
|---|---|
| **CCVA** | Climate Change Vulnerability Assessment |
| **DACF** | District Assembly Common Fund |
| **EPA** | Environmental Protection Agency Ghana |
| **GCF** | Green Climate Fund |
| **GIZ** | Deutsche Gesellschaft für Internationale Zusammenarbeit |
| **GMet** | Ghana Meteorological Agency |
| **GSS** | Ghana Statistical Service |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **KiMA** | Kintampo Municipal Assembly |
| **MoFA** | Ministry of Food and Agriculture |
| **NADMO** | National Disaster Management Organisation |
| **NAP** | National Adaptation Plan |
| **UNEP** | United Nations Environment Programme |
| **UNFCCC** | United Nations Framework Convention on Climate Change |
| **USAID** | United States Agency for International Development |

# 1. Background to the Vulnerability Assessment

## 1.1 Introduction

Ghana has witnessed the increasing impacts of climate change across various sectors in recent years, which present significant challenges for the country's sustainable development efforts (Ahenkan et al., 2021; Adzawla et al., 2021). The effects of climate change, including droughts, floods, and heat waves, have been particularly evident in sectors such as agriculture, fisheries, forestry, water resources, and health (Laube et al., 2012; Derbile et al., 2016). The agriculture sector, which is estimated to contribute about 20% of Ghana's gross domestic product (GDP) (World Bank, 2021), is significantly impacted by climate change. In several farming landscapes across the country, changes in rainfall patterns and temperature, as well as prolonged droughts, have disrupted planting and harvesting seasons, affecting food security and the livelihoods of farmers (Kyei-Mensah et al., 2019; Atanga et al., 2021).

Recognizing the urgency of addressing climate change and its consequences, the Government of Ghana, in collaboration with development partners, initiated the National Adaptation Plan (NAP) process to identify and understand the mediating effects of climate change on the country's social & Birkmann, 2015). As part of the NAP process, district-level vulnerability assessments have been conducted to assess current and anticipated climate change–induced vulnerabilities in key sectors, including agriculture, forestry, water, energy, gender, and health.

This vulnerability assessment (VA) was prepared for the Kintampo Municipal Assembly, which is located in the Bono East region in the transitional zone of Ghana. The transitional zone is particularly vulnerable to the impacts of climate change because it is characterized by a mix of savannah and forest ecosystems. Its ecological and climatic variability makes it sensitive to changes in temperature and rainfall patterns (Dumenu et al. 2016; Wrigley-Asante et al. 2019). The focus on district-level governance and local community engagement is integral to the adaptation planning process in Kintampo Municipality. By adopting a place-responsive approach, the municipality will ensure that its adaptation strategies are tailored to the geographical distribution of climate impacts and the specific needs of local communities (Krause, Schwab & Birkmann, 2015).

By integrating district-level vulnerability assessments and geographical considerations, the Kintampo Municipality VA helps to create awareness, understanding, and proactive action in addressing climate change impacts. The development of district-specific adaptation plans, such as this VA, enhance preparedness and responses to climate change-induced vulnerabilities, support sustainable development goals, and foster resilience in the face of a changing climate. Kintampo Municipality can use the outcomes of this assessment to prioritize adaptation planning that incorporates local knowledge and perspectives, and to identify essential steps needed to build a climate-resilient future for its communities and ensure the well-being of households. This assessment provides crucial information for developing stand-alone adaptation plans that address the unique challenges faced by Kintampo Municipality.

## 1.2 Purpose and Objectives of the Vulnerability Assessment

The overarching objective is this VA is to identify human and natural systems, as well as economic sectors, in Kintampo Municipality that are particularly vulnerable to climate variability and change and will need special attention in terms of adaptation. This assessment will help the government to make informed policy decisions when channeling funds for adaptation activities. The specific objectives are to

- identify district-specific vulnerabilities and prioritize them in Kintampo Municipality to inform adaptation planning and action under the NAP,
- inform the design of projects and programs to be implemented in target districts and communities, and
- provide knowledge products that can be used for awareness creation and advocacy campaigns.

## 1.3 Scope of the Vulnerability Assessment

The Kintampo Municipality VA covers the following scope:

**Sectors:** As stipulated in the Ghana NAP framework, this VA addresses a range of key sectors at risk from climate change impacts. In Kintampo Municipality, the following sectors were assessed: agriculture (crops and livestock), tourism, forestry (biodiversity and ecosystems), water resources, and transportation. Impacts and vulnerabilities were assessed in individual sectors and complemented with cross-sectoral analysis that takes into consideration the cascading nature of climate change impacts (see 3.2.2–3.2.4).

**Geographic scope:** The VA assessment covered Kintampo Municipality and considered townships as the minimum unit of analysis (see Box 1 for a description of the levels of government in Ghana). However, the township data was obtained through the aggregation of household information.

**Timeframe for analysis:** Given the long-term nature of climate change and its impacts, the VA examined current vulnerabilities as well as projected future impacts until 2100. This approach provided important information for planning into the future.

## Box 1. Definition of Administrative Divisions in Ghana

**Region:** In Ghana, a region represents an administrative division delineated for governance, administration, and developmental purposes, as defined by the Ghana Statistical Service (GSS). These regions, each governed by a Regional Coordinating Council, serve to streamline governmental functions, development planning, and the effective distribution of resources within specified geographical boundaries. Comprising several districts that include municipalities and towns, the regional structure facilitates the implementation of policies, planning, and statistical data collection essential for socio-economic development. Ghana consists of 16 regions.

**Metropolitan Area:** This is a highly urbanized region with a dense population, typically exceeding 250,000 residents, characterized by significant economic activities and a complex urban infrastructure. Governed by a Metropolitan Assembly, these areas represent the apex of local governance, tasked with overseeing urban planning, development, and the provision of essential services. Metropolitans are pivotal to the country's socio-economic fabric, acting as centres for commerce, industry, and culture. The classification into metropolitan status reflects not just the scale of urbanization and population density but also an area's capacity for revenue generation and the sophistication of its administrative structures, ensuring that urban development is managed in a sustainable, inclusive manner that caters to the diverse needs of its inhabitants.

**Municipality**: A municipality in Ghana is a local government area similar to a city or a town. It typically has a population of more than 95,000 people. Municipalities are governed by a Municipal Chief Executive, who is the political head and is responsible for the general administration of the area. Municipalities often contain a mix of urban and rural settlements.

**District**: Ghana is divided into 16 regions, which are further divided into 216 districts. Each district is headed by a District Chief Executive, who is responsible for the strategic direction and execution of government policies at the district level. Districts may be classified as either urban or rural, based on population size and economic activity.

**Township**: A township is usually a part of a district or municipality that is designated as a town. It has a distinct administrative and governance structure that is less than that of a municipality but more than that of a village. A township usually has a population size between that of a village and that of a municipality.

**Village**: A village in Ghana is a small rural community or settlement, usually with a small population. Villages are typically located in the more rural districts of the country. Traditional authorities, including the chief and elders, play significant roles in the governance and administration of the village.

## 1.4 Outputs of the Vulnerability Assessment

This VA produced the following seven outputs, which are elaborated upon in the report sections indicated in parentheses.

**Output 1:** Development of climate projections and scenarios for the Kintampo Municipal Assembly.

**Output 2:** Description and creation of representative district-level vulnerability narratives (3.2.2.2)

**Output 3:** Projections and description of potential future vulnerabilities (4.2)

**Output 4:** Analysis of pathways that link current vulnerabilities to the future (4.5)

**Output 5:** Description of prioritized vulnerabilities in key climate-sensitive sectors (3.2.2.1)

**Output 6:** Creation of a map of vulnerability hotspots in each district (3.3.2)

**Output 7:** Identification of available options to help people and communities adapt to the effects of climate variability and change (5.1)

## 1.5 Guiding Principles

The development of the VA for Kintampo Municipality was guided by the following principles:

- **District-specific and needs-driven**: The assessment was tailored to identify specific vulnerabilities in the Kintampo Municipality to inform the development of a district-specific adaptation response.
- **Inclusive**: The VA process made conscious efforts to identify, engage with, and include all institutions, sectors, communities, and groups (including women, youth, and marginalized stakeholder groups) who are currently impacted or projected to be impacted by climate change.
- **Relevant to the NAP and national priorities**: The VA process was aligned with and advanced Ghana's NAP process, as well as other national development priorities and Kintampo Municipal Assembly's development priorities. The VA incorporated sectors and areas of developmental priority in Kintampo Municipality's Medium Term Development Plan (MTDP) and considered how the results of the VA could inform actions in such areas.
- **Using existing structures and resources:** The Green Climate Fund (GCF) NAP Readiness Programme has been running in Ghana for some time and has generated knowledge and established stakeholder relationships and collaborations. The VA process used these existing structures to save time and costs, and to strengthen the existing structures to help ensure the sustainability of these and future vulnerability exercises.
- **Follows a gender-sensitive approach:** The VA process considered 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, disaggregated by gender and age, has been gathered and analyzed. This approach

recognizes that vulnerable groups (based on age, capabilities, gender, or economic standing) are affected in different ways by climate change and that these differentiated vulnerabilities must be integrated into the analysis. Men and women should be consulted both together and separately, for example in focus group discussions, about their perceptions of climate change, its risks and hazards, and its current and potential impacts on their livelihoods and well-being. The Government of Ghana has already produced a gender assessment of its NAP process, which the VAs will draw upon.

## 1.6 Definition of Key Terms

The terms and definitions for this VA are adopted from the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC, 2022):

- **Adaptation** is defined, in human systems, as "the process of adjustment to actual or expected climate impacts, in order to reduce risks or exploit beneficial opportunities." In natural systems, adaptation is "the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects."
- **Exposure** is "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" by climate impacts.
- **Vulnerability** is "the propensity or predisposition to be adversely affected" and "encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt."
- **Sensitivity** refers to "the degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise)."
- **Adaptive capacity** refers to "the ability of systems, humans, and other organisms to adjust to potential damage, to take advantage of opportunities or to respond to the consequences" of climate change—including climate variability and extremes.

## 1.7 Methodological Framework for the VA Process

Kintampo Municipality's vulnerability assessment adopted a blend of top-down and bottom-up approaches, also known as the hybrid approach. This approach is recommended by the NAP technical guideline (LDC Expert Group, 2012). Top-down approaches focus mostly on the biophysical impacts of climate change but say less about why, which, and how people are vulnerable. In contrast, bottom-up approaches mainly provide information about the vulnerability of different social groups and discuss the inherent characteristics of the system that make these groups and their context vulnerable to climate change. Comprehensively assessing vulnerability to climate change requires an integration of both approaches.

The bottom-up approach used in this VA sought to answer the following questions:

- Who or what is vulnerable to climate and non-climate stressors?
- Where is someone or something vulnerable within the municipality?
- When is someone or something vulnerable?
- Why and how is someone or something vulnerable?
- How important are climate stressors relative to non-climate stressors?

The minimum mapping unit for the assessment was the household, which was aggregated into the village or township unit. The approach assessed the vulnerability of the priority sectors indicated in the Ghana NAP Framework at the district level and zoomed in on agriculture at the township level. This assessment therefore adopted the Climate Vulnerability and Capacity Analysis tool developed by CARE International (2019), which provided a framework and instruction for the VA team to gather and analyze vulnerability information at the community level, to develop socio-economic and climate change scenarios, and to carry out top-down vulnerability assessments in individual sectors (such as forestry, tourism, water resources, agriculture, and transportation).

It is important to emphasize that this VA followed five key principles, as described in section 1.5: district-specific tailoring, inclusion of all potentially impacted groups, alignment with national priorities, use of existing resources, and a gender-sensitive approach. This thorough, integrated method provided a comprehensive view of the vulnerability landscape in Kintampo Municipality, accommodating both the physical impacts and the social aspects of climate change.

### 1.7.1 Institutional Arrangements and Stakeholder Engagement Plan

Climate change is an existential problem that affects people and systems differently. Addressing a problem of the magnitude of climate change requires collective action. It is therefore imperative to make conscious efforts to engage relevant and diverse stakeholders. Such an approach seeks to arrange engagement and consultation that not only serve the purposes of the VA, but also prepare all stakeholders to acquire the requisite knowledge to build their adaptive capacity, as well as to participate fully and effectively in subsequent adaptation planning processes in Kintampo Municipality. The stakeholder engagement plan is strategically aligned with the Ghana NAP's institutional engagement plan, which aims to develop and cultivate local ownership of the adaptation planning process (EPA, 2018).

The stakeholder engagement process involved identifying key relevant stakeholders within the district, those who will be affected (positively or negatively) by climate risk and impacts in the community. It included establishing their roles and responsibilities in regard to climate action, and understanding their challenges and opportunities in engaging in climate adaptation. The approach also considered the best and most convenient approach to engage all identified stakeholders. Working in close collaboration with the Local Government Team, particularly the Planning Unit of Kintampo Municipality, the VA team identified various entities and interest groups within the district and engaged with them in different ways (see Annex 1). Participatory workshops and consultations were used to engage stakeholders. This approach facilitated collaboration, ownership, learning, and knowledge refinement through dialogue.

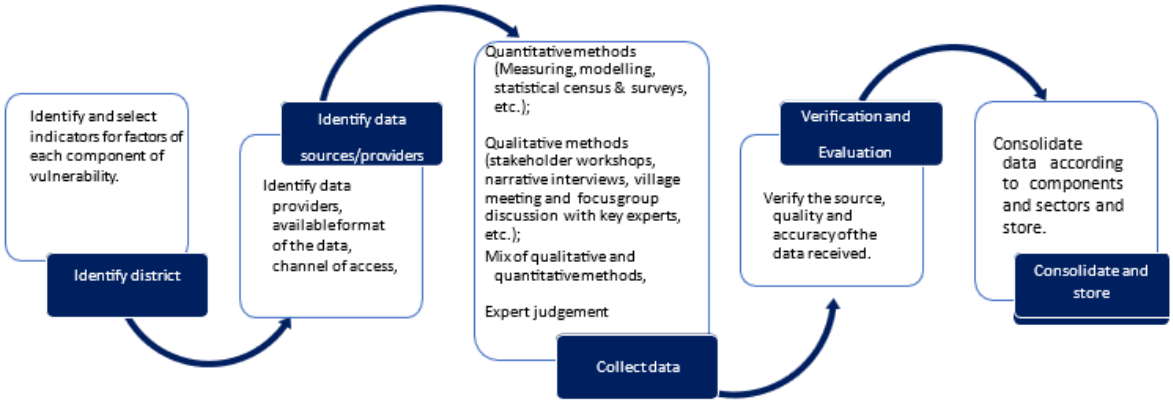
## 1.7.2 Ensuring Gender Responsiveness

The assessment process ensured that gender-sensitive vulnerabilities were captured and highlighted through (a) the inclusion of women and men in the stakeholder engagement process, (b) the creation of subsections for gender vulnerabilities, and (c) discussion of how sector impacts are linked to specific gender issues.

## 1.7.3 Methodology for Data Gathering and Management

Data collection and management are key to the VA process. Figure 1.1 summarizes the approach to data collection.

**Figure 1.1. Data collection framework**




Source: Assessment Team construct, 2022.

The methodology for data collection entailed:

- **Desktop review:** The review aimed to understand what information existed and where gaps persisted. The initial desk review provided a good stocktaking of climate and vulnerability data in Kintampo Municipality.
- **Stakeholder and expert consultation:** Experts at the national, regional, district, and local levels were consulted for information and data, and were asked to validate and triangulate secondary information connected to them.
- **Stakeholder workshop:** The stakeholder workshop was used to collect data on prevailing climate change, impacts, and vulnerabilities. The final workshop validated the final vulnerability assessment report.
- **Household survey:** An electronic questionnaire was administered to households by trained enumerators (primarily staff from the Municipal Assembly) to collect data for the indicators for the vulnerability assessment.

# 2. Kintampo Municipal Assembly Profile

This chapter provides a profile of the Kintampo Municipal Assembly. It summarizes information on the historical evolution of the municipality, physical, and environmental features, socio-demographic and economic characteristics, and administrative and governance systems. It also provides an overview of climate-related threats and hazards impacting the municipality.

Kintampo Municipality was selected for this Climate Change Vulnerability Assessment due to several factors that make it a significant area of concern:

- It is located in the transitional zone of Ghana, which is known for its ecological and climatic variability, making it particularly susceptible to the impacts of climate change;
- It relies heavily on climate-sensitive sectors such as agriculture, forestry, and water resources, which are highly vulnerable to changing climatic conditions; and
- It has experienced notable climate-related events in recent years, including droughts, floods, and windstorms, highlighting the urgency of assessing its vulnerability and implementing adaptation measures.

This assessment provides valuable insights that can inform targeted adaptation strategies and contribute to building resilience in the face of climate change not only within Kintampo Municipality, but also in similar districts across Ghana.

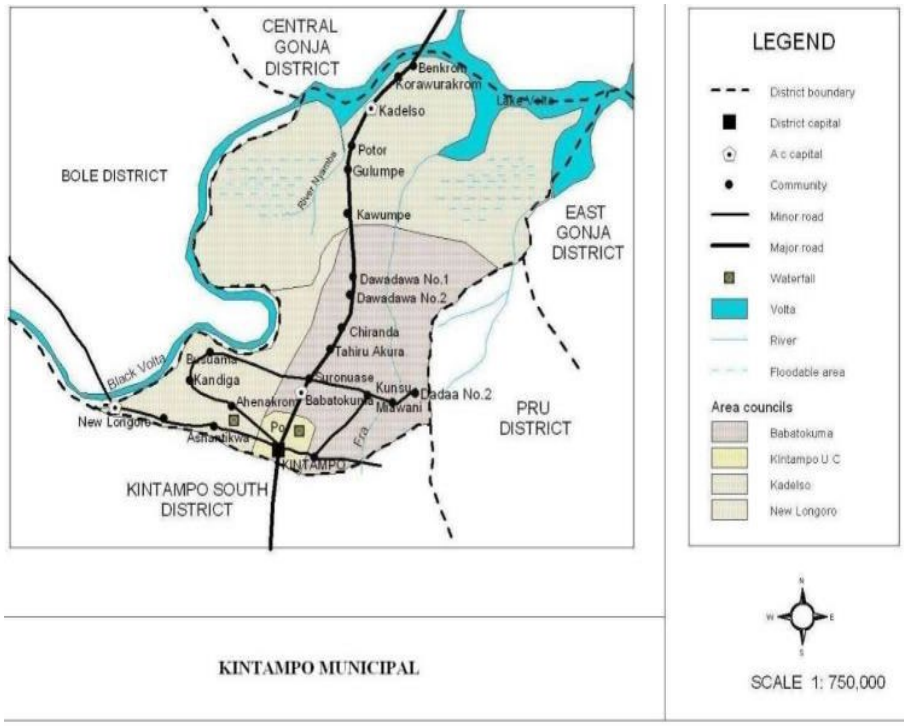
## 2.1 Background

The Kintampo Municipal Assembly traces its origins back to 1988, when it was established as the Kintampo District under Legislative Instrument (L.I.) 1480. However, in 2004, the district was divided into two smaller districts, Kintampo North and Kintampo South, under L.I. 1762, Act 462. This division aimed to enhance administrative efficiency and governance in the region.

In November 2007, Kintampo District was elevated to the status of a municipality by L.I. 1871, Act 1871. This change in status gave the local government increased autonomy and responsibilities in managing its affairs and providing essential services to the residents.

Kintampo Municipality is geographically located between latitudes 8°45’ and 7°45’ north and longitudes 1°20’ west and 2°1’ east. It covers a total land area of approximately 5,108 square kilometres. The municipality shares its borders with several neighbouring districts, including the Central Gonja District, East Gonja District, Pru District, Kintampo South District, and Bole District (Map 1).

**Map 1. Map showing the location of Kintampo Municipality**




Source: Planning Office, KiMA. 2022.

Kintampo Municipality plays a significant role as a transit point and transitional zone connecting the northern and southern regions of Ghana. The capital of the municipality is Kintampo town, which is strategically situated at the centre of the country. In recognition of its central location, the township erected a monument to symbolize its importance and pivotal position (Figure 2.1). This monument is a point of interest for visitors and residents alike.

**Figure 2.1. A monument in Kintampo township describing the town as the centre of Ghana**


Source: Boafo, 2022.

The Ghana 2021 Housing and Population Census recorded the population of Kintampo Municipality as 139,508 individuals, with a nearly even gender breakdown of 49.8% men and 50.2% women. The municipality consisted of both urban and rural areas. The urban population was reported to be 81,810, while the rural population stood at 57,698. This division reflects the mix of developed and less developed areas within the municipality (Ghana Statistical Service, 2022).

Some of the major towns in Kintampo Municipality include Kintampo, Babatokuma, Kadelso, New Longoro, and Gulumpe. These towns serve as key centres of economic and social activities in the region. The rural areas within the municipality are characterized by vast expanses of land, offering opportunities for agriculture and natural resource utilization, as well as potential for rural development initiatives.

## 2.2 Physical Features

### 2.2.1 Relief and Drainage

The dominant topographical feature in the municipality is the Voltaian Basin and Southern Plateau landscape. Much of the topography is undulating, with some dispersed hills and mountains. In terms of elevation, the municipality is between 60 and 150 metres above sea level (Dickson & Benneh, 2001). With the abundance of escarpments in the southern part of the municipality, the topography favours the formation of water resources, which ensure that the area is properly drained. The major rivers in the municipality are the Fra, Urukwain, Pumpum, Oyoko, and Nyamba. These drainage systems are the main sources of water for domestic and agricultural purposes. The Kintampo waterfalls and the Fuller falls are important sources of water for recreation and tourism. Most of these water resources drain into the Black Volta south of the municipality. All these sources of water experience annual fluctuations in volume during different parts of the year. In recent years, irregular rainfall and extreme temperatures have caused water shortages.

### 2.2.2 Geology Formation

Kintampo Municipality largely sits on Voltaian rock formations, which cover much of Ghana's geological space, especially the transitional area. This formation characteristically contains sedimentary rocks such as sandstone, mudstone, shale, and limestone, which are usually aligned horizontally. These rocks have contributed to the formation of the groundwater laterite soil and the savannah ochrosols. These two soils complement each order in the formation of high-grade humus with substantial nutrients that are key for growing crops, especially tubers, cereals, legumes, and vegetables. Cash crops such as cotton, cashew, and cocoa are grown on a large scale. Other parts of the municipality are also beneath the Birimian formation, an important geological formation composed of a varied assortment of minerals (Dickson & Benneh, 2001).

### 2.2.3 Climate

The municipality experiences the Tropical Continental climate, otherwise known as the Interior Savannah climate. This type of climatic zone is a modified form of the Wet Semi-Equatorial climate. The uniqueness of this zone is associated with the transitional nature of the municipality, which lies between two major climatic zones (GSS, 2012). Rainfall figures range from 1,400 mm to 1,800 mm annually during two seasons: a major and a minor rainy season. The major rainy season runs from April/May through July/August, while the minor rainy season begins in September/October and goes to December/January. During consultations that were held in 2022, stakeholders reported that the transition between the major and minor seasons has not been clearly defined in recent years. The temperature range for the municipality is relatively moderate, with a mean monthly range from 24°C to 30°C. The annual mean temperature ranges from 26.5°C to 27.2°C, which translates to prolonged sunny weather in most parts of the year. Humidity also varies from 90% to 95% during periods of intense rains to 75% to 80% during the off-season.

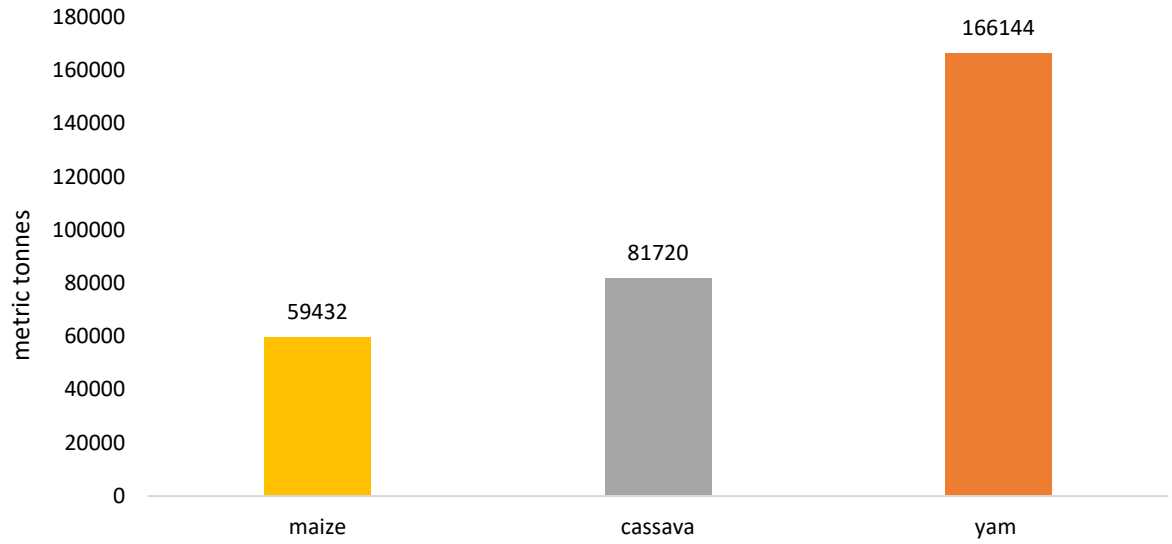
### 2.2.4 Vegetation

The vegetation in the area falls under the woodland savannah zone and is part of the semi-deciduous forest due to the transitional nature of the municipality (Ghana Statistical Service, 2022). There are some heavily wooded taller trees, but they are not as tall as trees in the deciduous forest areas of the rainforest vegetation zone. In addition, the municipality has some shorter trees like those in the typical savannah grassland areas of the north. The major species of trees in the municipality are the mahogany, odum, senya, apupuo, shea, wawa, and dawadawa (Dickson & Benneh, 2001). In some cases, trees are dispersed, especially in areas where farming and other economic activities have taken place. The characteristics of trees and plants in the municipality vary with the changing seasons, influenced by factors such as water availability and environmental conditions. However, these seasonal dynamics can be exacerbated by detrimental factors like bushfires, unsustainable logging, and poor agricultural practices. For example, extensive logging in the Bosomoa Forest Reserve has greatly reduced the quality of vegetation, necessitating vigorous reforestation by the Forestry Department to reclaim about 51.4 hectares of forest (Ghana Statistical Service 2014).

## 2.3 Socio-Economic Activities

Agriculture is the dominant livelihood occupation in the municipality, with approximately 70% of the population directly or indirectly engaged in the sector. Crop farming is done in most households in rural communities. The main crops cultivated by farmers include yams, cowpeas, groundnuts, maize, cassava, rice, sorghum, tomatoes, and mangoes. Groundnuts are the most cultivated, covering a total area of 1,800 hectares. The total output of maize is averaged at 59,432 metric tonnes, with outputs of cassava and yams being 81,720 metric tonnes and 166,144 metric tonnes, respectively (Kintampo Municipal Assembly, 2021).

**Figure 2.2. Production output of some major food crops in Kintampo Municipality, 2021**




Source: Kintampo Municipal Assembly (KiMA), 2021.

Livestock rearing is also an important activity in Kintampo Municipality, commonly including cattle, goats, sheep, and poultry. Commercial poultry production is also a huge industry in the municipality, and includes chicken, turkey, ducks, and guinea fowl, and more recently quail. The promising nature of the industry has led to the introduction of the Livestock Development Project, a national government program in Ghana in which sheep and other small ruminants were distributed to farmers to support and enhance livestock development. Other national government programs have been implemented to assist farmers, including the Root and Tuber Improvement and Marketing Program, Cashew Development Project, and Northern Rural Growth Program, among others (GSS, 2022).

Kintampo Municipality has huge potential to increase agricultural production due to its physical features. Relatively favourable climatic conditions, including the double-maxima rainfall regime (experience two distinct peak rainfall periods within a year), ensure continuous farming during most of the year, which results in increased productivity and provides employment opportunities to numerous people along the agricultural value chain (GSS, 2014). However, changes in the climate and adverse climate impacts are gradually hindering work to increase the growth and smooth practice of agriculture. Inadequate information on rainfall and poor adoption of adaptation strategies have particularly exposed some farmers to different levels of climate vulnerabilities (Baffour-Asare, 2018).

## 2.4 Administrative Arrangements

Kintampo Municipality is headed by the Municipal Chief Executive, although the coordinating director is largely in charge of the day-to-day administration. There are four zonal councils located in Kintampo, Babatokuma, Kadelso and New Longoro (see Map 1). These councils play key roles in the planning and implementation of district-level policies and programs. In addition to the Municipal Chief Executive, there are 45 elected members, one from each of the 45 electoral areas. Each electoral area also has a unit committee, with 225 committee members in total. There are also 19 government appointees, and one member of parliament represents the municipality (GSS, 2014).

Traditionally, the municipality is under two paramount chiefs: the Nkoranza Manhene and the Mo Traditional Council. The Mo paramount has 19 subchiefs, while Nkoranza has over 30 subchiefs. As a cosmopolitan area, the municipality includes several ethnic groups. The Mo and Nkoranza are more well-known because of their custodianship of the land, though the area is also home to migrant farmers from northern Ghana. The municipality enjoys many festive celebrations such the Nkyifie festival of the Bonos, the Damba festival of the Dagombas and Gonjas, and the Munufie festival of the Nkoranzas. The Kurubi Festival, enjoyed by the Wangara settlers in Kintampo, has a minor celebration on the 27th day of Ramadan and a major celebration in November (KiMA, 2017).

## 2.5 Overview of Climate Change Threats in the Municipality

This section summarizes the climate change–induced threats that were analyzed for the CCVA. Kintampo Municipality is increasingly vulnerable to climate change hazards that impact and threaten the livelihoods of individuals and communities. The main hazards in the municipality are listed in Table 1.

