




A HARMONIZED CLIMATE CHANGE AND HEALTH VULNERABILITY & ADAPTATION ASSESSMENT REPORT

December 2025

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List of Abbreviations

ANC	Antenatal care
CHIM	Centre for Health Information Management
cdd	Consecutive dry days (maximum number of consecutive days with precipitation < 1 mm)
cwd	Consecutive wet days (maximum number of consecutive days with precipitation ≥ 1 mm)
COP	Conference of the Parties
CSM	Cerebrospinal Meningitis
CVD	Cardiovascular Disease
CWC	Child Welfare Clinic
DCD	District Coordinating Director
DHIMS2	District Health Information Management System
EHO	Environmental Health Officer
EPA	Environmental Protection Agency
EWS	Early Warning System
GCF	Green Climate Fund
GEF	Global Environment Facility
GFATM	Global Fund for AIDS. TB and Malaria
GHS	Ghana Health Service
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GMET	Ghana Meteorological Agency
GPS	Global Positioning System
GSGDA	Ghana Shared Growth and Development Agenda
H-NAP	Health component of national climate adaptation plan
HPD	Health Promotion Division
ICD	Institutional Care Division
IDSR	Integrated Disease Surveillance and Response
IPCC	Intergovernmental Panel on Climate Change
LLINs	Long Lasting Insecticide Treated Nets
MDA	Ministries, Departments and Agencies
M&E	Monitoring and Evaluation
MESTI	Ministry of Environment, Science, Technology, and Innovation
MOFA	Ministry of Food and Agriculture
MOH	Ministry of Health
MoLGRD	Ministry of Local Government and Rural Development
NADMO	National Disaster Management Organisation
NAP	National Adaptation Plan

NCAP	Netherlands Climate Assistance Programme
NCD	Non-Communicable Disease
NCDP	Non-Communicable Disease Program
NCCP	National Climate Change Policy
NDA	Nationally Designated Authority
NMCP	National Malaria Control Program
NRSC	National Road Safety Commission
NTD	Neglected Tropical Diseases
OEHP	Occupational and Environmental Health Program
OPD	Out-Patient Department
PHD	Public Health Division
PPP	Policies, Plans and Programs
PPRSD	Plant Protection and Regulatory Services Division
r10mm	Number of days with precipitation ≥ 10 mm (heavy precipitation days)
r20mm	Number of days with precipitation ≥ 20 mm (very heavy precipitation days)
r95p	Annual total precipitation from days with rainfall > 95th percentile (very wet days)
r99p	Annual total precipitation from days with rainfall > 99th percentile (extremely wet days)
rh	Relative humidity
rx5day	Maximum consecutive 5-day precipitation total
RCC	Regional Coordinating Council
RDD	Research & Development Division
RTA	Road Traffic Accident
RTI	Respiratory Tract Infection
sdii	Simple daily intensity index (average precipitation on wet days, i.e., days with ≥ 1 mm)
tmax	Maximum temperature (usually daily maximum)
tmin	Minimum temperature (usually daily minimum)
tn10p	Percentage of days when daily minimum temperature < 10th percentile (cold nights)
tn90p	Percentage of days when daily minimum temperature > 90th percentile (warm nights)
tnn	Minimum value of daily minimum temperature (annual minimum of min temp)
tnx	Maximum value of daily minimum temperature (annual maximum of min temp)
tx10p	Percentage of days when daily maximum temperature < 10th percentile (cold days)
tx90p	Percentage of days when daily maximum temperature > 90th percentile (hot days)
txn	Minimum value of daily maximum temperature (annual minimum of max temp)
txx	Maximum value of daily maximum temperature (annual maximum of max temp)
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program
UNFCCC	United Nations Framework Convention on Climate Change
V & A	Vulnerability and Adaptation
WHO	World Health Organization

Glossary of Terms

Adaptation

Initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects. Various types of adaptation exist, e.g., anticipatory and reactive, private and public, and autonomous and planned. Examples are raising river or coastal dikes, the substitution of more temperature-shock resistant plants for sensitive ones, etc.

Anthropogenic emissions

Emissions of greenhouse gases, greenhouse gas precursors, and aerosols associated with human activities, including the burning of fossil fuels, deforestation, land-use changes, livestock, fertilisation, etc.

Carbon dioxide (CO_2)

A naturally occurring gas, also a by-product of burning fossil fuels from fossil carbon deposits, such as oil, gas and coal, of burning *biomass,* and of *land use changes* and other industrial processes. It is the principal *anthropogenic greenhouse gas* that affects the Earth's radiative balance. It is the reference gas against which other greenhouse gases are measured and therefore has a *Global Warming Potential* of 1.

Climate model

A numerical representation of the *climate system* based on the physical, chemical and biological properties of its components, and their interactions, *feedback* processes, and accounting for all or some of its known properties. The climate system can be represented by models of varying complexity, that is, for any one component or combination of components a spectrum or hierarchy of models can be identified, differing in such aspects as the number of spatial dimensions, the extent to which physical, chemical, or biological processes are explicitly represented, or the level at which empirical parameterisations are involved. *Coupled Atmosphere-Ocean General Circulation Models (AOGCMs)* provide a representation of the climate system that is near the most comprehensive end of the spectrum currently available.

Climate scenario

A plausible and often simplified representation of the future *climate*, based on an internally consistent set of climatological relationships that has been constructed for explicit use in investigating the potential consequences of *anthropogenic climate change*, often serving as input to impact models.

Exposure

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 a climate-related hazard.

Extreme weather event

An event that is rare at a particular place and time of year. Definitions of "rare" vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th *percentile* of the observed probability density function.

Greenhouse gas (GHG)

Greenhouse gases are those gaseous constituents of the *atmosphere*, both natural and *anthropogenic*, that absorb and emit radiation at specific wavelengths within the spectrum of *thermal infrared radiation* emitted by the Earth's surface, the atmosphere itself, and by clouds. This property causes the

greenhouse effect. Water vapour (H_2O), *carbon dioxide* (CO_2), *nitrous oxide* (N_2O), *methane* (CH_4) and *ozone* (O_3) are the primary greenhouse gases in the Earth's atmosphere.

Mitigation

Technological change and substitution that reduce resource inputs and emissions per unit of output. Although several social, economic and technological policies would produce an emission reduction, with respect to *Climate Change*, mitigation means implementing policies to reduce *greenhouse gas* emissions and enhance *sinks*.

Resilience

The capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system can organize itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures. (UN/ISDR, 2004)

Sensitivity

The degree to which a system may be affected, either adversely or beneficially, by climate-related stimuli.

Scenario

A plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships. Scenarios may be derived from *projections* but are often based on additional information from other sources, sometimes combined with a *narrative storyline*.

Sink

Any process, activity, or mechanism, which removes *greenhouse gas*, *aerosol* or precursors of greenhouse gas or aerosol from the *atmosphere*.

Source

Source mostly refers to any process, activity or mechanism that releases a *greenhouse gas*, an *aerosol*, or a precursor of a greenhouse gas or aerosol into the *atmosphere*. Source can also refer to e.g., an *energy* source.

United Nations Framework Convention on Climate Change (UNFCCC)

The Convention was adopted on 9 May 1992 in New York and signed at the 1992 Earth Summit in Rio de Janeiro by more than 150 countries and the European Community. Its ultimate objective is the "stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". It contains commitments for all Parties. Under the Convention, Parties included in *Annex I* (all OECD member countries in the year 1990 and countries with *economies in transition*) aim to return *greenhouse gas* emissions not controlled by the Montreal Protocol to 1990 levels by the year 2000. The Convention entered in force in March 1994.

Vulnerability

Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (AR4).

FOREWORD BY MINISTER FOR HEALTH

Climate change is redefining the development landscape of our time. For Ghana, it is not merely an environmental challenge, it is a profound public health threat that demands decisive leadership, bold policy action, and sustained national commitment.

Across our ecological zones, the impact of climate change is visible, from rising temperatures, unpredictable rainfall, flooding, drought, food insecurity to environmental degradation. These changes are already influencing the transmission patterns of climate-sensitive diseases, increasing heat-related illnesses, threatening maternal and child health, and placing additional strain on our health infrastructure.

Recognizing this urgency, the Ministry of Health has undertaken this comprehensive Harmonized Climate Change and Health Vulnerability & Adaptation Assessment. This landmark report provides the most robust national evidence on climate variability, risk, and levels of adaptive capacities within the health system. It also forward looking, projecting the likely future impact of climate variability on disease patterns.

Vulnerabilities are most pronounced among children, women, the elderly, low-income households, and communities in flood-prone and drought-affected regions. The assessment further reveals systemic gaps in infrastructure resilience, surveillance systems, emergency preparedness, and climate-informed planning.

The message is straightforward and clear. Climate change is not a future risk, it is a present and accelerating reality, which provides a strategic opportunity for adaptative planning to protect vulnerable populations and enhance the resilience of our health system. This report therefore marks a turning point. It aligns with our broader vision for Universal Health Coverage and sustainable development, signalling Ghana's commitment to placing health at the center of national climate action. It also strengthens Ghana's implementation of the Paris Agreement including advancing our Nationally Determined Contributions (NDCs).

The evidence contained in this report is a call to action. It compels us to invest strategically, to strengthen institutions, to mobilize climate financing, and to build a health system capable of withstanding the shocks of a changing climate.

I commend all technical experts, development partners, and institutions who contributed to this milestone achievement. I hope this assessment becomes the foundation for bold adaptation measures that safeguard the health of every Ghanaian today and for generations to come.

HON. KWABENA MINTAH AKANDOH (MP)
MINISTER FOR HEALTH
REPUBLIC OF GHANA

FOREWARD BY DIRECTOR GENERAL

As the primary public health implementing and health service delivery agency of the Ministry of Health, Ghana Health Service (GHS) is confronted by a dynamic and intensifying challenge: the profound and multifaceted impact of climate change on the health and well-being of our population. This seminal Vulnerability and Adaptation (V&A) Assessment report provides an authoritative and evidence-based analysis of this critical issue, translating complex climatic data into a clear agenda for public health action.

The report's findings affirm what our frontline health workers are increasingly witnessing: climate change is a potent health multiplier. It exacerbates existing health burdens, from malaria and meningitis to malnutrition and respiratory illness, while introducing new threats and straining our system's capacity. The identification and prioritization of thirteen Climate-Sensitive Health Outcomes offer a crucial framework for targeting our resources and interventions. Particularly concerning are the disproportionate burdens placed on our most vulnerable citizens—including the poor, women, children, the elderly, and rural communities—thereby threatening to widen existing health inequities.

This assessment is invaluable because it moves beyond identifying problems to diagnosing systemic gaps within our health infrastructure. It highlights critical vulnerabilities in our adaptive capacity, including the limited integration of climate data into health surveillance, insufficient early warning systems, and the need for greater cross-sectoral coordination. The regional-level data is especially critical, providing a granular understanding of risks across our sixteen administrative regions, which is essential for decentralized and context-specific planning.

For Ghana Health Service, building climate resilience is no longer a discretionary future project; it is an immediate operational imperative. This report serves as the definitive evidence base to inform our strategies, guide our investments, and strengthen our policies. It underscores the urgent need to fortify our infrastructure against extreme weather, equip our workforce with the skills to manage climate-related health risks, and ensure our supply chains and service delivery can withstand environmental shocks.

I therefore commend the multi-sectoral Technical Working Group, our dedicated regional and district health teams, and all partners for their rigorous work in producing this foundational document. It will directly guide the development of our Health National Adaptation Plan (H-NAP) and shape our annual operational planning.

Ghana Health Service is committed to championing the implementation of this report's recommendations. We call upon all our directors, facility managers, and health workers to engage with these findings. Furthermore, we reaffirm our commitment to collaborate closely with all relevant Ministries, Departments, Agencies, and development partners. Only through such a unified, whole-of-society approach can we protect health gains and build a resilient health system capable of meeting the needs of all Ghanaians in a changing climate.

Dr. Samuel Kaba Akoriyea
Director General
Ghana Health Service

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Executive Summary

Introduction

Climate change has emerged as one of the most pressing public health challenges of the 21st century. In Ghana, rising temperatures, erratic rainfall, recurrent floods, prolonged droughts, and accelerating sea level rise are no longer distant projections but realities reshaping the country's health landscape. These environmental shifts exert both direct and indirect effects on human health, ranging from heat stress, respiratory illnesses, and waterborne diseases to malnutrition, mental health burdens, and social instability. Without urgent and coordinated action, climate change threatens to erode the foundations of Ghana's health system and disproportionately affect vulnerable populations.

Climate Profile and Health Impacts

Empirical data demonstrate that average annual temperatures in Ghana have increased by approximately 1°C since 1960, with a notable rise in the frequency of "hot days" and "hot nights." Rainfall patterns have become increasingly unpredictable, with intense single-day precipitation events leading to floods, displacement, and infrastructure damage. Along the coast, sea levels are rising at nearly 4 mm per year, accelerating erosion and threatening communities and livelihoods.

Air quality deterioration is a critical concern, with PM2.5 concentrations six times higher than World Health Organization (WHO) limits. Water quality also varies significantly across river basins, compounding risks of diarrheal diseases and other waterborne infections. These environmental stresses heighten the incidence of malaria, respiratory infections, and malnutrition, while also undermining mental health and community resilience.

Demographic and Economic Context

Ghana's demographic trajectory intensifies climate-related health risks. The population, currently estimated at 30.8 million, is projected to exceed 50 million by 2050. This youthful age structure necessitates expanded health services and infrastructure. Poverty levels, which had been declining, have risen again in the aftermath of the COVID-19 pandemic and are projected to peak at over 31% in 2025. Economic growth remains uneven, with agriculture and services highly vulnerable to climate shocks.

The health sector contributes modestly to national GDP yet faces persistent challenges in financing, workforce distribution, and infrastructure. These systemic weaknesses leave the sector ill-equipped to absorb climate shocks, thereby amplifying the vulnerability of populations dependent on fragile health services.

Existing Assessments and Evidence Gaps

Several vulnerability and adaptation (V&A) assessments have been conducted by WHO, AfD, and the World Bank. While these studies provide valuable insights, they often lack regional specificity, strong stakeholder engagement, and clear prioritization of climate-sensitive health outcomes. The absence of harmonized and comprehensive assessments limits policymakers' ability to design effective adaptation strategies. This evidentiary gap underscores the urgency of building a climate-resilient health system supported by robust data and systematic analysis.

Pathways to Climate-Resilient Health Systems

A climate-resilient health system in Ghana must rest on several pillars:

- Policy Integration: Climate risk must be systematically embedded into health policy and planning, ensuring adaptation strategies are mainstreamed across governance levels.

- Infrastructure and Workforce Investment: Expanded and resilient infrastructure, coupled with workforce capacity building, is essential to maintain essential services during floods, droughts, and disease outbreaks.
- Robust Assessments: Harmonized V&A assessments aligned with WHO standards should be conducted nationally and regionally to identify vulnerabilities and guide targeted interventions.
- Community-Based Approaches: Local resilience must be strengthened, particularly in rural and coastal areas where climate impacts are most severe.
- Sustainable Financing: Public funding, private sector engagement, and international support must be mobilized to sustain long-term resilience.

Study Objectives

The overarching goal of this assessment was to produce a harmonized climate change V&A assessment report that will serve as the evidence base for Ghana's Health National Adaptation Plan (H-NAP). Specific objectives include:

1. Development of validation screening tools to evaluate methodological rigor and alignment with WHO guidelines.
2. Gap analysis of existing assessments to identify methodological, data, and thematic deficiencies.
3. Field data collection and updating previous assessments across all sixteen administrative regions to generate new datasets and address evidence gaps.
4. Preparation of a harmonized report synthesizing findings into a consolidated national V&A assessment to guide health adaptation planning.

Methodology

This study employed a harmonized, multi-level assessment framework to evaluate climate-related vulnerabilities and adaptive capacity within Ghana's health sector. The methodology was structured into national and regional level assessments, guided by a modified World Health Organization (WHO) Vulnerability and Adaptation (V&A) assessment process.

National Level Assessments

The national assessment aimed to synthesize and update existing evidence from three prior V&A studies. A multisectoral Technical Working Group (TWG), comprising experts from health, environment, disaster management, agriculture, water and sanitation, and academia, guided the process. The vulnerability and adaptation assessment followed a six-step process.

- **Step 1.** Framing and Scoping: A core study team defined the assessment scope after receiving WHO/AFRO training, addressed key questions regarding stakeholder involvement, policy context, geographical focus, climate-sensitive health outcomes (CSHOs), and data requirements. A pre-designed validity screening tool (annex II) was applied to the three existing V&A reports to identify methodological gaps, focusing on Steps 1–4 of the harmonized framework.
- **Step 2.** Vulnerability Assessment: A qualitative approach was used to assess vulnerability, defined by exposure to CSHOs and sensitivity to climate variability. The process involved:
    - Prioritization of CSHOs: A participatory expert process prioritized CSHOs based on the strength of the climate-health association, Ministry of Health priorities, and community concerns. Outcomes were categorized (e.g., vector-borne diseases, water/foodborne diseases, nutrition) and rated using a risk matrix based on impact severity and likelihood criteria.
    - Baseline Trend Analysis: National and regional trends of prioritized CSHOs (2014–2023) were analysed using data from the District Health Information Management

System (DHIMS) and Integrated Disease Surveillance and Response (IDSR), presented as rates per outpatient registrants.

- Exposure Analysis: Historical and current trends in rainfall, temperature, and extreme events were analysed. Sensitivity analyses explored relationships between weather variables and prioritized CSHOs (malaria, diarrhoea, meningitis, schistosomiasis).
- Identification of Vulnerable Populations/Regions: Vulnerable groups and geographical areas were identified through the analysis.

- **Step 3.** Adaptive Capacity Assessment: The TWG, divided into subgroups and assessed capacity gaps in key health system functions were aligned with standard objectives/components of the WHO Health National Adaptation Plan (H-NAP) guidance document.
- **Step 4.** Prioritizing adaptive capacity: Using structured templates (annex III), groups identified gaps in the health system at national level, mapped current/planned Policies, Plans, and Programs (PPPs), and recommended adaptive actions. Adaptive capacity of identified PPPs was rated on a scale (1=low to 3=adequate) based on workforce, supplies, technology, and policy availability.
- **Step 5:** Understanding future impacts on health: Using historical climate data (1980 to 2024) and DHIMS-2 data on CSHOs (2009–2024) the disease burden of CSHOs was projected for 2025-2050 for each agro-ecological zone, using advanced machine learning (ML) techniques. Projections were limited to Malaria, Upper Respiratory Tract Infections (URTIs), Diarrhoea, Pneumonia, Asthma, Road Traffic Accidents (RTA), Depression, Bilharzia and Snake bites health outcomes due to inadequate data/reporting of the other CSHOs.
- **Step 6:** Synthesise and recommend adaptive strategies as input for the H-NAP and policy.

Regional Level Assessments

Field assessments were conducted in all 16 administrative regions using an exploratory study design.

- A core study team was divided into four task teams:
  - Team 1: Retrieved secondary data on health sector climate resilience and 10-year CSHO burden from regional and district authorities.
  - Team 2: Conducted key informant interviews with health sector decision-makers to validate adaptive capacity to various climate-sensitive health risks.
  - Team 3: Designated to conduct quantitative analysis correlating climatic variables with CSHO incidence and project future risks but was later carried out by an expert team
  - Team 4: Interviewed heads of health-relevant Ministries, Departments, and Agencies (MDAs) to identify prioritized adaptation PPPs.
- Data Collection was conducted in two phases (Phase 1: 8 regions, 2023; Phase 2: 8 regions, 2024) through:
  - Review of DHIMS/IDSR data for CSHO trends.
  - Roundtable discussions and key informant interviews using semi-structured questionnaires.
  - Expert-based qualitative assessment of climatic hazards/upstream drivers, scored on presence, frequency, geographical extent, and trend.
  - Documentation of current/planned adaptive PPPs from health and health-relevant sectors to gauge regional adaptive capacity.

Data Analysis and Synthesis

- The harmonized report's introduction was constructed from relevant, quality information extracted from the three prior V&A studies, supplemented by TWG updates.
- Questionnaire responses were summarized into national and regional results tables. DHIMS data on CSHO incidence (2014–2023) were transformed into rates and visualized using bar charts and line graphs for trend analysis. An external consultant was employed by the MOH to analyse historical climate and health data to determine climate - disease sensitivity and to project CSHO burden for 2025-2050 by agro-ecological zone.
- Draft findings and synthesized adaptive strategies were reviewed and validated through a series of national-level TWG workshops. Plans were made for subsequent regional workshops to validate findings and develop regional health sector adaptation plans.

National findings

Prioritized Climate-Sensitive Health Outcomes

This assessment was able to identify, describe and prioritize thirteen climate-sensitive health outcomes (CSHOs) through a participatory process and based on the qualitative assessment of the strength of association between climate change and the health outcomes, priorities of the Ministry of Health, public/community concerns as well evidence from the literature. In all, thirteen (13) CSHO groups were short-listed and ranked by risk rating:

1. Vector-borne and zoonotic diseases (e.g., malaria, dengue)
2. Cerebrospinal meningitis
3. Malnutrition
4. Respiratory illnesses and allergic diseases
5. Cardiovascular diseases
6. Food-borne illness
7. Water-borne diseases
8. Mental health disorders
9. Injuries from extreme weather
10. Snake bites
11. Water-washed diseases
12. Heat-related illness
13. Road traffic accidents (climate-related)

Key Trends in CSHOs were described after analysis of DHIMS2 data from 2014–2023

- **Malaria**: Gradual increase, with higher incidence among males.
- **Yellow Fever**: Low but rising incidence, peaking in 2023.
- **Schistosomiasis**: Declined and stabilized post-2017.
- **Meningitis**: Slow increase, peaking in 2016.
- **Food Insecurity**: Affects ~3.6 million people, with northern regions most vulnerable.
- **Respiratory Diseases**: Asthma declined; pneumonia and URTIs showed cyclical patterns.
- **Cardiovascular Diseases**: Stroke cases doubled from 2017–2023.
- **Mental Health**: Depression and anxiety are higher among females; peaks in 2016–2017.

- **Snake Bites**: Higher incidence of snake bites were reported among males.
- **Heat-Related Morbidity**: Low birth weight (LBW) and stillbirth rates (SBR) served as indicators for heat related morbidity. While LBW increased, SBR declined over the period.

Climate–Health Sensitivity Analysis

Strong correlations were also observed between climate variables and disease incidence across ecological zones:

- **Guinea Savanna Zone**: Malaria positively correlated with rainfall and humidity.
- **Transition Zone**: Pneumonia and malaria were linked to wet conditions.
- **Deciduous Zone**: Malaria was sensitive to rainfall and RTAs were associated with cold extremes.
- **Wet Evergreen Zone**: Diarrhoea and URTIs were driven by temperature and humidity.
- **Coastal Savanna**: Malaria and respiratory illnesses were influenced by rainfall and temperature extremes.

Vulnerable Populations

- **The Poor: Higher poverty rates** in the northern regions, exacerbate climate risks.
- **Gender**: Women face higher vulnerability due to socio-economic and cultural factors.
- **Age**: Children and the elderly are at increased risk.
- **Disability**: Limited access to healthcare and higher prevalence of chronic conditions.
- **Migrants/IDPs**: Climate-induced migration increases health risks.
- **Indigenous Groups**: Experience structural disadvantages and poor health outcomes.
- **Rural Communities**: Lower adaptive capacity and resource access.
- **Occupational Groups**: Farmers and miners exposed to heat stress and environmental hazards.

Future Risk Projections (2025–2050)

Under SSP245 and SSP585 scenarios:

- **Pneumonia and malaria** are projected to increase significantly across most zones.
- **Diarrhoea and URTIs** show variable trends, with increases in wetter zones.
- Cardiovascular diseases and mental health disorders show moderate climate sensitivity.
- Road traffic accidents and snake bites generally decline or remain stable.

Health System Adaptive Capacity

Ghana's health system resilience was assessed using the WHO Operational Framework for Climate-Resilient Health Systems. Key gaps include:

- Limited integration of climate data into health surveillance.
- Inadequate early warning systems.
- Insufficient resources for climate adaptation in vulnerable regions.
- Need for strengthened cross-sectoral coordination and policy implementation.

Several national policies address climate and health, including:

- National Climate Change Policy

- Health Sector Adaptation Plans
- Food Security and Nutrition Programs
- Disaster Risk Reduction Frameworks.

The findings from this assessment were used to formulate evidence-based strategies that will ultimately inform the development of a H-NAP, under guidance of the WHO Operational Framework for Climate-Resilient Health Systems.

1. Introduction

1.1. Background

Climate change has become a defining public health issue for the 21st century as it affects the air people breathe, the food they eat, the water they drink, and the chances that they will get infected with a life-threatening infectious disease[1]. More than ever, the pursuit of public health at all levels, from local to global, now depends on careful attention to the processes of climate change[2].

The effects of climate change can be categorized as both direct and indirect; meaning some impacts are immediate and directly caused by changing climate conditions like rising temperatures or extreme weather events, while others are secondary effects that arise from changes in ecosystems or human behaviour due to climate change. Examples of the direct effects are heat stress, sea level rise, droughts, extreme weather events, whereas the indirect effects include changes in agricultural yields, spread of disease, and mass migration[3].

Changes in climatic conditions are evidenced by more frequent and intense weather events such as storms, extreme heat, floods, droughts, and wildfires. These are projected to significantly impact on socio-political, and economic systems[4], with most lower income countries especially at risk to multiple climatic hazards and/or shocks[5]. Already, an estimated 3.6 billion people reside in climate sensitive areas[5], and approximately 250 000 additional deaths, from climate-induced malnutrition, malaria, diarrhoea, and heat stress are expected annually, between 2030 and 2050[6]. The economic losses are significant, with one analysis estimating that almost $1.5 trillion was lost due to extreme weather, climate, and water-related events in 2019, compared to $184 billion in 1970[7]. This situation is projected to worsen with the direct damage costs to health alone estimated to be between US$ 2–4 billion annually by 2030.

In Africa, where the most vulnerable populations reside, they endure the consequences of climate change despite not being the primary contributors to global carbon emissions. This situation unfairly burdens those already facing challenges for survival. Rising temperatures, precipitation changes, and the increased occurrence of natural disasters such as cyclones, severe storms, and droughts contribute to the spread of diseases, food security problems, limited or no access to clean water and sanitation facilities, a high risk of waterborne disease, heat stroke, and mental health problems are common in Africa. Amid natural disasters, the health system becomes weak due to disruptions of essential health services and impaired health infrastructure. Health system resilience should be built through a multisectoral approach, including a health security plan.[8] Globally, climate health vulnerability assessments are a crucial step in integrating climate change impacts into development planning, identifying vulnerable populations and areas, and informing adaptation strategies. In Ghana, several vulnerability and adaptation assessment have been undertaken to identify weaknesses, opportunities

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[1]Chan, M. (Producer). (2014, 7/5/2015). How Climate Change Can Rattle the Foundations of Public Health. Retrieved from http://www.huffingtonpost.com/dr-margaret-chan/how-climate-change-can-ra_b_5822950.html

[2] Campbell-Lendrum D, Corvalán C, Neira M. 2007, Global climate change: implications for international public health policy, available at: https://pmc.ncbi.nlm.nih.gov/articles/PMC2636241/

[3] Hime, Neil & Vyas, Aditya & Lachireddy, Kishen & Wyett, Stacey & Scalley, Benjamin & Corvalan, Carlos. (2018). Climate change, health and wellbeing: challenges and opportunities in NSW, Australia. Public Health Research & Practice. 28. 10.17061/phrp2841824.

[4] Awuni S. et al. 2023, Managing the challenges of climate change mitigation and adaptation strategies in Ghana, Available at: https://www.sciencedirect.com/science/article/pii/S240584402302698 1#:~:text=Therefore%2C%20the%20increase%20in%20water,impact%20on%20women%20and%20children.

[5] IPCC 2022. The Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Report (AR6)

[6] WHO (2014). Quantitative Risk assessment of the effects of Climate change on selected causes of deaths, 2030s and 2050s.

[7] Armstrong M. (2023). Climate change and health: The Soaring Cost of Climate Change. Statistica daily data. **Available at:** https://www.statista.com/chart/11673/the-soaring-costs-of-climate-change/

[8] Integrated African Health Observatory, World Health Organization-Afro. (2024), Analytical fact sheet Available at: https://files.aho.afro.who.int/afahobckpcontainer/production/files/iAHO_Climate_change_in_health_Fact_Sheet-April_2024.pdf

and linkages between climate change and health. Under the joint Ministry of Health (MOH), United Nations Development Programme (UNDP) and Global Environment Facility (GEF) Climate Change and Health project (2012-2015), the health sector received support to build resilience to climate change in three piloted districts, to identify, implement, monitor, and evaluate adaptations to reduce current and likely future burdens of malaria, diarrheal diseases, and meningococcal meningitis in Ghana.

In 2015, the World Health Organization (WHO) and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) with the Ministry of Health/Ghana Health Service (GHS) and partners, initiated a climate change and health vulnerability and adaptation assessment. This initiative was aimed at determining a baseline of health sector vulnerability to climate change and climate variability in three ecological zones, with a focus on four priority climate sensitive diseases (malaria, diarrhoea, bilharzia and acute respiratory infections). However, the study failed to compute and compare risk of climate sensitive outcomes of interest and there was no adaptive capacity assessment in terms of availability of current and planned PPPs at national or regional level.

In 2021, the GHS collaborated with Agence Francaise de Development (AfD) to conduct climate change vulnerability and adaptation assessment of the health system to build national capacity on public health management of health risks related to climate change, identify Ghana's health sector vulnerabilities and develop adaptation measures at the national level as well as in six different districts, and develop a draft climate change and health policy that will include guiding principles, vision, goal, objectives, focus areas, institutions roles and responsibilities, and policy implementation arrangements.[9] However national level health stakeholder consultations for prioritization of risk and adaptive capacity as well as validation of findings was poor. There were no clearly defined criteria for prioritizing climate sensitive health outcomes through stakeholder participation.

In 2022, the World Bank also commissioned a climate and health vulnerability and adaptation assessment to assess climate impacts on climate sensitive health outcomes and the building blocks of the health system. The study was essentially a desktop review of national level data, with very limited key stakeholder consultations. The methodology adopted did not involve population-based assessment at the regional level which is key for development of regional action plans. [10]

Furthermore, the omission of regional level analysis in all these assessments need to be addressed, since V&A assessments at this level will be required to inform the development of region-specific climate and health action plans. Additionally, several years have elapsed since some of these V&A assessments were conducted and projections of future impacts on health risks will have to be re-evaluated. So, in view of all the identified gaps in the previous V&A studies, there was a need to develop a harmonized climate and health V&A assessment by harnessing robust evidence from the existing assessments, while addressing the identified gaps to ensure conformity with the WHO standard guidance for V&A assessment.

The main aim of this harmonised climate change vulnerability and adaptation assessment is to review, all the afore-mentioned three V&A assessment reports to glean the valid information, address the identified gaps and harmonize the findings to facilitate the development of evidence based adaptive strategies and actions that can be mainstreamed into health policy and plans.

[9] Agence Francaise de Development (2021). Vulnerability and adaptation assessment of Ghana's health system to climate risk

[10] World Bank, (2023). Climate and health vulnerability assessment for Ghana; a World Bank, Ghana report

1.2. Geography of Ghana

Ghana is located on West Africa's south-central coast, sharing borders with Togo to the east, Cote d'Ivoire to the west, Burkina Faso to the north, and the Gulf of Guinea and the Atlantic Ocean to the south. The country lies close to the equator between latitudes 4.5^0 N and 11.5^0 N, and longitude 3.5^0 W and 1.3^0 E.

Ghana has a total land area of 239,460 km², and its marine territories reach about 200 nautical miles offshore. Ghana is divided into sixteen central administrative regions, with its regional capitals headed by a politically appointed Regional Minister.

Figure 1: Map showing Ghana's Administrative regions

Figure 1 shows the 16 administrative regions of Ghana is divided into 16 regions, each further divided into districts that represent a decentralized local governance system and further represented by zonal committees.

1.3. Current climate and environment

Ghana has six ecological zones which are the Guinea-Savannah, Sudan-Savannah, Coastal-Savannah, Transitional Zone, Deciduous Forest and the Rainforest zones. Figure 2 shows the geographical distribution of these zones.

The country's climate is tropical and strongly influenced by the West Africa monsoon winds; it is generally warm with variable temperatures masked by seasons and elevation. The northern part of the country typically records one rainy season, which begins in May and lasts until September. Southern Ghana records two rainy seasons; major season from April to July and minor from September to November.

Figure 2: The six ecological zones of Ghana

1.3.1. Temperature trends

Ghana has experienced a noticeable increase in temperatures over the past few decades. The mean annual temperature has risen by approximately 1.0°C since 1960. This reflects an average rate of 0.21°C per decade, with the most significant warming observed between April and July. This temperature increase has been more pronounced in the northern regions compared to the south. Furthermore, the frequency of 'hot' days (days when temperatures exceed the threshold that occurs on 10% of days or nights in the current climate of that region and season) has risen significantly in all seasons except between December and February.

Similarly, 'hot nights' (nights with temperatures exceeding the threshold for 10% of nights) have increased by 13.2% and 20%, respectively, between 1960 and 2003. Conversely, the number of 'cold' days and 'cold' nights (days or nights with temperatures falling below the threshold recorded on 10% of days or nights) has decreased by 3.3% and 5.1% over the same period.[11] The overall rise in average annual temperatures, as well as the increase in days with a heat index above 35°C, is shown in Figures 3 and 4. Both trends indicate significant warming trends across the country.

[11]World Bank Global facility for disaster reduction and recovery (2011). Climate Risk and Adaptation Country Profile: Ghana. Available at: https://climateknowledgeportal.worldbank.org/sites/default/files/2018-10/wb_gfdrr_climate_change_country_profile_for_GHA.pdf

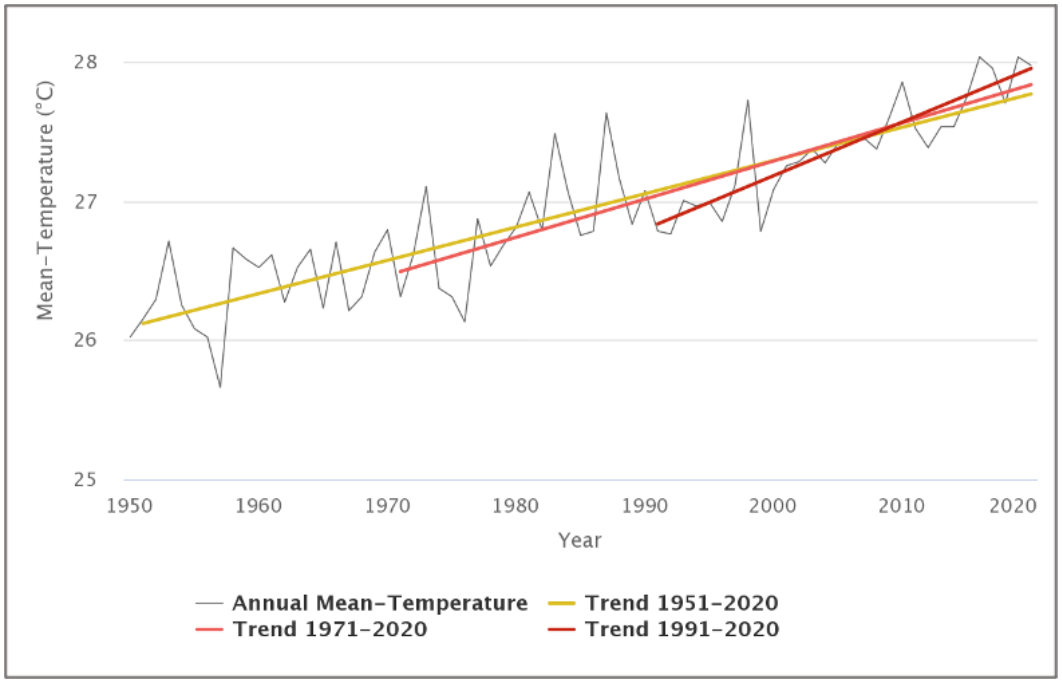

Figure 3: Annual Mean Temperature trends for Ghana.

Source: CCKP from UNEP 2023a

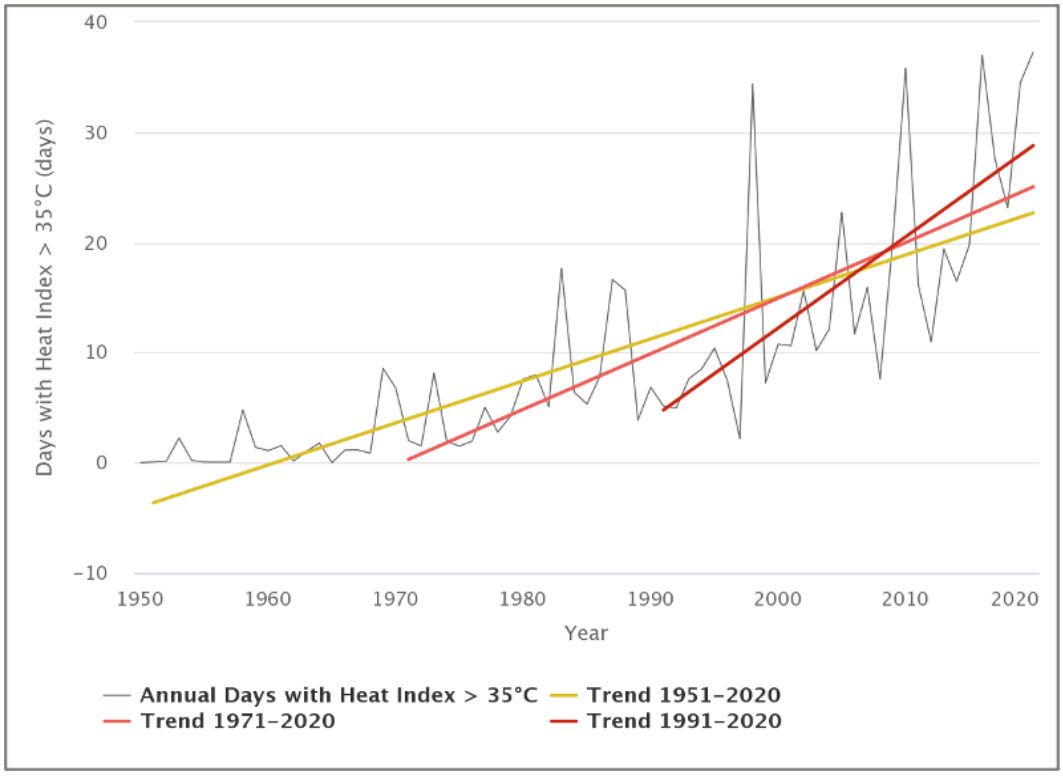

Figure 4: Days with Heat Index > 35 C trends for Ghana

Source: CCKP from UNEP 2023a

1.3.2. Rainfall trends

Mean annual precipitation in Ghana averages 1,189.9 mm, with the highest rainfall typically occurring between May and September and significantly lower precipitation from November to January (1991–2020). Observed trends indicate a gradual increase in annual precipitation since 2000, although long-term data suggest a slight negative change that is not statistically significant (Figure 5).

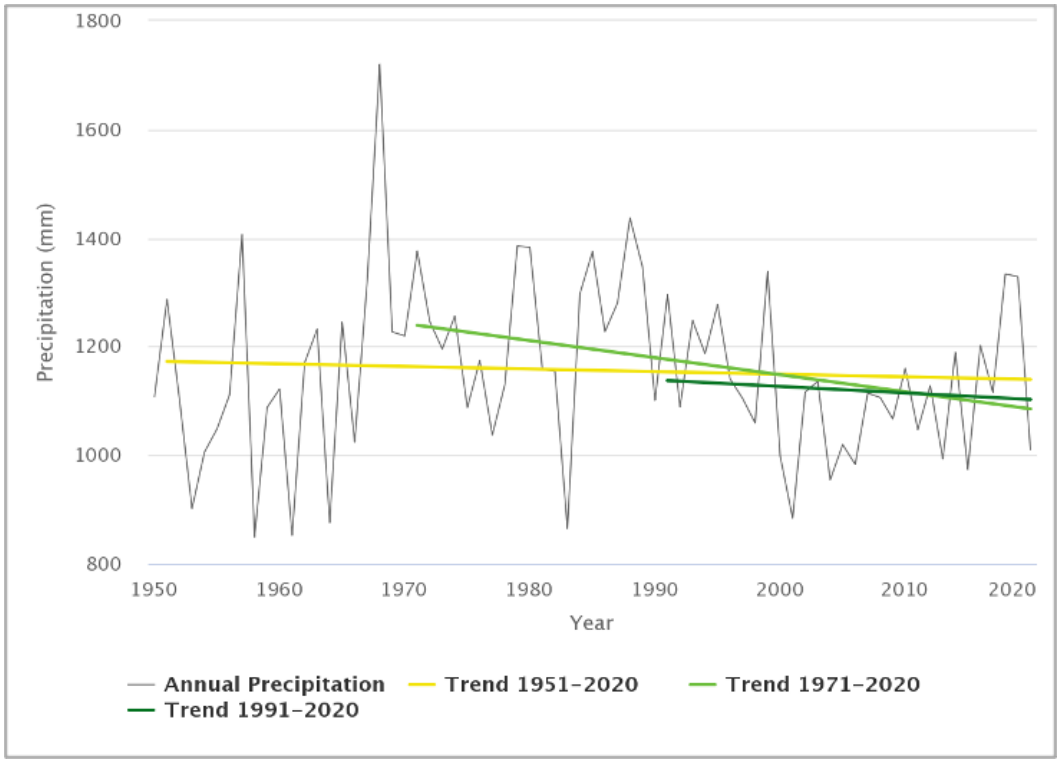

Figure 5: Annual precipitation trends for Ghana

Source: CCKP

Notably, maximum daily rainfall has shown a significant upward trend since the 1990s (Figure 6), indicating heightened rainfall intensity and an increased risk of flooding. Rainfall is highly variable on inter-annual and inter-decadal timescales suggesting that long-term trends and associated consequences would be both difficult to identify and manage, as scientific evidence confirms changing climatic conditions over the last three decades, including evidence of deteriorated prevailing climatic conditions. There are uncertainties in the rainfall patterns that vary across the different ecological zones in Ghana.[12]

[12] Spatiotemporal Variations in Rainfall and Temperature in Ghana Over the Twentieth Century, 1900–2014 - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Agro-ecological-zones-of-Ghana-Savannah-Transitional-Zone-Deciduous-Forest-Evergreen_fig1_323992423 [accessed 14 Mar 2025]

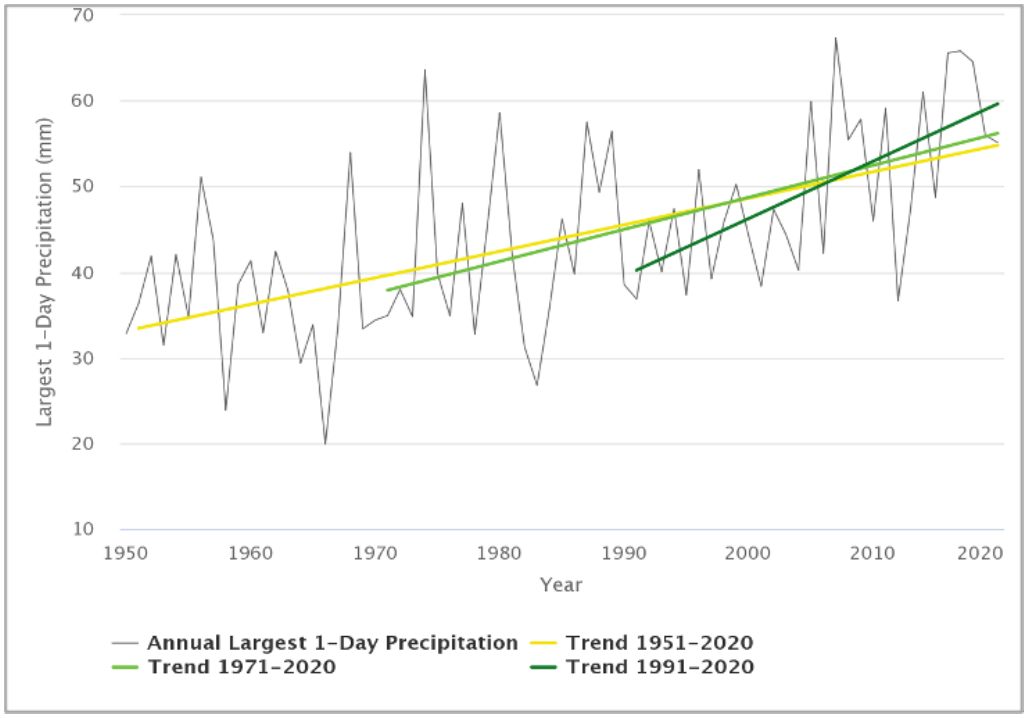

Figure 6: Annual largest 1-day precipitation trends for Ghana

Source: CCKP

1.3.3. Trends in sea level rise

Ghana's coastline is naturally prone to erosion, threatening critical infrastructure and communities situated along the shore. Climate change contributes to rising sea levels through thermal expansion and the melting of glaciers and sea ice. Currently, the global average rate of sea level rise is approximately 3 mm per year, while off the coast of Ghana, the rate is slightly higher at 4 mm per year (Figure 5). The already high rate of coastal retreat is expected to intensify due to further sea level rise, along with more frequent and severe storm surges and stronger winds resulting from climate change.

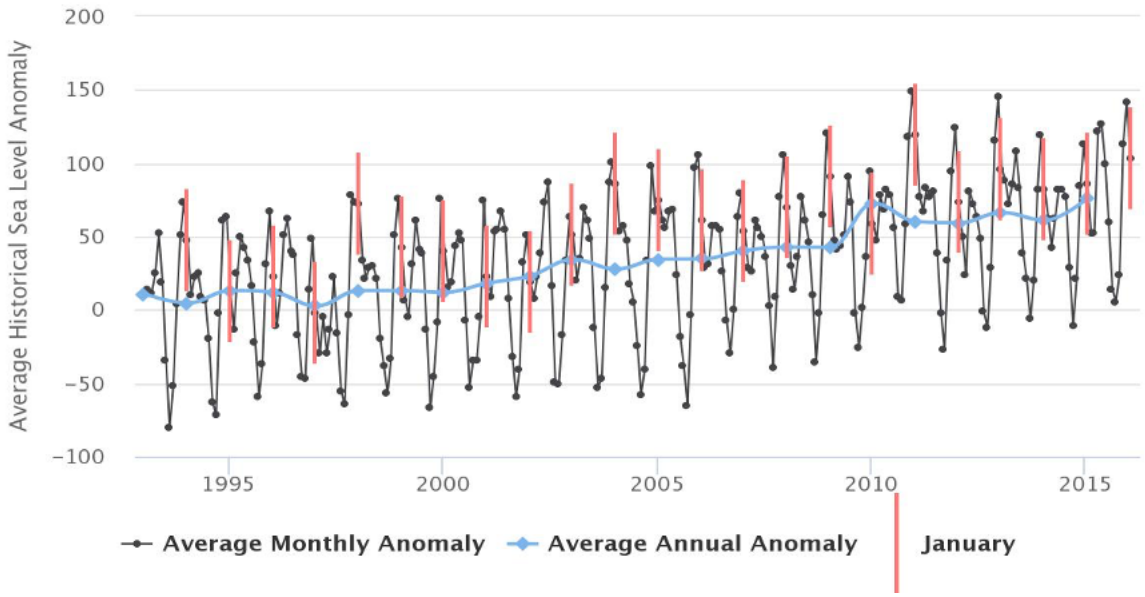

Figure 7: Historical Sea level for Ghana (1993-2015) – observed anomalies relative to mean of 1993-2012. Source: The World Bank Group, 2021

1.3.4. Water quality

The water quality of Ghana's surface water resources has a Class II or "fairly good" water quality status, though there are spatial and seasonal differences. Ghana's surface water resources are mostly derived from the Coastal, South-Western, and Volta. The latter comprises of the Red, Black, and White Volta, as well as the Oti River. The South-Western River systems comprise of the Bia Tano, Ankobra, and Pra rivers. Coastal river systems include the Tordzie/Aka, Densu, Ayensu, Ochi-Nakwa, and Ochi-Amissah. These river systems account for approximately 70%, 22%, and 8% of the total surface water. The finest and worst water quality occurs within the Densu basin.[13]

1.3.5. Air quality

As a measure of Ghana's air quality, the annual mean PM2.5 concentrations are up to six (6) times higher than the WHO recommended limits. These ultra-fine particles 2.5 micrometers or smaller in diameter are known to clog human lungs and constitute a health risk (refs). The WHO recommends a PM2.5 yearly guideline of 5 micrograms per cubic meter (g/m3), against Ghana's annual mean PM2.5 concentrations of 31.1 g/m3. However, these data are recorded at only a few locations in the Greater Accra Region and are not accessible to the public. The airflow and circulation over Ghana are dry and dusty north-east trade winds during the Harmattan seasons and the moist and warm south-west monsoon winds during the Rainy Season. The Hadley Circulation drives the general atmospheric air circulation, with its converging arm largely linked with cloudiness and associated rainfall bands that drench the region with seasonal rains. Low-level air quality is driven by dangerous amounts of toxic air, primarily from car emissions, trash fires, road dust, and soot from biomass-fuelled cookstoves and pollutants and other aerosols, which are mixed, especially during peak sunshine hours.

[13] Darko, H. F., Ansa-Asare, O., & Paintsil, A. (2013). A number description of Ghanaian Water Quality-A case study of the Southwestern and coastal rivers systems of Ghana. Journal of Environmental Protection, 4(11), 1318

1.4. Population and demographic trends

Ghana's annual intercensal population growth rate was 2.1% between 2010 and 2021, which is the lowest observed since independence (Figure 8). Ghana has a total population of 30.8 million, of which 50.7% are females and 49.3% males. The national sex ratio is 97 males for every 100 females and the national population density is 129 persons per square kilometre as per the 2021 Population and Housing Census. The average national household size is 3.6 persons with the country's population expected to double within 33 years. By 2050, the population of Ghana will be over 50 million.[14]

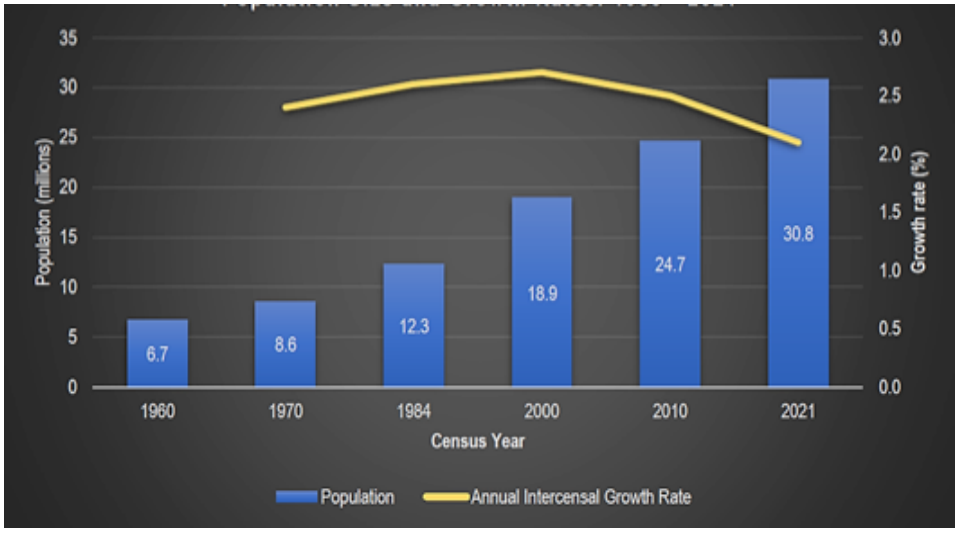

Figure 8: Ghana's population size and growth rate: 1960 – 2021. Source: Ghana Statistical Service (GSS) 2021 Population and Housing Census (PHC)

The country's population pyramid is transitioning from one dominated by children aged 0-14 years to that dominated by young people aged 15-35 years (see Figure 9), which is evident in all the regions of Ghana. The population pyramid represents the age and sex composition of the population. The report indicates that the proportion of children declined from 41.3% in 2000 to 35.3 in 2021, while the young population increased from 34% in 2000 to 38.2 in 2021.

[14] Ghana Statistical Service (GSS) 2021 Population and Housing Census (PHC) www.census2021.statsghana.gov.gh/dissemination.

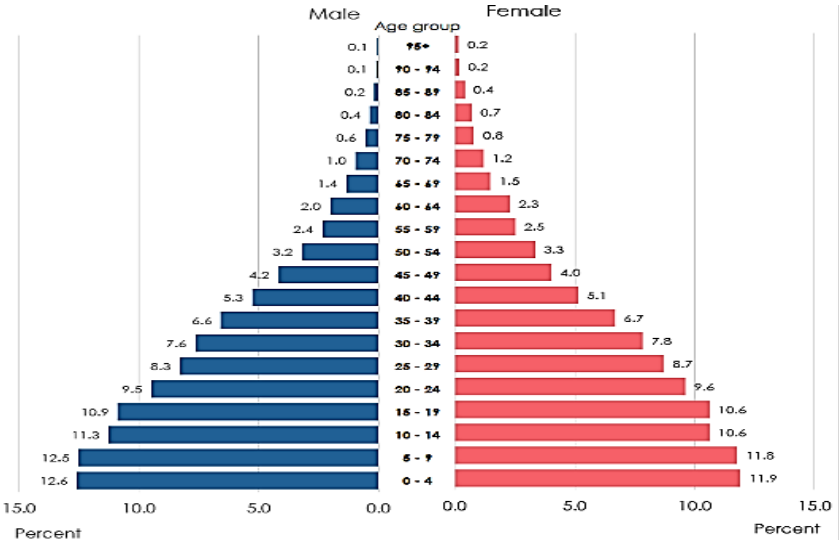

Figure 9: Distribution of population size by region,2021. Source: Ghana Statistical Service (GSS) 2021 Population and Housing Census (PHC)

The life expectancy in Ghana was 59.4 years and 64.4 years among males and females respectively, as per the 2010 Population and Housing Census. The observed higher life expectancy among females was evident in both urban and rural areas.

1.5. Economic Development

Ghana is a lower-middle income country. Poverty in Ghana had been on a downward trend since the 1990s, but the COVID-19 pandemic marked a turning point, leading to a rise in poverty levels since 2020. Weak economic growth, limited government spending, and high inflation—particularly in food prices—have worsened living standards, pushing more people into poverty, and increasing the risk of food insecurity.

In the first half of 2024, Ghana's GDP surged by 5.9%, up from 2.8% in in the first half of 2023, driven by an 8.1% growth in the industry sector, particularly in oil and gas. Agriculture expanded by 5.1%, despite a significant contraction in cocoa, while the services sector grew by 4.5%, down from 6% in 2023H1. Growth projections for 2024 have been revised upwards to 4%. Poverty rates are projected to rise until 2026, peaking at 31.5% in 2025 before slightly declining to 30.6%, with rates at the Lower Middle-Income Countries (LMIC) line potentially reaching 55.1% by 2026 due to limited growth in services and agriculture and rising prices outpacing income growth for the poorest.[15] However, this outlook faces risks from drought impacts, commodity price volatility, exchange rate uncertainties, high domestic financing needs and energy sector shortfalls.

The health sector contribution to Ghana's Gross Domestic Product (GDP) in recent years has increased from 1.97% to 2.28% from 2013 to 2020 reflecting both the growing demand for healthcare services and the expansion of health infrastructure. Total Government expenditure on health has also increased from GHS7.4b to 22.5b from 2018 to 2022[16] This includes government expenditure on healthcare, private sector involvement in health services, as well as contributions from health-related industries such as pharmaceuticals, medical equipment, and health insurance. The growth of the private health sector, coupled with increased investments in public health initiatives, has boosted the overall economic output of the sector. In addition to direct contributions to GDP, the health sector also has

[15] https://www.worldbank.org/en/country/ghana/overview [accessed 23 Jan,2025]
[16] Ministry of Health, 2018-2022 National Health Accounts

a broader economic impact through job creation, with thousands employed in healthcare-related roles, including doctors, nurses, pharmacists, technicians, and administrative staff.[17]

1.6. Ghana's Health System

In Ghana, the Ministry of Health (MOH) is the governing body that oversees health policy formulation, resource mobilization, monitoring, and evaluation of the health sector. The MOH is also mandated to provide leadership and direction to the health sector, as well as coordinate the implementation of the Health Sector Medium Term Development Plan. The Ghana Health Service (GHS) and the Teaching Hospitals Act (ACT525), passed in 1996, separated governance and policy from the operational and service aspects of health service delivery. As it is the mandate of the Ministry to formulate policies and design appropriate measures for implementation, the GHS and the Teaching Hospitals are responsible for implementing national health policies and providing health services.

The mission statement of the Ministry of Health (MOH) is to "*contribute to socio-economic development by promoting health and vitality through access to quality health for all people living in Ghana, using well-motivated personnel*". However, limited financial access to health care, poor physical infrastructure, and limited resources contribute to significant geographical and wealth-related service discrepancies. All these factors combine to make it difficult for planners and politicians to provide universal access to healthcare services. To address these challenges, the revised Ghana National Health Policy (2020 – 2030), dubbed 'Ensuring Healthy Lives for all" which aligns with the Universal Health Coverage (UHC, 2030)[18] and the Sustainable Development Goals, was developed to improve the health of all Ghanaians by promoting, restoring, and maintaining good health.

Ghana's health service delivery system is plural and decentralized. Health service providers include public, private, faith-based, and traditional medicine services. Public health facilities are operated by the government and deliver the largest proportion of healthcare services in Ghana. The public sector is organized at primary, secondary, and tertiary levels of care, with primary levels of care including Community-Based Health Planning and Services (CHPS) compounds, community health centres, clinics, polyclinics, hospitals and the district hospitals. The district hospitals serve as the referral centres for the district and sub-district facilities at the primary health care level. Regional hospitals provide secondary level of care and are the referral centres for district hospitals. The Teaching Hospitals deliver tertiary level of care, offering advanced clinical services and conducting medical research. They function as referral centres for regional hospitals, providing specialized treatment and expertise not available at lower levels of the healthcare system.

In Ghana, private health care is one of the fastest growing segments of the healthcare system, and private providers (i.e., non-government providers for profit individuals, facilities and businesses) are an important source of healthcare. Unfortunately, there is no consensus on the size, scope and the performance of Ghana's private health care providers. However, it is suggested that it is the second largest provider of outpatient department (OPD) services after government providers, contributing about 42% of services. It is believed for instance that about a third of Ghana's health sector is owned by the private sector while another assessment[19] by McKinsey (2008) estimates that the private sector contributes about 50% in the provision of healthcare in Ghana. A publication by Pharmaccess foundation however shows that the private sectors share of ownership is about 38%. These inconsistencies suggest the need to improve upon the collection of the requisite data on the performance of the private health sector in Ghana. Unfortunately, HeFRA, the institution clothed with

[17]National Health Insurance Authority, (2022). Ghana's Healthcare Sector Report. Available at: https://www.gipc.gov.gh/wp-content/uploads/2023/03/Ghanas-Healthcare-Sector-Report.pdf

[18] Ministry of Health, Ghana's Roadmap for Attaining Universal Health Coverage (2020 – 2030)

[19] Otchi E., Fikre M., Lattof S., O'Hanlon B., Yaqub N., et al. (2021), Private sector delivery of quality maternal and newborn health services in Ghana: A paper prepared for the Multi-Stakeholder Dialogue. Available at: https://www.qualityofcarenetwork.org/sites/default/files/2021-06/Ghana%20situational%20analysis%20report.pdf

the mandate to among others address such anomalies in the size, scope and performance of both the public and private sector does not even know where some of the Page 9 of 67 facilities are located (HeFRA, 2019). Presently, not all private health facilities in the country are routinely reporting the performance of their service delivery into DHIMS.

Public funding through the Ministry of Health and Ghana's National Health Insurance Scheme (NHIS) constitute the major source of financing health care, followed by out-of-pocket expenditures. The National Health Insurance Scheme (NHIS) was established in 2003, with the goal of eliminating imbalances in service provision between the rich and poor people. It evolved rapidly by transitioning its existing community health insurance schemes into a national health insurance program supported by significant amounts of earmarked national government revenues.