**Table 1. Climate-related hazards and their definitions as used in Kintampo Municipality CCVA (literature review)**

| Hazard | Definition |
|---|---|
| Flood extremes | Flood extremes are temporary events where a large volume of water exceeds its normal boundaries, resulting in the inundation of areas that are typically dry. Floods can occur due to heavy rainfall, rapid snowmelt, or the overflow of rivers and other water bodies. They can cause damage to infrastructure, disrupt ecosystems, and pose risks to human lives and livelihoods. |
| Drought | Drought is a prolonged period of below-average precipitation in a specific region, leading to a scarcity of water resources. Droughts can result in water shortages for agriculture, industry, and domestic use, impacting ecosystems, crop production, and livestock. They can also contribute to soil degradation, wildfires, and economic losses. |
| Dry spells | Dry spells are shorter periods of abnormally dry weather within a larger climatic context. While they are less severe than droughts, they can still have detrimental effects on agriculture and water availability. Dry spells can impact crop growth, reduce water supplies, and increase the risk of wildfires. |
| Pests and diseases | Pests and diseases refer to organisms, such as insects, fungi, bacteria, or viruses, that have a harmful impact on crops, livestock, and forests. Climate change can influence the distribution and behaviour of pests and diseases, leading to increased outbreaks and damage to agricultural systems and ecosystems. |

| Hazard | Definition |
|---|---|
| Bushfires | Bushfires are uncontrolled fires that occur in grasslands, bushes, woodlands, and scrublands. They are often fuelled by dry vegetation and can spread rapidly, posing risks to human lives, property, and ecosystems. Climate change can contribute to the occurrence and severity of bushfires by creating drier and hotter conditions, promoting the ignition and spread of fires. |
| Windstorms | Windstorms are characterized by very strong winds or violent gusts, often associated with intense weather systems. While windstorms are primarily related to wind speed rather than climate change itself, the changing climate patterns can influence the frequency and intensity of windstorms in certain regions, potentially causing damage to structures, vegetation, and infrastructure. |
| Climate-induced erosion | Climate-induced erosion refers to the process where changes in climate patterns, such as increased rainfall intensity or altered precipitation patterns, lead to the removal and transport of soil, rocks, or dissolved material from one location to another. This erosion can result in the degradation of soil quality, loss of agricultural productivity, and environmental damage. |
| Changes in rainfall patterns | Changes in rainfall patterns refer to alterations in the timing, frequency, intensity, or distribution of precipitation over a specific region or timeframe. Climate change can influence rainfall patterns, leading to shifts in the occurrence and duration of wet and dry periods. These changes can have significant implications for water availability, agricultural practices, and ecosystem dynamics |
| Seasonal temperature changes | Seasonal temperature changes refer to variations in temperature patterns across different seasons within a specific region. Climate change can lead to shifts in seasonal temperature patterns, including changes in average temperatures, heat waves, or cold spells. These changes can impact various sectors, including agriculture, health, and energy demand. |
| Climate-induced soil infertility | Climate-induced soil infertility refers to the degradation or deterioration of soil quality and fertility due to changes in climate conditions. Factors such as increased temperatures, altered rainfall patterns, and prolonged drought can negatively affect soil health, nutrient availability, and organic matter content, limiting agricultural productivity and the ability of soils to support plant growth. |
| Increase in temperature | An increase in temperature refers to a rise in the average or extreme temperatures in a given region or globally. Climate change is leading to higher temperatures, primarily due to the buildup of greenhouse gases in the atmosphere. Increased temperatures can have wide-ranging impacts on ecosystems, agriculture, human health, and the frequency of heat waves. |

Sources: Literature review; key informant interviews.

Bushfires are a common climate-related hazard in Kintampo Municipality (Figure 2.3), and their occurrence is influenced by the conditions created by climate change as well as human activities such as agricultural practices and hunting. Rising temperatures and changing precipitation patterns can lead to drier vegetation and increased fuel load, making the environment more susceptible to ignition and rapid fire spread. Additionally, climate change can alter weather patterns, including the frequency and intensity of droughts, which further exacerbate fire risk in the municipality. Human activities, particularly those related to agriculture and hunting, also play a significant role in the occurrence of bushfires. Farmers in Kintampo Municipality often use fire as a traditional land-management tool to clear agricultural fields, control pests, and promote regrowth. However, these practices can sometimes get out of control and result in uncontrolled bushfires. Similarly, hunters may use fire to drive out animals or create open areas for better visibility, unintentionally causing bushfires if not properly managed. Hunters usually set fires to trap game like greater cane rats (*Thryonomys swinderianus*).

The combination of climate change and human activities creates a worrisome situation with intensified conditions for more frequent and larger bushfires. This situation poses significant risks to the local ecosystem, biodiversity, livelihoods, and infrastructure in Kintampo Municipality.

**Figure 2.3. Destruction of vegetation by bushfires in Kadelso, Kintampo Municipality**

Source: Boafo, Y.A. (2022).

The effects of bushfires on the environment in the municipality include the destruction of vegetation in ecologically sensitive areas, as well as the destruction of plants and crops, especially cashew plants (*Anacardium occidentale*). The resulting lack of vegetation makes the land bare and exposes it to harsh climate conditions, which in turn leads to reduced agricultural production.

# 3. Climate Change Impacts and Vulnerabilities

First, this chapter focuses on the analysis of the observed climatic conditions and changes that have occurred over time. Historical climate data obtained from the Ghana Meteorological Agency. The assessment team's climate scientist analyzed historical climate data sourced from the Ghana Meteorological Agency (GMet) to identify trends and patterns in temperature, rainfall, and other relevant climatic variables. Consequently, all the graphs presented in this section are based on this data from the GMet. Examining past climatic conditions provides insights into how the climate has evolved and helps identify notable shifts and anomalies. Second, this chapter delves into the factors of vulnerability within Kintampo Municipality. It explores the specific elements that contribute to the region's susceptibility to climate change impacts, analyzing social, economic, and environmental factors that interact with climate change to increase the vulnerability of local communities. An understanding of these underlying factors assists policy-makers and stakeholders in developing targeted strategies to address and reduce vulnerabilities. Finally, the chapter focuses on the impacts of climate change in Kintampo Municipality, examining specific impacts on different locations, sectors, and groups within the region. It analyzes how climate change affects natural resources, ecosystems, livelihoods, and human well-being. Identifying the specific impacts allows stakeholders to prioritize adaptation and mitigation measures. This helps minimize negative consequences and enhances resilience.

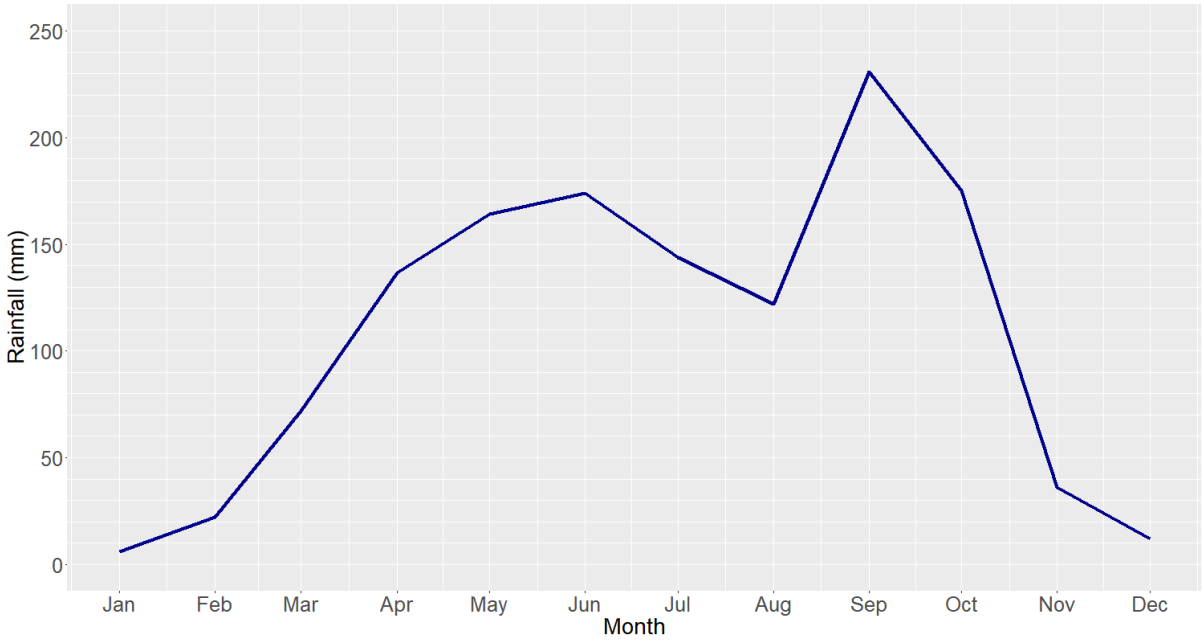
## 3.1 Observed Climate Change Conditions

Kintampo Municipality is located in the transitional zone of Ghana and between two extreme rainfall patterns: the unimodal and bimodal rainfall regimes. Kintampo may differ from other locations in Ghana in terms of its climatology, seasonal cycle, and amount of rainfall received annually. An understanding of the climatic characteristics of Kintampo is critical to develop a meaningful adaptation strategy, since people's livelihood activities are directly and indirectly linked to the area's climate. Developing adaptation strategies for community resilience requires understanding the past climate, changes in climate experienced to date, and additional projected changes in climate.

### 3.1.1 Rainfall Characteristics in Kintampo Municipality

The rainfall regime over Kintampo is characterized by the north-south movement of the Intertropical Convergence Zone. The climate of Kintampo Municipality is characterized by the wet and dry seasons, and the rainfall pattern is bimodal (Figure 3.1). Rainfall begins in March and increases until its first peak in June. After June, rainfall decreases until it reaches a low in August and begins to rise again in September, when it reaches its second peak and then begins to decline again until the end of October. Unlike the other stations in the southern part of Ghana, the second peak in Kintampo Municipality is higher than the first peak, and it also receives more rainfall in August compared to other places in the south. Kintampo receives rainfall about 8 months of the year. The dry season begins in November and ends in March.

**Figure 3.1. Total monthly rainfall over Kintampo Municipality**



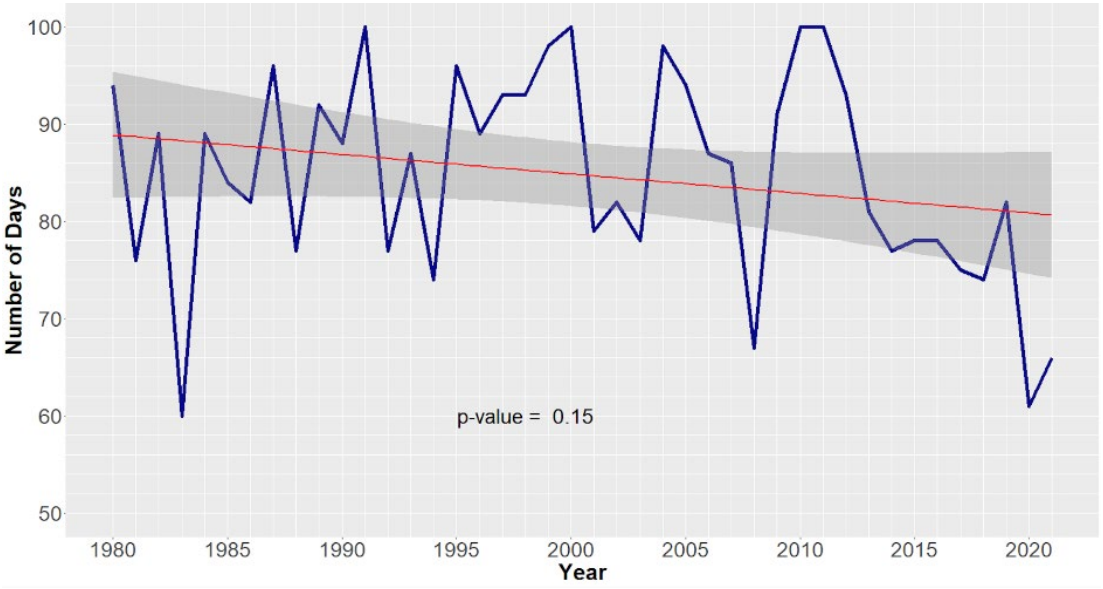

Source: Klutse & Asare, 2022.

### 3.1.1.1 Annual Rain Days

When rainfall was assessed over the past 40 years, the total number of days it rained (blue line) remained variable from year to year, but a decreasing trend over time became apparent (Figure 3.2). The variability in the number of rainy days suggested that rainfall patterns in Kintampo were not consistent from year to year; some years experienced more rainy days, while others had fewer. This variability could have significant implications for agricultural activities, water availability, and ecosystem dynamics.

In addition, the decreasing trend in the total number of rainy days (red line) indicated a long-term shift in rainfall patterns in Kintampo; on average, the region was experiencing fewer days of rainfall compared to previous years. Such a trend could have implications for water resources, as reduced rainfall might lead to water scarcity and could affect agricultural productivity. The grey shaded area around the trend line represents the confidence interval, which gives an idea of the uncertainty in the trend estimate.

**Figure 3.2. Rainfall events over Kintampo**




Source: Klutse & Asare, 2022.

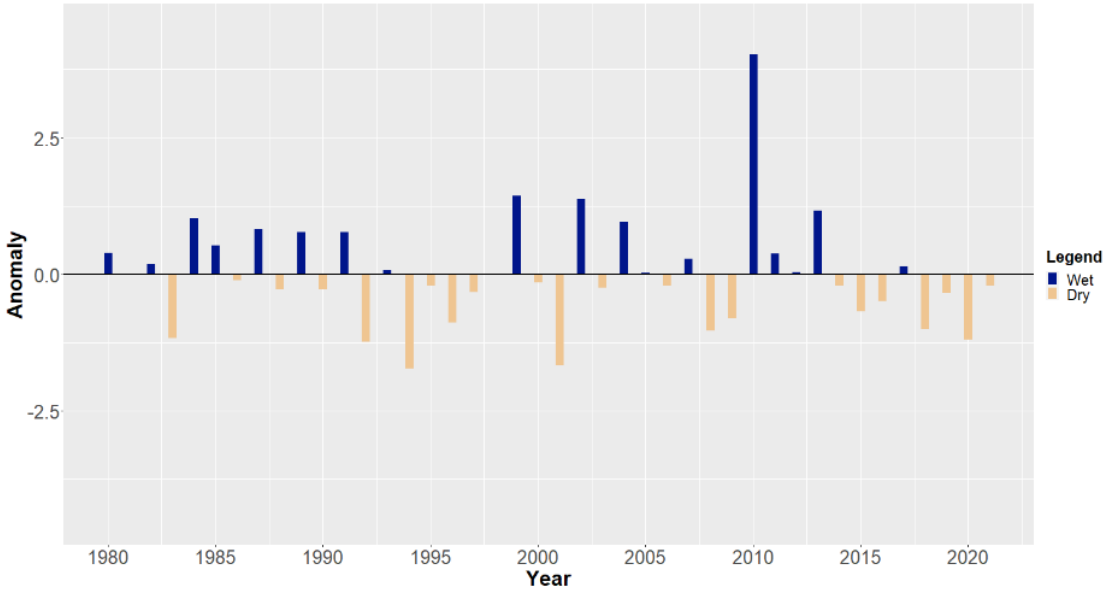
The decreasing trend was not significant, but it would likely still affect total rainfall amount and distribution, which in turn would negatively impact agriculture. Years with more rain days would likely have better rainfall distribution (how rain is spread out over a period of time) suitable for agriculture. The lowest number of days of rainfall were recorded in 2020, with 61 rain days, and 1983, with 60 rain days. The highest number of annual rain days in Kintampo was 100, which occurred in 1991, 2009, and 2010. In most years, Kintampo recorded more than 75 days of rainfall.

The mean annual rainfall for Kintampo for the past 40 years was 1,320 mm. Annual total rainfall over Kintampo could be described as variable, ranging from 1,084 mm to 1,617 mm. The mean annual rainfall over Kintampo also showed a decreasing trend, although it was not significant compared to the long-term mean.

### 3.1.1.2 Annual Rainfall Anomaly

The past 40 years in Kintampo were dominated by dry conditions. The annual rainfall totals in many of these years were below the long-term mean, but the dry conditions were inconsistent and interspersed with wet conditions (Figure 3.3). During the past 40 years, the annual total rainfall decreased slightly over Kintampo with high variability. This variability was confirmed by an analysis of the rainfall anomaly, which measures the deviation in the amount of rainfall in a given region over a specific period of time compared to the long-term average rainfall for that region. Figure 3.3 shows the rainfall anomaly for Kintampo, with wet (blue) and dry (yellow) years. For example, the year 2010 was extremely wet. On the other hand, the years 2014 to 2021 were dry, meaning Kintampo has received less rainfall than average in recent years.

**Figure 3.3. Rainfall anomaly over Kintampo**

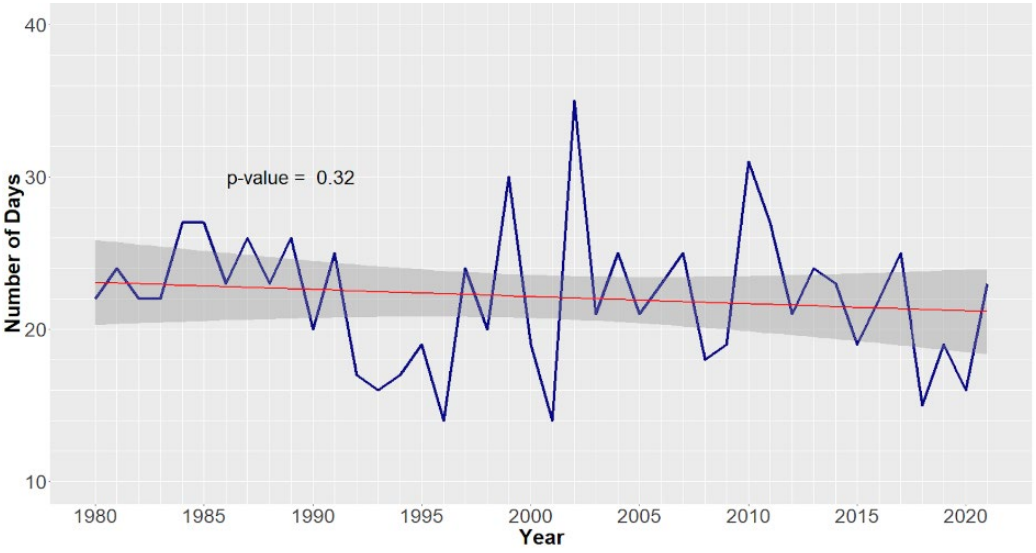



Source: Klutse & Asare, 2022.

### 3.1.1.3 Heavy Rainfall Events

Heavy rainfall events (over 20 mm a day) have the potential to impact the livelihoods of people in Kintampo due to the possibility of triggering floods. The number of days of heavy rainfall events did not change significantly over the past 40 years, although there were indications of a decline, which could signal a lower possibility of flooding if other non-meteorological factors are kept in place. Because of the variable nature of heavy rainfall events, it is difficult to predict which years will have more or fewer. Most of the years from 1980 to 2020 had between 20 and 35 heavy rainfall events (Figure 3.4). It's important to note that trends in heavy rainfall may differ across various parts of Kintampo.

**Figure 3.4. Heavy rainfall events over Kintampo**




Source: Klutse & Asare, 2022.

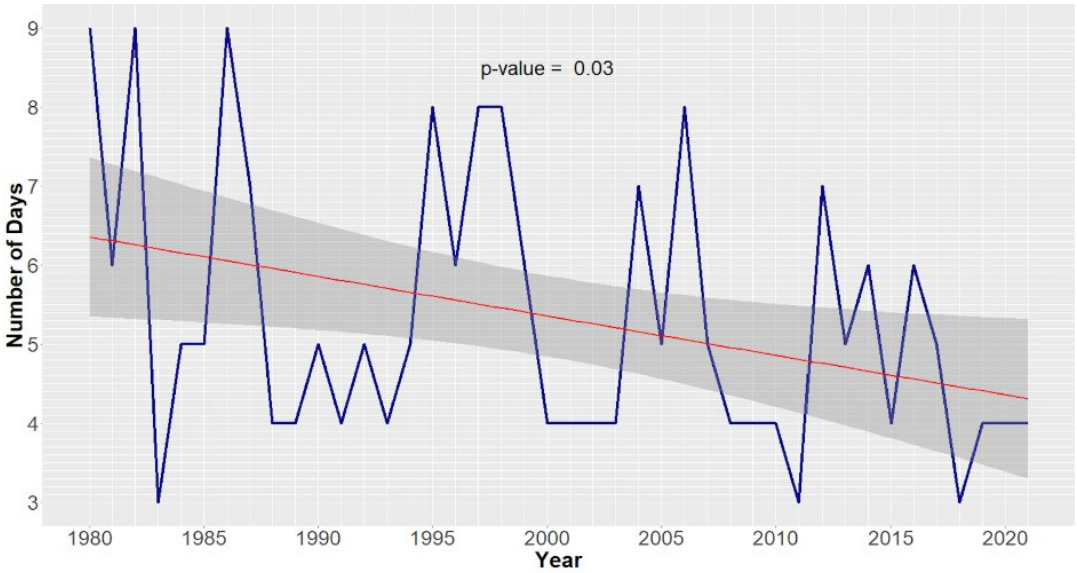
### 3.1.1.4 Consecutive Wet and Dry Days

The assessment of consecutive days with rainfall at Kintampo revealed wet spells lasting 3 to 9 days over the period under review. In addition to this variation, there was a significant decline in the number of consecutive days with rainfall in recent years (Figure 3.5). The red line in the graph represents the trend line, indicating a downward trend in the number of days over the period from 1980 to 2020. The grey shaded area around the trend line represents the confidence interval, showing the range of values within which the true trend is expected to lie with a given level of confidence.

The length of wet spells decreased significantly over Kintampo from 9 days in 1980 to 4 days in 2021, with variability in the intervening years. For example, just 3 consecutive days of rain were recorded in the years 1981, 2011, and 2018, while 9-day-long wet spells were recorded in 1980, 1982, and 1986.

In Figure 3.5, there is a general downward trend in the number of days with rainfall events from 1980 to 2020 in Kintampo Municipality. Despite the overall decrease, considerable year-to-year variability is evident. The trend is statistically significant, with a p-value of 0.03, indicating that the decline in rainfall days is unlikely to be due to random chance. The confidence interval, represented by the grey shaded area, suggests some uncertainty in the trend's precision.

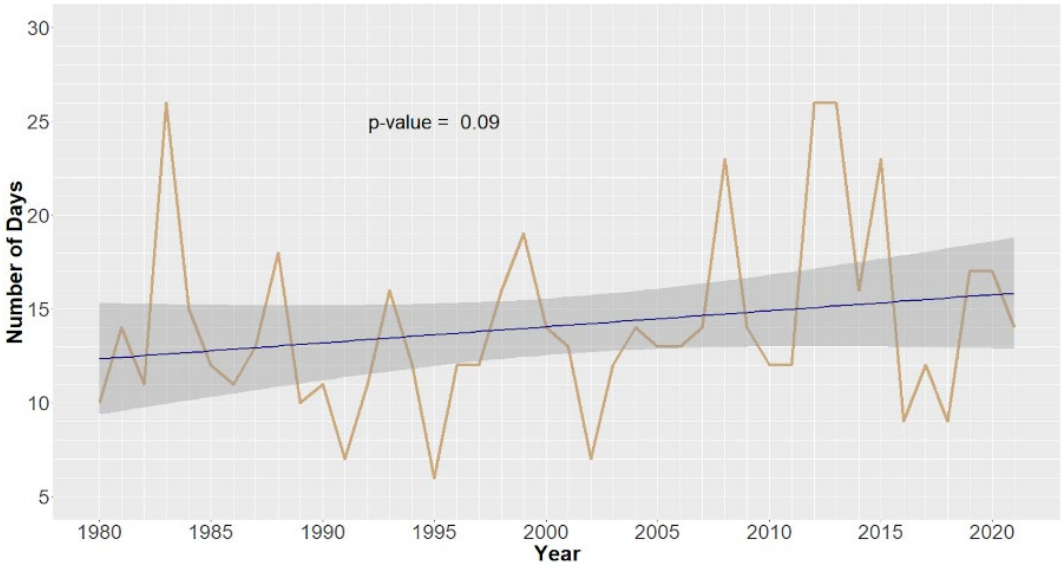
**Figure 3.5. Wet spells over Kintampo**




Source: Klutse & Asare, 2022.

Successive days without rain could negatively impact the rainfall-dependent livelihood activities in Kintampo, potentially leading to drought, an extreme climate event which often disrupts livelihood activities within the study area. The assessment of successive days without rainfall indicates the shortest dry spell occurred in 1995 (6 days) and the longest (26 days) in 1983, 2013, and 2014 (Figure 3.6). Kintampo experienced an increasing trend in dry spell duration over the review period, with high variability. The occurrence of drought in Kintampo could increase if the current trend persists.

**Figure 3.6. Dry spell duration over Kintampo**




Source: Klutse & Asare, 2022.

The blue line represents the trend of the data over time, specifically the number of dry spell days per year in Kintampo. It shows the moving average or a fitted trend line, which smooths out the fluctuations to give a clearer picture of the overall trend in the data over the period from around 1980 to beyond 2020. The grey bar, or shaded area, represents the confidence interval around the trend line. This gives an indication of the uncertainty surrounding the trend estimate. The wider the shaded area, the greater the uncertainty. In other words, the true trend line is expected to lie within this grey area a certain percentage of the time (often 95% for a 95% confidence interval).

## 3.1.2 Temperature Characteristics

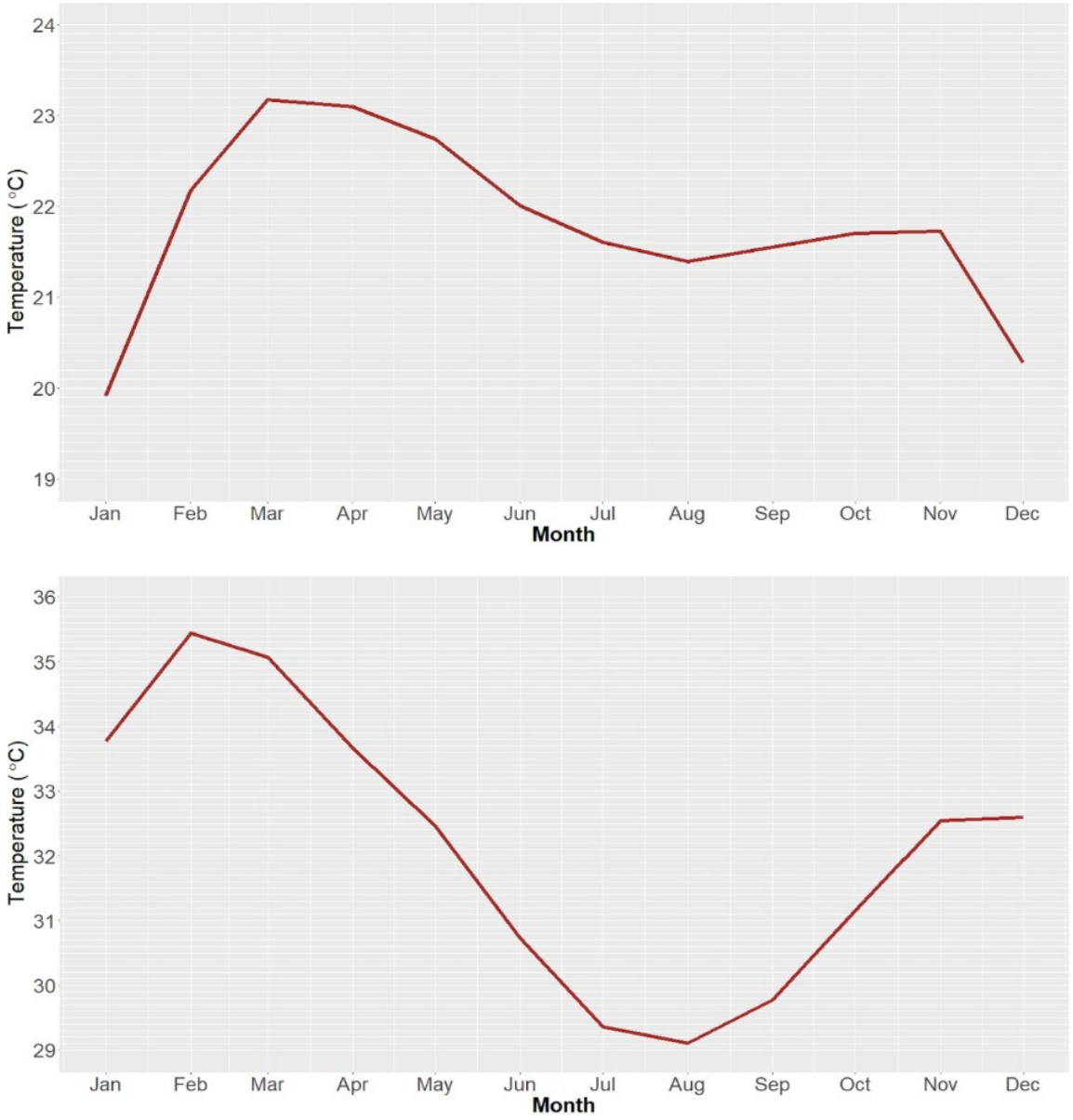
Temperature is an essential climate variable that affects people's livelihood activities. Therefore, understanding the current state of temperature during both day and night is essential to developing an effective adaptation strategy. The seasonal nighttime temperature cycle over Kintampo is similar to the daytime cycle, though the cycles differ in their peak months. The coldest average nighttime and daytime temperatures occur in August. Daytime temperatures are highest in February, while nighttime temperature peaks in March.

### 3.1.2.1 Mean Monthly Minimum and Maximum Temperatures

The mean monthly minimum and maximum temperatures from 1980 to 2021 are shown in Figure 3.7. Over this period, the mean minimum temperature peaked in March at 23.1°C, declined to 21.4°C by August, and rose to 21.7°C in October through November (Figure 3.7a). It then decreased to its lowest of about 20°C by January.

The mean monthly maximum temperature over Kintampo from 1980 to 2021 peaked in February, reaching 35.5°C (Figure 3.7b). It then dipped until August, reaching about 29°C, before rising to 32.5°C by December. The observed pattern influences the local agricultural cycles, with the cooler months offering respite from the heat for both crops and livestock. The temperature trend also has implications for human activities, such as energy consumption and water usage.