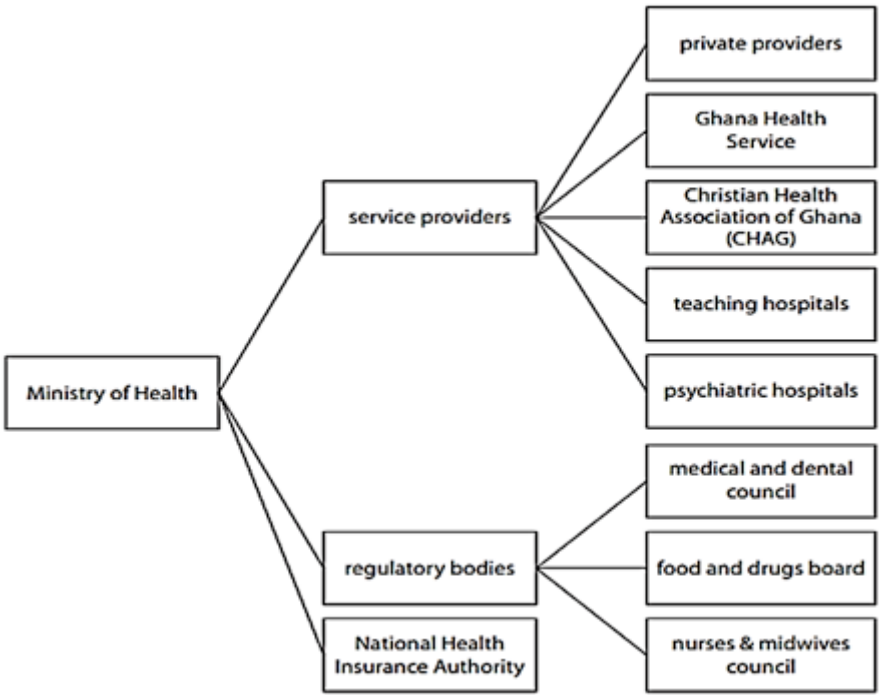

Figure 10: Organizations of the Health System in Ghana.

The Ghanaian health system is managed by the Ministry of Health (MoH) and organized into public, private for-profit and private not-for-profit infrastructure. Public health facilities are operated by the government and deliver the largest proportion of healthcare services in Ghana. Private healthcare consists of private for-profit facilities owned by private individuals or companies which are privately funded through payments for medical services, and private not-for-profit services such as mission or faith-based facilities involved in the direct delivery of health services.

In addition to the national health system, district governments have District Assembly Common Funds (DACFs), but the allocation to health across districts varies, leading to variable outcomes. Inefficiencies in public spending also exist – people tend to prefer visiting hospitals to clinics due to the higher proportion of healthcare workers and better facilities – but the cost per capita is higher. The ratio of healthcare workers to population has also increased relatively more in urban areas than rural areas (Saleh, 2013).

Ghana's health density mirrors that of countries with a UHC index above 50. Its UHC index of 48 raises concerns about equitable distribution, effective utilization and productivity of the current workforce, given that a large proportion are not employed. There is therefore the need for a more

balanced allocation of specialized health care roles across different regions. This could involve initiatives aimed at encouraging health care professionals to practice in underserved areas.

Despite some improvements, the efforts made, and the policies implemented, the health system remains fragile due to their slow operational implementation, a lack of funding, skilled workforce, and the low quality of care.

1.7. Climate change and health

Globally there has been unabated rise in the health impacts of climate change and the current health consequences of the delayed and inconsistent response of countries around the globe—providing a clear imperative for accelerated action that puts the health of people and planet above all else.[20] Changes in temperature and rainfall patterns and the incidence of extreme events have implications for the health system. For example, flooding and sea level rise contribute to loss of life and displacement[21]. Various studies project the area of land, and numbers of people, who will be at risk of future sea level rise and reflect on the adequacy (or otherwise) of existing adaptation options.[22]

The disease burden is likely to increase for vector- and water-borne diseases, such as malaria, dengue and cholera. Malaria already affects 50% of children, and this is likely to increase as temperature changes and water masses after flooding alter the distribution of the mosquito[23].

Regional studies in West Africa suggest that the epidemic fringe for malaria will shift southward, with temperatures in the Sahel becoming unsuitable towards the end of the century. Hence, malaria will decline overall in the region, although there will be an increase in epidemics in the south of the region, which includes much of Ghana[24]. Likewise, the mean relative vectorial capacity for dengue transmission is projected to increase from 0.73 to 0.80 over the same time, again with little differences between the low and high emissions scenarios (WHO, 2015). The health impacts of climate change will not be distributed evenly[25].

Cholera outbreaks are already an issue after floods, and increased incidence of flooding is likely to have an impact particularly in urban areas with high population density and already-inadequate access to water, sanitation, and hygiene facilities.

Incidences of heat stress are likely to increase, with a rise in temperature and increase in number of hot days and hot nights. In Ghana if there is a 4°C temperature increase, approximately 25% of annual daily work hours is projected to be lost by workers carrying out heavy labour, for example in agriculture or construction)[26]. Cerebrospinal meningitis is also associated with hot temperatures and the dusty conditions that often arise from cumulative high heat[27].

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[20] Romanello, Marina, et al. "The 2021 report of the Lancet Countdown on health and climate change: code red for a healthy future." *The Lancet* 398.10311 (2021): 1619-1662.

[21] Evadzi, Prosper IK, et al. "Awareness of sea-level response under climate change on the coast of Ghana." *Journal of Coastal Conservation* 22 (2018): 183-197.

[22] Nyadzi, E., Bessah E., and Kranjac-Berisavljevic, G. 2021. Taking Stock of Climate Change Induced Sea Level Rise across the West African Coast, *Environmental Claims Journal*, 33:1, 77-90, DOI: 10.1080/10406026.2020.1847873

[23] Netherlands Commission for Environmental Assessment, 2015

[24] Diouf, Ibrahima, et al. "Impact of future climate change on malaria in West Africa." *Theoretical and Applied Climatology* (2022): 1-13.

[25] Costello, Anthony et al. Managing the health effects of climate change, The Lancet, Volume 373, Issue 9676, 1693 - 1733

[26] Kjellstrom, Tord, et al. "Estimating population heat exposure and impacts on working people in conjunction with climate change." *International journal of biometeorology* 62.3 (2018): 291-306.

[27] Sultan B, Labadi K, Guégan J-F& Janicot S. 2005 Climate drives the meningitis epidemics onset in West Africa. *PLoS Med.* **2**, e6.doi:10.1371/journal.pmed.0020006

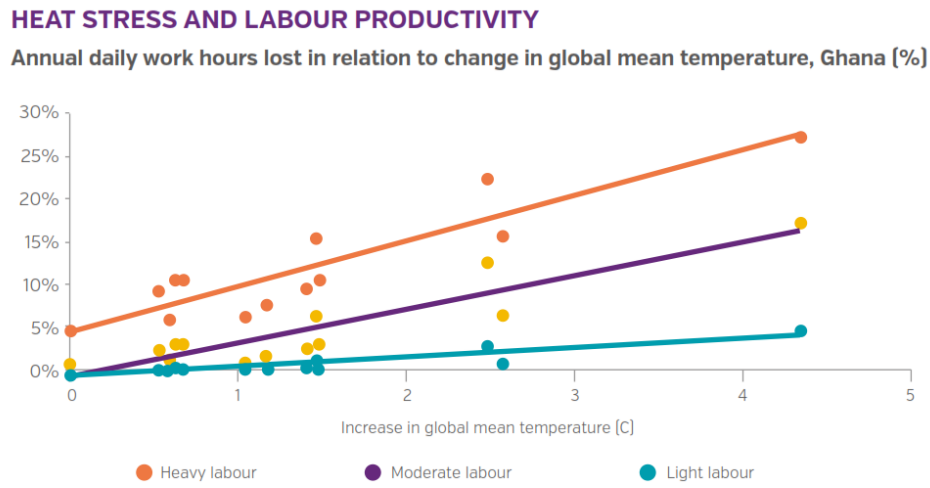

Figure 11: Effects of increase in heat stress on labour productivity (Source: Kjellstrom et al, 2015)

Climate change also influences health indirectly through impacts on food security (including production levels and nutrition). Rain-fed food production systems are vulnerable to a change in climate, and particularly to drought, in the semi-arid central and northern zones (Antwi-Agyei et al, 2012). Temperature is also a strong driver of food production levels[28]. The relationship between climate change, food security and health require vulnerability assessment at local level. Food security has been shown to increase with women's empowerment[29]. Poor health status may increase vulnerability to climate change through reduced range of tolerance for physiological stress, limited mobility, and psychosocial impacts and mental stress[30]. Impacts on infrastructure also have primary and secondary implications for the health sector, with increasing recognition of the need for climate-resilient infrastructure (GCA and ADB, 2021).

Table 1 summarises the primary and secondary health system impacts of climate parameters and extreme events.

Table 1 : Primary and secondary health system impacts of climate parameters and extreme weather events (source: World Bank study)

Climate parameter	Impacts	
	Primary	**Secondary**
Rising temperatures	Heat stress events	Food insecurity and nutrition insecurity
Increased intensity and	Increase in malaria outbreaks, particularly in coastal areas	Food insecurity and nutrition insecurity

[28] Etwire, P.M., Kahui, V. and Fielding, D. 2016. Impact of climate change on Ghana's agriculture: A structural Ricardian analysis. Paper presented at the New Zealand Agricultural and Resource Economics Society 2016 Conference, August 25-26, Nelson, New Zealand. 10.22004/ag.econ.260794

[29] Essilfie, G., Sebu, J., Annim, S.K. and Asmah, E.E. 2020. Women's empowerment and household food security in Ghana, *International Journal of Social Economics*, Vol. 48 No. 2, pp. 279-296. https://doi.org/10.1108/IJSE-05-2020-0328

[30] Cianconi, P., Betrò, S. and Janiri, L. 2020. The Impact of Climate Change on Mental Health: A Systematic Descriptive Review. *Frontiers in Psychiatry* 11, DOI=10.3389/fpsyt.2020.00074

variability of rainfall		
Floods	Loss of life and injuries; infrastructure damage (buildings, roads)	Cholera outbreaks, particularly in crowded urban areas; difficult or no access to health infrastructures and services due to disruption in transport infrastructures; food insecurity and nutrition insecurity
Droughts	Increase in respiratory diseases (e.g., asthma, meningitis) due to increased exposure to dust	Food insecurity and nutrition insecurity

The American Psychological Association report, 2017 found that climate change is triggering stress, anxiety, depression, and relationship strain[31]. Emotional, psychological, and social well-being are all a part of mental health[32], impacting the way we think, feel, and act. Mental health conditions are the leading cause of years lived with disability worldwide, with significant negative consequences, especially in low-income nations. With few exceptions, there is a scarcity of nationally representative prevalence data for major mental health conditions in low-income countries, notably in Africa. In Ghana, the WHO STEPS survey provides national prevalence data on depression (8%) and suicidal attempt (2.3%) among the adult population.[33] According to the World Health Organization (WHO), there is no single cause of mental disorder; although there are many identified risk factors include stress, genetics, nutrition, perinatal infections, and exposure to environmental hazards. There is some evidence of severe adverse physical and mental health impacts of flooding in the Old-Fadama community in Accra[34].

[31] American Psychological Association. (2017). Stress in America: Coping with change. American Psychological Association.
[32] Sipsma, H. O.-A.-A. (2013). Poor mental health in Ghana: who is at risk? BMC public health, 1.
[33] Ghana STEPS Survey Report,2023
[34] Adams, E. A., & Nyantakyi-Frimpong, H. (2021). Stressed, anxious, and sick from the floods: A photovoice study of climate extremes, differentiated vulnerabilities, and health in Old Fadama, Accra, Ghana. Health & Place, 67, 102500.

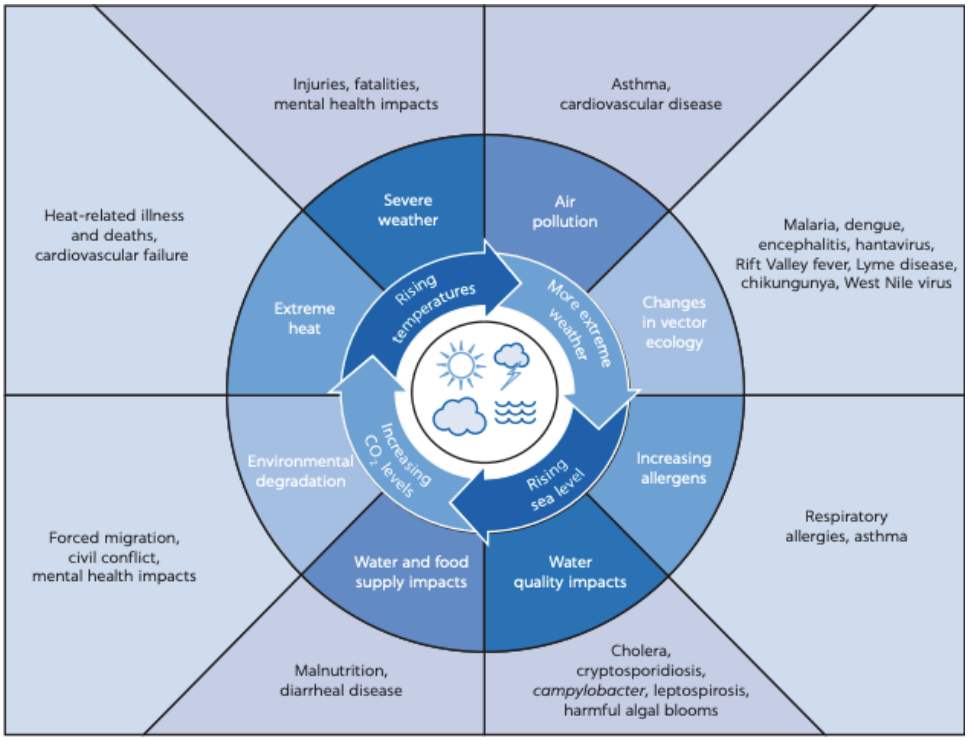

Figure 12: Pathways by which climate change affects human health [Source: Roser-Renouf, Connie & Maibach, Edward. (2018). Strategic Communication Research to Illuminate and Promote Public Engagement with Climate Change]

1.8. Health system vulnerability

Vulnerability is defined as the "The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt". Climate vulnerability is measured as a function of Exposure (climate variability / extreme weather events), Sensitivity (health, food and water) and their potential impact and the Adaptive Capacity i.e., the capacity to cope with the impact of climate change. Reducing vulnerability and creating resilient health systems and healthier populations that can respond to potential health effects from climate change requires continued investments to reduce poverty and inequity and universal access to essential services, such as health, education, clean water, and adequate food. [35]

Figure 13 depicts the WHO framework for a climate resilient health system. WHO defines a climate resilient health system as one that can anticipate, respond to, cope with, recover from and adapt to climate-related shocks and stress, to bring sustained improvements in population health, despite an unstable climate. For the whole health system to become more climate-resilient, its independent building blocks (i.e., leadership and governance, health workforce, health information systems, essential medical products and technologies, service delivery and financing) must also become climate resilient. It is also essential that the health response to climate change provide a comprehensive approach considering the operational framework to ensure that the 10 key components are analysed and

[35] IPCC (Intergovernmental Panel on Climate Change) 2023. Climate Change 2023 Synthesis report: A Report of the Intergovernmental Panel on Climate Change. Available at https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_FullVolume.pdf

addressed for a climate resilient health system.[36] This operational framework served as a guide throughout this climate change vulnerability and adaptation assessment.

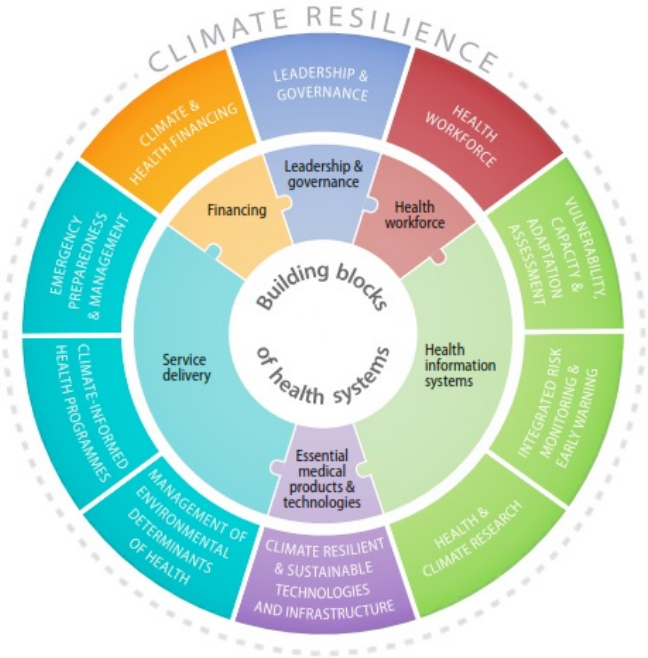

Figure 13: Ten components comprising the WHO operational framework for building climate resilient health systems, and the main connections to the building blocks of health systems

1.9. Climate sensitive health outcomes in Ghana

Available data suggests that air pollution related diseases have a high mortality rate and high cost of treatment in Ghana. The contamination of indoor or outdoor environment by any chemical, physical, or biological agent that alters the natural characteristics of the atmosphere is termed air pollution. The World Meteorological Organization (WMO) defines air quality to be ambient air with a particulate matter with a diameter of 10 µm less than or equal to 50 µg m^{-3}. In Ghana, the Environmental Protection Agency (EPA) defines air quality as ambient air with particulate matter less than or equal to 70 µg/ m^3. The quality of air has a greater influence on the health and wellbeing of humans. Air pollution is one of the causes of climate change, and a major threat to both health and the environment. Agricultural activities, industrial activities, burning of fossil fuels, mining operations, indoor pollution etc. are some of the causes of air pollution. The effects of air pollution include respiratory and heart problems. Every year, the combined effects of ambient (outdoor) and household air pollution kill millions of people prematurely, primarily due to increased mortality from stroke, heart disease, chronic and acute respiratory infections. Household air pollution from solid fuel cooking was responsible for 4.3 million deaths worldwide in 2012, according to the World Health Organization[37].

In terms of the economic costs of air pollution, a 2020 report from Accra, Ghana by the WHO Urban Health Initiative[38] showed that Chronic Obstructive Pulmonary Disease (COPD) patients spent the

[36] World Health Organization (2022), Measuring the climate resilience of health systems. Available at: https://iris.who.int/bitstream/handle/10665/354542/9789240048102-eng.pdf#:~:text=In%202020%2C%20WHO%20published%20guidance%20for%20climate%20resilient%20and%20environmentally%20sustainable%20health%20care%20(4).&text=Linking%20these%20two%20definitions%2C%20climate%20resilient%20health,population%20health%2C%20despite%20an%20unstable%20climate%20(3).

[37] WHO. (2004). Promoting Mental Health: Concepts, Emerging Evidence, Practice (Summary Report). Geneva, Switzerland.

[38] WHO-UHI (2020). Health and economic impacts of transport interventions in Accra, Ghana

most amount of time in the hospital, an average of 29 days, followed by lung cancer patients, who spent 23 days, and Road Traffic Injuries (RTI) patients, who spent 21 days. Pneumonia patients stayed an average of 8.5 days in the hospital. The highest number of affected people in terms of socioeconomic status are the middle income (44.8 %), followed by the poor (31%) and the poorest (13.8 %). The treatment of air pollution-related diseases was very costly, with patients who suffered RTI paying on average US$ 885 for medical care, patients suffering from lung cancer paying as much as US$ 2135, stroke patients paying US$ 351 and Ischaemic heart disease (IHD) patients paying US$ 638, on average.

Climate change is likely to increase the incidence of certain diseases such as malaria, bilharzia, and diarrhoeal disease. Malaria is hyper-endemic in all parts of the country and still the leading cause of outpatient morbidity in all ages and sex groups and is responsible for a substantial number of miscarriages among pregnant women and low birth weight babies[39].

The main environmental variables that influence transmission of malaria include rainfall, temperature, and humidity, and it is estimated that the costs of malaria care can consume 30% of the income of poor people[40], Climate and anomalous weather events have a direct influence on malaria transmission by either hindering or enhancing vector and parasite development and survival. A change in temperature may lengthen or shorten the season during which mosquitoes or parasites can survive.

Projected decreases in rainfall and increased frequencies of droughts in Ghana may further aggravate the cerebrospinal meningitis (CSM) outbreaks and possibly increase the geographical range of the disease in Ghana. In Ghana, diarrhoeal diseases continue to remain a disease of public health importance. Outbreaks of cholera are cyclical, and the frequency of these outbreaks is increasing. Scenario analysis carried out in the early 2000s in Ghana indicates the possibility of diarrhoeal diseases increasing due to water scarcity and contamination[41].

Climate pollutants, particularly air pollution, are significantly linked to the development and worsening of non-communicable diseases (NCDs) like cardiovascular diseases (heart disease, stroke), chronic respiratory diseases (COPD, asthma), and certain cancers (lung cancer), with the primary mechanism being the harmful effects of inhaling particulate matter and other pollutants on the body's systems[42]. Air pollution can also lead to traffic accidents either by reducing the road visibility or impacting the driver's health and cognitive abilities[43].

1.10. Upstream drivers of CSHOs

Besides the risk of infectious diseases, key climate risks in Ghana also include droughts, coastal erosion, floods, and landslides, which may be exacerbated by the rapid urbanization and demographic changes. In Ghana, floods and droughts are among the most devastating climate-induced disasters, with far-

[39] Schantz-Dunn J, Nour NM. Malaria and pregnancy: a global health perspective. Rev Obstet Gynecol. 2009 Summer;2(3):186-92. PMID: 19826576; PMCID: PMC2760896

[40] Asante F.A., Asenso-Okyere K, ISSER, UG.A technical Report submitted to WHO, Nov 2003- Economic burden of malaria in Ghana, *www.who.int/countries/gha/publications/EconomicBurden_of_Malaria_in_Ghana_Final_Part Nov03.pdf*

[41] United Nations Environment Programme/ Global Environment Facility (UNDP/GEF), 2011, Adaptation Project: Integrating climate change into the management of priority health risks in Ghana. http://www.gh.undp.org/content/dam/ghana/docs /Doc/Susdev/ UNDP_GH_SUSDEV_Climate%20change%20and%20health%20project.pdf

[42] WHO, (2023), Europe newsroom: New WHO tools to support action on noncommunicable diseases and climate change, (available at: https://www.who.int/europe/news-room/11-12-2023-new-who-tools-to-support-action-on-noncommunicable-diseases-and-climate-change#:~:text=NCDs%20–%20including%20cardiovascular%20diseases%2C%20diabetes, NCDs%20and%20Innovation%20(SNI).)

[43] Hritan E.H., Vanna-iampikul P., (2022), The impacts of air pollution on traffic accidents across the United States (2022), Electronic Journal, DOI:10.2139/ssrn.4039404. Available at: https://www.researchgate.net/publication/359533349_The_impacts_of_air_pollution_on_traffic_accidents_across_the_United_States#:~:text=PDF%20%7C%20Air%20pollution%20can%20lead%20to,the%20driver%27s%20health%20and%20cognitive%20abilities.%20The&text=%7C%20Find%2C%20read%20and%20cite%20all%20the%20research%20you%20need%20on%20ResearchGate.

reaching consequences on food security[44],[45]. With a large population depending directly on agriculture, the impacts of localized disasters resulting from climate change will likely have a compounded effect, especially on rural livelihoods and food security[42]. Health-related vulnerabilities to and experience of climate change are determined by physical exposures and a range of socio-economic, political, demographic, biological and geographical factors[46]. It is important to underscore that, while these factors are not causative, they interact to act as covariables to amplify health risks from climate change[47]. The elderly, women, children, the chronically ill, the socially isolated and at-risk occupational groups, populations living in low-lying coastal communities, rural and urban poor are particularly vulnerable, as they may have limited adaptive capacity to climate-related hazards. Accordingly, the Conference of the Parties (Decisions 1/CP.16, paragraph 12 and 5/CP, paragraph 3) and the Paris Agreement (Article 7) recognises the differential vulnerability and exposure of vulnerable people, communities, and systems to climate hazards, and underscored the need for targeted considerations in development of national action plans.

1.11. A climate-resilient heath system

A climate-resilient heath system is one that is "capable to anticipate, respond to, cope with, recover from and adapt to climate-related shocks and stress, so as to bring sustained improvements in population health, despite an unstable climate" (WHO, 2015b: 8). Building a climate-resilient health system requires reducing vulnerability and building adaptive capacity.

Building health system resilience to climate change is a cumulative process. It begins with making resilience a goal, in addition to current goals of improving population health, being responsive and efficient and providing social and financial protection. Crucially, it also requires a vulnerability and adaptation assessment of which populations are most vulnerable to different kinds of health effects, to identify weaknesses in the systems that should protect them, and then to specify interventions that enable adaptation and risk reduction.

The necessity for resilient health systems is underscored by past shocks, such as the H1N1 influenza, Ebola outbreaks, and Zika, which exposed vulnerabilities and emphasized the need for reform. The recent COVID-19 pandemic has reinforced the critical importance of resilient health systems.[48]

Ghana Health Service (GHS) has over the years implemented measures to improve contact tracing, testing, and disease surveillance, expanding infrastructure, expanding testing in public and private labs, but despite progress, Ghana's health system resilience remains insufficient for potential emergencies.[49],[50]

Shortages persist in infrastructure, equipment, and skilled personnel for emergency care leading to exhaustion of healthcare providers and patient care challenges. Despite improvements in the health workforce, significant shortages remain, especially in critical areas such as surgery, obstetrics, trauma, and anaesthesia care. Peripheral facilities struggle with emergency and nonemergency care as skilled

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[44] Asumadu-Sarkodie S, Owusu Phebe A, Rufangura P (2015) Impact analysis of flood in Accra, Ghana. Adv Appl Sci Res 6:53–78.

[45] Atinga, R. A., & Tankpa, V. (2021). Climate Change, Flood Disaster Risk and Food Security Nexus in Northern Ghana. Frontiers in Sustainable Food Systems, 273

[46] World Health Organization; (2021) Climate change and health vulnerability and adaptation assessment. Geneva: Licence: CC BY-NC-SA 3.0 IGO.

[47] Makharia, K. G., Sadeghi, A, Leddin, D & Costello, A (2023). Impact of climate change on vulnerable populations. Gut BMJ, vol 72 (12).

[48] Ankomah M, Abor PA and Karamagi H. Building resilience of the Ghanaian healthcare system: Lessons from a global health stage: Preparedness for the next pandemic: A scoping review [version 1; peer review: awaiting peer review]. *F1000Research* 2024, **13**:1203 (https://doi.org/10.12688/f1000research.143051.1)

[49] Asiedu-Berkoe F, Chandi GM, Akosua Bandoh D, et al.: State of Public Health Emergency Preparedness and Response Capacity of Ghana. 2022.

[50] Ayee RA: Reflections on Ghana's Public Policy Space and Wicked Problems Today. GIMPA Quarterly. 2022; 2(5): 22–30.

professionals are concentrated in regional centres.[51,52] Limited IT integration, aging and inadequate equipment, frequent stock-outs, lack of training, professional migration, and underfunded ambulance services further impede emergency care.[53,54]

Vulnerability and adaptation assessments can improve evidence and understanding of the linkages between the climate and health, serve as a baseline analysis against which changes in disease risk and protective measures can be monitored, and knowledge gaps identified. It also provides the opportunity for building capacity and strengthens the case for investment in health protection. As the drivers of vulnerability and options for adaptation are dynamic, vulnerability and adaptation assessments are not one-time studies, but an iterative process that involve phased investigation, periodic reviews, additional studies, and assessments to update with new information, and active stakeholder communication. Vulnerability and adaptation assessments can also be conducted both quantitatively and qualitatively and using a combination of the two data sources depending on the level of resource availability and technical capacity.

All previous climate and health vulnerability and adaptation assessments conducted in Ghana have proposed adaptation and mitigation measures for implementation. Areas with greater vulnerability to multiple climatic hazards and shocks include coastal regions, river deltas, arid and semi-arid zones, mountainous regions, small island nations, and regions with high poverty and limited access to resources are considered "climate sensitive areas" where an estimated 3.6 billion people currently reside, facing heightened risk from events like floods, droughts, heatwaves, storms, and sea level rise.[55] However, several years have passed and climate change risks have not been adequately mainstreamed into the health information system and there is a need to scale up integration of priority climate related health risks into health policies, plans and programmes in Ghana. There is inadequate funding for scaling up implementation of recommendations (especially training in development & use of early warning system) to cover all the vulnerable districts. Disease surveillance systems still require capacity building. Capacity for early warning and response to key climate-related diseases is still weak and information management and dissemination of climate change-related health risks is not carried out systematically.

To support the health sector become more resilient to the impact of climate change, the AfD has conducted a V&A assessment, but with inadequate participation of the MOH and GHS at the national level. Furthermore, the conceptual framework and the methodology adopted by the various projects to assess V&A were not uniform and therefore the reports are not harmonized.

There is therefore a need to review, validate and harmonize the results of all the three assessment reports to update current climate risks and health risks and facilitate acceptability and adoption of findings for mainstreaming into health policy.

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[51] Yevoo LL, Amarteyfio KA, Ansah-Antwi JA, et al.: The “No bed syndrome” in Ghana — what, how and why? A literature, electronic and print media review. Frontiers in Health Services. 2023; 3.

[52] Jumbam DT, Amoako E, Blankson PK, et al.: The state of surgery, obstetrics, trauma, and anaesthesia care in Ghana: a narrative review. Global Health Action. 2022; 15(1). Taylor and Francis Ltd.

[53] Ankomah J, Stewart BT, Oppong-Nketia V, et al.: Strategic assessment of the availability of paediatric trauma care equipment, technology, and supplies in Ghana. Journal of Paediatric Surgery. 2015; 50: 1922–1927.

[54] Okyere E: Assessing Policies and Strategies to Reduce the Impact of Health Worker Shortages in Primary Health Care Facilities in Ghana. 2018

[55] IPCC. The Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Report (AR6)

1.12. Observed and projected trends in climate variables

This section describes observed, historical climatic changes (1991-2020) and projected climatic changes in rainfall and temperature (mean, minimum, maximum) across Ghana for the periods, 2020 - 2039 and 2040-2059. Climate data were retrieved from the World Bank Groups' Climate Change Knowledge Portal (CCKP). The Climatic Research Unit (CRU) time series data processed and archived by the University of East Anglia, was used for the historical assessment, whereas the ensemble mean of Coupled Model Intercomparison Project Phase 6 (CMIP6) data with Shared Socioeconomic Pathways (SSP5.85) was used for the projection assessment.

1.12.1. Observed spatial distribution of temperature and precipitation

There is wide variability in the annual temperature and precipitation across the country, with the northern part receiving less rainfall and experiencing higher mean and maximum temperature. On an annual basis, lesser amounts of rainfall are received in the northern part and areas within the south-eastern part of the country (Fig. 14a). These differences can be attributed to differences in rainfall onset dates, moisture build-up and transport, and rainfall regimes (uni- and bi-modal), to mention a few [56,57,58&59].

Observed data shows that the annual range of mean temperatures increases from the south to the north. The climatological mean temperature over Ghana shows that the average air temperature increases with latitude, except for some areas of the east coast (Fig. 14b), ranging from 26°C to 30°C, with the highest in the north, ~~and~~ which is characteristic of climatic conditions within the tropics. The climatological maximum temperature (Fig. 14c) indicates that the mean daytime temperature recorded at the period of peak solar insolation, mimicked the mean temperature pattern (Fig. 14b) with magnitudes ranging from 31 to 35°C. On the other hand, a reverse pattern is observed with the minimum temperature (which is usually an indication of mean night-time temperature), where higher values are recorded along the coast and the Volta basin.

[56] Kumi, N., & Abiodun, B. J. (2018). Potential impacts of 1.5 C and 2 C global warming on rainfall onset, cessation and length of rainy season in West Africa. Environmental Research Letters, 13(5), 055009

[57] Omotosho, J. B., & Abiodun, B. J. (2007). A numerical study of moisture build-up and rainfall over West Africa. Meteorological Applications: A journal of forecasting, practical applications, trainings techniques and modelling, 14(3), 209-225

[58] Omotosho, J. B., Balogun, A. A., & Ogunjobi, K. (2000). Predicting monthly and seasonal rainfall, onset, and cessation of the rainy season in West Africa using only surface data. International Journal of Climatology: A Journal of the Royal Meteorological Society, 20(8), 865-880.

[59] Sylla, M. B., Giorgi, F., Coppola, E., & Mariotti, L. (2013). Uncertainties in daily rainfall over Africa: assessment of gridded observation products and evaluation of a regional climate model simulation. International Journal of Climatology, 33(7), 1805-1817

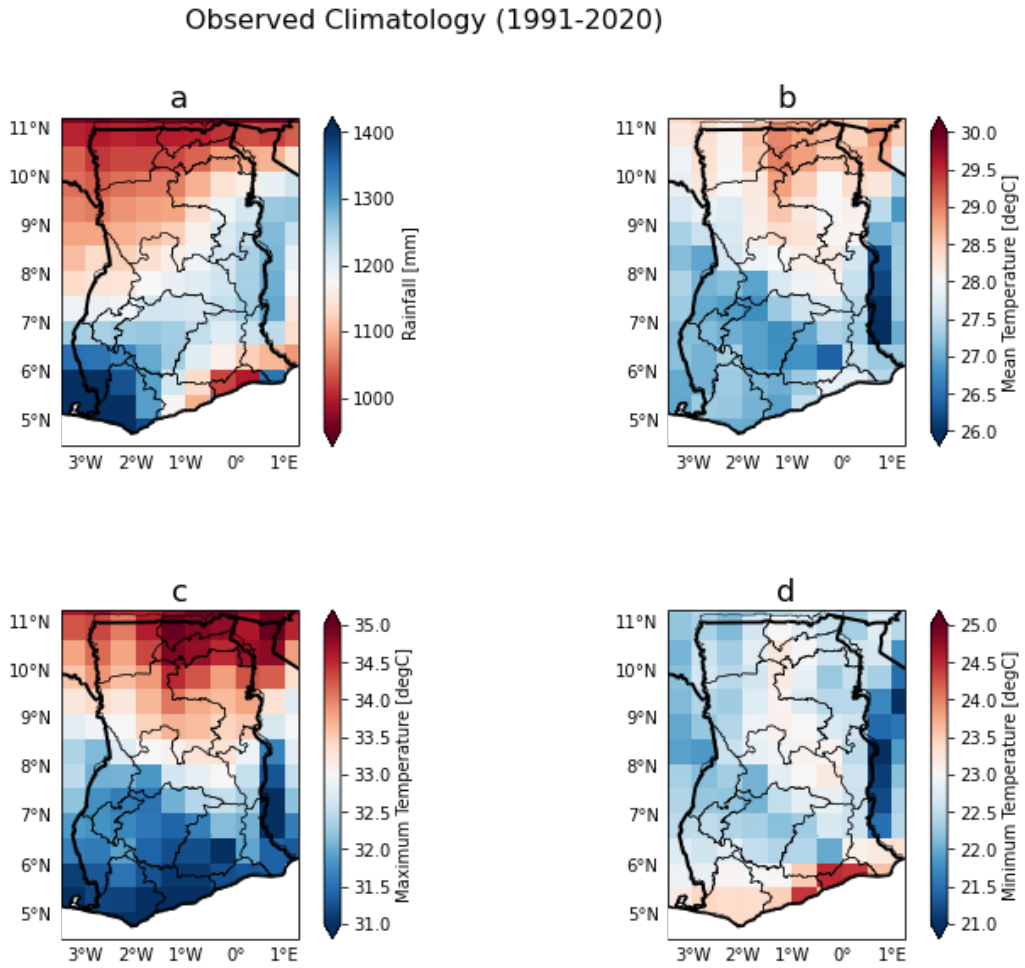

Figure 14 : Observed annual climatology of (a) rainfall, (b) mean-, (c) maximum- and (d) minimum- temperatures over Ghana (1991 - 2020).

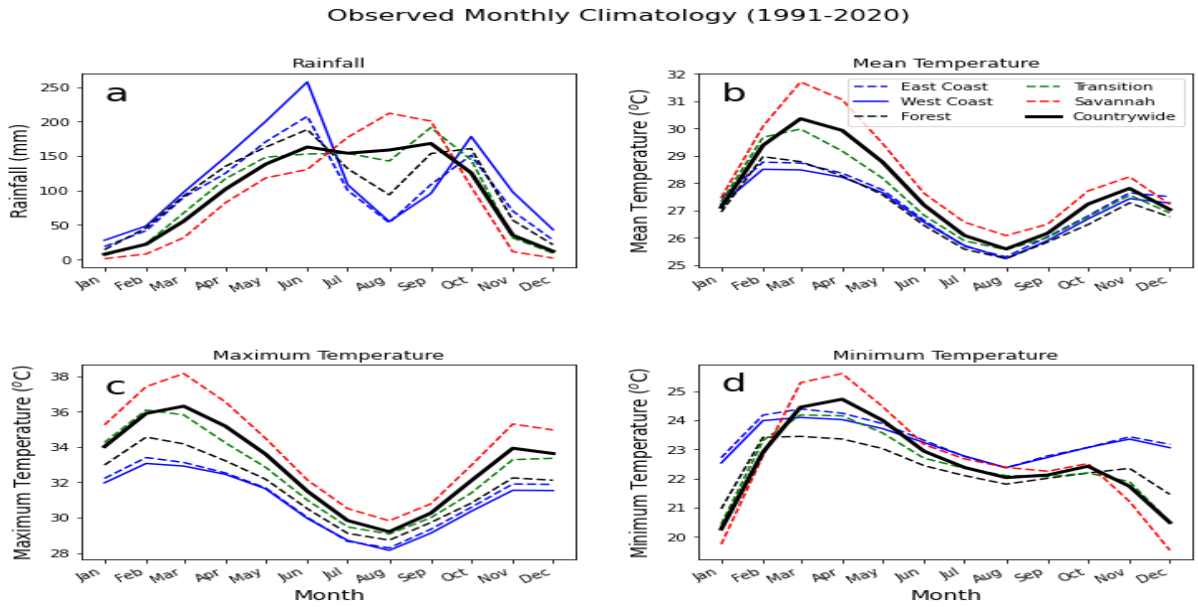

Figure 15: Observed monthly climatology of (a) rainfall, (b) mean-, (c) maximum- and (d) minimum- temperature, averaged over the defined agro-ecological zones. The east coast is shown in blue dashed line, west coast (continuous blue line), forest (black dashed line), transition (green dashed line), and the savannah (red dashed line). A continuous black line denotes the countrywide climatological information

The monthly rainfall patterns vary by agro-ecological region whilst the monthly temperature trends show a bi-modal pattern across all regions of the country. The observed monthly climatological rainfall depicts the major and minor rainy seasons from March to June, and September to November, respectively for southern Ghana, with a "little dry season[60] in August (Fig. 15a). The bi-modal rainfall patterns observed characterize the Forest, East- and West-Coast zones, separated by the little dry season in August. Despite the transition zone showing a similar bi-modal pattern, rainfall peaks are recorded during the minor rainy season. On the contrary, a unimodal rainfall pattern characterizes the northern savannah zone, with peak rainfall recorded in August due to shifts in the rain belt.

The observed mean and maximum temperatures, show a bi-modal pattern with magnitudes ranging from 25 – 32°C, and 28 – 38°C, respectively (Fig. 15b and 15c) and their peaks recorded within the months of February and March. Following the rainfall pattern in Figure 15a, low-temperature values are recorded in July – September, with August recording the minimum and November the maximum towards the dry season. Meanwhile, night-time temperature (minimum temperature) peaks in February – April, and October, respectively, except for the coastal areas (Fig. 15d). The low values are recorded in June – August, with the lowest from November to January coinciding with the dry season.

[60] Omotosho, J. B., & Abiodun, B. J. (2007). A numerical study of moisture build-up and rainfall over West Africa. Meteorological Applications: A journal of forecasting, practical applications, training techniques and modelling, 14(3), 209-225

1.12.2. Projected spatial distribution of temperature and precipitation

In figure16, the spatial patterns of climate variables (rainfall and temperature) are shown for the historical period (1850-2014) and the projections (2015-2100) for the RCP4.5 and RCP8.5 scenarios of the sixth phase of the Coupled Model Intercomparison Project (CMIP6). This diagnostic study includes the IPSL (Institute Pierre Simon Laplace), one of the several model members of the CMIP6 Project. A latitudinal gradient was observed on both the precipitation and temperature map for all periods and scenarios.

It was observed that, there is a decrease in the amount of rainfall from the south of the country towards the north. This observation is more visible with the RCP8.5. However, an opposite signal was found for temperature which rather increases northward with an increasing trend.

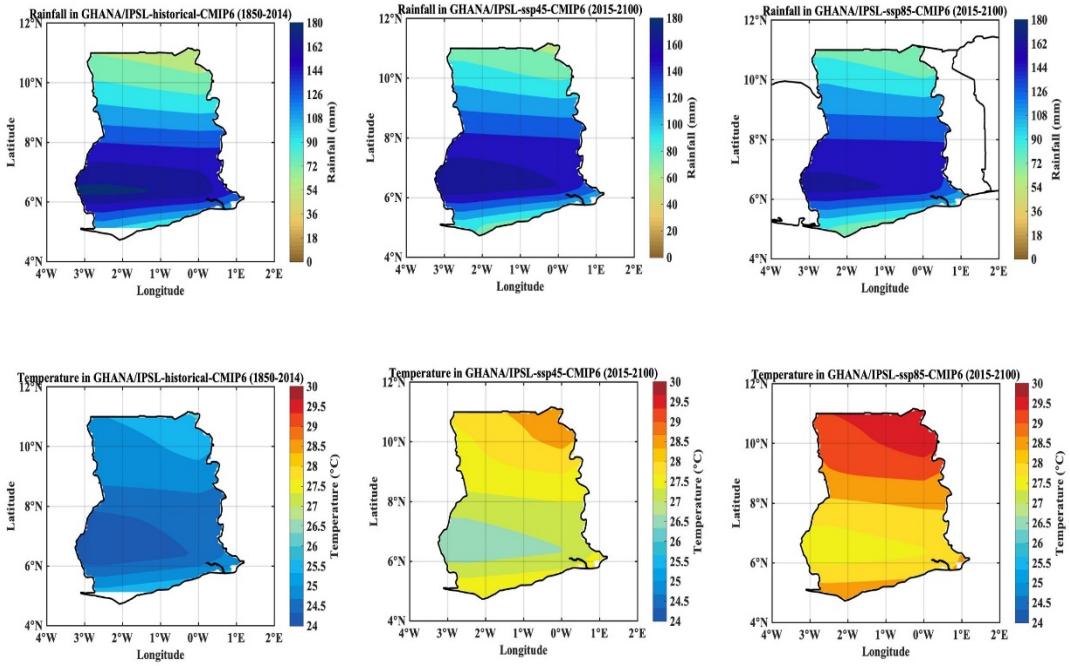

Figure 16: Spatial distribution of climate rainfall and temperatures over two time periods under two different scenarios. (Source: AfD study)

Figure 17 represents the annual rainfall and temperature cycles for the historical period and the RCP4.5 and RCP8.5 scenarios. For these two periods, the peak of the rainfall takes place in August. Both scenarios (RCP4.5 and RCP8.5) illustrate slightly higher amount than in the historical period. Regarding the temperatures, a bimodal evolution is shown with two maximum peaks respectively in April and in November. A substantial seasonal increase in temperature is shown with both scenarios, especially with RCP8.5, which revealed the highest values.

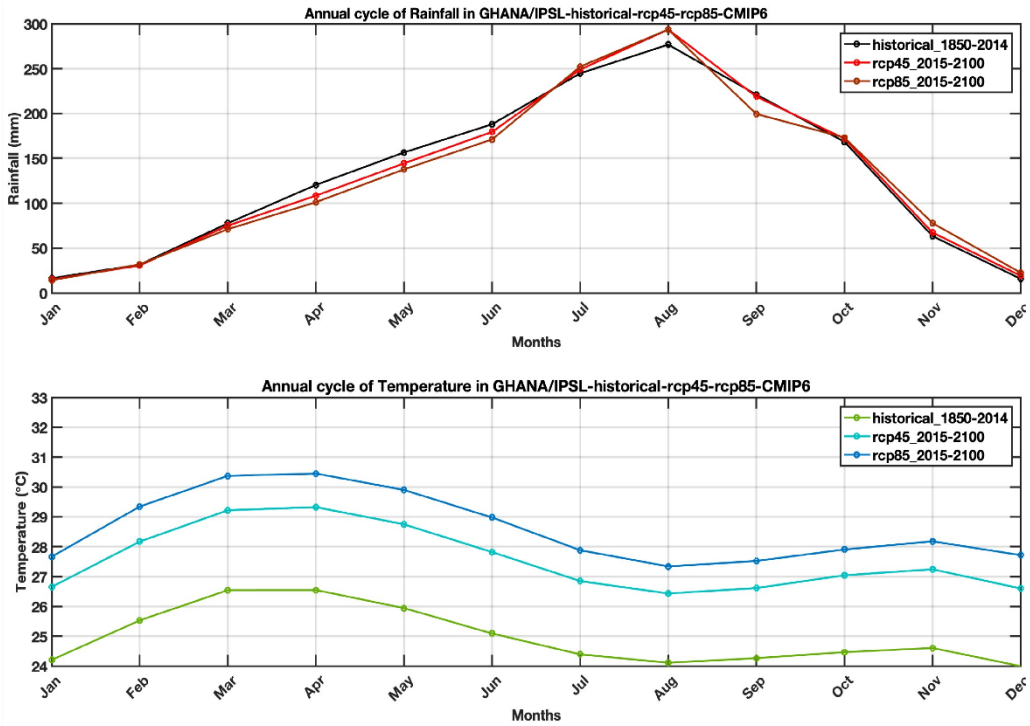

Figure 17: Annual rainfall cycles (upper panel) and temperatures (lower panel) for Ghana's historical, RCP4.5, and RCP8.5 scenarios (Source: AfD study)

Figures 18 and 19 shows the interannual variability of rainfall and temperature for the historical period and projections (RCP4.5 and RCP8.5). In the historical period, the rainfall variability is slightly marked, ranging between 1400 mm and 1800 mm. For the projections, the rainfall variability for RCP4.5 is less marked compared to the RCP8.5 scenario.

The temperature in the historical period has increased overall over the years (from 24 °C to 26.5 °C). The scenarios (RCP4.5 and RCP8.5) show a substantial rise in temperatures in the future, an average of 29 °C for RCP4.5 and 32 °C for RCP8.5 are projected.

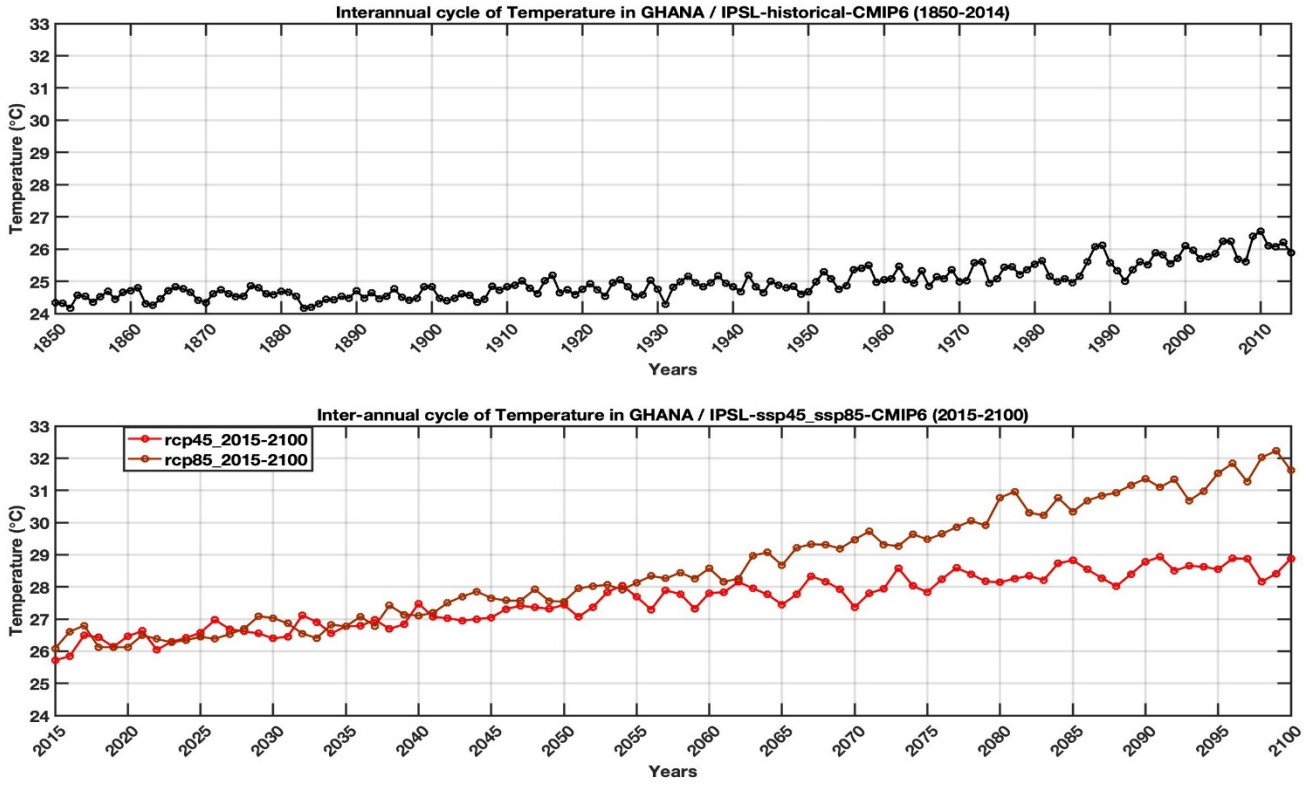

Figure 18: Interannual variability of temperature for the historical RCP4.5 and RCP8.5 in Ghana. (Source: AfD study)

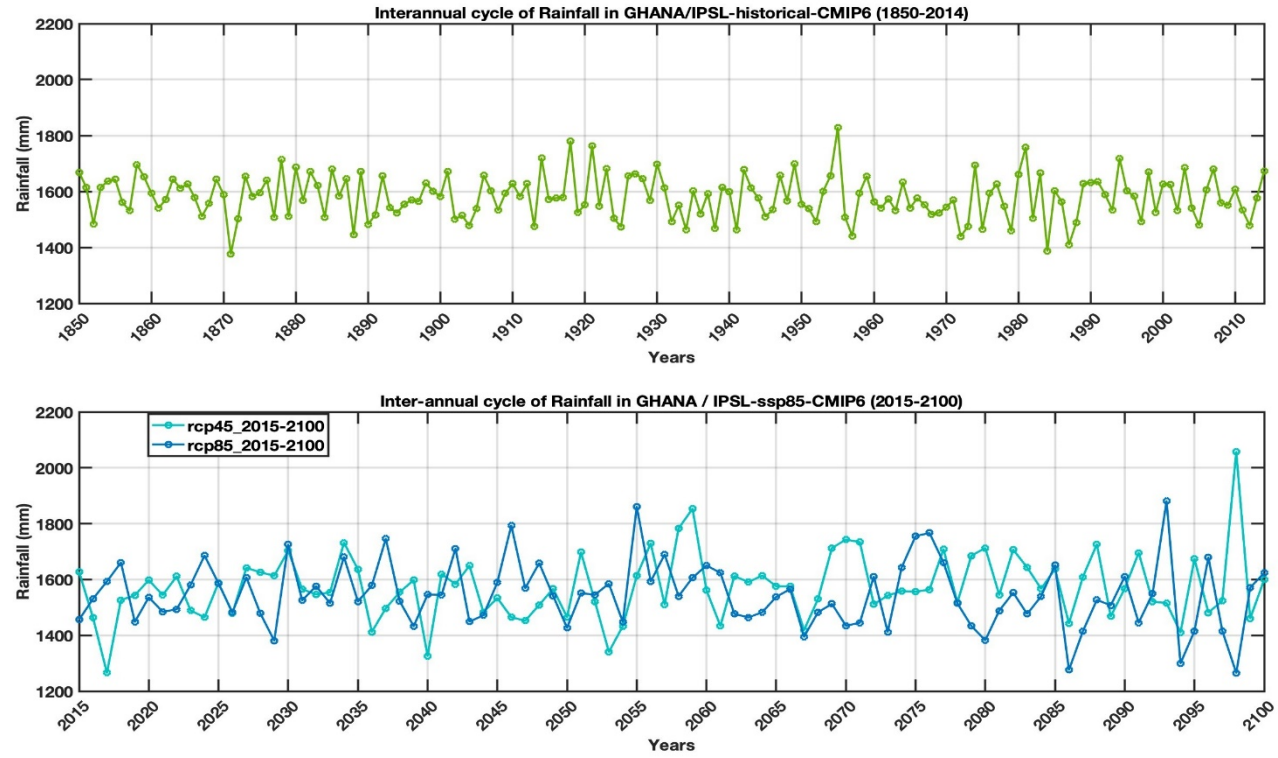

Figure 19: Interannual variability of temperature for the historical RCP4.5 and RCP8.5 in Ghana (Source: AfD study).

1.12.3. Sea level rise

Climate change is precipitating sea level rise in the country resulting in sea erosion and flooding along the coastal stretch,[61, 62] particularly pervasive on the eastern coast along the Volta delta and affecting communities along the coast[31]. The coastal Ramsar sites in the Muni-Pomadze lagoon experienced an average coastal retreat of 0.22 m/year between 1972 and 2014,[63] whilst the Dansoman coastline, which covers Panbros, Glefe, and Gbegbeyise communities, could recede by about 202 m by the year 2100, displacing the dense population (EPA 2020).

On average, there has been a 3.44 mm rise in sea levels per year over the period 1993 – 2016, yet current years exhibit estimated rise of 50 mm and above. This is a significant upward shift/trend in the yearly and long-term anomaly signals in Ghana's coastal waters (Fig. 21). There are monthly anomalies with heightened or reduced levels with the highest in November which is approximately 90 mm above mean sea level (Fig. 21b), as opposed to August's shallowest observed level at approximately 40 mm below mean sea level.

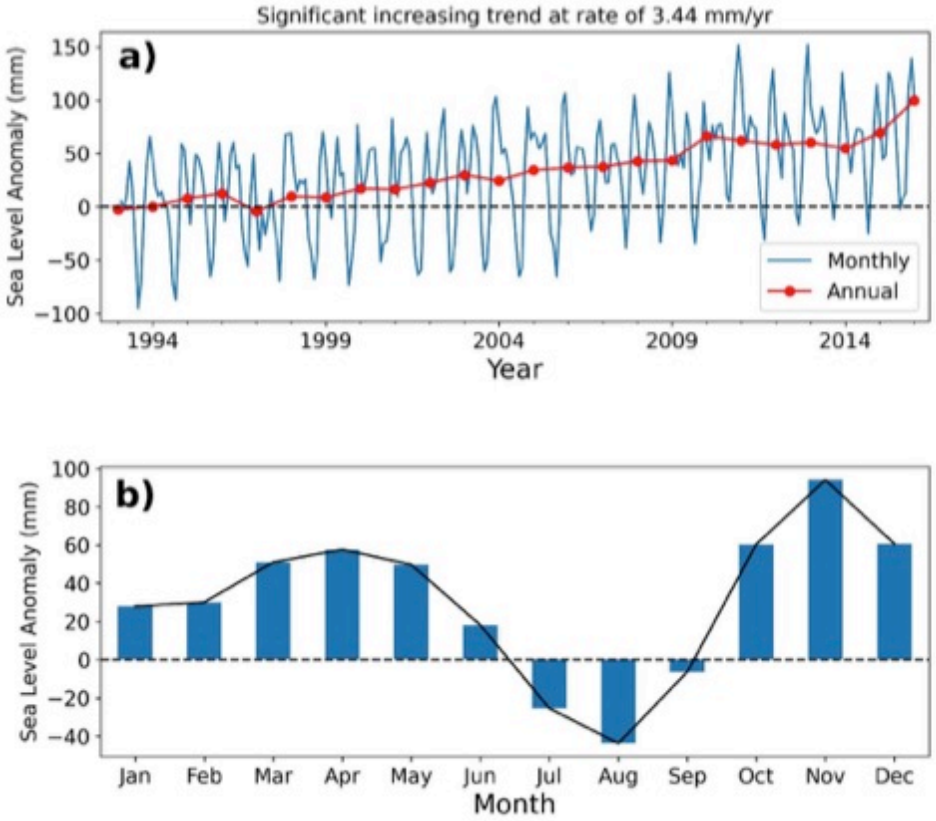

Figure 20 : (a) Timeseries analysis of Sea-level Anomaly and (b) Monthly climatology of sea level anomaly

[61] Boateng, I. (2012). An assessment of the physical impacts of sea-level rise and coastal adaptation: a case study of the eastern coast of Ghana. Climatic Change, 114(2), 273-293.
[62] Evadzi, P. I. K. (2017). Regional sea-level at the retreating coast of Ghana under a changing climate (Doctoral dissertation, Staats-und Universitätsbibliothek Hamburg Carl von Ossietzky).
[63] Davies-Vollum, K. S., & West, M. (2015). Shoreline change and sea level rise at the Muni-Pomadze coastal wetland (Ramsar site), Ghana. Journal of coastal conservation, 19(4), 515-525.

Stratification of sea level rise based on different emission scenarios.

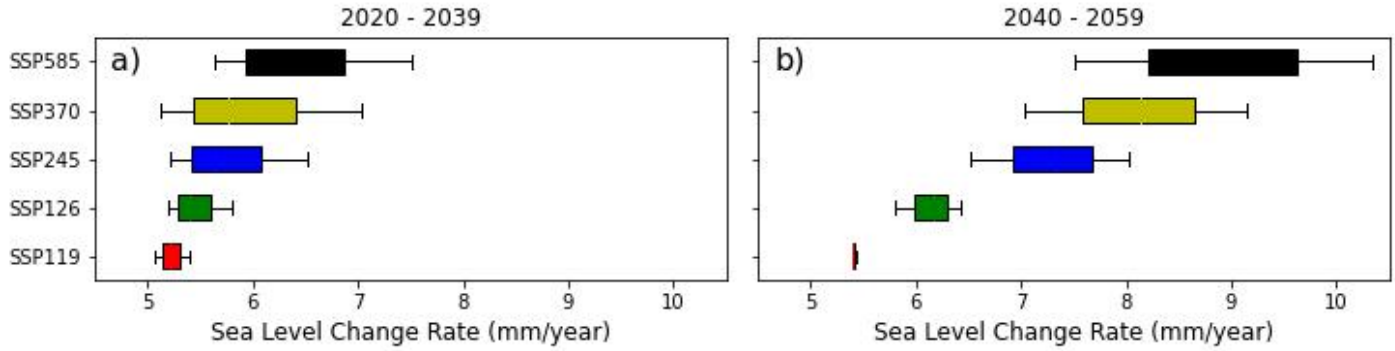

Figure 21: Sea Level Change Rate by (a) 2020-2039 and (b) 2040-2059 period under 5 Shared Socio-economic Pathways (SSPs).

Stratification of sea level rise based on different emission scenarios indicates that the influence of emissions on sea level rise could be detrimental if appropriate mitigation and adaptation measures are not put in place. The new Shared Socio-economic Pathways (SSPs) that are an indication of climate change projections and socio-economic scenarios for evaluating climate impact and adaptation measures were assessed with a keen consideration on regional sea level change rate. Four SSPs, with varying adaptation and mitigation pathways, were assessed (Figure 22) for the 2020-2039 and 2040-2059 periods. Under different emission scenarios, a coupled change in sea level is expected over the Gulf of Guinea. For extreme emission scenarios, with no-to-limited complementing adaptation and mitigation strategies, the sea level will possibly rise by 6 – 7 mm/year within the 2020-2039 period and 8.5 – 9.7 mm/year by the 2040-2059 period. If stringent measures are adopted to limit the emissions, we expect the sea level to rise by about 5.3 mm/year within the 2020-2039 period with a marginal increase to about 5.5 mm/year in 2040-2059. Conclusively, we project that the influence of emissions on sea level rise could be detrimental if appropriate mitigation and adaptation measures are not put in place. These could contribute to the development and spread of several water-related diseases and morbidities. These could also lead to the development of novel water-related diseases, coastal floods and submergence of habitable lands, etc.

1.13. Observed climate -related extreme events

In the past 50 years, 22 major hydrometeorological events in Ghana have affected 16 million people with over 400 deaths [35]. The World Bank identifies six different yet interrelated hazards that are also associated with extreme events in Ghana. They are drought, earthquake, epidemics, flood, wildfire storm, and storm[64] . This section focuses on the three extreme events that confront Ghana: heavy rainstorms / floods, sea level rise and drought.