**Figure 3.7. Mean monthly minimum (a) and maximum (b) temperatures over Kintampo (1980–2021)**

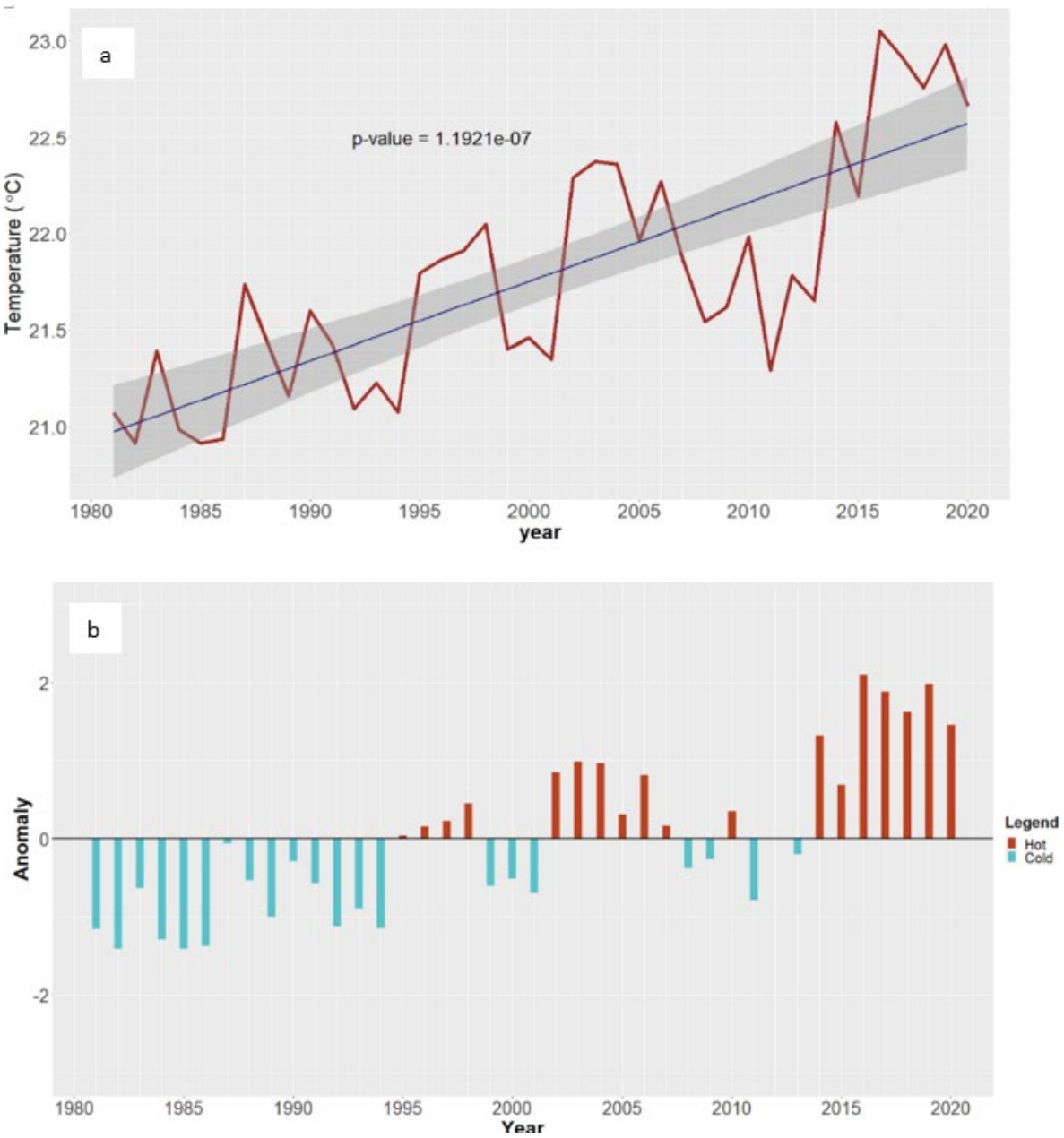



Source: Klutse & Asare, 2022.

### 3.1.2.2 Mean Annual Minimum Temperature and Anomaly

Figure 3.8a shows a significant increasing trend in the mean annual minimum temperature over Kintampo from 1980 to 2020, with year-to-year variation ranging from 20°C to 23°C. The mean nighttime temperature was 21.7°C. Figure 3.8b shows that 1980 to 1994 were cold years over Kintampo, according to an analysis of temperature anomaly (departure from a reference value or long-term average). This cold period was followed by varying hot and cold anomalies from 1995 to 2013. The years 2014 to 2020 were the warmest over Kintampo, as expected from the global temperature trend (National Centers for Environmental Information, 2020).

**Figure 3.8. Mean annual minimum temperatures (a) and mean minimum temperature anomaly (b) over Kintampo**



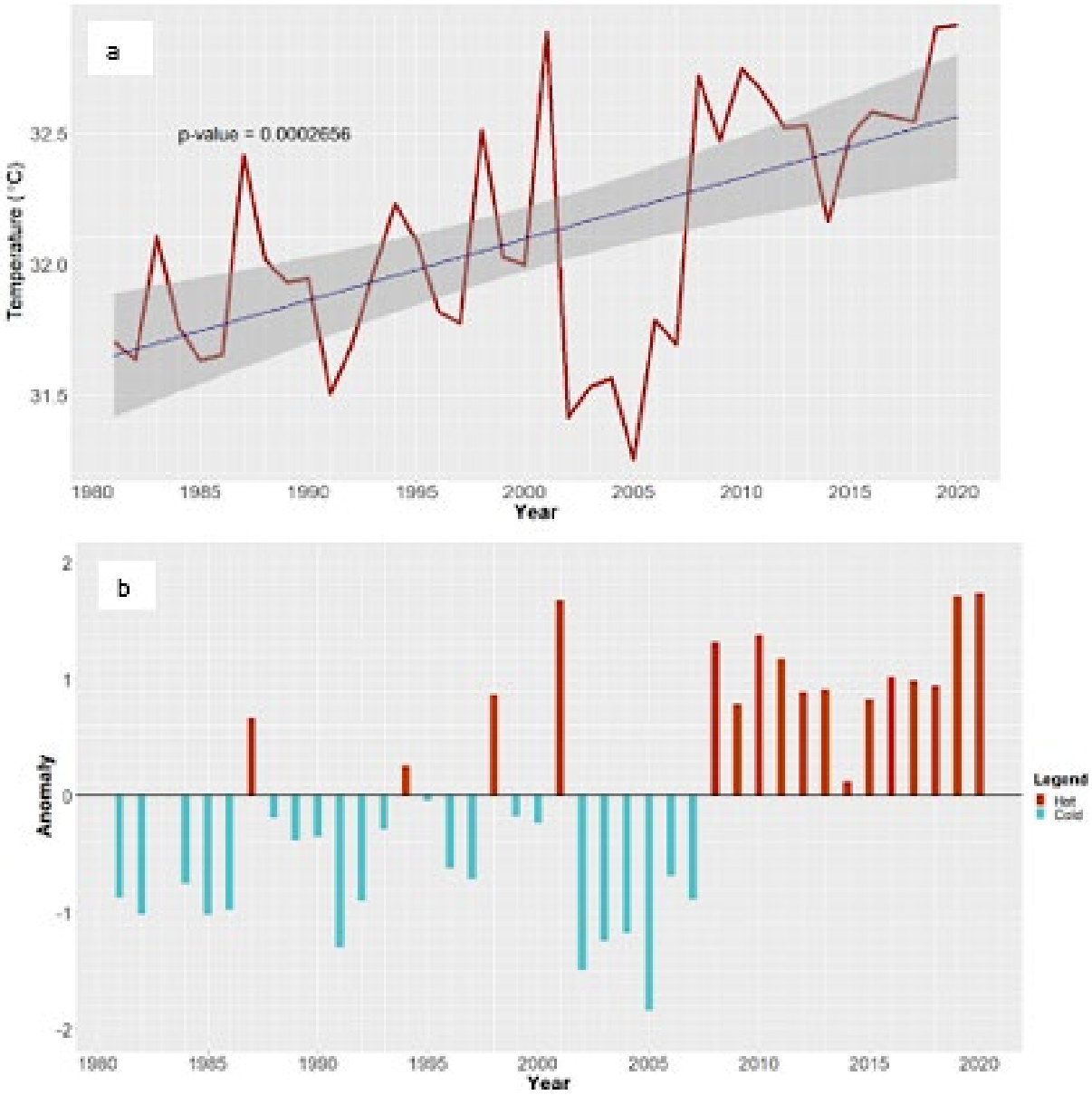

Source: Klutse & Asare, 2022.

In Figure 3.8a, the red line represents the actual observed temperatures over the years, demonstrating the fluctuations and trends in temperature for the period from 1980 to 2020. The grey bar, often referred to as the confidence interval, represents the uncertainty in the trend line (the blue line), which is the linear model fit to the data. This interval suggests where the true line of best fit may lie with a certain level of confidence, typically 95%. The width of the grey bar indicates the level of certainty we have in the slope of the trend line; a narrower bar would indicate more confidence.

### 3.1.2.3 Mean Annual Maximum Temperature and Anomaly

The mean annual maximum temperature over Kintampo (Figure 3.9a) increased significantly from 1980 to 2020. This increasing trend was consistent with the global trend in mean annual temperatures. Figure 3.9b shows the mean maximum temperature anomaly, with cold years occurring from 1980 to 2007, except in 1987, 1994, 1998 and 2001. Since 2008, all years have had mean maximum temperatures above the long-term mean, indicating warming in Kintampo.

**Figure 3.9. Annual mean maximum temperatures (a) and mean maximum temperature anomaly (b) over Kintampo**

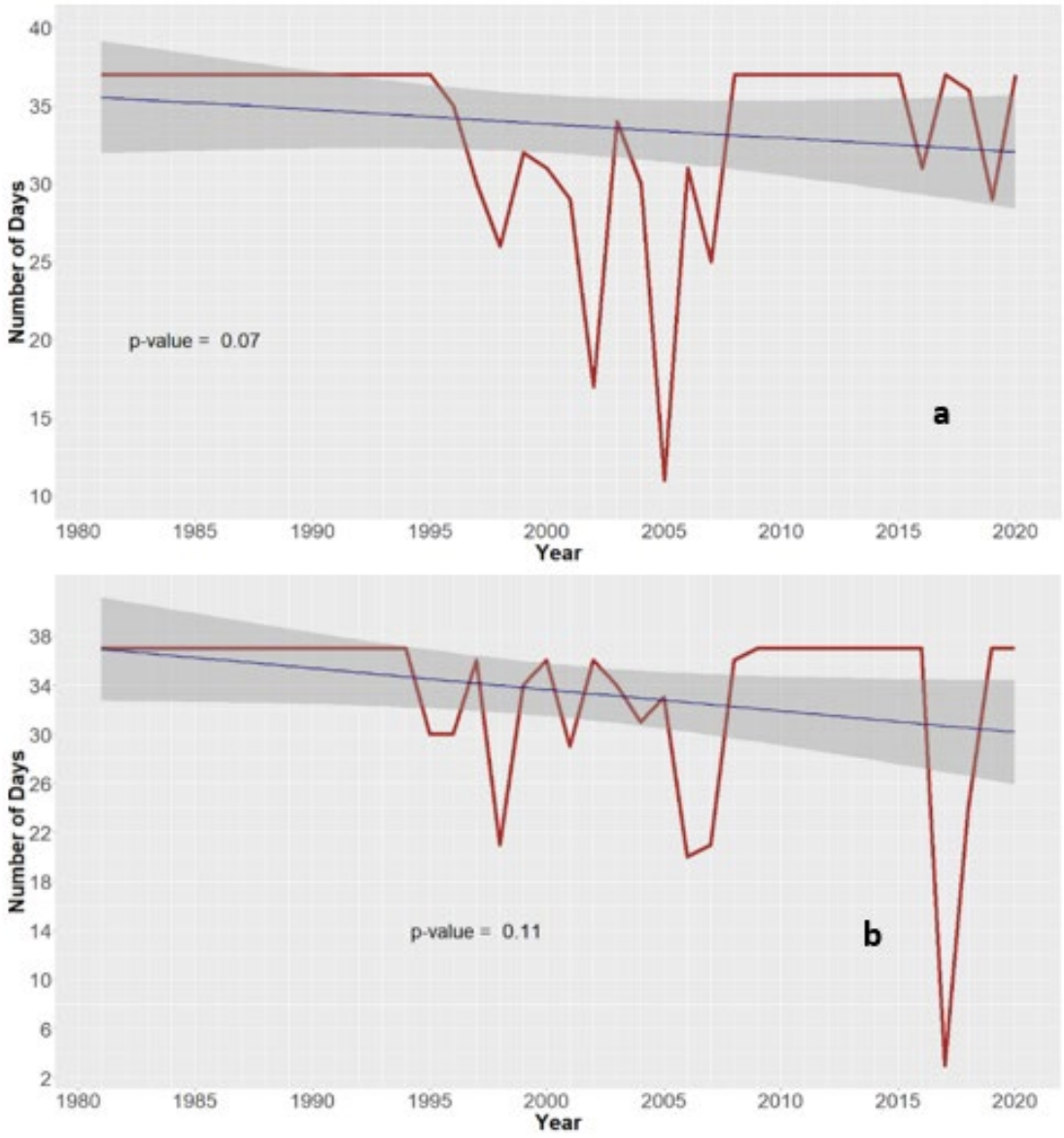



Source: Klutse & Asare, 2022.

### 3.2.2.4 Frequency of Hot Days and Nights

The number of hot days decreased in Kintampo over the period assessed, with considerable variability from 1994 to 2008 (Figure 3.10). The red lines in the graphs represent the observed number of days for the respective climate variable over time, allowing us to track changes from year to year. The grey bars indicate the confidence intervals, which show the range within which we can be certain the true value lies, given a certain level of confidence. There were 37 hot days recorded in 1981, a number that stayed consistent until 1995, when a period of wide variability began that lasted until 2008. A consistent number of hot years occurred from 2010 to 2016, followed by 6 years that varied slightly in their numbers of hot days. The fewest hot nights in Kintampo were recorded in 2017 (Figure 3.10b). The assessment of the frequency of hot days and hot nights at Kintampo revealed a general decreasing but non-significant trend over the past 40 years.

**Figure 3.10. Frequency of hot days (a) and hot nights (b) over Kintampo**




Source: Klutse & Asare, 2022.

## 3.1.3 Summary of Historical Climate Information for 1980–2020

- Average annual rainfall in Kintampo has decreased slightly since 1980 and is variable on monthly and annual scales. While the decreasing trends in the number of days of rain and average annual rainfall in Kintampo are not significant, rainfall amounts are inconsistent from year to year. This variability makes planning and decision-making difficult.
- The number of rainy days in a given year varied widely, consistent with interannual variations in total annual rainfall, and is generally decreasing. The last 8 years have been dry over Kintampo, with less rainfall than average. This lower overall rainfall will impact rainfall distribution, which may affect agriculture and other rainfall-dependent livelihood activities.
- Heavy rainfall events showed a slight downward trend, though it was not significant. It is however important to note that these events may vary across the Municipality. Years with more heavy rainfall events may also have more floods, which can have significant impacts on local communities, causing damage to infrastructure, displacing people, and disrupting livelihoods.
- While there was wide variation in the number of days with continuous rainfall, the downward trend in wet spell duration was significant. The duration of wet spells over Kintampo decreased significantly from 9 days in 1980 to 4 days in 2021, with wide variability during the intervening years.
- Dry spell duration is increasing. While variability was high, Kintampo experienced an increasing trend in the length of dry spells. The shortest dry period observed was 6 days (1995) and the longest was 26 days (in 1983, 2013, and 2014).
- A significant increasing trend in mean annual minimum temperature was recorded, with a slight year-to-year variation. The period from 1980 to 1994 was characterized by generally colder conditions, while the years from 1995 to 2013 alternated between warmer and cooler anomalies. Since 2014, there has been a consistent trend towards warmer temperatures, aligning with the global pattern of rising temperatures. Additionally, both daytime and nighttime temperatures have seen a significant rise over the last 7 years in Kintampo. However, it is important to distinguish this from the frequency of extreme temperature events, which has been decreasing, although this latter trend is not statistically significant. The frequency of hot days and hot nights in Kintampo generally decreased, though not significantly, from 1980 to 2020, although the numbers of hot days and hot nights varied from year to year. The temperature during the day peaked in February, and the nighttime temperature peaked in March.
- The mean annual maximum temperature increased significantly from 1980 to 2020. Since 2008, temperatures above the long-term mean have been consistently recorded, indicating warming in Kintampo.
- The temperature during the day peaked in February, and the nighttime temperature peaked in March.

- There is evidence of climate change in Kintampo, particularly reflected in temperature trends, which have shown a clear increase. However, it's important to recognize that the observed decreasing trends in rainfall-related variables also represent evidence of climate change, affecting different climate and weather parameters in the KiMA.

### 3.1.4 Kintampo Municipality Seasonal Change Calendar

The seasonal calendar of Kintampo Municipality was discussed with participants at the workshop and in key informant interviews. In discussions during the participatory workshop and key informant interviews about the Kintampo Municipality's seasonal calendar, participants shared their personal observations of shifts in the timing of food crop production and in the practices of poultry and livestock rearing. These activities form the backbone of livelihoods for most communities and households in the region. The collective insights from these discussions highlighted noticeable changes in the seasonal patterns that are traditionally known and followed by the locals. The seasonal calendar in the context of the Kintampo Municipal Assembly refers to a yearly timeline outlining the socio-economic and livelihood activities (mainly agricultural) that align with the different seasons (wet and dry) and their characteristics. This calendar includes planting seasons, harvesting seasons, periods of high rainfall, periods of drought, and any significant seasonal events that may affect farming (Table 2).

**Table 2. Seasonal change calendar for Kintampo Municipality (based on agricultural cycle; varies per community)**

| Season (length) | Key events (annual cycle) | Typical climate | Observed changes | Observed impact |
|---|---|---|---|---|
| Dry Season (November-March) | Sensitization and training of farmers on bush fire prevention | No rains | Previously started in December | High incidence of bushfires |
| | Harvesting of grains and cereals | Very cool during the day | | Increase in farm destructions by Fulani herdsmen |
| | Dry season farming, especially vegetables using irrigation | Very windy and dusty | | Difficulty in performing farming operations such as raising of mounds |
| | Commencement of land preparation for farming activities | Hot and dry weather | | Difficulty in getting feed for livestock |
| | | | | Drying up of water bodies |
| | | | | Difficulty in harvesting roots and tuber crops |
| | | | | Reduction in pests and diseases infestation |
| Major Rainy Season (April-June) | Planting by farmers | Frequent and heavy rains accompanied by thunderstorms | Currently occurring between June and September | High incidence of pests and diseases |
| | | | | Erosion increases |
| | | | | Growing of vegetation |

| Season (length) | Key events (annual cycle) | Typical climate | Observed changes | Observed impact |
|---|---|---|---|---|
| | | | | Rivers and streams overflow their banks |
| | | | | Leaching of soils and depletion of nutrients as a result of heavy rains |
| Minor Rainy Season (July-October) | Planting continues, especially with grains and cereals | Less and discontinuous rains | Shifted to November | Reduction in bushfires |
| | Post-harvest trainings in storage, processing, and marketing | | | |
| | Harvesting of farm produce | | | |

Source: Participatory mapping and key informant interviews, 2022.

Observed changes on the district seasonal calendar refer to changes in these traditional timelines and activities that are caused by external factors. These factors might include shifts in climate patterns, such as alterations in the timing, intensity, and duration of rainy and dry seasons, or fluctuations in temperature. For instance, if the onset of rains is delayed or the dry season is extended, the planting and harvesting schedule is significantly impacted. This shifted schedule results in crop failures, reduced yields, and food insecurity, thereby affecting the livelihoods of farming communities in Kintampo Municipality.

The time frame for the observed changes could be a decade, two decades, or more, depending on the availability of data and the specific impacts being studied. The observed changes are generally compared against a baseline period in the past to provide a clearer picture of how climatic variables have changed over time and farming practices have evolved in response.

## 3.2 Qualitative Assessment of Vulnerability to Climate Change in Kintampo Municipality

This section of the assessment explains how climate change is affecting the social, economic, ecological, and political situations of households and communities in Kintampo Municipality. The section assesses results from qualitative data collection activities, including the review of existing documents, key informant interviews, participatory workshops, and expert observations. In this assessment, the terms “extreme climate events,” “climate hazards,” and “climate change-related hazards” are used interchangeably to encompass the wide range of weather and climate-related phenomena that have significant impacts on natural and human systems in the Municipality. This approach allows us to address the broad spectrum of climate-related challenges without delving into the specific statistical or causal distinctions that might separate an “extreme event” from a “hazard.” The focus is on the overarching implications of these phenomena, including their frequency, intensity, and potential for causing damage or disruption, which are all exacerbated under current climate change trends.

### 3.2.1 Evidence of Extreme Climate Events in the Municipality

The geographical location of Kintampo Municipality exposes it to extreme climate events all year round. Extreme weather events such as extreme floods, excessive rainfall, drought, and windstorms negatively affect various sectors of the local economy, including agriculture, transportation, health, tourism, and forestry. In the agricultural sector, extreme climate events like increased temperatures, variable rainfall, and windstorms affect the yield and income of small-scale farmers.

From Table 3, bushfires, floods, and windstorms appear to be the major climate-related extreme events affecting communities and households in the municipality. The agricultural sector is the most vulnerable sector to climate change in Kintampo Municipality, according to this inventory of seasonal extreme climate events.

**Table 3. Overview of seasonal extreme climate events**

| Year | Occurrence | Climatic or non-climatic | Description of damage | Affected sectors | Number of affected people | Source (e.g., literature, survey etc.) |
|---|---|---|---|---|---|---|
| 2022 | Bushfires | Climatic and non-climatic | 200-acre rice farm burnt by bushfire in Kintampo | Agriculture | | MyNewsGH. (n.d.). |
| 2022 | Windstorm/ rainstorm | Climatic | Destruction of homes and schools in the Asantewa area | Education, households, agriculture | N/A | Express News Ghana. (2022, July 16). |
| 2017 | Windstorm | Climatic | Death of students on excursion at Kintampo waterfalls due to the collapse of trees | Education | 20 students were injured or killed | MyJoyOnline. (2017, March 20). |
| 2017 | Windstorm/ rainstorm | Climatic | Destruction of 16 household, health, and educational facilities (CHPS/SDA basic school) | Education and health | 40 | Ghanaweb (2017) MyJoyOnline. (2017, March 20). |
| 2013 | Bushfire | Climatic (medium confidence) and non-climatic | Destruction of farmlands and crops | Agriculture | N/A | Global Fire Monitoring Center (GFMC). (2013, December 11). |

## 3.2.2 Vulnerability to Climate Change-Related Hazards in Kintampo Municipality

The vulnerability of different sectors to climate change-related hazards in Kintampo Municipality varies, with some sectors being more susceptible than others. Available evidence suggests that a significant portion of the employed population (70% of the total population) is engaged in a climate-sensitive sector such as agriculture.

### 3.2.2.1 Ranking of Climate Change-Related Impacts on Socio-Economic Sectors

Preparation of this VA included a ranking of the potential impacts of climate change-related hazards on the various sectors of the KiMA (Table 4). This assessment used secondary data to support information from a review of the existing literature and discussions with key KiMA stakeholders, including the Municipal Coordinating Director, Municipal Agriculture Director, Municipal Planning Officer, Municipal Health Officer, and climate change focal person. Climate change-related hazards and their potential impacts to five key sectors were ranked using a scale from 1 to 5, with 5 = high, 4 = medium-high, 3 = medium, 2 = medium-low, and 1 = low.

**Table 4. Ranking of the impact of climate change–related hazards on key socio-economic sectors.**

| Sector | Certainty of impact | Timing of impact | Severity of impact | Importance of resource | Weighted average |
|---|---|---|---|---|---|
| Agriculture | 5 | 5 | 5 | 5 | 5 |
| Tourism | 4 | 4 | 4 | 5 | 4.7 |
| Water resources | 4 | 4 | 5 | 5 | 4.5 |
| Forestry | 5 | 4 | 5 | 5 | 4.5 |
| Transportation | 4 | 2 | 3 | 3 | 3.25 |

Source: Validation Workshop with stakeholders, 2023.

These five key sectors contribute significantly to the economic well-being of communities and households in Kintampo Municipality, as described below based on the KiMA Planning Report:

- **Agriculture:** Agriculture is the backbone of the local economy in Kintampo. The sector provides employment opportunities for more than two-thirds of the population and contributes to food security and income generation. Farmers in the municipality cultivate various crops, including cocoa, maize, yam, millet, sorghum, and vegetables. The agricultural sector not only sustains livelihoods but also generates income through the sale of agricultural produce, both within the municipality and for wider markets.
- **Tourism:** Kintampo is known for its natural attractions, including the Kintampo waterfalls, Fuller falls, and the Tanoboase Sacred Grove. These tourist sites draw visitors from within Ghana and abroad, contributing to the local economy. The tourism sector generates revenue through visitor expenditures, including accommodation, food services, transportation, and souvenir sales. Additionally, tourism creates employment opportunities in the hospitality industry, tour guiding, and related services.

- **Water resources:** Kintampo Municipality is endowed with water resources including rivers, streams, and waterfalls. These water sources provide opportunities for fishing, irrigation, and water-based activities. Fishing activities contribute to the local economy by providing a source of income and protein-rich food for the community. Furthermore, the availability of water resources supports agricultural activities, enabling farmers to cultivate crops and sustain their livelihoods.
- **Forestry:** The municipality is also rich in forest resources. The forestry sector contributes to the local economy through timber production, non-timber forest product harvesting, and ecotourism. Timber production involves the sustainable extraction and processing of timber from forest reserves, providing employment and income for local communities. Non-timber forest products, such as medicinal plants, honey, and shea butter, offer additional economic opportunities. Furthermore, the preservation and promotion of forest ecosystems attract tourists interested in ecotourism and wildlife conservation.
- **Transportation:** Transportation plays a crucial role in facilitating economic activities within Kintampo Municipality. Well-connected transportation infrastructure, including road networks and transport services, enables the movement of agricultural produce from farms to markets and processing facilities. It also facilitates trade and commerce, linking the municipality with neighbouring regions and markets. The transportation sector itself creates employment opportunities and contributes to the local economy through services such as public transport, logistics, and freight handling.

#### 3.2.2.2 Sectoral Assessment of Climate Change Impacts

The participatory workshop (Figure 3.11) provided a platform for participants to identify and discuss the various ways in which climate change affects different sectors, and the subsequent implications for social, ecological, economic, and cultural systems. This section presents the findings from the workshop, focusing on the vulnerability of selected sectors within Kintampo Municipality to climate change-related hazards. Led by the lead researcher (Figure 3.12), the vulnerability assessment was conducted using exposure, sensitivity, and adaptive capacity scales.

During the workshop, 37 participants (19 men and 18 women) ranked the vulnerability of the five sectors to climate change. The appendices show a list of stakeholders who participated in the different workshops. During the workshop, a total of 37 participants engaged in evaluating the vulnerability of five sectors to climate change impacts. The composition and contributions of the participants were as follows:

- **Academic Professionals:** Two participants, offering scholarly insights on climate change impacts and adaptation strategies.
- **Farmer Groups:** Four groups represented, highlighting the agrarian focus of the region and sharing firsthand experiences of climate vulnerabilities in agriculture.
- **Private Sector Experts:** Three participants, providing perspectives on how climate change affects private sector operations and opportunities for resilience.
- **Traditional Authorities:** Three representatives, ensuring the inclusion of cultural perspectives and traditional knowledge in addressing climate vulnerabilities.

- **Governmental Representatives:** 15 delegates from various departments, including:
  - Ghana National Fire Service
  - National Youth Authority
  - Ministry of Food and Agriculture
  - Ghana Education Service
  - Ghana Health Services
  - Forestry Commission
  - Kintampo Municipal Assembly
  - District Chief Executive
  - Department of Urban Roads
  - Contributing to the alignment of workshop discussions with regional and national policy directives
- **Other Sector Representatives**: Six participants from vulnerable groups and other sectors, adding diversity to the discussions.
- **Regional and Municipal Entities**: Over 27 attendees, ensuring robust local expertise and insight into the discussions.

**Organizations and Institutions Represented**:

- Tropenbos Ghana
- College of Health Kintampo
- Kintampo Health Research
- Abotre Ye Process Group
- University of Development Studies
- Women's Group
- Local and National Media

Participants were guided to provide justifications for their vulnerability rankings, aiming to achieve a comprehensive understanding of the different sectors' susceptibilities within the municipality.

**Figure 3.11. Workshop participants displaying their map of vulnerability to climate change in Kintampo Municipality**


Source: Validation workshop, 2023.

## Agriculture

According to the Ministry for Food and Agriculture, agriculture is the most important economic activity, engaging more than 70% of the population in Kintampo municipality (GSS, 2022). Food crop production and livestock rearing are both common in the municipality, with food crops being grown by almost every household. The main crops cultivated in the municipality are yams, maize, cowpeas, cassava, rice, plantain, egusi, groundnuts, and beans. Additional foods such as cashews, mangoes, tomatoes, onions, watermelons, garden eggs, and soybeans are also farmed by households and communities. Cattle, goats, sheep, and poultry are also reared in communities across Kintampo Municipality.

Climate change can have negative impacts on crop yields (Challinor, Wheeler et al. 2007). Wrigley-Asante et al. (2019) indicated that rainfall variability in the transitional zone of Ghana has affected food production. In the municipality, rainfall variability, extreme temperatures, and long drought periods affect yam tubers and cassava stakes, which are both very sensitive to changes in temperature. Several additional crops have been found to be highly sensitive to climate-related hazards in Kintampo Municipality. Low yields of staple crops during drought periods are observed in parts of the municipality. Farmers surveyed for this VA indicated that several major staple crops, including maize, sorghum, rice, millet, groundnuts, okra, cassava, and yams, are sensitive to climate-related risks and hazards. Rainfall variability has been linked to crop failure in the area and this variability is expected to increase during the minor rainy season (Owusu & Waylen, 2013).

Crop production is expected to be negatively impacted by climate variability in the transitional zone, consistent with regional projections of a decrease in vast areas of the West African cocoa belt as a result of climate change and increased prevalence of pests and diseases (Asante & Amuakwa-Mensah, 2014). Extreme temperatures will also intensify the incidence of bushfires, leading to the destruction of farms. Coupled with high farm input costs and harvest losses, particularly during the harvesting season, food crop farmers will feel the brunt of these climatic stressors. In the long run, food and health security will be jeopardized as more and more people lose the ability to contribute to the agricultural sector.

The participatory workshop confirmed some of the findings from the review of existing literature and key informant interviews. Participants in the workshop highlighted the following as direct outcomes and vulnerabilities of the agricultural sector to climate change-related hazards in the municipality:

- Emergence of pests and diseases, such as fall army worm
- Low crop yields during the harvesting season
- More frequent bushfires
- Windstorms negatively affect households on a seasonal basis

In addition, the migratory or nomadic patterns of Fulani herdsmen have shifted as a result of climate change. The new patterns can have implications for the environment and exacerbate climate change effects such as vegetation destruction, farmland degradation, and increased risk of bushfires. As studies have shown (Dhakal, & Kattel,2019; Thornton & Herrero, 2012), climate change can alter the availability and distribution of natural resources, including water and grazing lands, which are essential for nomadic pastoralists like the Fulani herdsmen. Shifts in rainfall patterns, prolonged droughts, and changing vegetation cover often disrupt traditional grazing routes and force herders to search for alternative grazing areas, sometimes encroaching on farmland or protected areas. As the Fulani herdsmen seek suitable pastures and water sources for their livestock, they inadvertently contribute to vegetation destruction. Overgrazing in the municipality occurs when the number of livestock exceeds the carrying capacity of the land, resulting in the depletion of grasses and other vegetation. Additionally, the movement of herds, particularly during dry seasons, can increase the risk of bushfires. Dry grasses trampled by the livestock are easily ignited, and human activities such as cooking or campfires can lead to accidental bushfires, which can spread rapidly in the dry, vulnerable vegetation. These bushfires not only destroy vegetation but also release carbon dioxide and other greenhouse gases into the atmosphere, contributing to climate change.

**Figure 3.12. Dr. Boafo presenting on the NAP process to workshop participants**


Source: Validation workshop, 2023.