In summary, Ghana faces four areas of concern: rainfall variability leading to extreme unpredictable events, increased temperatures, sea-level rise, and increasing greenhouse gas emissions and loss of carbon sinks. These broad areas of concern can precipitate natural disasters making the country vulnerable to extreme events such as floods, heat, drought / aridity. Projected increases in dry spells can exacerbate drought conditions, especially in the Savanna region. Second, the country is made up of mostly low plains to a low elevation of between zero meter from the Atlantic Ocean with coastal plains stretching across the entire south interspersed with saltwater lagoons, exposing it to fluctuating oceanic influences accompanied by water related extreme events.

[64] World Bank Group 2021. Climate Risk Country Profile Ghana, 2021.

An estimated 50% of the 540 km shoreline of Ghana is vulnerable to sea-level rise[65]. Third, the current development challenges of poor spatial planning and demographic changes including urbanization and densification of critical landscapes such as coastal zones increase exposure to extreme events. Fourth, there are limitations placed on preparedness to respond to extreme events due to data paucity and related uncertainties [31]. Fifth, the severe effects of land use and land cover changes which have resulted in deforestation, loss of biodiversity, soil erosion and disruption of soil structure are at the forefront of land degradation which tend to modulate the impacts of extreme events. Sixth, weak social and environmental determinants of human well – being including extreme poverty in some parts predisposes populations to the impacts of extreme events. Finally, heat stress is a recently emerging phenomenon and can exacerbate or magnify the impacts of the other extreme events[35].

1.13.1. Floods

There have been over 19 significant flood events in the past five decades (EPA 2020). Despite declining trends, heavy rainfall events are expected to increase in Ghana resulting in flooding, flash floods and riverbank erosion. More erratic and intense rainfall is expected during the wet season, along with lower precipitation levels. The occurrence of floods is common, with at least 11 flood events recorded in the past decade which caused widespread damage to infrastructure and farmland, impacting the livelihoods of many Ghanaians. For example, a flood in the Greater Accra Region in 1991 affected an estimated two million people and caused over US$12 million worth of damage. Besides, floods have had significant impacts on Ghana's agricultural sector, including among other things: i) the loss of crops – such as cassava, rice, yams, and groundnuts – and livestock; ii) the destruction of farmlands, houses, bridges, schools and health facilities; iii) damage to water supply infrastructure and irrigation facilities, and iv) damage to food storage and post-harvest processing facilities[66]. Severe floods that affected northern Ghana in 2007, led to the Government pronouncing the then three northern regions and some parts of the Afram Plains and Keta Area as a disaster zone, which claimed 56 lives, damaged ~500 km of roads, destroyed 69 bridges and displaced ~332,000 people[67] . In 2010, floods in the White Volta River Basin affected hundreds of thousands of people and destroyed many of their livelihoods. Urban floods also regularly impacted key cities, with the last major event occurring in Accra in June 2015[68]. The flood event experienced in Accra in June 2015 caused extensive harm to human life, infrastructure, and businesses[69].

[31] Conway, G. (2009). The science of climate change in Africa: impacts and adaptation. *Grantham Institute for Climate Change Discussion Paper*, *1*, 24.
[65] Boateng, I., Wiafe, G., & Jayson-Quashigah, P. N. (2017). Mapping vulnerability and risk of Ghana's coastline to sea level rise. Marine Geodesy, 40(1), 23-39.
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[67] Government of Ghana 2007. Joint assessment report of flood disasters in the three northern regions of Ghana. Inter-ministerial Disaster Relief Committee and UN Country Team
[68] Environmental Protection Agency (2020)
[69] Amoako C, Inkoom DKB (2018) The production of flood vulnerability in Accra, Ghana: re-thinking flooding and informal urbanisation. Urban Stud 55:2903–2922. https://doi.org/10.1177/0042098016686526

Year	Disaster description	Regions affected	Total deaths	Total people affected
1968	Flood	Central	--	25,000
1971	Drought	Countrywide	--	12,000
1977	Drought	Northern, Upper East, Upper West	--	--
1983	Drought	Countrywide	--	12,500,000
1989	Flood	Northern	7	2,800
1991	Flood	Greater Accra	5	2,000,000
1995	Flood	Greater Accra	145	700,000
1999	Flood	Northern, Upper East, Upper West	52	324,602
2001	Flood	Greater Accra	12	144,025
2002	Flood	Greater Accra	--	200
2002	Flood	Greater Accra	4	2,000
2007	Flood	Northern, Upper East, Upper West	56	332,600
2008	Flood	Northern	--	58,000
2009	Flood	Greater Accra, Ashanti, Volta, Western, Central, Eastern	16	19,755
2009	Flood	Northern	24	139,790
2010	Flood	Greater Accra, Central, Volta	45	7,500
2010	Flood	Brong Ahafo, Eastern, Western, Upper East, Upper West, Northern	18	9,674
2011	Flood	Eastern	6	12,571
2011	Flood	Greater Accra, Eastern, Volta	14	81,473
2013	Flood	Northern, Volta	5	25,000
2015	Flood	Greater Accra	25	5,000
2016	Flood	Greater Accra	10	--

Table 2: List of extreme climate events and their impacts in Ghana between 1968 and 2017[70]

1.13.2. Drought

Three drought events have occurred in the past five decades in Ghana with varying degrees of impacts (EPA 2020). Drought exposes smallholder farmers to significant climate risk when seasons changes and droughts occur. Given Ghana's reliance on rain-fed agriculture, drought poses a significant threat to the agricultural sector, with the most immediate consequence being a decrease in the production of staple crops – especially sorghum, millet, maize, and groundnuts, and negative impact on the livelihoods of smallholder farmers, particularly in the northern savanna zones. For example, a severe drought in 1983 affected 12.5 million people across the country, resulting in severe hunger and the deaths of hundreds of people, mostly children. The most affected regions of the 1983 drought were the Upper East, Upper West and Northern regions, southern Brong-Ahafo and northern Ashanti[71] . Table 2 summarizes extreme climate events and their impact in the country between 1968 and 2017.

[70] EM-DAT 2016. Disaster List for Ghana. Available at: http://emdat.be/disaster_list/index.html]

[71] Agency for International Development 1984. Disaster Case Report: Ghana – Food Shortage. Available at: http://pdf.usaid.gov/pdf_docs/PBAAB318.pdf / Choudhary V, Christienson G, D'Alessandro S.P, Josserand H.P. 2016. Ghana: Agricultural Sector Risk Assessment. World Bank Agriculture Global Practice Note.

1.14. Goal and objectives for the harmonized V&A assessment

1.14.1.Goal

To develop a harmonized climate change vulnerability and adaptation (V&A) assessment report to provide evidence to inform the development of a Health National Adaptation Plan (H-NAP) for Ghana.

1.14.2. Objectives

- To develop climate change V&A assessment validation screening tools that can be applied to already existing or future climate change V&A assessment reports or proposals and to assess how well they align with WHO V&A assessment guidelines.
- To conduct gap analysis for already existing climate change V&A assessment reports for Ghana, using the validation screening tools.
- To conduct field work covering all 16 regions of Ghana to update data and fill gaps for a more up-to date climate change V & A for Ghana
- Prepare the harmonized climate change V&A assessment report for Ghana.

2. Methodology

2.1. National level assessments

2.1.1. Steps in the harmonized climate and health V&A assessment process

At this level, the study aimed to harness evidence from three already existing V&A studies in Ghana, by identifying the gaps and updating the information with support of a multisectoral technical working group of experts. This was important to ensure conformity with a harmonized V&A assessment framework adopted by the MOH of Ghana, which is essentially based on the WHO guidance on V&A assessments. The following steps were followed:

Step 1. Framing and scoping the assessment

Step 2. Vulnerability assessment

Step 3. Adaptive capacity assessment

Step 4. Prioritizing adaptive capacity

Step 5: Understanding future impacts on health

Step 6: Synthesise and recommend adaptive strategies as input for the H-NAP and policy

In developing the harmonized climate and health V&A assessment report, the processes followed are described below.

2.1.2. Framing and scoping the assessment

Core study team of experts

After receiving an online training conducted by a WHO/AFRO technical expert, a core study team from the MoH, GHS, Academia and WHO Country Office, defined the scope of the assignment by guided by the following questions:

- Who should be invited into the project technical working group?
- What are the key questions and policy context of the assessment?
- Which geographical areas of the country must be visited?
- What are the climate sensitive health outcomes of interest?
- What data and information will be required to inform the assessment?

This study followed an exploratory study design, based on the steps in the WHO guidance for V&A assessment.

Multisectoral technical working group of experts

The national level assessments relied mostly on data collected through group discussions with key informants and/or experts at national level during technical working group (TWG) meetings. Members included representatives from the health, environment, disaster management, agriculture, academia, water and sanitation and hygiene sectors. The assumption was that stakeholders at ministries, departments, and agencies (MDAs) at the national and regional levels have a good understanding of the distribution and trends in current climatic risks and health vulnerabilities by regions and districts respectively. Data collection methods also included desktop review of relevant information, key informant interviews using semi-structured questionnaires, and analysis of District Health Information Management System (DHIMS) data.

Gap analysis of already existing V&A assessment reports

During the inception workshop referred to in section 2.1.3, members of the technical working group were presented with a pre-designed validity screening tools that was pre-tested on the three already existing V&A reports to identify any existing gaps in vulnerability and adaptation assessment methodology. The scope of this gap assessment was limited to Steps 1 to 4 in the harmonized climate and health V&A assessment process. Based on feedback, the tools were improved and finalized by a core V&A task team. A sample of the screening tool for assessing gaps in methodology in V&A reports is shown in annex 2.

2.1.3. Vulnerability assessment

National level vulnerability was assessed as the level of exposure to climate sensitive health outcomes and the sensitivity of these outcomes to climate variability. The assessment revealed that each CSHO has different levels of priority, reflecting the different levels of exposure, sensitivity and adaptive capacity. A qualitative approach was adopted in assessing vulnerability to CSHOs which involved:

- Prioritization of CSHOs.
- Current trend and burden of climate- sensitive health outcomes over a 10-year period (2014-2023).
- An analysis of the relationships between current and past weather conditions and health outcomes was also performed to determine how sensitive these health outcomes were to changes in weather variables.
- Identification of populations and geographical regions that are particularly vulnerable to the health impacts of climate change.

Prioritization of Climate Sensitive Health Outcomes (CSHOs)

The vulnerability assessment involved the identification, description and prioritization of the current distribution and burden of climate-sensitive health outcomes. During a meeting of the technical working group of experts at national level, a primary list of climate sensitive health outcomes in Ghana that had been developed through literature review was prioritized through a participatory process based on the following criteria:

- Qualitative assessment of strength of association between climate change and the health outcome.
- Priorities of the Ministry of Health.
- Public/community concerns.

Subsequently, the CSHOs were grouped into the following categories:

- Health outcomes related to extreme weather events.
- Vector borne, rodent borne, zoonotic diseases.
- Water and foodborne diseases.
- Health outcomes related to air quality.
- Nutrition.
- Health outcomes related to health care facilities.

CSHOs were then rated by applying the risk matrix table in Figure 22. Overall impact severity ratings were based on the aggregate sum of impact/sensitivity ratings across a range of 4 consequence criteria (Extent, Duration, Adaptive capacity and Prevention), where for each criterion, impact was rated on a scale of 0 – 3.

Every level of impact severity was then compared with different levels of likelihood criteria to obtain overall ratings of CSHO risk on a scale of 1 – 4, where 1 is low risk; 2 is moderate risk; 3 is high risk and 4 is very high risk. The CSHOs were then ranked in descending order of risk.

Step 1				
Impact/sensitivity level (Score)	Consequences			
	A – Extent	B – Duration	C – Level of disability	D – Prevention and remedy
Low (0)	Punctual Rare individual cases	Very short term: a few days	Health effect is not perceptible	A comprehensive set of preventive measures is in place Remedy is available and accessible to the general population
Medium (1)	Small and limited A small number of households is affected Only a specific population group is affected	Short-term: a week up to a month	Health effect resulting in annoyance, minor injuries or illness that does not require hospitalisation	A reasonable set of preventive measures is in place Remedy is available but not everybody is having access
High (2)	Medium but localised Village level Anybody can be affected	Medium term: several months up to a year	Health effect resulting in moderate injury or illness that may require hospitalisation	Only few preventive measures are in place Access to remedy is difficult and restricted to a minority of the population
Very high (3)	Extends beyond the immediate impact area Regional level Anybody can be affected	Long-term: several years	Health effect resulting in severe disability or even loss of life.	No preventive measures are in place Access to remedy is very difficult

Step 2	Likelihood				Step 3
Impact severity (Score range of A+B+C+D)	Improbable (< 10%)[a]	Possible (10% - 50%)[a]	Probable (51% - 90%)[a]	Definite (> 90%)[a]	
Low (0 – 3)	♦	♦	♦	♦♦	Step 4
Medium (4 – 6)	♦	♦♦	♦♦	♦♦♦	
High (7 – 9)	♦♦	♦♦♦	♦♦♦	♦♦♦♦	
Very high (10 – 12)	♦♦♦	♦♦♦♦	♦♦♦♦	♦♦♦♦	

Figure 22: Risk matrix table

Baseline trend of CSHOs

National trends in CSHOs were analysed by gender using bar charts, while the regional trends were depicted in line graphs where the data was available. The annual totals of incident cases of CSHOs reported in the DHIMS were converted into rates using total OPD registrants from 2021 and expressed as number of incident cases per 1,000 OPD registrants, except for under-5-year pneumonia and diarrhoea, which were expressed as number of incident cases per 1,000 OPD registrants under 5 years. Still birth rates were computed as the number of still births per 1,000 live births.

For diseases like Yellow Fever, Meningitis and Cholera, the data was sourced from IDSR because it was more reliably reported there, even though it was not disaggregated by sex.

Exposure to climate variability

The trends in current and past weather and climate conditions and the geographical distribution of rainfall and temperature were analysed to show the seasonal variations.

Trends in observed monthly rainfall and temperature, averaged over a defined period as well as extreme weather events were also documented. Spatial and trend distribution of rainfall, temperature and sea level rise were projected over three time periods and under two different scenarios.

2.1.4. Sensitivity analysis

Sensitivity analysis of relationship between historical weather and climate conditions and health outcomes were performed for the prioritized climate sensitive health outcomes. Historical records on climate data (1980 to 2024) from Ghana Meteorological Agency and reported incident cases of CSHOs from GHS' DHIMS2 database, (2009–2024), were analysed to assess climate–health outcome sensitivity. Spearman's rank correlation was used to examine relationships between climate and disease incidence. Climate variables were lagged at 0 to 3 months (Lag 0–3) to capture delayed health effects. Analyses were stratified by ecological zones to capture spatial heterogeneity.

2.1.5. Future projections of CSHOs

For future projections of CSHO burden from 2025-2050, historical climate variables rainfall, temperature (Tmin and Tmax), and humidity were obtained from the Ghana Meteorological Agency (GMeT) for the period 1980–2024, while historical health data covering the prioritized climate-sensitive diseases were sourced from Ghana Health Service's DHIMS-2 platform, spanning 2009–2024.

Future climate projections were derived from CMIP6 Global Climate Models (GCMs), using SSP245 (intermediate) and SSP585 (high emissions) scenarios to capture a range of plausible climate futures. For disease burden forecasting, several machine learning models were evaluated which include Random Forests, Ridge Regression, Gaussian Process Regression, and Gradient Boosting with the best-performing models used for final projections over the period 2025 – 2050. This approach ensured both statistical rigor and ecological relevance in quantifying climate health dynamics across Ghana.

2.1.6. Adaptive capacity assessment and prioritization

Assessment of capacity gaps in key health system functions at national level

Members of the TWG were put into three groups and then each group was assigned a template with a set of H-NAP objectives as shown in annex 3. Members for each group were purposively assigned to ensure they have expertise to contribute to the assigned H-NAP components to be discussed.

Group one (1) was tasked to work on the following components of the H-NAP - Leadership and governance, Monitoring progress, Health workforce, Climate and health financing, Climate resilient and sustainable technologies and infrastructure. Group two (2) focused on the following areas: Vulnerability, capacity, and adaptation assessment, CSHOs, Integrated risk monitoring and early warning, Emergency preparedness and management. Lastly, Group 3 discussed issues related to Management of environmental determinants of health, and climate resilient and sustainable technologies and infrastructure.

Each group had to complete a template requiring members to identity health system capacity gaps, current and planned adaptive Policies, Plans and Programs (PPPs), ratings for adaptive capacity ratings, recommended adaptive actions, Lead health sector and non-health sector agencies. The identified gaps in key health system functions were further supplemented by the gaps identified from the validity screening of already existing V&A reports. Baseline information on current or planned climate-related PPPs of the health and health-relevant sectors were mapped to the identified gaps.

Ratings for adaptive capacity in key health system functions at national level

The adaptive capacities of the PPPs analysed in the previous section were rated on a scale of 1 to 3 based on availability of workforce, essential supplies, technology, and relevant PPPs (Table 6).

A rating of 3 denotes adequate adaptive capacity whereas 2 and 1, depict moderate and low adaptive capacity respectively that required action to be taken. The names of national level institutions that have capacity to address the identified vulnerabilities were also listed on the template.

2.2. Regional level assessments

Field visits were conducted to all the 16 administrative regions of Ghana to hold interviews and discussions with key stakeholders in health and health-relevant sectors. In some regions, some impacted districts were also visited to observe at first hand some of the vulnerabilities.

2.2.1. Study design

The regional level field assessments followed an exploratory study design, aimed at collecting information from heads of climate relevant MDAs in the region. These included regional representatives of GHS, National Disaster Management Organization (NADMO), Environmental health, Agriculture, EPA, Community Water and Sanitation Agency (CWSA)/ Ghana Water Company Limited (GWCL) and the Regional Planning Officer from the Regional Coordinating Council (RCC).

Data collection methods employed included desktop review of relevant information, key informant interviews using semi-structured questionnaires, and analysis of DHIMS data.

2.2.2. Core study team

A core study team of officers of the OEH unit of GHS and the Policy, Planning, Monitoring and Evaluation (PPME) of MOH was formed, and members were grouped into four (4) task teams based on their technical expertise to accomplish the four data collection tasks summarized below:

Task team 1: This team was to retrieve secondary data related to the health sector climate resilience from the Regional Coordinating Councils (RCCs) and Regional Health Directorates (RHD) at the regional level and Metropolitan, Municipal, District Assemblies (MMDAs) and District Health Directorates (DHD) at the district level. This included extracts from DHIMS2, on 10-years (2003-2022) historical data on the burden of prioritized climate sensitive health outcomes in each study region and district. In the selected districts, the team also retrieved information from documents like the district medium term development plans (MTDPs) and health annual report.

Task team 2: Team members conducted interviews with key health sector decision makers in the study regions and districts to validate the health system's adaptive capacity to increase in temperature, relative humidity, extreme weather events, vector-borne diseases, water-borne diseases, air-borne diseases, malnutrition etc.

Task team 3: Monthly time series datasets will be compiled from the DHIMS2 with climatic data obtained from Ghana Meteorological Agency (GMET) will be used to quantify the strength of correlation between precipitation, ambient temperature and humidity on one hand, with monthly reported cases of assigned CSHOs from 2014 to 2023 in the 6 ecological zones of Ghana. Future trends in the risk of CSHOs will also be projected under different climate scenarios and time periods. This sub-project was to be conducted by a consultant appointed by the MOH. This task has however been frozen pending the recruitment a consultant with the requisite capacity.

Task team 4: Team members conducted key informant interviews with regional heads of health-relevant MDAs, to identify prioritized health system adaption policies, programs, and actions at national and sub-national level, which can enhance the adaptive capacity of the health sector to climate change. The lead responsible government agencies & support agencies were also identified.

2.2.3. Study areas

Field data collection was conducted in two phases. During phase 1, which was sponsored by WHO and FCDO, members of the core study team embarked on field visits to the 8 regions and districts that had benefitted from previous climate change and health V&A assessments from 2015-2016 and AfD from 2000 to 2022 to validate and update their findings. Data collection spanned the period 26th

June 2023 to 6th October 2023 in phase 1. Phase 2 data collection was conducted over the period 22nd April 2024 to 12th July 2024 with funding from the World Bank.

	Regions	MMDAs visited
Phase 1	• Northern	Tamale
	• Ashanti	Kumasi
	• Greater Accra	Accra
	• Upper West	Nadowli-Kaleo
	• Savanna	North Gonja
	• Bono	Jaman North
	• Western	Nzema East
	• Oti	Krachi East
Phase 2	• Bono East	Techiman
	• Ahafo	Goaso
	• Central	Cape Coast
	• Eastern	Atiwa East (New Jejeti)
	• Volta	Ho
	• Upper- East	Bolgatanga
	• North- East	Nalerigu
	• Western-North	Sefwi Wiawso

Table 3: Study areas visited by regions and Metropolitan, Municipal, District Assemblies (MMDAs)

2.2.4. Data collection

The following datasets were obtained at the regional level either by review of DHIMS data, conduct of round table discussions or key informant interviews.

Trends in prioritized climate sensitive health outcomes by regions

Datasets of the prioritized CSHOs were extracted from different sources within DHIMS2 for the period 2014-2023 (section 4.1). Unlike the data sourced from monthly out-patient morbidity reports that were disaggregated by sex, the IDSR data was not disaggregated by sex.

2.2.4.1. Regional trends in climatic hazards & upstream drivers of CSHOs

During each regional visit, representatives of the various relevant MDAs in the region were invited by the regional coordinating council for a round table discussion with the research team. With the help of a pre-designed data collection tool (see annex 5), information was collected with respect to each climatic risk factor or upstream driver for CSHOs. For each variable, the interviewer directed the questions to the representative(s) of the most relevant MDAs for their expert opinion on rating scores. The overall approach was therefore a qualitative assessment of hazard ratings of severity of health risks based on expert opinion.

The overall rating for severity of each health risks under study was scored based on the following criteria:

- The presence or absence of the climatic hazards or upstream driver (Yes=1, No=0)
- The frequency of exposure to the hazard (Rare=1; Occasionally=2; Frequently=3)
- The geographical extent i.e., percent of districts involved (<33%=1; 34-66%=2; >66%=3)
- The trend of distribution over the past 5-10 years (Upward=1; Unchanged=2, Downward=-1

The aggregate sum of ratings for each variable under study was the "Total rating score" for that variable. The minimum rating score is 0, and the maximum is 8. The comment section in the tool was also used to capture more detailed information on the names of the districts involved and other information that can further explain the rating scores.

2.2.4.2. Regional adaptive capacity of health and health-relevant sectors

During the round table discussions in each region, experts from the relevant MDAs, were asked to list current or planned PPPs in their respective sectors, that may contribute to alleviating the negative impacts of the weather or climate on human health. They were also requested to provide short descriptions of these PPPs. The same process was repeated with key informants from the regional health directorate to obtain a list of health sector ongoing PPPs, and their descriptions (section 4.3).

The aggregate output of PPPs from both health and health-relevant sectors will give an indication of the existing adaptive capacity rating within the region.

2.2.5. Data analysis and report writing

Analysis of already existing V&A reports

The introduction section of the draft harmonized V&A report was mostly constructed by review of information extracted from the three already existing V&A reports, based on the relevance, quality and recentness of the information. This was supplemented by updates provided by the members of the technical working group.

Analysis of semi-structured questionnaires

During technical working group meetings at both national and regional level, the semi-structured questionnaires designed for use by Task teams 1,2, and 4 was used to guide the group discussions. The questionnaire responses from each task team were entered into Microsoft word copies of the questionnaires.

Subsequently all the captured results were extracted from each questionnaire and summarized into national and regional level tables of results.

Analysis of DHIMS data at national and regional level

National and regional tables of gender disaggregated DHIMS data on incident cases of CSHOs from year 2014 to 2023 were transformed into rates of CSHO cases per 1000 outpatient registrants. This data was then used to generate bar charts and line graphs depicting trends in rates of CSHOs.

Discussion and interpretation

This involved the discussion of observed national and regional trends in CSHO, as well as intra and inter-regional comparison of CSHO trends.

2.2.6. Final validation of harmonized V&A assessment report

A series of national level workshops were held for the project's TWG during which the members reviewed the draft harmonized climate change V&A assessment and synthesised adaptive strategies.

During these workshops, participants continued to identify and review vulnerabilities or gaps in adaptive capacity of key health system functions at national level. They also matched these vulnerabilities with the PPP of health and health-relevant systems, that supports adaptation to health impacts of climate change. The adaptive capacity of PPPs was then rated on a scale of 1-3.

Plans are that the results of analysis and discussion of regional level findings (summary tables and charts) will be presented to the regional level stakeholders during regional based workshops for validation and development of health sector regional adaptation plans.

3. National findings

This section summarizes the findings of both vulnerability and adaptive capacity assessments at the national level.

3.1. Vulnerability assessment

3.1.1. Nationally prioritized climate sensitive health outcomes

The methodology adopted by the technical working group to prioritize climate sensitive health outcomes (CSHOs) in Ghana is described in section 2.1.3. In all, thirteen (13) categories of CSHOs were shortlisted and ranked in descending order of priority according to their risk ratings, as shown in table 4.

Table 4: Climate sensitive health outcomes in Ghana ranked by risk ratings

Climate Sensitive Health Outcomes	Risk ratings
1. Vector-borne and zoonotic Diseases e.g., Malaria, Dengue fever, Filariasis, Onchocerciasis, Yellow fever etc.	8
2. Cerebrospinal Meningitis	7
3. Malnutrition	7
4. Respiratory Illnesses and allergic diseases	7
5. Cardiovascular Diseases	6
6. Food-borne illness	6
7. Water-borne diseases (cholera, Typhoid, Diarrhoea	6
8. Mental Health and psychosocial Disorders	6
9. Injuries & Accidents (from extreme weather events)	6
10. Snake Bites	6
11. Water-washed diseases (Yaws, Scabies, Trachoma etc.)	5
12. Heat Related Illness (Heat stress, heat strokes)	5
13. Injuries & Accidents (from RTAs)	2

3.1.2. National trends in risk of prioritized climate sensitive health outcomes, 2014-2023

Ten-year trends in health facility reported incident cases of prioritized climate sensitive health outcomes are discussed in this section. The primary data was sourced from DHIMS2

Uncomplicated Malaria Tested Positive

Figure 23 shows that although there has been an overall gradual rise in the trend of malaria risk in Ghana over the period under study, the rate of increase has slowed since 2020. The distribution shows that the risk of malaria among males has been consistently higher over the period.

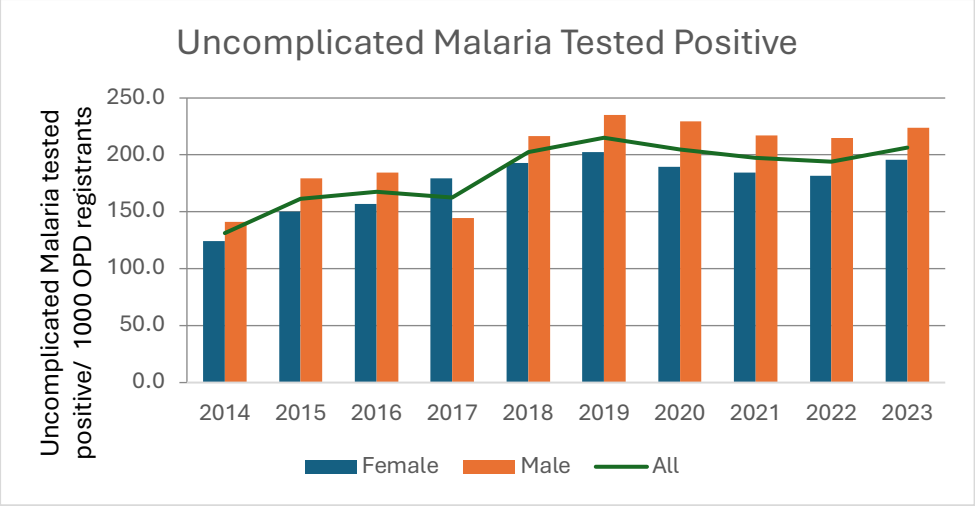

Figure 23: Incident cases of uncomplicated Malaria tested positive per 1000 OPD registrants, disaggregated by gender, 2014-2023

Yellow fever

Figure 24 also shows that although the risk of Yellow fever has been consistently very low, there has been a steady increase in the observed risk over the period 2014-2023. The rate of this increase has been rapidly accelerating since 2021 reaching a peak of 1.5 cases per 1000 OPD registrants in 2023.

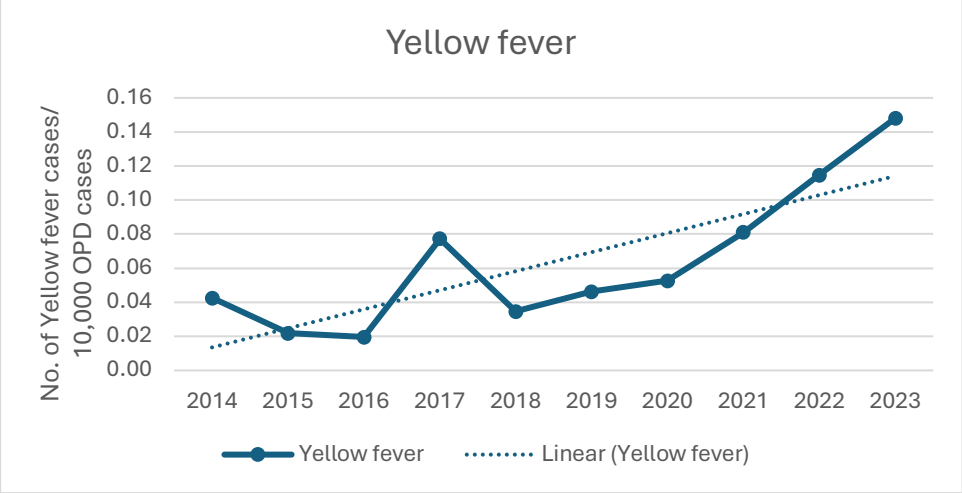

Figure 24: Incident cases of Yellow fever per 1000 population, 2014-2023

Schistosomiasis

An analysis of incident cases of OPD Schistosomiasis cases at the national l showed a significant reduction from 0.3 in 2014 to 0.1 per 1000 OPD registrants in 2017 and has since stayed constant at 0.1 till 2023 (figure 25). Incidence among males consistently remained higher than females throughout the years.

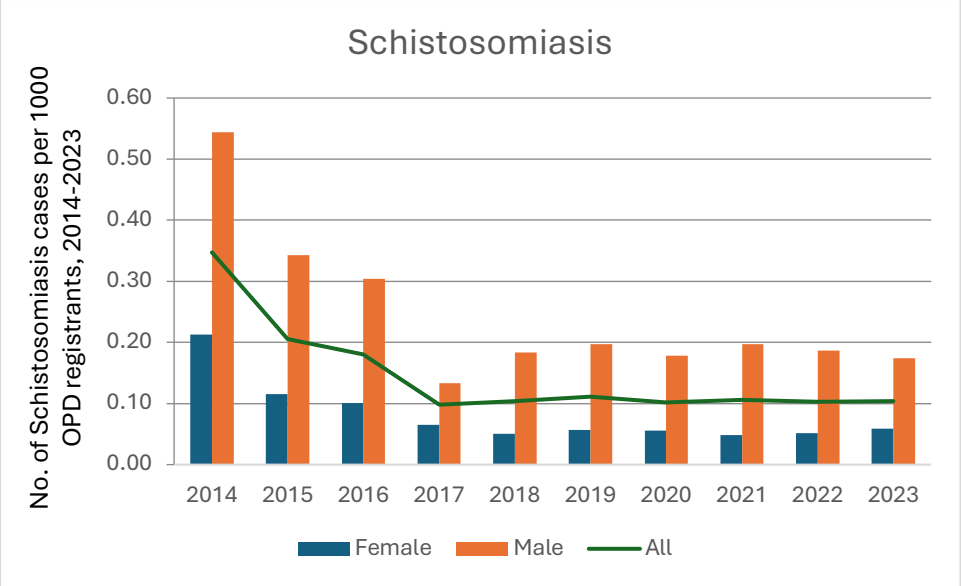

Figure 25: Incident cases of Schistosomiasis per 1000 OPD registrants disaggregated by gender, 2014-2023

Dengue fever

Dengue is an important vector-borne viral disease impacted by climate change; studies have shown an association between spatiotemporal patterns of dengue and climate.[72,73] Despite the complexities in the linkages between climate and dengue, it has been established that both rainfall and drought conditions affect dengue fever. It has been observed that high rainfall and temperature can lead to increasing disease transmission while drought conditions promote household water storage and consequently increases the number of suitable breeding sites for the vector.[74] The first dengue virus infection was reported in Ghana in 2008. Although cases of dengue have been reported in Ghana over subsequent years, there is the challenge of distinguishing between the symptoms of dengue infection and other infections such as malaria, measles, gastroenteritis, viral hepatitis and other bacterial infection.[75] This similarity has contributed immensely to the over-diagnosis of malaria and the under-recognition of dengue.[76] A study conducted between 2022 and 2023 among 218 febrile ill children clinically diagnosed with malaria from Accra, Navrongo and Kintampo showed a DENV IgG seroprevalence of 21.6% collectively (Delmini et al.2015). Other Studies have shown 87.2% of dengue prevalence among 236 HIV infected individuals[77], and 3.6% dengue IgG seroprevalence among 360 yellow fever (YF) suspect individuals across all regions in Ghana[78]. Pappoe et al., (2018) have also found low to moderate levels of dengue virus infection in Ghana with infections occurring in all age groups and all regions in Ghana. However, the Upper East and the Volta regions had a significantly higher seroprevalence than the overall seroprevalence in Ghana. Despite the existing evidence of dengue

[72] Hales, Simon, et al. "El Niño and the dynamics of vector borne disease transmission." *Environmental Health Perspectives* 107.2 (1999): 99-102.
[73] Corwin, A.L., et.al., Epidemic dengue transmission in southern Sumatra, Indonesia. Trans R Soc Trop Med Hyg. 2001 May-Jun;95(3):257-65. doi: 10.1016/s0035-9203(01)90229-9. PMID: 11490992.
[74] Pontes, R. J., et al. "Vector densities that potentiate dengue outbreaks in a Brazilian city." *The American journal of tropical medicine and hygiene* 62.3 (2000): 378-383.
[75] Stoler, J. et al., (2015). Evidence of recent dengue exposure among malaria parasite-positive children in three urban centres in Ghana. The American journal of tropical medicine and hygiene, 92(3), 497.
[76] Delimini, R. K. (2014). Investigation of dengue exposure and infection in Ghanaian children with malaria (Doctoral dissertation, University of Ghana).
[77] Sherman KE, Rouster SD, Kong LX, Shata TM, Archampong T, Kwara A, et al. Zika Virus Exposure in an HIV-Infected Cohort in Ghana. JAIDS J Acquir Immune Defic Syndr. 2018 Aug 15;78(5): e35–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/29771784 9.
[78] Ofosu-Appiah L, Kutame R, Ayensu B, Bonney J, Boateng G, Adade R, et al. Detection of Dengue Virus in Samples from Suspected Yellow Fever Cases in Ghana. Microbiol Res J Int. 2018 May 22;24(1):1–10. Available from: http://www.sciencedomain.org/abstract/24730

prevalence in Ghana, its linkage with climatic conditions is yet to be explored due to a paucity of reliable data on its diagnosis.

3.1.2.2. Zoonotic diseases

Anthrax, Highly Pathogenic Avian Influenza (HPAI), Trypanosomiasis, Rabies and Viral Haemorrhagic Fevers (VHF) are examples of zoonotic diseases in Ghana that may emerge in vulnerable populations due to climate change, flooding, reduced immunity, famine, or illness[79].

Anthrax

Anthrax is a serious disease usually caused by a spore-forming bacterium, Bacillus anthracis. It is found naturally in the soil around the world and commonly affects livestock. Humans can become infected by eating the meat or handling the wool, hides, bones or carcasses of affected animals or by inhaling spores. Although some cases of the disease respond to antibiotics, advanced inhalation anthrax may not. By the later stages of the disease, the bacteria have often produced more toxins than drugs can eliminate.

Heavy rains and floods following a long dry spell combined with high temperature results in transportation of a deposition of the spores in low- lying areas as well as speeding up bacterium life cycle. Apart from this during long dry spells livestock tend to pick early stages of growth of pasture that is so close to the ground increasing the probability of picking spores from the soil. In its spore form, anthrax is hard to kill. Spores are naturally present in soil, where they can survive for many years.

Rabies

It is a viral disease that causes encephalitis in humans and other mammals. The Rabies virus is transmitted through direct contact (such as through broken skin or mucous membranes in your eyes, nose, or mouth) with saliva or brain/nervous system tissue from an infected animal. The disease is fatal but preventable. It can spread to people and pets if they are bitten or scratched by a rabid animal.

In the journal Echography[80], it is established that climate change is correlated with the range of vampire bats habitats and increase the risk of rabies spill over events since the bats act as reservoirs. Climate change that affects environmental factors such as land use, water bodies, forests and land slopes are the defining factors for migrating rabid animals to move from one place to the other.

Highly Pathogenic Avian Influenza (HPAI)

It is a disease that is highly contagious and often deadly in poultry, caused by highly pathogenic influenza A (H5) and A (H7) viruses. It is also known as bird or avian flu. HPAI viruses can be transmitted by wild birds to domestic poultry and other bird and animal species. The only subtypes that are reported to cause disease in humans are H5, H7 and H9. The most well-known highly pathogenic avian subtype is H5N1, although the newly reported subtype H7N9 has recently attracted attention.

Alarmingly, evidence indicates that climate change seems to be impacting the emergence of zoonotic viruses like H5N1. As global climate conditions change, avian migratory patterns and routes are also changing.[81]

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[79] Gonzalez JP, Macgregor-Skinner G. Dangerous Viral Pathogens of Animal Origin: Risk and Biosecurity: Zoonotic Select Agents. Zoonoses - Infections Affecting Humans and Animals. 2014 Aug 22:1015–62. doi: 10.1007/978-94-017-9457-2_41. PMCID: PMC7121609.

[80] Paige Van de Vuurst, Huijie Qiao, Diego Soler-Tovar, Luis E. Escobar, Climate change linked to vampire bat expansion and rabies virus spillover, Volume2024, Issue10, Disease Ecology Special Issue, October 2024

[81] Pan American Health Organization, Health Emergencies: Disaster Newsletter N.132.- The impact of climate change on emerging viral diseases

Trypanosomiasis

Animal trypanosomiasis, also known as nagana and nagana pest, or sleeping sickness is a disease of vertebrates. It is caused by trypanosomes of several species in the genus Trypanosoma such as T. brucei. T. vivax causes nagana mainly in West Africa, although it has spread to South America.

It is a parasitic infection that spreads through the bites of tsetse flies mainly in equatorial Africa. Early symptoms include swollen bumps around the bite, fever and muscle pain. Advanced symptoms cause confusion and trouble walking and make it difficult to stay awake. Treatment in humans depends on the type and stage of the infection.

Rise in temperatures associated with climate change is expected to transform the dynamics of vector-borne diseases including African Trypanosomiasis. A mathematical model developed by Dr. Lord and co-authors[82] suggests that temperature increases over the last decades have already caused major declines in local populations of tsetse flies. High temperatures can affect the natural metabolic activities in the flies, leading to high death rates in them which could lead to extinction of tsetse populations.

3.1.2.3. Meningitis

Figure 26 provides information on the reported incidence of meningitis cases within the 2014 - 2023 period. There is an overall slow but gradual increase in trend of meningitis risk over the period, with peak incidence of 0.34 cases per 1000 OPD registrants was reported in 2016. It is however worth noting that DHIMS2 reporting on meningitis does not distinguish between sporadic and epidemic cases, where the latter are mostly being driven by climatic changes. Factors such as population immunity, overcrowding, vaccine coverage, and the emergence of new strains are also significant confounders that are often not included in national datasets.

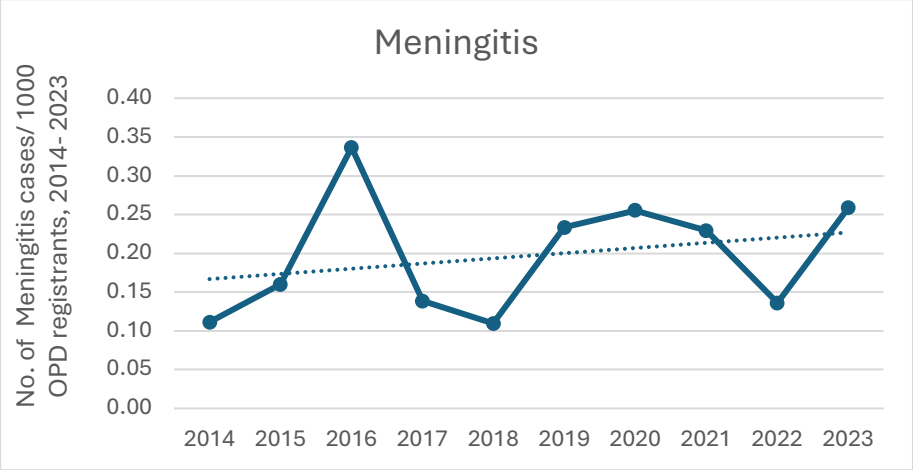

Figure 26: Incident cases of Meningitis per 1000 OPD registrants, 2014-2023

3.1.2.4. Food insecurity and malnutrition

Food insecurity

Ghana faces food insecurity because of low annual yield, attributable to adverse weather conditions. Global food security, according to the United Nations, demands that people have physical and economic access to sufficient, safe, and nutritious food that satisfies their food choices and dietary

[82] Science News. Science Daily newsletter, Climate change and African trypanosomiasis vector populations in Zimbabwe's Zambezi Valley, October 23, 2018. Available at: https://www.sciencedaily.com/releases/2018/10/181023110523.htm

needs to live an active and healthy life. A review of general agricultural trends and challenges in Ghana[83] highlights that there are pockets of food insecurity in all regions of the country due to scarcity of resources and inadequate alternatives for most people to achieve their nutritional demands.

A 2024 World Bank report[84] indicated that about 2 million Ghanaians are vulnerable to food insecurity and that should any natural disaster occur; food availability will be greatly affected. The Northern regions will be the most hit at about 25%, while the remaining 75% will be distributed across the other regions. The World Food Programme, in a Comprehensive Food Security and Vulnerability Analysis (CFSVA) in Ghana in 2020 observed that about 3.6 million people, which represents about 11.7% of Ghana's population, are food insecure. Furthermore, 1.6 million out of the 3.6 million are severely food insecure and the remaining 2 million people are moderately food insecure. 2.8 million of the 3.6 million people who are food insecure, live in the rural areas and 0.8 million people who are food insecure live in the urban areas. In another report issued by the Ministry of Food and Agriculture, Ghana, indicated that approximately 1.2 million people are food insecure which represents about 5% of the country's population.[85]

Malnutrition

Since the data on malnutrition as captured from CWC attendance or OPD attendance in Ghana is grossly unreliable and grossly underestimates the burden of malnutrition, we will resort to the Cadre Harmonise[86] survey of the WFP data on food security and a brief from the USAID to provide an overview of trends in food insecurity and by extension malnutrition.

According to a USAID Brief in February 2023, the food security situation in Ghana continues to witness progressive deterioration. There is sustained increase in the number of people that are food insecure since 2021. People in the emergency phase of the Integrated Food Security Phase Classification and the Cadre Harmonisé (IPC/CH[87] phase 4) increased 11,000 in 2021 to 92,000 in 2024 and inflationary challenges (high inputs and food costs), coupled with hazards (such as floods), remain major impediments to food security.

[83] Darfour, B., & Rosentrater, K. A. (2020). Cost assessment of five different maize grain handling techniques to reduce postharvest losses from insect contamination. Insects, 11(1), 50.

[84] World Bank Group (2024). Press release: New World Bank Report Calls for Strengthening Resilience of Ghana's Health System in Response to Climate Change. Available at: https://www.worldbank.org/en/news/press-release/2024/04/30/new-world-bank-report-calls-for-strengthening-resilience-of-ghana-health-system-in-response-to-climate-change

[85] World Food Program (2020), Comprehensive Food Security and Vulnerability Analysis (CFSVA) GHANA, Available at: ComprehensiveFood Securityand VulnerabilityAnalysis (CFSVA)GHANA

[86] The Cadre Harmonisé (CH) is a harmonized, regional framework used to analyse acute food and nutrition insecurity in the Sahel and West Africa.

[87] IPC/CH Phases 3 and 4 represent serious levels of acute food insecurity, with Phase 3 (Crisis) indicating a critical situation and Phase 4 (Emergency) signifying an extremely severe situation requiring urgent action to save lives and livelihoods.

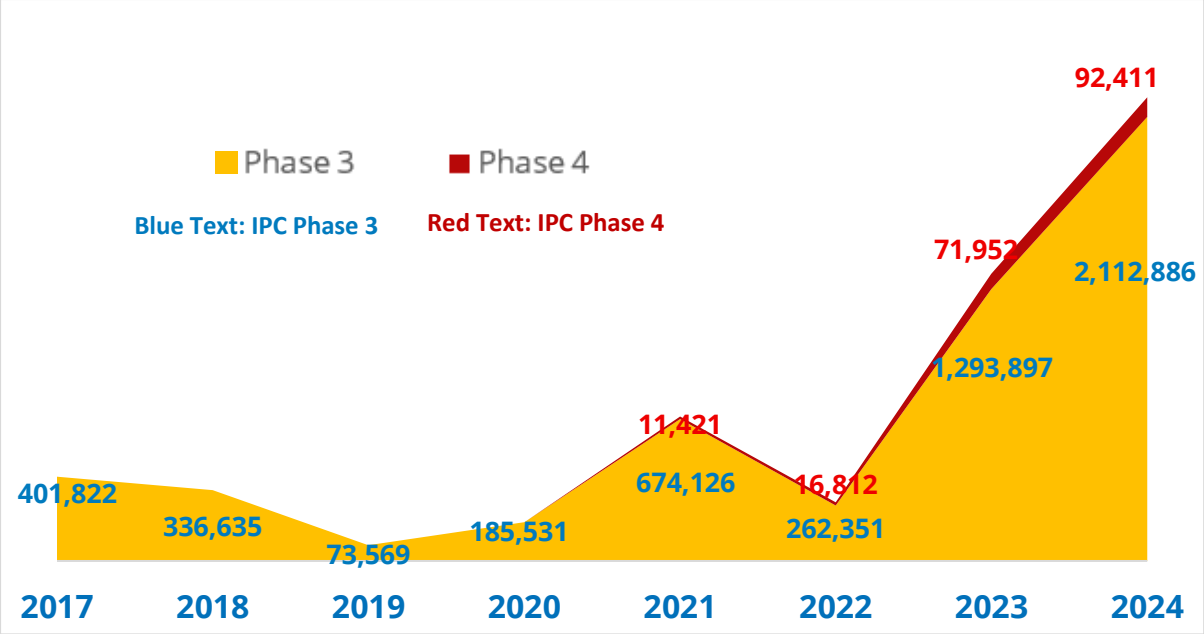

Figure 27: Latest trends in the Cadre Harmonise in Ghana, 2017-2024

Based on the latest findings from the Cadre Harmonise, 719,000 people are projected to be food insecure (IPC/CH Phase 3 &4) during the 2023 lean season of June to August. Compared to historic trends, this marks an increase of 158 percent compared to 2022 projections and 5 percent, compared to post COVID-19 projections of 2021. Over 27,000 food insecure people are projected to experience emergency levels of food insecurity (IPC/CH Phase 4), characterized by severe food deficit and high use of negative coping measures. This marks an increase of 63 percent compared to 2022 and 139 percent compared to 2021.

According to the same report, Inflation remains a key driver of food insecurity, which continues to weaken purchasing power of Ghanaians and restrict economic access to food and non-food items, including fertilizers:

- The Government of Ghana through the National Development Planning Commission (NDPC) and the World Food Programme (WFP) commissioned two tailored analysis - Fill the Nutrition Gap (FNG)/Minimum Expenditure Basket (MEB) - to assess economic access of Ghanaians to their essential needs (food and non-food, including agricultural inputs) and nutritious food.
- Findings from the MEB analysis showed that over half (52 percent) of households in Ghana are unable to meet their essential needs (food and non-food), and 16 percent of these vulnerable households are unable to meet their food needs, based on their economic capacity. The situation for farming households was particularly worrisome with 64 percent of households found to lack capacity to meet their essential needs, and one in every five (24 percent) not able to meet their food needs. These rates recorded for farmers were the highest, compared to other categories of occupation assessed. At the regional level, at least 40.0% of households in each region lack economic capacity to meet their essential needs, with higher prevalence rates recorded in regions in northern areas of Ghana.
- Moreover, findings from the FNG analysis further showed that 44.0 % of households in Ghana are unable to afford a nutritious diet, with rates as high as 80 percent in regions like Savannah (81 percent) – which equates to four in every five household not being able to afford a nutritious diet.

Poverty rates in Ghana continue to witness a progressive increase based on historic trend:

- 46.7 percent of all Ghanaians - 14.4 million people - are multidimensionally poor in the second quarter of 2022, which marked a slight increase of over one percentage point, compared to data published by the Ghana Statistic Services (GSS) in the first quarter of 2022 (44.1 percent)[88]. This suggests that more households in Ghana have slipped below the poverty line, when compared to World Bank published pre-covid poverty rates of 25.5 percent. Moreover, all five regions in the north, which were the epicentre for food insecurity, have multidimensional poverty rates exceeding 50 percent.

Sustained Inflation, concerning rates of poverty and limited economic capacity, coupled with fiscal challenges, would potentially continue to weaken purchasing power of households, reduce economic access to essential needs (including productive agricultural inputs) and threaten livelihoods and food security in Ghana.

3.1.2.5. Respiratory Illnesses and allergic diseases

Asthma

As shown in figure 28, the incidence of OPD cases attributable to Asthma gradually reduced from 3.7 in 2014 to 2.8 per 1000 OPD cases in 2017 and has since remained stable. The incidence among females slightly decreased from 3.7 in 2014 to 2.9 per 1000 OPD cases in 2016 and has also plateaued since 2018. Among the males, incidence remained consistently higher than females across the years except in 2017 when more cases were seen among females.

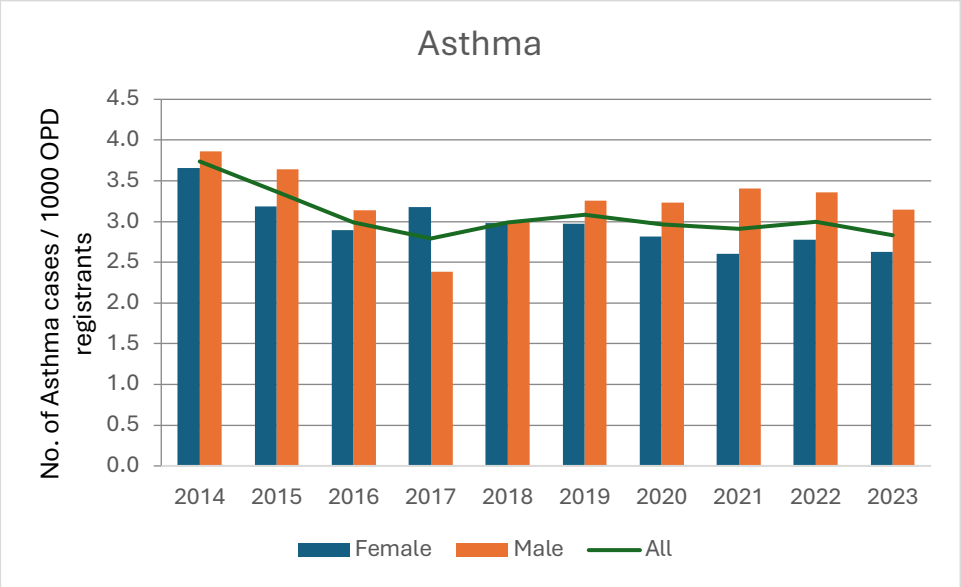

Figure 28: Incident cases of Asthma per 1000 OPD registrants, disaggregated by gender, 2014-2023

Upper respiratory tract infections

Upper respiratory tract infection (URTI) is one of the most common acute illnesses that is managed in the outpatient department (OPD). There has been a cyclical pattern of OPD cases attributable to URTI with peaks in 2015 and 2018, then sharply declined from 139 to 102.3 per 1000 OPD cases in

[88] AHIES executive summary 1 (3_24PM).pdf (statsghana.gov.gh)

2020 and has remained stable from 2021 to 2023 (Figure 29). URTI incidence was higher among males throughout the years except for 2017.

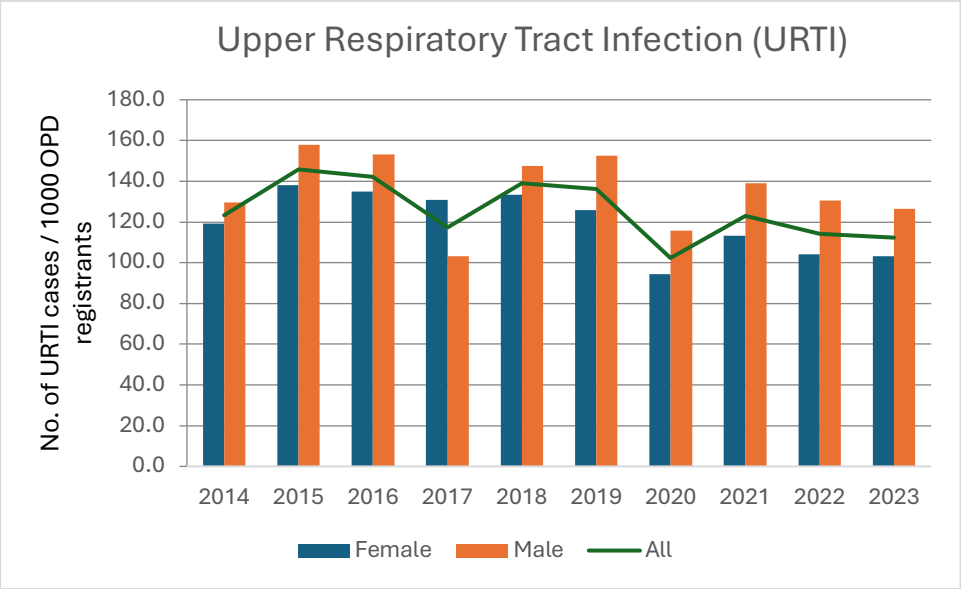

Figure 29: Incident cases of URTIs per 1000 OPD registrants, disaggregated by gender, 2014-2023

Pneumonia

With regards to OPD cases attributable to Pneumonia, as shown in figure 30, there was a rise from 8.0 cases per 1000 OPD registrants under 5 years in 2017 to 22.0 cases per 1000 OPD registrants under 5 years in 2019, followed by a dip in 2020 and has since been increasing sharply till 2023. Incidence among both females and males similarly have been rising steadily. However, there was a higher incidence of pneumonia cases among males, except in 2017 throughout the period.

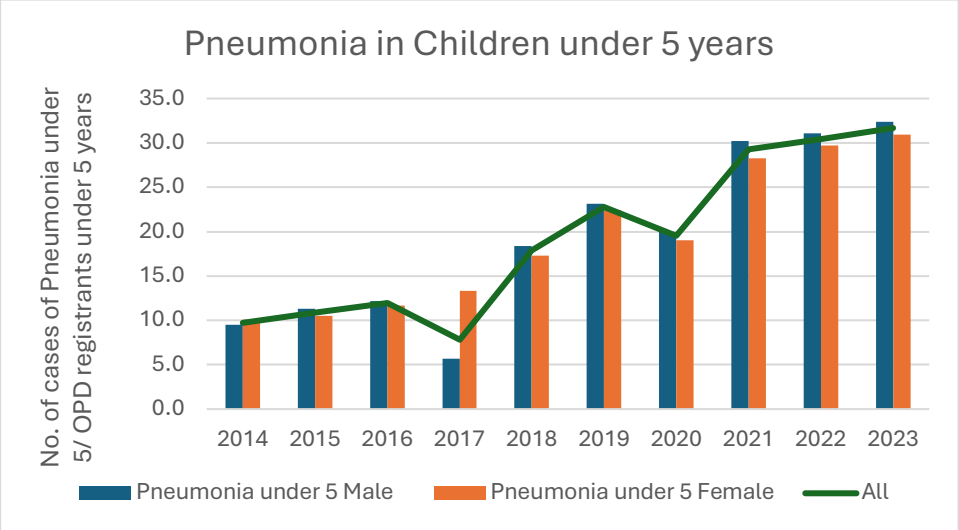

Figure 30: Incident cases of URTIs per 1000 OPD registrants, disaggregated by gender, 2014-2023

3.1.2.6. Cardiovascular diseases

Stroke

With regards to stroke, the incident cases have been increasing over time. Incident cases doubled from 0.4 per 1000 OPD cases in 2017 to 0.8 per 1000 OPD cases in 2019 and continued to rise till 2023. The trend for both males and females also shows a steady increase across the years (Figure 31). There has been an upward trend among the males with significant increases from 2018 to 2023.

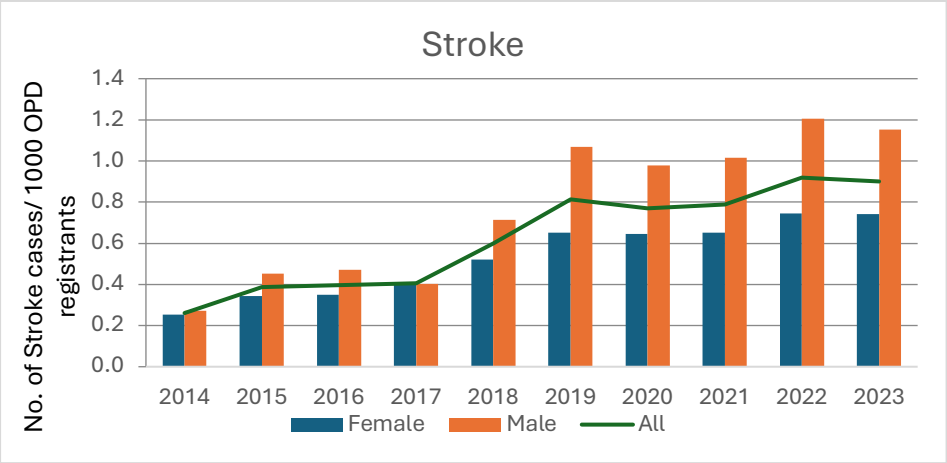

Figure 31: Incident cases of Stroke per 1000 OPD registrants, disaggregated by gender, 2014-2023

Cardiac diseases

The overall trend for the risk of cardiac diseases (Figure 32) remained stable over the period, with a minor increase observed from 2020 onward. The risk of cardiac diseases among males and females were nearly equal throughout the years.

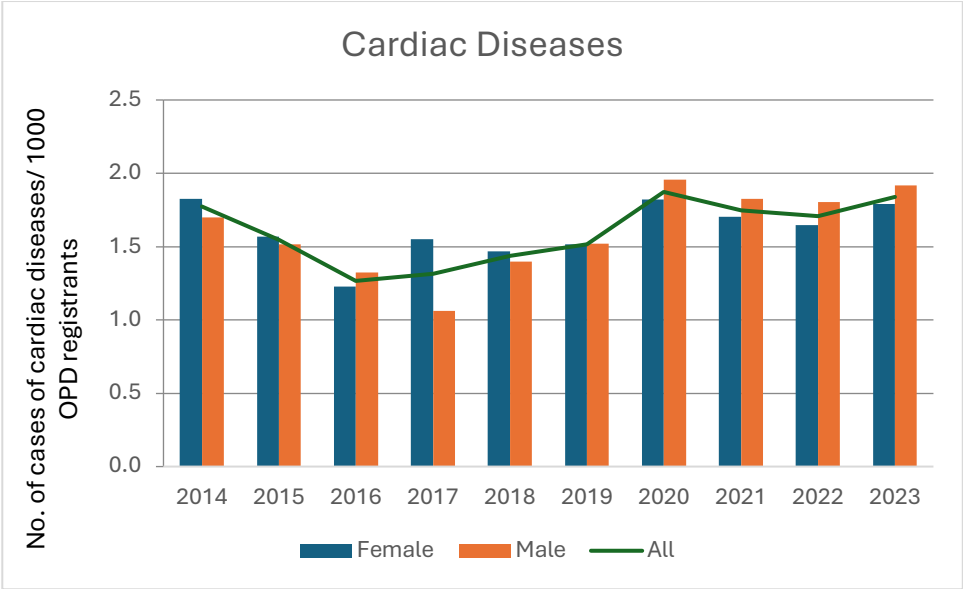

Figure 32 : Incident cases of Cardiac diseases per 1000 OPD registrants, disaggregated by gender, 2014-2023

3.1.2.7. Road traffic accidents

The trend in incident cases of Road Traffic Accident (RTA) shows a significant peak in 2020 followed by a slight decrease up to 2023 (Figure 33). Across all the years, the risk of RTAs among the males have been constantly higher than among females while the risk among females remained stable with minor fluctuations.

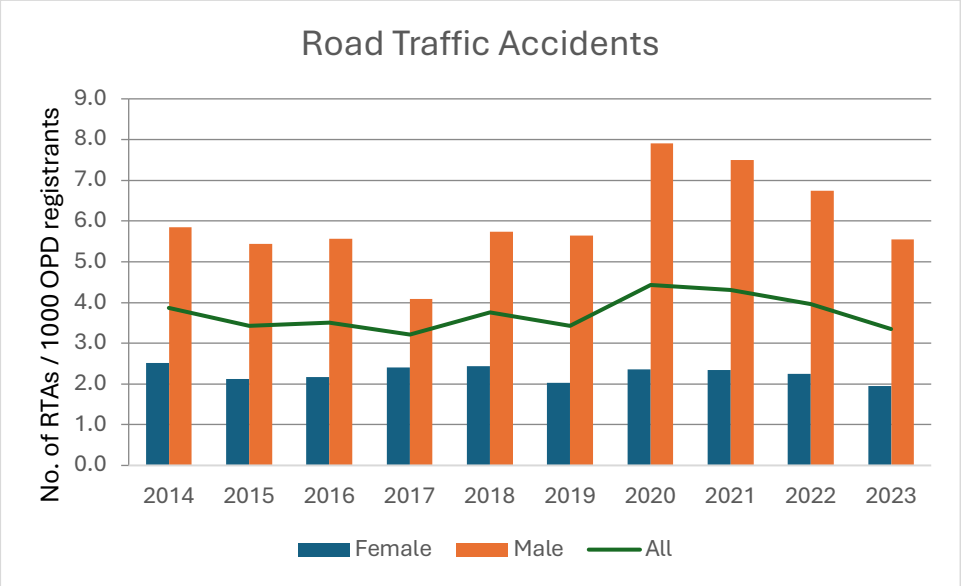

Figure 33: Incident cases of RTAs per 1000 OPD registrants, disaggregated by gender, 2014-2023

3.1.2.8. Food and water borne diseases

In this section, cases of acute watery diarrhoea in children <5years and all cases of cholera served as proxy indicators for food and water borne diseases. Such diseases usually manifest symptoms of diarrhoea and vomiting.

Diarrhoea in children <5 years

In figure 34 the risk of diarrhoea in children <5 years has remained stable between 80.0 to 100.0 cases per 1000 OPD registrants < 5 years, except for the year 2016 when there was a significant drop in incidence to 60 cases per 1000 children < 5years. There was no significant gender disparity in risk except in 2016 when there was a disproportionately higher risk of diarrhoea among females.

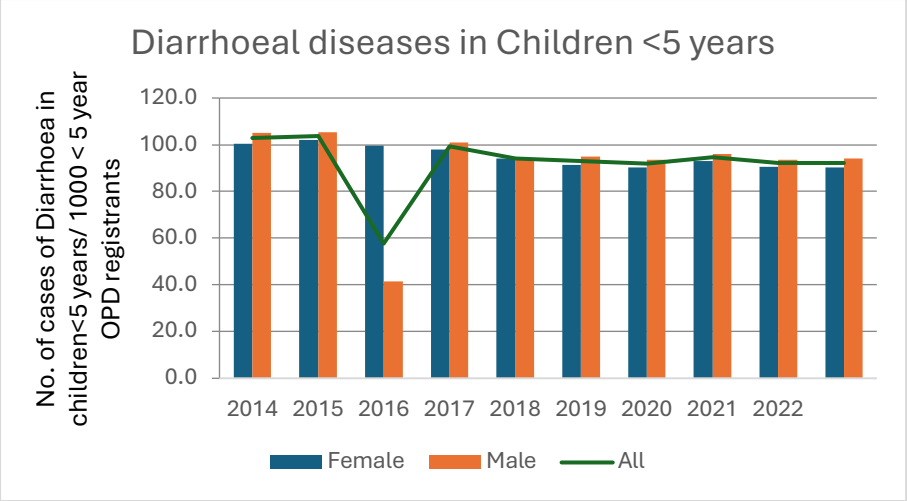

Figure 34 : Incident cases of acute watery diarrhoea per 1000 OPD registrants, 2014-2023

Cholera

Overall, the incidence of Cholera has been very low over the period under study. However, there has been a major drop in the incidence of Cholera cases from a peak of 0.3 cases per 1000 OPD registrants in 2014, to almost 0 cases per 1000 OPD registrants in 2023.

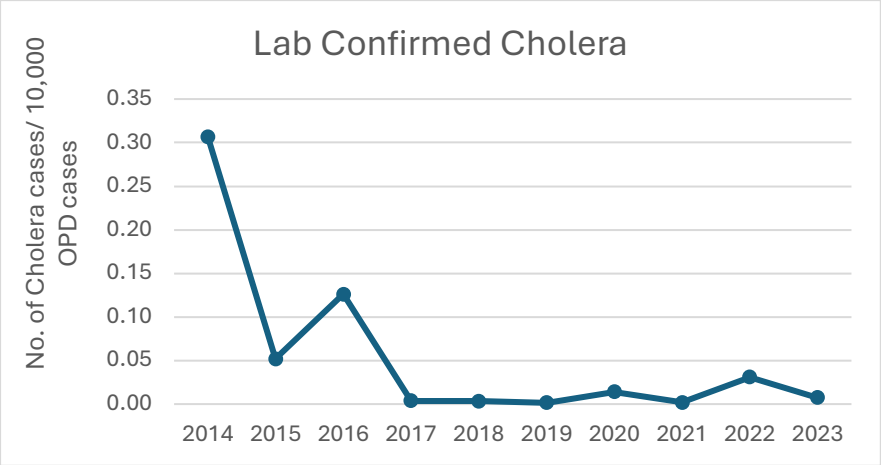

Figure 35: Incident cases of Cholera per 1000 OPD registrants, 2014-2023

3.1.2.9. Mental health

Depression and anxiety disorders were chosen as proxy indicators for mental health and psychological disorders in this study due to availability of the data in DHIMS.

Depression

The risk of depression mostly remained below 0.25 cases per 1000 OPD registrants throughout the period except in 2016 and 2017. A peak incidence of 0.38 cases per 1000 OPD registrants was recorded in 2017 (Figure 37). The risk of depression among females was consistently higher throughout the period under study with peak of 0.5 female cases per 1000 registrants in 2017.

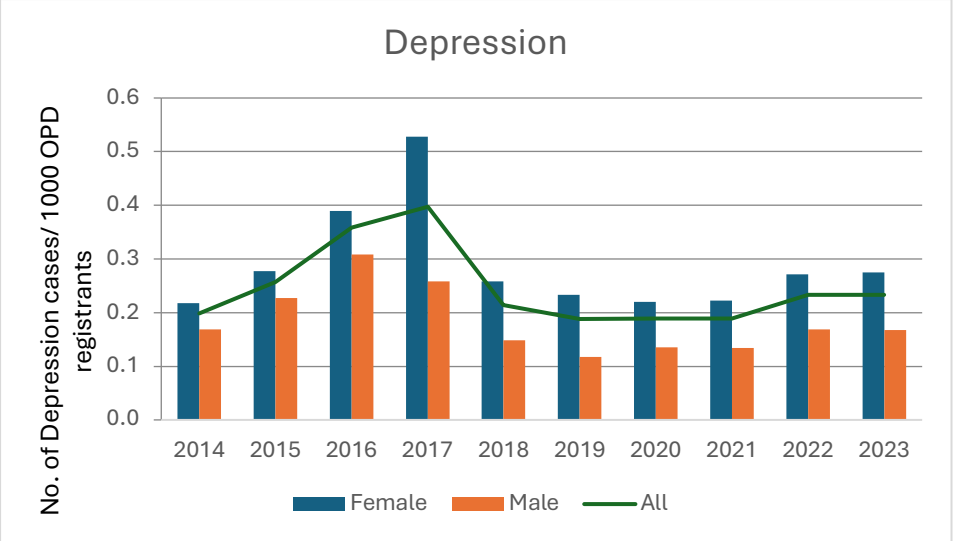

Figure 36: Incident cases of Depression per 1000 OPD registrants, disaggregated by gender, 2014-2023

Generalized anxiety

The risk of generalized anxiety increased from 0.2 cases per1000 OPD registrants in 2014 to attain peak incidence of 0.39 cases per1000 OPD registrants in 2016. Subsequently, the incidence of generalized anxiety disorder sharply declined and stabilized below 0.17 cases per 1000 OPD registrants over the period 2018 to 2023 (Figure 37). There was also significantly higher incidence among females from 2014 to 2019, after which the incidence was almost equal.

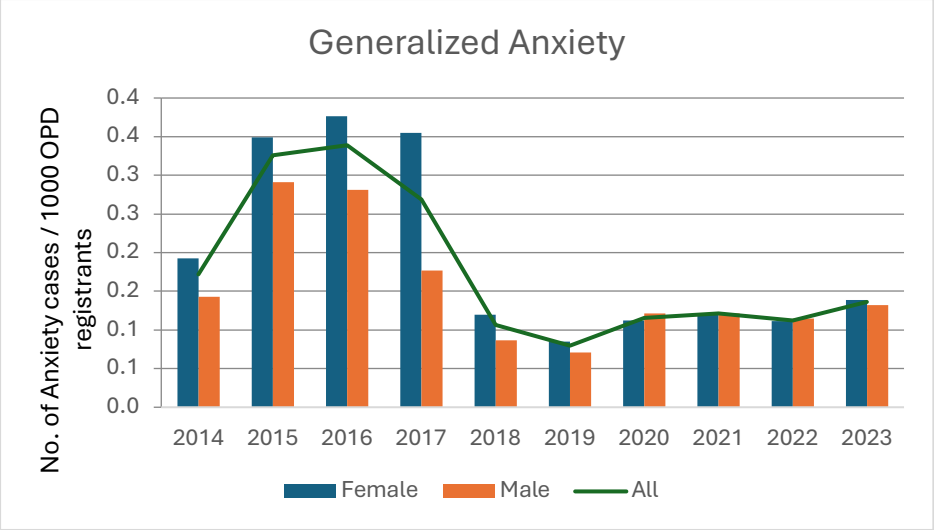

Figure 37: Incident cases of generalized anxiety per 1000 OPD registrants, disaggregated by gender, 2014-2023

3.1.2.10. Injuries and accidents from extreme weather events

Injuries and fatalities occur from the direct impact of extreme climate events including floods, droughts, and heat stress. Climate change is expected to increase mean annual temperature, and the intensity and frequency of heat waves are putting a greater number of people at risk of heat-related conditions. Several studies in Ghana have found both direct and indirect impact of climate variability and change on the health of the population89. There is exposure to temperature extremes, and a higher frequency and/or intensity of climatic hazards in recent times. Recent floods experienced in the country have been associated with fatalities, leaving many injured and others with long term psychological trauma. Accra experienced one of the worst flood events in June 2015 which resulted in the loss of over 150 lives with many others exposed to injuries[90, 91]. Victims of flood events and their immediate families suffer from long term mental health conditions[92].

3.1.2.11. Snake bites

Figure 385 shows that the incidence of snake bites was relatively stable over the period under study. However, the incidence among males were observed to be consistently and significantly higher throughout the period under study. The level of risk among females remained stable around 0.3 cases per 1000 OPD registrants throughout the years, whiles among the males the risk ranged between 0.3-0.7 cases per 1000 OPD registrants. The maximum peaks for males were recorded in 2019 and 2020.

[89] Adams, E. A., & Nyantakyi-Frimpong, H. (2021). Stressed, anxious, and sick from the floods: A photovoice study of climate extremes, differentiated vulnerabilities, and health in Old Fadama, Accra, Ghana. Health & Place, 67, 102500

[90] Asumadu-Sarkodie S, Owusu Phebe A, Rufangura P (2015) Impact analysis of flood in Accra, Ghana. Adv Appl Sci Res 6:53–78.

[91] Amoako C, Inkoom DKB (2018) The production of flood vulnerability in Accra, Ghana: re-thinking flooding and informal urbanisation. Urban Stud 55:2903–2922. https://doi.org/10.1177/0042098016686526

[92] Dziwornu E, Kugbey N (2015) Mental health problems and coping among flood victims in Ghana: a comparative study of victims and non-victims. Curr Res Psychol 6:15–21. https://doi.org/10.3844/crpsp.2015.15.21

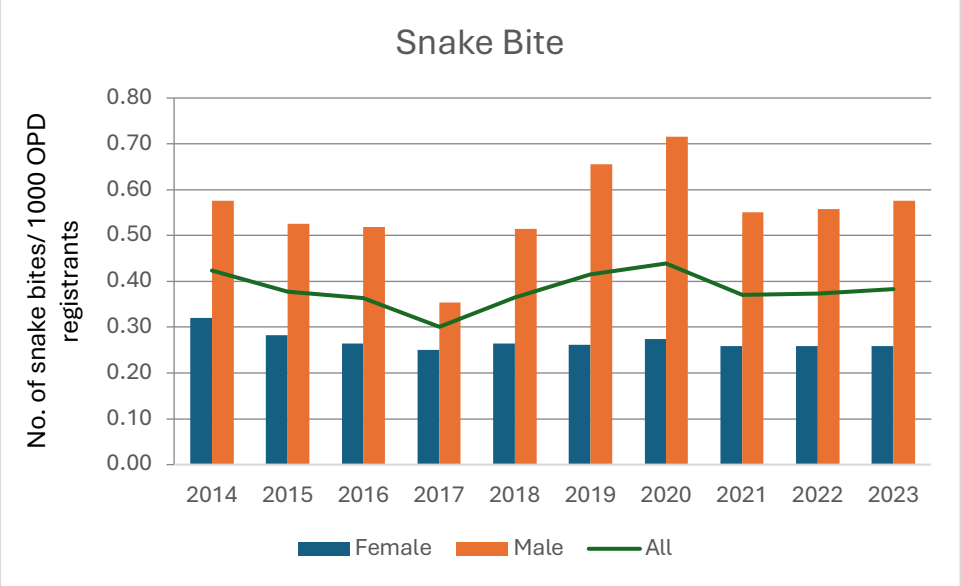

Figure 38: Incident cases of snake bites per 1000 OPD registrants, disaggregated by gender, 2014-2023

3.1.2.12. Water-washed diseases

These are diseases due to the lack of proper sanitation and hygiene.[93] They are infections that result from inadequate water availability for proper hygiene, leading to conditions like scabies, lice, and superficial fungal infections, as well as eye diseases like trachoma. Trachoma is used here as a proxy indicator for this group of diseases.

Trachoma

Figure 39 shows national trend in the risk of all Trachoma diagnosed in all its stages at the OPD over the 2014 to 2023. It shows fluctuations in Trachoma risk with peaks recorded in 2015 (0.12 incident cases per 1000 OPD registrants), 2019 (0.14 incident cases per 1000 OPD registrants), and 2023 (0.12incident cases per 1000 OPD registrants). The risk of Trachoma among males is 2-3 times higher than in females.

[93] World Health Organization, 1988, Environmental Management for Vector Control: Training and informational materials. Slides set series. Available at: https://iris.who.int/bitstream/handle/10665/69487/vectcont_2_eng.pdf?sequence=2&isAllowed=y

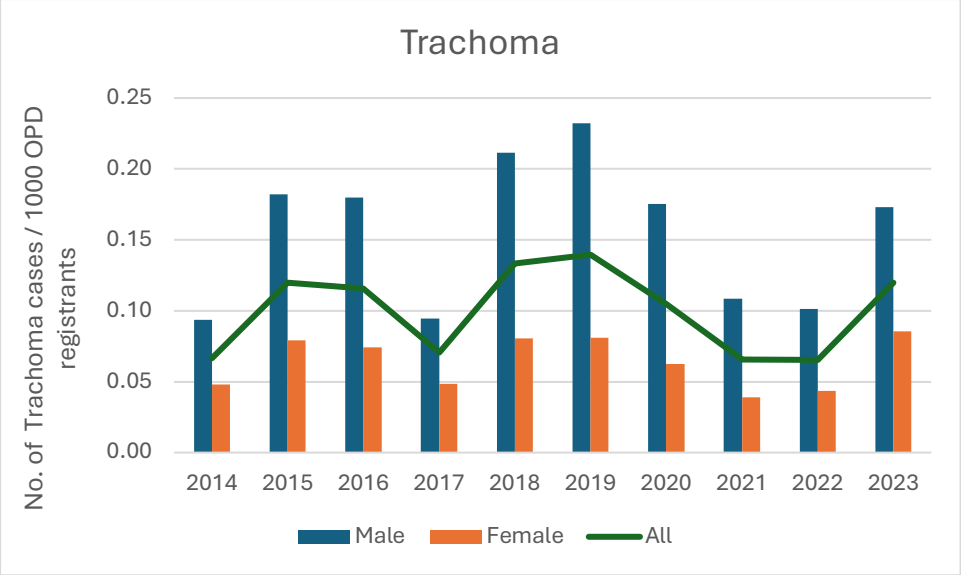

Figure 39: Incident cases of Trachoma per 1000 OPD registrants, disaggregated by gender, 2014-2023

3.1.2.13. Heat related morbidity

Preterm birth and stillbirth were selected as indicators for heat related morbidity due to the evidence from scientific literature as well as availability of data in Ghana.

Low birth weight

Over the period under study, low birth weight (LBW) per 1000 births followed an increasing trend while still birth per 1000 births steadily decreased. This suggests that, rising global temperature may be having an adverse impact on birth weight although it does not seem to have any significant impact on still birth rates. Similar trends were found in the regional analysis.

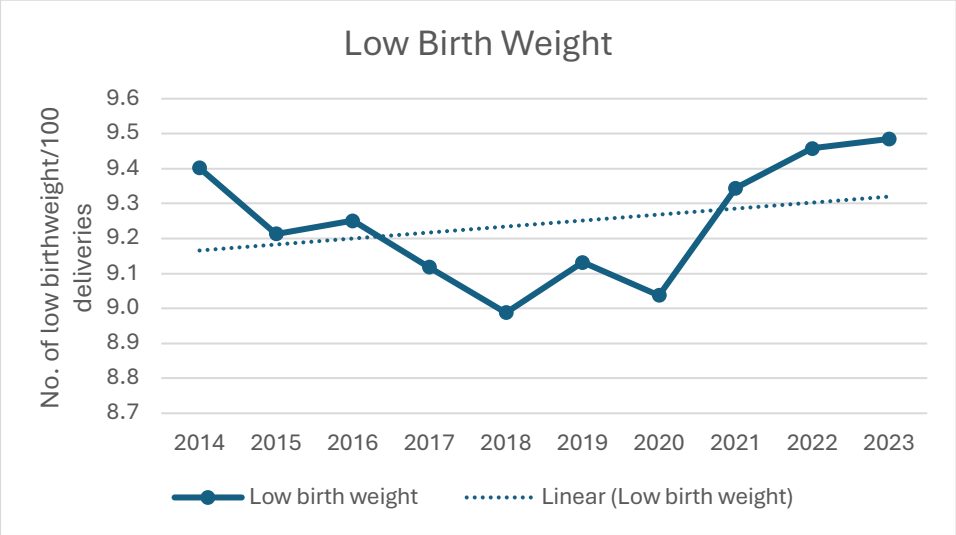

Figure 40: Number of low-birth-weight babies per 100 deliveries, 2014-2023

Still birth rate

Figure 41 shows that the still birth rate has been steadily falling over the period under study.

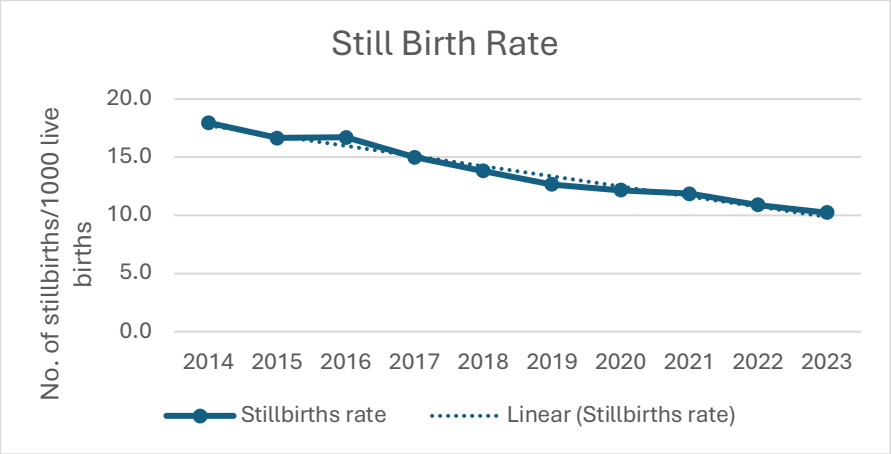

Figure 41: Number of still births per 1000 live births, 2014-2023

3.1.3. Sensitivity analysis of relationships between CSHOs and weather patterns

Understanding the relationships between health outcomes and weather/climate variables is critical for strengthening climate-informed public health planning, including early warning systems, climate–health surveillance, and targeted seasonal interventions.

In this section, an analysis of the relationships between selected health outcomes & weather/climate variables is summarized by the ecological zones of Ghana. For further sensitivity analysis for lag 2 and 3 months, the reader should refer to the full report on *"projecting disease burden of climate sensitive health outcomes in Ghana for vulnerability assessment"* by the MOH (MOH, 2024). Some CSHOs (e.g. Meningitis, Yellow Fever, etc.) were excluded in the analysis due to issues related to data quality, reporting and significant confounding factors.

Guinea savanna zone

Malaria is the most climate-sensitive disease, with strong positive correlations with rainfall, extreme rainfall events, and humidity especially at 1–2-month lags. High temperatures consistently reduced incidence. Pneumonia incidence increases under wet, humid, and cooler conditions. Rainfall and humidity showed moderate positive associations, while lower daytime and night-time temperatures were strong predictors of increased cases. This highlights vulnerabilities during prolonged rainy seasons and sudden temperature drops. URTI (Upper Respiratory Tract Infection) risk rises significantly with rainfall, extreme rainfall events, and humidity, with effects intensifying at longer lags.

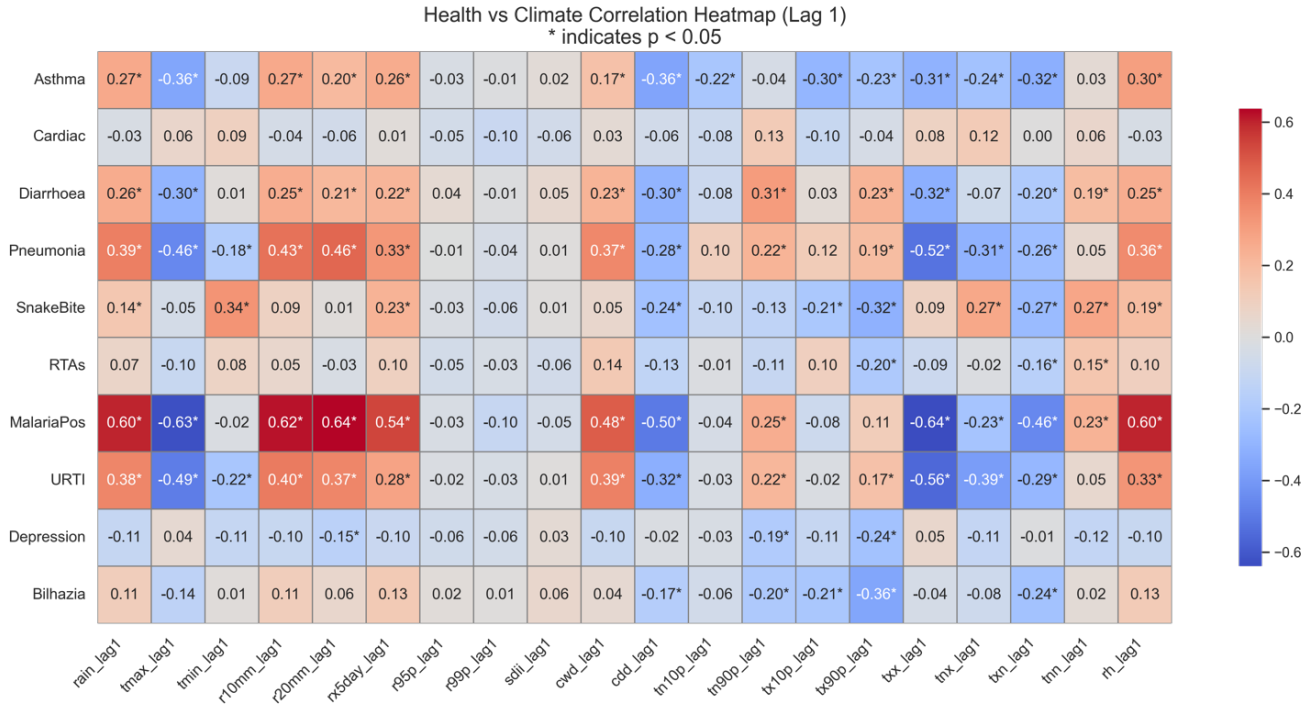

Figure 42:Correlation matrix between climate variables and diseases after lag 1 month – Guinea savanna

Persistent negative correlations with warm temperature extremes indicate that cool, damp conditions heighten respiratory risk. Diarrhoea shows moderate sensitivity to rainfall, humidity, and night-time temperature extremes, with stronger impacts at longer lags (2–3 months). This pattern supports the need for post-rainfall water safety monitoring and improved WASH interventions. Asthma displays delayed sensitivity to rainfall and humidity, with cooler and wetter conditions elevating incidence.

Snakebite risk increases immediately during humid and rainy months but later responds to heat extremes suggesting that both rainfall events and sustained high temperatures increase human snake encounters. Bilharzia shows weak but consistent negative associations with temperature extremes, indicating sensitivity to stable freshwater conditions rather than short-term rainfall variability. Cardiac diseases, RTAs, and Depression showed minimal climate sensitivity, implying stronger influence from behavioural or structural factors.

Transition zone

Recent analysis of climate–health relationships in Ghana's Transition Zone shows that several high-burden diseases are strongly influenced by rainfall, humidity, and temperature extremes.

Malaria remains the most climate-sensitive disease in the Transition zone. Wet and humid conditions particularly heavy rainfall events (r20mm, rx5day), prolonged wet spells, and high humidity consistently increased malaria incidence across all lags, with associations strengthening at 1–2 months. Warmer temperature extremes showed negative correlations, reinforcing the biological influence of rainfall-driven mosquito breeding and parasite development cycles. Pneumonia incidence rises during prolonged and intense rainfall and under humid conditions, with effects most pronounced at lag 2–3. This is consistent with increased pathogen survival, damp living conditions, and heightened respiratory vulnerability.

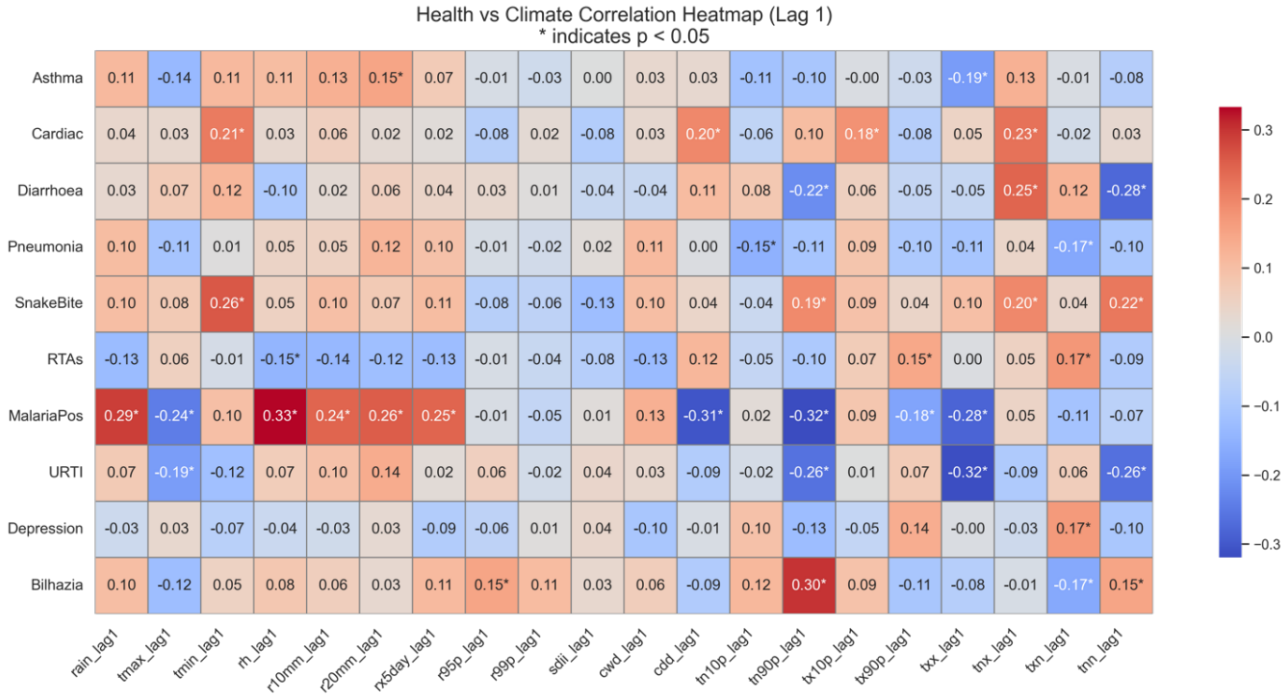

Figure 43:Correlation matrix between climate variables and diseases after lag 1 month – Transition zone

URTIs (Upper Respiratory Tract Infections) showed strong negative associations with extreme cold conditions and dry spells, while humidity exhibited mild positive effects at later lags. Diarrhoeal diseases were associated with warm night-time temperatures and warm day extremes at later lags (1–3), while extreme cold nights reduced incidence. Snakebite incidence increased during cold nights and dry spells conditions that alter snake behaviour and increase human exposure. Bilharzia showed sensitivity to extreme warm nights and very wet days, particularly at lag 0–1. Cardiac diseases displayed moderate sensitivity, increasing during warm nights and prolonged dry spells, aligning with known heat-

stress risks. Depression showed weak and inconsistent climate associations, suggesting stronger social and structural determinants.

Deciduous zone

Emerging evidence from the Deciduous zone shows that several priority diseases particularly malaria, pneumonia, URTI, diarrhoea, and RTAs are strongly influenced by rainfall patterns, humidity, and temperature extremes. Malaria is the most climate-sensitive disease in the zone. Strong and consistent positive associations were observed with rainfall metrics (rain, r10mm, rx5day, cwd), humidity, and minimum temperatures across all lags. Climate–malaria linkages intensified from Lag 0 through Lag 2, peaking around Lag 2–3.

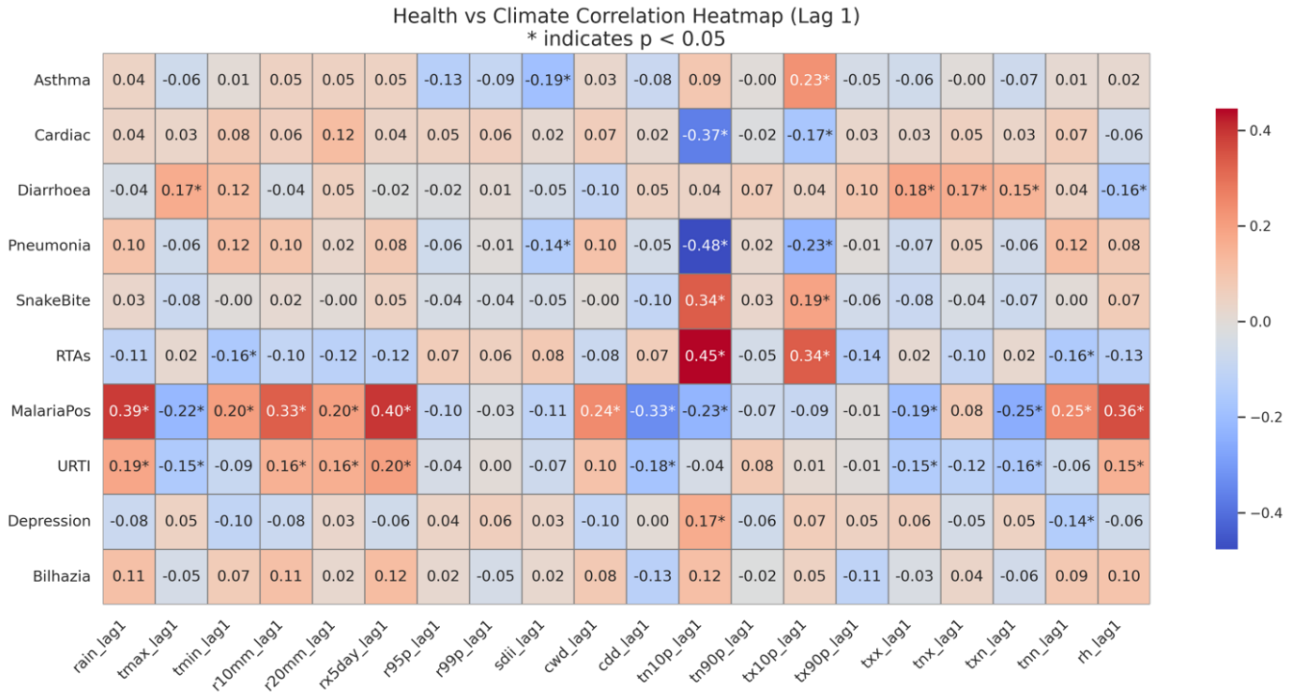

Figure 44: Correlation matrix between climate variables and disease after lag 1 month – Deciduous zone

Negative correlations with high daytime and night-time temperature extremes (tmax, txx, tnx) further reinforce malaria's dependence on wet, humid, and moderately warm conditions. Pneumonia displayed consistent negative correlations with cold temperature indices (tn10p, tx10p) across all lags, while warm night-time temperatures (tmin, tn90p) were weakly positive.

Snakebite incidence increased under colder conditions, showing significant positive correlations with cold day and night extremes (tn10p, tx10p) across multiple lags. Additionally, long dry spells contributed to increased risk. This implies heightened vulnerability in rural communities during cooler months and prolonged dry periods. Road Traffic Accidents (RTAs) demonstrated strong positive correlations with extreme cold day and night temperatures (tn10p, tx10p), suggesting reduced visibility, slippery surfaces, or behavioural changes during cold spells. Temperature, rather than rainfall, appears to be the dominant climatic influence on RTAs in this zone. URTIs were moderately sensitive to rainfall, humidity, and mild night-time temperatures, particularly at Lags 1–2. Increased rainfall likely promotes indoor crowding and damp environments, conditions that facilitate respiratory infections.

Diarrhoea prevalence increased during warm conditions, with consistent positive correlations with warm day and night temperatures (tmax, tmin, txn, txx) across multiple lags.

Wet evergreen zone

Recent climate health analysis in the Wet Evergreen Zone shows that several high-burden diseases including malaria, diarrhoea, URTI, pneumonia, and cardiac conditions are strongly influenced by rainfall, humidity, and temperature extremes.

Malaria is highly climate-sensitive and strongly linked to temperature extremes. Across all lags, malaria incidence correlates positively with warm day and warm night indicators (tx90p, tn90p), minimum temperatures, and nighttime temperature extremes (tnn). These associations intensify from lag 0 to lag 3, confirming malaria's strong responsiveness to warmer, humid conditions.

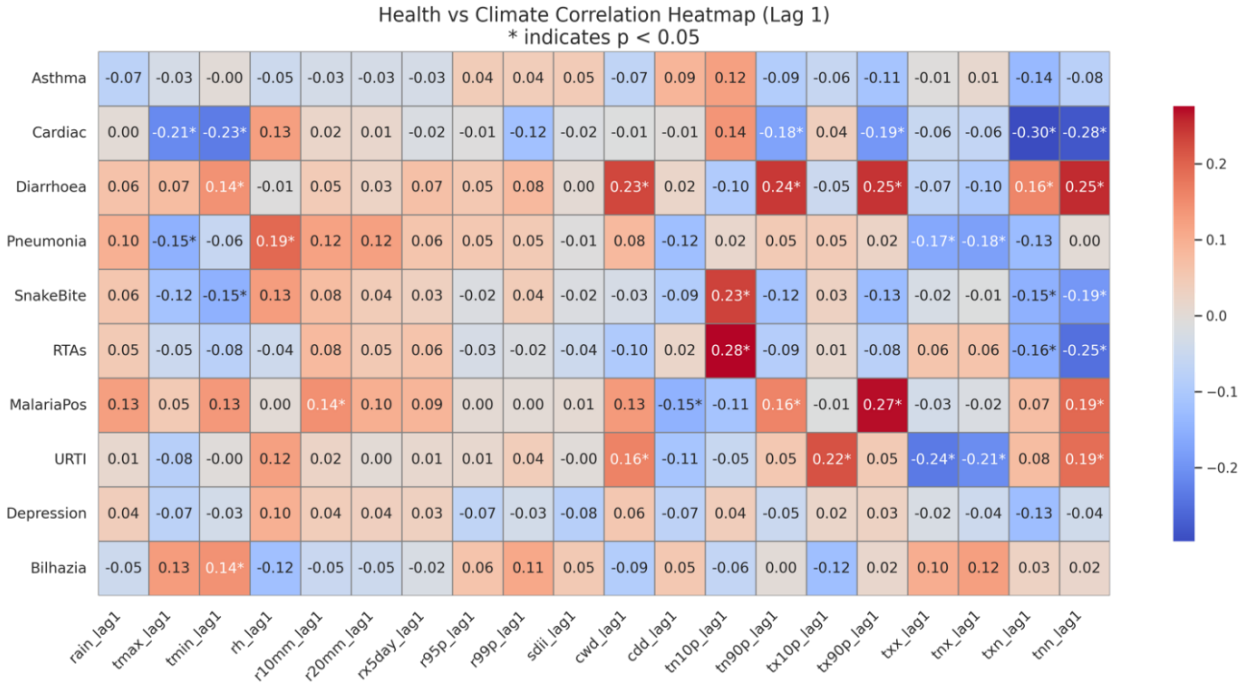

Figure 45: Correlation matrix between climate variables and disease after lag 1 month – Wet evergreen zone

A few rainfall indicators emerge at lag 1, but temperature is the dominant driver in this zone. Warmer nights and prolonged warm spells appear to elevate mosquito survival and human exposure, reinforcing the need for temperature-informed early warning systems. Diarrhoeal diseases are among the most climate-sensitive outcomes, showing strong positive relationships with warm night/day temperatures (tmin, tnn, tnx, tx90p) and consecutive wet days.

These effects intensify across the lag structure, indicating that diarrhoea risk rises under sustained warm and wet conditions, which accelerate microbial contamination of food and water. URTIs show strong sensitivity to temperature extremes and humidity. Both warm and cold temperature indices influence incidence, with URTIs increasing under cold day/night conditions and declining with heat extremes. Humidity and consecutive wet days also contribute modestly. URTI patterns reflect vulnerability to temperature fluctuations, damp environments, and changes in indoor crowding. Pneumonia demonstrates moderate climate sensitivity, increasing during periods of high humidity and cooler conditions, and decreasing during warm and hot periods. Negative correlations with daytime and night-time temperature extremes (tmax, txx, tnx) suggest pneumonia risk rises during humid, cool, and low-temperature episodes, particularly at 1–3-month lags. Cardiac conditions show strong

negative correlations with high temperature extremes, an unusual pattern warranting further epidemiological assessment. However, positive links with cold nights and wet days (tn10p, cwd) at lag 2 align with established cardiovascular stressors. Temperature variability remains a relevant environmental risk for cardiac health. Snakebites are moderately climate-sensitive, with higher incidence under cooler night/day conditions (tn10p), possibly reflecting increased human activity outdoors and snake movement in cooler weather. Asthma and Depression show the weakest climate associations, with only isolated temperature-related signals. Climate appears to play a secondary or indirect role in their burden.

Coastal savanna zone

Recent climate-health analyses in Ghana's Coastal savannah zone reveal strong linkages between weather variability and disease patterns. The zone's alternating wet and dry seasons,

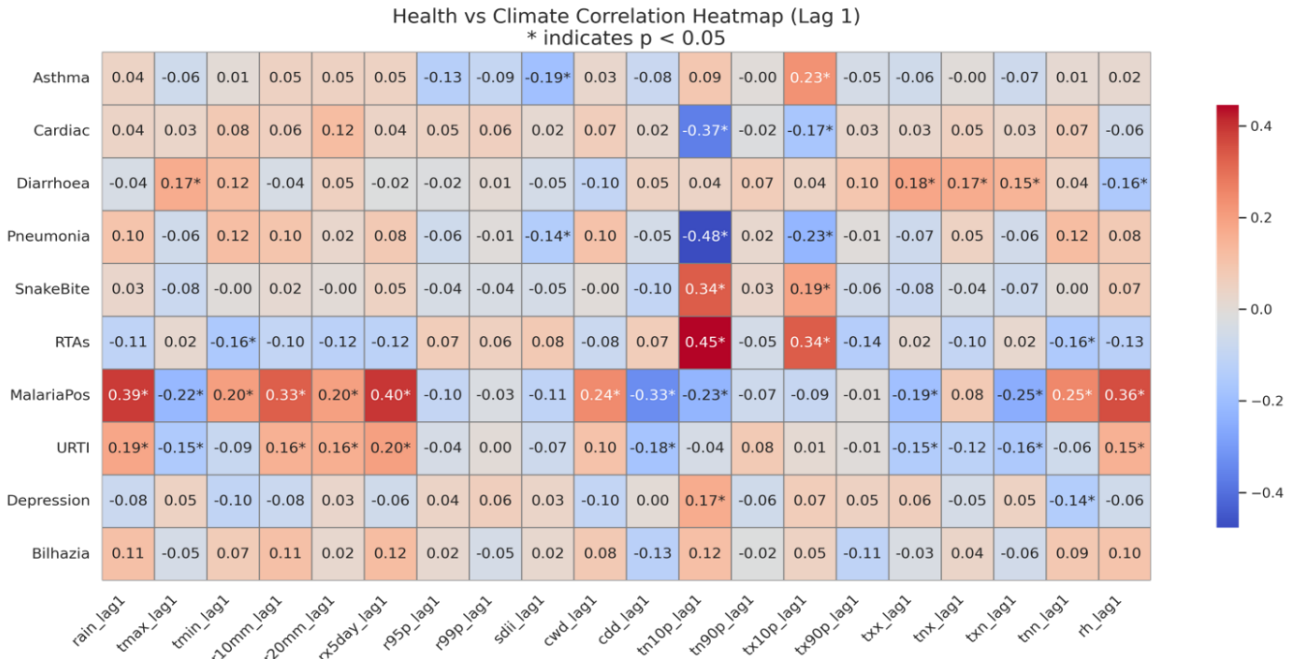

Figure 46: Correlation matrix between climate variables and disease after lag 1 month – Coastal savanna zone

coupled with climate extremes, are contributing to shifts in disease incidence across time. Malaria remains the most climate-sensitive disease in the zone. It shows strong positive correlations with rainfall totals, frequency of heavy rain events, and prolonged wet spells.

These effects are most pronounced about a month after major rainfall events. Respiratory illnesses such as URTI and pneumonia are influenced by both cold nights and hot days. URTI tends to rise in wet and cold conditions, while pneumonia is more likely during periods of extreme heat during the day and night while Asthma likely under extreme cold day and night. These trends point to the need for improved thermal comfort, public health messaging, and ventilation strategies, particularly for children and the elderly. Diarrhoea diseases show sensitivity to wet, cold day and night conditions, with risks peaking when night-time temperatures are high. Emerging signals for bilharzia, snakebites, and depression highlight the broader health implications of rainfall accumulation, habitat disruption, and prolonged heat exposure. Building health system resilience to these evolving climate patterns is vital for protecting lives and reducing disease burdens in this climate-sensitive region.

3.1.4. Vulnerable populations and geographical regions

Several people are at risk from these disasters due to increasing rural poverty, rapid urbanization, growth of informal settlements, poor urban governance, and declining ecosystem and land conditions. With a large population depending directly on agriculture, the impacts of localized disasters resulting from climate change are likely to have a compounded effect on rural livelihoods over time.[94] The elderly, children, the chronically ill, the socially isolated and at-risk occupational groups are particularly vulnerable. The following factors influence a population's vulnerability to health impacts of climate change.

Poverty

The third IPCC assessment report confirms that the poorest people are most vulnerable to climate change shocks and identified several poverty-related climate change impacts, including decreased crop yields due to decreased water availability, food insecurity, unemployment, reduction in incomes and economic growth, population displacement, and increased exposure to health risks.[95]

Though poverty rates ($1.90 PPP) in Ghana have declined from 47.4% in 1991 to 13.3% in 2016, inequalities exist across the country. Inequality in poverty has widened with higher poverty levels observed in the three northern regions (Northern, Upper East and Upper West Regions) of the country and the Volta Region[96], which has the potential of exacerbating climate related health risks. Additionally, these regions largely depend on subsistence agriculture for livelihood, which is adversely affected by perennial floods and droughts, limiting food security, incomes and access to health care.[97]

Droughts and floods cause severe damage to farmlands, water supply, irrigation systems, food storage, and loss of livestock. The Ministry of Food and Agriculture estimated that floods effect about 70,500 hectares of land resulting in the loss of 144,000 metric tonnes of maize, sorghum, millet, groundnuts, yam, cassava, and rice.[98] Frequent exposure to flood events caused by high-intensity rainfall, coupled with the opening of the Bagre Dam in Burkina Faso affected 100,000 people in 2018. It destroyed 196 km^2 of farmland in northern Ghana[99]. As a result, the groups most vulnerable to food insecurity include farmers, children and people with lower economic status. There are, however, differential effects on diverse groups of farmers; in terms of gender, types of crops being cultivated, access to external support, and alternative livelihood strategies.[100]

3.1.4.2. Gender

Climate change magnifies existing gender inequalities, reinforcing the disparity between women and men in their vulnerability to and capability to cope with climate change.[101] Women, as the majority of

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[94]Atinga, R. A., & Tankpa, V. (2021). Climate Change, Flood Disaster Risk and Food Security Nexus in Northern Ghana. Frontiers in Sustainable Food Systems, 273

[95] IPCC. 2001. Climate Change 2001: Summary for Policymakers, A Contribution of Working Groups I, II and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Watson R.T. and the Core Writing Team (eds). Cambridge University Press: Cambridge

[96] World Bank report, (2019). Poverty & Equity Brief: Ghana. Available at: https://databankfiles.worldbank.org/public/ddpext_download/poverty/33EF03BB-9722-4AE2-ABC7-AA2972D68AFE/Archives-2019/Global_POVEQ_GHA.pdf

[97] Wood, A. L., Ansah, P., Rivers III, L., & Ligmann-Zielinska, A. (2021). Examining climate change and food security in Ghana through an intersectional framework. The Journal of Peasant Studies, 48(2), 329-348.

[98] Armah, F. a., Yawson, DO, Yengoh, GT, Odoi, JO, and Afrifa, EKA (2010). Impact of Floods on Livelihoods and Vulnerability of Natural Resource Dependent Communities in Northern Ghana.

[99]Atanga, R. A., & Tankpa, V. (2021). Climate Change, Flood Disaster Risk and Food Security Nexus in Northern Ghana. Frontiers in Sustainable Food Systems, 273

[100]Nti, F. K. (2012). Climate change vulnerability and coping mechanisms among farming communities in Northern Ghana (Doctoral dissertation). Kansas State University, Manhattan, Kansas

[101] Onwutuebe, C. J. (2019). Patriarchy and Women Vulnerability to Adverse Climate Change in Nigeria. *Sage Open*, *9*(1). https://doi.org/10.1177/2158244019825914

the world's poor, are the most vulnerable to the effects of climate change.[102] Poor women are more likely to become direct victims (mortalities and injuries) of climate change disasters, such as hurricanes and flooding.[103] Additionally, during natural disasters women die more often than men because they are not warned, cannot swim or cannot leave the house alone.[104] When poor women lose their livelihoods, they slip deeper into poverty and the inequality and marginalization due to gender is exacerbated. Women and men also differ in their vulnerabilities to food insecurity due to their roles at home, access to information, control over resources, and influence in household and community decision-making. Men have a traditional role in managing agricultural production in Tariganga in Northern Ghana. They have better adaptive capacity to climatic stressors than women since they tend to control decision-making around land use and agricultural assets such as livestock.

Under varied climate scenarios, cases of cholera, diarrhoea, malaria, malnutrition and heat related deaths are likely to increase. Pregnant women and children are particularly susceptible to malaria which also contributes to pre-natal mortality, low birth weight and maternal anaemia[105]. Climate change can also affect the availability of certain medicinal plants used by a vast majority of women, especially rural poor women, who rely on traditional medical plants for their health needs. According to a study on water needs and women's health in Ghana, women who maintain traditional norms are particularly vulnerable during water scarcity, as they often give priority to their husbands, ensuring that the man's water needs are met before their own.[106] In addition, recent studies on adaptation planning have revealed that a lack of money and inadequate access to labour among women and inadequate access to extension and old age/poor health among men were the major constraints to mitigating climate change impacts in Ghana, recommending the integration of gender needs in climate change adaptation planning and intervention development to help build resilient farm households in many communities.[107]

3.1.4.3. Age

Climate change, pollution, damaging commercial promotion, unhealthy lifestyles and diets, injury and violence, conflict, migration, and inequality pose new hazards to children (ages 0 to 18).[108] Air pollution is linked to poor respiratory health in children; it damages the lungs and the brain and increases the risk of cardiovascular disease, obesity, type 2 diabetes, and metabolic syndrome throughout a child's life.[109] Adolescent and young adult mortality rates are particularly alarming. The rising tendency toward suicide, which is substantially higher in the 15-29 age range than in the following age groups, is one

[102] UNEP, WEDO. (2009), Climate change connections 1. Overview: Women at the Forefront. Available at: https://www.unfpa.org/sites/default/files/pub-pdf/climateconnections_1_overview_1.pdf

[103] Neumayer, Eric and Thomas Plümper, Jan.2007. The Gendered Nature of Natural Disasters: the impact of catastrophic events on the gender gap in life expectancy, 1981-2002. London School of Economics, University of Essex and Max Plank Institute for Economics, London.

[104] Dankelman, I.E.M.; Alam, K.; Bashar Ahmed, W.; Diagne Gueye, Y.; Fatema, N.; Mensah-Kutin, R. (2008). Gender, Climate Change and Human Security: Lessons from Bangladesh, Ghana and Senegal. External research report Prepared for ELIAMEP

[105] Rogerson SJ, Mwapasa V, Meshnick SR. Malaria in Pregnancy: Linking Immunity and Pathogenesis to Prevention. In: Breman JG, Alilio MS, White NJ, editors. Defining and Defeating the Intolerable Burden of Malaria III: Progress and Perspectives: Supplement to Volume 77(6) of American Journal of Tropical Medicine and Hygiene. Northbrook (IL): American Society of Tropical Medicine and Hygiene; 2007 Dec. Available from: https://www.ncbi.nlm.nih.gov/books/NBK1710/

[106] Buor D. Water needs and women's health in the Kumasi metropolitan area. Kumasi, Ghana, Health and Place, 2003.

[107] Assan E, Suvedi M, Olabisi LS, & Bansah KJ (2020) Climate change perceptions and challenges to adaptation among smallholder farmers in semi-arid Ghana: A gender analysis. J Arid Envts. (182) 104247.

108 World Health Organization. Children: new threats to health 19 November 2020. Available at: https://www.who.int/news-room/fact-sheets/detail/children-new-threats-to-health [Accessed 02/04/22]

109 Child, G., & Collaborators, A. H. (2019). Diseases, injuries, and risk factors in Child and adolescent health, 1990 to 2017: findings from the global burden of diseases, injuries, and risk factors 2017 study. JAMA Pediatrics, 173(6), e190337.

source of worry. Injury-related mortality accounts for more than half of all deaths in the 15-24 age range, primarily in motor vehicle accidents.[110]

There are generally very few age-related studies ascribing age as a key factor to climate-related health risk. However, a study on cerebrospinal meningitis (CSM), a climate sensitive disease in Ghana shows that although majority of participants rightly linked CSM infections to dry, very hot and dusty conditions experienced during the dry season, a few elderly participants ascribed fatal causes (disobedience to gods, ancestors, and evil spirits) to CSM infections.[111]

3.1.4.4. Disability

People with disabilities are a heterogeneous group who all share living experiences with significant functional restrictions and, consequently, are often excluded from full community engagement. The number of persons with a disability is growing due to an increase in chronic health issues and population aging. When persons with disabilities seek health care, they may face stigma, prejudice, and poor-quality treatment.[112] Long-term health issues may induce disability, while impairment can exacerbate health problems. The kind and severity of a person's handicap might also impact their health. It might, for example, restrict their access to social and physical activities as well as their involvement in them. Persons with impairments, on average, have lower overall health and experience more psychological distress than people without disabilities. They also have greater rates of various controllable health risk factors and behaviours than those without impairments, such as poor nutrition and tobacco use.[113] Individuals with disabilities are at a greater risk of developing chronic diseases such as obesity, hypertension, fall-related injuries, and mood disorders such as depression. They are more likely to participate in risky habits that endanger their health, such as smoking and insufficient physical exercise.[114] Individuals with disabilities have greater levels of stress and depression than non-disabled individuals. Children and people with disabilities are more likely to be overweight than children and adults without disabilities. Being overweight and obese may harm everyone's health.

3.1.4.5. Migrants, refugees and internally displaced populations

Migrants, refugees, and internally displaced people (MRDPs) are among the world's most vulnerable populations, with several health and healthcare difficulties. People migrate for various reasons, including violence, poverty, catastrophes, urbanization, a lack of rights, discrimination, inequality, and globalization. The vast majority of the world's over 244 million migrants do so freely and without incident. However, about 65 million people are displaced forcefully due to persecution, violence, food insecurity, or human rights abuses.[115] Temporary migration is apparent in many areas, however the most vulnerable to climate change are not necessarily most likely to migrate.[116] The risk of illness and adverse health outcomes are not equal across MRDP groups and are influenced by the multiple dimensions of migration. The number of people migrating because of the adverse impacts of climate change on their livelihoods, daily lives, and health are expected to rise.[117] The effects of climate change on water stress and agriculture are potential drivers of rural-urban migration. Population movement

110 Pecora, P. J., Whittaker, J. K., Barth, R. P., Borja, S., & Vesneski, W. (2018). The child welfare challenge: Policy, practice, and research. Routledge.

111 Codjoe NA &Nabie VA (2014) Climate Change and Cerebrospinal Meningitis in the Ghanaian Meningitis Belt. Int. J. Environ. Res. Public Health 2014, 11, 6923-6939; doi:10.3390/ijerph110706923

112 World Health Organisation (2021), Disability and health. Available at: https://www.who.int/news-room/fact-sheets/detail/disability-and-health [Accessed 02/04/22]

113 Australian Institute of Health and Welfare. The health of people with disability 23 July 2020. Available at: https://www.aihw.gov.au/reports/australias-health/health-of-people-with-disability [accessed 02/04/22]

114 Institute on Disability. Annual Disability Statistics Compendium [online]. Durham, NH: University of New Hampshire. https://disabilitycompendium.org/sites/default/files/user-uploads/2016_AnnualReport.pdfExternal Web Site Policy. [Accessed 02/04/22]

115 United Nations High Commissioner for Refugees UNHC, R. (2015). UNHCR Global Trends Forced Displacement in 2015. http://www.unhcr.org/statistics/unhcrstats/576408cd7/unhcr-global-trends-2015.

116 IOM, 2008. Migration and Climate Change

117 IOM, 2020. Health and migration, environment, climate change

through rural-urban migration due to crop failure and other climatic induced shocks can cause health problems through overcrowding, psychological stress and the increased pressure on health and social services in destination areas.[118] In Ghana, the drivers of migration, particularly in rural areas are linked to climatic impacts as climate change have threatened the sustainability of agrarian livelihoods. In the Northern semi-arid regions as well as coastal areas for example, migration is influenced by drought, while coastal communities face additional challenges of coastal sea erosion, flooding, soil salinization and the destruction of critical habitats such as mangroves.[119] Other studies in Ghana however indicate that though flood and drought are more likely to trigger migration among people in communities that have savannah characteristics, when other socio-demographic and economic factors are controlled, a similar experience is less likely in communities that have forest characteristics. This paper concludes that climate-related environmental events alone may not trigger migration if it is not linked to other socio-economic issues.[120] The linkages between climate, migration and health outcomes have not been explored.

3.1.4.6. Indigenous persons and ethnic minorities

Indigenous peoples and members of many ethnic minorities are far more likely to live in poverty on average than the ethnic majority and non-indigenous population in any nation.[121] The word "ethnic minority" refers to ethnic or racial groups in a nation that are subordinate to the main ethnic population.[122] Indigenous peoples have distinct social, economic, and political systems, languages, traditions, and beliefs, and are adamant about preserving and developing their unique identities.[123] Studies about indigenous peoples' health has shown that to date, indigenous peoples have a life expectancy at birth that is more than five years shorter than the non-indigenous population.[124] Discrimination is a significant factor in indigenous peoples' and ethnic minorities' social isolation. In many nations, ethnic minorities are less adequately protected by health insurance than the ethnic majority. Similarly, linguistic barriers between patients and doctors, along with a lack of awareness of indigenous culture and traditional health care institutions, resulting in a dearth of culturally appropriate health treatments. In Ghana, there is no known evidence of ethnic related climate change and health vulnerability, though socio-economic variabilities exist among the diverse ethnic groups.

3.1.4.7. Urban / rural vulnerabilities

Both the rural and urban communities in Ghana are vulnerable to changing climate exposures, however, the level of vulnerability is higher in the rural area due to lower adaptive capacity and lack of resources. Despite the global impact of climate change, its negative consequences are projected to be felt more strongly in developing countries, particularly in communities that are reliant on natural resources and have little ability to adapt to climate unpredictability and extremes. Climate change

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[118] Toole MJ, Waldman RJ. Prevention of excess mortality in refugee and displaced populations in developing countries. JAMA. 1990 Jun 27;263(24):3296-302. PMID: 2348541. Available at: https://nl.ircwash.org/sites/default/files/154-90PR-8524.pdf

[119] Adiku P & Khan A (2018) The Cariaa Team. Migration in Climate Change Hotspots: Opportunities and Challenges for Adaptation.

[120] https://uaps2011.princeton.edu/papers/110974.

[121] Hall, G. H., & Patrinos, H. A. (Eds.). (2012). Indigenous peoples, poverty, and development. Cambridge University Press.

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makes impoverished people more vulnerable by hurting their health and livelihoods, limiting their possibilities for economic progress. [125,126&127]

Africa is anticipated to warm faster than the rest of the world, with drier subtropical parts like Ghana expected to warm faster than the wetter tropics. Droughts in the Sahara, the Sahel, and the Guinean Coast in the 1970s and 1980s indicate that more dry weather and reductions in rainfall are extremely likely.[128]

In a study by Owusu et al (2019), they demonstrate that by enhancing our understanding of social differentiation and vulnerability in poor urban communities in the Global South, it becomes obvious that the differential vulnerabilities faced by slum residents are closely linked to the interplay between gender and sociocultural norms or institutional arrangements prevailing in slums and Ghanaian society in general.[129] A general observation is that both the rural and urban communities in Ghana are vulnerable to changing climate and other exposures, however, the level of vulnerability is higher in the rural area due to the less adaptive capacity and lack of resources. Moreover, women are disproportionately affected, particularly within the rural communities, due to their restricted access to and control over resources and lack of participation in crisis management and control decision-making at the household, community, and national levels. This also hampers the rural communities' ability to fully engage in income-generating activities, which is crucial for poverty reduction and strengthening adaptive capacities. Urban communities face additional stresses and challenges stemming from populations migrating from rural to urban areas. [130&131]

3.1.4.8. Occupation related vulnerabilities

Climate change has adverse effects on various working groups and occupations in the country. Ghana's socioeconomic growth and development primarily depends on the various formal and informal sectors. In the advent of changing climate, climate-dependent occupations have been vastly affected. For instance, crop losses due to climate change have adversely impacted the agricultural sector including farmers, agricultural extension officers, food sellers, and others. Moreover, heavy physical workload for long hours coupled with increasing workplace heat exposure due to rising temperatures stemming from climate change, especially in situations with inadequate prevention and control policies, adversely affect workers' health and safety, productive capacity and social well-being. In a report on Climate Change and Health of Vulnerable Farmers in Ghana, increased heat exposure in Northern Ghana was observed to have a significant influence on the health of the local population and agriculture, which is the people's main source of income. In a related study[132] that assessed perceptions of climate change and occupational heat stress risks and adaptation strategies of mining workers in Ghana, it was observed that the workers experienced heat-related morbidities, but the variation in heat-related

[125] Hulme M, Doherty R, Ngara T, New M, Lister D. 2001. African climate change: 1900–2100. Climate Research 17: 145–168.
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morbidity experienced across the type of mining activity was not significant, although the type of heat-related morbidities differed across the type of mining activity.