Workshop participants assessed the vulnerability of the agricultural sector to specific climate change hazards, and the results are presented in Table 5. A ranking of high exposure, and sensitivity was determined by 70% of participants rated it high. Exposure and sensitivity were directly ranked, revealing that the sector is highly sensitive to climate change hazards. However, the assessment of adaptive capacity differs; it is calculated as the average of the exposure and sensitivity rankings. This approach highlights that the sector's ability to adapt is closely linked to its exposure to and sensitivity towards climate change impacts.

Table 5 evaluates the vulnerability of the agricultural sector to various climate hazards based on exposure, sensitivity, and adaptive capacity. Floods show high exposure and sensitivity but have a medium adaptive capacity. Droughts are rated with high exposure and sensitivity, yet with a high adaptive capacity. Erosion and Bushfires show a medium vulnerability across all criteria. Windstorms are considered to have medium exposure and sensitivity, but low adaptive capacity. Pests and diseases have medium exposure, high sensitivity, and medium adaptive capacity. Low rainfall has a high exposure, medium sensitivity, and high adaptive capacity. Lastly, excessive rainfall is considered to have high exposure, medium sensitivity, and low adaptive capacity.

**Table 5. Workshop participants' ratings of agricultural sector vulnerability to climate hazards**

| | Agriculture sector vulnerability rating | | |
|---|---|---|---|
| **Climate hazard** | **Exposure** | **Sensitivity** | **Adaptive capacity** |
| Flood | | | |
| Drought | | | |
| Erosion | | | |
| Bushfires | | | |
| Windstorms | | | |
| Pests and diseases | | | |
| Low rainfall | | | |
| Excessive rainfall | | | |
| *Interpretation* | **High** | **Medium** | **Low** |

Source: Participatory workshop, 2022.

### Tourism

KiMA lies at the geographic centre of Ghana. The district's rich historical heritage is one of its main draws for tourists, including the Slave Market, Kunsu Caves and Night Lamp, and the European Cemetery where eight of the "Gold Coast Regiment" were buried. The British established several operational offices in Kintampo, which was the seat of the Commissioner of the Ashanti Region, and several of the original British buildings from the colonial period are still standing. The main natural attractions are the Kintampo waterfall, where the Pumpum river falls 70 m down rocky steps before continuing its journey toward the Black Volta at Buipe (Figure 3.13), and the Fuller falls 7 km west of Kintampo, which provides a pool and stool-like carved rocks for sitting. These natural sites have been sources of tourism revenue for the Kintampo Municipal Assembly.

Extreme climatic events such as windstorms negatively affect the tourism industry in Kintampo Municipality by leading to a decline in demand (personal communication, tourism operator, 2022). For example, storms of 2017 recently pulled down trees at the Kintampo waterfall site, leading to the injury and deaths of some tourists (MyJoyOnline, 2017). Such unfortunate situations could lead to a reduction in the number of tourists at these attractions and potentially erode the financial gains from the tourism industry, consequently affecting the resources available to the municipality for development projects.

**Figure 3.13. View of the Kintampo waterfall, a popular tourism attraction**

Source: Boafo et al., 2022.

A tourism facility owner at Kintampo waterfall summarized the impact:

> Since the recent windstorm that caused trees to fall at the Kintampo Waterfall site, the number of visitors has significantly declined. The incident not only resulted in the tragic injury and loss of lives but also generated fear and concern among potential tourists. The negative impact of extreme climatic events on tourism cannot be understated, as it has directly affected the demand for visiting the falls.

Participants at the workshop highlighted the following issues as climate change risks and impacts on the tourism sector in Kintampo Municipality:

- Heavy rainfall and windstorms uprooted trees around the Kintampo waterfall, causing injury and death and limiting access. The restriction of access hampered the overall tourism experience and contributed to a decline in visitor numbers, impacting the local economy and livelihoods dependent on tourism.
- Water dries up in the drought season: The drying up of water during the drought season significantly impacts tourist visits to Kintampo falls. The falls are a major attraction for visitors due to their picturesque cascades and the captivating experience of being surrounded by flowing water. However, decreased water levels or a complete lack of water during the drought season diminish the appeal and overall visitor experience.
- Tourism facilities are poorly developed: The increased frequency and intensity of extreme weather events such as storms and heavy rainfall have damaged tourism infrastructure, including hotels, resorts, roads, and recreational facilities.

Table 6 illustrates the opinions of participatory workshop participants on the vulnerability of the tourism sector to climate hazards. Floods are perceived to have high exposure and sensitivity with a medium adaptive capacity. Drought shows medium exposure, sensitivity, and adaptive capacity. Erosion has medium exposure and sensitivity but low adaptive capacity. Bushfires are seen as having medium exposure, high sensitivity, and medium adaptive capacity. Windstorms rate high on exposure and sensitivity with low adaptive capacity. Pests and diseases display medium exposure and sensitivity, coupled with high adaptive capacity. Low rainfall has low exposure, sensitivity, and adaptive capacity, indicating a minimal impact on tourism.

**Table 6. Workshop participants' ratings of tourism sector vulnerability to climate hazards**

| Climate hazard | Tourism sector vulnerability rating | | |
|---|---|---|---|
| | Exposure | Sensitivity | Adaptive capacity |
| Flood | | | |
| Drought | | | |
| Erosion | | | |
| Bushfires | | | |
| Windstorms | | | |
| Pests and diseases | | | |
| Low rainfall | | | |
| Excessive rainfall | | | |
| *Interpretation* | **High** | **Medium** | **Low** |

Source: Participatory workshop, 2022.

### Forestry (Biodiversity and Ecosystems)

In the Kintampo Municipality, forest resources (biodiversity and ecosystems services) are indispensable to human well-being, providing a diverse array of benefits that span economic, ecological, and cultural dimensions. Timber from local forests supports construction and furniture making, offering sustainable employment opportunities. Non-timber forest products, such as medicinal plants, shea butter, and honey, play critical roles in health care, nutrition, and income generation, particularly for women engaged in shea butter processing. These forests are also pivotal in delivering ecosystem services like water regulation and climate regulation, ensuring clean water supply and mitigating climate change by sequestering carbon dioxide, which in turn supports agricultural productivity and reduces the risk of extreme weather events.

The forestry sector is therefore a key livelihood asset for the municipality (Asumang-Yeboah et al., 2022), providing food, income, and construction materials to the people of Kintampo Municipality. Prolonged and indiscriminate wood extraction continues to affect the transitional ecosystem. Illegal mining operations (galamsey, or small-scale gold mining), unregulated wood logging, and intensive large-scale charcoal production are collectively causing considerable damage to the forest ecosystem—potentially transforming the vegetation into an advanced savannah zone (Aabeyir et al., 2016).

Forests that have become degraded due to excessive logging are more vulnerable to climate change because they are more susceptible to fire as logging residues dry up and become more combustible. The unsustainable practices of galamsey operators (due to its extensive environmental degradation, water pollution, health hazards) (Mantey et al., 2020). Also have repercussions for households in the municipality, where bushfires have become a major problem. Deforestation and bushfires, for example, reduce the soil fertility and forest cover, and consequently affect the forest ecosystem.

Workshop participants highlighted the following issues as climate change risks and threats to the forestry sector in Kintampo Municipality.

- Bushfires were rated as the most serious climate hazard affecting the integrity of the forests in the KiMA. Illegal logging activities result in the extraction of valuable timber, but also make the forests more susceptible to bushfires as they often leave behind branches, slash, and other logging residues that serve as fuel.
- Extensive and indiscriminate removal of wood for the production of charcoal also causes significant harm to the forest ecosystem, resulting in the loss of the region's rich forest vegetation. The workshop participants expressed religious sentiments by stating that the plants were gifts from God to humans and that they must be used responsibly. Attendees also highlighted how the habitats of local animals had been destroyed as a result of these human activities.
- Workshop participants agreed that the relationship between charcoal production and climate impacts in Kintampo is contingent upon the sustainability of production practices. Unsustainable charcoal production has resulted in deforestation and land degradation, exacerbating climate change impacts. However, sustainable charcoal production, including selective tree harvesting and proper management of harvested areas, can contribute to adaptation efforts and increase the resilience of the municipality's forests to climate change.

- Longer droughts and dry spells contribute to the loss of forest cover, which is also largely caused by illegal small-scale mining operators (galamsey operators) who destroy forests and associated ecosystem elements like water sources.

Table 7 presents the vulnerability of the forestry sector to climate hazards as rated by participants of a workshop. The sector shows high exposure to floods, with a medium sensitivity and a low adaptive capacity. Drought is perceived with medium exposure and sensitivity, but with a low adaptive capacity. Erosion and Bushfires are both rated as having high exposure and sensitivity, with Bushfires having a medium adaptive capacity. Windstorms and Pests and Diseases are considered to have medium exposure and sensitivity; however, the adaptive capacity for Windstorms is low, while for Pests and Diseases, it is high. Low rainfall has low exposure, sensitivity, and adaptive capacity, suggesting minimal vulnerability. Excessive rainfall is viewed as having high exposure, medium sensitivity, and low adaptive capacity.

**Table 7. Workshop participants' ratings of forestry sector vulnerability to climate change hazards**

| Climate hazard | Forest Sector Vulnerability Rating | | |
|---|---|---|---|
| | Exposure | Sensitivity | Adaptive capacity |
| Flood | | | |
| Drought | | | |
| Erosion | | | |
| Bushfires | | | |
| Windstorms | | | |
| Pests and diseases | | | |
| Low rainfall | | | |
| Excessive rainfall | | | |
| *Interpretation* | **High** | **Medium** | **Low** |

Source: Participatory workshop, 2022.

### Water Resources

The major sources of water in KiMA are wells, boreholes, rivers, streams, and standpipes. Currently, the water situation in the municipality is relatively promising, though several rivers have shown signs of drying up. Some rivers and streams have also been narrowing due to bad farming practices and mining activities (personal communication, Planning Officer, KiMA). Rainfall is one of the major recharge sources for groundwater, which is the largest source of water for domestic use. Instances of wells drying up have been reported by community leaders, farmers, and agricultural extension officers, who have direct interactions with and knowledge of the local water resources. Farmers, who rely heavily on water for farming and livestock-rearing purposes, are particularly attuned to changes in water availability. Their observations and experiences provide valuable evidence of the drying up of water sources, affecting their agricultural productivity and livelihoods. These changes are partly blamed on rainfall patterns, which have been erratic in recent years based on Ghana Meteorological Agency data and anecdotal evidence. Extreme temperature conditions that lead to drying up of water sources can generate conflicts, exacerbate the risk of sanitation-related and waterborne diseases, and spur the proliferation of insects that spread diseases, as well as reduce water accessibility for domestic and irrigation purposes.

Some of the issues raised at the participatory workshop include:

- Drying up of rivers due to high temperatures and erratic rainfall. The prolonged dry season, which is partially attributed to the recent increase in erratic rainfall patterns, has forced the Cheranda community to divert river water to their farms for irrigation, preventing nearby communities like Gulumpe, Kwampe, and Atta-Akura from using the same river for domestic purposes.
- Flooding of major rivers and lakes. Flooding resulting from heavy rains has significantly affected Kintampo falls and the surrounding communities. Flooding has damaged infrastructure, including schools, homes, and health centres, and led to the displacement of communities. Homes and livelihoods have been destroyed or severely damaged, forcing residents to evacuate temporarily or permanently.
- Shortage of water for domestic use.
- High demand for water among households and communities.

Table 8 reflects the vulnerability ratings of the water sector to various climate hazards, based on exposure, sensitivity, and adaptive capacity, as determined by participants in a workshop. The sector exhibits high exposure and sensitivity to floods, with a medium adaptive capacity, suggesting a significant risk yet some potential to manage impacts. Drought shows medium exposure, high sensitivity, and low adaptive capacity, indicating vulnerability due to a reduced ability to adjust to water scarcity. Erosion has high exposure and sensitivity, paired with a medium adaptive capacity. Bushfires are represented with low exposure and sensitivity, but a high adaptive capacity, suggesting a lesser concern for the water sector. Windstorms are rated with medium exposure and sensitivity, and low adaptive capacity. Pests and Diseases have low exposure and sensitivity, but the sector has a high adaptive capacity to address these hazards. Low rainfall is seen as having a medium exposure, high sensitivity, and medium adaptive capacity. Excessive rainfall presents high exposure, medium sensitivity, and low adaptive capacity, implying that heavy rain events pose a significant threat to the water sector due to limited coping strategies.

**Table 8. Workshop participants' ratings of water resources sector vulnerability to climate hazards**

| Climate hazard | Water Sector Vulnerability Rating | | |
|---|---|---|---|
| | Exposure | Sensitivity | Adaptive capacity |
| Flood | | | |
| Drought | | | |
| Erosion | | | |
| Bushfires | | | |
| Windstorms | | | |
| Pests and diseases | | | |
| Low rainfall | | | |
| Excessive rainfall | | | |
| *Interpretation* | **High** | **Medium** | **Low** |

Source: Participatory workshop, 2022.

### Transportation

The transportation network within Kintampo Municipality is currently inadequate. Apart from the main trunk road, many of the district's roads suffer from poor development and limited upkeep and maintenance.

Within the municipality, the main lorry stations are situated at the Kintampo market (four stations) and the Babatokuma market (one station). However, access to the hinterlands on non-market days proves challenging due to the poor surface conditions of feeder roads. The situation is exacerbated by erosion resulting from heavy rainfall, which further hampers transportation. In addition, floods in Kintampo Municipality have obstructed access to communities by destroying road networks. This lack of access results in significant challenges for the affected communities, which become isolated and face difficulties in accessing essential services, including health care facilities, schools, markets, and emergency response resources. Flooding poses a significant problem in major towns, such as Kintampo and Babatokuma, where choked gutters and unauthorized structures and buildings obstruct road networks and drainage systems, leading to increased negative impacts of flooding. The damage to transportation infrastructure due to climatic conditions result in financial losses for Kintampo Municipality. Extreme climatic events, including flooding, windstorms, erosion, and thunderstorms, are expected to worsen the already precarious state of the transportation networks.

Workshop participants emphasized the following climate change impacts on transportation:

- Lack of transportation options leads to post-harvest losses. Farm products often rot because they cannot be transported to markets in a timely manner. The absence of well-maintained roads, bridges, and transportation networks restricts the movement of farm produce, making it difficult for farmers to reach potential buyers or transport their products to distant markets. Farmers invest significant time, effort, and resources into cultivating and harvesting their crops. However, if these products cannot be transported promptly, they are susceptible to spoilage, degradation, or damage, leading to substantial financial losses for farmers. Post-harvest losses not only impact the income of individual farmers but also have broader implications for food security, market stability, and the overall economy of Kintampo Municipality.
- High temperatures expand tarred roads and accelerate deterioration. High temperatures can exacerbate the formation of ruts and potholes on tarred roads. As the road surface expands under extreme heat, it becomes more susceptible to deformation and indentation caused by vehicle traffic. The repeated passage of vehicles over the weakened road surface can further worsen the rutting and pothole formation, compromising the road's smoothness and ride quality.
- Windstorms affect road accessibility. Weakened trees are more likely to lose branches or topple over during strong winds, blocking roads and impeding transportation. Fallen trees are hazardous to road users and require immediate removal to restore accessibility. The frequency of tree-related road obstructions has increased as climate change leads to more frequent windstorm events.
- Erosion makes roads impassable. Erosion contributes to the deterioration of road surfaces in the municipality, especially in Kintampo township. When soil erosion occurs along the edges or shoulders of roads, it can undermine the integrity of the road structure. One workshop participant stated:

  "I have witnessed firsthand the detrimental effects of erosion on road infrastructure. The erosion-induced damage has made several roads unmotorable, severely disrupting transportation networks and isolating communities in the Kintampo Municipality. It is crucial that we prioritize erosion control measures and invest in regular maintenance to ensure the longevity and accessibility of our road systems."

Table 9 workshop participants' assessments of the transportation sector's vulnerability to climate hazards Floods are considered to have high exposure and sensitivity, but a medium adaptive capacity, indicating that flooding poses a significant risk to transportation infrastructure, although some measures are in place to manage these risks. Drought has low exposure and sensitivity, along with a high adaptive capacity, suggesting minimal impact on transportation. Erosion is seen with medium exposure, high sensitivity, and medium adaptive capacity, indicating concerns for infrastructure stability. Bushfires have low exposure and sensitivity, but a medium adaptive capacity, while Windstorms show medium exposure and sensitivity but low adaptive capacity, highlighting potential disruptions. Pests and Diseases have low ratings across all three metrics, implying limited direct impact on the transportation sector. Low rainfall and excessive rainfall are both rated with medium exposure and sensitivity; however, excessive rainfall has a low adaptive capacity, suggesting that heavy rains could significantly disrupt transportation services due to the sector's limited ability to cope with these events.

**Table 9. Workshop participants' ratings of transportation sector vulnerability to climate hazards**

| Climate hazard | Transportation Sector Vulnerability Rating | | |
|---|---|---|---|
| | Exposure | Sensitivity | Adaptive capacity |
| Flood | | | |
| Drought | | | |
| Erosion | | | |
| Bushfires | | | |
| Windstorms | | | |
| Pests and diseases | | | |
| Low rainfall | | | |
| Excessive rainfall | | | |
| *Interpretation* | **High** | **Medium** | **Low** |

Source: Participatory workshop, 2022.

### 3.2.3 Ranking the Most Severe (Impactful) Climate Hazards

Workshop participants ranked the five most impactful climate-related hazards to which the municipality is exposed (Table 10). There was overwhelming agreement that bushfires are the most impactful, followed by windstorms.

The effects of climate change combined with unsustainable management practices have increased bushfire risk in Kintampo Municipality. Bushfires are more common in the north, where grassland is interspersed with trees and the temperature is higher. The area experiences a long dry spell between October and April that contributes to the drying up of vegetation. The increase in temperatures in recent years exacerbates bushfires, which are often caused by spontaneous lightning or lit by residents for agricultural purposes (e.g., to facilitate the growth of new grass for livestock) and for hunting. The communities most affected by bushfires in Kintampo Municipality include Cheranda, Babato, Dawadawa, and New Longoro.

Data on human-caused fires in the municipality is lacking. However, anecdotal evidence of bushfires in the area can be connected to the frequency of long dry spells, and many communities are affected (Agriculture Officer, KiMA MOFA). The Kintampo Municipal Assembly has taken steps to prevent and control bushfires, such as public education and awareness creation measures. However, the situation is anticipated to deteriorate further due to projected increases in maximum temperatures in the area over the coming decades.

**Table 10. Ranking the severity of the impact of climate-related hazards in Kintampo Municipality**

| Hazard | Rank (severity of impact) |
|---|---|
| Bushfires | 1 |
| Windstorms | 2 |
| Drought | 3 |
| Pests and diseases | 4 |
| Floods | 5 |

Source: Participatory workshop, 2022.

Kintampo Municipality has witnessed an escalation in flood-related disasters due to heavy thunderstorms, leaving several villages vulnerable to the devastating consequences. An example of such a calamity occurred in 2010, when 3 consecutive days of torrential rain led to the destruction of seven communities along the Kintampo–Buipe route. Communities such as Taihiru Akuraa, Bawa Akuraa, Mahama Akuraa, Jato Akuraa, Cheranda, Ata Akuraa, and Dawadawa were among those severely impacted by the floods (Chronicle, 2010).

Floods in Ghana, including those in Kintampo Municipality, are typically attributed to a combination of climatic and non-climatic factors, including land topography, inadequate management of surface runoff, and the intensity of rainfall. In the transitional zone, which encompasses Kintampo Municipality, there is a higher likelihood of reduced rainfall in the near future compared to the Sudan savannah, deciduous forest, and forest-savannah biological zones. However, as temperatures rise, rainfall intensity is expected to increase due to the capacity of warmer air to hold more water vapour.

While specific data on floods in Kintampo Municipality may be limited, a National Disaster Management Organization (NADMO) officer who participated in stakeholder engagements acknowledged that flooding is a widespread problem with significant and diverse impacts on various communities within the municipality.

### 3.2.4 Gender and Climate Change Issues

Gender-based vulnerabilities to climate change in Kintampo Municipality are a pressing concern requiring attention and action. Climate change impacts such as increased temperatures, erratic rainfall patterns, and extreme weather events disproportionately affect women and girls, exacerbating existing gender inequalities and vulnerabilities. Secondary information highlights the unique challenges faced by women in the municipality and underscores the need for gender-responsive climate change adaptation and mitigation strategies.

Several underlying factors exacerbate women's vulnerability to the impacts of climate change, including limited livelihood options, traditional cultural and social practices, and limited education. Though more than half of the population (60.7%) of Kintampo Municipality is literate, there are more non-literate women (45.8%) than non-literate men (32.6%; Figure 3.14; Ghana Statistical Service, 2020). Education is an important aspect of social development. It is the process of acquiring knowledge, skills, values, and attitudes to fully develop individual capacities, and education can positively impact the decision-making processes of women as they adapt to climate change.

**Figure 3.14. Gendered literacy characteristics in Kintampo**


Source: Field survey, 2022.

Skilled agriculture, forestry, and fisheries are the industries that employ the most workers of both genders, employing 62.1% of men and 46.2% of women (Boateng, 2020). However, the high illiteracy rate among women leads to fewer women being employed in the formal sector. Less involvement in economically viable sectors can also lead to income disparities, with negative implications for women's welfare, adaptability to climate variability and change, and involvement in decision making.

The VA team's review determined that existing climate-related actions and programs on climate change impacts in the municipality have few or no considerations of gender. One exception is the Climate Change, Agriculture, and Food Security (CCAFS) program implemented by the International Center for Tropical Agriculture (CIAT) in Ghana, which has had significant benefit for the Kintampo municipal area. This program aims to improve climate change resilience and food security among smallholder farmers. It recognizes the importance of gender mainstreaming and includes activities that address gender-based vulnerabilities and promote women's participation and leadership in climate-smart agriculture. The National Climate Change Gender Action Plan (NCCGAP), developed by the Environmental Protection Agency (EPA) of Ghana, seeks to integrate gender considerations into climate change policies and programs at the national level. Although its direct implementation may vary across different regions and municipalities, the NCCGAP provides a framework for mainstreaming gender in climate change actions, programs, and adaptation planning in Kintampo Municipality.

Women and youth are particularly vulnerable to the impacts of climate change in Kintampo Municipality. Their high reliance on natural resources for subsistence, coupled with limited access to decision-making processes and resource allocation, exacerbates existing disparities and leaves them more susceptible to the adverse effects of climate change. Promoting the active involvement and participation of women, youth, children, the elderly, and other vulnerable groups in the formulation and implementation of climate change adaptation projects is essential. Engaging these stakeholders ensures that their perspectives, needs, and priorities are considered, leading to more effective and inclusive climate change initiatives in Kintampo Municipality. To foster resilience and enhance adaptive capacities among vulnerable groups in the Kintampo Municipality, particularly women and youth, the following strategic initiatives are proposed.

- Capacity building and empowerment: Providing training and capacity-building opportunities for women and youth in the municipality can enhance their knowledge and skills related to climate change adaptation. This empowerment can enable them to actively participate in decision-making processes, project implementation, and natural resource management, thereby increasing their resilience and agency in the face of climate change impacts.
- Access to resources and livelihood opportunities: Ensuring equitable access to resources, such as land, water, and credit, is crucial for women and youth in Kintampo Municipality. Facilitating their access to sustainable livelihood opportunities, including climate-smart agriculture, renewable energy initiatives, and entrepreneurship, can reduce their vulnerability and enhance their adaptive capacities.
- Awareness and education: Promoting awareness and education on climate change, its impacts, and adaptation measures is essential for women, youth, and other vulnerable groups. Providing information through targeted outreach campaigns, workshops, and community-based programs can empower them to make informed decisions and adopt sustainable practices that enhance their resilience.

# 3.3 Quantitative Assessment of Climate Change Vulnerability

## 3.3.1 Methodological Approach

There are various methods for assessing vulnerability depending on the objective, the available data, and the restrictions. For this VA, the team used various engagement processes (including a participatory risk mapping workshop and engagement with Assembly Planning Officers and traditional authorities) and a review of the literature to select and sample climate change-vulnerable communities and socio-economic sectors. The multifaceted approach to identify vulnerability parameters for Kintampo Municipality involved reviewing scientific research to identify common climate change vulnerability factors (e.g., rainfall variability, temperature extremes). The team also consulted stakeholders (local farmers, community leaders, NGOs, and government officials) to understand unique local factors contributing to climate vulnerability, including specific land-use practices and crop types.

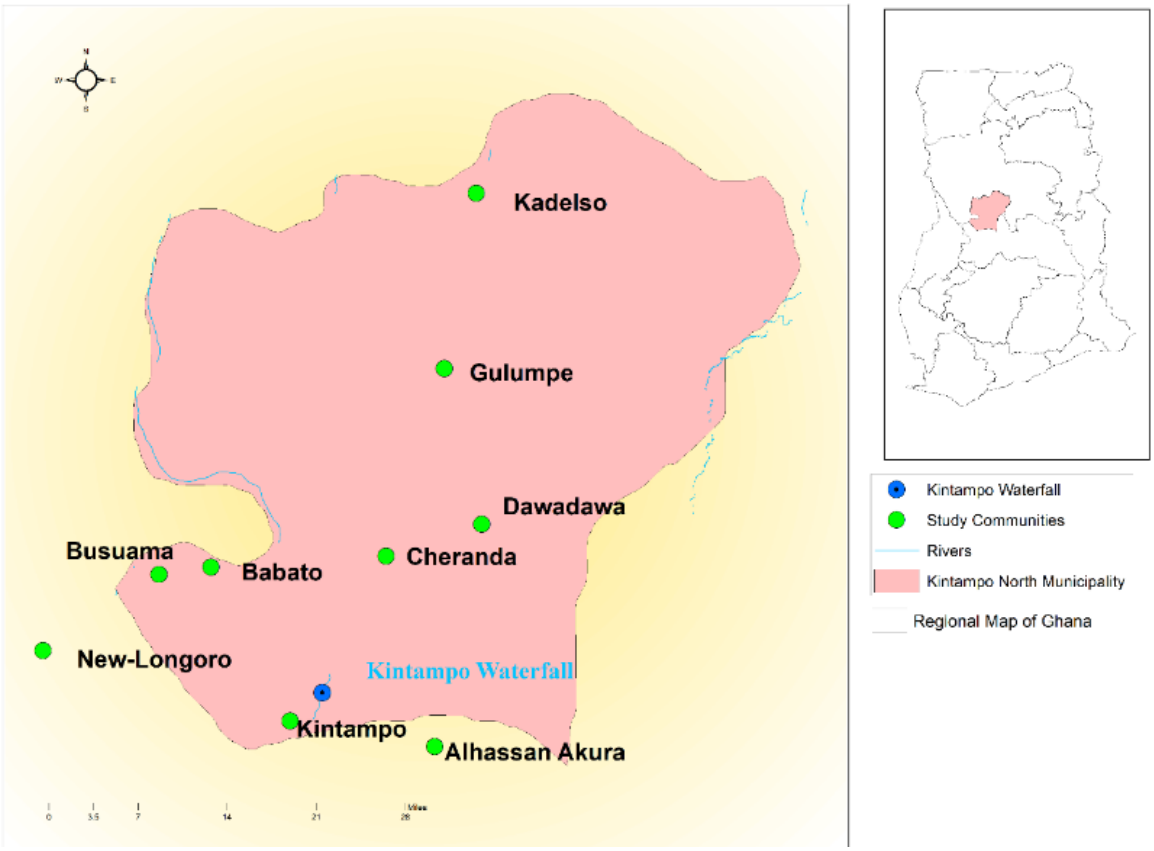
To select communities for the quantitative survey, the VA team used the purposive sample method to identify communities vulnerable to climate-related hazards. The ranking process was conducted using secondary data obtained through an extensive review of existing literature and engaging in discussions with key stakeholders from KiMA, including the Municipal Coordinating Director, Municipal Agriculture Director, Municipal Planning Officer, Municipal Health Officer, and the designated Climate Change focal person. We also considered places with high and low population densities in order to comprehend their dynamics of vulnerability. Agricultural hubs and areas where charcoal burning and forestry degradation are prevalent were among the communities sampled. We sampled a total of 153 households from nine communities, including two communities that were prone to hazards (35 households total), two high-density populated areas (60 households), two low-density populated areas (20 households), two agricultural centres (20 households), and one charcoal-burning/forest-degraded community (18 households). In selected communities with an average household size of 4.1 persons or more, enumerators moved across the community. The nine communities (and numbers of households) were Kintampo (n = 30), Kadelso (n = 15), Gulumpe (n = 15), Dawadawa (n = 15), Cheranda (n = 15), Babato (n = 15), Busuama (n = 15), New Longoro (n = 15), and Alhassan Akuraa (n = 18) (Map 2).

The sectors assessed for this study were agriculture, tourism, forestry (biodiversity and ecosystems), water resources, and transportation, which are all sectors of focus of the NAP process in Ghana. The qualitative vulnerability assessment results were used to derive indicators that quantitatively measured the vulnerabilities identified in the communities and sectors of the municipality. These indicators encompassed a range of dimensions, including socio-economic, environmental, and institutional aspects. They provided measurable metrics to assess the severity and magnitude of vulnerabilities related to climate change impacts across sectors evaluated for this assessment. Various stakeholders and experts attested to the questionnaire's validity.

Both quantitative and qualitative methods were used in the data analysis. Questionnaires were derived based on the variable for each indicator and administered to a predetermined sample size of households in each community. Data enumerators (primarily staff from the municipal assembly) were trained to visit the communities and interview households to collect the needed information digitally and save it to a cloud database.

Sensitivity in Kintampo Municipality measures the impact of climate-related factors on a sector. For example, in agriculture, a sensitivity assessment examines how crop yields shift in response to changes in temperature or precipitation. The resulting sensitivity is normalized on a scale from 0 (insensitive) to 1 (highly sensitive). Adaptive capacity assesses a system's resilience and ability to mitigate potential damage from climate change or exploit opportunities that arise. Adaptive capacity—calculated based on parameters like resource availability, technology, infrastructure, and social capital—is normalized on a scale from 0 (low adaptive capacity) to 1 (high adaptive capacity). In this normalized scale, a sector with high sensitivity and low adaptive capacity is more vulnerable to climate change. Conversely, a sector is less vulnerable if it exhibits low sensitivity and high adaptive capacity.

**Map 2. Map of Kintampo showing the location of the surveyed communities**




Source: VA Team Field survey, 2023.

The IPCC (2022) defines vulnerability as the propensity or predisposition to be adversely affected and includes three components: exposure, sensitivity, and adaptive capacity. The quantitative vulnerability assessment determined the magnitude and rate of variation in climate change vulnerability components across the communities and sectors. The district-specific climate change vulnerability was calculated using the IPCC equation:

***Climate change vulnerability (CCV) = (Exposure x Sensitivity) – Adaptive Capacity*** ***Equation 1***

The climate change vulnerability index has a scale of –1 to +1, with –1 indicating low vulnerability and +1 indicating high vulnerability. A negative index indicates that the combined effects of exposure and sensitivity to climate change are less than the capacity of the impacted population to adapt to the changes, meaning the population has the capacity to adapt to the expected changes. On the other hand, a positive index indicates that the adaptive capacity of the impacted population is lower than the combined effects of exposure and sensitivity. In this case, efforts are urgently needed to enhance the population's adaptive capacity.