3.2. Capacity assessment of national health system functions

Since the purpose of V&A assessment is to provide evidence for the development of an action plan to build health system resilience, the decision was taken early in the assessment process to anchor the framework for assessing capacity gaps in key health system functions, to the ten components of the WHO operational framework for developing climate resilient health systems. The methodology adopted has been described under section 2.3.

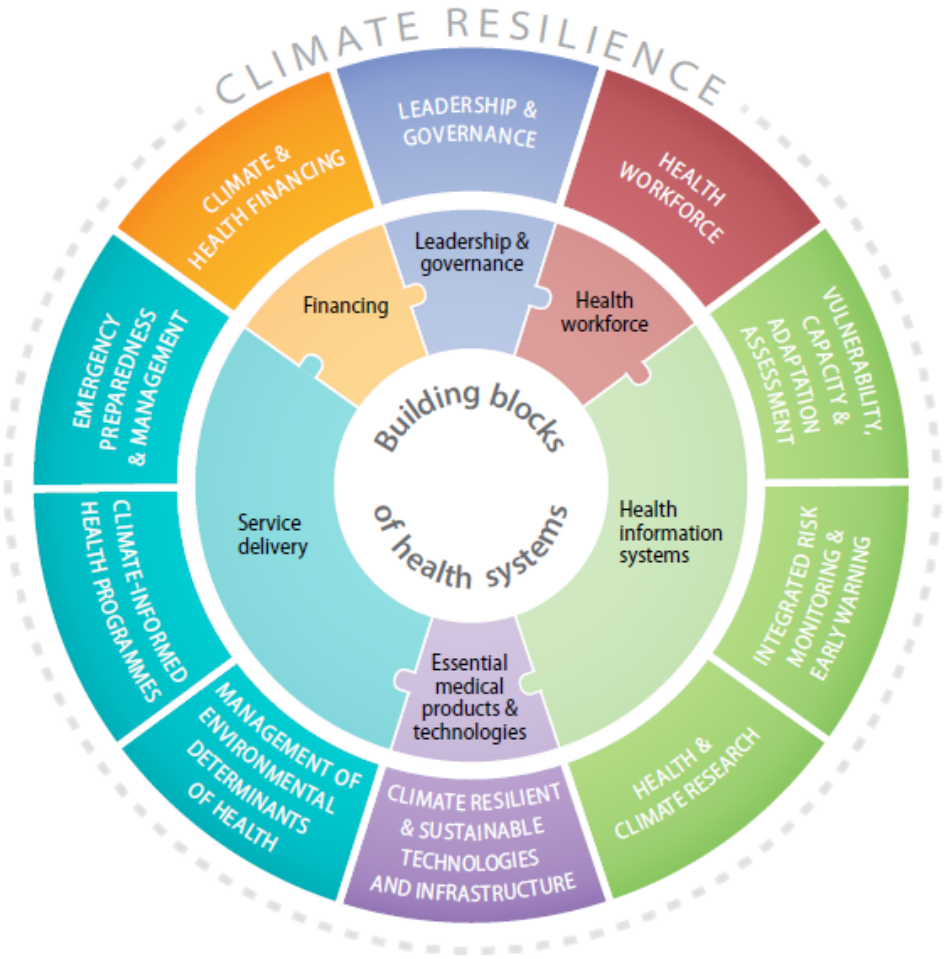

Figure 47: WHO Operational Framework for developing climate resilient health systems

3.2.1. Assessment of capacity gaps in key health system functions

The national level technical working group of experts carried out this assignment. The methodology employed has been described in section 2.1.4. and the results are summarized in Table 5.

Table 5: Capacity gaps in health system functions identified and grouped by components of the WHO operational framework (Figure 47)

WHO operational framework components	Capacity gaps in health system functions
Leadership and governance	
Governance	• There is no climate change and health policy and action plan. • The health component of the national climate change policy (2013) is very limited. • Lack of comprehensive climate change adaptation coordination mechanism in health sector.
Policy	• Lack of a climate change and health strategy aligning with the H-NAP • Health and health-relevant sectors operating in silos: uncoordinated nature of climate change policies and strategies. • Inadequate mainstreaming of climate change and health adaptation into PPPs of health and other health-relevant sectors.
Multilateral and Cross-sectoral collaboration	• Limited collaboration at the national and international levels
Monitoring progress	
Monitoring and evaluation	• Infrequent NDC updates by relevant sectors.
	• Low quality CSHOs data in DHIMS.
	• Quarterly activity reporting by ROEHCs is still rudimentary due to lack of funding.
Health workforce	
Human resource capacity building for health sector adaptation to climate change.	• Despite an increase in the magnitude of the health workforce in the country, the country faces a shortfall.
	• Health workforce training initiatives relevant to climate change and health have largely focused on infectious diseases, particularly malaria, with little emphasis on understanding the wide-reaching health outcomes and systems implications of climate change.
	• Health workers have limited knowledge on how to reduce risks, etc.
	• The distribution of the health workforce is inequitable with resources concentrated in the urban areas of the country.
	• The density of health facilities and the health workforce is low, particularly in rural areas, which limits access to and availability of care to address the burden of climate related health risks.
Organizational capacity development	• Lack of medium to long-term climate resilient Health sector development structures.
	• Absence of realistic and innovative capacity-building plans (e.g., from capacity or vulnerability and adaptation assessments) to address identified human resources and institutional capacity gaps

	• Contingency plan not in place for safe and efficient personnel evacuation not available in vulnerable Health care facilities
Communications and awareness raising	• Climate and health risk communication plan not available.
	• Stakeholder engagement on the impact of climate change on health.
	• Absence of climate change and health sector communication strategy.
	• Inadequate awareness/knowledge on climate change
Vulnerability, capacity, and adaptation assessment	
Vulnerability	• There is an absence of technical capacity and institutional mechanisms that integrate strategies for addressing the impact of climate change into all vertical health programs by utilizing a systems approach.
Baseline information on capacities and gaps	• There are no baselines on existing human resources, technical and health service delivery capacity, for Health care facilities that have been prioritized to provide service in event of natural disasters or emergencies.
	• The routine health information and surveillance systems in Ghana collect information on specific climate sensitive infections, namely malaria, diarrhoea, meningitis, and schistosomiasis. • There are information systems outside the health sector that track changes in climate and weather, though they are not integrated with the health information systems.
Management of environmental determinants of health	
Coordinate management of environmental risk factors for CSHOs	• Storms / floods causing Injuries /accidents, displacement and drowning of both children and adults because of storms and floods.
	• Storms / floods causing victims to suffer from psychological and mental health issues because of damage to houses, loss of properties and livestock and other animals from storms and floods.
	• Access to the health facilities within the communities is a problem during flooding.
	• Storms / floods causing contamination of both surface and ground drinking water sources due to storms and floods.
	• Storms / floods causing breeding of disease vectors such as mosquitoes.
	• Storms / floods causing food insecurity leading to malnutrition.
	• Drought causing food insecurity leading to malnutrition.
	• Drought causing lack of access to potable water during drought leading to communicable and NCDs.
	• Extreme heat causing high risk of heat stress / stroke among outdoor workers.
	• Extreme heat causing adverse reproductive health outcomes because of heat wave and stress.
	• Extreme heat causing dehydration due to heat waves and stress.
	• Bushfires causing bushfires causing destruction of food crops leading to malnutrition.
	• Sea level rise causing injuries and displacement leading to psychological and mental health issues
	• Poor mining practices causing contamination of food chain
	• Poor mining practices causing pollution of both surface and groundwater sources leading to both communicable and NCDs

	• Logging / charcoal production causing deforestation
	• Charcoal production causing air pollution-related diseases
	• Poor sanitation leading to contamination of surface and ground water resulting in both communicable and NCDs.
	• Poor sanitation leading to breeding of disease vectors.
	• Conflicts / fighting leading to injuries, accidents, displacements and deaths
	• Psychological and mental health issues resulting from conflicts / fighting.
	• Vulnerable shelter / haphazard built environment leading to injuries, diseases, and displacements because of Vulnerable shelter / haphazard built environment.
	• Forced migration / displacement leading to displacement and psychological and mental health issues resulting from forced migration.
	• Sand winning leading to loss of farmlands
	• Sand winning leading to creation of breeding ground for disease vectors.
	• Overgrazing / destruction by livestock leading to food insecurity and malnutrition
	• Unsafe drinking water leading to communicable and NCDs
Monitor environmental risk factors for CSHOs	• Limited access to data on environmental risk factors for CSHOs due to financial barriers and unawareness of open sources.
	• Limited technical capacity to analyse environmental risk factors for CSHOs
Develop/ strengthen regulations for management of environmental risk factors for CSHOs	• Inadequate mainstreaming of health impacts of climate change into regulations that control environmental risk factors of CSHOs
Vector-borne and zoonotic diseases	
	• Malaria incidence has risen steadily since 2014 and plateaued from 2019
	• Most interventions for vector borne disease are target malaria, YF, some NTDs with few interventions and awareness on emerging threats like Dengue, Chikungunya, Rift Valley fever, Zika, Tick-borne diseases and others.
	• Limited awareness on dengue fever prevention and control.
Cerebrospinal Meningitis	
	• Spread of meningitis to non-endemic parts of the country due to climate change
Malnutrition	
	• Poor mining practices, sand winning and other causes of loss of farmlands threatening food security.
	• Drought threatens food security.
	• Floods can threaten food security by destroying farmlands
Respiratory Illness and allergic dxs	
	• Inadequate surveillance on allergic diseases

Cardiovascular Diseases	
	• Low awareness about links between air pollution (outdoor & indoor) and CVD
	• High usage of biomass fuel causing indoor air pollution
	• Increased exposure to harmattan (desert) dust
	• Inadequate surveillance on allergic diseases
Food-borne illness	
	• Inadequate access to information/data on food borne illnesses (FDA-INFOSAN)
	• Low awareness raining on preventive measures among the food vendors
	• Poor sanitation and hygienic practices
Water-borne diseases (cholera, Typhoid, Diarrhoea	
	• Increased disease risk due to shortage of drinking water (Drought).
	• Contamination of drinking water sources (ground and surface water) during flooding events
	• Poor mining practices causing chemical pollution of water sources
	• Poor environmental sanitation and hygienic practices
Mental Health and psychosocial Disorders	
	• Inadequate surveillance on mental health.
	• Displacements due to disasters caused by extreme weather events
Injuries & Accidents (from extreme weather events)	
	• Increase in disasters caused by extreme weather events
	• Inadequate access to data on injuries & accidents (extreme weather events)
	• Inadequate data linking injuries & accidents to extreme weather events
Snake Bites	
	• Increase risk of exposure during heat episodes.
	• Destruction of habitats by wildfires
	• Inadequate access to anti-snake venom (ASV).
Water washed diseases (Yaws, Scabies, Trachoma etc.)	
	• Increased disease risk due to shortage of water (Drought)
	• Poor sanitation and hygienic practices.
Heat Related Illness (Heat stress, heat strokes)	
	• There is no surveillance, inadequate preventive interventions for heat related illnesses
	• Loss of work hours and productivity among large section of workforce engaged in outdoor work.
	• Heat related adverse reproductive health outcomes
Injuries & Accidents (from RTAs)	
	• Dust storms and fog reducing visibility for drivers.
	• Inadequate access to data on injuries & accidents (extreme weather events) and data on injuries & accidents (RTA)

Integrated risk monitoring and early warning	
Integrated disease surveillance and early warnings	• There is no systematic sharing of health and environment data
	• There is no IT system/platform for sharing, managing or analysing shared health and environment data.
	• There are no operational EWSs for CSHOs based on an integrated health and environment surveillance platform
Monitoring climate change indicators	• There is poor quality of data on many CSHOs reported in the DHIMS
	• Limited access to data on environmental risk factors for CSHOs due to financial barriers and unawareness of open sources.
Risk communication	• There is no structured risk communication and community engagement strategy for CSHOs based on reliable predictions from EWS, health impact models and other sources of scientific evidence.
Emergency preparedness and management	
Inform policies and protocols	• There are no costed emergency preparedness plans
	• There is no post evaluation response planning
Risk management	• A weak Contingency plan for evacuation purposes
Climate and health financing	
Health-specific funding mechanisms.	• The government's health budget has increased in absolute terms in recent years, but health facilities are highly dependent on NHIS payments for services to cover non-salary costs.
	• There is a need to establish sustainable streams of funding for climate change.
Climate resilient and sustainable technologies and infrastructure	
Adaptation of current infrastructures, technologies, and processes.	• Floods and other extreme weather events are known to damage hospitals and other health care facilities.
	• Various national policy documents mention the need to strengthen health facilities and "climate proof" existing health infrastructure, though concrete steps need to be taken to further these strategies.
	• No assessments have been conducted to determine the climate resilience of health facilities in the country.
	• There is limited information however, on the frequency of stock outs of these and other drugs used to prevent and manage common climate sensitive conditions.
	• There is no systematic reporting on health facilities being flooded due to extreme weather events.
	• Some health facilities have access cut off due to flooding.
	• There is limited information/data on the state of health infrastructure.
	• Knowledge, experience (considering previous damages) and resource capacity (including human, material, financial, supplies chain and logistics) is provided only during disease outbreaks but not to manage flood risk reduction in health facilities.
	• Inadequate collaboration with the regional government/agencies (e.g., NADMO) to support vulnerable populations to actively participate in risk reduction management, policy making, planning and implementation.
	• Little capacity for conduct of climate risk and vulnerability assessments at sub-national levels to identify risk scenarios, vulnerabilities, and the facility's response capacity.

	• Inadequate protection and insulation against moisture and mould
	• Many health facilities with secret roof design are leaking
Promotion of climate resilient and sustainable technologies and infrastructure	• Availability of diagnostic tools, vaccine, and treatment available at most health facilities is not yet targeted at addressing health risks of climate change.
	• Very few health facilities are using renewable energy sources such as solar energy.
Sustainability of health operations	• Inadequate tree planting to serve as wind brake
	• No evaluation of the condition and safety of structural and non-structural elements impacted by previous exposure to flood.
	• No operation of a regular schedule to inspect health facilities both internally and externally, for signs of deterioration (e.g., cracks or sinking structural elements) to avoid or reduce flood impacts.
	• No contingency plan in place for safe/efficient personnel evacuation (including health staff and patients), and for equipment and other essential supplies before, during and following a flood
Supply chain for essential drugs, vaccines, logistics etc	
Strengthen supply chains for health facilities, especially those in climate vulnerable hotspots	• Consumption of essential medical, pharmaceutical, nutritional, and laboratorial supplies, personal protective equipment, food, etc. is not estimated for flood periods.
	• No risks assessment of the supply chain undertaken
	• Plan not available to ensure continuity of the facility's supply and delivery chain in case of disaster/emergencies
	• Vulnerable Health care facilities have no cooperate agreements with other facilities to secure access to essential services like sterilization/laundry/blood bank
	• Plan for relocating medical devices, medicines etc. not available
Climate and health research	
Research agenda	• No climate and health research agenda developed
	• Inadequate research into relation between human exposure to climatic variables and health outcomes
Connect to policy	• No policy fora, meetings and conferences organized where researchers could engage policy- makers to disseminate research that support development of evidence-based policies on climate change and health.

3.3. Future risk projections

In this section, the projected annual disease burdens for nine key health outcomes in Ghana from 2025 to 2050 across five ecological zones in Ghana were analysed. These projections are based on two climate scenarios: SSP2-4.5 (a moderate stabilization pathway) and SSP5-8.5 (a high-emissions trajectory). The analysis uses time-series plots and summary bar charts to visualize long-term trends, interannual variability, and the percentage change in average disease burden between the baseline period (2009-2024) and 2050. The findings reveal a highly heterogeneous future, with the direction and magnitude of change varying significantly by disease and ecological zone, underscoring the need for spatially targeted public health planning and climate adaptation strategies. The reader may refer to the full report on projecting disease burden of climate sensitive health outcomes in Ghana by the

MOH[133], for more detailed analysis. However, the future burden of some CSHOs (e.g. Meningitis, Yellow fever etc.) could not be projected due to issues related to data quality and confounding factors.

3.3.1. Coastal Savanna Zone

In the Coastal Savanna zone, the projections reveal a mixed picture of increasing and decreasing disease burdens. Figure 48 illustrates the annual projections, showing a clear divergence in long-term trends.

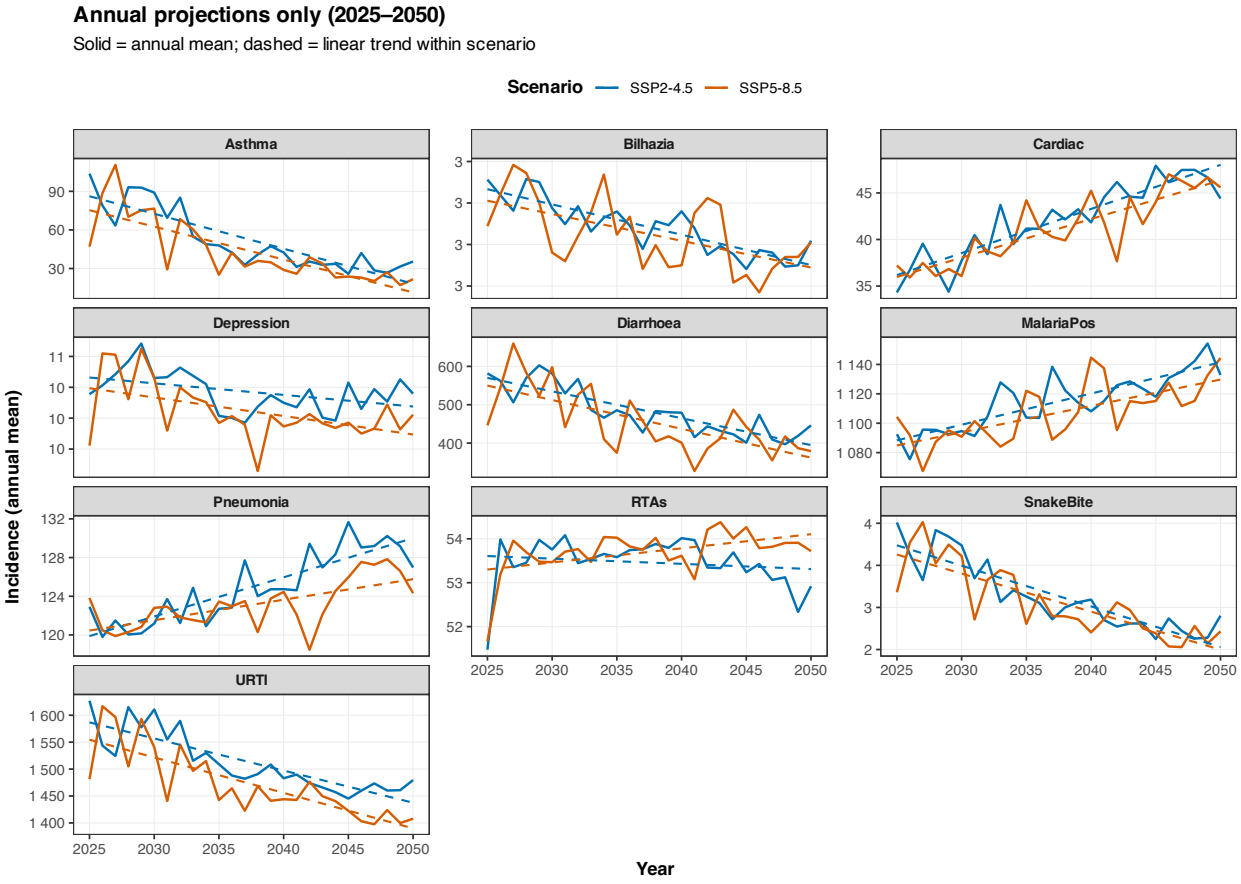

Figure 48: Projected annual disease burden - Coastal savannah zone

Cardiac diseases, malaria, and pneumonia are projected to show a clear, steady, and sustained increase in incidence counts toward mid-century under both scenarios. This signals a growing demand on health systems. Road Traffic Accidents (RTAs) also show a gradual but persistent increase.

Asthma, Upper Respiratory Tract Infections (URTIs), diarrhoea, and depression are projected to follow declining trajectories, with incidence counts falling below historical levels. Asthma shows the most dramatic decline.

Bilharzia and snake bites are projected to remain low and relatively stable, with no indication of a systematic future increase, though snake bites show episodic fluctuations.

[133] MOH (2024), Projecting disease burden of climate sensitive health outcomes in Ghana for vulnerability assessment

Figure 49 presents the percentage change in average disease burden from the baseline to 2050. This quantitative view reinforces the trends:

- Cardiac diseases show a significant increase of 20-25%, while pneumonia and malaria are projected to rise by 5-10%.
- Asthma shows a dramatic decline of 35-40%. Diarrhoea is also projected to decrease by 10-15%, and snake bites by 10-15%.
- Bilharzia and URTI show minimal change or slight declines, hovering around a 0-10% reduction.

The key public health signal for the Coastal Savanna is the rising burden of cardiovascular, respiratory, and vector-borne diseases like pneumonia and malaria, contrasted with a notable decline in conditions like asthma and diarrhoea.

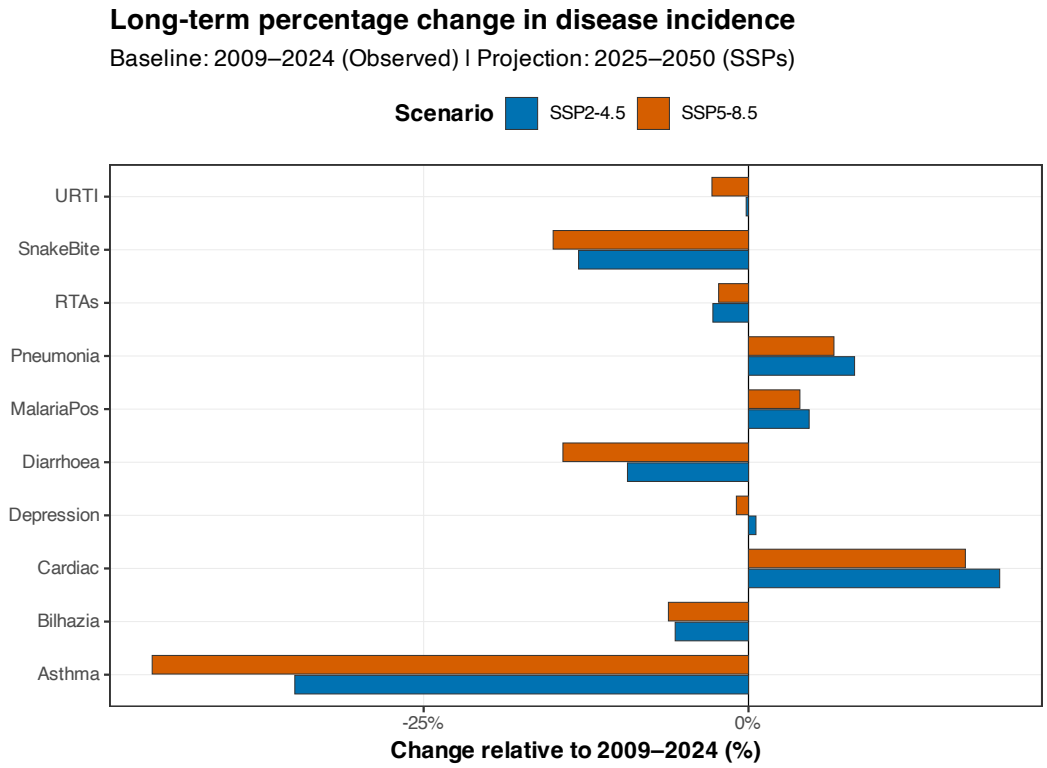

Figure 49: Projected change in disease burden - Coastal savannah zone

3.3.2. Deciduous Zone

The Deciduous zone presents a contrasting picture, with a different set of diseases projected to increase. Figure 50 shows the annual projections, highlighting significant upward trends for several conditions.

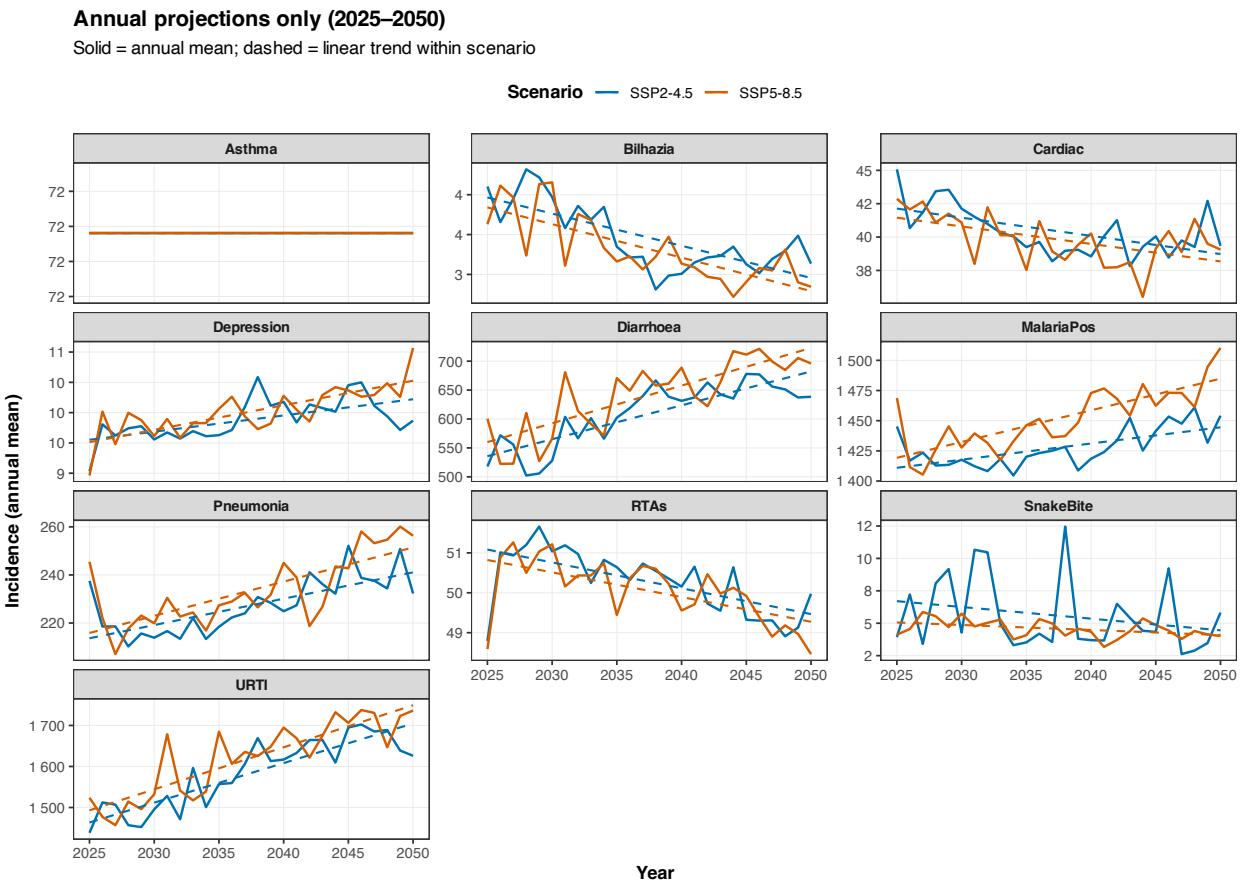

Figure 50: Projected annual disease burden - Deciduous zone

Diarrhoea shows a pronounced and sharp projected increase, with wide variability and intermittent peaks, especially under SSP5-8.5. URTIs and pneumonia also display a strong and sustained increase. Depression and malaria are projected to rise steadily.

In contrast to Coastal Savanna, cardiac diseases exhibit a projected decrease in incidence. Asthma remains largely stable. RTAs and snake bites show declining or stable trends with episodic peaks. Figure 51 quantifies these changes, revealing the most dramatic shifts in this zone:

Diarrhoea is projected to rise by a striking 17-23%, making it the most urgent threat in this zone. Pneumonia (13-16%), URTIs (12-15%), and asthma (10-15%) also show substantial increases. Depression (7-8%) and malaria (3-5%) are also projected to increase.

Bilharzia shows the highest decline (15-18%), while RTAs and snake bites demonstrate significant reductions of up to 30-40%. Cardiac diseases show a modest decline of 2-4%.

The Deciduous zone emerges as a hotspot for increasing communicable and respiratory diseases, particularly diarrhoea, pneumonia, and URTIs, warranting urgent interventions in water sanitation and pollution control.

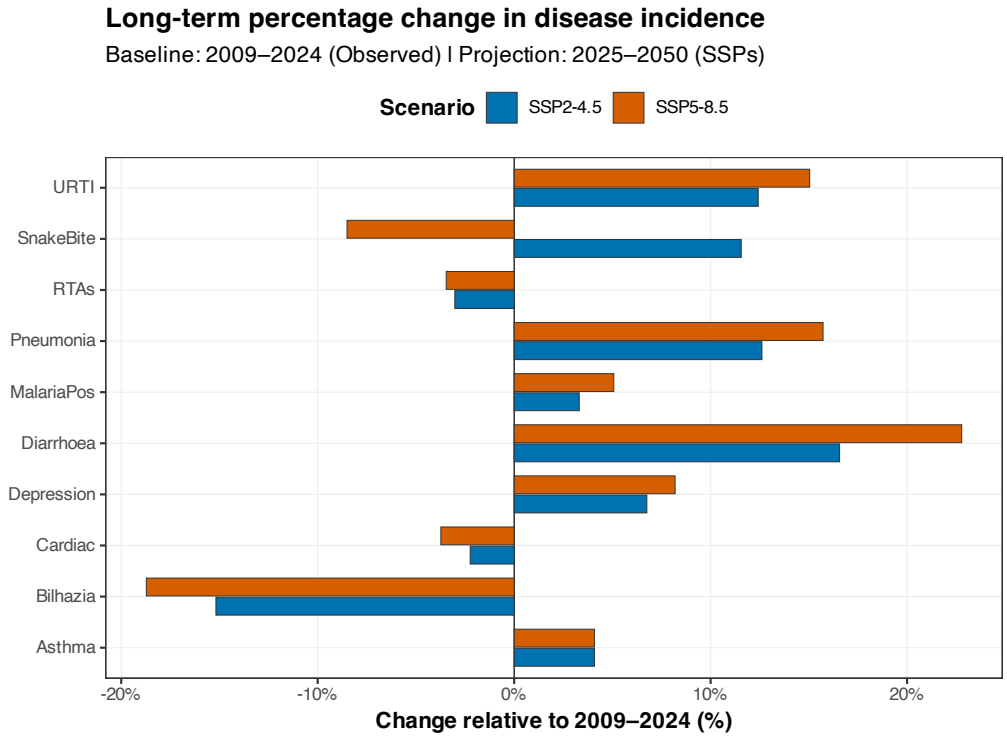

Figure 51: Projected change in disease burden – Deciduous

3.3.3. Transition Zone

The Transition zone is projected to experience selective but significant increases in disease burden. Figure 52 displays the annual projections, showing clear upward trajectories for several key diseases.

- URTIs, diarrhoea, and asthma show clear and sustained increases. Malaria, pneumonia, and cardiac diseases also exhibit rising trajectories, though with some variability. RTAs and snake bites show slight increases or remain stable.
- Bilharzia remains very stable with nearly flat projections, while depression shows a gradual decline or stabilization.

Figure 53 provides the percentage change, highlighting the following:

- Diarrhoea (15-20%), asthma (12-20%), and malaria (~15%) are projected to see the most substantial increases. Pneumonia (10-15%) and URTIs (5-10%) also show strong positive changes.
- Cardiac diseases (0-5%), RTAs (5-10%), and snake bites (0-5%) are projected to increase modestly.
- Declining Burden: Bilharzia (~10% decline) and depression (0-5% decline) are the only conditions projected to fall below baseline levels.

The analysis confirms that pneumonia, malaria, diarrhoea, asthma, cardiac diseases, and URTIs pose the most urgent climate-sensitive public health threats in the Transition zone by mid-century.

Figure 52: Projected annual disease burden - Transition zone

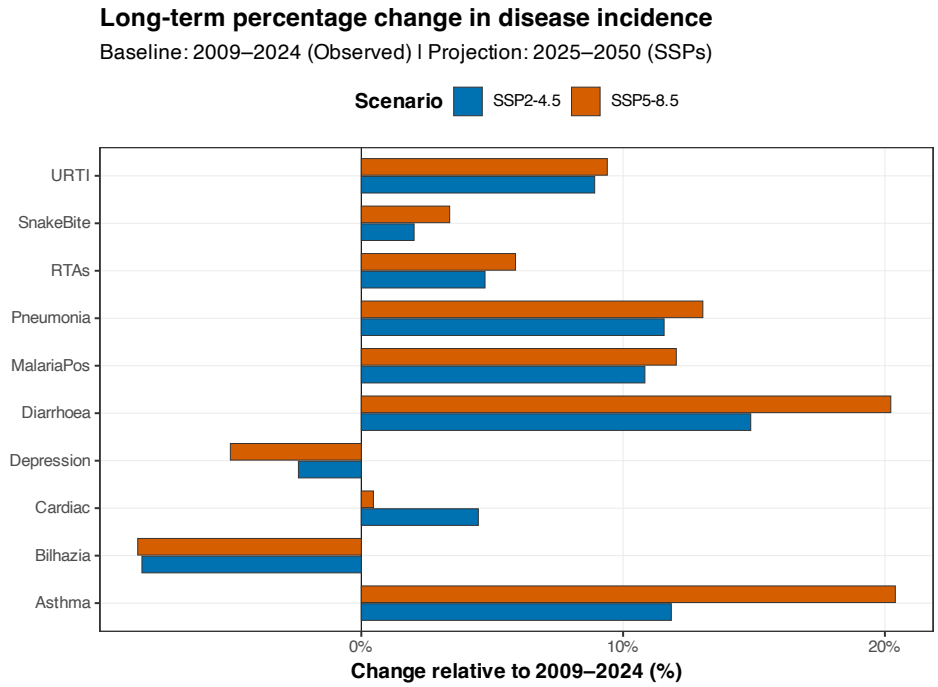

Figure 48: Projected change in disease burden – Transition

3.3.4. Guinea Savannah Zone

The Guinea Savannah zone is projected to experience the most widespread and substantial increases in disease burden. Figure 54 shows strong upward trends for most of the diseases analysed.

- Widespread Increases: Asthma, diarrhoea, malaria, pneumonia, URTIs, and cardiac diseases all show strong and sustained increases in incidence. The high-emissions scenario (SSP5-8.5) consistently amplifies these projections.
- Stable/Declining Trends: In contrast, bilharzia, snake bites, RTAs, and depression show relative stability or a slight decline.

Figure 54: Projected annual disease burden - Guinea savanna zone

Figure 55 quantifies these dramatic shifts, showing the largest percentage increases across all zones: Asthma leads with a staggering 40-45% increase. Diarrhoea follows with a 20-30% rise. Malaria (10-20%) and URTIs (0-10%) also show significant positive changes. Cardiac diseases (0-10%) and pneumonia (0-5%) are projected to increase moderately. However, bilharzia (0-10% decline), depression (0-5% decline), RTAs (0-5% decline), and snake bites (0-5% decline) are projected to remain stable or decline slightly.

The Guinea Savannah zone emerges as a future hotspot for a compounding health crisis, with large increases projected across respiratory, vector-borne, and enteric diseases, underscoring the urgent need for a climate-resilient health system.

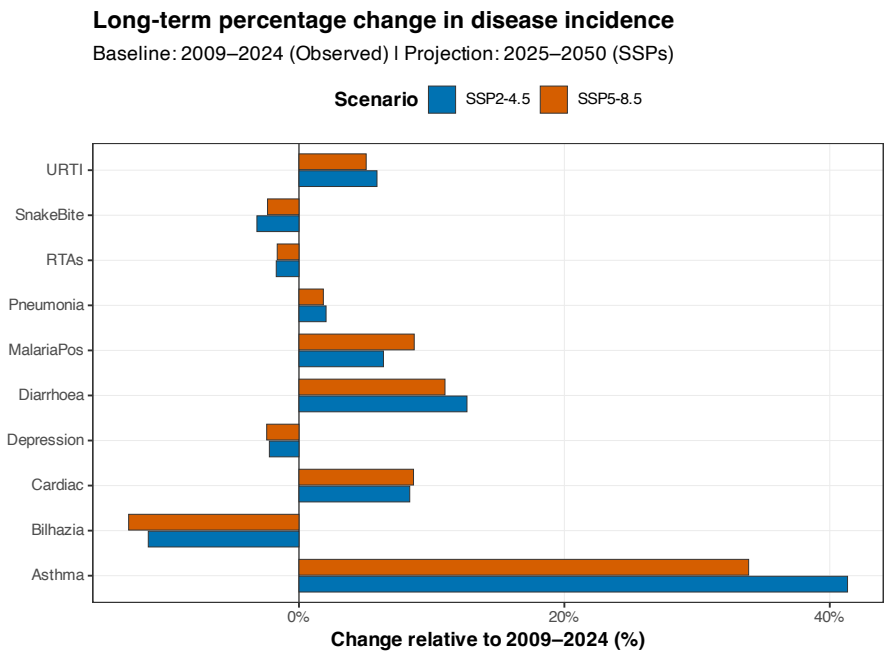

Figure 55: Projected change in disease burden - Guinea savannah zone

3.3.5. Wet Evergreen Zone

The Wet Evergreen zone presents a unique and contrasting epidemiological regime. Figure 56 shows that while some diseases increase sharply, others are in steep decline.

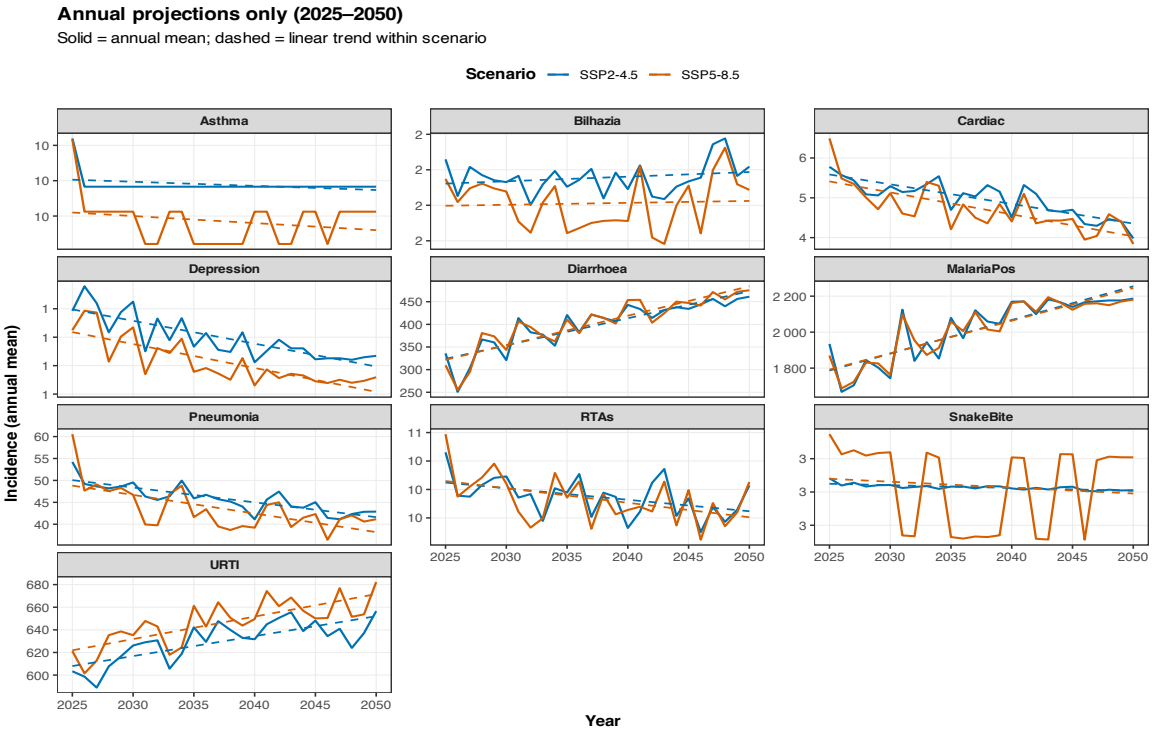

Figure 49: Projected annual disease burden - Wet evergreen zone

Diarrhoea and malaria show strong and sustained increases, reflecting the zone's vulnerability to water- and vector-borne diseases in a high-rainfall environment. URTIs also show a clear upward trend. In stark contrast, depression, cardiac diseases, pneumonia, and asthma show clear and sustained declining trajectories. Figure 57 confirms this divergent pattern:

- Diarrhoea (20-30%) and malaria (5-20%) show the most robust increases. URTIs also increased by 10-15%.
- Depression shows a notable decline of 20-30%. Cardiac diseases and pneumonia decline by 15-20%. Asthma and bilharzia also decline by 5-10%.
- RTAs and snake bites show minimal change, remaining close to or slightly below baseline levels.

This divergent pattern suggests that in the Wet Evergreen zone, improvements in non-communicable and some respiratory conditions may coexist with worsening exposure-driven infectious risks, creating a highly mixed future disease profile.

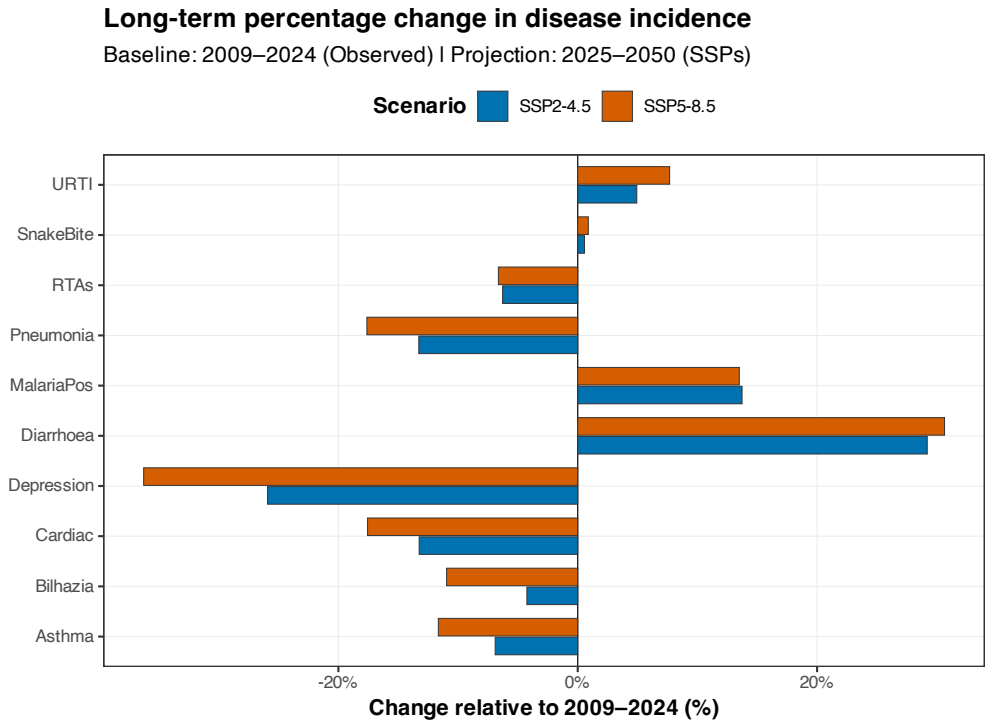

Figure 50: Projected change in disease burden - Wet evergreen zone

3.3.6. Spatial distribution of projected percent changes for selected CSHOs by 2050

Figure 58 compile hazard maps depicting the spatial distribution of projected percent changes in burden of selected CSHOs in different ecological zones by 2050.

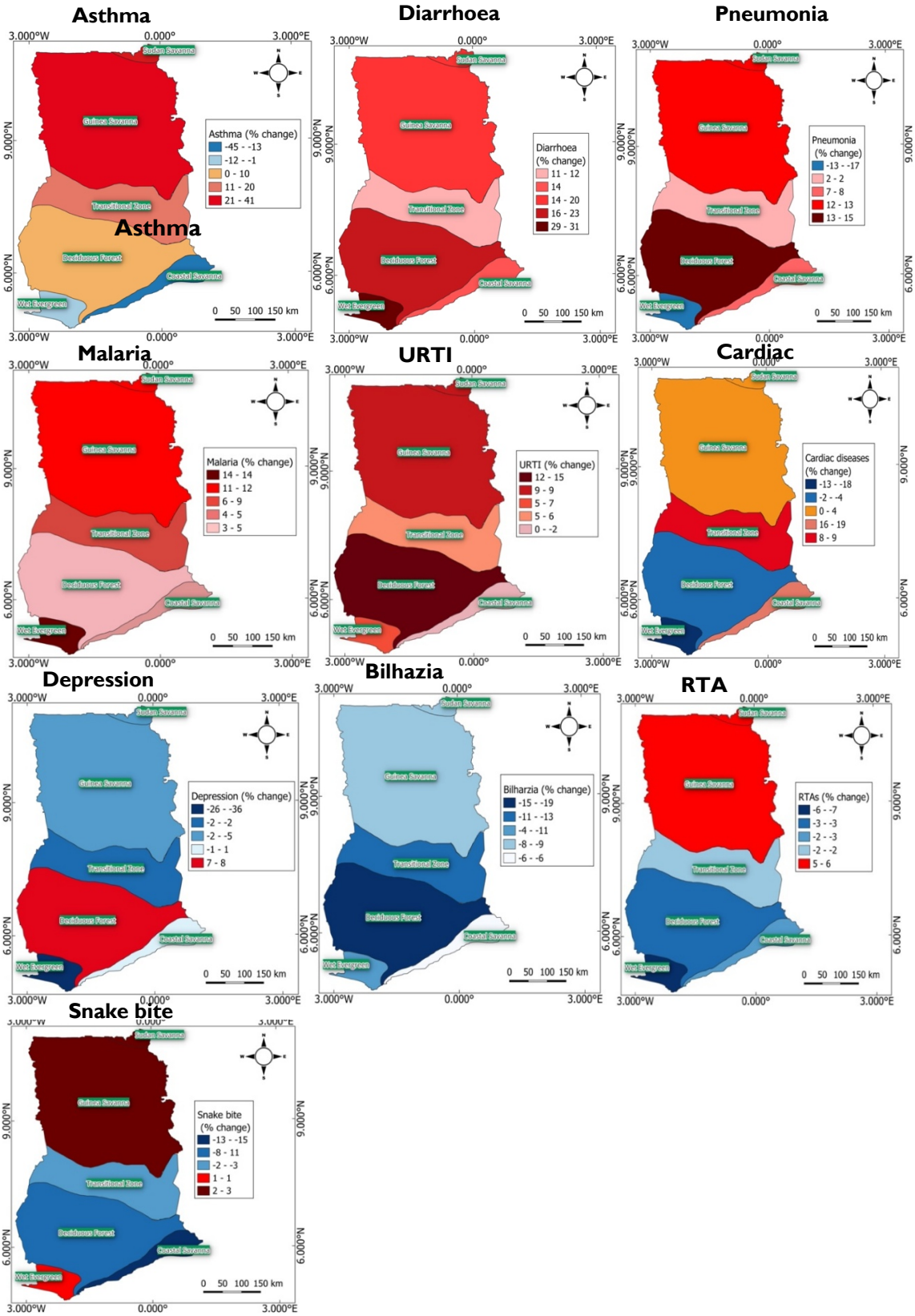

Figure 51 : Projected percent changes in burden of selected CSHOs in different ecological zones by 2050

3.4. Adaptive capacity of PPPs for health and health-relevant systems at national level

Ghana has taken steps to introduce policies, plans and programs (PPPs) addressing climate change and its health risks. Ghana has released several national climate change policy documents across various sectors that are relevant for health, national health sector specific policy documents and sub-national level policy documents on climate change and health.

The relevant current or planned health and health-relevant sectors policies, plans and programs for climate change adaptation, highlight the existing adaptive capacity of the health system to climate risks. They reflect the various critical strategies required for adaptive action, including partnerships between the health and health-relevant sectors. There is therefore a need to integrate targeted actions towards groups most vulnerable to the health effects of climate change.

3.4.1. Relevant PPPs of the health and health-relevant sectors that address health impacts of climate change

The methodology employed in identifying the relevant PPPs and assessing adaptive capacity ratings is described under section 2.1.6. Initially the relevant health sector PPPs were listed as shown in Table 6.

Table 6: List of relevant current or planned PPPs of the health sector that address climate change related health risks

No.	Health sector PPPs addressing climate impacts	Brief Description	Lead MDA	Climate change related pages
1.	National Healthcare Quality Strategy (2017 – 2021)	To create a health system that places the client at the centre of health care and ensures continuously improved measurable health outcomes	MOH	Pages 4, 9, 13, 21 and 34
2.	Healthcare Facilities WASH/IPC Strategy and Technical Guidelines (2018)	To protect health workers and clients from the risk of infections by improving access to water, sanitation and hygiene facilities at the healthcare settings in Ghana	MOH	x, xi, 2,3, 4, 6, 7, 8, 12, 13, 17, 18 ,21 25,
3.	Ten Year Mental Health Policy (2019 - 2030)	To improve mental health situation in Ghana, prevent and reduce mental ill-health, disability and preventable deaths associated with mental health conditions across the life span of the individual	MOH	Pages 32, 34and 47
4.	National Health Policy (2020)	To promote, restore and maintain healthy lives for all people living in Ghana by mainstreaming "health-in-all policies" and "one health" approaches to stir action in other sectors for health and Human Capital Development.	MOH	Pages 5, 7, 12, 13, 14, 25, 27, 28, 29, 30, 34
5.	Ghana's Roadmap for Attaining Universal Health Coverage (2020 – 2030)	To ensure increased access to high quality essential healthcare and population-based services for all by 2030. It outlines the priority areas for action towards the attainment of UHC for all people living in Ghana.	MOH	Pages 6, 12, 15

6.	Workplace HIV/TB Policy and Technical Guidelines for the Health Sector (2020)	To mitigate the risk of HIV and TB infections and promote healthy working environment at the health workplace.	MOH	Pages 16, 20, 23
7.	National healthcare Waste Management Policy and Technical Guidelines	To provide direction for effective, efficient and safe management of healthcare waste through the adoption of Best Available Techniques (BAT) and Best Environmental Practices to prevent injuries, infections and other hazards; protect and promote public health and the environment for sustainable development.	MOH	Pages 14, 15, 16, 17, 19, 20, 21, 25, 31, 34,36, 38, and 39
8.	Human Resource Policy and Strategies for the Health Sector (2020)	To ensure the availability of the required motivated health workforce with the requisite knowledge, skills, competencies and attitude, equitably distributed and providing the needed quality healthcare at all levels.	MOH	Pages 1, 2, 35
9.	Health Sector Medium-Term Development Plan (2022 – 2025)	To ensure increase access to quality essential health care and population-based services for all by 2030.	MOH	
10.	National Food Safety Policy and Strategic Action Plan (2022)	To build a resilient system that assures safe and suitable food for all consumers.	MOH	Pages VI, VII, 2, 4, 6, 17
11.	Essential Health Service Package (2022)	To elaborate the set of priority essential services and interventions to be made universally accessible to all persons living in Ghana by 2030. It is meant to help address critical gaps in healthcare equity across the country.	MOH	
12.	National Health Financing Strategy (2023)	The goal of the Ghana HFS is equitable, efficient, effective, transparent, and sustainable health financing mechanisms that contribute to achieving improved health outcomes, financial risk protection, consumer responsiveness, and access to quality essential health care and population-based services for all by 2030.	MOH	
13.	National Infection Prevention and Control Strategy (2024)	To prevent, reduce, and control healthcare-associated infections (HAIs) and Anti-microbial Resistance (AMR), ultimately improving patient safety and health outcomes.	MOH	
14.	Health Security Policy for Ghana	The goal for this Policy is to work towards preparedness and immediate response to achieve a country that is safe and secure from health threats posed by infectious diseases, natural and man-made disasters (bioterrorism, effect of radioactive substances and chemicals, inappropriate use	MOH	

		of antimicrobials) and NCDs (including mental disorders, road traffic crashes).		
15.	National Health Infrastructure Strategy	To ensure equitable geographical access to health infrastructure and technologies for all people living in Ghana.	MOH	
16.	National Health Sector Gender Policy	To address gender inequalities in health to promote, restore and maintain good health for women, men, girls and boys living in Ghana.	MOH	Pages 8
17.	National Medical Devices Policy and Strategic Action Plan	To establish an enabling environment led by the Ministry of Health for the planning, production, implementation, monitoring and evaluation of effective and efficient medical devices systems at all levels of the health sector, both public and private.	MOH	

Table 7: List of non-health relevant sectors current or planned PPPs that address climate change related health risks

No.	Health-relevant sector PPPPs addressing climate impacts	Brief Description	Lead MDA
1	Ghana National Climate Change policy 2013	Policy provides strategic direction and co-ordinates issues of climate change in Ghana.	MESTI
2	Ghana Landscape restoration and small-scale mining project by World bank	The project seeks to restore degraded lands for agricultural productivity; strengthening sustainable management of forest landscapes for biodiversity conservation and ecosystem services.	MOFA
3	Ghana Secondary city districts project initiative	This project seeks to build infrastructure for cities i.e., markets, roads) for improved living conditions, economic growth, and sustainable environment.	MLGRD
4	Planting for Food & Jobs Phase II	to improve food security, reduce poverty and create employment opportunities.	MOFA
5	Green Ghana project	Project seeks to undertake national afforestation/ reafforestation aimed at restoring the country's degraded landscape.	Forestry commission
6	PROCASHEW	production of large-scale cashew designed to address identified constraints relating to cashew development in Ghana.	MOFA
7	The Ghana Clean Water Project	The Ghana Clean Water Project follows the United Nations Framework Convention on Climate Change's (UNFCCC) protocol for low greenhouse gas emitting water purification systems.	Ministry of Sanitation and Water Resources
8	West Africa Food System Resilience Program (FSRP) Project	to increase preparedness against food insecurity and improve the resilience of food systems.	MOFA
9	Rice Value Chain Improvement Project	project "improving the technology and quality control system for higher value addition in the post-harvest processes of the rice value chain".	MOFA
10	National affordable housing scheme	Aims to address the housing affordability gap by subsidizing housing units with land and infrastructure, while the private sector complements these efforts by raising funds to build apartments.	MOWH
11	Strengthen Investment in Gender Responsive Adaptation-SIGRA project	empowering women and children in pro-poor area in climate sensitive adaption initiatives	MOFA
12	G-SHEP	building of farmers to produce vegetables to sell as response to climate variability.	MOFA
13	Gulf of Guinea Northern Regions Social Cohesion (SOCO) Project	building of resilient community infrastructure and assets for island communities	MOFA

14	National Disaster Management Plan.	To improve the understanding of disaster risk, hazards, and vulnerabilities; Strengthen disaster risk governance at all levels from local to centre; Invest in disaster risk reduction for resilience through structural, non-structural and financial measures; Enhance disaster preparedness.	NADMO
15	Environmental Health and Sanitation Policy-2010	The overall goal of this new policy is to develop a clear and nationally accepted vision of environmental sanitation as an essential.	Ministry of Local Government and Rural Development (MLGRD).
16	National WASH policy 2017	The goal of the Ghana WASH Project is to "improve access to safe and adequate water supply and basic sanitation facilities infrastructure for households, clinics, and schools and promote complementary hygiene practices to maximize the health impacts from this improved infrastructure.	Ministry of Sanitation and Water Resources
17	Ghana National Energy transition framework (2022-2070)	This is a long- term net-zero framework (2022-2070), expected to complement existing efforts with new measures, such as increased renewable energy penetration, conversion of thermal plants to natural gas and the integration of nuclear power into the energy mix.	Ministry of Energy
18	Planting for Export and Rural Development	PERD is a decentralized National Tree Programme to promote rural economic growth and improve household incomes of rural farmers through the provisions of certified seedlings and extension services.	MOFA

3.4.2. Adaptive capacity ratings of relevant PPPs of the health system at national level

Adaptive capacity ratings were based on availability of adequate human resource, essential supplies/ technology/ infrastructure and relevant PPPs (PPPs from the health sector, as well as PPPs from health relevant sectors that address CSHOs or their upstream drivers) to address the identified capacity gaps in health system functions. Refer to section 2.1.6 for description of the methodology employed.

Experts on the technical working group gave the ratings based on their experts' opinion and these ratings were classified as either limited, moderate or adequate. The results of this exercise are summarized in Table 8.