The parameters for each component are further divided into general and sector-specific categories. General parameters were used for community-level vulnerabilities, while sector- specific parameters were used for sectoral vulnerabilities. The VA team collected information and data on the vulnerability parameters (sensitivity and adaptive capacity) listed in Table 11 from the survey of 153 households. The vulnerability parameters were identified through a systematic approach that included a review of existing literature and stakeholder engagement through interviews and workshops. Primary data was collected through surveys and observations, including climate data analysis and identification of relevant vulnerability indicators. Weighting and scoring systems were applied to assess vulnerability levels and were followed by data analysis and integration. Vulnerability mapping using GIS techniques helped visualize high- and low-vulnerability areas.

**Table 11. Vulnerability parameters assessed for the study**

| Vulnerability parameters | Scale | Variables | Spatial data |
|---|---|---|---|
| Exposure | Community | Mean annual rainfall | |
| | | Average number of Consecutive Dry Days (CDD) | |
| | | Average number of Consecutive Wet Days (CWD) | |
| | | Average number of warm days | |
| | | Average number of days of heavy precipitation | |
| | | Annual minimum temperature | |
| | | Annual maximum temperature | |
| | | Frequency of flood events | |
| | | Frequency of long dry spells | |
| Sensitivity | Community | % of community population with livelihoods dependent on rainfed agriculture | |
| | | % of community population living in flood-prone areas | |
| | | % of community population with challenges with water access | |
| | | % of community population with challenges with health care access | |
| | | % of community population with no education | |

| Vulnerability parameters | Scale | Variables | Spatial data |
|---|---|---|---|
| Adaptive capacity | Community | Social | % of community population belonging to a social organization |
| | | | % of community population on NHIS |
| | | | % of community population with alternative livelihoods |
| | | Economic | % of community population with access to credit |
| | | | % of community population that receive remittances from family and friends |
| | | | % of community population with access to safe sanitation facilities |
| | | | % of community population with access to good road network |
| | | Infrastructure | % of community with market access |
| | | Individual knowledge | % of community population that received awareness training on climate-related events |
| | | Access to information | % of community population with access to early-warning systems |

Source: Field survey, 2022. Ley informant interviews and participatory workshop.

## 3.3.2 Vulnerability Index

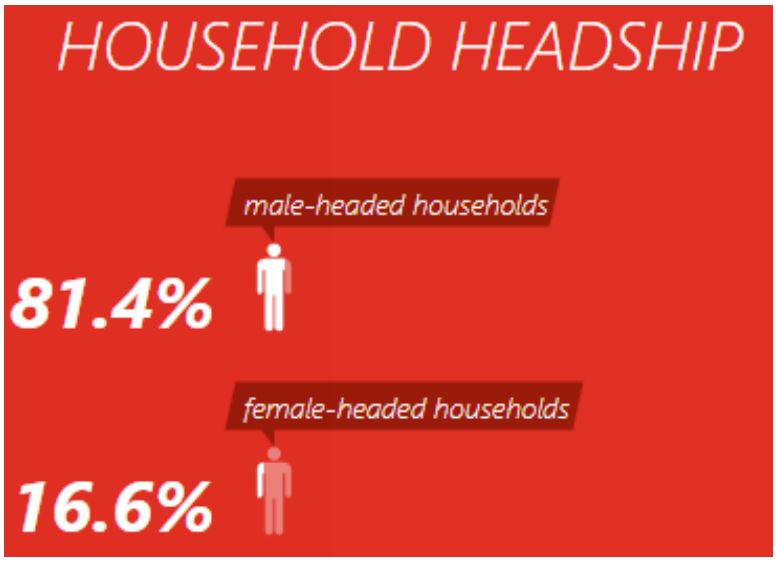
### 3.3.2.1 Overall Household Socio-Demographics Data

This section shows the demographic characteristics of respondents in the study area.

***Distribution of Female- and Male-Headed Households***

Of the 153 households assessed, 81.4% were headed by men and 16.6% were headed by women (Figure 3.15), despite efforts to interview available women household heads. This disparity may be due to the local culture and religion, which inhibits female leadership and contributions to major decision making. The dominance of male-headed households compared to female-headed households in Kintampo can have implications for the vulnerability of households to climate change. The local culture and religious norms that inhibit female leadership and involvement in major decision-making processes might limit women's access to resources, information, and opportunities to build resilience against climate change impacts. This gender disparity could result in increased vulnerability for female-headed households, as they may face challenges in adapting to climate-related hazards and accessing support systems.

**Figure 3.15. Distribution of male- and female-headed households**

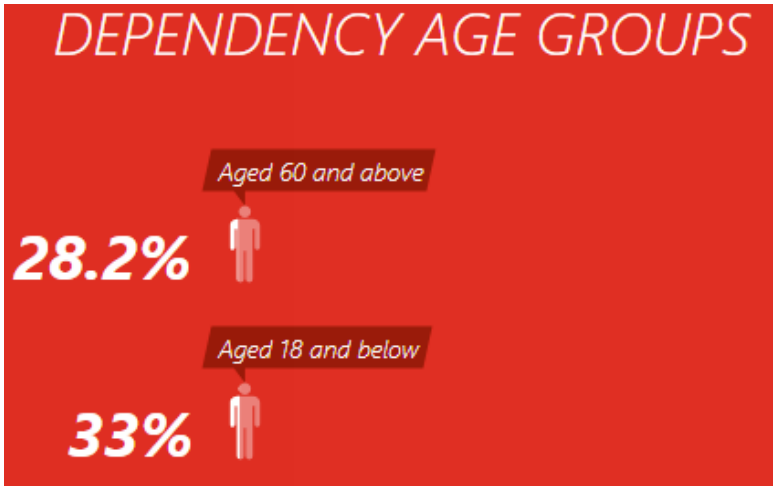



Source: Field survey (Household Questionnaire), 2022.

***Age Distribution of Dependents***

Across the surveyed communities, 28.2% of all household members were aged 60 and above, whereas 33% of household members were aged 18 and below (Figure 3.16). More than half of the population is either under 18 or over 60, compared to the 39.8% of adults between those ages. The presence of a substantial older adult population and a significant number of children places an increased care burden on working-age adults. Climate change events such as extreme weather, heat waves, or prolonged droughts can disrupt normal daily routines and require additional resources and support to care for vulnerable family members, such as young children or older adults. Additionally, these vulnerable family members may be more susceptible to health risks associated with climate change, including heat-related illnesses, waterborne diseases, and malnutrition.

**Figure 3.16. Distribution of dependency age groups of survey respondents**

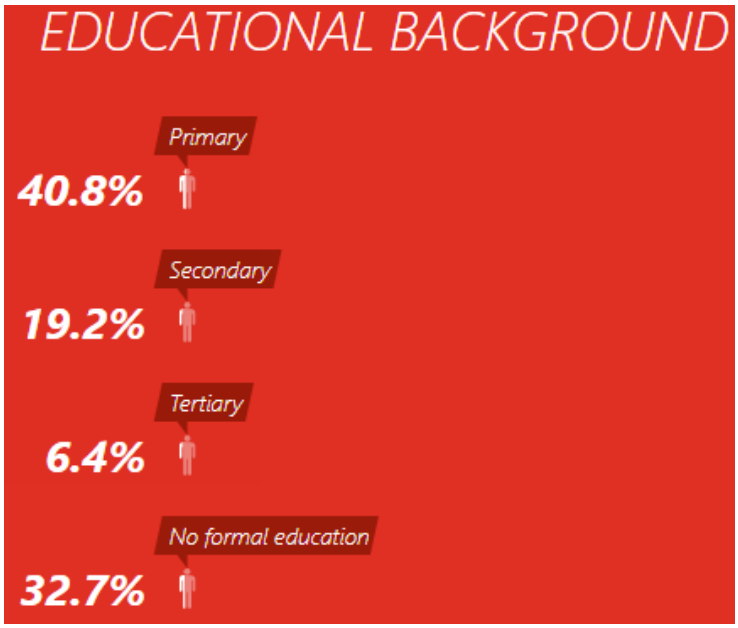



Source: Field Survey (Household Questionnaire), 2022.

***Highest Level of Formal Education***

Figure 3.17 shows the highest level of formal education attained by the household heads surveyed. The majority of household heads (40.8%) reported primary school to be their highest level of formal education, followed by secondary-level education (19.2%). Significantly, 32.7% of the household heads surveyed stated that they had no formal education.

**Figure 3.17. Highest level of education attained by household heads**




Source: Field survey, 2022.

The findings suggests that many individuals may have limited access to formal information about climate change, its impacts, and available adaptation strategies. This lack of knowledge can hinder their ability to understand and respond effectively to climate-related risks, making them more vulnerable to the adverse effects of climate change. Household heads with lower levels of formal education may face challenges in accessing resources, services, and support systems needed to cope with climate change impacts, including climate information, financial resources, technology, and training opportunities. Consequently, their ability to adopt climate-resilient practices, implement adaptation measures, and access support networks may be constrained, leading to increased vulnerability.

***Involvement in Socio-Economic Sectors (Occupation)***

The overwhelming majority (73.1%) of respondents were involved in the agricultural sector (Figure 3.18), followed by household heads who were engaged in the service sector (21.8%). The infrastructure sector employed a marginal percentage of household heads (3.8%). The service sector in the municipality encompasses various industries and activities, including hospitality and tourism, retail and wholesale trade, financial services, transportation and logistics, professional and business services, health care and social assistance, education and training, as well as communications and information technology. The infrastructure sector includes the development and maintenance of

essential physical structures and facilities including transportation, energy, water and sanitation, and housing infrastructure.

**Figure 3.18. Household heads involvement in socio-economic sectors in KiMA**

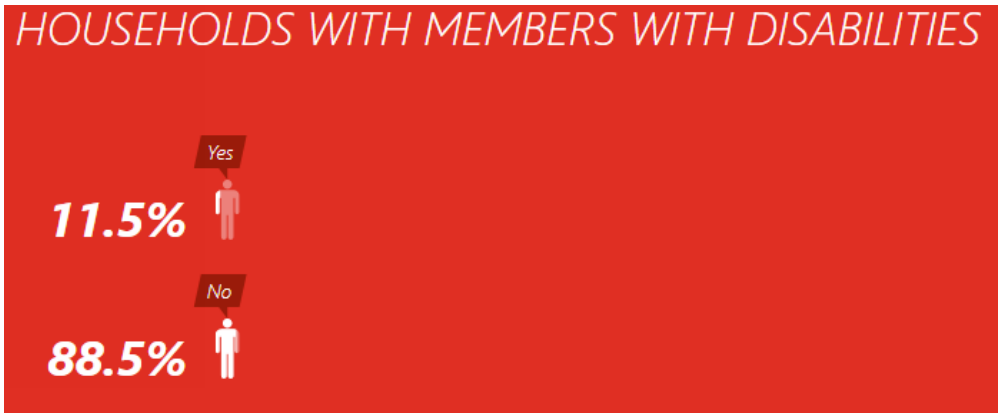

Source: Field survey (Household Questionnaire), 2022.

The majority of household heads were engaged in the agricultural sector, making them vulnerable to climate change impacts such as crop failure resulting from erratic rainfall. The high dependence on agriculture and the interconnectedness of sectors highlights the need for climate-smart agriculture, diversification of livelihoods, resilient service industries, and investments in climate-resilient infrastructure to reduce vulnerability to climate change in Kintampo.

***Household Members with Disabilities***

Figure 3.19 shows that 11.5% of respondents reported having household members with disabilities. Households with members who have disabilities may face challenges in accessing resources and services needed to cope with climate change impacts. They may also be more susceptible to health risks and face social exclusion and marginalization, limiting their participation in resilience-building efforts.

**Figure 3.19. Percentage of survey respondents with household members with disabilities**



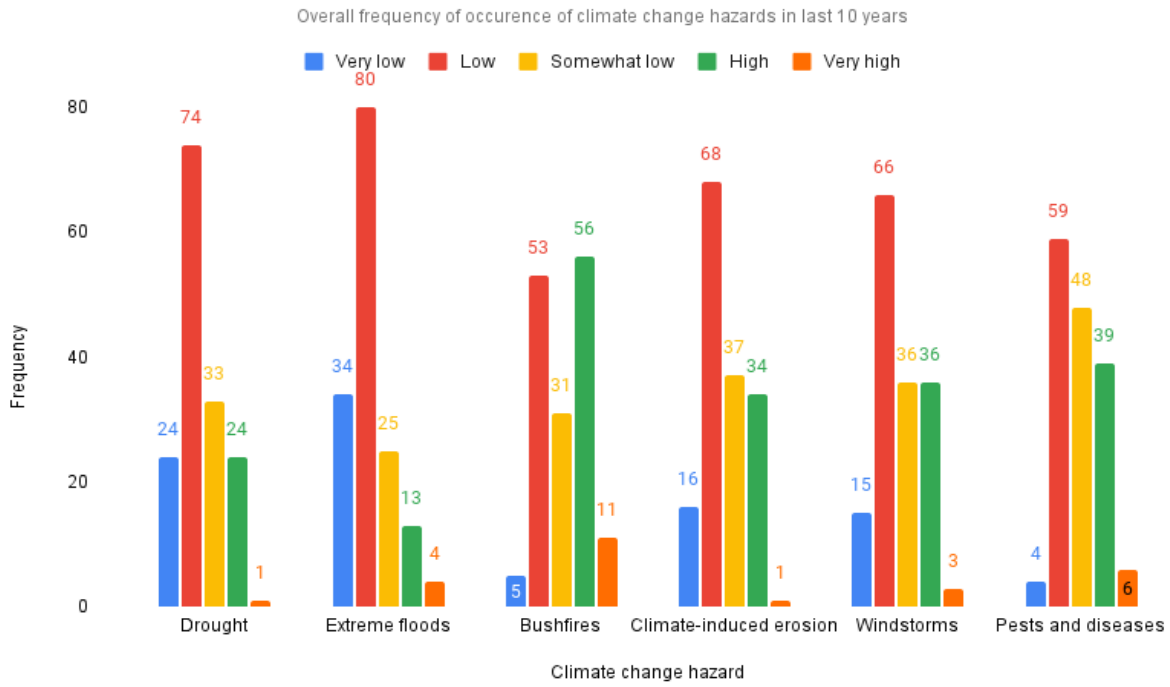

Source: Field survey (Household Questionnaire), 2022.

### 3.3.2.2 Exposure Results

This section reports on the household heads' perceived levels of exposure to the different climate-related hazards assessed for this study (droughts, bushfires, extreme floods, climate-induced erosion, windstorms, and pests and diseases). The responses were collected during the household questionnaire surveys administered in randomly sampled communities and households in Kintampo Municipality. The responses were measured on a Likert scale (1 = very low to 5 = very high).

Figure 3.20 illustrates the perceived frequency of various climate change hazards in the KiMA over the last 10 years, as perceived by survey respondents. Drought and extreme floods are primarily considered to occur with "very low" frequency, receiving the highest counts. These hazards also have significant counts in the "low" frequency category. In contrast, bushfires are seen as a more prevalent hazard, with the majority of respondents rating their occurrence as "high." Additionally, bushfires have the highest number of "very high" frequency ratings amongst all the hazards, although this number is relatively small. Climate-induced erosion is largely perceived to have a "somewhat low" frequency, with the highest count of all the ratings in this particular hazard category. Windstorms are also reported to occur with a "somewhat low" frequency but have a fairly even distribution of responses across the "low" to "high" frequency categories. Pests and diseases are similarly rated as "somewhat low" by most, but there is a considerable number of respondents who consider their occurrence "high."

**Figure 3.20. Exposure to assessed climate-related hazards in Kintampo Municipality**




Source: Field survey, 2022.

One clear example of the high exposure to bushfires in Kintampo Municipality is the occurrence of frequent bushfires in the dry season, when the municipality experiences dry and hot conditions that increase the risk. The dry vegetation, coupled with human activities such as farming practices and land clearing, can lead to the rapid spread of fires. These bushfires pose a threat to agricultural lands, natural resources, and human settlements, impacting livelihoods and ecosystems. One household head in the Cheranda community shared this concern during the questionnaire survey:

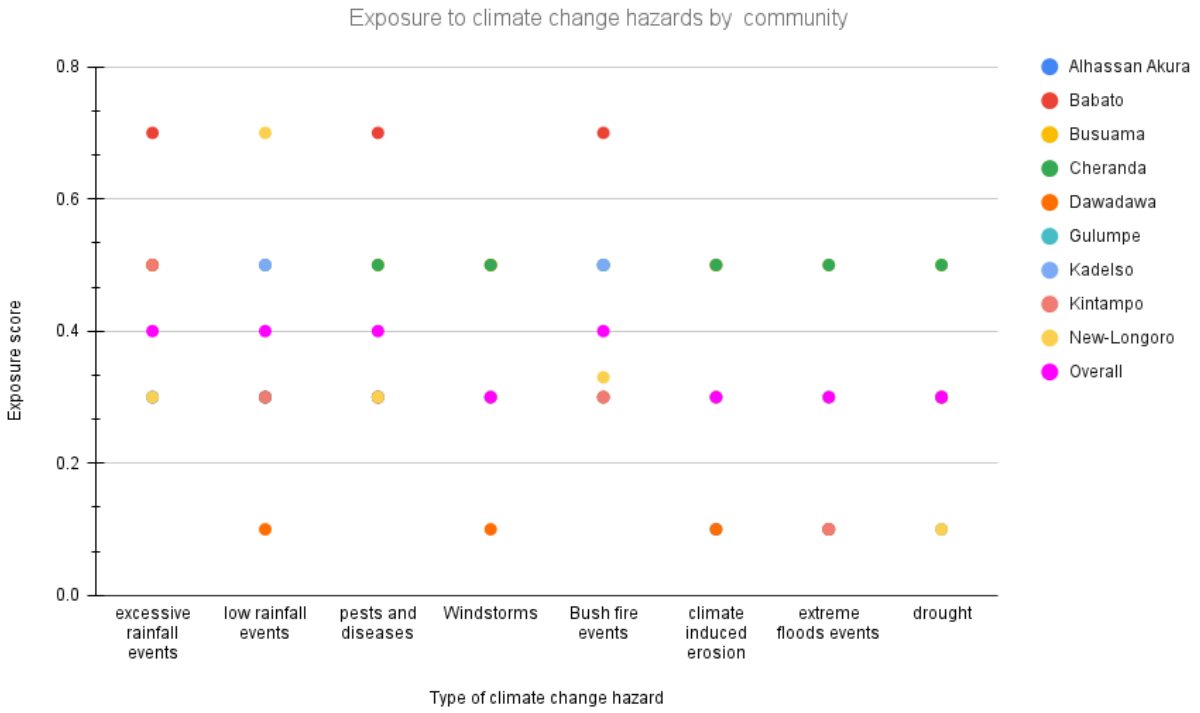
> Look, young man, people in this and the adjoining community and in fact the whole of the Kintampo area are very careless when it comes to the use of fire for farming and hunting. I say so because they set the fire to burn their farm in preparation for the farming season without constructing belts. This is a well-known strategy for avoiding burning but out of laziness, they do not do it. The hunters are also to blame for several fires in the dry season. Please educate people as you go to their homes to talk about bushfires. (Farmer, 57 years old)

Following bushfires, pests and diseases were identified as the second-highest hazard with “high” and “very high” exposure ratings. In the context of agriculture, pests and diseases can cause significant damage to crops, affecting food production and the livelihoods of farmers. For example, infestations of pests like fall armyworms have led to crop losses, impacting the income and food security of farmers in Kintampo Municipality.

Windstorms were also identified as a hazard with “high” and “very high” exposure ratings. Windstorms have often resulted in structural damage, particularly to housing and infrastructure. In the rural areas of the municipality where housing is often constructed with traditional materials, strong winds cause houses to collapse, leading to the displacement of households and economic losses. Additionally, windstorms can disrupt power supply and transportation networks, affecting daily life and economic activities in the municipality.

According to the scatter chart (Figure 3.21), the climate hazards that most households and communities in Kintampo Municipality are exposed to include bushfires, excessive rainfall events, pest and diseases, and low rainfall events. When analyzing the exposure index by community, it was observed that Babato households have a high exposure to excessive rainfall events, low rainfall events, and bushfires. Similarly, Cheranda has high exposure to multiple climate change hazards such as windstorms, pests and diseases, climate-induced erosion, and drought. Map 3 further supports these findings, illustrating the exposure ratings of different communities and the types of hazards they are exposed to.

**Figure 3.21. Exposure to climate change hazards in Kintampo Municipality**

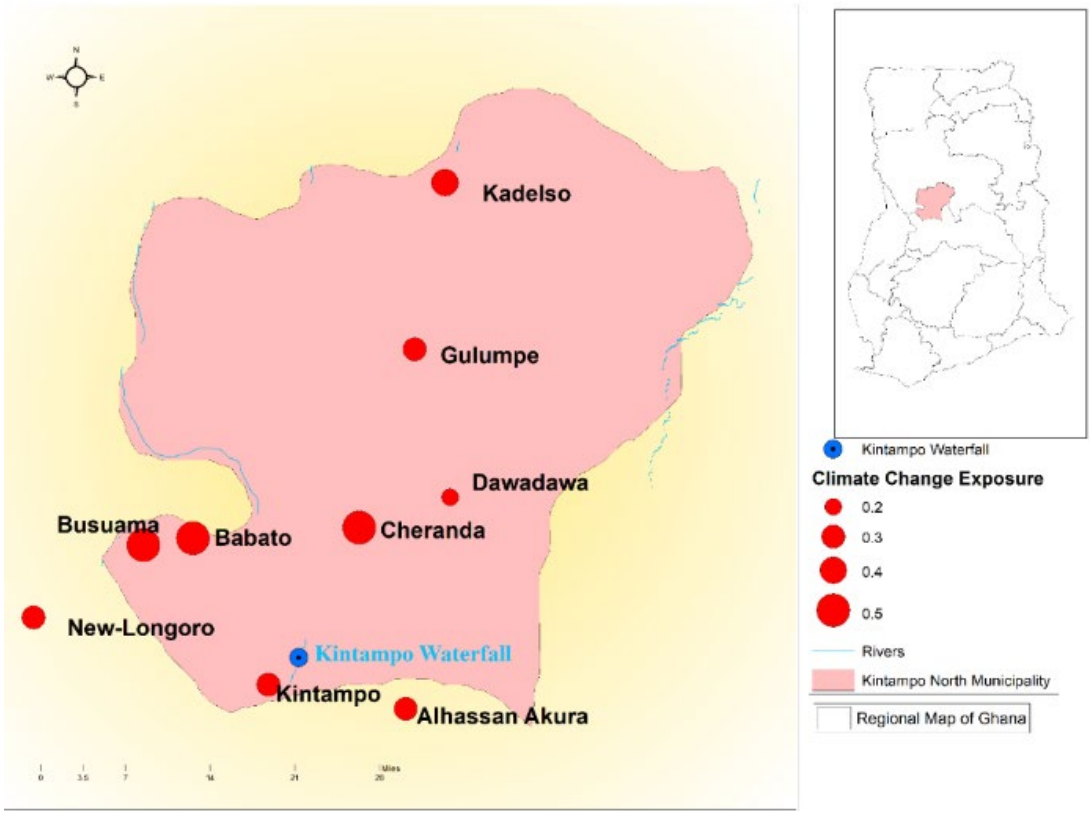



Source: Field survey, 2022.

For example, Babato's proximity to rivers and low-lying areas may contribute to its high exposure to excessive rainfall events, putting its households at risk of flooding and associated damage. Additionally, the presence of dry vegetation or inadequate fire management practices may increase the vulnerability of the community to bushfires.

Cheranda's location in an area prone to windstorms and erosion could explain their high exposure to these hazards. The prevalence of certain crops susceptible to pests and diseases may also contribute to their vulnerability to those hazards. Moreover, the community's reliance on rainfall for agriculture and limited access to water resources may amplify the impacts of drought events on their livelihoods.

**Map 3. Mapping of community-level overall exposure to climate change hazards**




Source: Field survey, 2022.

Table 12 shows sub-indicators related to community exposure to various climate change-induced hazards in Kintampo Municipality. These sub-indicators include the frequency of droughts and dry spells, extreme floods, climate-induced erosion, bushfires, windstorms, pests and diseases, low rainfall events, and excessive rainfall events. The numbers in the table represent the frequency of occurrence or severity of each climate change-induced hazard in different communities or regions. The values range from 0.1 to 0.7, with a higher value indicating higher frequency or severity. The average index at the bottom provides an overall assessment for each community.

**Table 12. Sub-components of the exposure to climate change hazards index in Kintampo Municipality**

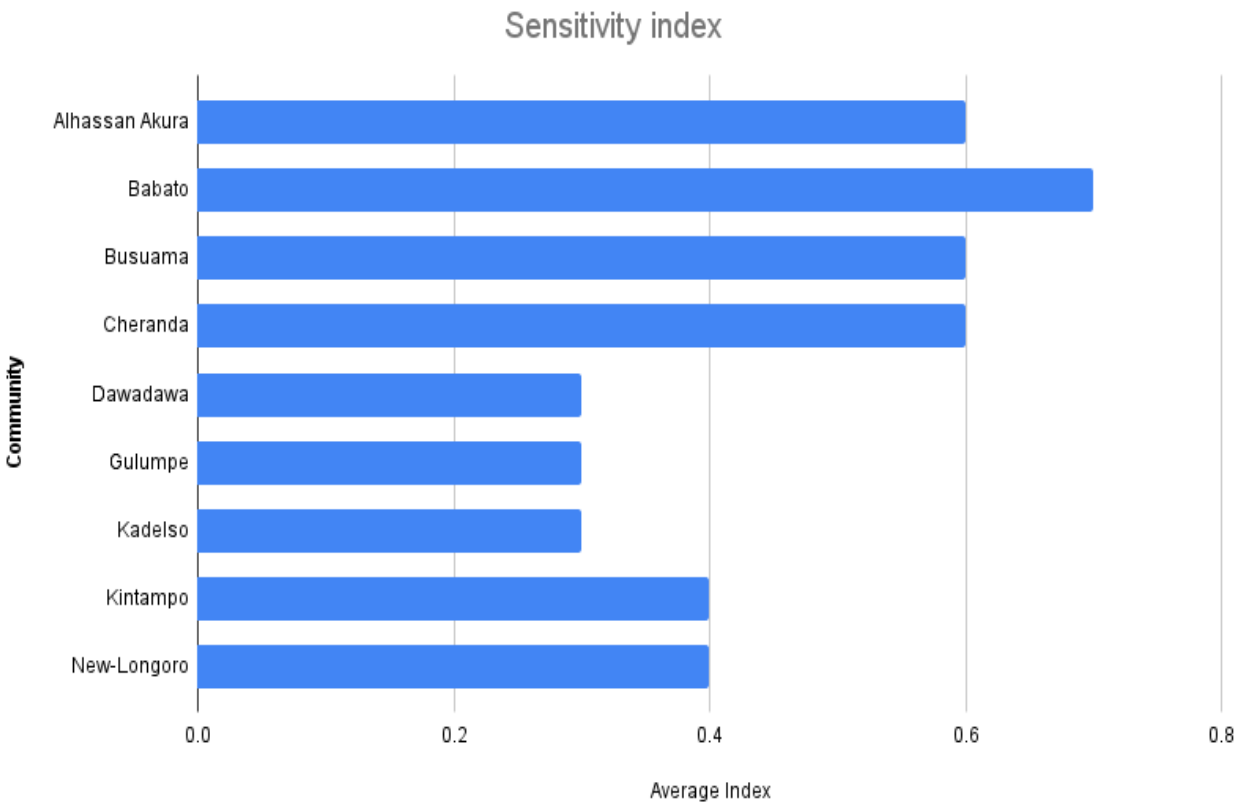
| Index | Sub-Indicators | Community | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Alhassan Akura | Babato | Busuama | Cheranda | Dawadawa | Gulumpe | Kadelso | Kintampo | New Longoro | Overall |
| Exposure | Frequency of droughts/dry spells | 0.3 | 0.3 | 0.5 | 0.5 | 0.3 | 0.1 | 0.3 | 0.3 | 0.1 | 0.3 |
| | Frequency of extreme floods | 0.1 | 0.1 | 0.5 | 0.5 | 0.1 | 0.3 | 0.3 | 0.1 | 0.3 | 0.3 |
| | Frequency of climate-induced erosion | 0.1 | 0.5 | 0.5 | 0.5 | 0.1 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | Frequency of bushfires | 0.3 | 0.7 | 0.5 | 0.5 | 0.3 | 0.50 | 0.5 | 0.3 | 0.33 | 0.4 |
| | Frequency of windstorms | 0.3 | 0.5 | 0.5 | 0.5 | 0.1 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | Frequency of pests and diseases | 0.3 | 0.7 | 0.5 | 0.5 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 |
| | Frequency of low rainfall events | 0.3 | 0.3 | 0.5 | 0.3 | 0.1 | 0.5 | 0.5 | 0.3 | 0.7 | 0.4 |
| | Frequency of excessive rainfall events | 0.3 | 0.7 | 0.5 | 0.5 | 0.5 | 0.3 | 0.3 | 0.5 | 0.3 | 0.4 |
| | **Average index** | **0.3** | **0.5** | **0.5** | **0.5** | **0.2** | **0.3** | **0.4** | **0.3** | **0.3** | **0.4** |

Source: Field survey, 2022.

### 3.3.2.3 Sensitivity

Figure 3.22 and Table 13 present the computed results of the sensitivity index for Kintampo Municipality. Babato had the greatest sensitivity to the impacts of climate change, followed by Alhassan Akura, Busuama, and Cheranda. An analysis of the indicators shows that Babato has many unemployed persons, no access to a good road network, and many houses in flood-prone areas. In addition, the community has water availability problems, and a significant majority of community members have no formal education. The communities with high sensitivity also have high proportions of people aged 18 and below and 60 and above, compared to their overall populations. This proportion of people above and below the traditional working age is a plausible explanation for the high percentage of unemployment in these communities.

**Figure 3.22. Sensitivity scores stratified by community**




Source: Field survey, 2022.

Busuama and Babato share the top rankings for sensitivity in terms of lacking access to good road networks and having houses in flood-prone areas. On the other hand, communities like Kadelso, Gulumpe, Kintampo, and Dawadawa rated low for sensitivity based on their numbers of people below the age of 18, unemployed people, and access to health facilities.

The findings (Table 13) provide insights into the subcomponents of the sensitivity index in Kintampo Municipality. These indicators shed light on various factors that contribute to the levels of vulnerability within different communities.