Table 8: Health system capacity gaps, relevant health and health-relevant sector PPPs and adaptive capacity ratings at national level

Health system building blocks	Capacity gaps in health system functions	PPPs of health and health relevant sectors	Adaptive capacity ratings (L=Limited, M=Moderate, A=Adequate)
Leadership and governance			
Governance	• The health component of the national climate change policy (2013) is very limited. • There is no standalone climate change and health policy and action plan. • Lack of comprehensive climate change adaptation coordination mechanism in health sector.	• National climate change policy (2013)	L
Policy	• Lack of a climate change and health strategy aligning with the H-NAP. • Health and health-relevant sectors operating in silos: uncoordinated nature of climate change policies and strategies. • Inadequate mainstreaming of climate change and health adaptation into PPPs of health and other health-relevant sectors.	• National climate change policy (2013)	L
Multilateral and Cross-sectoral collaboration	• Limited collaboration at the national and international levels.	• National focal point for climate change (MESTI) • Nationally Designated Authority (MOFEP)	M
Monitoring progress			

	• Infrequent NDC updates by relevant sectors. • Low quality CSHOs data in DHIMS. • Quarterly activity reporting by ROEHCs is still rudimentary due to lack of funding.	• National Communications to the UNFCCC secretariat • DHIMS2 • IDSR • OEHP reports	M
Health workforce			
Human resource capacity building for health sector adaptation to climate change.	• Despite an increase in the magnitude of the health workforce in the country, the country faces a shortfall in some fields of specialization. • Health workforce training initiatives relevant to climate change and health have largely focused on infectious diseases, particularly malaria, with little emphasis on understanding the wide-reaching health outcomes and systems implications of climate change. • Health workers have limited knowledge on how to reduce risks, etc. • The distribution of the health workforce is inequitable with resources concentrated in the urban areas of the country. • The density of health facilities and the health workforce is low, particularly in rural areas, which limits access to and availability of care to address the burden of climate related health risks.	• National Health Policy (2020) • Ghana's Roadmap for Attaining Universal Health Coverage (2020 – 2030) • Health Sector Medium-Term Development Plan (2022 – 2025) • Human Resource Policy and Strategies for the Health Sector (2020)	L
Organizational capacity development	• Lack of medium to long-term climate resilient Health sector development structures. • Absence of realistic and innovative capacity-building plans (e.g., from capacity or vulnerability and adaptation assessments) to address identified human resources and institutional capacity gaps. • Contingency plan not in place for safe and efficient personnel evacuation not available in vulnerable Health care facilities	• Human Resource Policy and Strategies for the Health Sector (2020)	L

Communications and awareness raising	• Climate and health risk communication plan not available. • Stakeholder engagement on the impact of climate change on health. • Absence of climate change and health sector communication strategy. • Inadequate awareness/knowledge on climate change	• None	L
Vulnerability, capacity, and adaptation assessment			
Vulnerability	• There are inadequate technical capacity and institutional mechanisms that integrate strategies for addressing the impact of climate change into all vertical health programs by utilizing a systems approach.	• None	L
Baseline information on capacities and gaps	• There are no baselines on existing human resources, technical and health service delivery capacity, for Health care facilities that have been prioritized to provide service in event of natural disasters or emergencies. • The routine health information and surveillance systems in Ghana collect information on specific climate sensitive infections, namely malaria, diarrhoea, meningitis, and schistosomiasis. • There are information systems outside the health sector that track changes in climate and weather, though they are not integrated with the health information systems.	• None	L
Management of environmental determinants of health			

Coordinate management of environmental risk factors for CSHOs	• Storms / floods causing Injuries /accidents, displacement and drowning of both children and adults because of storms and floods. • Storms / floods causing victims to suffer from psychological and mental health issues because of damage to houses, loss of properties and livestock and other animals from storms and floods. • Access to the health facilities within the communities is a problem during flooding. • Storms / floods causing contamination of both surface and ground drinking water sources due to storms and floods. • Storms / floods causing breeding of disease vectors such as mosquitoes. • Storms / floods causing food insecurity leading to malnutrition.	• National Disaster Management Plan. • Ten Year Mental Health Policy (2019 - 2030). • Ghana's Roadmap for Attaining Universal Health Coverage (2020 – 2030) National Health Infrastructure Strategy. • The Ghana Clean Water Project. • West Africa Food System Resilience Program (FSRP) Project. • Rice Value Chain Improvement Project. • Gulf of Guinea Northern Regions Social Cohesion (SOCO) Project. • Planting for Export and Rural Development. • PROCASHEW	M
	• Drought causing food insecurity leading to malnutrition. • Drought causing lack of access to potable water during drought leading to communicable and NCDs.	• The Ghana Clean Water Project.	M
	• Extreme heat causing high risk of heat stress / stroke among outdoor workers. • Extreme heat causing adverse reproductive health outcomes because of heat wave and stress. • Extreme heat causing dehydration due to heat waves and stress.	• Kintampo Health Research Centre is conducting study into Health impacts of excessive heat.	L
	• Bushfires causing destruction of food crops leading to malnutrition.	• None	L
	• Sea level rise causing injuries and displacement leading to psychological and mental health issues because of sea level rise.	• WB support to build Ghana's coastal area resilience.	L

	• Poor mining practices causing contamination of food chain due to poor mining practices. • Poor mining practices causing pollution of both surface and groundwater sources leading to both communicable and non-communicable diseases due to poor mining practices.	• Ghana Landscape restoration and small-scale mining project.	M
	• Logging / charcoal production causing deforestation due to logging / charcoal production. • Charcoal production causing air pollution-related diseases	• Ghana Landscape restoration and small-scale mining project by World bank. • Green Ghana project	L
	• Poor sanitation leading to contamination of surface and ground water resulting in both communicable and NCDs. • Poor sanitation leading to breeding of disease vectors.	• Community Lead Total Sanitation	L
	• Conflicts / fighting leading to injuries, accidents, displacements and deaths because of conflicts / fighting.	• DISEC and REGSEC committees	L
	• Psychological and mental health issues resulting from conflicts / fighting.	• Counselling services	L
	• Vulnerable shelter / haphazard built environment leading to injuries, diseases and displacements because of Vulnerable shelter / haphazard built environment.	• Ghana Secondary city districts project initiative.	M
	• Forced migration / displacement leading to displacement and psychological and mental health issues resulting from forced migration.	• National Disaster Management Plan.	M
	• Sand winning leading to loss of farmlands • Sand winning leading to creation of breeding ground for disease vectors.	• None	L
	• Overgrazing / farm destruction by livestock leading to food insecurity and malnutrition.	• None	L
	• Unsafe drinking water leading to communicable and NCDs from unsafe drinking water.	• The Ghana Clean Water Project	M

Monitor environmental risk factors for CSHOs	• Limited access to data on environmental risk factors for CSHOs due to financial barriers and unawareness of open sources. • Limited technical capacity to analyse environmental risk factors for CSHOs.	• MOH CC steering committee. • Inter-ministerial and technical agency committee for CC.	L
Develop/ strengthen regulations for management of environmental risk factors for CSHOs	• Inadequate mainstreaming of health impacts of climate change into regulations that control environmental risk factors of CSHOs.	• MOH CC steering committee. • Inter-ministerial and technical agency committee for CC.	L
Vector-borne and zoonotic diseases			
	• Malaria incidence has risen steadily since 2014 and plateaued from 2019 • Most interventions for vector borne disease target malaria, Yellow Fever (YF), some NTDs with few interventions and awareness on emerging threats like dengue fever. • Limited awareness on dengue fever prevention and control.	• Indoor Residual Spraying, Larviciding • Larval source management, LLINs distribution • Malaria Vaccine. • Distribution of bednets to school children, pregnant women and children due for measles II immunization. • IPTp • EPI Yellow Fever routine childhood vaccination. • Mass Drug Administration (MDA) for Bilharzia by NTD • IDSR. • Emergency preparedness and response plan by MOH/ GHS. • Routine Public education and sensitization by PHD, GHS activity. • Center for Health Security programs	M
Cerebrospinal Meningitis			

	• Spread of meningitis to non-endemic parts of the country due to climate change	• IDSR. • Emergency preparedness and response plan by MOH/ GHS. • Routine Public education and sensitization by PHD, GHS activity. • Center for Health Security programs	M
Malnutrition			
	• Poor mining practices, sand winning and other causes of loss of farmlands threatening food security. • Drought threatens food security. • Floods can threaten food security by destroying farmlands	• Ghana Nutrition Improvement Program, GHS • Ghana Landscape restoration and small-scale mining project • Education/awareness creation by Public Health Division (PHD), GHS. • Community based management of acute malnutrition by PHD, GHS. • Growth monitoring and promotion by FHD, GHS.	M
Respiratory Illness and allergic diseases			
	• Inadequate surveillance on allergic respiratory diseases	• Standard treatment guidelines, MOH/GHS • TB vaccination/ screening/case detection by NTP	M
Cardiovascular Diseases			
	• Low awareness about links between air pollution (outdoor & indoor) and CVD • High usage of biomass fuel causing indoor air pollution • Increased exposure to harmattan (desert) dust	• Case management guidelines by PHD &ICD MOH/GHS • Health Education • Health screening by NCDP • Capacity building of health workers by NCDP	M

Food-borne illness			
	• Inadequate access to information/data on food borne illnesses (FDA-INFOSAN) • Low awareness raising on preventive measures among the food vendors • Poor sanitation and hygienic practices	• Health Education • Treatment guidelines	L
Water-borne diseases (Cholera, Typhoid, Diarrhoea)			
	• Increased disease risk due to shortage of drinking water (Drought). • Contamination of drinking water sources (ground and surface water) during flooding events • Poor mining practices causing chemical pollution of water sources • Poor environmental sanitation and hygienic practices	• IDSR • IPC/WASH activities • Health Education • Standard treatment guidelines • Ghana Landscape restoration and small-scale mining project	M
Mental Health and psychosocial Disorders			
	• Inadequate surveillance on mental health. • Displacements due to disasters caused by extreme weather events	• Capacity building of staff • NADMO	M
Injuries & Accidents (from extreme weather events)			
	• Increase in disasters caused by extreme weather events • Inadequate access to data on injuries & accidents (extreme weather events)	• Public Education • NADMO	M
Snake Bites			
	• Increase risk of exposure during heat episodes. • Destruction of habitats by wildfires • Inadequate access to ASV.	• Standard treatment guidelines • Free ASV and anti-rabies policy	M
Water washed diseases (Yaws, Scabies, Trachoma etc.)			
	• Increased disease risk due to shortage of water (Drought) • Poor sanitation and hygienic practices.	• NTDP of GHS	M
Heat Related Illness (Heat stress, heat strokes)			

	• There is no surveillance, inadequate preventive interventions for heat related illnesses • Loss of work hours and productivity among large section of workforce engaged in outdoor work. • Limited knowledge between Heat exposure and adverse health outcomes	• KHRC study	L
Injuries & Accidents (from RTAs)			
	• Dust storms and fog reducing visibility for drivers. • Inadequate access to data on injuries & accidents (extreme weather events) and data on injuries & accidents (RTA)	• NRSC Regulations • EPA AQMPs	M
Integrated risk monitoring and early warning			
Integrated disease surveillance and early warnings	• There is no systematic sharing of health and environment data. • There is no IT system/platform for sharing, managing or analysing shared health and environment data. • There are no operational EWSs for CSHOs based on an integrated health and environment surveillance platform.	• HESA (Defunct)	L
Monitoring climate change indicators	• There is poor quality of data on many CSHOs reported in the DHIMS. • Limited access to data on environmental risk factors for CSHOs due to financial barriers and unawareness of open sources.	• None	L
Risk communication	• There is no structured risk communication and community engagement strategy for CSHOs based on reliable predictions from EWS, health impact models and other sources of scientific evidence.	• None	M
Emergency preparedness and management			
Inform policies and protocols	• There are no costed emergency preparedness plans. • Health systems within the health sector not resilient to withstand emergency situations. • There is no post evaluation response planning.	• None	L
Risk management	• Weak contingency planning for evacuation purposes	• None	L
Climate and health financing			

Health-specific funding mechanisms.	• The government's health budget has increased in absolute terms in recent years, but health facilities are highly dependent on NHIS payments for services to cover non-salary costs. • There are no sustainable streams of funding for climate change and health.	• Between 2015 and 2020, the Government of Ghana (GoG) reportedly spent an average of 4% of the total government expenditure on Climate Relevant Actions.	L
Climate change funding streams.	• Inadequate utilization of global Climate change funding streams • No representation of the health sector on GCF disbursement committee at Nationally Designated Authority (NDA)		L
Climate resilient and sustainable technologies and infrastructure			
Adaptation of current infrastructures, technologies, and processes.	• No assessments have been conducted to determine the climate resilience of health facilities in the country. • There is limited information on the frequency of stock-outs of drugs used to prevent and manage common climate sensitive conditions. • There is no systematic reporting on health facilities being flooded due to extreme weather events. • Floods and other extreme weather events are known to cause damage and cut off access to hospitals and other health. • There is limited information/data on the state of health infrastructure. • Knowledge, experience (considering previous damages) and resource capacity (including human, material, financial, supplies chain and logistics) is provided only during disease outbreaks but not to manage flood risk reduction in health facilities. • Inadequate collaboration with the regional government/agencies (e.g., NADMO) to support vulnerable populations to actively participate in risk reduction management, policy making, planning and implementation. • Little capacity for conduct of climate risk and vulnerability assessments at sub-national levels to identify risk scenarios, vulnerabilities, and the facility's response capacity.		L

	• Inadequate protection and insulation against moisture and Mould. • Many health facilities with secret-roof design are leaking.		
Promotion of climate resilient and sustainable technologies and infrastructure	• Availability of diagnostic tools, vaccine, and treatment available at most health facilities is not yet targeted at addressing health risks of climate change. • Very few health facilities are using renewable energy sources such as solar energy.	•	L
Sustainability of health operations	• Inadequate tree planting to serve as wind break. • No evaluation of the condition and safety of structural and non-structural elements impacted by previous exposure to flood. • No operation of a regular schedule to inspect health facilities both internally and externally, for signs of deterioration (e.g., cracks or sinking structural elements) to avoid or reduce flood impacts. • No contingency plan in place for safe/efficient personnel evacuation (including health staff and patients), and for equipment and other essential supplies before, during and following a flood.	•	L
Supply chain			
	• No risks assessment of the supply chain undertaken. • Consumption of essential medical, pharmaceutical, nutritional, and laboratorial supplies, personal protective equipment, food, etc. is not estimated for flood periods. • Plan not available to ensure continuity of the facility's supply and delivery chain in case of disaster/ emergencies. • Vulnerable Health care facilities have no cooperate agreements with other facilities to secure access to essential services like sterilization/laundry/blood bank. • Plan for relocating medical devices, medicines etc. not available.	• None	L
Climate and health research			

Research agenda	• No climate and health research agenda developed. • Inadequate research into relation between human exposure to climatic variables and health outcomes.	• OEHP • GHS Research centres	M
Connect to policy	• No policy fora, meetings and conferences organized where researchers could engage policy-makers to disseminate research that support development of evidence-based policies on climate change and health.	• None	L

4. Regional findings

4.1. Regional trends in risk of prioritized climate sensitive health outcomes, 2014-2023

In this section, 10-year (2014 to 2023) trends in current morbidity caused by prioritized CSHOs are discussed by regions to provide a baseline. The data is sourced mostly from the monthly out-patient morbidity, IDSR and Growth monitoring reports on the DHIMS platform of GHS. Whereas the data sourced from monthly out-patient morbidity and growth monitoring reports is disaggregated by gender at source, the IDSR data is not disaggregated by gender.

The analysis revealed that each region has different climate-sensitive health risk priorities, reflecting different levels of exposure, sensitivity and adaptive capacity.

4.1.1. Vector-borne diseases

In figure 59, there has been a gradual rise in malaria risk in all regions except for Greater Accra where the risk is relatively low, and the trend has been declining over the period. The rise in malaria risk has been more rapid in the North East, Upper West region, Savannah, Northern and Central regions. The highest risk was recorded in the Upper West region in 2023 (34% of OPD registrants).

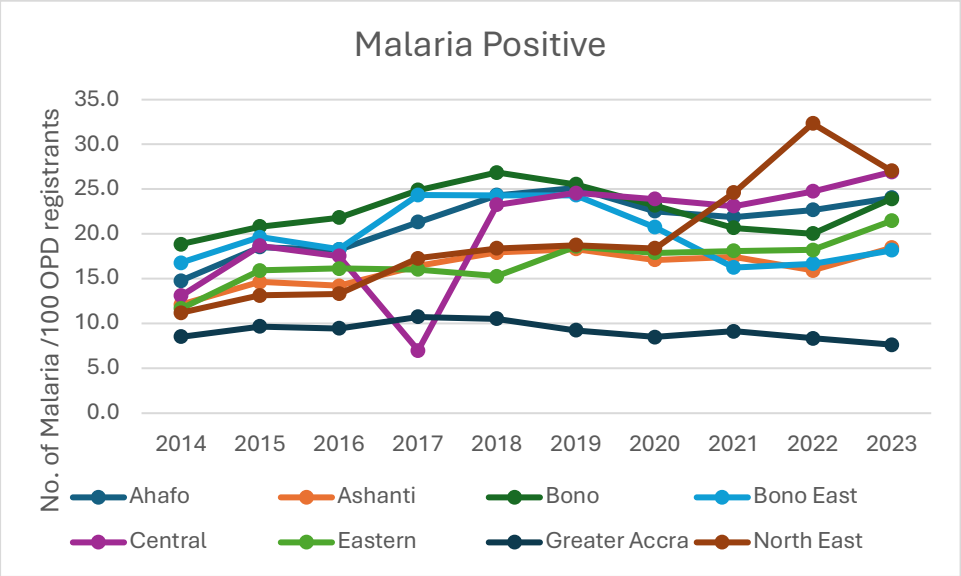

Figure 52a: Incident cases of malaria per 100 OPD registrants, 2014-2023

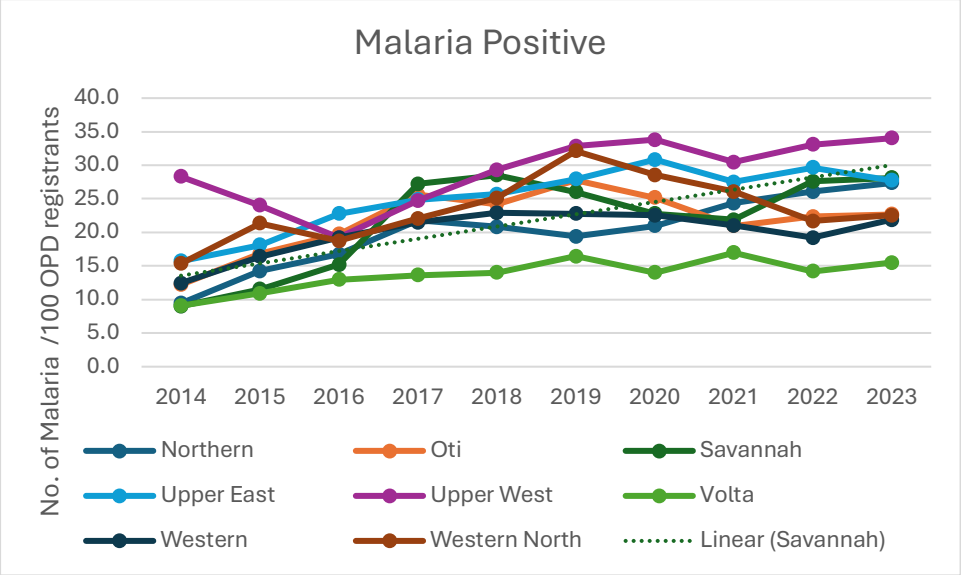

Figure 59b: Incident cases of malaria per 100 OPD registrants, 2014-2023

4.1.1.2. Schistosomiasis

Figure 60 shows a gradual decline in the risk of Schistosomiasis over the period in all regions, the steepest decline being reported in Bono east and Upper east regions. Currently, this disease seems to be under control in all regions.

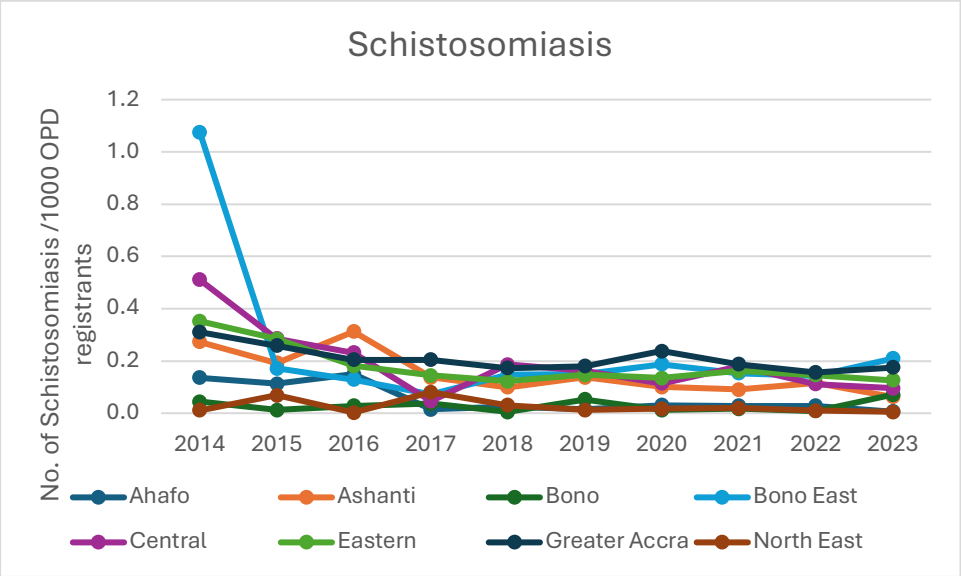

Figure 60a: Incident cases of Schistosomiasis per1000 OPD registrants, 2014-2023

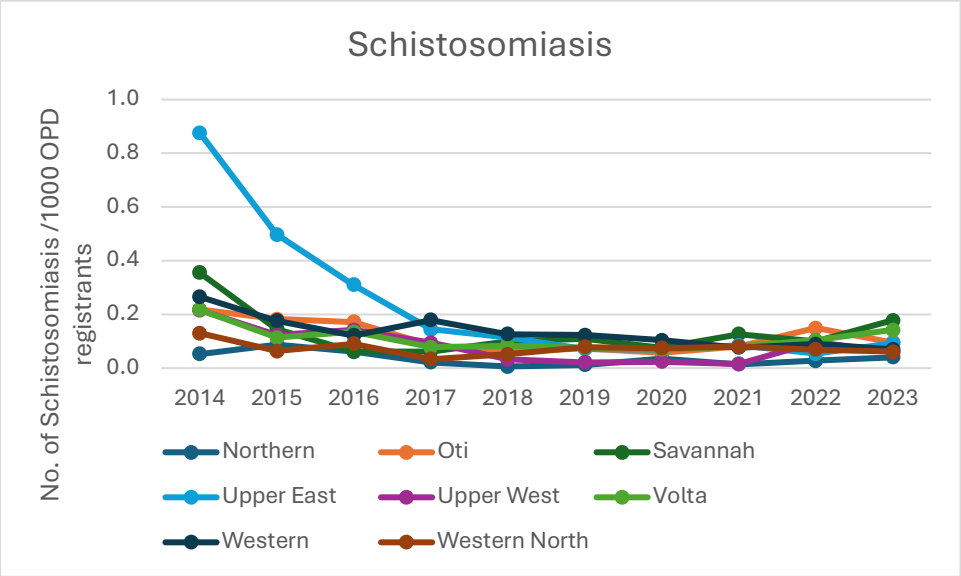

Figure 60b: Incident cases of Schistosomiasis per1000 OPD registrants, 2014-2023

4.1.1.3. Lymphatic Filariasis

Figure 61 shows that the incidence level of lymphatic filariasis was well under control after 2014 until spikes in incidence begun to occur in the Western, Western North, Savannah, Upper West and Bono East regions between the period 2019 to 2023. The peak incidence of 1.2 cases per 1000 OPD registrants was recorded in Savannah region in 2021.

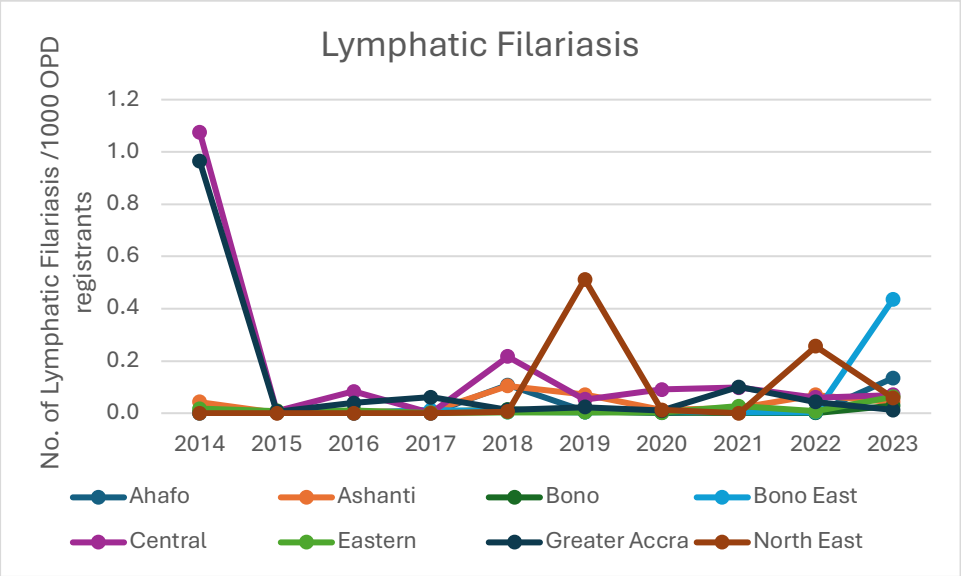

Figure 531a: Incident cases of lymphatic filariasis per1000 OPD registrants, 2014-2023

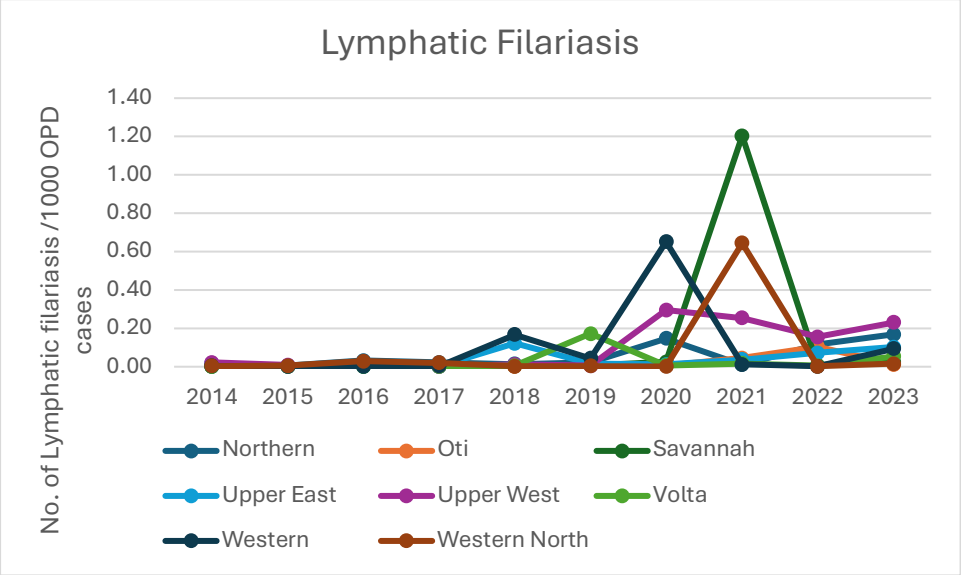

Figure 61b: Incident cases of lymphatic filariasis per1000 OPD registrants, 2014-2023

4.1.1.4. Yellow Fever

In figure 62, there were sudden spikes or outbreaks of Yellow fever risk over the period. The first surge occurred in the Upper East region in 2017 with about 1.0 case per10,000 OPD registrants. This was followed by Savannah region in 2020 with 2.2 cases per10,000 OPD registrants. In terms of current trends, the risk of Yellow fever in the Eastern region rose sharply from 0.1 to 0.7 cases per10,000 OPD registrants between 2022 and 2023.

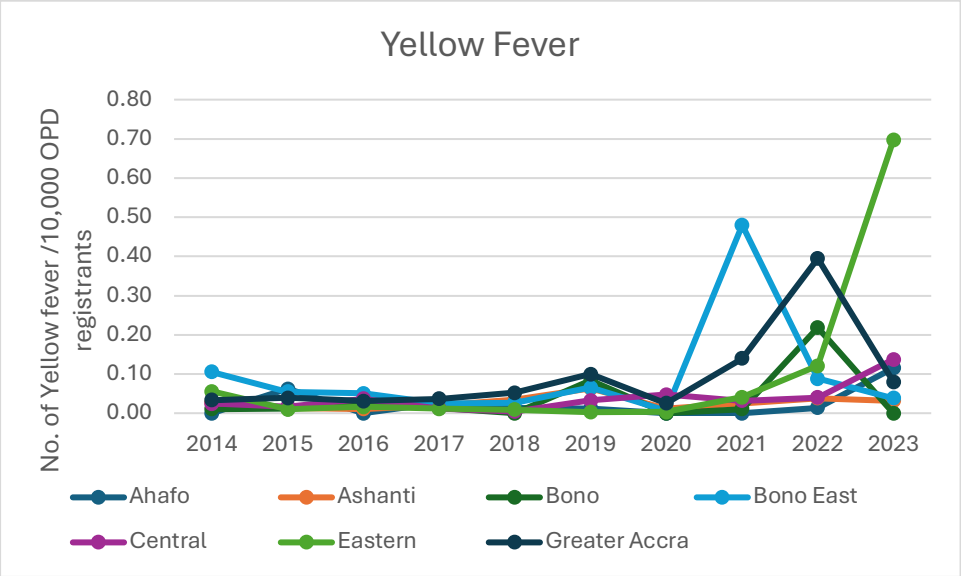

Figure 62a: Incident cases of Yellow fever per 10,000 OPD registrants, 2014-2023

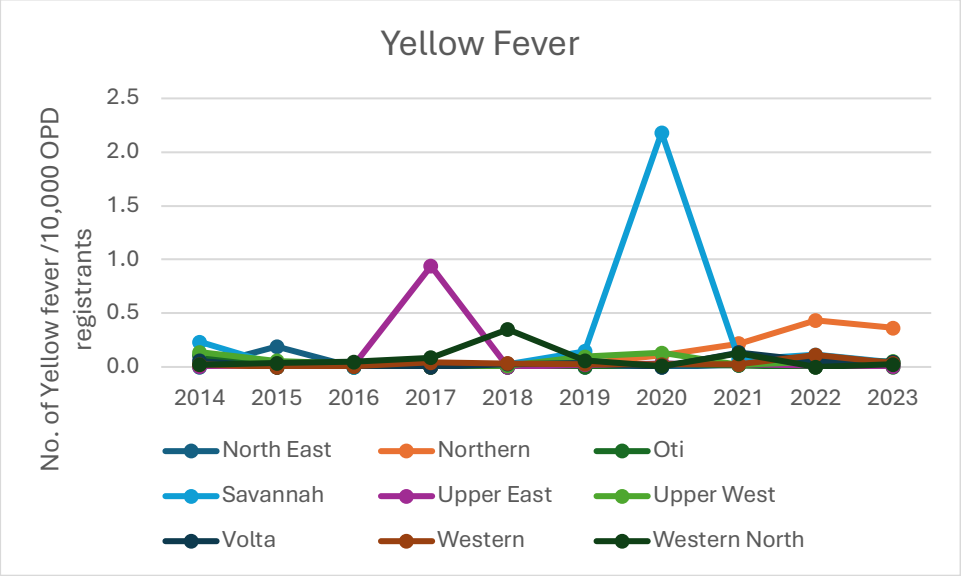

Figure 62b: Incident cases of Yellow fever per10,000 OPD registrants, 2014-2023

4.1.1. Meningitis

Figure 63 shows that over the period, outbreaks of meningitis have largely cantered around four (4) regions, despite sporadic spikes in others. There has been outbreaks of meningitis in the Northern region in 2015, Upper West region in 2016, 2020, 2023, Savannah region in 2017 and Ahafo region in 2021, otherwise levels, of risk have remained low in the other regions over the period. The peak incidence was reported in the Upper West region in 2023.

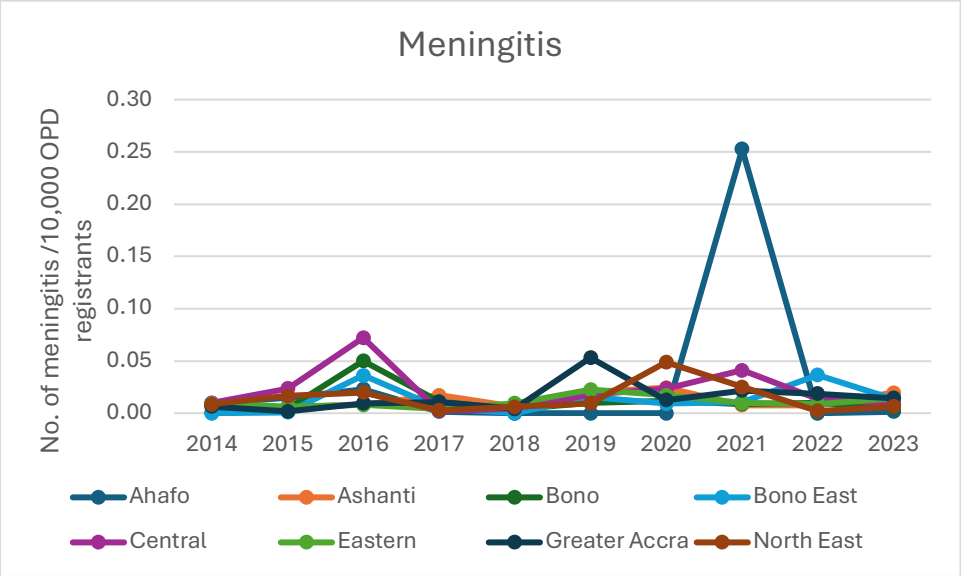

Figure 63a: Incident cases of meningitis per10,000 OPD registrants, 2014-2023

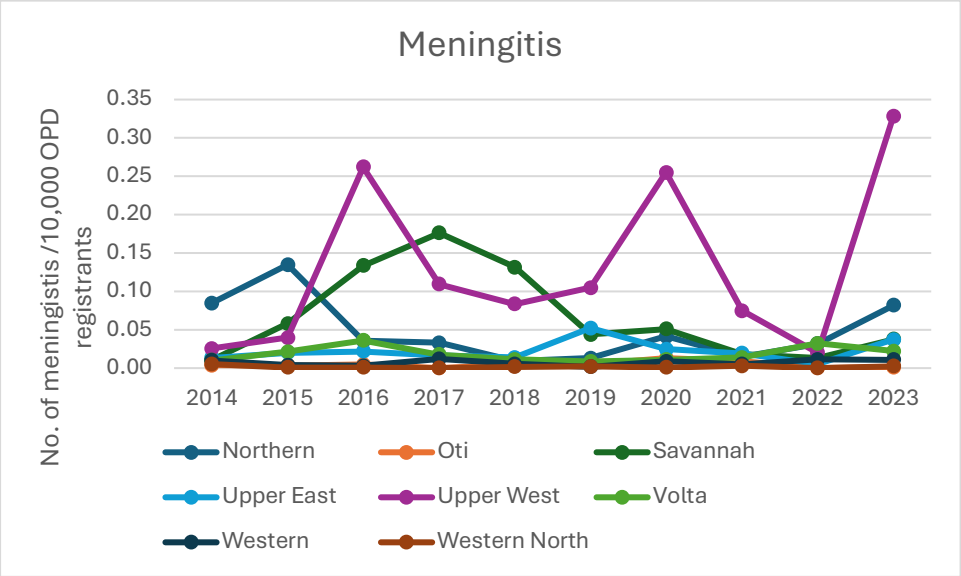

Figure 63b: Incident cases of meningitis per10,000 OPD registrants, 2014-2023

4.1.2. Food insecurity and malnutrition

Figure 64 shows that the risk of malnutrition among children below 5 years remained below 4.0 cases per 1000 OPD registrants in most regions from 2014 to 2023. A significant increase in the risk was observed in the Greater Accra region from 2016 onwards, however, the highest surge occurred in the Northern region in 2021, when a peak level of 18.1 cases per 1000 OPD registrants was recorded.

The risk of child malnutrition in the Bono East region fell sharply from about 5.6 to 0.6 children <5 years per1000 OPD registrants in 2015 and remained low. There has also been a very gradual decrease in risk over the period in the Savannah region.

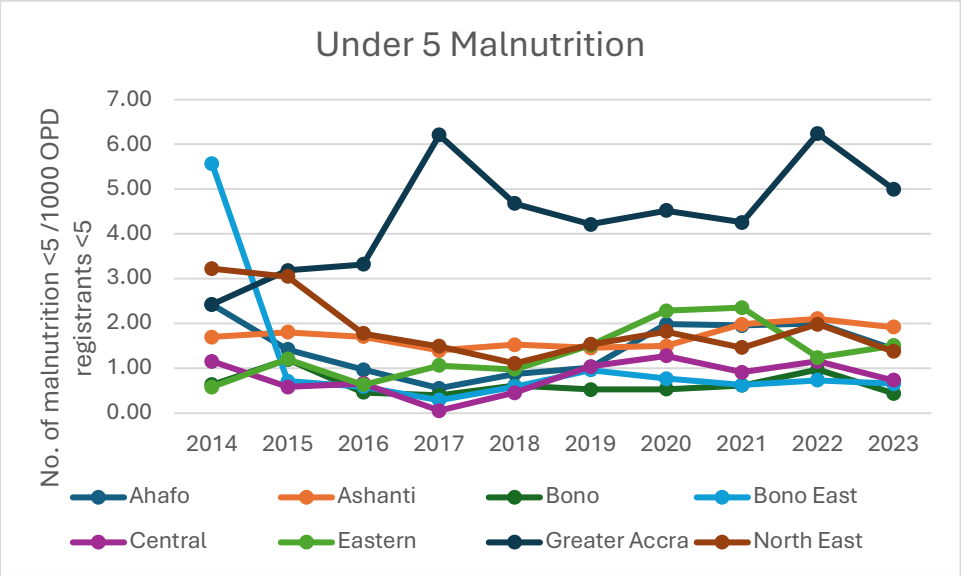

Figure 64a: Incident cases of malnourished children <5 years per1000 OPD registrants <5 years, 2014-2023

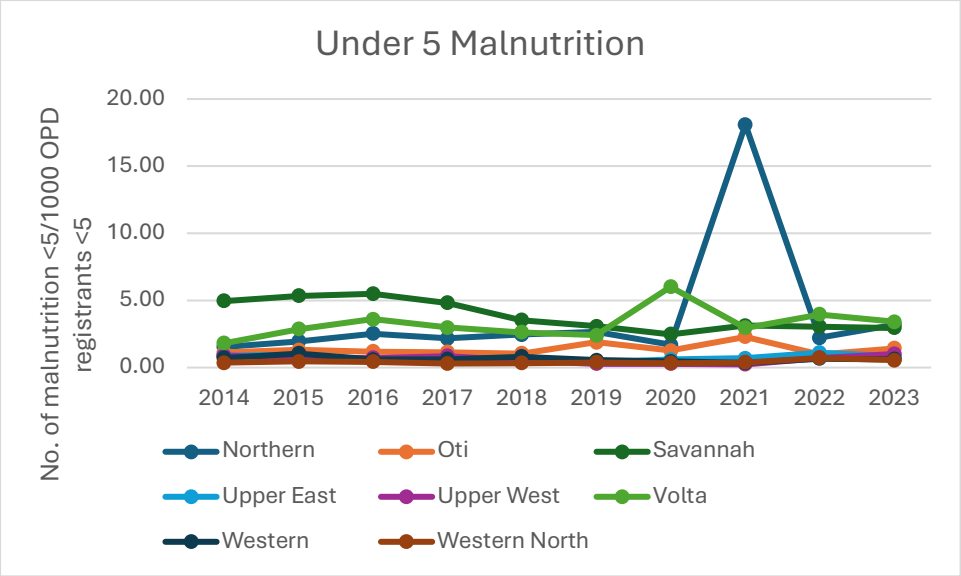

Figure 64b: Incident cases of malnourished children <5 years per1000 OPD registrants <5 years, 2014-2023

4.1.3. Air pollution related diseases

The trend in risk levels for some of these diseases from 2014 to 2023 are discussed by regions in the section. The data source is mostly from the DHIMS platform of GHS.

Figure 65 shows that over the period, the North East region reported the highest risk of Upper Respiratory Tract Infection (URTIs) with a peak incidence of 20.8 cases per1000 OPD registrants in 2018. All the other regions reported incidences between 8.0 and 18.0 cases per1000 OPD registrants over the period except for Central region that experienced a sharp decline in risk in 2017.

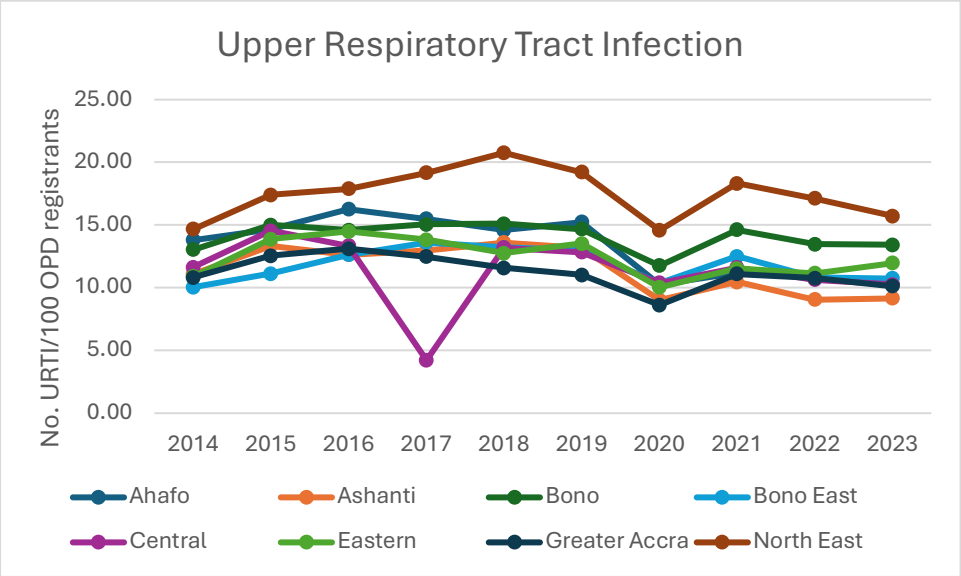

Figure 65a: Incident cases of upper respiratory tract infections per1000 OPD registrants, 2014-2023

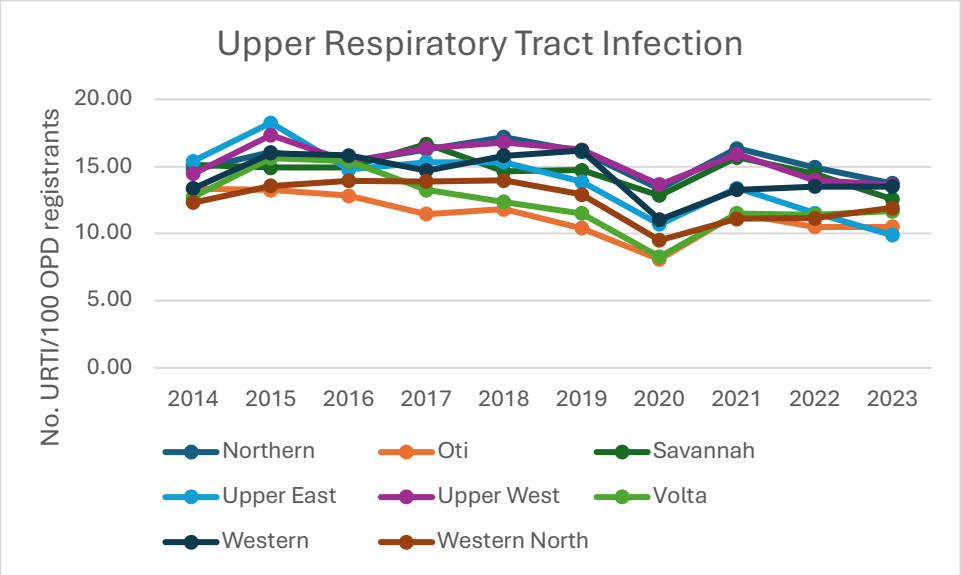

Figure 65b: Incident cases of upper respiratory tract infections per1000 OPD registrants, 2014-2023

4.1.3.2.: Asthma

According to the observed regional distribution of asthma cases in figure 66, the risk of Asthma was mostly below 4.0 cases per1000 OPD registrants throughout the period. Higher levels were mostly reported in the Greater Accra region, followed by the Ashanti region. However, the risk of Asthma has been gradually increasing in the Greater Accra region, recording a peak incidence of 7.6 cases per1000 OPD registrants in 2012, but then slowly declining in the Ashanti, Volta and Upper east regions.

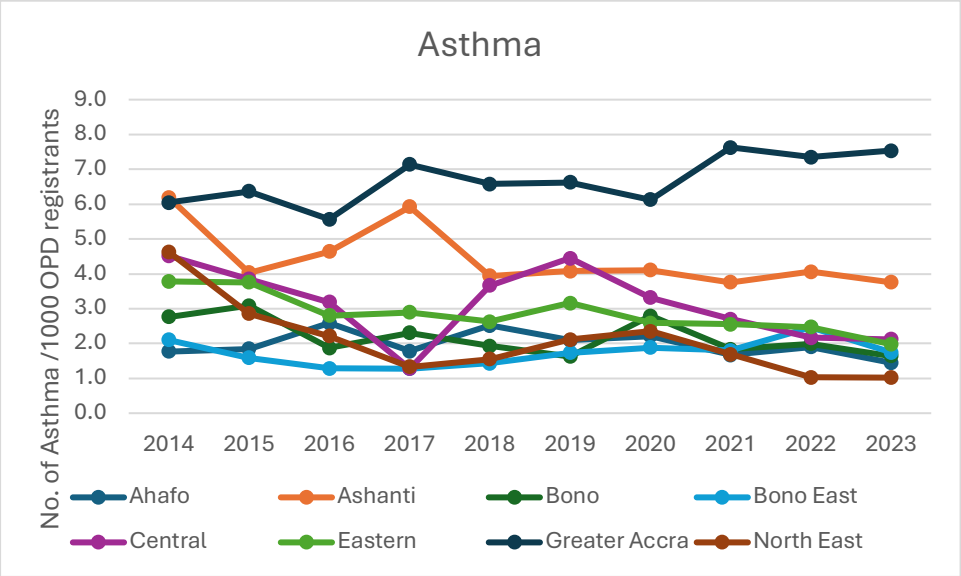

Figure 66a: Incident cases of Asthma per1000 OPD registrants, 2014-2023

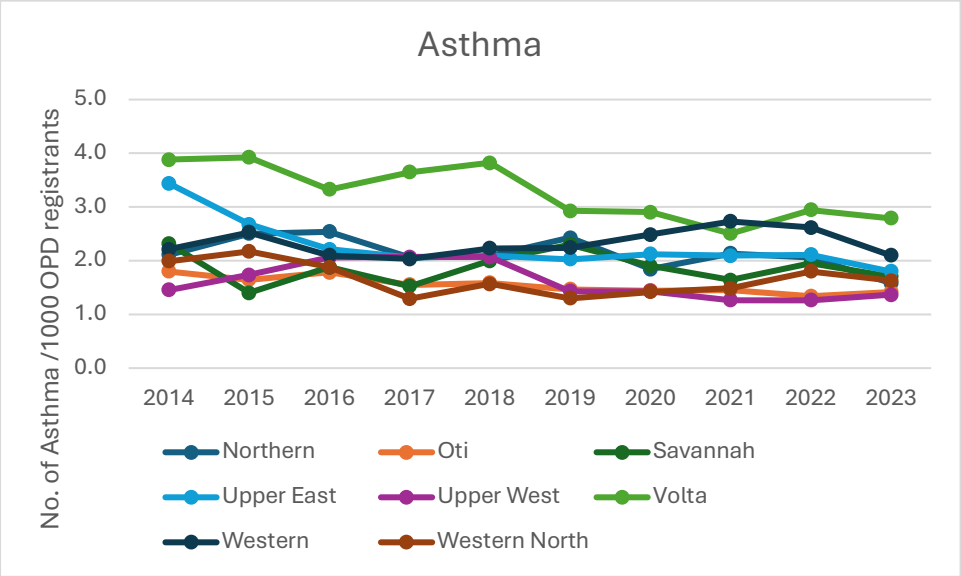

Figure 66b: Incident cases of Asthma per1000 OPD registrants, 2014-2023

4.1.3.3. Pneumonia

In figure 67, the risk of pneumonia among children below 5 years was observed to be increasing in all regions over the period 2014-2023. The highest incidence of 59.0 cases per1000 OPD registrants under 5 years was reported in the Volta region in 2021, followed by Bono East. Peak incidences of under 5 pneumonias, ranging between 33.0 and 53.0 cases per 1000 OPD registrants under 5 years

were observed in 2023 (at the end of the period of observation) in the Ashanti, Eastern, Greater Accra, Oti and North East regions.

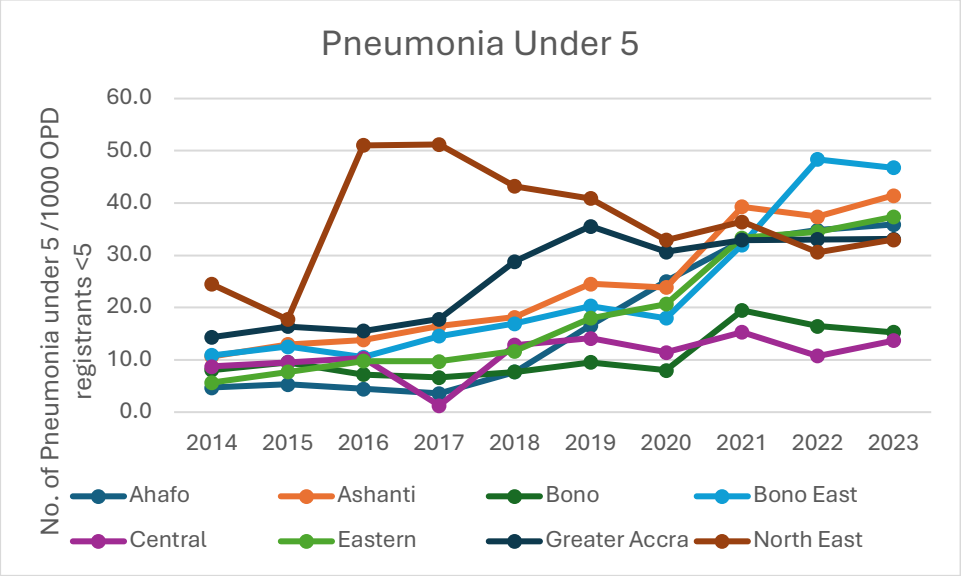

Figure 67a: Incident cases of Pneumonia per1000 OPD registrants under 5 years, 2014-2023

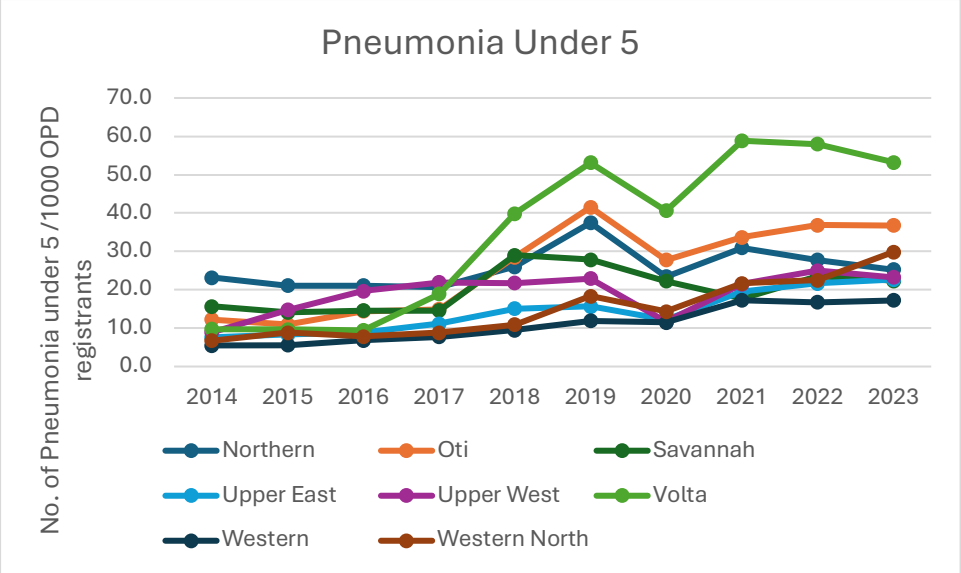

Figure 67b: Incident cases of Pneumonia per1000 OPD registrants under 5 years, 2014-2023

4.1.4. Cardiovascular diseases

In figure 68, the incidence of stroke (ischaemic and/or haemorrhagic) was below 0.5 cases per1000 OPD registrants in many regions. In five regions (Greater Accra, Ashanti, Eastern, Central and Volta), higher levels of stroke risk were observed. In Greater Accra, Ashanti, Eastern, and Volta regions the risk was steadily rising over the period while in Central region the risk begun to decrease from 2020

onwards. A peak incidence of 2.7 cases per1000 OPD registrants was observed in Greater Accra region in 2022.

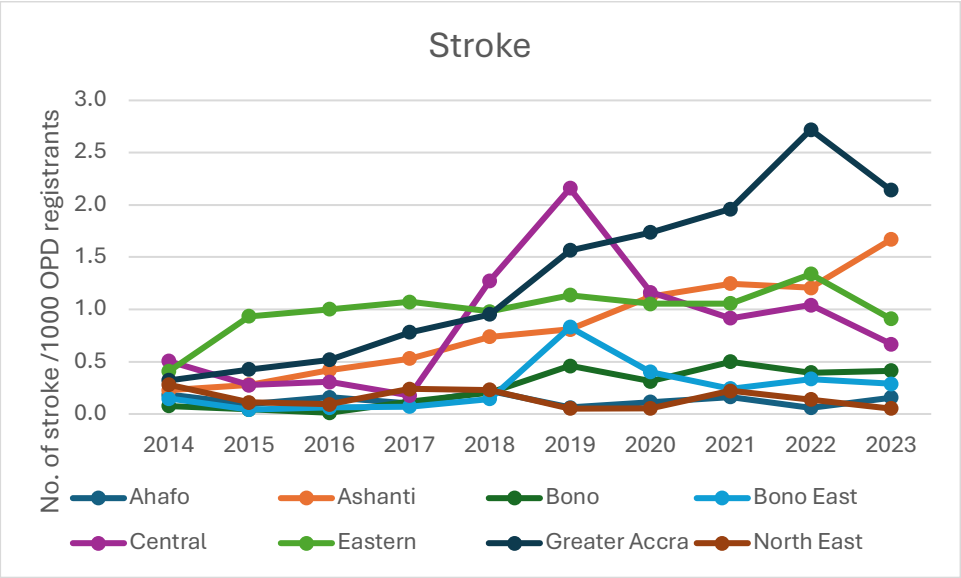

Figure 68a: Incident cases of Stroke per 1000 OPD registrants, 2014-2023

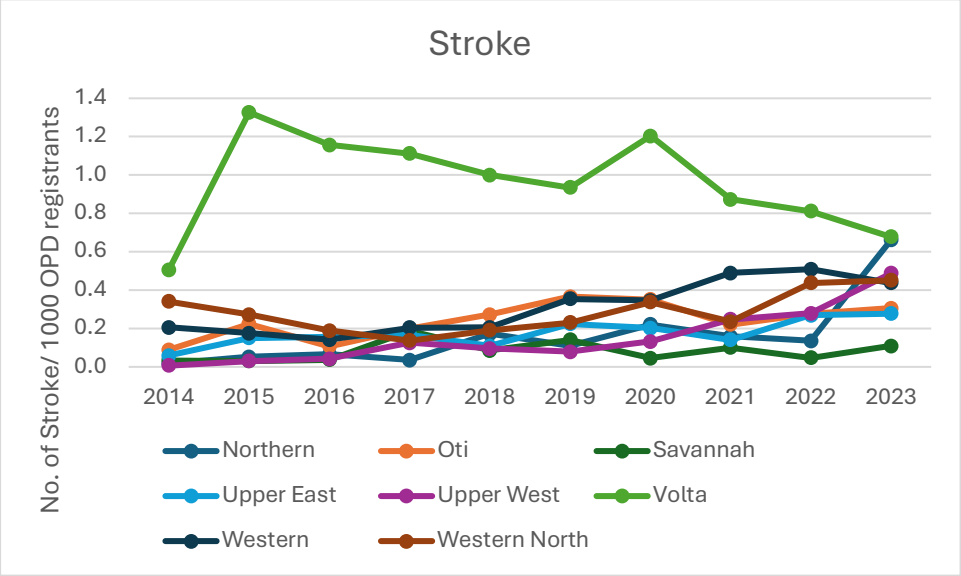

Figure 68b: Incident cases of Stroke per 1000 OPD registrants, 2014-2023

4.1.4.2. Cardiac Diseases

Cardiac diseases refer to diseases like ischaemic heart disease, heart failure etc. In figure 69 the risk of cardiac diseases kept fluctuating in most regions without any significant net change over the period. Relatively high levels of cardiac disease risk between 2.0 and 4.0 cases per 1000 OPD registrants were mostly reported in the Volta, Greater Accra and Eastern regions.

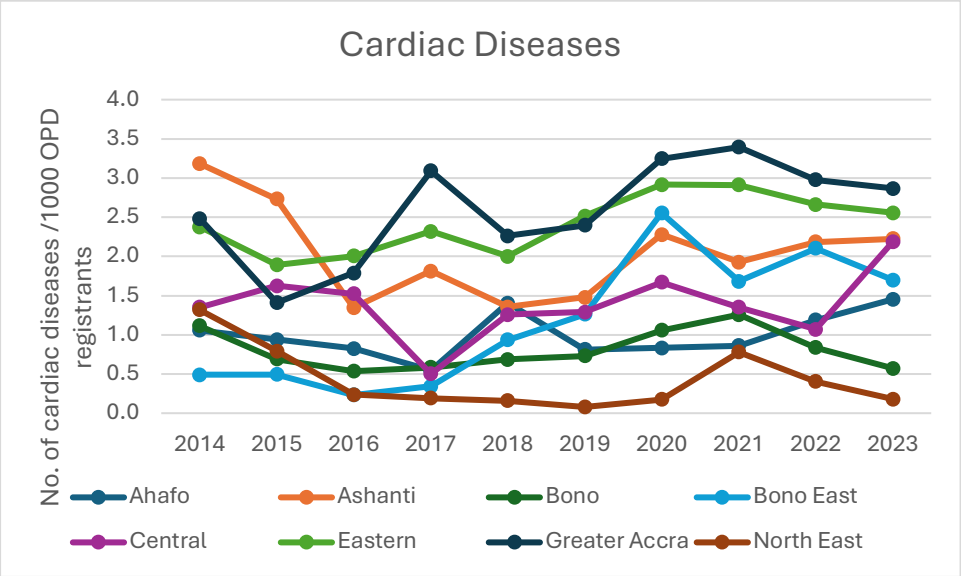

Figure 69a: Incident cases of Cardiac disease per 1000 OPD registrants, 2014-2023

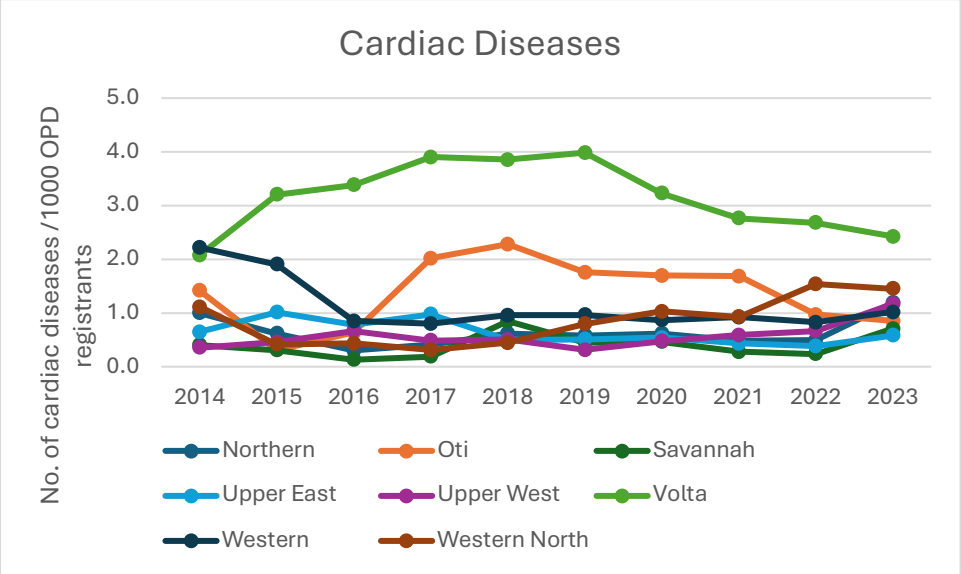

Figure 69b: Incident cases of Cardiac disease per 1000 OPD registrants, 2014-2023

4.1.4.3. Injuries and accidents related to RTAs

The incidence of transport injuries in most regions ranged between 2.0 to 6.0 cases per 1000 OPD registrants over the period 2014-2023 (figure 70). However, higher levels of transport injury risk were observed in the Ahafo, Greater Accra and Upper West regions. The highest risk of 12.8 cases per 1000 OPD registrants was observed as an incidence spike in Ahafo region in 2018. Overall, there were no net changes in risk in all regions, over the reporting period.