- Age-related vulnerability: The indicators related to households with people aged over 60 years and below 18 years show variation across communities. Cheranda and New Longoro have a higher proportion of elderly individuals, while Babato and Kintampo have a higher proportion of households with children. This suggests that different communities may face specific challenges associated with different age groups.

- Education- and employment-related vulnerability: The indicators related to households with no formal education and more unemployed people reveal disparities across communities. Gulumpe and Kadelso have a higher proportion of households with low education levels, while Babato and Dawadawa have a higher prevalence of unemployment. These factors may contribute to increased vulnerability in terms of adopting alternative economic opportunities and accessing resources.

- Infrastructure and service access vulnerability: The indicators related to access to weather information, good road networks, health facilities, and water availability highlight disparities among communities. New Longoro has a high proportion of households without access to weather information, while Alhassan Akura and Gulumpe face challenges with road networks. These disparities can impact each community's ability to respond to and cope with environmental risks and emergencies.

- Environmental vulnerability: Communities such as Kintampo and Cheranda that have a higher number of houses located in flood-prone zones have an increased susceptibility to flood-related damage and disruptions.

**Table 13. Subcomponents of the sensitivity index in Kintampo Municipality**

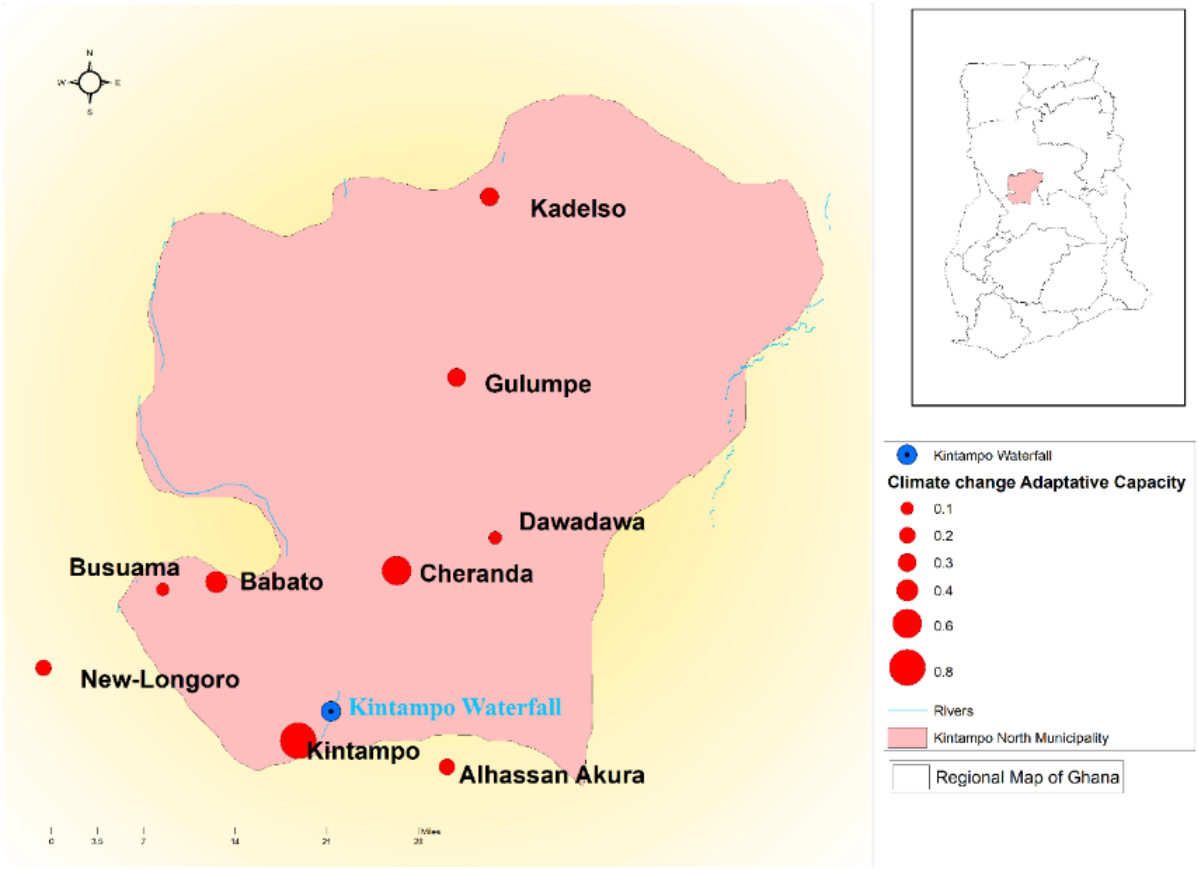
| Indicator | Community | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Alhassan Akura | Babato | Busuama | Cheranda | Dawadawa | Gulumpe | Kadelso | Kintampo | New Longoro |
| Households with people above 60 years | 0.1 | 0.3 | 0.1 | 1 | 0 | 0.3 | 0.2 | 0.1 | 0.6 |
| Households with people below 18 years | 1 | 0.8 | 1 | 0.1 | 0.2 | 0 | 0.6 | 0.5 | 0.1 |
| Households with members with any form of disability | 0 | 0.3 | 0.1 | 1 | 0 | 0.1 | 0 | 0.1 | 0.1 |
| Households with people who have no education | 0.8 | 0.8 | 0.4 | 0.6 | 0.3 | 1 | 0.4 | 0.1 | 0 |
| Households depending on rainfed agriculture | 1 | 0.6 | 1 | 0.6 | 0.9 | 0.7 | 0.7 | 0 | 0.1 |
| Households with unemployed people | 0.3 | 1 | 0.9 | 1 | 0.2 | 0 | 0.3 | 0.7 | 0.1 |
| Households that receive no weather information | 0.6 | 0.4 | 0.5 | 0 | 0.7 | 0.4 | 0.5 | 0.4 | 1 |
| Households with no access to good road network | 0.9 | 1 | 1 | 1 | 0.9 | 0.4 | 0 | 0.9 | 0.9 |
| Houses in flood-prone areas | 1 | 1 | 1 | 0.4 | 0 | 0.8 | 0.9 | 1 | 0.8 |
| Households with no access to health facilities | 0 | 0 | 0.1 | 1 | 0.2 | 0 | 0 | 0.1 | 0 |
| Households with water availability problems | 0.4 | 1 | 0.8 | 0 | 0.5 | 0 | 0.1 | 0.7 | 0.6 |
| Average index | **0.6** | **0.7** | **0.6** | **0.6** | **0.3** | **0.3** | **0.3** | **0.4** | **0.4** |

Source: Field survey, 2022.

### 3.3.2.4 Adaptive Capacity

Map 4 and Table 14 present the computed results of the adaptive capacity index for Kintampo Municipality. Kintampo and Cheranda top the list with high adaptive capacity. However, adaptive capacity turned out to be very low in Busuama, Dawadawa, Alhassan Akura, and New Longoro.

**Map 4. Adaptive capacity results map of Kintampo Municipality**




Source: Field survey, 2022.

In both Kintampo and Cheranda, the majority of households have access to credit, receive remittances, have access to the internet, have the capacity to access markets with their farm produce, have access to irrigation systems, are able to grow other crops in addition to traditional ones, and can access agricultural extension services with limited difficulty. In low-adaptive-capacity communities, including Busuama, Dawadawa, and New-Longoro, the majority of the households have no access to health insurance, do not benefit from any social interventions, have no access to agriculture extension services or subsidies, and cannot afford to grow additional food crops.

**Table 14. Subcomponents of the adaptive capacity index in Kintampo Municipality**

| Indicator | Community | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sub-Indicator | Alhassan Akura | Babato | Busuama | Cheranda | Dawadawa | Gulumpe | Kadelso | Kintampo | New Longoro |
| Adaptive capacity | Households with people who have access to health insurance | 0.0 | 0.2 | 0.2 | 0.2 | 0.0 | 0.7 | 0.2 | 1.0 | 0.2 |
| | Households with people who are members of social organizations | 0.0 | 1.0 | 0.0 | 1.0 | 0.4 | 0.3 | 0.2 | 0.9 | 0.3 |
| | Households that benefit from government social intervention | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.7 | 0.4 |
| | Households that received support from any organizations/institutions | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 |
| | Households that have access to credit | 0.1 | 0.6 | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | 1.0 | 0.4 |
| | Households that receive remittances | 0.6 | 0.2 | 0.0 | 0.8 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 |
| | Households that have access to subsidies | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 1.0 | 0.0 |
| | Households that are aware of gender-related organizations/associations | 0.0 | 0.8 | 0.2 | 0.4 | 0.0 | 0.6 | 0.4 | 1.0 | 0.0 |
| | Households that have access to the internet | 0.5 | 0.7 | 0.9 | 1.0 | 0.0 | 0.5 | 0.4 | 1.0 | 1.0 |
| | Households that grow other crops | 1.0 | 0.6 | 0.0 | 0.9 | 0.5 | 0.8 | 0.6 | 1.0 | 0.5 |
| | Households with irrigation systems | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.0 |
| | Households with access to roads | 0.0 | 1.0 | 0.0 | 0.9 | 0.0 | 0.0 | 0.9 | 0.7 | 0.0 |
| | Households with access to market | 0.3 | 0.5 | 0.5 | 1.0 | 0.0 | 0.1 | 0.1 | 0.4 | 0.3 |

| Indicator | Community | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sub-Indicator | Alhassan Akura | Babato | Busuama | Cheranda | Dawadawa | Gulumpe | Kadelso | Kintampo | New Longoro |
| | Households that are part of farmer-based organizations | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.6 | 1.0 | 0.1 | 0.1 |
| | Households that have access to agricultural extension services | 0.3 | 1.0 | 0.0 | 0.0 | 0.7 | 0.8 | 0.1 | 0.8 | 0.0 |
| | **Average index** | **0.2** | **0.4** | **0.1** | **0.6** | **0.1** | **0.3** | **0.3** | **0.8** | **0.2** |

Source: Field survey, 2022.

### 3.3.2.5 Overall Vulnerability

From the overall vulnerability index, the three most vulnerable communities in Kintampo Municipality are, in order, Busuama, Dawadawa, and Alhassan Akura (Figure 3.23 and Map 5). Kintampo is the least vulnerable. The other communities are rated to be moderately vulnerable to the effects of climate change, based on their exposure, sensitivity, and adaptive capacity ratings.

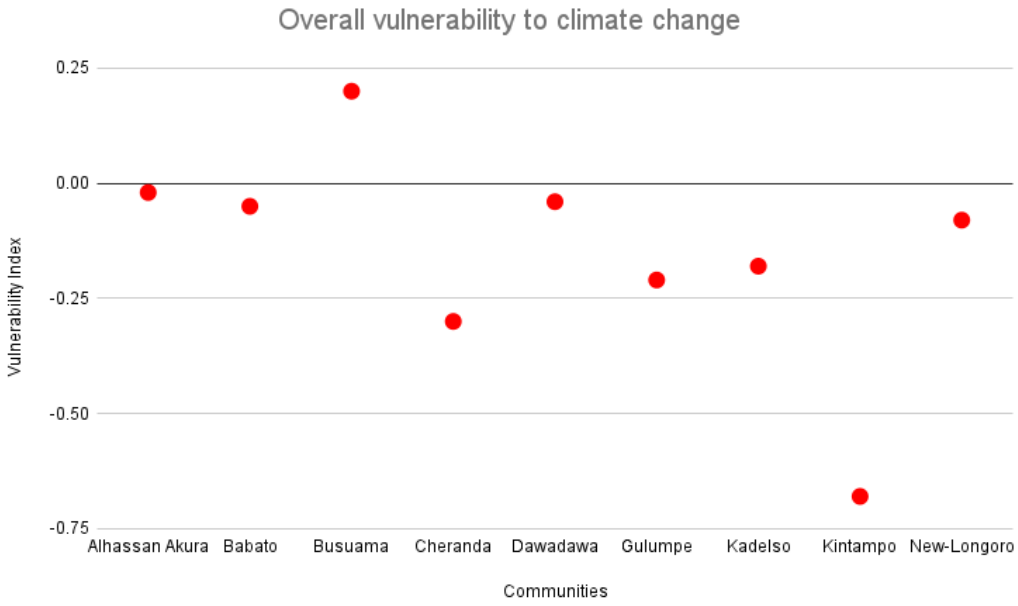
Busuama's low adaptive capacity is a result of most households lacking access to good road networks, markets, credit, and subsidies, and being heavily reliant on rainfed agriculture and receiving no benefits from government social intervention programs. The low adaptive capacity has a significant impact on the community's high vulnerability to climate change, which is made worse because many homes are situated in flood-prone locations.

Alhassan Akura is the next most vulnerable community, although it is slightly less exposed and has a stronger adaptive capacity than Busuama primarily because it is common to plant different crop varieties.

Kintampo households are better able to adapt to the effects of climate change due to their high accessibility to markets, good internet connectivity, and wide availability of a variety of crops. The households in this community are better educated and have access to health facilities. They may have higher incomes that help them deal with the effects of climate change, such as by acquiring readily available farm inputs to boost crop outputs. Households in Kintampo have fewer household members over age 60 and fewer people with disabilities.

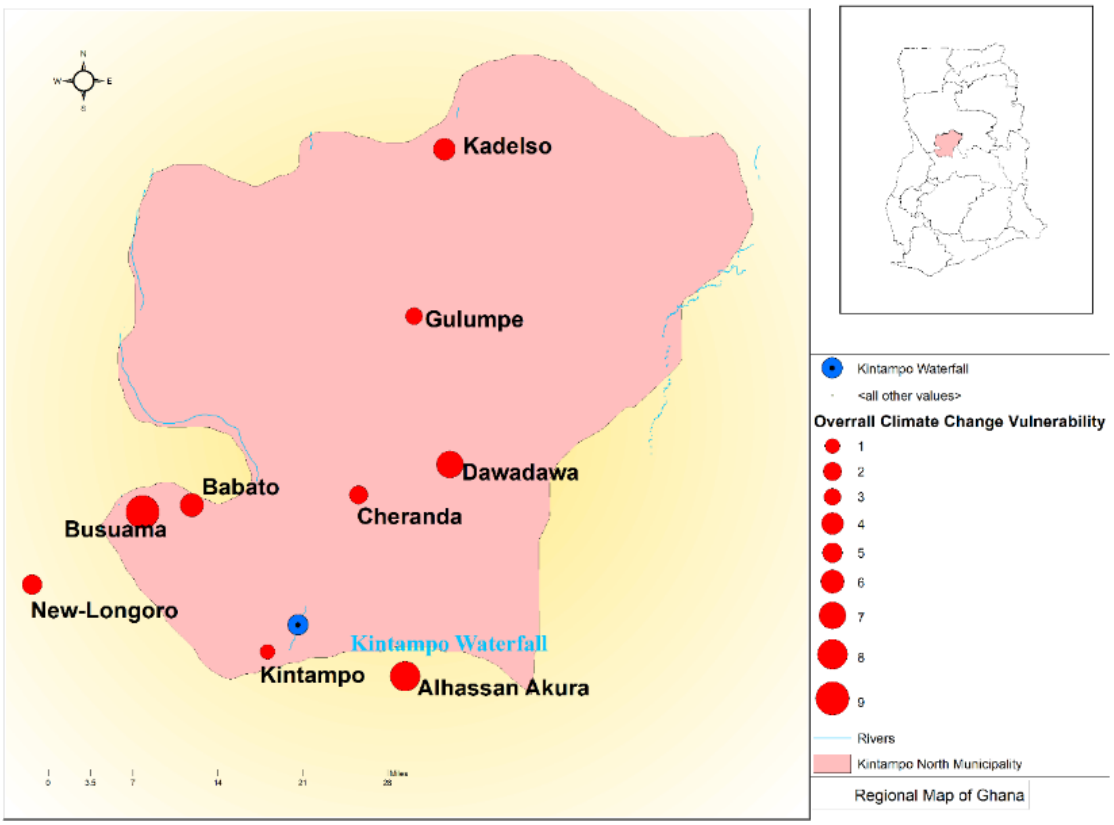
Cheranda has low vulnerability because many households have access to health insurance and agricultural extension programs.

**Figure 3.23. Overall vulnerability ratings of various communities**




Source: Field survey, 2022.

**Map 5. Map showing adaptive capacity ranking of communities in Kintampo Municipality**




Source: Field survey, 2022.

### 3.3.2.6 Key Observations and Implications

- Low vulnerability in Kintampo and Cheranda: Kintampo and Cheranda stand out with their high adaptive capacity. These communities have relatively better resources, infrastructure, and access to services that enhance their ability to adapt to changing conditions. The majority of households in these communities have access to credit, receive remittances, benefit from internet connectivity, can access markets with their farm produce, use irrigation systems, grow diverse crops, and have access to agricultural extension services with limited difficulty. These factors contribute to their lower levels of vulnerability to climate change.
- High vulnerability in Busuama, Dawadawa, Alhassan Akura, and New Longoro: The communities of Busuama, Dawadawa, Alhassan Akura, and New Longoro exhibit low adaptive capacity. In these communities, the majority of households face various challenges that limit their ability to adapt. For example, they lack access to health insurance, do not benefit from social interventions, have no access to agriculture extension services and subsidies, and struggle to afford growing additional food crops. These limitations contribute to their high vulnerability to climate change.

- Implications for community resilience: The disparities in vulnerability across the municipality have significant implications for community resilience. Lower vulnerability in Kintampo and Cheranda suggests that these communities are better equipped to respond to and recover from climate-related shocks and stressors. They have more opportunities to diversify income sources, access resources, and utilize support services. Conversely, the higher levels of vulnerability in Busuama, Dawadawa, Alhassan Akura, and New Longoro indicate a need for support to enhance their resilience. These communities may require targeted interventions such as improving access to health services, expanding social interventions, providing agricultural extension services, and implementing affordability measures for agricultural inputs.

#### 3.3.2.7 Sectoral Vulnerability Analysis: Agricultural sector stratified by community

The results from the questionnaire survey, which confirmed that the majority of households interviewed engaged in agriculture-related activities, corroborated the well-established evidence that agriculture is the most dominant livelihood activity and socio-economic activity in Kintampo Municipality (e.g., GSS, 2014). The existing literature and the qualitative assessment results (participant workshop and interviews) indicated that the agricultural sector is the most vulnerable sector to climate change in the municipality.

We analyzed the vulnerability of this sector to climate change-related hazards. Table 15 presents the results of the computation of agricultural sector vulnerability based on the household survey. The results are stratified by community to provide a good understanding of the spatial dimensions underlying the exposure, sensitivity, and adaptive capacity indicators of vulnerability.

In the agricultural sector, Busuama and Babato were the two most exposed communities to the various climate change hazards assessed. The majority of households in these communities reported high susceptibility to bushfires, drought, flooding, and erosion.

**Table 15. Vulnerability of the agricultural sector to climate change in Kintampo Municipality**

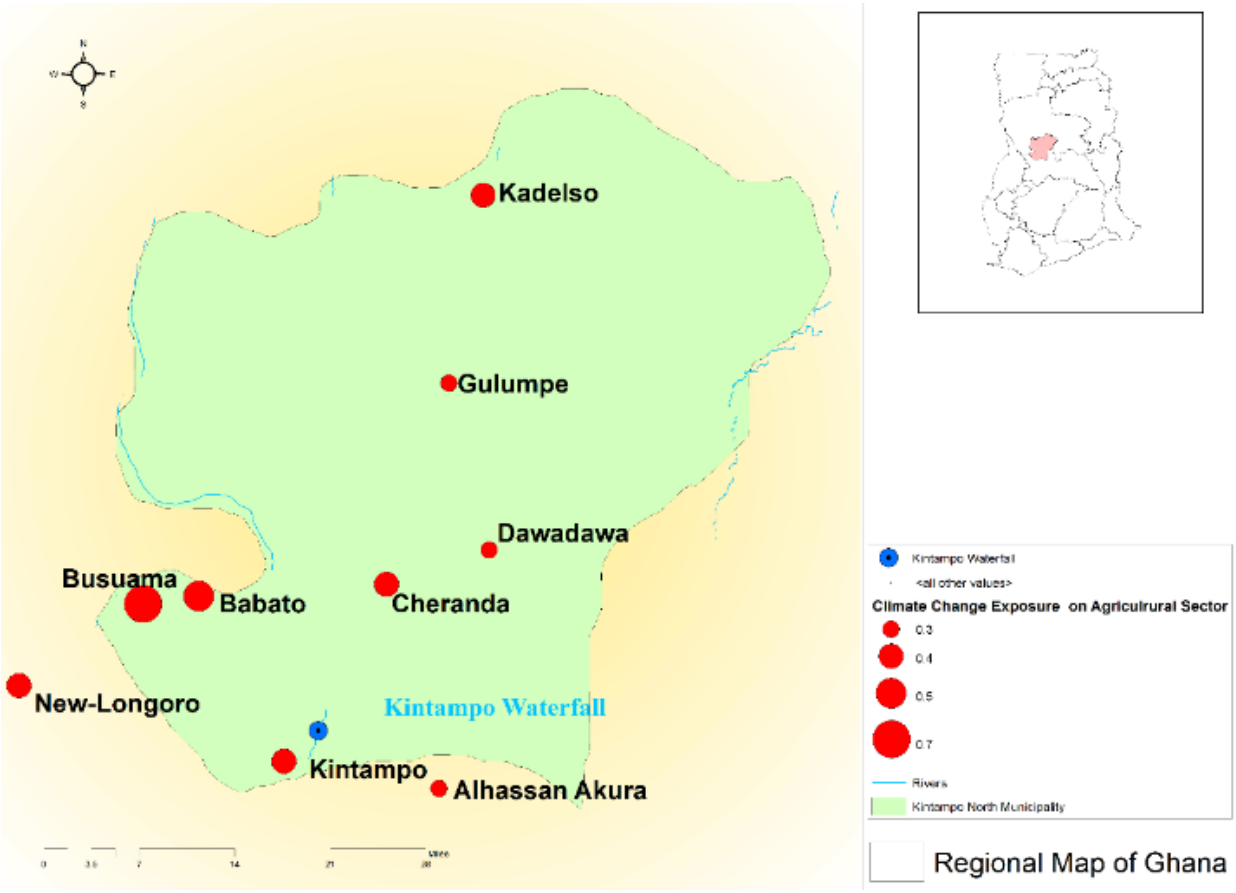
| Vulnerability determinant | Indicators | Alhassan Akura | Babato | Busuama | Cheranda | Dawadawa | Gulumpe | Kadelso | Kintampo | New Longoro |
|---|---|---|---|---|---|---|---|---|---|---|
| Exposure | Susceptibility of agricultural sector to flooding | 0.3 | 0.1 | 0.7 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | Susceptibility of agricultural sector to drought | 0.3 | 0.5 | 0.7 | 0.3 | 0.3 | 0.3 | 0.5 | 0.3 | 0.5 |
| | Susceptibility of agricultural sector to climate-induced erosion | 0.3 | 0.3 | 0.7 | 0.5 | 0.1 | 0.3 | 0.3 | 0.3 | 0.3 |
| | Susceptibility of agricultural sector to bushfires | 0.3 | 0.7 | 0.9 | 0.5 | 0.3 | 0.3 | 0.5 | 0.5 | 0.5 |
| | Susceptibility of agricultural sector to windstorms | 0.3 | 0.5 | 0.7 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | Susceptibility of agricultural sector to pests and diseases | 0.3 | 0.7 | 0.7 | 0.5 | 0.3 | 0.3 | 0.3 | 0.5 | 0.5 |
| | Susceptibility of agricultural sector to low rainfall events | 0.3 | 0.5 | 0.7 | 0.3 | 0.3 | 0.5 | 0.7 | 0.5 | 0.7 |
| | Susceptibility of agricultural sector to excessive rainfall events | 0.3 | 0.7 | 0.7 | 0.5 | 0.3 | 0.3 | 0.5 | 0.5 | 0.3 |
| | **Average index** | **0.3** | **0.5** | **0.7** | **0.4** | **0.3** | **0.3** | **0.4** | **0.4** | **0.4** |
| Sensitivity | Households with no knowledge of agricultural insurance | 0.7 | 0 | 1 | 1 | 0.3 | 0 | 0.9 | 0 | 1 |
| | Households with no access to market | 1 | 1 | 1 | 0.1 | 1 | 1 | 1 | 0 | 1 |
| | Households that receive no weather information | 0.6 | 0.4 | 0.5 | 0 | 0.7 | 0.4 | 0.5 | 0.4 | 1 |

| Vulnerability determinant | Indicators | Alhassan Akura | Babato | Busuama | Cheranda | Dawadawa | Gulumpe | Kadelso | Kintampo | New Longoro |
|---|---|---|---|---|---|---|---|---|---|---|
| | Households with no access to good road network | 0.9 | 1 | 1 | 1 | 0.9 | 0.4 | 0 | 0.9 | 0.9 |
| | Households depending on rainfed agriculture | 1 | 0.6 | 1 | 0.6 | 0.9 | 0.7 | 0.7 | 0 | 0.1 |
| | Households with people who have no education | 0.8 | 0.8 | 0.4 | 0.6 | 0.3 | 1 | 0.4 | 0.1 | 0 |
| | **Average index** | **0.8** | **0.6** | **0.8** | **0.6** | **0.7** | **0.6** | **0.6** | **0.2** | **0.7** |
| Adaptive capacity | Households that have access to credit | 0.1 | 0.6 | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | 1.0 | 0.4 |
| | Households that have access to subsidies | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 1.0 | 0.0 |
| | Households that grow other crops | 1.0 | 0.6 | 0.0 | 0.9 | 0.5 | 0.8 | 0.6 | 1.0 | 0.5 |
| | Households with irrigation system | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.0 |
| | Households with access to market | 0.3 | 0.5 | 0.5 | 1.0 | 0.0 | 0.1 | 0.1 | 0.4 | 0.3 |
| | Households that are part of farmer-based organizations | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.6 | 1.0 | 0.1 | 0.1 |
| | Households that have access to agricultural extension service | 0.3 | 1.0 | 0.0 | 0.0 | 0.7 | 0.8 | 0.1 | 0.8 | 0.0 |
| | **Average index** | **0.3** | **0.4** | **0.1** | **0.5** | **0.2** | **0.4** | **0.3** | **0.7** | **0.2** |
| | **Vulnerability index** | **-0.1** | **-0.1** | **0.5** | **-0.3** | **0.0** | **-0.2** | **-0.1** | **-0.6** | **0.1** |
| | **Rank** | **4** | **4** | **9** | **2** | **7** | **3** | **4** | **1** | **8** |

Source: Field survey, 2022.

Overall, Busuama's agricultural sector is extremely vulnerable to the impacts of climate change (Average CCV = 0.5) due to a combination of factors, including high exposure to bushfires, droughts, and pests and diseases (Map 6). The community possesses the highest sensitivity ranking because of a lack of access to irrigation infrastructure and limited knowledge of agricultural insurance and weather forecasting among households. New Longoro also exhibits a high level of vulnerability caused by frequent droughts and bushfires, as well as a lack of agricultural extension services and irrigation infrastructure.

**Map 6. Agricultural sector exposure to climate change in Kintampo Municipality**



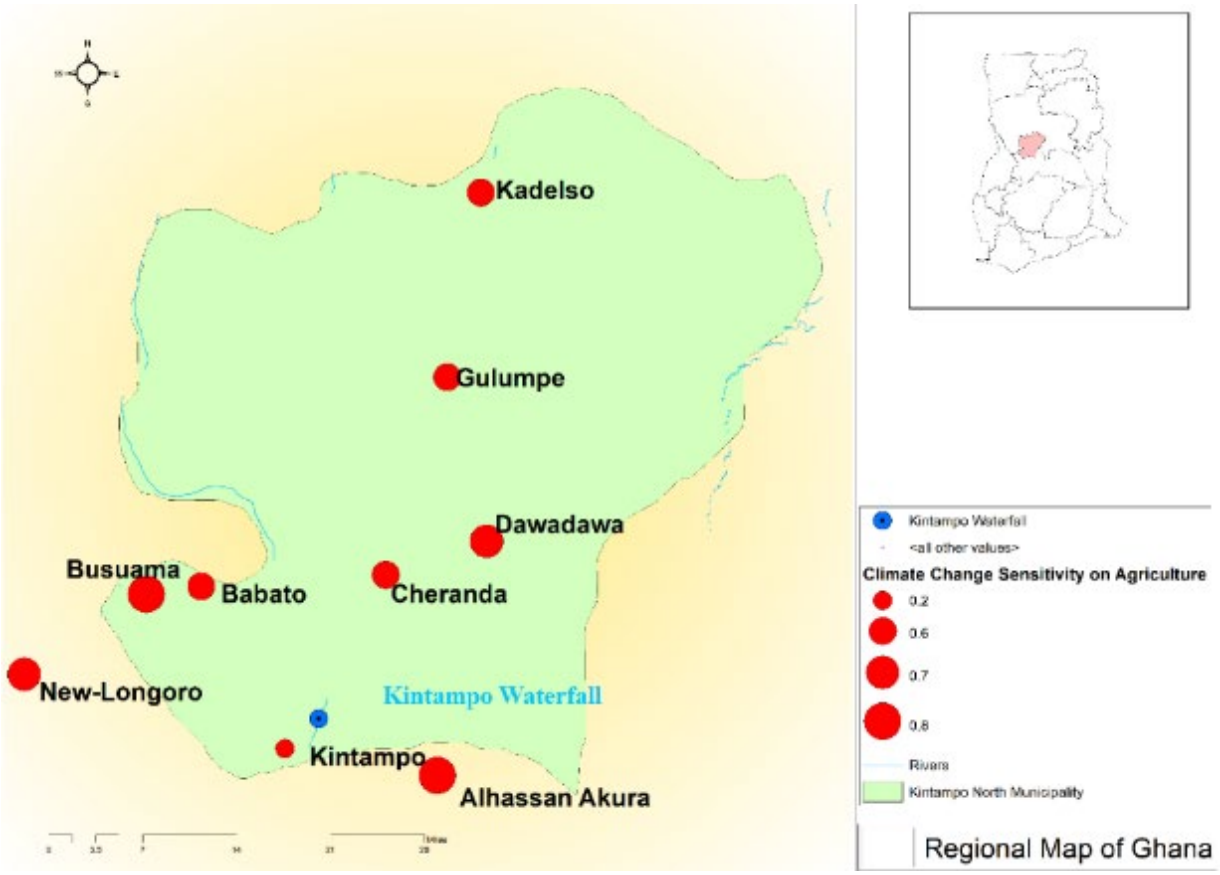

Source: Field survey (Household Questionnaire), 2022.

In contrast, Kintampo has the lowest level of vulnerability, which can be attributed to two key factors, both of which are key in increasing climate resilience (Map 7).

- Availability of irrigation systems: Kintampo benefits from the presence of irrigation systems, which provide reliable access to water for agricultural purposes. Irrigation allows farmers to supplement rainfall during periods of low precipitation, enhancing their climate resilience by reducing their dependence on unpredictable rainfall patterns, allowing them to maintain consistent crop production. By using irrigation, farmers can maintain adequate soil moisture levels even during dry periods, reducing the impact of droughts and erratic rainfall.

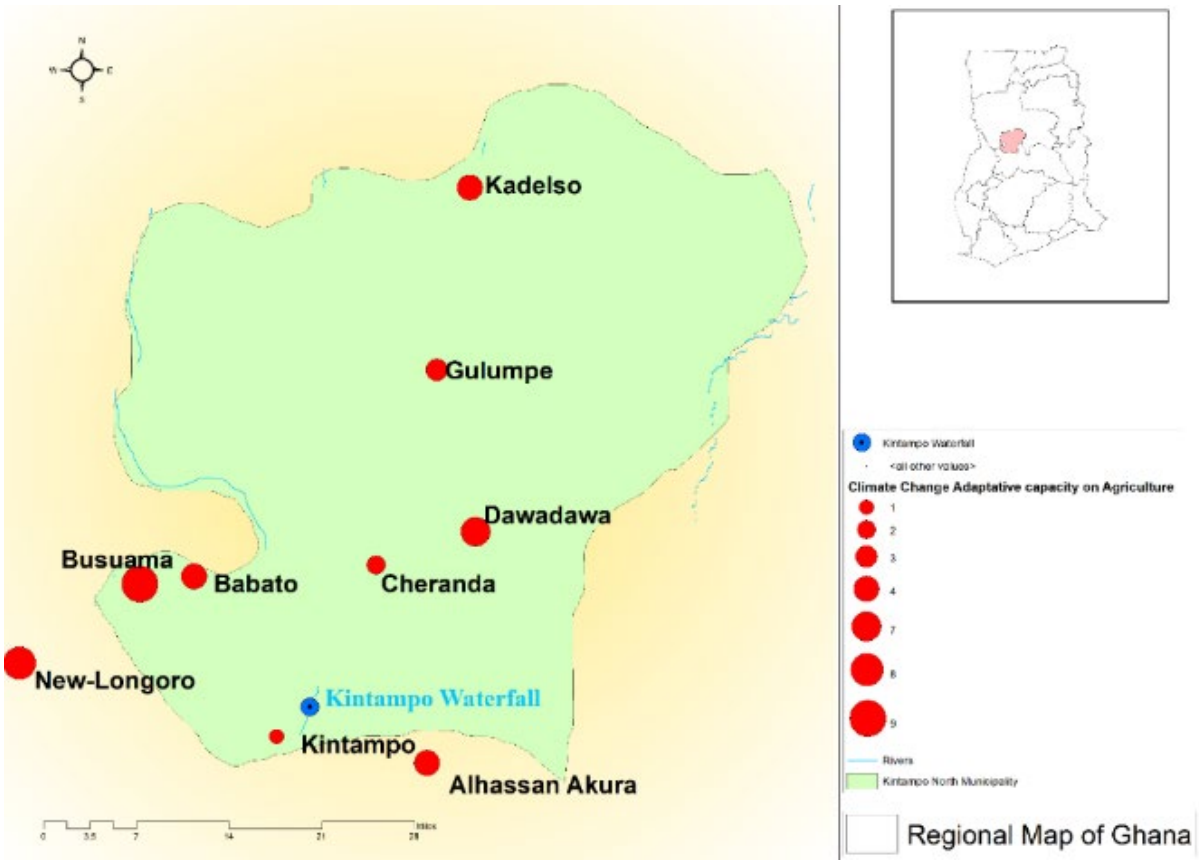
- Agricultural extension services: The availability of agricultural extension services contributes to the overall knowledge and awareness of farmers in Kintampo and plays a crucial role in enhancing their adaptive capacity. These services provide valuable knowledge, training, and guidance to farmers on climate-smart agricultural practices, ways to reduce bushfires, pest and disease management and control, irrigation techniques, and other relevant strategies. Being aware of the potential climate-related risks and having access to information on adaptation strategies means farmers can make informed decisions and take proactive measures to minimize risks to their crops and livelihoods and safeguard their agricultural activities. This awareness empowers them to adopt suitable practices and technologies that improve their resilience to climate change impacts.

**Map 7. Sensitivity mapping of agricultural sector in Kintampo Municipality**




Source: Field survey (Household Questionnaire), 2022.

**Map 8. Adaptive capacity mapping of Kintampo Municipality stratified by community**




Source: Field survey (Household Questionnaire), 2022.

Cheranda also exhibits a relatively low level of vulnerability, as do Alhassan Akura, Babato, and Kadelso (Map 8). However, Babato has a higher adaptive capacity than the others because its households have more access to market and credits. The overall results show that interventions are necessary, particularly irrigation projects in the most vulnerable communities. Cheranda's relatively low level of vulnerability to climate change impacts can be attributed to two key factors.

- Access to credit: Cheranda benefits from the availability of credit, which enables households to secure financial resources for agricultural activities and other livelihood needs. Access to credit allows farmers to invest in their farms, purchase necessary inputs, and withstand financial shocks caused by climate-related events. Having access to credit means farmers in Cheranda have a greater capacity to adapt and recover from climate-induced challenges, reducing their vulnerability.
- Cultivation of a diverse range of crops: The cultivation of a diverse range of crops in Cheranda contributes to its lower vulnerability. By growing multiple crops, households reduce their reliance on a single crop, which can be more susceptible to climate impacts. Diversification enhances resilience by spreading risks associated with climate variability. It ensures a more stable and secure food supply, income generation, and livelihoods, even in the face of climate-related uncertainties.

#### 3.2.2.8 Summary

The findings from the VA about the climate vulnerability of the agricultural sector in different communities within the Kintampo municipality are summarized below.

**Busuama** is extremely vulnerable to climate change impacts in the agricultural sector. This vulnerability stems from various factors, including high exposure to bushfires, drought, and pests and diseases. Additionally, the community lacks access to irrigation infrastructure, and households have limited knowledge of agricultural insurance and weather forecasting.

**New Longoro** also exhibits a high level of vulnerability in the agricultural sector. This vulnerability is caused by frequent droughts and bushfires, which pose significant risks to agricultural productivity. Additionally, the community faces challenges due to a lack of agricultural extension services and irrigation infrastructure, limiting the ability of households to adapt to climate-induced changes effectively.

In contrast, **Kintampo** demonstrates the lowest level of vulnerability in the agricultural sector, likely due to the availability of irrigation systems and agricultural extension services. These resources enable most households to adapt more effectively to climate-induced changes in rainfall patterns, bushfires, and pest and disease outbreaks. The presence of these supportive systems enhances the community's resilience in the face of climate change impacts.

**Cheranda** exhibits a relatively low level of vulnerability in the agricultural sector, which is attributed to factors such as access to credit and the cultivation of a diverse range of crops. These factors contribute to increased resilience, as they provide households with additional resources and flexibility to adapt to climate change impacts.

**Alhassan Akura, Babato,** and **Kadelso:** These communities have similar levels of vulnerability in the agricultural sector. However, Babato stands out with a higher adaptive capacity compared to the others due to its greater access to markets and credit, which provide additional opportunities for households to cope with climate change impacts and enhance their resilience.

# 4. Future Climate Change Risks in Kintampo Municipality

Based on historical climate data, climate change projections were made from 2024 until the end of the century for rainfall, as well as minimum and maximum temperature. The climate observation data for Kintampo spanning over 40 years (1980 to 2020), which formed the baseline, was obtained from the Ghana Meteorological Agency. The spatial plots were based on data from the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) for the rainfall historical plots and the ERA5 for the minimum and maximum temperature. Data cleaning and quality control were performed to avoid any non-climatic factors influencing the analysis. The RClimdex package in R statistical software was used for quality control checks.

The historical climate data was transformed into useful information as defined in Table 16. The information generated from the historical rainfall datasets is the rainfall climatology, number of rainy days, heavy rainfall events, longest dry and wet spells, annual rainfall totals, and rainfall anomaly. Similarly, the information extracted from the historical maximum and minimum temperature datasets is the temperature climatology, mean annual temperature, temperature anomaly, and frequency of hot days and nights.

**Table 16. Definition of climate characteristics**

| Term | Definition |
|---|---|
| Monthly rainfall/climatology | Monthly rainfall totals |
| Rain day | Defined as a day with rainfall event = > 85% |
| Annual total rainfall | Total rainfall calculated per year |
| Anomaly | Deviation of annual rainfall/mean temperature from annual averages as defined in equation 1 |
| Dry spell | Continuous days without rain during the rainfall season |
| Wet spell | Continuous days with rain during the rainfall season |
| Heavy Rainfall | Rainfall events exceeding 20 mm |
| Monthly mean temperature/climatology | Average temperature per month over the period under consideration |
| Mean annual temperature | Average temperature per year |
| Frequency of hot nights | Minimum temperature above the 90$^{th}$ percentile |
| Frequency of hot days | Maximum temperature above the 90$^{th}$ percentile |

$$ano_{xk} = \frac{x_k - \mu_x}{\sigma_x} \qquad \text{equation 1}$$

Where $x_k$ is the monthly average variable for each year and $\mu_k$ and $\sigma_x$ are the long-term average and standard deviation of the variable x for the month, respectively.

The study analyzed 15 model simulations from an ensemble of five Regional Climate Models (RCMs) from the Coordinated Regional Downscaling Experiment (CORDEX) driven by three Global Climate Models (GCMs) from the 5th Coupled Model Intercomparison Project (CMIP5) (see Table 17). The future climate scenarios of rainfall and temperature were generated using the Representative Concentration Pathways (RCPs) 4.5 and 8.5. The RCP 4.5 and RCP 8.5 comprise the largest ensemble common for the two emission-scenario pathways. The RCP 4.5 was assessed as a midway scenario and RCP 8.5 as a realistic business-as-usual scenario given the current trajectory of greenhouse gas emissions.

**Table 17. List of the CORDEX models and CMIP5 used**

| RCM | Driving GCM |
|---|---|
| RCA4 | ICHEC-EC-EARTH<br>MPI-ESM-LR<br>CNRM-CM5 |
| CCLM4 | ICHEC-EC-EARTH<br>MPI-ESM-LR<br>CNRM-CM5 |
| RACMO22T | ICHEC-EC-EARTH<br>MPI-ESM-LR<br>CNRM-CM5 |
| CRCM5 | ICHEC-EC-EARTH<br>MPI-ESM-LR<br>CNRM-CM5 |
| RegCM4-3 | ICHEC-EC-EARTH<br>MPI-ESM-LR<br>CNRM-CM5 |

Source: Jones et al., 2011.

The downscaled RCMs for the selected stations in the study area were transformed such that the magnitude and distribution of the transformed variables came as close as possible to the gauged points. The quantile-quantile statistical technique was applied to make the statistical distribution of the downscaled variables as close as possible to the statistical distribution of historical observations. Furthermore, the quantile-quantile transformation was done to remove the residual bias. A delta change correction was applied to allow the downscaled data and the gauged data to have the same mean in the historical period. The time series, comprising both historical data and projections, analyzed rainfall, as well as minimum and maximum temperatures. These were averaged across two stations in the study area, covering the period from 1980 to 2100.

# 4.1 Climate Change Projections

## 4.1.1 Description of the Climate Projection Method

The analysis covered two timeframes. The baseline was the period 1980-2020, whereas the future projections are up to the year 2100. The steps taken as part of the climate projection are detailed in this section.

## 4.1.2 Data Collection for Climate Projection

Observational climatological data from 1980 to 2020 was derived from data provided by the Ghana Meteorological Agency and model data from satellite observations. The model data used for the rainfall-related indicators was from the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS), while ERA5 data was used for the temperature-related indicators. The data was cleaned by eliminating outliers and inaccuracies resulting from administrative or transposition errors. After cleaning, the data was used in further analysis during the simulation and downscaling stage.

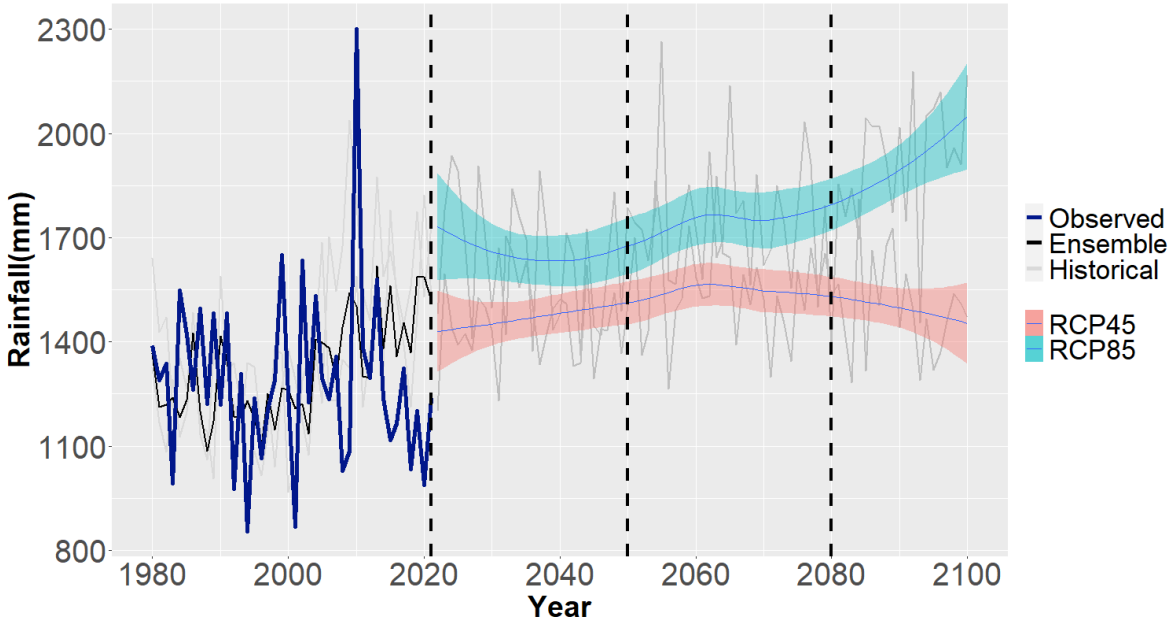
## 4.1.3 Simulation and Downscaling

The team downscaled daily rainfall and maximum and minimum temperature data using the quantile-quantile transformation method. The projections (corresponding to 10 different combinations of GCMs and RCMs) were produced for RCPs 4.5 and 8.5 emission scenarios. The downscaled data was transformed into annual averages of rainfall and temperatures and plotted.

## 4.2 Projected Climatic Conditions over the Municipality

Projected rainfall over Kintampo will be variable in both annual and decadal time steps for both pathways. Kintampo will gradually experience an increase in rainfall over the assessed period, as shown in Figure 4.1, with mean annual rainfall increasing from 1,320 mm to 1,550 mm by 2021. The inter-annual variations will be evident in regard to rainfall distribution, heavy events, and dry spells. Years with low annual rainfall are likely to experience long dry spells within the rainy season, while years with heavy rainfall may also experience floods. Mean annual rainfall will vary between 1,300 mm and 1,700 mm, although some years may experience amounts outside this threshold.

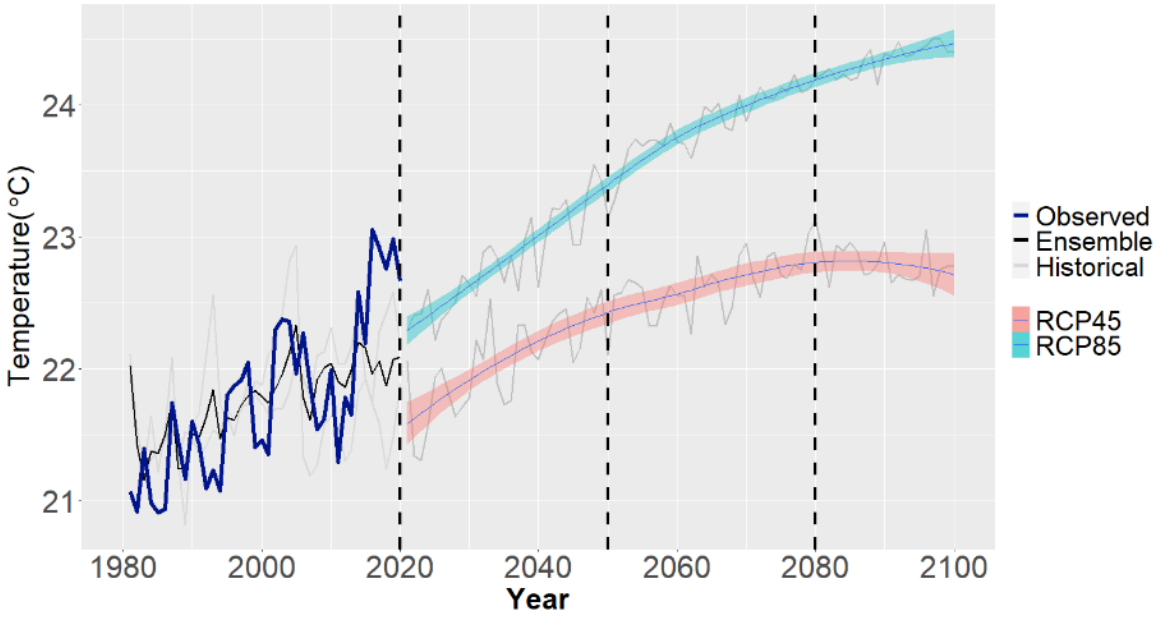
**Figure 4.1. Projected rainfall over Kintampo**




Source: Asare & Klutse, 2022.

The temperatures during both day and night will rise until the end of the century, as depicted by both pathways. Nighttime temperature, as shown in Figure 4.2, will likely increase by approximately 1°C by the middle of the century in the RCP 4.5 scenario. The mean annual minimum temperature will vary between 22°C and 24.5°C, meaning that the temperature at night will continue to be warm while the number of cold nights will continue to decrease.

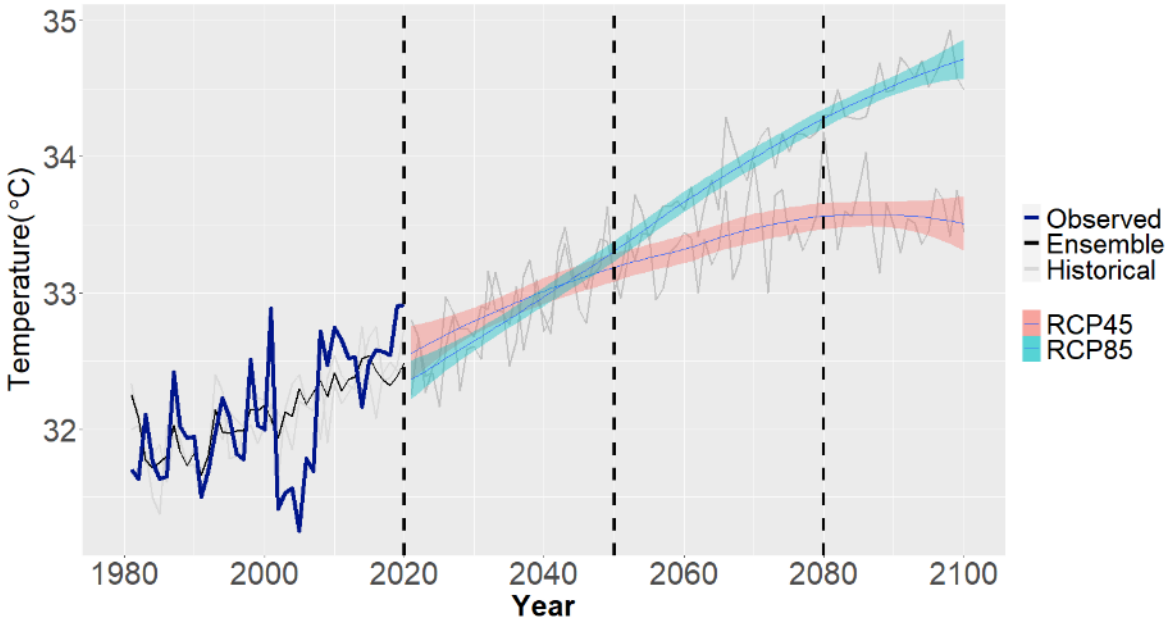
**Figure 4.2. Projected mean annual minimum temperatures over Kintampo**




Source: Asare & Klutse, 2022.

Daytime temperature is projected to reach an annual mean of 33°C by the middle of the century, increasing from the current mean of 32°C (Figure 4.3). Further increases are likely, with variations in the mean annual maximum temperature ranging between 33°C and 34.5°C by the end of the century. The number of cold days will continue to decrease, while the number of warm days will rise.

**Figure 4.3. Projected mean annual maximum temperatures over Kintampo**




Source: Asare & Klutse, 2022.

## 4.3 Summary of Climate Change Projections

Rainfall over Kintampo will remain variable at decadal and annual time steps, with a gradual increase in annual total rainfall beyond the year 2050. Rainfall variability will lead to intermittent dry and wet years over Kintampo. This variation in rainfall could impact the start of rainy seasons, with some years having an early onset while others experience delays. Some years may also experience prolonged dry spells.

The temperature will increase over Kintampo for both days and nights, meaning that the municipality will generally become warmer over time. Cold days and nights, characterized by lower temperatures, are expected to become less frequent, while warm nights and days will become more common in Kintampo.

## 4.4 Expected Climate Change Hazards

The future climate scenarios and projections suggest that Kintampo Municipality will experience an increase in mean temperature of up to 2°C above present levels by 2050, as well as changes in precipitation. The climate hazards resulting from these climatic changes include:

- Excessive rainfall and flooding in some places during wet years
- Changes in precipitation patterns
- Extreme weather events
- Windstorms
- Increased incidence of bushfires
- Prolonged dry spells and drought

## 4.5 Potential Impacts and Future Climatic Risks

The projected changes in rainfall and temperature in Kintampo Municipality will have significant implications for people's livelihoods and for various sectors, including agriculture, tourism, water resources, health, and forests. The impacts and risks in each sector were identified through a literature review, stakeholder workshop, and expert opinions, and are summarized below:

- Agriculture**:** The projected increase in annual total rainfall suggests a positive impact on agriculture in terms of water availability for crop growth. However, the variability in rainfall and the occurrence of dry spells and heavy rainfall events can pose challenges. Prolonged dry spells may lead to water stress, reduced crop yields, and potential crop failures. Conversely, heavy rainfall and floods can damage crops and cause soil erosion. Farmers will need to adapt their farming practices to manage these challenges, such as by adopting water-management strategies, diversifying crop varieties, and implementing soil-conservation measures.

- Tourism: The changes in rainfall and temperature can also influence tourism in Kintampo Municipality. The increase in rainfall may enhance the attractiveness of natural attractions such as waterfalls and lush landscapes. However, the variability in rainfall and the potential for extreme events like floods and windstorms can disrupt tourism activities and damage infrastructure. Additionally, the rising temperatures can affect visitor comfort and the suitability of certain outdoor activities. Proper planning and adaptation measures will be necessary to maintain and promote sustainable tourism in the face of these changes.

- Water resources: The projected changes in rainfall patterns will impact water resources in Kintampo Municipality. The increase in annual total rainfall can contribute to higher water availability. However, the variability in rainfall can lead to challenges in water management. Dry spells may reduce surface-water availability and groundwater recharge, affecting the water supply for domestic, agricultural, and industrial use. Adequate water storage, efficient water-management systems, and conservation practices will be crucial to ensure a reliable water supply throughout the year.

- Forests (biodiversity and ecosystems): The changes in rainfall and temperature can influence the health and composition of forests in Kintampo Municipality. Increased rainfall can support forest growth and regeneration. However, the variability in rainfall and the potential for dry spells can increase the risk of forest fires and impact forest ecosystems. Rising temperatures can also affect the distribution and growth of tree species, potentially leading to shifts in forest composition. Rising temperatures and variable rainfall can also contribute to an increase in bushfires. Forest management strategies, including fire-prevention measures and sustainable forest practices, will be important to preserve the ecological integrity and ecosystem services provided by forests.

- Health: Increasing temperatures and erratic rainfall patterns can affect health. Flooding can contaminate water sources and increase the spread of waterborne diseases such as cholera and diarrhea. Droughts and heat waves can contribute to dehydration, heat exhaustion, and heatstroke, particularly among vulnerable populations. Diseases that thrive in high temperatures may increase or emerge in the region.

- Infrastructure: Flooding and windstorms are expected to damage roads, bridges, and other transportation infrastructure, leading to disruptions in travel and logistics.

# 5. Adaptation Policy and Planning Implications

This chapter presents climate response scenarios for Kintampo Municipality amid escalating climate change issues and outlines suitable adaptation measures. It discusses prospective scenarios, each with distinct responses and impacts, that serve as a strategic guide for navigating climate change. To enhance the municipality's resilience, particularly in its predominant agricultural sector, this chapter proposes practically relevant on-farm and off-farm adaptation strategies. Special emphasis is placed on gender-sensitive adaptation strategies in the municipality. These strategies have been crafted based on extensive expert consultations, literature reviews, field observations, and an in-depth study of relevant national policies and actions.

## 5.1 Climate Response Scenarios

The prevailing and projected climate change scenarios from the assessment require that measures are taken to build resilience to the identified vulnerabilities to limit current and future climate change impacts. The VA results and the draft KiMA Medium-Term Development Plan (NMTPF) (2022-2025) informed the following scenarios, as well as recommendations for adaptation options to consider in building resilience (Table 18).

**Table 18. Climate scenarios for Kintampo Municipality**

| Scenario | Required response and impact |
|---|---|
| **A: Business as usual** | **Response:** Authorities and communities do not recognize the urgent need to address current and future climate change impacts and vulnerabilities or do recognize the need but no action is taken.<br>**Impact:** Climate change will increasingly affect people's lives, livelihoods, health, and safety until 2050 and beyond; current socio-economic and environmental vulnerabilities will increase; development will be impeded. Changes in temperature, precipitation patterns, and extreme weather events will impact agriculture, water availability, and natural resources. These impacts will result in reduced crop yields, food insecurity, loss of income, and increased vulnerability to poverty. Marginalized communities, including women, children, the elderly, and the poor, will be disproportionately affected by climate change due to limited resources, access to information, and decision-making power. |
| **B: Climate change resilience is built to maintain current living standards by 2050** | **Response:** Kintampo Municipality recognizes the urgent need to address climate change and implements some district-level projects in the course of fulfilling its responsibilities to improve the well-being of its citizenry, ranging from agricultural-related supports to health and infrastructure projects. |

| Scenario | Required response and impact |
|---|---|
| | **Impact:** This scenario will enhance current adaptive capacity and reduce the impacts of current climate change. The implementation of agricultural-related supports, such as conservation agriculture and agroforestry promotion, may enhance the adaptive capacity of farmers in the municipality. These practices may improve soil fertility, increase agricultural productivity, and strengthen resilience to climate-related risks. Health and infrastructure projects can contribute to reducing the impacts of current climate change on the residents of Kintampo Municipality. Improved health care facilities and services can help mitigate health risks associated with climate change, such as vector-borne diseases or heat-related illnesses. However, resilience might not be built enough to withstand future impacts. |
| **C: Climate change resilience is built that enables economic and social development, despite changes in climate by 2050** | **Response:** Kintampo Municipality prioritizes climate change action and considers it a development issue by mainstreaming adaptation and low-carbon economy issues into district development policies, programs, and projects in a manner that promotes gender inclusivity.<br>**Impact:** Kintampo Municipality will attain climate-compatible development by harnessing the triple synergies of socio-economic development, climate-resilient development, and low-carbon development. By incorporating climate change considerations into development policies and programs, the municipality can better prepare for and respond to the challenges posed by climate change. By implementing climate-resilient development projects, promoting sustainable land- and water-management practices, and enhancing disaster preparedness and response, the municipality can minimize the negative consequences of climate-related events. These changes will reduce socio-economic loss and damage resulting from the impacts of climate change beyond 2050. |

## 5.2 Recommended Adaptation Options

The findings of this VA confirm that climate change impacts are not uniform and vary across different locations, social groups, and gender. The evaluation of climate-related hazards, exposure, sensitivity, and adaptive capacity indicators in Kintampo Municipality has identified specific risks and future vulnerabilities. In light of these findings, it is crucial to implement appropriate and location-specific adaptation options to enhance the resilience of households and communities. The adaptation options primarily focus on the agricultural sector in Kintampo Municipality due to the significant number of households (70%) engaged in agriculture. This high level of agricultural dependence highlights the sector's importance in the local economy and in the livelihoods of community members.

The adaptation options, including conservation agriculture, irrigation schemes, agroforestry promotion, adaptive trials, and demonstration sites, were identified through a combination of approaches, including expert interviews, a literature review, key observations, and the review of past national policies and actions related to climate change and agricultural practices in Ghana. Experts from various fields, such as agriculture, environmental science, and climate change, were consulted to gather insights and knowledge on the specific challenges and potential solutions in Kintampo Municipality. These experts provided valuable input on the most effective adaptation options for improving agricultural productivity and resilience to climate change.

A thorough review of existing research papers, reports, and publications on climate change adaptation and agricultural practices in similar contexts was conducted to identify proven strategies and best practices that have been successful in enhancing agricultural resilience and productivity. Field visits and assessments were carried out to observe the current agricultural practices, the challenges faced by farmers, and the impact of climate change on the local environment. These on-the-ground observations provided valuable firsthand information on the specific needs and opportunities for adaptation in Kintampo Municipality. Finally, existing national policies and actions related to climate change and agricultural development in Ghana were reviewed to understand the broader context and identify relevant strategies and approaches that have been prioritized at the national level. This review helped to ensure that the identified adaptation options align with the existing policy frameworks in the country.

The adaptation options being proposed are discussed below under the following categories: on-farm, off-farm, and gender based.

## 5.2.1 On-Farm Adaptation Options

### 5.2.1.1 Conservation Agriculture

Implementing conservation agriculture practices in Kintampo Municipality can lead to improved soil quality and increased agricultural output. Key practices include minimizing soil disturbance, managing crop residues, practicing crop rotation and diversification, using cover crops, implementing integrated nutrient management, optimizing water management, adopting pest and disease control measures, providing farmer training and awareness, and ensuring supportive policies. These practices will enhance soil fertility, composition, and natural biodiversity while making more efficient use of arable lands. Involving stakeholders and promoting sustainable farming systems are vital for successful implementation and long-term benefits. From our engagement with the municipality's Agriculture Department and other stakeholders, key conservation agriculture management practices that could be implemented include, but are not limited to:

- reducing the burning of crop residues and weeds
- applying conservation tillage practices such as no-till, ridge-till, and mulch-till
- efficient application of fertilizers and manure, including giving careful attention to the production of household manure from poultry and livestock droppings
- improving, maintaining, and managing permanent soil cover through the planting of cover crops such as *mucuna pruriens* and practising crop rotation

### 5.2.1.2 Irrigation Schemes

The VA identified drought as one of the challenges facing agriculture in the municipality. Availability of adequate water for irrigation is vital for improved and sustainable farming. The establishment and management of irrigation schemes is therefore important to increase agricultural productivity. In collaboration with Ghana Irrigation Development Authority, communities with existing but non-functional irrigation schemes could be rehabilitated to provide sustainable water for smallholder farmers. Provision and maintenance of small-scale irrigation dams in communities with poor access to water for agricultural purposes will improve on-farm activities during the dry seasons. A number of irrigation tools are available locally to support irrigation schemes, such as irrigation booms, irrigation pivots, irrigation guns, sprinklers, pump-set packages, power units, soft hoses, and other

fittings and accessories. Farmers would need capacity building in managing irrigation schemes and ensuring sustainable and efficient use of water for farming activities.