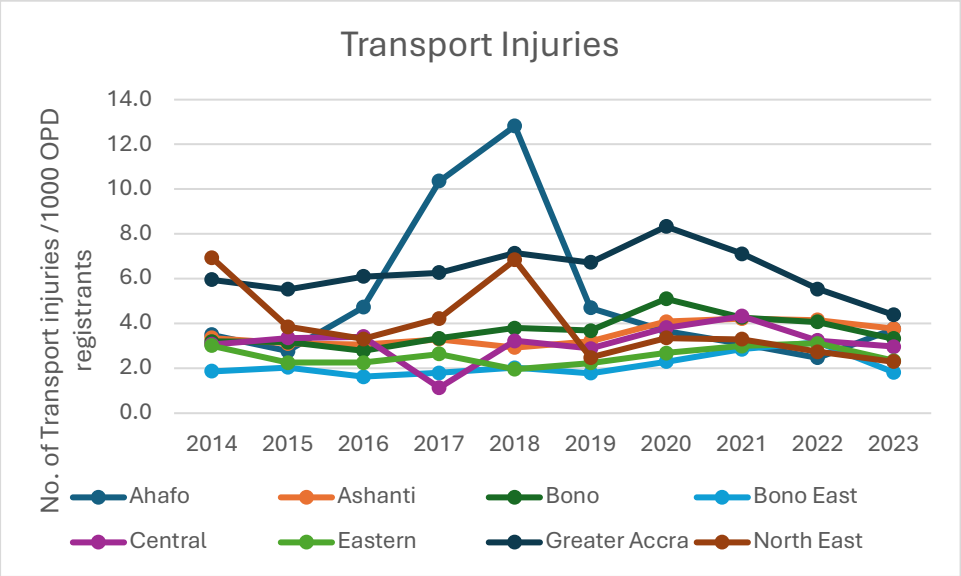

Figure 70a: Incident cases of RTA per 1000 OPD registrants, 2014-2023

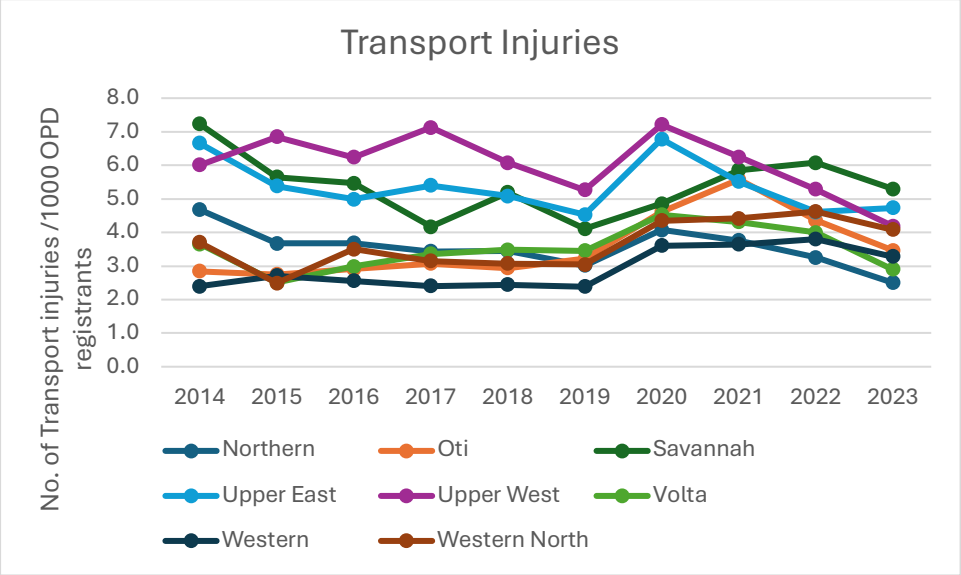

Figure 70b: Incident cases of RTA per 1000 OPD registrants, 2014-2023

4.1.5. Food and water borne diseases

In most regions the incidence of diarrhoea among children under 5 year was below 15.0 cases per 100 OPD registrants under 5 years. However, relatively higher risk was observed in the North East, Northern, Savannah and Oti regions (figure 71). The peak incidence of 22.0 cases per 100 OPD registrants under 5 years was reported in the North East region in 2018.

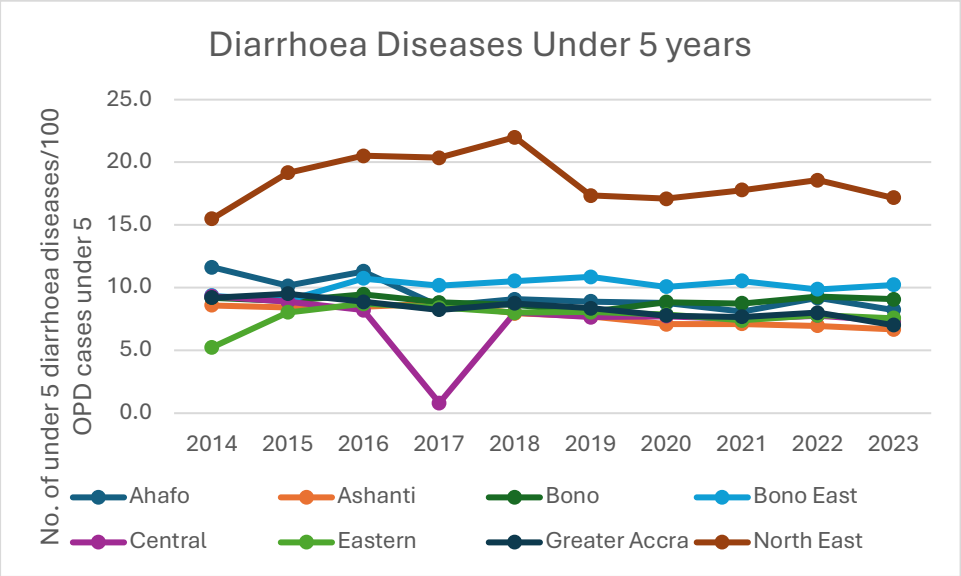

Figure 71a: Incident cases of diarrhoea in children <5years per 100 OPD registrant< 5 years, 2014-2023

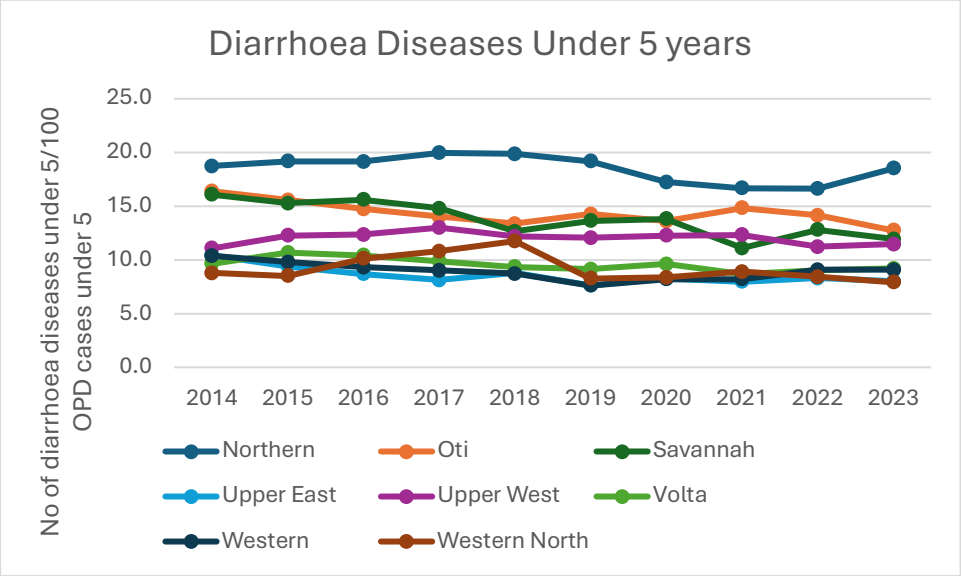

Figure 71b: Incident cases of diarrhoea in children <5years per 100 OPD registrants< 5 years, 2014-2023

4.1.5.2. Cholera

Figure 72 shows that overall cholera risk was very low in all regions, however, occasionally there were spikes in incidence (outbreaks) observed in some years in specific regions. Outbreaks were observed in the Central region (2016) and Western North region (2022) over the period.

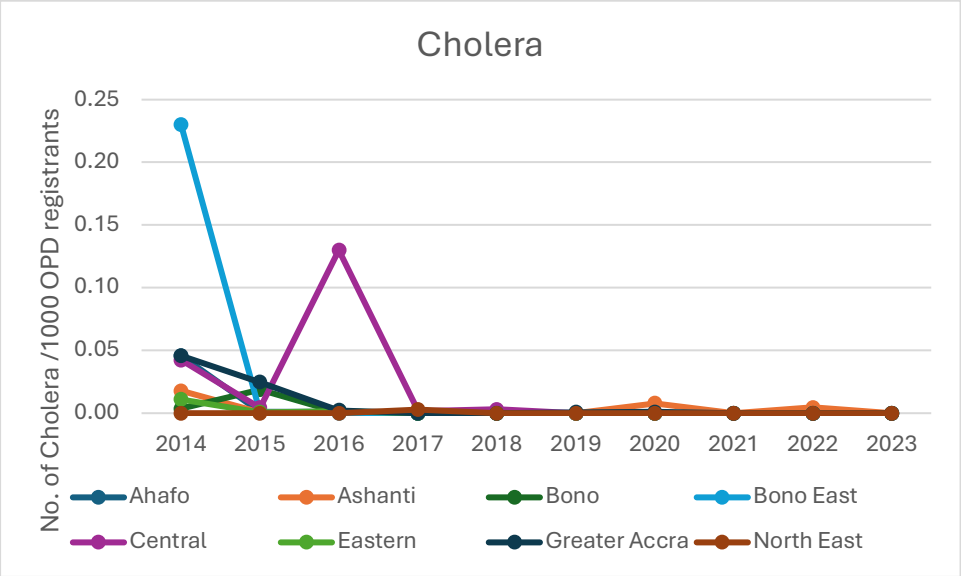

Figure 72a: Incident cases of Cholera per 1000 OPD registrants, 2014-2023

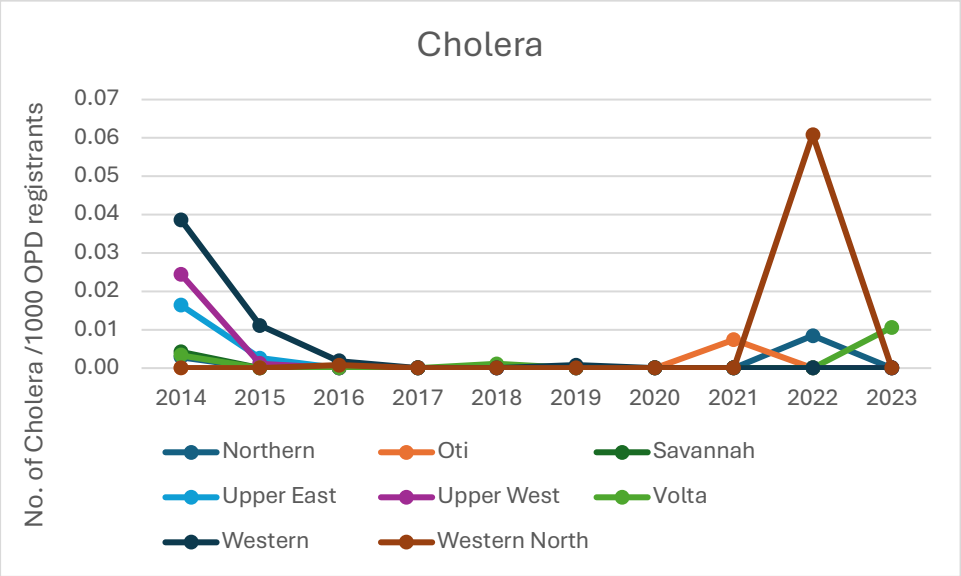

Figure 72b: Incident cases of Cholera per 1000 OPD registrant, 2014-2023

4.1.6. Mental health disorders

The risk of depression was fluctuating in most regions without any significant net change over the period (figure 73). Most of the risk levels fluctuated below 1.0 per 1000 OPD registrants in all regions except for Volta region where there was a surge in reported risk of depression in between 2016 and 2017. The highest incidence reported was 6.3 cases per 1000 OPD registrants in 2017 in the Volta region.

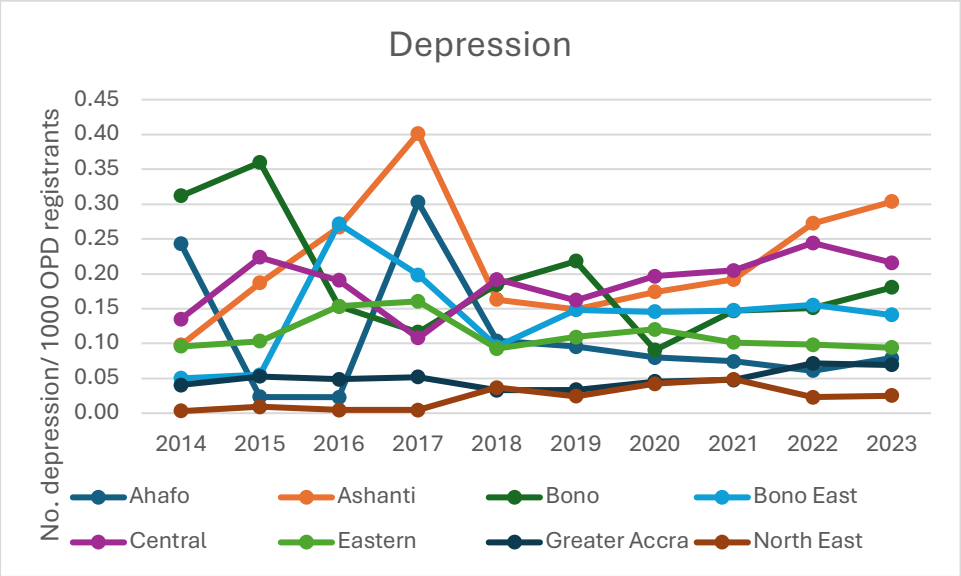

Figure 73a: Incident cases of Depression per 1000 OPD registrants, 2014-2023

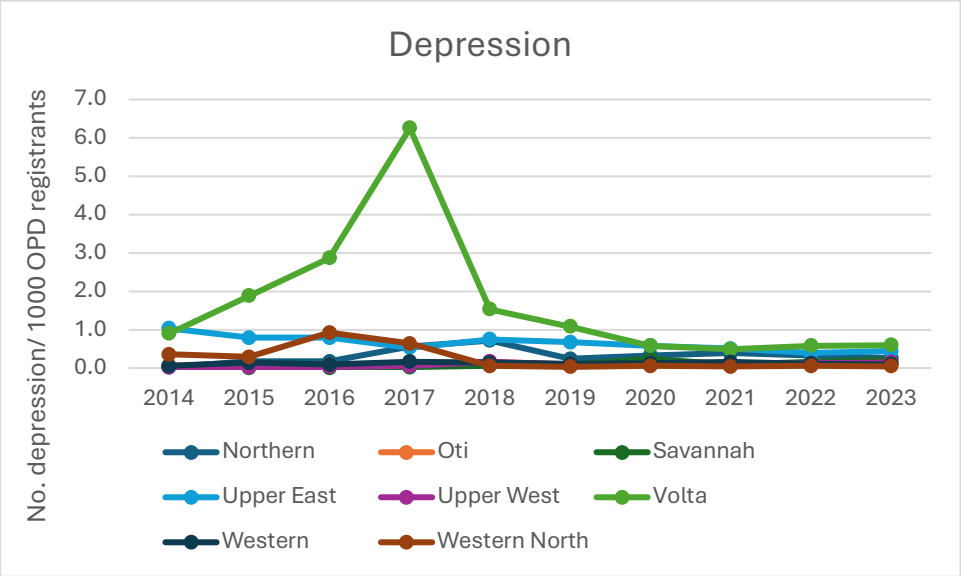

Figure 73b: Incident cases of Depression per 1000 OPD registrants, 2014-2023

4.1.6.2. Generalized Anxiety

Figure 74 shows that the risk of generalized anxiety has been declining in all regions since 2017. However, the trends in the Bono east and Ashanti regions show a gradual increase in risk since 2019.

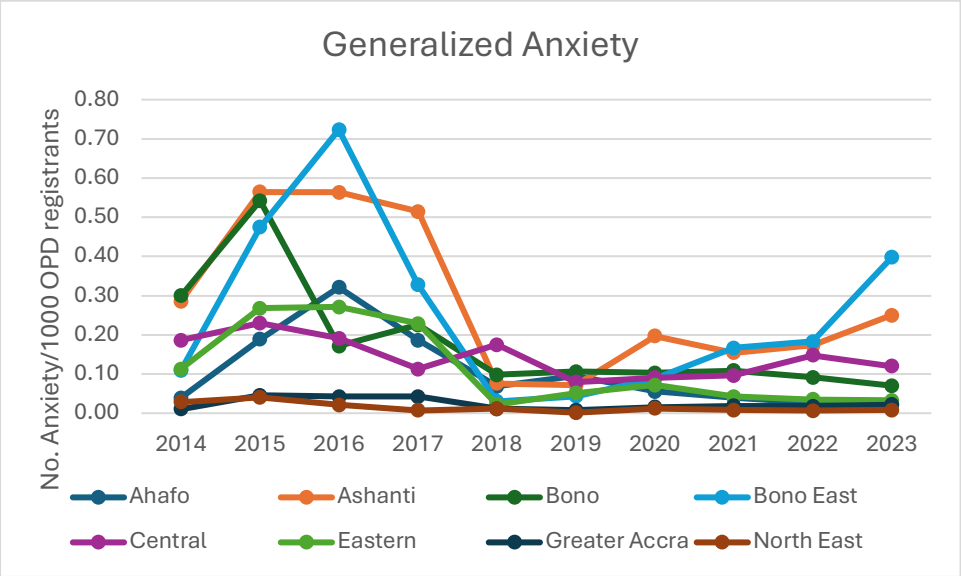

Figure 74a: Incident cases of generalized anxiety per 1000 OPD registrants, 2014-2023

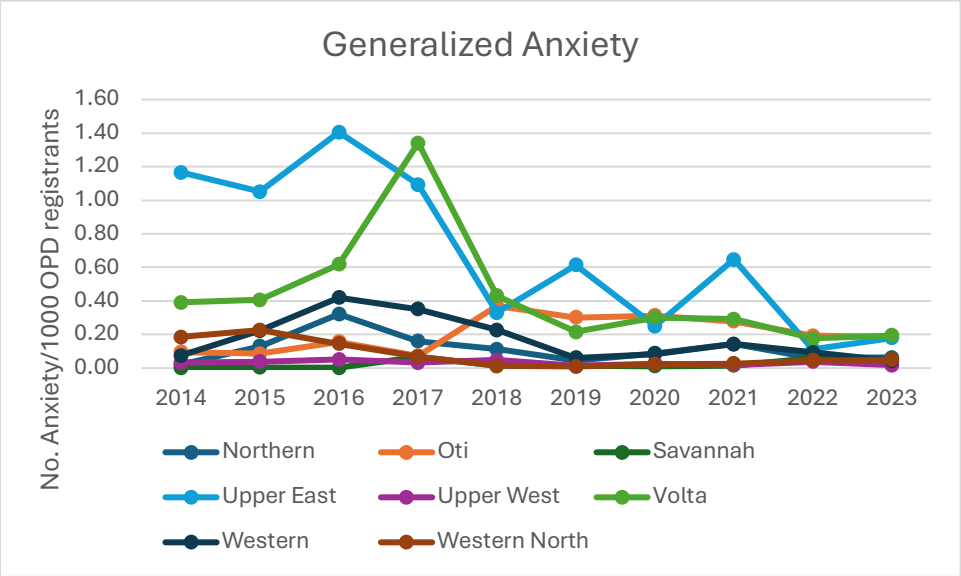

Figure 74b: Incident cases of generalized anxiety per 1000 OPD registrants, 2014-2023

4.1.7. Snake bites

In figure 75, the risk of snake bites in most regions was usually less than or equal to 6.0 cases per 1000 OPD registrants over the period. Notable exceptions were in the Upper West, Savannah, Northern and North East regions where the incidence was much higher. The highest incidence of 2.0 was achieved in Upper West region (2017) and Savannah region (2023).

In 2017, the trend begun to rise in the North East region, and in 2018 it started rising in the Northern and Savannah regions.

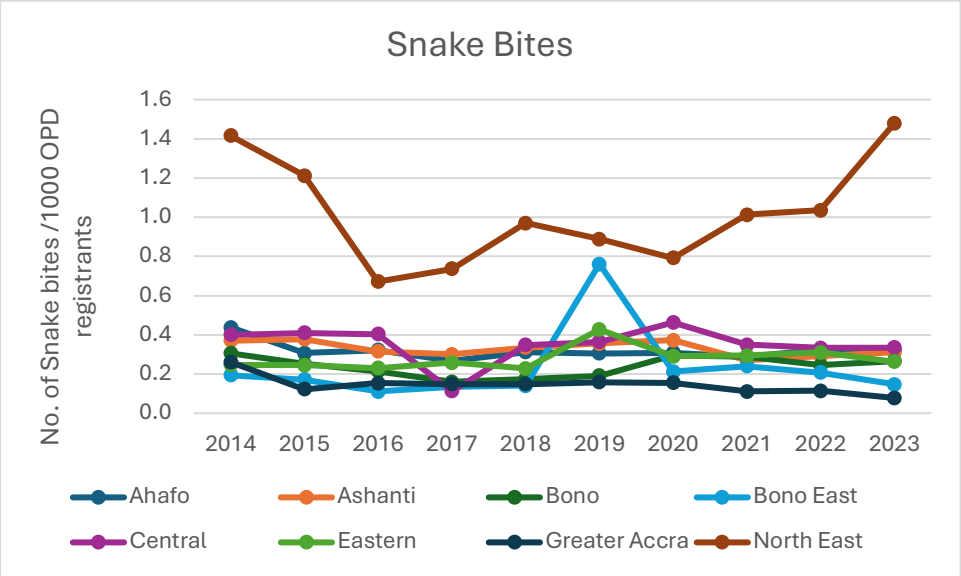

Figure 75a: Incident cases of snake bites per 1000 OPD registrants, 2014-2023

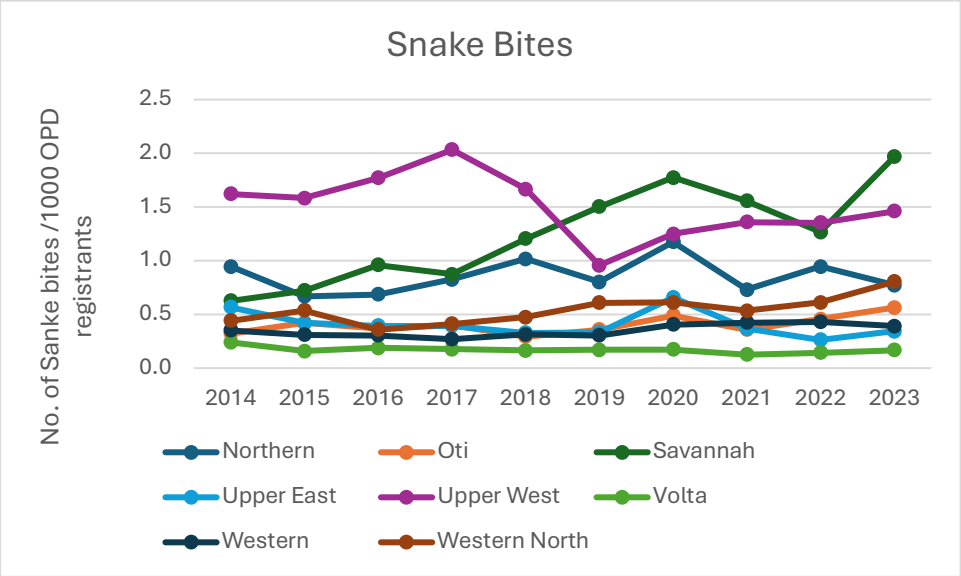

Figure 75b: Incident cases of snake bites per 1000 OPD registrants, 2014-2023

4.1.8. Water-washed diseases

Figure 76 shows that the risk of Trachoma was mostly below 3.0 cases per 1000 OPD registrants in all districts except for the Ashanti and Bono East regions where much higher risk was observed. From 2022 and 2023 there has been a rising trend in risk in Bono East and Upper West regions.

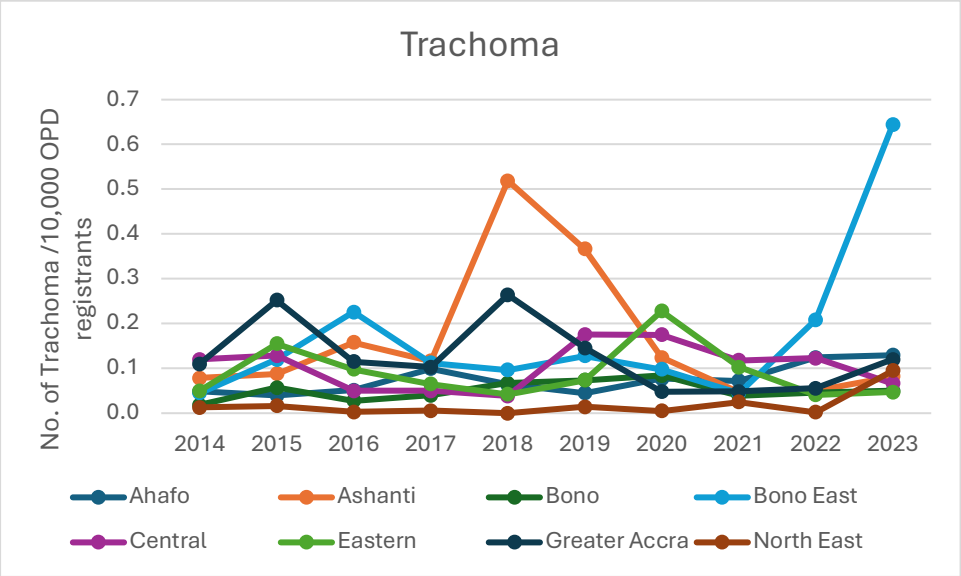

Figure 76a: Incident cases of Trachoma per 10,000 OPD registrants, 2014-2023

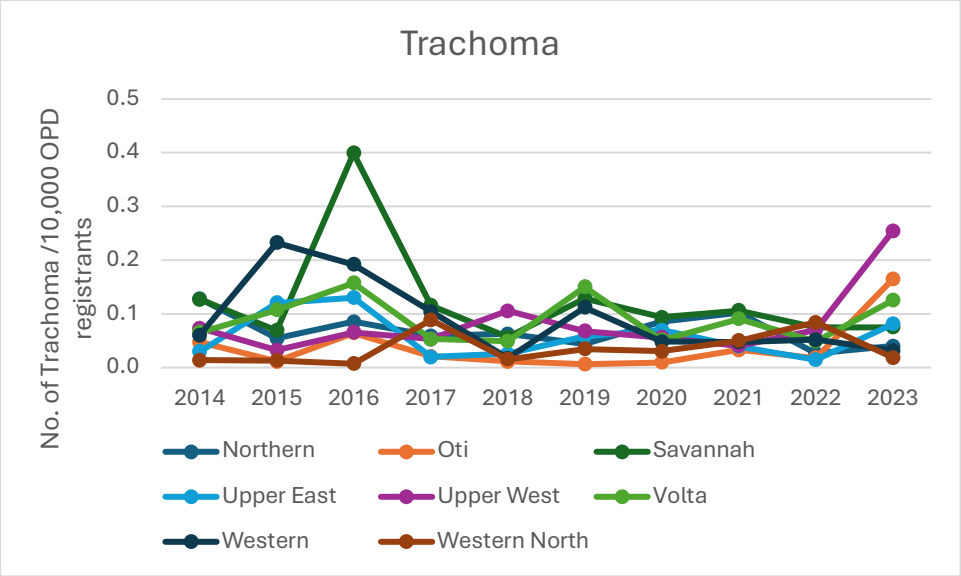

Figure 76b: Incident cases of Trachoma per 10,000 OPD registrants, 2014-2023

4.1.9. Heat-related health outcomes

Exposure to extreme heat during pregnancy can negatively impact various reproductive health outcomes, including increased risk of preterm birth, low birth weight, stillbirth, early pregnancy loss, and potential long-term health effects on the developing foetus. Here still birth and low birth weight rates are used as proxy indicators of heat-related reproductive health outcomes.

Figure 77 shows a steady decline in still birth rates in all regions over the period 2014-2023.

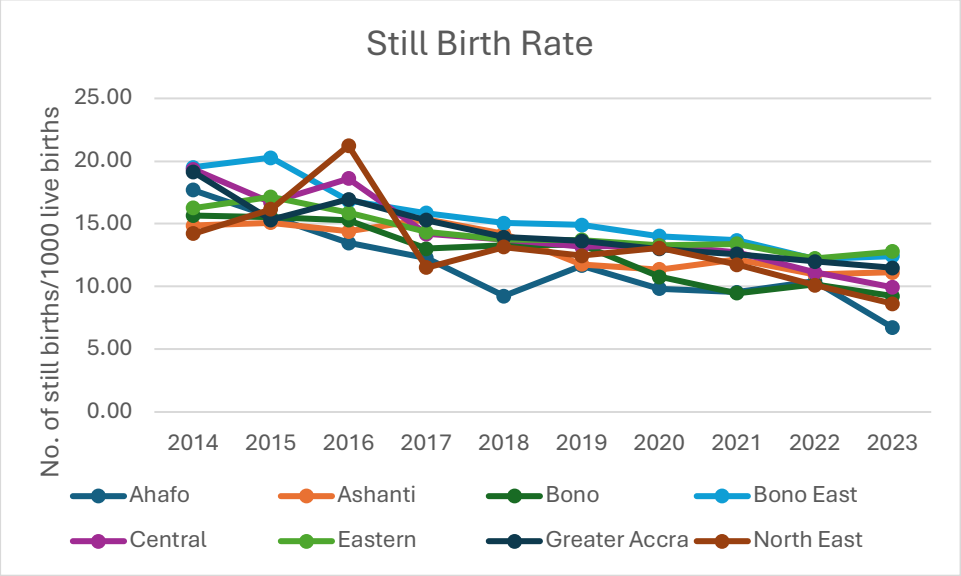

Figure 77a: Number of Still births per 1000 live births, 2014-2023

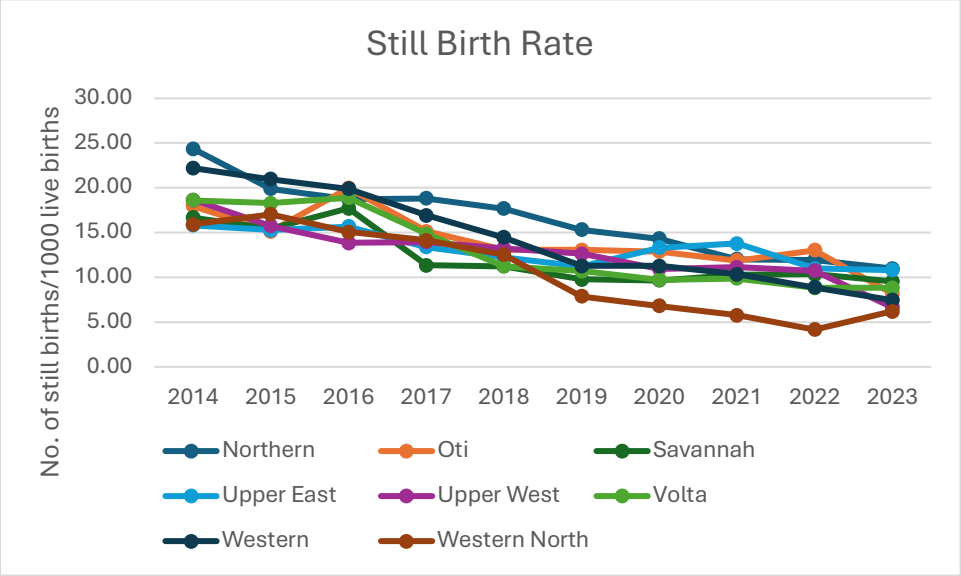

Figure 77b: Number of Still births per 1000 live births, 2014-2023

4.1.9.2. Low Birth Weight

Figure 78 does not show any significant change in the trends of low birth weight over the period.

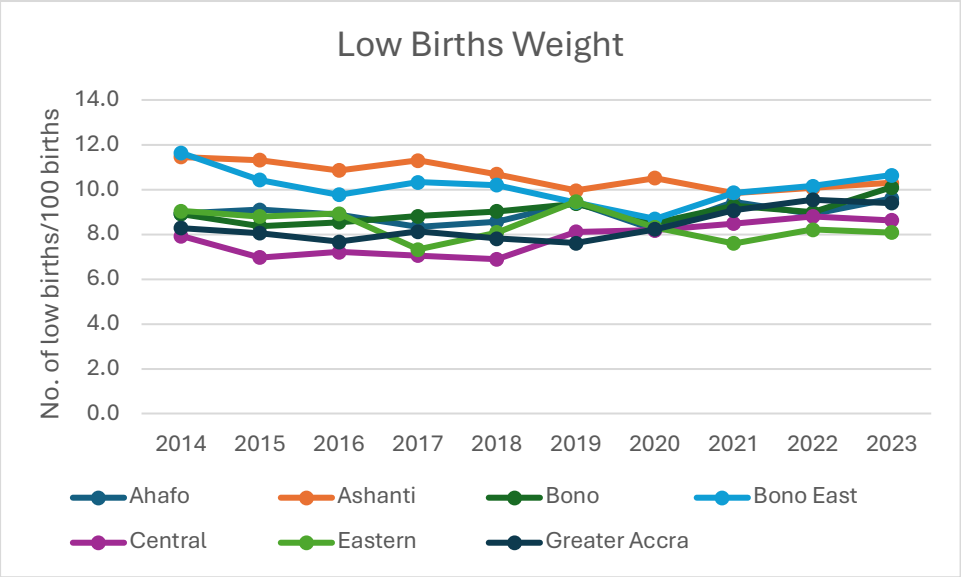

Figure 78a: Number of low-birth-weight babies per 1000 births, 2014-2023

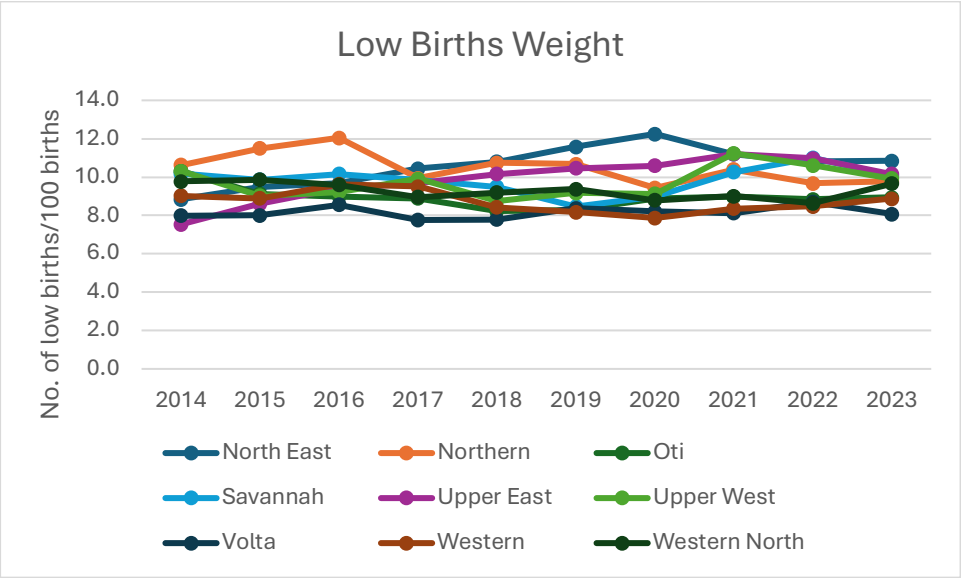

Figure 78b: Number of low-birth-weight babies per 1000 births, 2014-2023

4.2. Regional ratings and geographic distribution of climatic hazards and upstream drivers of CSHOs

In this section, the qualitative methodology described under section 2.2.4.2. was used to generate hazard ratings for severity of climatic hazards and upstream drivers of CSHOs under study. The minimum rating score is 0, and the maximum rating score is 8. The geographical distribution of the risk was based on expert knowledge of the districts involved and trends in frequency and severity of exposure over the past 5-10 years, depending on the extent of institutional memory.

Figure 79 summarizes the ratings for climatic hazards and upstream drivers of CSHOs by regions, but the detailed comments explaining the ratings are in annex 6. A descriptive account of the ratings is also summarized below.

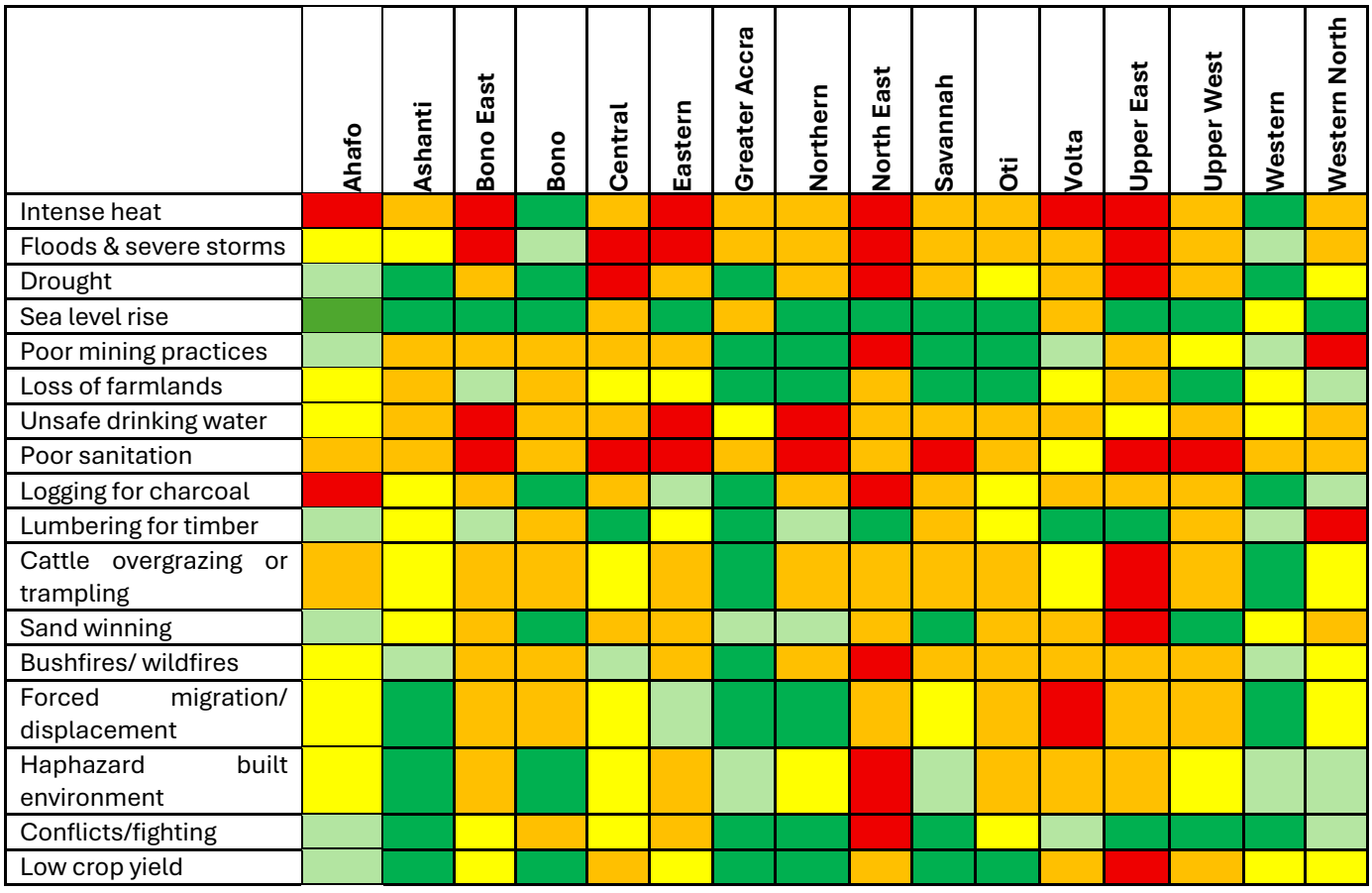

Figure 79 : Map of ratings of climatic hazards and upstream drivers of CSHOs by regions

Legend for ratings

Very low	Low	Moderate	High	Extreme
0-1	2-3	4	5-6	7-8

4.2.1. Intense heat

This was rated a major climatic hazard in all regions (5-8) except in Bono and Western regions and the perceived trend was upwards in all the affected regions. North East, Upper East and Upper West regions were rated extreme (7-8) for this climatic hazard.

4.2.2. Flooding and severe storms

Flooding that followed severe rainstorms or overflow of water bodies was acknowledged as a significant climatic hazard in all the regions was rated as extreme (7-8) in the Bono east, Central, Eastern, North East and Upper east regions. The highest hazard rating (8) was in the North East and Upper East regions. This problem was perceived to be worsening in all regions except for Upper West, Ahafo, Bono and Western regions where it remains unchanged.

4.2.3. Drought

This hazard was rated as extreme (7-8) in the North East and Central regions. High ratings (5-6) were also scored in the Northern, Upper East, Bono East, Eastern, Upper West, Savannah, and Volta regions. The perceived trend was upwards in the North East, Central, Upper Eastern and Volta regions.

4.2.4. Sea level rise

This was recognised as a climatic hazard in all the coastal regions (Central, Greater Accra, Volta, and Western regions) and was highly rated (4-5) in all these regions.

4.2.5. Poor sanitation

This was rated as a significant upstream diver of some CSHOs in all the regions. Extreme ratings (7-8) were assigned to the Bono East, Central, Eastern, Northern, Savannah, Upper East and Upper west regions. The highest rating (8) was in the Upper West region.

This problem was perceived to be worsening in all the regions except for the Ashanti, Western North, Western and Volta regions where the situation was perceived to be improving. In Oti and Ahafo regions the trend was perceived to be unchanged.

4.2.6. Unsafe drinking water

This was recognized as a significant driver for some CSHOs in all regions. The highest rating (7) for this issue was assigned to Bono east, Eastern and Northern regions.

The trend was perceived as worsening in the Bono east, eastern, Western north, Central, Volta, Northern and Ashanti regions but improving in the North East, Upper East and Western regions.

4.2.7. Overgrazing or trampling

Overgrazing or trampling of farmlands by livestock was recognized as a significant climatic risk factor (4-8) in all regions except the Greater Accra and Western regions. This hazard was rated as extreme (7) in the Upper east region, but Bono East, Central, Eastern, Northern, Savannah, Volta, Western North, Greater Accra, Oti and Upper West were also highly rated (5-6).

The trend was also perceived to be worsening in the Upper East, Bono East, Bono, Eastern, Northern, North East, Upper West, Ashanti, Central and Western North regions.

4.2.8. Bushfires/ wildfires

This issue was rated as extreme (7) in North East region. Ratings in Bono east and Volta, Bono, Eastern, Northern, Oti, Savannah, Upper East and Upper West regions were also high (5-6). The trend

was perceived to be upwards in the Northeast, Bono East, Volta, Bono, Northern, Savannah and Upper west regions.

4.2.9. Conflicts/fighting

This issue received the highest rating (8) in the North East region and was also highly rated (5) in Bono and Eastern regions. in all the afore-mentioned regions the trend was perceived to be upwards.

4.2.10. Forced migration / displacement

This issue was rated as extreme (7) in the Volta region and was also highly rated (5-6) in the Volta, North East, Upper East, Bono East, Bono, Oti, and Upper West regions. The perceived trend was upward in the Volta, North East, Bono East and Bono regions.

4.2.11. Vulnerable shelter/ Haphazard built environment

This issue was rated as an extreme (7) driver of CSHOs in the North East region. It was also a rated as a significant driver of CSHOs (4-6) in the Bono East, Volta, Eastern, Oti, Upper East, Ahafo, Central and Upper West regions. The trend was perceived as worsening in the Volta, Eastern, and Upper East regions, but improving in the Central and Upper East regions.

4.2.12. Logging for charcoal production

This upstream driver of CSHOs was rated as extreme (7) in Ahafo and North East regions, but also highly rated (5-6) in the Bono East, Central, Upper East, Upper West, Bono, Eastern, Northern, Savannah and Volta regions.

This problem was perceived to be worsening in all the affected regions except for Oti, Western North and Western regions where it was unchanged.

4.2.13. Loss of farmlands

Loss of farmlands to estate development was highly rated (5-6) as a driver of CSHOs in the Ashanti, Upper East and Bono regions and the problem is perceived to be worsening.

4.2.14. Low crop yield

This was recognized as an extreme upstream driver of CSHOs in the Upper East region and highly rated drivers in North East, Volta, Central and Upper West regions. The trend is worsening in the Upper East, Volta, and Western North regions, but improving in the other regions.

4.2.15. Poor mining practices

This issue causes loss of farmlands. This was rated as an extreme driver (7) in the Northeast and Western north regions but rated as high (5-6) in the Ashanti, Central, Eastern, Bono East, Upper East, and Bono regions. This problem is however worsening in the North East, Ashanti, Central, Eastern, Bono, Upper west and Volta regions, but improving in the Western and Ahafo regions.

4.2.16. Sand winning

This is one of the causes of loss of farmlands and the problem was rated highest (8) in the Upper East region. It was also highly rated (4-6) in the Central, North East, Volta, Bono East, Eastern, Oti, Western North, Ashanti and Western regions. The trend is perceived to be worsening in all the affected regions, except for Ahafo, Greater Accra and Northern regions.

4.3. Regional adaptive capacity of health and health-relevant systems

4.3.1. Regional health sector adaptive capacity for management of prioritized CSHOs

This section focuses on the adaptive capacity within the health sector, in terms of availability of current and planned PPPs that support the management of CSHOs. Several PPPs were identified in the health sector that supported the prevention, control or elimination of Vector-borne diseases, childhood malnutrition and mental health disorders only. The health sector manages the other CSHOs through routine clinical and public health services provided through the health facilities.

Vector-borne diseases

The health sector has several ongoing programs to prevent and control several vectors borne diseases in the country. The notable ones are the National Malarial Elimination Program (NMEP) and the Neglected Tropical Diseases Control Programs (NTDCP) that covers diseases like Lymphatic filariasis, Schistosomiasis and Onchocerciasis.

The NMEP has programs running in all the regions. The number of programs may however vary from region to region, usually based on the level of risk. Some examples of the ongoing malaria preventive interventions are listed below:

- Seasonal Malaria Chemoprophylaxis (SMC) for ages 3months to 59 months.
- Distribution of treated bed nets routinely during ANC
- Point Mass Distribution of LLIN
- Home based drug administration to children under 5 years.
- Larval source management
- Malaria vaccination as part of routine EPI
- Indoor residual spraying

The NMEP is also involved in the control of mosquito transmitted disease like Dengue fever and Yellow fever.

In every region, the Disease Surveillance Department of GHS also coordinates the implementation of the Integrated Disease Surveillance and Response (IDSR) to strengthens disease surveillance and response actions.

NTDCP activities are ongoing in the Ahafo, Bono East, Bono, Volta, North East, Upper East and Western North regions. They include Mass Drug Administration programs for control of Lymphatic filariasis and Onchocerciasis, and mass school drug administration programs for Schistosomiasis control.

Malnutrition

The health sector is implementing several community-based projects for managing malnutrition among children and adolescents. Many of these programs are focused in regions in the northern part of Ghana, but there are also a few in the Southern sector (i.e. Greater Accra region). Examples are:

- The Ghana Nutrition Improvement Program. This is an affordable complementary feeding nutrition supplementary program funded by KOKO plus and implemented in Ashanti, Bono east, Northern, Upper East and Upper West regions.
- UNICEF's community Management of Acute Malnutrition (CMAM) is implemented in many regions of Ghana, including the Greater Accra, Central, Ashanti, Upper East, Upper West, and Northern regions.

- UNICEF also carries out folate supplementation for Anaemia treatment and control and Safety Net programs to reintegrating adolescent girls who drop out of school in several regions that.
- The International Potato Center (CIP) is combating vitamin A deficiency in the Northern and Upper east regions.
- The infant and Young Child feeding (IYCF) practices is also being implemented in the Central, Volta, Eastern, and Northern regions.
- USAID Advancing Nutrition program promotes food demonstrations, savings, and loans for women. Involves capacity building, logistic support in the Northern, Volta, Greater Accra, Central, and Western Regions.
- USAID Ring II project is in all the districts of the Northern, Upper West, North East, and Upper East regions.
- UNICEF's Nutrition Friendly Initiative and Integrated Social Services Initiative searches for the vulnerable to link them to health care services.

Mental health disorders

The Mental Health Authority of Ghana aims to improve the quality of care in Ghana by improving service delivery and more. There are mental health officers in the community who have been trained to identify and manage people with mental health needs.

However, there were obvious challenges with the capacity of this program to deliver on its goal. Mental health programming was observed to be weak in all regions and there was widespread shortage of psychotropic drugs.

4.3.2. Regional adaptive capacity for management of climatic risk factors and upstream drivers of CSHOs

For each climate risks or upstream driver of CSHOs, the relevant PPPs provided by health-relevant MDAs were identified by region, and the lead MDAs responsible for implementation of these PPPs were also indicated.

Table 9: List of current and planned PPPs that address impacts of drought by regions and lead MDAs

Regions	PPPs	Lead MDA
Ahafo	MAG (Modernizing Agriculture in Ghana) training sessions for farmers in conversation agriculture.	MOFA
	Safety net project (oil production training and planting)	MOFA
	PROCASHEW (production of large-scale cashew)	MOFA
	Green Ghana land irrigation project by Newmont (all year-round water supply for continuous farming)	MOFA
	Tonja system reclaiming old farms for planting crop planting in the forest	MOFA
	UNDP REDD plus (cultivate the forest Asunafo north)	Forestry
	Planting for Food and Job Phase II,	MOFA
	Goaso Expansion project (use of solar energy and hybrid pumps to conserve energy and renewable energy.	MOFA
	Construction of Smart water system (2 over-tanks to supply water to Asutifi north and Kenyasi districts)	MOFA
Bono East	Ghana Landscape restoration project by world Bank	MoFA

	Green Ghana project	MoFA
	Trooping box project by Ghana NGO. cooperatives (planting of fast-growing species acacia and border plants)	MoFA
	Planting for Food and Jobs II (climate smart agriculture)	MoFA
	Food System Resilient Project (FSRP) planting of new varieties of crops	MoFA
	Planting for export and rural development (PERD) (provisions of certified seedlings and extension services to farmers.)	MoFA
Central	Climate smart agriculture (crop rotation, fertilizers, cover cropping, zero tillage, early maturing variety of crops introduced) by Canada Government.	MoFA
	Rice value chain improvement project (new varieties of rice crop and climate sensitive production practice)	MoFA
	GSHEP (Ghana) vegetable farming for crops.[134]	MoFA
	West African food system resilient project by World Bank supporting farmers with inputs to increase food crop in vegetables poultry, legumes, soya, rice maize).	MoFA
	AKILIMO (data collection on food crop yields and production)	MoFA
	E-extension (use of technology smart devices for information and extension delivery for farmers)	MoFA
	Planting for food and jobs model II.	MoFA
	Ghana landscape restoration & small-scale mining project (recapturing and reclaiming forest lands in Assin North and Twifo Praso)	MoFA
Eastern	Ghana Landscape Restoration and Small-Scale Mining Project (GLRSSMP) currently been implemented in 5 districts (Kwahu East and South, Afram plains district, Nkawkaw)	MoFA
	Implementing the World food program (Value addition project; 5 district training sessions farmers (women and youth) on conservation agriculture	MoFA
	Planting for Food and Jobs part 2.	MoFA
	Ghana rice improvement program JICA project in Birim and Atiwa east district (2 out of 16 districts)	MoFA
	Ghana Agricultural Sector Investment Programme (GASIP) small holder empowerment program.[135]	MoFA
	JICA program for vegetables Ally cropping planting of fast-growing trees and nitrogen fixing crops (Eugenia brasiliensis and Guarea kunthiana) for sustainable agriculture	MoFA
	Construction of Fodder banks for cattle (Miim Chemre and Amankwaw) food veterinary, clinics and food for cattle)	MoFA
	Provision of oil palm seedlings (tree crop development authority oil plan and coconut and cashew)	MoFA
	Food system resilient program (provision of fertilizers, training program in Kwahu and Nsawam districts)	MoFA
	Water aid boreholes project (10 for Afram Plains South)	CWSA

[134] Ghana-SADC (Southern Africa Development Community) Horticultural Export Project (GSHEP) focuses on improving vegetable farming in Ghana, aiming to build capacity for farmers to produce for the market

[135] The Ghana Agriculture Sector Investment Programme (GASIP) funded by the International Fund for Agricultural Development (IFAD) and the Government of Ghana (GOG) is a long-term initiative aimed at contributing to sustainable poverty reduction in rural Ghana.

	ESRF (Emergency support for rural livelihood (construction of 20 boreholes in communities.	CWSA
Upper East	Planting for food and Jobs II	MoFA
	Food system resilient program (sorghums bean and tomatoes farming)	MoFA
	Ghana landscape restoration project by World bank	MoFA
	Policy link project (climate smart agriculture)	MoFA
	Tree Aid conservation agriculture	MoFA
	Ghana Agriculture sector investment program (support women in agriculture)	MoFA
	Gulf of Guinea social cohesion program -	MoFA
	Water Aid, Ghana	CWSA
	Mechanization of exiting boreholes	CWSA
	Hybrid pump solar	CWSA
Volta	Coastal Mangroves redevelopment project (replanting reclaiming mangrove at Keta and Anloga)	MoFA
	Food system resilient project (FSRP by FAO) provide inputs for farmers	MoFA
	Planting for Food and Jobs PFJ I & II	MoFA
	Modernizing Agriculture in Ghana- MAG (improved seedlings and breeding foreign and local hybrid of seedlings)	MoFA
	Construction of boreholes by world vision.	CWSA
	Phase 4 of construction of pipelines	CWSA
	Community Water and Sanitation Agency (CWSA) reform ACT 598	CWSA
Western North	Climate smart agriculture (crop rotation, fertilizers, cover cropping, zero tillage, early maturing variety of crops introduced) by Canada Government.	MoFA
	Planting for food and jobs	MoFA
	Cocoa rehabilitation program (GoG sponsored program provide capital for cocoa farmers to buy seedlings, fertilizer and pay labourers)	MoFA
	Planting for export and rural development (seedling for oil palm, cocoa nut and oil palm for production and export	MoFA
	Rearing for food and jobs (animal rearing, pigs) for food and jobs (fish farming)	MoFA
	Fall army worm control (Supply chemical for farmers to control fall army worm)	MoFA
	ARMSEC (Agriculture mechanization) Supply of tractor services for farmers	MoFA
	Green Ghana initiative (planting of trees and cash crops)	MoFA
	Rain Forest Alliance – funded by USAID – RESTORE project – conducts tree planting along the sui river landscape within Sefwi Wiaso and Bibiani	MoFA
	Re-Construction of Sefwi Wiawso water system Water policy for the region	CWSA

4.3.3.2. Floods/ Storms

Table 10a: List of current and planned PPPs that address impacts of flood/storms by regions and lead MDAs

Regions	PPPs	Lead MDA
Ahafo	Clean water program (embarking on water quality testing and monitoring and routine maintenance of water facilities)	CWSA
	WASH policy (water Sanitation and hygiene policy)	CWSA
	MAG (Modernizing Agriculture in Ghana) training sessions for farmers in conversation agriculture	MOFA
	Safety net project (oil production training and planting)	MOFA
	PROCASHEW (production of large-scale cashew)	MOFA
	Green Ghana land irrigation project by Newmont (all year-round water supply for continuous farming)	MOFA
	UNDP REDD plus (tree planting in the forest Asunafo North)	MOFA
	Planting for Food and Job Phase 2,	MOFA
	Tonja system reclaiming old farms for planting crop planting in the forest)	MOFA
Bono East	Providing relief items, DRR education and sensitization, construction of safe haven temporary structures	NADMO
Upper East	Planting for food and Jobs II	MoFA
	Food system resilient program (sorghums bean and tomatoes farming)	MoFA
	Ghana landscape restoration project by World Bank	MoFA
	Policy link project (climate smart agriculture)	MoFA
	Tree Aid conservation agriculture	MoFA
	Ghana Agriculture sector investment program (support women in agriculture)	MoFA
	Gulf of Guinea social cohesion program - SOCO (mechanized borehole for farmers)	MoFA
Volta	Coastal Mangroves redevelopment project (replanting reclaiming mangrove at Keta and Anloga)	MoFA
	Food system resilient project (FSRP by FAO) provide inputs for farmers)	MoFA
	Planting for Food and Jobs PFJ I &2	MoFA
	Modernizing Agriculture in Ghana- MAG (improved seedlings and breeding foreign and local hybrid of seedlings)	MoFA

4.3.3.3. Forced migration / displacement

Table 10b: List of current and planned PPPs that address impacts of Forced migration / displacement by regions and lead MDAs

Regions	PPPs	Lead MDA
Ahafo	Providing relief items, DRR education and sensitization, construction of safe haven temporary structures	NADMO
Upper East	Providing relief items, DRR education and sensitization, construction of safe haven temporary structures	NADMO

4.3.3.4. Heat waves and stress

***No PPPs identified

4.3.3.5. Vulnerable shelters / haphazard built environment

Table 11: List of current and planned PPPs that address impacts of Vulnerable shelters /haphazard built environment by regions and lead MDAs

Regions	PPPs	Lead MDA
Bono East	Ghana secondary city districts project initiative seeks to build infrastructure for cities (i.e., markets, roads)	NADMO
Central	Rural housing projects (construction of climate resilient homes)	NADMO
Eastern	National affordable housing scheme	NADMO
	Development of structural and spatial plans for regions	NADMO
Western north	Construction of new buildings for mining communities	NADMO

4.3.3.6. Logging / charcoal production

Table 12: List of current and planned PPPs that address impacts of Logging / charcoal production by regions and lead MDAs

Regions	PPPs	Lead MDA
Central	Early warning system alert, sensitization, and advocacy	MoH/GHS

4.3.3.7. Overgrazing / destruction by livestock

Table 13: List of current and planned PPPs that address impacts of Overgrazing/ destruction by livestock by regions and lead MDAs

Regions	PPPs	Lead MDA
Eastern	Farmer herder conflict policy document 2024	MoFA

4.3.3.8. Poor mining practices

Table 14: List of current and planned PPPs that address impacts of poor mining practices by regions and lead MDAs

Regions	PPPs	Lead MDA
Ahafo	Clean water program (embarking on water quality testing and monitoring and routine maintenance of water facilities)	Lead MDA
Upper East	Planting for food and Jobs Phase II	MoFA
	Food system resilient program (sorghums bean and tomatoes farming)	MoFA
	Ghana landscape restoration project by World bank	MoFA
	Policy link project (climate smart agriculture)	MoFA
	Tree Aid conservation agriculture	MoFA
	Ghana Agriculture sector investment program (support women in agriculture)	MoFA
	Gulf of Guinea social cohesion program	MoFA
Western North	Rapid deployment (security services deployed)	EPA
	Advocacy for illegal mining.	EPA
	Climate smart agriculture (crop rotation, fertilizers, cover cropping, zero tillage, early maturing variety of crops introduced) by Canada Govt.	MoFA
	Planting for food and jobs.	MoFA
	Cocoa rehabilitation program (GoG sponsored program provide capital for cocoa farmers to buy seedlings, fertilizer and pay labourers)	MoFA
	Planting for export and rural development (seedling for oil palm, cocoa nut and oil palm for production and export	MoFA
	Rearing for food and jobs (animal rearing, pigs) for food and jobs (fish farming)	MoFA
	Fall army worm control (Supply chemical for farmers to control fall army worm)	MoFA
	ARMSEC (Agriculture mechanization) Supply of tractor services for farmers	MoFA
	Green Ghana initiative (planting of trees and cash crops)	MoFA
	Rain Forest Alliance – funded by USAID – RESTORE project – conducts tree planting along the sui river landscape within Sefwi Wiawso and Bibiani	MoFA

4.3.3.9. Poor sanitation

Table 15: List of current and planned PPPs that address impacts of poor sanitation by regions and lead MDAs

Regions	PPPs	Lead MDA
Ahafo	IRECOP (establishment of Integrated Recycling and Composite Plant for Waste Management in the region.	MMDAs
	WASH programs (Tano North and Asutifi South)	MMDAs

	WaterAid and World Vision building toilet facilities	MMDAs
	Elite-waste program (private company involved in the collection of waste management from households)	MMDAs
Bono East	Community Lead Total Sanitation (CLTS) by UNICEF	MoSWR
	WASH sensitization and engagement	MoSWR
	By laws to improve sanitation situation (11 municipalities)	MoSWR
Eastern	CLTS Community lead total sanitation (by world vision in the construction of household toilets)	MoSWR
	FOREST Okyeman project (10 district promote environment sanitation, Plan Ghana international (Afram Plains)	MoSWR
	National Sanitation Policy and bylaws for improving and building toilet facilities	MoSWR
Upper East	Community Lead total sanitation (CLTS)	MoSWR
	World Vision, Bawku and Timpani	MoSWR
	Zoom lion collection and disposal of waste	MoSWR
Volta	Rural sanitation model and strategy (CLTS) which involves the construct of household latrine Urban sanitation (supported by UNICEF)	MoSWR
	Processing of solid waste and recycling supported by the Netherland government support sleg drying bed (treatment of solid waste for fertilizers)	MoSWR
	Waste segregation at basic school.	MoSWR
	Rural sanitation model and strategy (CLTS) which involves the construct of household latrine Urban sanitation (supported by UNICEF)	MoSWR
	Processing of solid waste and recycling supported by the Netherland government	MoSWR
	Support sludge drying bed (treatment of solid waste for fertilizers)	MoSWR
	Waste segregation at basic school.	MoSWR
Western North	IRCOP (integrated recovering and composite plant Composite Plant (Agri waste centre) Aboabedua	MoSWR

4.3.3.10. Sand winning

Table 16: List of current and planned PPPs that address impacts of sand winning by regions and lead MDAs

Regions	PPPs	Lead MDA
Upper East	Ghana landscape restoration project	EPA

4.3.3.11. Unsafe drinking water

Table 17: List of current and planned PPPs that address impacts of unsafe drinking water by regions and lead MDAs

Regions	PPPs	Lead MDA
Ahafo	Construction of Smart water system (2 over-tanks to supply water Asutifi north and Kenyasi)	MMDA
	Goaso Expansion project (use of solar energy and hybrid pumps to conserve energy and introduce renewable energy	MMDA
Central	Solar powered resilient pump housing projects	CWSA
	Availability of water safety plans (WSP) documents that outline water safety action plans	CWSA
	Availability of National Water Policy	CWSA

5. Recommended adaptive strategies

This section presents adaptative actions that have been synthesised, based on the identified vulnerabilities and adaptive capacity ratings during the V&A assessment. The recommended adaptive strategies were synthesised to address those vulnerabilities for which current or planned adaptive capacity has been rated as either limited or moderate.