#### 5.2.1.3 Agroforestry Promotion

Agroforestry practices should be promoted to strengthen the resilience of farmers and communities to boost agricultural production in Kintampo Municipality. Promoting agroforestry will improve soil fertility, encourage food security and increase the incomes of the people. Climate-resilient tree species that are drought-tolerant are highly recommended because they are able to withstand extreme climate events. Agroforestry practices would also help to support farmers during crop failure by enabling the sale of fuelwood and timber, or the processing of shea butter. Agroforestry also protects water bodies from excessive evaporation and, when well implemented, can boost food production and income generation. To promote and sustain agroforestry, it is necessary to encourage farmers to actively participate in the planting of short-rotation trees and crops in a manner that ensures minimal conflict with land-use systems. The knowledge of the farmers and other community members on agroforestry must be improved to reduce land degradation, reduce erosion, improve soil fertility, and boost agricultural productivity. It is recommended that a collaboration with existing institutions such as the Forestry Commission be established and strengthened, and that these collaborating institutions are asked to provide tree seedlings and species that can grow well in the transitional zone. The tree species selected must be income-generating, easy to maintain, drought- and climate-tolerant, acceptable to the local people, and fast-growing. Some specific examples of how agroforestry can be implemented in the municipality include:

- Integration of shade trees. Farmers can plant shade trees, such as African mahogany (*Khaya spp.*) or acacia (*Acacia spp.*), alongside crops like cocoa or coffee. The shade provided by these trees helps to create a microclimate that benefits the understory crops, reducing temperature stress and conserving moisture. This integration enhances crop yields and improves income for farmers.

- Alley cropping. This involves planting rows of nitrogen-fixing trees, such as *Gliricidia sepium* or *Leucaena leucocephala*, between rows of crops like maize or vegetables. The trees provide nitrogen to the soil, acting as a natural fertilizer for the crops. Alley cropping helps to improve soil fertility, reduce erosion, and increase crop productivity.

- Agroforestry in shea butter production. Shea trees (*Vitellaria paradoxa*) are native to Ghana and their nuts are used for shea butter production. Promoting the planting of shea trees alongside food crops can provide multiple benefits. The trees contribute to soil fertility and act as windbreaks, and their nuts can be harvested for income generation through the production of shea butter and other value-added products.

- Agroforestry and fuelwood production. Trees like the fast-growing *Gmelina arborea* or *Senna siamea* can be planted on farms to provide a sustainable source of fuelwood for households. Planting fuelwood trees reduces pressure on natural forests and ensures the availability of firewood for cooking and other needs.

- Agroforestry for water management. Planting trees along riverbanks and water bodies helps to protect them from excessive evaporation and erosion. Tree species like the African locust bean tree (*Parkia biglobosa*) or the neem tree (*Azadirachta indica*) are well-suited for such purposes.

#### 5.2.1.4 Adaptive Trials

Commercially viable adaptive trials can also be implemented with climate-resilient crop varieties that can withstand the effects of climate change, such as droughts, dry spells, climate-induced erosion, pests and diseases, and others. These adaptive trials could include technical approaches that are designed with built-in climate change adaptation strategies that promote improved agricultural production technologies for households and communities in the municipality. The adaptive trials should include information on climate change and natural resource management. Different types of adaptive trials could be implemented at selected sites within Kintampo Municipality. The successful results from the adaptive trials could then be used in demonstration sites as evidence to support smallholder farmers' adoption of improved varieties of crops and planting materials, as well good agronomic practices.

#### 5.2.1.5 Demonstration Sites

The establishment of pilot plots within the project sites can provide practical and technical training to farmers and other community members. Demonstration sites would help to create farmers' awareness of climate change adaptation activities. These demonstration sites could be developed to enable farmers, including women and youth, to effectively implement climate change adaptation research findings and recommendations from Ghana and other countries.

#### 5.2.1.6 Holistic Approach for Reducing Bushfires

To address the impact of bushfires in Kintampo Municipality, three key recommendations have been identified. First, strengthening community fire management through raising awareness, training, and establishing community-based fire management committees can enhance fire prevention and emergency response. Second, improving agricultural practices by promoting alternative land-preparation methods, sustainable farming techniques, and climate-smart agriculture can minimize the risk of accidental fires. Last, establishing firebelts, wide strips of land with reduced vegetation, can create effective barriers against the spread of fires, and their implementation should involve collaboration with local communities and authorities.

### 5.2.2 Off-Farm Adaptation Options

This section discusses the off-farm adaptation options that need to be prioritized in Kintampo Municipality to help reduce communities' and households' vulnerability to climate change.

#### 5.2.2.1 Access to Financial Support

The VA revealed inadequate financial and non-financial support for smallholder farmers. Financial support to smallholder farmers is highly inadequate and extremely difficult to access. Commercial and rural banks are not providing enough credit facilities to smallholder farmers due to their inability to provide a guarantee or collateral. This lack of credit might affect agricultural production and food security. Financial and non-financial support to smallholder farmers could enhance their resilience to the adverse impacts of climate change. This support could be in the form of soft loans with no or low interest rates and cashless inputs, as well as agricultural insurance packages offered through farmer groups.

#### 5.2.2.2 Awareness and Knowledge on Climate Change and Adaptation Strategies

Awareness and knowledge creation on climate change will help to enhance adaptation among smallholder farmers. There is therefore the need to increase awareness on climate change in the different communities within the Kintampo Municipal Assembly. This will involve community sensitization campaigns, media engagement, and communicating climate change impacts to communities and smallholder farmers in ways that they will understand. The community sensitization campaign can include community workshops and interactive sessions, focus group discussions, drama and choreography, and the development of toolkits such as booklets, fliers, and posters displaying information about climate change and adaptation strategies. Community radio programs also offer a viable avenue for the dissemination of information to help build the capacity of smallholder farmers.

#### 5.2.2.3 Capacity Development for Agricultural Extension Officers

The development of the capacity of agricultural extension officers has the potential to support farmers to adapt to the effects of climate change. The professional development and technical training will enable the agricultural extension officers to effectively provide technical and extension support to farmers and educate them on climate change adaptation strategies.

#### 5.2.2.4 Access to Weather Information and Early Warning Systems for Agriculture

Developing climate information services and increasing farmers' access to meteorological information can help promoting climate-smart agriculture and enhance farmers' resilience to climate change. Smallholder farmers require different types of climate information during each stage of the agricultural production process in order to adapt to climate variability and change. Major climate change information includes seasonal climate outlooks, early-warning signals, weather forecasts, pest attacks, input management practices, cultivation practices, pest and disease management strategies, and prices. It is very important that smallholder farmers have this information to enhance their farming activities.

Better access to weather information will have a positive influence on the decisions of smallholder farmers to invest in their farming activities, use drought-tolerant crop varieties, and diversify livelihood options in response to climate change. Communities can access weather information through various channels, including the GMet local offices, mobile phone applications and SMS services, community radio, and community-based extension services. Kintampo Municipality should collaborate with the GMet to establish weather information centres in selected communities to provide prompt weather reports so that the communities can prepare for planting and mitigate any negative effects such as floods.

### 5.2.3 Gender-Based Vulnerability Reductions and Sustainability

The VA also identified gender-based vulnerabilities to climate change in the municipality. Several underlying factors exacerbate women's vulnerability to the impacts of climate change, including limited livelihood options. Women (and youth) are disproportionately vulnerable to the effects of climate change, which aggravates existing disparities because of their high dependency on natural resources for subsistence and their limited roles in decision making and resource allocation. Any adaptation actions should fully integrate gender-based perspectives at all levels.

#### 5.2.3.1 Prioritization of Actions to Support Women

To effectively address the needs of women, promote gender equality, and enhance the resilience of the agricultural sector to climate change impacts, the following actions are recommended for implementation in Kintampo Municipality.

- **Capacity building and training:**
  - Provide targeted training and capacity-building programs that empower women in agricultural practices, including climate-smart agriculture techniques and agroforestry. These programs will enhance their skills, knowledge, and decision-making abilities in adapting to climate change and improving agricultural productivity.
  - Include gender-responsive training modules in climate change adaptation programs, addressing the specific needs and constraints faced by women farmers and promoting their active participation in decision-making processes.
- **Access to resources and livelihood diversification:**
  - Establish women-focused agricultural cooperatives or self-help groups, which can contribute to ensuring equitable access to resources such as land, credit, agricultural inputs, and technologies for women farmers. Support initiatives that promote women's ownership and control over productive resources, which will enhance their resilience and economic empowerment.
  - Promote income diversification by supporting women's involvement in income-generating activities beyond agriculture, such as agro-processing, value addition, or non-farm activities. This diversification will provide alternative sources of income and reduce their vulnerability to climate-related risks in agriculture.
- **Women's participation and leadership:**
  - Promote gender-inclusive decision-making processes at all levels related to agriculture and climate change adaptation. Encourage women's active participation in community-based organizations, farmer groups, and decision-making bodies to ensure their voices are heard and their perspectives are considered in planning and implementing adaptation strategies.
  - Facilitate the establishment of platforms for women's leadership and participation, such as women's forums or networks, to empower them to take active roles in shaping climate change adaptation initiatives.
- **Climate-smart agriculture and conservation practices:**
  - Introduce women farmers to climate-smart agriculture practices, such as agroecology, organic farming, and water-efficient irrigation techniques. Provide training and support in adopting these practices to enhance agricultural productivity and resilience to climate change.
  - Promote conservation agriculture practices among women farmers, including reduced tillage, mulching, and cover cropping, to improve soil health, water retention, and carbon sequestration.

- **Access to climate information and services:**
    - Develop and disseminate gender-responsive climate information and advisory services that cater to the specific needs of women farmers. Use accessible channels such as SMS and texts that are accessible on yam phones, mobile phone applications, radio programs, or community-based extension services to provide timely and context-specific information.
    - Strengthen women's access to climate finance mechanisms, such as microfinance or savings schemes, to enable them to invest in climate-resilient technologies, inputs, and infrastructure.
- **Strengthening gender-disaggregated data and research:**
    - Invest in gender-disaggregated data collection and research to better understand the differentiated impacts of climate change on women and men in Kintampo Municipality. This data will inform evidence-based decision making and the design of targeted adaptation interventions.
    - Collaborate with local research institutions and organizations to conduct gender-responsive studies on climate change adaptation, considering women's knowledge, coping strategies, and innovations in managing climate-related risks.

### 5.2.4 Concluding Remarks

The VA team adhered closely to district-specific, needs-driven criteria in the development of the Kintampo Climate Vulnerability Assessment, with a focus on the unique vulnerabilities of the region. A conscious effort was made to ensure inclusivity by engaging a diverse range of stakeholders, including marginalized groups, to understand the varied impacts of climate change. The VA aligns with Ghana's National Adaptation Plan and national development priorities, reinforcing the relevance of our work to the broader national context. Existing structures and resources from the Green Climate Fund NAP Readiness program were leveraged, optimizing cost-effectiveness and efficiency. Importantly, a gender-sensitive approach was adopted, incorporating both qualitative and quantitative data to analyze the differentiated impacts of climate change on men and women. Thus, the Kintampo VA provides a comprehensive, inclusive, and gender-sensitive assessment that aligns with both local and national priorities. While the assessment team acknowledges that the granularity of gendered analyses might not be as detailed as desired, this lack of granularity in no way diminishes the robustness of the assessment's conclusions. Emphasis has been placed on ensuring that the recommendations for adaptation are comprehensive and specifically address the critical concerns unearthed in the VA. Adopting this approach ensures that, even with certain data constraints, the proposed strategies are tailored to directly mitigate the identified vulnerabilities, with a particular focus on the unique challenges faced by different gender groups.

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# Appendix 1. Stakeholder Mapping

**Table A1. Relevant stakeholders, their key roles, responsibilities, and expected outcomes from the vulnerability assessment**

W = Workshop; I = Interview; S = Survey

| **Public/Government Sector** | | | | |
|---|---|---|---|---|
| Ghana National Fire Service | Municipal Director | • Organize public education programs to create and sustain awareness of the hazards of fire; and heighten the role of the individual in the prevention of bushfires.<br>• Train and organize fire volunteer squads at the community level to deal with bushfire. | W, I | • Education on Ghana Fire Service actions and efforts to address climate change impacts.<br>• Improved knowledge how climate change influences bushfires in the Municipality.<br>• Understanding and appreciation that climate-induced warmer and drier conditions affects firefighting interventions |
| Ghana Education Service | Municipal Director | • Oversee the integration of climate change and sustainability education into national curricula.<br>• Support training teachers on climate change and green economy. | W, I | • Teachers to be aware of the NAP framework.<br>• Adaptation actions to be transferred to teachers and students at different levels of educational system.<br>• Enhanced knowledge on climate change causes, effects, and local actions. |
| NADMO | NADMO Director | • Coordinate adaptation planning and mainstreaming at the district level.<br>• Promote disaster risk reduction and climate change risk management.<br>• Contribute to effective social mobilization for disaster prevention and poverty reduction.<br>• Provide disaster relief and assistance in times of disasters in the district. | W; I | • Reduction in vulnerability related to climate change and disasters.<br>• Adaptation planning and mainstreaming at the district level is well coordinated. |

| | | | | |
|---|---|---|---|---|
| NDPC | NDPC Regional Officer | • Formulate national development policy frameworks and ensure that the strategies, including consequential policies and programs, are effectively carried out.<br>• Ensure effective coordination of the preparation, implementation, monitoring and evaluation of national policies, projects, and plans in the district. | W; I | • Programs/projects of the district disaster plans will be incorporated into their adaptation plans.<br>• Full integration of climate change into economic, environmental, and social decision making of the district. |
| GMET | GMET Officer | • Provide efficient and reliable meteorological information by collecting, processing, archiving, analyzing, and dissemination of findings/meteorological information. | W; I | Assess to climate and weather data of the locality. |
| EPA | EPA Regional Director | • Provide environmental checks on pollution and sanitation, environmental protection, and climate action.<br>• Educate stakeholders on policies and actions for climate change adaptation and mitigation across the country. | W; I | • Strategic and holistic vulnerability reports will be developed for key sectors in the municipality.<br>• Sectoral priorities and local adaptation priorities will be identified. |
| Municipal Planning Unit | Mun. Planning Officer | • Facilitate and coordinate the preparation of the development plans of the KiMA.<br>• Lead monitoring and evaluation activities of the KiMA.<br>• Coordinate implementation of development programs, projects and activities in the Municipality. | W; I | • Effective and coordinated mainstreaming of climate change adaptation.<br>• Officials empowered to integrate climate change adaptation into their development plans.<br>• Capacities improved to undertake monitoring and evaluation of climate change adaptation plans and actions.<br>• Increased adaptation finance form development partners, the private sector and civil society organizations through improved engaged with the Assembly. |
| Forestry Commission | Forestry Commission officer | • Regulate the utilization of forest and wildlife resources, the conservation and management of those resources, and the co-ordination of policies related to them. | W; I | Technical support. |

| | | | | |
|---|---|---|---|---|
| Ministry of Food and Agriculture | MoFA Mun. Director | • Coordinate and implement agricultural policies and practices in the municipality | W; I | Increased capacity of extension staff will be built at regional and district levels to be able to appropriately mainstream climate change in their extension message |
| | Agriculture Extension Agent | • Technology transfer<br>• Formal knowledge on climate change and agriculture | W; I; S | |
| National Commission on Civic Education | NCCE Officer | • Responsible for the education of residents on concept of climate change, measures to adopt to mitigate and adapt to its effect and other civic matters | W; I | Increased awareness creation and climate change education |
| Regional Coordinating Council | RCC Director | • Responsible for monitoring and evaluating District Climate Change Adaptation Strategy<br>• Coordinate from a regional level by formulating, monitoring and evaluating of all plans and programs of Ministries, Departments and Agencies (MDAs), | W; I | Strongly liaise with monitoring staff of National Climate Change Committee to remove bottlenecks in the implementation of Municipal programs |
| National Youth Authority | Municipal Officer | • Supporting municipality in creating awareness and running educational programs on climate action<br>• Supporting national, regional and local projects on climate change adaptation and mitigation (e.g. Green Ghana Initiative)<br>• Engaging youth to identify and promote green entrepreneurship opportunities | W, I | • Skills, knowledge and competencies on climate change adaptation under NAPF will enhanced<br>• Capacity of youth enhance and empowered to contribute to decision making at the local and regional level on climate action. |
| Gender Department | Gender Officer | • Promotes the implementation of activities that address the rights of women, children, and youth | W; I | A strategic focus will be given to them for priority gender vulnerabilities to be addressed |
| Ghana Health Service | Municipal Environmental Health Officer | • Support the integration of climate change into the management of priority health risks in the municipality in harmony with national health development priorities. | W; I | A strategic focus will be given to them for priority health vulnerabilities to be addressed |

| | | | | |
|---|---|---|---|---|
| UNFCCC Focal Point | UNFCCC Focal Person | • Coordinate UNFCCC-led policies and programs<br>• Support the global response to the threat of climate change | W; I | Development priorities will be set out |
| Ministry of Finance | Representative | • Support identification and categorization of multi-scalar assessment of vulnerability and adaptation options<br>• Oversee, coordinate, and manage financing and support in natural resources and climate change activities | W; I | Budget support for vulnerability assessment and implementation of adaptation strategies |
| **Research/Academia** | | | | |
| College of Health and Well-Being, Kintampo | Deputy Principal | • Climate change for education, research and capacity building. In relation to climate change, the academia and research institutions are expected to engage in studies and projects where they explore solutions to improve climate vulnerability of the municipality. | W; I | • To provide technical support and contribute research findings in development of the VA and adaptation planning for the Kintampo Municipal Assembly.<br>• Increased climate change education and capacity building |
| Kintampo Health Research Centre | Representative | • Investigating and educating communities on the nexus between climate change and health | | |
| **Development Partners** | | | | |
| GIZ | Representative | • Resource mobilization, capacity development and technology development and transfer for current and future adaptation action.<br>• Support in conducting national level vulnerability assessments | W; I | • Technical knowledge shared on Vulnerability assessments<br>• Financial and technical support for successful adaptation actions |
| USAID | Representative | | I | |

| | | | | |
|---|---|---|---|---|
| **Vulnerable Groups** | | | | |
| Women Groups | Representative | Participate in the design and implementation of activities under the NAP | W; I; S | • Increased awareness of the public and policy-makers on the impacts of climate change on the vulnerable groups, especially young people and the roles the young people can play in the development and implementation of climate change mitigation and adaptation strategies.<br>• Stronger advocacy, public engagements, awareness creation and other technical support<br>• Identification of the greatest risks to them from climate change impacts.<br>• Cooperation for effective implementation of climate adaptation practices<br>• The voice of the youth will be heard and included in climate change negotiations. |
| People with Disability | Representative | | W; I; S | |
| **Private Sector (NGO, CSOS)** | | | | |
| TROPENBOS GHANA | Project Coordinator | • Promoting climate change mitigation through climate-smart agriculture adoption<br>• Educating rural-based community people on combating deforestation and opportunities for alternative and sustainable livelihood systems | W, I | • Contribute data and information to enhance the implementation of existing projects like "Mobilizing more for climate (MoMo4C)"<br>• Identify relevant stakeholders for engagement and partnership |
| Input dealers | Representative | Promote adoption of improved and resilient technological farm inputs | W; I; S | Improve access to information through their communication networks |
| CYDEF | Project Manager | • Engaging communities and households (young people, women, and children) in developmental activities aimed at reducing poverty level through economic values, social and environmental changes among rural people. | W | Enhanced knowledge on opportunities for collaborative on climate change adaptation and mitigation projects<br>Transferring knowledge on climate change adaptation in the context of NAP to communities and households. |

| | | | | |
|---|---|---|---|---|
| Financial institutions | Commercial Banks | Provide access to credit facilities | | Access to financial and technical support |
| | Savings and loans | | | |
| **Traditional Authorities** | | | | |
| Traditional council | Representatives | • Community mobilization and granting of permission to enter a community and to engage the community members | W; I | • Identification of the greatest risks to them from climate change impacts.<br>• Cooperation for effective implementation of climate adaptation practices |
| **Other Relevant Groups** | | | | |
| Farmer-based organizations | Representatives | • Provide opportunities for farmers to benefit from economies of scale, better bargaining power and a stronger voice in policy development. | W; I; S | • Identification of the greatest risks to them from climate change impacts.<br>• Effective implementation of climate adaptation practices<br>• Champion community awareness creation of climate change<br>• Advocacy, public engagements |
| Faith-based organizations | Representatives | Community mobilization and advocacy | W; I; S | |
| Opinion leaders | Representatives | | W; I; S | |
| Assembly members | Representatives | | W; I | |
| Town/Area councils and unit committees** | | | W; I; S | Should be able to prepare their own climate change adaptation plans and submit to the District Assemblies |
| **Media** | | | | |
| Adars FM (Peace, UTV, Adom) | Representative | • Advocacy and communication of findings<br>• Engage the community by sensitizing and educating on measures to adopt to mitigate and adapt to the issues of climate change | W; I | • Increased community awareness creation of climate change<br>• Advocacy, public engagement |

# Appendix 2. Stakeholder List

1. People with Disabilities
2. Traditional Authorities
3. Kintampo Municipal Assembly
4. National Disaster Management Organization (NADMO)
5. Ghana Boys Scout
6. Ghana Education Services (GES)
7. Ghana Health Services (GHS)
8. Ghana National Forse Service (GNFS)
9. Ghana Meteorological Agency (GMET)
10. Forestry Commission
11. Environmental Protection Agency (EPA)
12. Youth Group
13. Agro Chemicals Ghana
14. Kintampo Health Research Center
15. Assembly Members
16. Market Women Association
17. Ghana Revenue Authority (GRA)
18. University of Development Studies (UDS)
19. Parks and Gardens
20. Local Media
21. National Commission on Civic Education

# Appendix 3. Research Questions

| Date: | Operational area: | Community/Town/Village: |
|---|---|---|
| Latitude: | Longitude: | |
| Questionnaire ID: | Enumerator: | |

### A. Respondents Profile

A1. Name of household head: _____ (Is the respondent same as household head? [YES] [NO]) Contact phone No: _____

A2. Gender of household head: 1=Female 2=Male

### B. Household Composition

B1. How many people in the household are Male [ _____]

B2. How many people in the household are Female [ _____]

B3. How many people in the household are above 60 years [ _____]

B4. How many people in the household are below 18 years [ _____]

B5. How many people in the household have any form disability [ _____]

B6. Highest level of formal education of members of the household (enter number in bracket)

- Basic (Primary/Middle/JHS) = [ _____]
- Secondary (Secondary/vocational) = [ _____]
- Tertiary (Training college/Polytechnic/University) = [ _____]

### C. Livelihood strategies

C1. Primary occupation of the household (select a sector most applicable to your household)
Agriculture (Crop = [___] Livestock & Poultry = [___] Fishing = [___])
Forestry (Ecosystems and Biodiversity) = [___] Water = [___]
Human Health and Sanitation = [___] Infrastructure (Roads and Buildings, Transport) = [___]
Service Sector (Finance, Trade and Industry, Tourism) = [___]

C2. Are you engaged in other income generating activities? [___] 1 = Yes 2 = No

C3. If yes, which other income generating activities are you engaged in? Agriculture (Crop = [___] Livestock & Poultry = [___] Fishing = [___]) Forestry (Ecosystems and Biodiversity) = [___] Water = [___] Human Health and Sanitation = [___] Infrastructure (Roads and Buildings, Transport) = [___] Service Sector (Finance, Trade and Industry, Tourism) = [___]

C4. Does any member of your household work outside this community? [___] 1 = Yes 2 = No

C5. How many people of the household are unemployed? [___]

**D. Assessment General Climate Exposure**

D1. How many extreme drought/dry spells have occurred in this community since 2012 (10 years ago) [___]

D2. How many extreme flood(s) have occurred in this community since 2012 (10 years ago). [___]

**E. Assessment of General Sensitivity**

E1. Do you receive information on weather forecasts for your livelihood activities or in the community? [___] 1 = Yes 2 = No

E2. 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*)_____

E3. How often do you access this information for your activities [___]
1 = Very often 2 = often 3 = Sometimes 4 = Less often 5 = Not at all

E4. Do you have access to good road network? [___] 1 = Yes 2 = No

E5. What material is your house made of? [___]
1 = Cement 2 = Bricks 3 = Mud 4 = Cement/Brick/Mud 5 = Other (specify)

E6. Is your house in a flood prone area? [___] 1 = Yes 2 = No

E7. What is the level of proximity of your house and the Odo River? [___]
Very close = 5 close = 4 somewhat low = 3 far = 2 very far = 1

E7. Do you have access to internet connectivity? [___] 1 = Yes 2 = No

E8. Do you have a health facility in this community? [___] 1 = Yes 2 = No

E9. How long (minutes) does it take to get to a health facility? _____minutes

E10. Are you on the National Health Insurance Scheme? [___] 1 = Yes 2 = No

E11. Do you have access to ready market in this community? [___] 1 = Yes 2 = No

E12. If yes, how long (minutes) do you have to travel to the market? _____minutes

E13. Has water availability been a problem? [__] 1 = Yes 2 = No

E14. How long (minutes) does it take to get to the water source? _____Minutes

## Assessment of General Adaptive Capacity

### F. Social network

F1. Are you a member of any social organisation? [__] 1 = Yes 2 = No

F2. Are you aware of any active gender related organisations and associations in the community? [__] 1 = Yes 2 = No

F3. Does your household benefit from any government social interventions (e.g., LEAP, subsidy, land tenure arrangement) in the [__] 1 = Yes 2 = No

F4. Did you received support from any organisations/institutions (Research and Development Institution, governmental organisation, non-governmental organization) to coping with climate-related issues? [__] 1 = Yes 2 = No

### G. Availability and access to credit

G1. Do you have access to credit for your economic activities? [__] 1 = Yes 2 = No

G2. Has your household received remittances/assistance from family or friends within the past 12 months? [__] 1 = Yes 2 = No

G3. Do you have access to any subsidies ? [__] 1 = Yes 2 = No

## Sector Specific Indicators

### H. Agriculture Sector

H1. What is the total size of your farm? (Average since 5 years ago): _____ acres

H3. What is the major crop you cultivate? _____

H4. Do you grow other crops? [__] 1 = Yes 2 = No

H5. Do you have livestock/poultry? [__] 1 = Yes 2 = No

H6. Do you have irrigation system on your farm? [__] 1 = Yes 2 = No

H7. If yes, what percentage of your farm land is under irrigation? _____

H8. Do you have access to water for dry season farming? [__] 1 = Yes 2 = No

H9. Are you a member of a Farmer Based Association (FBO)? [__] 1 = Yes 2 = No

H10. Do you have access to/contact with Agricultural Extension Agents (AEA) [__] 1 = Yes 2 = No

H11. If yes how often? [ ] 1) Weekly 2) Monthly 3) Quarterly 4) Every six months 5) Annually

H12. Do you get information on improved production methods and systems? [___] 1 = Yes 2 = No

H13. Is your farm in a flood prone area? [___] 1 = Yes 2 = No

H14. What is the level of proximity between your farm (fish, poultry, livestock) and the Odo River? [___] Very close = 5 close = 4 somewhat low = 3 far = 2 very far = 1

H15. What percentage of your total output do you lose as a result of post-harvest losses? _____

H16. Do you know about agricultural insurance? [___] 1 = Yes 2 = No

H17. If yes, have you subscribed to any insurance product? [___] 1 = Yes 2 = No

**I. Health Sector**

I1. 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
(*e.g. Cholera; Typhoid, Bacillary dysentery, Infectious, hepatitis, Giardiasis, Scabies, Lice, Trachoma, Dysenteries, Ascariasis, schistosomiasis, Bilharziasis, Threadworm, Yellow fever, Dengue fever, and Malaria*)

I2. Do you have access to safe sanitation facilities? [___] 1 = Yes 2 = No

I3. Do you have access to health care? [___] 1 = Yes 2 = No

I4. How many health facilities do you have in this community/town?_____

I5. How many public toilet facilities do you have in this community/town _____

I6. Have you had any training/sensitization on climate related diseases like malnutrition and diarrhea, respiratory diseases, waterborne diseases etc. [___] 1 = Yes 2 = No

**J. Water Sector**

J1. What is the Average cost of water per month? _____ (GHS)

J2. What is the level of NGOs and CSOs activity (Collective action - e.g., NGOs and CSOs investing in water) in the community [___]
Very low = 5 low = 4 somewhat low = 3 high = 2 very high = 1

J3. Do you have access to potable water? [___] 1 = Yes 2 = No

J6. Are you aware of any water management regulations (conservation, watershed management) protects our water resources [___] 1 = Yes 2 = No

J7. 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

**K. Forestry Sector**

K1. What is the frequency of forest pest and disease in this community since 2012 (10 years ago) [___] Very low = 1 low = 2 somewhat low = 3 high = 4 very high = 5

K2. What is the frequency of forest fire in this community since 2012 (10 years ago) [___]
Very low = 1 low = 2 somewhat low = 3 high = 4 very high = 5

K3. What is the level of forest cover in this area [___]
Very low = 1 low = 2 somewhat low = 3 high = 4 very high = 5

K5. What is your level accessibility to biodiversity [___]
Very low = 1 low = 2 somewhat low = 3 high = 4 very high = 5

K6. Do you obtain income from engagement with the forestry? [___] 1 = Yes 2 = No

K7. What average distance (km) do you have to travel from the community to the forest?
_____km

K8. 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

K9. 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. Service Sector**

L1. Is your business in a flood prone area? [___] 1 = Yes 2 = No

L2. Do you depend on agriculture for raw materials in your business activities? [___]
1 = Yes 2 = No

L3. Have you insured your business? [___] 1 = Yes 2 = No

L4. Are you a member of any business cooperative? [___] 1 = Yes 2 = No

L5. Are you aware of any government intervention, strict enforcement of regulations and laws (e.g., education policy, credit for businesses) [___] 1 = Yes 2 = No

L6. 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. Infrastructure Sector**

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

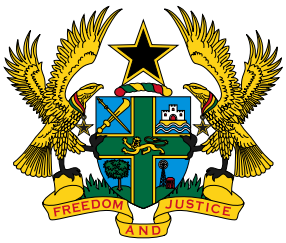
L3. Are you aware of any climate driven risk based on past threats? [___] 1 = Yes 2 = No

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

**The end: Thank you for your cooperation.**


KINTAMPO SOUTH DISTRICT ASSEMBLY
DEVELOPMENT IN UNITY
JEMA


FREEDOM
AND
JUSTICE