The recommendations are organized into twelve thematic pillars, each outlining specific strategic and operational actions. The following is a structural summary:

5.1. Leadership and Governance

- Institutionalize climate change and health focal points and a multi-sectoral steering committee within the Ministry of Health (MoH) and Ghana Health Service (GHS).
- Integrate climate resilience into national health policies, legislation, and standards, including the development of a National Climate and Health Policy and a National Adaptation Plan (H-NAP).
- Allocate dedicated budgets and ensure health sector representation in regional and global climate change forums.

5.2. Health Workforce Capacity Building and Policy

- Develop and implement targeted training programmes for health workers on climate-related health risks, vulnerability assessment, and management of climate-sensitive conditions.
- Integrate climate change and health into medical and nursing curricula.
- Advocate for policies ensuring equitable health workforce distribution and organize awareness campaigns on climate-health linkages for stakeholders and the public.

5.3. Vulnerability, Capacity, and Adaptation (V&A) Assessment

- Conduct comprehensive national V&A assessments every ten years and facility-level baseline assessments to inform the H-NAP.
- Assess greenhouse gas emissions from the health sector and identify data gaps within health information systems for climate-sensitive outcomes.
- Establish a defined mechanism for the iterative review of adaptation options based on updated scientific evidence.

5.4. Management of Environmental Determinants of Health

- Integrate Climate Resilience into Urban and Transport Planning: To address rising road traffic accidents in zones like the Coastal Savanna and cardiac diseases linked to heat stress, update building codes to improve ventilation and thermal comfort, and design transport infrastructure with climate resilience and road safety in mind.
- Conduct Health Impact Assessments for policies in key sectors (e.g., transport, agriculture).
- Strengthen multi-sectoral coordination through established committees and develop integrated IT platforms for environmental and health data.
- Finalize and enforce legislation on key environmental determinants (air, water, waste) and build capacity for climate-resilient water safety plans.

5.5. Management of Prioritized Climate-Sensitive Health Outcomes (CSHOs)

- Strengthen zone-specific disease control Strategies by moving beyond one-size-fits-all approaches by tailoring interventions to the specific disease profiles of each zone. For example, prioritize asthma and diarrhoea control in the Guinea Savanna, while focusing on cardiovascular and malaria prevention in the Coastal Savanna.
- Supplement traditional vector control methods (like insecticide-treated nets and indoor residual spraying) with dynamic, climate-informed strategies. This includes targeted pre-emptive campaigns in high-risk zones like the Guinea Savanna and Wet Evergreen zones before anticipated rainy seasons.
- With depression projected to rise in zones like the Deciduous zone, integrate mental health support into climate adaptation programs, particularly for rural communities facing livelihood disruptions, food insecurity, and displacement due to climate extremes.
- Enhance surveillance, prevention, and control for specific CSHOs, including vector-borne diseases (malaria, dengue, yellow fever), respiratory illnesses, malnutrition, and mental health disorders.
- Foster inter-programmatic and inter-agency collaboration (e.g., between MoH, GHS, Ministry of Agriculture, FDA) for integrated disease management.
- Raise public and professional awareness on the links between environmental factors (e.g., air pollution, food contamination) and specific health outcomes.

5.6. Integrated Risk Monitoring and Early Warning

- Develop a national, zone-specific early warning system that integrates climate forecasts (rainfall, temperature, humidity) with disease surveillance data to predict outbreaks of climate-sensitive diseases like malaria, diarrhoea, and meningitis, enabling proactive rather than reactive responses.
- Promote research for emerging sensitivities to better understand the climate sensitivity of diseases like asthma, cardiac conditions, and snake bites, and expand surveillance to track their evolving burden and inform future interventions.
- Develop/strengthen integrated health and environment surveillance systems and design a multi-hazard Early Warning System (EWS).
- Update health information systems to capture climate-related data, develop risk maps, and employ early detection tools.
- Establish data-sharing agreements, community feedback mechanisms, and conduct regular capacity reviews for monitoring systems.

5.7. Emergency Preparedness and Management

- Integrate climate-sensitive health risks into national disaster risk reduction strategies and develop specific health sector contingency plans.
- Reinforce health infrastructure in disaster-prone areas, ensure backup power, and develop evacuation plans.
- Build community capacity for risk identification and response and actively participate in national disaster management coordination structures.

5.8. Climate and Health Financing

- Mobilize domestic and international resources (e.g., GCF, GEF, Adaptation Fund) specifically for health system climate resilience.
- Develop targeted investment plans based on V&A assessment gaps and prioritized actions in the H-NAP.
- Advocate for formal inclusion of the health sector in national climate finance governance structures.

5.9. Climate-Resilient and Sustainable Technologies and Infrastructure

- Invest in Climate-Resilient Water, Sanitation, and Hygiene (WASH) Infrastructure: Given the projected rise in diarrhoeal diseases across multiple zones (Guinea Savanna, Transition, Deciduous, Wet Evergreen), invest in robust water supply systems, flood-proof sanitation facilities.
- Periodically assess and database health infrastructure, revising construction specifications for climate resilience.
- Promote climate-resilient and sustainable technologies for energy, water, sanitation, and health service delivery (e.g., telemedicine, renewable energy).
- Launch campaigns for safer hospitals and update procurement guidelines to prioritize sustainability.

5.10. Climate-Resilient Health Supply Chains

- Conduct risk assessments of medical and non-medical supply chains for extreme weather events.
- Develop continuity plans for supply chains, including stockpiling in vulnerable facilities and establishing cooperative agreements between facilities.
- Ensure equitable resource allocation criteria that incorporate climate vulnerability.

5.11. Climate and Health Research

- Develop and fund a national research agenda, synthesizing existing evidence and promoting international research partnerships.
- Investigate specific topics such as heat-health relationships, energy efficiency, and the integration of local knowledge.
- Establish knowledge management systems and regularly disseminate findings to policymakers and communities through dialogues and publications.

5.12. Climate-Informed Health Programmes

- Invest in community-led total sanitation campaigns, particularly in rural and flood-prone areas.
- Mainstream climate change adaptation into existing health and environment programmes and national climate frameworks (e.g., NAP).
- Strengthen integrated vector management, water safety plans, and all-hazards emergency risk management programmes.
- Establish an inter-programmatic coordinating mechanism within the health sector to oversee climate and health activities.

5.13. Monitoring and Evaluation

- Establish mechanisms (e.g., steering committee at the MOH and Technical Working Group at GHS) to oversee the conduct of desktop HIAs for policies in the health and health-relevant sectors, thereby ensuring that climate and health considerations are explicitly integrated into national development policies and plans to secure sustainable financing and multi-sectoral collaboration.
- Develop and mainstream process, outcome, and impact indicators for the H-NAP into existing health management information systems (e.g., DHIMS2).
- Establish mechanisms to monitor the health impacts of adaptation programmes and sectoral carbon emissions.
- Update the climate and health vulnerability and adaptation (V&A) assessment and the H-NAP iteratively, with a decadal review cycle.

6. Conclusion

The purpose of this climate change vulnerability and adaptation assessment was to provide an evidential basis for the development of a need-based health national adaptation plan that will inform prioritized actions, required to build a climate resilient health sector. This goal was achieved through three (3) integrated approaches: synthesis of already existing V&A assessment reports in Ghana; primary data collection through group discussions; prioritization of vulnerabilities and gaps in adaptive capacity exercise by national and regional level experts; and analysis of national/regional level climatic and health outcome data.

The vulnerability assessment involved the identification, description and prioritization of the current distribution and burden of climate-sensitive health outcomes. Gender sensitive analysis of trends in climate-sensitive health outcomes was performed only at the national level. This was not possible at the regional level, since it was not practicable to construct gender disaggregated charts because of the sheer volume of variables involved. The analysis of national level data from 2014 to 2023 also revealed several vulnerabilities to CSHOs.

At the end of the V&A assessment, several implementable adaptation strategies were identified for each component within the WHO proposed framework for developing H-NAPs. This will ensure that, in future the development of the H-NAP will be informed by a plurality of evidence-based strategies from which the country can prioritize actions for the H-NAP. Regional disparities in CSHO trends also underscore the need for tailored public health adaptive interventions. These findings reinforce the need for climate-informed public health planning that is spatially tailored, temporally responsive (considering lag effects), and proactive in deploying early warning systems, resilient infrastructure, and targeted interventions. As Ghana faces an intensifying climate future, integrating these insights into national and subnational adaptation strategies will be essential for safeguarding health outcomes and promoting a climate resilient health sector.

Without decisive action, the health system will remain fragile and unable to protect the population from escalating risks. However, with a clear vision and coordinated effort, Ghana can build a health system that is resilient, equitable, and sustainable. Embedding climate adaptation into the fabric of health governance will safeguard vulnerable populations, reduce economic losses, and ensure that Ghana's development trajectory remains on course despite mounting climate pressures.

Enhancing climate-informed surveillance, strengthening data disaggregation, enhancing community-based programs, and integrating targeted adaptation strategies into health planning will therefore be critical to strengthening health system resilience to future climate-related health risks.

Annexes

Annex 1: Project technical working group members

Harmonization and Validation of Climate Change and Health Vulnerability and Adaptation Assessments of the Health System in Ghana: Project Inception Workshop, 02nd – 04th November 2022, Forest Hotel, Dodowa.

No.	Institution/Department	Designation
1	NBUCYEP-GHS	Program Manager
2	PPMED-GHS	Health Planner
3	DSD-GHS	Disease Surveillance
4	GMeT	Head of Climate Unit
5	MoH-ID	Health Planner
6	School of Public Health, U of G	Lecturer
7	NMCP-GHS	Ag. Program Manager
8	School of env, sciences, U of G	Researcher
9	NDPC	P. A
10	OEHU-GHS	DDNS/PH
11	OEHU-GHS	PPO
12	WHO	NPO/SDH
13	MoH	Adm. Mgr
14	ICD-GHS	Nurse M&E Officer
15	EPA	Deputy Director
16	OEHU-GHS	Head, Poison Control
17	OEHU-GHS	Deputy Program Manager
18	HASS-GHS	Estate Manager
19	OEHU-GHS	Program Manager

Annex 2: Screening tool used for assessing gaps in methodology in V&A reports

	Issue	Issue has been…	Comments
STEP 1: SCOPING & DESIGN OF ASSESSMENT			
1	Has a multi-sectoral project team been established?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
2	Do project team members have the relevant expertise and experience in interest?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
3	Does project have a management plan showing: • Timeline? • Roles and responsibilities? • Budget?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
4	Are the goals and objectives of the assessment clearly stated?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
5	Have vulnerable regions and populations been defined?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
6	Has the Geographical region of interest been identified?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
7	Have key stakeholders and a stakeholder plan been stated?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
8	Have other factors that determine vulnerability been identified? (e.g., geographical, socioeconomic, political, demographic, biological factors)	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
9	Has the current burden and distribution of climate-sensitive health outcomes been considered?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
10	Have gaps in current health & other policies been considered?	☐ Fully addressed.	

		☐ Partially addressed. ☐ Not addressed.	
11	Have the likely health impacts of climate change over next decades been considered?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
12	Has health system vulnerabilities been considered?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
13	Has a communication plan for informing and disseminating the assessment process and outcome of the assessment been developed?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
14	Has the costs & benefits of proposed policy changes been considered?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
STEP 2: VULNERABILITY ASSESSMENT **(Describing the Current Burden of Climate Sensitive Health Outcomes and Vulnerabilities to Climate Variability and Change)**			
1	Have the key climate-sensitive outcomes been clearly Identified, described and prioritized?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
2	Have the relationships between current and past weather and climate conditions and health outcomes been analysed?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
3	Have the trends of upstream drivers of climate-sensitive health outcomes and the geographical distribution of risks been clearly identified?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
4	Have the vulnerable populations and geographical regions of interest been clearly identified?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
5	Is there a documentation of baseline information for monitoring changes in future vulnerability and evaluating adaptation options."?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	

6	Was the assessment participatory? Were stakeholder and the identified communities consulted and involved in the vulnerability assessment?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
STEP 3—ADAPTIVE CAPACITY ASSESSEMENT: **(Assessing the capacity of Health and Health-Relevant systems)**			
1	Has the study assessed the current capacity of the health system to address the risks of climate-sensitive health outcomes?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
2	Has the study assessed the current actions of other sectors that affect the risks of climate-sensitive health outcomes?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
3	Was the assessment participatory? Were stakeholder and the identified communities consulted and involved in the vulnerability assessment?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
4	Has the study specifically assessed for capacity to respond to climate sensitive Health outcomes related to extreme weather events?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
5	Has the study specifically assessed for capacity to respond to Vector-borne, rodent-borne and zoonotic diseases	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
6	Has the study specifically assessed for capacity to respond to Water- and foodborne diseases	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
7	Has the study specifically assessed for capacity to respond to climate sensitive Health outcomes related to air quality	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
8	Has the study specifically assessed for capacity to for capacity to prevent child malnutrition	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
9	Has the study specifically assessed for capacity of the health sector workforce?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	

STEP 4—PRIORITIZATION OF ADAPTIVE CAPACITY: **(Rating the adaptive capacity of Health and Health-Relevant systems PPPs)**			
I	Did the report show any evidence of prioritization of adaptive capacity?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	
STEP 5: FUTURE RISK ASSESSMENTS OF CLIMATE CHANGE IMPACTS ON HEALTH			
I	Did the report include analysis to project the future Health risks of Climate Change either Quantitatively or Qualitatively?	☐ Fully addressed. ☐ Partially addressed. ☐ Not addressed.	

Annex 3: Sample template for assessing health system capacity gaps by H-NAP components at national level

H-NAP objectives	Capacity gaps	Current and planned PPPs	Adaptive capacity ratings (Limited-1; Moderate-2; Adequate -3)	Adaptive actions recommended	Lead health sector agencies	Non-health sector agencies
Management of environmental determinants of health						
Coordinate management of environmental risk factors for CSHOs						
Monitor environmental risk factors for CSHOs						
Develop/ strengthen regulations for management of environmental risk factors for CSHOs						
Climate resilient and sustainable technologies and infrastructure						
Adaptation of current infrastructures, technologies, and processes.						
Promotion of climate resilient and sustainable technologies and infrastructure						
Sustainability of health operations						

Annex 4: Sample screening tool for assessing adaptive capacity of health system at regional level

	Questions	Rating of knowledge, experience, and resource availability (Limited-1; Moderate-2; Adequate -3)	Comments
	Infrastructure, Technologies, and Processes		
	Do you have reports of health facilities in districts being flooded due to extreme weather events?		
	How many districts have health facilities cut off from access by clients seeking care.		
	Do you have data on the state of health infrastructure in the region?		
	Does the region have the knowledge, experience (considering previous damages) and resource capacity (including human, material, financial, supplies chain and logistics) to manage flood risk reduction in health facilities? *		
	Does the regional estate office work with the local government/ other regional agencies (e.g., NADMO) to support vulnerable local populations to actively participate in risk reduction management, policy making, planning and implementation?		
	Have you conducted climate risk and vulnerability assessments for all facilities to identify risk scenarios, vulnerabilities, and the facility's response capacity?		
	Have you evaluated the condition and safety of structural and non-structural elements impacted by previous exposure to flood?		
	Do you operate a schedule to inspect the facilities regularly, both internally and externally, for signs of deterioration (e.g., cracks or sinking structural elements) to avoid or reduce flood impacts?		
	Do the facilities have a contingency plan in place for safe and efficient personnel evacuation (including health staff and patients), and for equipment and other essential supplies before, during and following a flood?		
	Do the facilities have walls protected and insulated against moisture and mould?		
	Do the facilities have rooftop structures that are leak-proof and insulated against rainfall?		
	Are there any facilities in the district tree planting initiatives as a wind shield break against extreme weather events? If yes, what proportion of districts have this initiative		

	Questions	Rating of knowledge, experience, and resource availability (Limited-1; Moderate-2; Adequate -3)	Comments
	Are there any facilities in the district using renewable energy sources such as solar energy? If yes, state the proportion		
B	Workforce		
	Are health workers trained to improve knowledge on how to reduce risks, be prepared and respond to climatic hazard emergencies, and recover better than before through adaptation measures?		
	Do you have an effective emergency risk communication plan to reduce risks and impacts for health workers and patients? *		
	Do you have a contingency plan in place for safe and efficient personnel evacuation (including health staff and patients) before, during and following a flood? *		
C	Supply chain		
	Do you have estimates of the consumption (such as amount used per week) of essential medical, pharmaceutical, nutritional, and laboratorial supplies, personal protective equipment, food, etc., using the most likely flood scenario?		
	Do you undertake risk assessments of the supply chain for essential medical and non-medical products?		
	Do you have a secure plan to ensure continuity of the facility's supply and delivery chain in case of operational disruption caused by extreme weather event?		
	Do you have secure access to essential backup services, such as sterilization, laundry and through cooperative agreements with other facilities to maintain functioning of critical services.		
	Do you have a plan for relocating medical devices, medicines, mobile equipment and other supplies and services in case of operational disruption or outbreaks and epidemics that overwhelm the facility?		

Annex 5: Tool for assessing regional trends and ratings for climatic risk factors and upstream drivers of CSHOs

Regional level key informant interviews

Region: **Date:**

	Sources/ Informant's MDA	Climatic hazard/ Upstream drivers	Comments	? Present		Frequency of exposure (1-Rare /2-occationally/ 3 - Frequently)			Geographical extent (no. of districts)	Trends			Total score
				Y(1)	N(0)	1	2	3	1.2.3	⬆	➡	⬇	
1	**Are these climatic hazards present?**												

Annex 6: Results of qualitative assessment of regional trends and ratings for climatic risk factors and upstream drivers of CSHOs

Ashanti Region

Climatic hazards & upstream drivers	Ratings	Trends	Comments
Poor mining practices	6	Upwards	• Except Kumasi, Sekyere Kumawu, Sekyere Central, transition districts. • Farmlands are destroyed due to galamsey activities which eventually leads to low crop production in the area. • Destroyed water bodies reducing source of clean drinking water in the region.
Heat waves and stress	6	Upwards	• Especially, Mampong to Odwira and within the city. • Worst from December -January. • Especially, Mampong to Odwira and within the city. • Worst from December -January
Loss of farmlands	6	Upwards	• Small scale farmers lose their farmlands to other activities such as estate development, mining etc. and therefore they are pushed to farm in the forest. • Loss of farmlands occur in almost all the districts. Typical examples are at Odwira, Bosomtwe. • There are interventions such as Ghana landscape and restoration project sponsored by world bank by introducing tree planting; about 7 years there was support from Canada – modernizing Agric in Ghana.
Unsafe drinking water	6	Upwards	• Previously people fetched water from streams, dams but now every community has either borehole or are supplied by piped water. • During the dry seasons, water supply from some of the boreholes and wells are badly affected. Some people depend on streams and wells for water supply. • Ghana water company is the major source of water in the urban areas. • Water quality tests are carried out when there is a problem like outbreak of water borne diseases. • The major source of water in the rural areas is boreholes. • Some communities must travel long distances for water. Mamsu Nkwanta and Adobea, Amansi west and south, and Amansi central experience the drying up of wells and boreholes. This may also be related to galamsey activities.
Poor sanitation	6	Downward	• People litter especially the drains, expecting the rain to wash the waste away. • Solid waste disposal has improved because of sanitation improvement package. Every district has been given communal containers and vehicle. There is a contract with Zoomlion to assist with the management of waste.

			• KMA has constructed an engineered landfill. The problem of littering therefore is under control. • Open defecation is currently being managed by world vision program, GKMA (expected to construct 30,000 household toilets by December 2024, currently 23,000 constructed so far within 16 districts, Water, and sanitation for the urban poor, MMDAs also using the same COMMUNITY led total sanitation approach to achieve the control of open defecation. • There is a shift from community toilet to household toilets. There are few community toilets around.
Logging	4	Upwards	• Atwima Mponuah, Amansi West, East, Central, Adansi South, North, Central, in the transitions.
Charcoal production	4	Upwards	• In the transition zones– Odwira, Agogo, Mampong, Nsuta, Sekyere Afram plains and Asante Akim north. There is deforestation within the area due to logging for timber, charcoal, open fire, estate development and mining
Overgrazing/ destruction by livestock	4	Upwards	• Asante Akim North, Sekyere Afram Plains, Sekyere Central, Odwira Sekyi Odumase, (Transitional Zones), Offinso North
Sand winning	4	Upwards	• Atwema Kwanwoma, Nwabiagya, Afigya Kwabre North and South, Adweso, Mamponteng, Agona
Heavy rainstorms and floods	4	Upwards	• Greater Kumasi, Bekwai, farm areas, some mining areas, • Floods normally destroy farmlands but not settlements. • Most of floods occur because of human activities such as encroachment of water ways. • Mampong – dining hall and dormitory served as haven. Hospital at Odwira and Odwiramen secondary schools, Obuasi, area around Kwadaso – population was moved into a church for about 3 days (Owabi stream) – over 60 buildings affected, people were rescued with canoes, population were relocated.
			• Uncommon. Heavy storms were experienced within this year (2023). The roof of a secondary school got ripped off. One health facility in Kumawu had its roof ripped off.
Wildfires	3	Unchanged	• Happens within the rural areas, where most of these farmlands are located. In the city centre. It is mostly caused by humans.
Drought	0	N/A	
Forced migration	0	N/A	
Vulnerable shelter	0	N/A	
Conflicts/ fighting	0	N/A	
Low crop yield	0	N/A	
Sea level rise	0	N/A	

Bono Region

Climatic hazards & upstream drivers	Rating	Trends	Comments
Conflicts/fighting	5	Upward	• There are many disputes, but few deteriorate into conflicts. There are conflicts between Fulani herdsmen and the locals around Banda, Wenchi and Sunyani west. In Fiapre and Sunyani there are conflicts over ethic boundaries.
Forced migration	5	Upward	• People from Brekum migrate to Sefwi for farming jobs. Others go in and out to Ivory Coast causing a surge in HIV. There are also Fulanis, Miners, Herdsmen and Fisher folks who have migrated into the Region.
Lumbering	5	Upward	• Lumbering is a major problem. Dormaa Central, Sunyani West and East.
Overgrazing/ destruction by livestock	5	Upward	• Trampling by cattle is an issue.
Poor sanitation	5	Upward	• Banda area mostly affected. The problem is worsening across the region due to population increase.
Loss of farmlands	5	Upward	• Land use for food production is decreasing. Cashew production is also displacing land area for food production.
Wildfires	5	Upward	• Mostly common around Wenchi, Brekum, Banda, Sunyani and Tain areas.
Poor mining practices	4	Upward	• There is illegal mining in Banda district.
Unsafe drinking water	4	Unchanged	• 30-40% have wells and boreholes. Piped borne water is not sufficient. Many of the bore boles are broken down. E.g., at Jaman south and Banda.
Floods	3	Unchanged	• Nkrankwanta was devastated by storm in 2022.
Heavy rainstorms	2	Downward	• Nkenkenkye in Dormaa area experiences floods in the area. There are not many rivers in the Region.
Charcoal production	0	N/A	• Not a problem.
Drought	0	Upward	• Occurs especially in the Banda area where sometimes it does not rain. The area has changed from tropical to Savanna areas. Rains are decreasing overtime.
Heat waves and stress	0	N/A	• No problems with heat waves and stress
Vulnerable shelter	0	N/A	• No problem with Vulnerable shelter
Low crop yield	0	Upward	• Soil fertility is declining, and fertilizer use is increasing. Fewer people are cultivating food crops. Because of technology, yield per acre is increasing
Sea level rise	0	N/A	• No problem with sea level rise
Sand winning	0	N/A	• Not a problem

GAR Region

Climatic hazards & upstream drivers	Rating	Trends	Comments
Heat waves and stress	6	Upward	-
Floods and heavy rainstorms	5	Upward	-
Poor sanitation	5	Upward	Open defecations done mostly at the beach. Due to indiscipline and positive defiance.
Sea level rise	5	Upward	
Unsafe drinking water	4	Unchanged	Inadequate access is the issue when it comes to safe drinking water.
Vulnerable shelter/ haphazard built environment	3	Upward	A lot of squatters due to high cost of rent
Sand winning	3	N/A	
Drought	0	N/A	Not a problem
Forced migration	0	N/A	Not a problem
Conflicts/fighting	0	N/A	Not a problem
Logging	0	N/A	Not a problem
Charcoal production	0	N/A	Not a problem
low crop yield	0	N/A	Not a problem
Overgrazing/ destruction by livestock	0	N/A	Not a problem
Mining	0	N/A	Not a problem

Northern Region

Climatic risk factors	Rating	Trends	Comments
Poor sanitation	7	Upward	
Unsafe drinking water	7	Upward	Peri-urban areas (Around Vittin Estates and road to Yendi). Many are drinking dam water. Rapid growth in Tamale population is faster than production of drinking water. Gushegu, Karaga are water stressed areas
Heavy rainstorms and Floods	6	Upward	Major hazard. Peaks around July-September. Endemic districts are Savelugu, Kumbungu, Tolon, Karaga, Zabzugu, Saboba, Tatale, Tamale metro 10/16 districts. Mainly caused by excessive rains and spillage from Bagre dam. In Tamale the cause is poor drainage system. Trend is upwards because rains are intensifying. A proposed adaptive measure is to dredge the heavy silted white and Black Volta River. Inadequate narrow drainage system. Open drains are filled with refuse. Gumani is flood risk area. Heavy rainstorms mostly in August -September. Associated with gusty winds
Overgrazing/ destruction by livestock	5	Upward	Cattle herds migrate from Burkina, Mali, etc. into region and trample the farms. Major issue
Logging for Charcoal production	5	Upward	Generalized issue everywhere. For charcoal and firewood.
Heat waves and stress	5	Downward	Getting better
Wildfires	5	Upward	
Drought	3	Downward	Drought occurs when the rains fail
Sand winning	3	Unchanged	2/16 districts (Savelugu. Kumbungu)
Sea level rise	0	N/A	Not a problem
Forced migration	0	N/A	Not a problem
Conflicts/fighting	0	N/A	Not a problem
Low crop yield	0	N/A	Not a problem
Mining	0	N/A	Not a problem

Oti Region

Climatic risk factors	Rating	Trends	Comment
Poor sanitation	6	Unchanged	Partner NGO are supporting with latrines, about 28% latrine. There are still issues of open defecation. Waste transportation and final disposal is a challenge. Most of households engage in open burning. Recycling compositing plant has been constructed by zoom lion in Dambai, this has been commissioned but not in use. Currently all districts are using landfill.
Unsafe drinking water	6	Unchanged	No pipe borne water across the region. Population has increased significantly and therefore access to safe drinking water is a challenge. Only a few can afford bore holes and even some of those who have boreholes do not follow the necessary procedures to make it safe for consumption. Some Landlords don't follow the required procedure when constructing bore holes. Most of these boreholes are also not regularly tested. Plans are in place for the commencement of the Dambai water project by Ghana water.
Overgrazing/ destruction by livestock	6	Downward	Migration of nomadic herdsmen, due to conflicts.
Forced migration	5	Unchanged	Flooding affects the communities close to river, sometimes community members relocate and return when it subsides.
Heat stress	5	Unchanged	High temperatures are experienced every year.
Vulnerable shelter	5	Unchanged	Housing is a problem within the region. The demand is high due to increase in population.
Heavy rainstorms and Floods	5	Upward	Across the regions. Storms are mostly strong, and this affects crop yield in the region. Flood occurs in five districts within the Oti region. These are Krachi Nchumuru, Krachi east, Krachi west, Biakoye, Nkwanta north (most flood prone districts). Anytime the Bagri dam is spilled, flooding also occurs. Most structures around the river are affected.
Sand winning	5		Rampant due to construction of new structures within the region.
Wildfires	5	Unchanged	Bush fires occur during the dry season.
Conflicts/fighting	4	Unchanged	Nkwanta south (tribal/land ownership), Krachi Njumuru (chieftaincy), Biakoye (land ownership).
Charcoal production	4	Unchanged	Nkwanta north and south, Krachi East and Ntsumuru
Drought	4	Downward	Drought was experienced in 2021. In that year, rains truncated earlier, thus the dry season was extended. In 2022 to date, it has reduced because more rains experienced.
Lumbering	4	Downward	One of the reasons is the construction of new structures in the regions Guan, Jasikan, Biakoye and Kedjebi.
Low crop yield	0	Not an issue	
Mining	0	Not an issue	Prospecting on iron ore.
Sea level rise	0	Not an issue	N/A

Savanna Region

Climatic hazards/ risk factors	Rating	Trends	Comment
Poor sanitation	7	Upward	There is a problem with latrines. There are only6 houses with latrines. There are about 57 households (Cluster). Support from Global Communities.
Rainstorm and floods	6	Upward	Destruction of farms getting worse (this is the indicator for them). There are flood risk zones here in some districts.
Heat waves and stress	6	Upward	It is because of the excessive logging and cutting down of the big trees and the shade trees. So now there are only shea butter trees left for shade. The chiefs grant consent for tree logging for financial reasons.
Unsafe drinking water	6	Unchanged	Improved- Now there is improved water supply. There is 24/7 water supply from a borehole.
Drought	5	Unchanged	The Fulani people bring in their cattle and destroys their produce. farm destruction from cattle grazing.
Lumbering	5	Upward	There is increase in the logging activities.
Logging for Charcoal production	5	Upward	Charcoal burning is ongoing mostly done by the Sisala tribes. The cutting is getting worse. They come from outside and come to cut it here and burn here and transport it.
Overgrazing/ destruction by Animals	5	Unchanged	There is an issue with overgrazing. More Fulanis are coming in here. They send their cattle, and the cattle destroy the crops like millet, groundnut and maize crops, before these are harvested, and that causes loss of their food crops. This is a seasonal problem
Wildfires	5	Upward	
Forced migration	4	Unchanged	Fulani persons move into the community to graze with their cattle
Vulnerable shelter	2	Downward	This is getting better, due to improved building housing materials
Conflicts/fighting	0		There are no conflicts now.
Low Crop yield	0		
Mining	0		No mining issues
Sea level rise	0		
Sand winning	0		Not a problem here

Upper West Region

Climatic risk factors	Rating	Trends	Comments
Poor sanitation	8	Upward	• Disposal of solid waste is a challenge in the region. There is partnership with the waste management company Zoomlion to help in this regard. • Treatment of liquid waste is also a real challenge. The assembly is helping by building pit latrines for the communities to prevent open defecation. • New technologies are being introduced to help communities put up household latrines. The support is technical and capacity building, but not financial. Loans are provided to be repaid by instalment.
Drought	6	Unchanged	• At times the drought is experienced when the rains stop earlier than anticipated or delays in onset. • It is a big challenge in the Region. Mostly during the dry season, the vegetative cover of the land is removed. The fragile soil means the soil cover is light and the little vegetation covering the soil is gone. • Animals that need water continue to trample on the soil and the fragile top cover and the organic matter is wash away. • It is mostly experienced at Wa East, Wa West and Jirapa areas. Mostly from October the drought affects the livestock because most of the river bodies become very dry, and it also affects the crop yields.
Heat waves and stress	6	Unchanged	Sometimes during the peak of the dry season especially in 2020 and 2021. The severe dryness was accompanied with heat waves leading to increased cases of CSM in the district.
Logging for Charcoal production	6	Upward	• Economic trees are being harvested for the charcoal and this is degrading the environment. • Shear nut being cut i.e., the alternative livelihood is in danger affecting the rain fall pattens. • Trees on individual lands and the owners at homes are responsible for the cutting of the tress. Some of the chiefs too are involved.
Forced migration	5	Unchanged	• This challenge arises in areas that get flooded, and the people move to new areas e.g. People from Burkina. • Others when fleeing from conflicts in their countries also migrate to the region. For instance, a district called Banu saw about 2000 migrates from Burkina and they were overwhelmed. • They are mostly supported by the Assembly for some time and the central government also must come into support. • Some also migrate to new areas due to economic factors.

Unsafe drinking water	5	Unchanged	• The source of drinking water mostly for the rural communities and the urban centres is bore holes. • Others also drink from open source which is already polluted i.e., Streams and this cuts across the entire region.eg. Siiru in the Wa West district among others. • Generally, the situation is good but there is about 20 % of some of the communities that do not have access to portable water. • Some NGOS have been involved in texting the safety of the water. • The findings showed that at the household level there is mostly contamination at the storage and usage level and those communities have been educated to boil the water before drinking or use aqua tabs to treat it. • Support is being given to about 17 of the communities to get access to water.eg. • Lambuse, DBI and Nandowli are water stress areas this is due to the challenge of accessibility to the community, • Some dotted community also dig to even get the water from the ground which is also used by the animals. • There is some intervention by some NGOs to improving access to water situation this is also part of their social responsibility. • The people also move into the bush before they farm and so whilst in the bush, they do not have access to water.
Floods	5	Unchanged	• It is an annual challenge. Mostly depending on the volumes due to heavy rains the dams called Kompiani and Borkibe dams are spilled, and this leads to destructions of farm produce. • The communities along the black volta in the last 2 years were heavily flooded and roads cut off leading to difficulty in accessing the other nearby communities. • Most of the farmers despite the vulnerability of the area, still farm along the river due to indigenous knowledge. • Close to the rivers the soil is very rich, but they are vulnerable to the floods. • Again, due to the economic hardship of some of the farmers who are unable to buy fertilizers for the farms they aways prefer to keep planting near the river side. • The farmers are always hopeful that they can harvest before the floods come. • The floods also affect their drinking water. • There is a new technology to dig out trenches in the farms to collect water for irrigations to plant the crops. There is also need for technology to help with the harvesting and need for the farmers to plant early especially in June to ensure good yield and then harvest on time to prevent the non-shatter of the crops. • Incinerator at Dafiema Buse Issa District destroyed by floods in 2023

Wildfires	5	Upward	•
Lumbering for timber	5	Unchanged	• Logging is a real problem i.e., at Sisala East and West and Wa and the entire region seem to have logging as a challenge. • Rose wood lumbering for export and this even. • became a security issue. That needed the intervention of major stakeholders.
Low crop yield	5	Downward	• It is a key challenge that brings out issues with food security. • Low crop yield is due to declining soil fertility. Once the soil fertility is low, the cereals.eg. sorghum and maize are produced in low quantities. However, whenever the farmers can use fertilizers for farming, the crop yield increases. • When fertilizer prices were subsidized, the farmers could afford to purchase it, and it improves the crop yield. • From Nandom, Lawra and Jirapa districts are more vulnerable. The use of fertilizers increases the crop yield. There could be several causative factors i.e., over the years the population is also increasing, and the land is limited. Generally, the food yield is increasing due to increased fertilizer usage which has been helping with the yield. • 2017 there are hybrid varieties of improved yields. Normal supply of fertilizers was halted briefly. • Weather pattern not normal, most of farmers have cultivated a lot of maize. • Intermittent dry spells also affect the yield. • Without rain the germination will be poor. • There must buy more yield to help, and it affects them at times the dry spells can last at least 2 weeks. • This can affect entire fields. It follows up with serious flood and the water washes off people's crops. • Prolonged dry spells occur followed by floods. • Rains cease in October due to dry spells and if you plant late then it will affect it. • They need more of irrigation. Medium to large scale farmers need bore hole irrigation in the farms to supplement the period that is drought. Since not all can get access to the dam site. • Bore hole irrigation for commercial farmers. • Very good water table. Good for bore holes. • Inputs in the markets • People are doing commercial farming and so the produce is increasing at Sisala • In July there use to be dry spells but now it is changing. Best time June planting but now is changing. • They are also encouraged do composting

Overgrazing/ destruction by livestock	5	Upward	Big problem in the region, originating from Burkina and Corte d'Ivoire. A lot of farmlands are destroyed by the foreign livestock. This also leads to conflicts since they have issues with community members. Sisala East and West and Wa East are hotspots.
Poor mining practices	4	Upward	Gold mining in Wa East and West, Sisala East and Nadowli Kaleo, Laura and Jirapa districts. Affecting the water bodies. Farmlands are being sold for miming.
Vulnerable shelter	4	Unchanged	• During heavy storms vulnerable buildings that are made from mud collapse, and some also have their roofs ripped off. • The affordability for quality houses is also a challenge since most of the community members are unable to afford the quality houses.
Storms	3	Unchanged	Occasionally there is a storm. In 2023 a heavy storm caused severe havoc at Diafiama and Bussuai and Issai (DBI) destroying homes and farmlands. In 2022 a health care facility in Jirapa and Lara Municipals got roofs ripped off by storm.
Conflicts/fighting	0		conflict on land but cannot be related to climate issues.
Sand winning	0		Not a problem
Sea level rise	0		N/A

Western Region

Climatic risk factors	Rating	Trends	Comments
Poor sanitation	6	Downward	Issues with waste collection because of frequent breakdown of Zoomlion truck. Open defecation is practiced within the region e.g., Axim, Sekondi, Jomoro etc. Currently inspections have been intensified especially at the shores using E town council.
Sea level rise	4	Upward	Shama, New Takoradi, Jomoro, Nzema east (Axim). In occurs every year
Unsafe drinking water	4	Downward	Urban communities depend on Ghana Water. Rural communities depend on Mechanized bole holes and hand dug wells. Some communities also depend on streams and rivers. Water quality testing is a problem within the region especially in the rural area. Water quality test is done at the installation stage, but no subsequent testing is done. Ghana Water needs to spend more to treat water due to human activities like Galamsey.
Low crop yield	4	Downward	Focus is now on tree crops like rubber. There is a directive to leave about 10 % of cash crop farmland for food crops.
Sand winning	4	Upward	Around the coastal areas and account to the rise of the sea level. Some communities in the inlands also practice sand winning
Floods	3	Unchanged	Sekondi - Takoradi, Effiakuma market
Wildfires	3	Unchanged	It is not common, normally occur due to accident
Storms	3	Unchanged	
Logging	3	Unchanged	Northern part of the region – Asankrekua, Amenfi East, Amenfi Central, Wassa East. Trees are cut down for illegal mining in most area.
Mining	3	Downward	
Vulnerable shelter	2	Downward	Some buildings within the rural areas are substandard. Slums are developed in the galamsey communities, it includes all districts except the coastal area (predominant in the Amenfi areas).
Drought	0		
Heat waves and stress	0		
Forced migration	0		People are migrated to a haven when flooding occurs
Conflicts/fighting	0		Used to be between STM and Shama but that has been resolved
Charcoal production	0		
Overgrazing/ destruction by livestock	0		

Ahafo Region

Climatic risk factors	Rating	Trend	Comments
Logging / Charcoal production	7	Upward	Charcoal production occurs everywhere in the region. Logging occurs in Asunafo South.
Heat waves and stress	7	Upward	Scale of problem is widespread in all districts.
Overgrazing/ destruction by livestock	5	Unchanged	Overgrazing / destruction of farmlands by livestock occurs in all districts but the problem is not a major one.
Poor sanitation	5	Unchanged	Four (4) districts have prepared plans for Water, Sanitation and Hygiene (WASH) activities. Two (2) districts are yet to prepare plans for WASH. There are no engineered land fill sites. Dumping of waste is done at located areas. The exception is Asunafo North where there is integrated recycling, IRECOP plant for recycling of plastics, composting etc.
Storms / Floods	4	Unchanged	Not a major problem in the region. Occurs periodically. Affected areas are fields and places closer to riverbanks and wetlands such as Asunafo North, South and West, Asutifi North and Kenyasi.
Bushfires	4	Upward	Few bushfires occur in the region.
Unsafe drinking water	4	Unchanged	The bulk of drinking water supply is ground water. Accessibility is about 80%. Water quality may however be a problem. Vulnerable districts are Asutifi South and Tano South. Only Akyesua get water from Tano river i.e., surface water.
Vulnerable shelter / Haphazard built environment	4	Unchanged	Is a problem in the region due to lack of policy and plans. The problem is common in rural areas. There are few rural areas in the region and there are few atakpame houses in the region.
Forced migration / displacement	4	Unchanged	Not a major problem in the region.
Conflicts/fighting	3	Unchanged	Not a major problem in the region.
Sand winning	3	Unchanged	Sand wining is not a widespread problem in the region. Affected areas are Gambia, Asutifi North and Kenyasi.
Low crop yield	3	Downward	Low crop yield is not a major problem in the region. Production of crops e.g., cereals are increasing. Loss of farmlands for estate development is ongoing. The problem is widespread. There is a need for proper land use plan.
Poor mining practices	2	Downward	Not a major problem in the region. There are small scale miners, but the scale of the problem is improving.
Drought	2	Downward	Not a major problem in the region. There are few fire outbreaks. Affected area is Asutifi South.
Sea level rise	0		Not applicable to region.

Central Region

Climatic risk factors	Rating	Trend	Comment
Storms / Floods	7	Upward	Storms / floods are a problem in the region. The floods occur not necessarily because of large volumes of water but due to people building on water ways hindering the flow of water. Okrudu river in Awutu also gets overflow and cause flooding. Flood cause damage to farms in the north and cause damage to school and households in the south. They occur during the rainy season every year. The situation is getting better due to engineering measures. However, places like Kasoa are getting worse. Storms are getting worse. Storms were experienced within this year (2024); a secondary school got ripped off. Affected areas are Kasoa, Upper Denkyira East & West Municipality, Twifu/Atii/Morkwaa District, Efutu, Assin North, Cape Coast, Assin Fosu, KEA, Mfantsiman, Ekunfi, Abra Asiedu Brahman Kaise (AAK), Asikuma/Odoben/Brakwa (KOB) and Agona East and West districts, AOB, AAK, Assin Fosu, Assin North, Efutu, KEA, Gomoa West, Upper Denkyira East and West and Mfantsiman districts.
Drought	7	Upward	Climate affect agriculture through crop, livestock and fish production. Climate patterns have changed. Drought affects most of the communities. At Papase near Awutu Senya, the volume of ground water reduces during dry season. Surface water is even worse during the dry season. Water production is often reduced by about 30% attributed to climate change. Period is from September to November to February. Affect access to drinking water, leading to rationing of water within the enclave. Awutu Senya district has issues with ground water whiles Agona East district has issues with surface water. Other affected areas are Mfantsiman, Koenyaku, Agona East. There is also the issue of dry spells i.e., mild drought. Severely affected areas are all coastal districts such as Awutu Senya East, Awutu Senya, Gomoa East, Efutu, Gomoa Central, Gomoa West, Ekumfi, Mfantsiman, AAK, Cape Coast and KEEA districts.
Poor sanitation	7	Upward	Community Lead Total Sanitation (CLTS) is used to control sanitation. Flooding and storms destroy sanitation systems causing them to get submerged. There is also improper disposal. There are limited containers for disposal so there is indiscriminate dumping of refuse, gutters get choked, there are no engineered dumping sites and most of the dumping are crude, burning etc. Containers for waste disposal are often broken down, leading to spillages of waste and people create their own dumping sites. The following districts however have sanitation issues relatively under control. Areas are Agona West, Upper Dekyira East, Twifu Atimukoa, Ekumfi and Kasoa districts.
Heat waves and stress	6	Upward	The year 2024 has been terrible for heat waves. The problem occurs during the dry season. The problem is widespread. Situation is however better in forest areas such as Assin, KOB and Agona East districts.
Sand winning	6	Upward	Is a problem in all the coastal districts in the region. Sea sand is more expensive than normal sand. Some people even mould blocks at the beach using the sea sand and carry it away. Most affected areas are all the coastal districts including Awutu Senya district.
Logging / Charcoal production	6	Upward	Is a problem in the region. The forest is being cut down. All the areas are now losing the forest. The region has become savanna transition. Galamsay activities are contributing factors. Affected areas are Upper Denkyira West and East, Twifo Atimokua, Twifo Heman, Lower Denkyira, Assin North, Assin Fosu, Assin South, Asikuma Odoben Brakua, Ajumako Enya Asian, Agona East and West and part of Gomoa Central. There are plans with China to help with production of charcoal from coconut husk.

Poor mining practices	6	Upward	Is a problem in the region. Affected areas are Upper Denkyira East and West, Twifo Heman, Twifu Atimakua, Assin North, Assin Fosu and Agona West.
Sea level rise	5	Upward	Sea level rise is a problem at coastal areas due to various factors including sand wining. Some areas are getting better due to architectural designs that are being put in place that is helping with resilience. Other areas too are getting worse. Impact areas are where measures are yet to be put in place. Affected areas are Ekumfi, Mfantsiman, Efutu, Cape Coast and KEA districts.
Low crop yield	5	Downward	Whenever farmers experience a problem, they increase production the following year. Production is rather increasing. Rainfall patterns have changed. Rainfall did not favour production in 2020 - 2022. Rain is coming late and reduces early. In 2022, it rained more in the minor season than in the rainy season. The yield of most agricultural products is increasing except casava. Yields are increasing but at a decreasing rate. Climate change affect coastal savanna more than forest savanna. Coastal areas affected are Efutu, Cape Coast, Mfantsiman, Awutu Seyna, Abora Asebo Kwamankese, Komenda Edina and the problem is more pronounced at Ekumfi.
Unsafe drinking water	5	Upward	Is a problem in the region but in a few areas. Majority of the population, about 70% - 80% get drinking water through either Ghana Water Company or community water and small-town water systems interventions. Perineal water shortage of underground water however affects about 20% - 30% of the population. Also, flood water pollutes underground water. Areas affected are Bontrase and Papase districts.
Conflict / Fighting	4	Upward	Land disputes are ongoing due to estate development. Normally conflicts are due to encroached lands. Affected areas are Kasoa, Cape Coast, Elmina, Assins Fosu, Agona Swedru and Wineba districts.
Overgrazing/ destruction by livestock	4	Upward	Is a problem in the region affecting most of the savanna areas from Awuto Senya to Elmina, Gomoa West, Ekufi, Mfantsiman, AAK, KEA, Assin South, Gomoa East and Central and Komenda Adina Aguafo districts.
Vulnerable shelter	4	Downward	Generally, resilient housing is a challenge especially in the rural sector. Wetlands are being developed.
Forced migration	4	Upward	People are building and blocking water ways leading to flooding and displacement. There is also displacement of communities along riverbanks. Affected areas are KEA, Cape Coast, Awutu Senya, AAK, Mfantsiman, AEE and AOB districts. Displacement at Twifo occurs because of displacement of communities along river Pra because of a lot of rain. The catchment areas are Assin North and Twifo Atimokua. Displacement at Mankessim occurs due to River Ochin.
Bushfires	3	Downward	Domestic fires still occur but trend is coming down. It happens within the rural areas where most farmlands are located.

Eastern Region

Climatic risk factors	Rating	Trend	Comment
Floods/ Storms	7	Upward	Afram plains south and Kwahu East experience flooding annually. Sometimes Atiwa East also. The white volta overflows its banks annually. Floods are usually due to spillage of Bagre dam of Burkina Faso and recently spillage of Akosombo dam. Rainfall is another factor that affects especially low-lying areas. Occurs due to torrential rain. Storms are increasing across the region. Flood prone areas are known. They include Afram Plain North and South, Fanti Akua, Asogyaman, Lower Manya Krobo and Zongo, Adu washing bay and Adom roundabout all in Koforidua Municipality. All 33 districts in the region record some level of floods. Floods cut off access to Health care facilities so PH nurses could not provide routine outreach services. Clients sometimes must use canoes to access HFs. In 2018 New Jejeti Health facilities became flooded due to heavy rains.
Heat waves and stress	7	Upward	Heat stress occurs during the dry season. The weather is getting warmer due to indiscriminate felling of trees.
Poor sanitation	7	Upward	There are issues concerning toilet facilities, solid and liquid wastes management in the region. The problem is widespread. Every home must have a decent toilet. Household toilets are encouraged. Public toilets are usually not encouraged. 33% of households have toilet facilities and 11% does not have toilet facilities. Almost all districts in the region have sanitation issues.
Unsafe drinking water	7	Upward	Is a challenge especially community water. The region has 32 community water systems but currently managing 22. 14 of the community water systems have water quality challenges especially those near areas of mining activities due to small scale and galamsey mining. Chemical contamination issues have been identified at Agogo area. Chemical contaminants include mercury, heavy metals, cobalt, iron, arsenic and fluoride. There is no treatment for fluoride. 28.1% of the population use boreholes while 32.3% use water from Ghana Water company. Issues of emerging contaminants appears to be linked to disturbance of the ground. Affected areas cut across the region mainly where mining is taking place in both urban and rural areas. Ghana Water company provides water to urban areas. Covers all the urban areas i.e., about 100%. Community water and sanitation agency (CWSA) provides water to communities through boreholes and surface water small town water systems. CWSA operates in about 90% in the region.
Poor mining practices	6	Upward	Is a problem in the region. It affects air pollution and agriculture production. Affected areas are Etiwa East and West districts.
Drought	6	Upward	Occurs because of the climate. There are delay in onset of rains. Occurs where there are not much of tree cover. The forest zones are better. Affected areas are Krobo, Kwawu, Upper Manya, Lower Manya and toward the volta region.
Vulnerable shelter / Haphazard built environment	5	Upward	Is a problem in the region due to lack of policy and plans. There is huge housing deficit in the region. Quality of housing for households in terms of ventilation and resilient structures are not the best.
Logging / Charcoal production	5	Upward	Logging is a problem since about 2014. Affected areas are the 2 Afram Plains, i.e., North and South.

Sand winning	5	Upward	Is a major challenge in the region. Affected areas are Suhun, Ahesu North, Upper West Akyem, Aboakwa North and Nsawan Adugyiri.
Conflict / Fighting	5	Upward	Is a challenge between farmers and nomadic herdsmen. Affected areas are the 2 Afram Plains, the 2 Fanti Akuas and Upper Manya Krobo districts.
Overgrazing/ Destruction by livestock	5	Upward	Is a big challenge. Herdsmen cut unapproved crops. There is a Farmer-herder policy which involve creation of food banks for animals. However, the policy appears not to be working. Main challenge is the nomadic herdsmen. Affected areas are generally the Afra Plains, all the 5 Kwawu districts and Amankwakrom.
Bushfires	5	Downward	Bush burning is a problem in the region. It is caused by cattle farmers, nomadic herdsmen, hunters for bush meat and those who cook food on the farms. Affected areas are the 2 Afram Plains and Kwawu East.
Low crop yield	4	Downward	Crop yield in terms of production and productivity is improving everywhere. Land conservation agriculture programs and interventions for effect of climate on agriculture exist. They include cultivation of oil palm seedling, coconut and cashew. Bush burning is also reducing. Other intervention include planting for food and jobs. Farmlands are increasingly being used for estate development. People are looking for more lands for farms especially in the Afram Plains area. Most affected areas are the Birims.
Forced migration	3	Upward	Occurs due to floods.
Sea level rise	0		Not applicable to region.

North-East Region

Climatic risk factors	Rating	Trend	Comments
Floods	8	Upward	Storms / flooding is a significant problem in the North-East Region. Cause of floods include annual spillage of Bagre dam of Burkina Faso, choked gutters, building of structures in water ways and siltation of dams and rivers due to people farming along dams and rivers. Almost every district in the region is a flood prone zone. Notorious flood risk areas are Manprugu Moageduri, Chereponi, East & West parts of Mamprusi. Access to the communities is a problem during flood season, there is collapses of houses, drowning of children and animals, environmental sanitation issues, issues of erosion, increase breeding of mosquitoes and dam breakages especially in west Mamprusi Municipality.
Storms	8		Causes of storms include pruning of trees and cutting of trees either for firewood or charcoal. The problem is widespread in the region.
Drought	8	Upward	Drought is a significant problem in North-East Region. The problem is widespread, affecting all districts in the region.
Heat waves and stress	8	Upward	Heat waves is a significant problem in the North-East Region. The problem is widespread in the region affecting all districts in the region. The year 2024 has been the worse year for heat wave. The rain normally starts in April – November. The dry season normally starts in December.
Conflicts/fighting	8	Upward	Is a problem in the region. Yes, the problem occurs because of land for farming. Population is growing. Conflict can arise between community to community or clan to clan. Affected areas are Chereponi, Yoyoo, Walewale, Brumprugu and district capitals. The problem is widespread in the region. The problem occurs every farming season.
Bushfires	7	Upward	Bushfires are significant problem in the region. The problem is widespread in the region. The problem occurs every year during the dry season. Causes include people who own animals such as cattle as well as those who hunt for bush meat.
Vulnerable shelter / Haphazard built environment	7	Upward	Vulnerable shelter is a problem in the Northeast Region. Most of the housing units are made of mud houses and most of the mud houses collapse during raining season and flooding. Bungalows are also collapsing; 3 bungalows collapse last year. The mud houses are not being built in a sustainable way, so the mud houses collapse easily. Some communities are also water / flood prone areas, but people are not willing to relocate. There is no plan and enforcement, people are not building according to plans and regulations, and enforcement of laws and regulations is a problem. The problem is widespread in the region. Gradually, there are cement block buildings. Mud houses are cooler than cement block houses. Windows are now made of glasses and there are not enough windows in the buildings. Roofing is however OK. Affected areas are West and East Mamprusi, Yoyoo, Gambaga, Nalerigu, Walewale and Brumprugu and the new district capitals.
Logging / Charcoal production	7	Upward	Is a significant problem in the region. Trees are cut for charcoal production and firewood. Affected areas are West Mamprusi, Mamprugu and Magduri where there are issues with rose wood. Then East Mamprusi where tick plants concessions are being cultivated by Indians.

Poor mining practices	7	Upward	Is a problem in the region. There are 2 legal mining companies located at East Mamprusi district. Then there are small scale and galamsey mining ongoing at Mambrugu-Magduri districts.
Poor sanitation	6	Upward	Poor sanitation is a significant problem in the North-East Region. The problem is widespread in the region. Although the population is increasing, there are no engineered land fill site. Crude dumping is the practice in the region. Zoomlion company collects the waste. Septic tanks are siphoned when full. During dry season the liquid waste is sent to farmlands. Schools in the region use KVIP. The waste challenge is the residence and some of the public toilets.
Forced migration / displacement	6	Upward	Is a problem due to flooding. The problem is widespread in the region.
Sand winning	6	Upward	Is a problem in the region and the problem is widespread.
Low crop yield	6	Downward	Is a significant problem in the region. Causes include floods, drought etc. Crop yield depends on the cause of the problem and the type of crop. For example, if flooding occurs in rice production area, then good yield for rice because rice like lots of water. However, if it is a legume, then the yield will be low because legumes do not like a lot of water. The problem is widespread in the region.
Unsafe drinking water	5	Downward	Community Water and Sanitation Agency (CWSA) is the main government institution in charge of water in the region. Ghana Water Company is not available in the region. Drinking water is sourced mainly from the ground. Ground water quality in the region is good except Chereponi. For Chereponi, surface water after treatment is used for drinking water. Water contaminants in the region are fluoride and iron especially in the Chereponi area. After several years of observation, CWSA's conclusion is that the fluoride may be coming from the rocks in the area. Fluoride is the main problem. Iron is easily treatable. Water quality test is done once a year instead of twice a year. Generally, water quality is better during the dry season. Other causes of water pollution are farming activities where people use chemicals. The common chemical use is called condemn. Other causes of water pollution are water handling and hygiene issues, people washing clothing at the dam sites, open defecation near dam sites and hygiene issues during transporting of water to the home. Safe drinking water coverage of the population is about 60%. The trend of water contamination due to natural causes such as floods is going up. On the contrary, the trend of water contamination due to manmade causes such as hygiene issues is going down because of education of the population. Wells are clean thoroughly before water is made available from them to the public whenever wells are found to be contaminated. Programs and projects to ensure water quality - Build resilient structures around water sources. Build plinth concrete is now being built high depending on the nature of the place so that in case of floods water doesn't enter the well directly.
Overgrazing/ destruction by livestock	5	Upward	Is a problem in the region and the problem is widespread.
Sea level rise	0		Not applicable to region.

Upper East Region

Climatic risk factors	Rating	Trend	Comment
Storms / Floods	8	Upward	Floods are a major problem in the region. Floods affect entirely the whole region. Almost all the districts are affected. The problem was more severe last year (2023) and this year (2024). Some of the communities are low lying areas. The floods occur sometimes due to torrential rains, or spillage of Bagre dam from Burkina Faso or due to building in water ways. In addition, there are some streams in the region that also overflows its banks. Also, the problem is getting worse due to increase rate of deforestation and bush burning. Affected areas are Binduri, Nabdam, Bawku West, Talensi, Namdam, Bolga municipal and Bolga East. Kasina Nankana and Bongo districts are affected by overflowing streams. Builsa North and South are exceptions.
Heat waves and stress	8	Upward	Is very much a problem during the dry season. The dry season starts from February – May before the rainy season starts, and then after the rainy season from October. The harmattan sometime starts from November and the heat season comes down up to February. The problem is widespread, especially this year (2024). People must bath or take shower frequently to cool off.
Low crop yield	8	Upward	Is a problem and widespread in the region. All districts are affected because of erratic rain fall pattern and dry season spells that affect crop yield. Dry spells are getting worse except that there are now new variety of seeds and farmers try to plant as and when the short rainy season comes in. Food security issues vary from community to community depending on types of crops that are cultivated communities. For instance, for some time now, maize crop yield is OK but that is not the case for millet because of the rainfall pattern. Also, some legumes such as groundnut production have suffered from low yield. Generally, however, in terms of what can be access from the market, food security issues are OK because food stuffs come from other places such as Burkina Faso and other parts of the country. However, generally, crop yield is decreasing.
Overgrazing/ destruction by livestock	8	Upward	Is a problem and the problem is widespread in the region.
Sand winning	8	Upward	Is a problem and the problem is widespread in the region.
Drought	7	Upward	Is a problem but for a long time now (about 5 years) we have not had drought. Normally, rainy season starts from April - May, but now the rains come through to July. By this time (July) we should have been harvesting early millet but that is not the situation. Sometimes the crops planted are changed. The problem is widespread.
Poor sanitation	7	Upward	Almost all the districts in the region have poor sanitation problem and the problem is getting worse because of urbanization. Also, behaviour change is not improving. Zoomlion company does most of the collection and transportation of waste in the region. Some few districts have temporary place that holds the waste.
Forced migration / displacement	6	Downward	Is a problem and widespread in the region. There are challenges getting logistics to support displaced people, sometimes school compound used to provide temporary shelter for displaced people are not available.
Logging / Charcoal production	6	Upward	Is a problem in the region. Logging occurs in forest reserve areas for rose wood. Affected areas are Garu, Timpani, Talensi, Bulsa South, Nabdam

			and Kasina Nankana West districts. The problem is getting worse because it is some peoples source of energy for heating etc.
Loss of farmlands due to estate developments	6	Upward	Is a very big issue especially in the urban and peri-urban areas. Affected districts are Bolga East, Navrongo, Talensi, Bolga municipal and Nabdam districts.
Bushfires	5	Downward	Is a problem but the problem is isolated. Areas affected are Bongo district, Talensi district, Bulsa South and North and Nabdam district.
Poor mining practices	5	Unchanged	Is a very big issue in the region. There are 2 large scale mining companies in the region. There is also galamsey work in the region. Affected districts are Bolga municipal, Bongo, Bawku West, Talensi and Nabdam.
Vulnerable shelter / Haphazard built environment	5	Downward	Is a problem in the region. People build without regard to plan. There are collapse houses in Kasina Nankana district, Kasina Nankana West and Bongo districts. Houses collapse during the peak of the rainy season i.e., August – September. The problem is widespread in the region. The problem is getting better because of education by the department of Land Use and Spatial Planning and the District Assembly. The Ghana Red Cross Society through the Building Back Better program have provided support to improve buildings in the region.
Unsafe drinking water	4	Downward	Ghana Water company supplies drinking water to 4 districts out of 15 districts. The rest of the 11 districts including rural communities get their water supply from CWSA. Over 64% of the population have access to safe drinking water in the rural areas. Water quality tests are done quarterly. Bongo districts have issues of fluoride in drinking water. Also, water levels fall over time.
Conflicts/fighting	0		Conflicts / fighting in the region are not climate related.
Sea level rise	0		Not applicable to region.

Volta Region

Climatic risk factors	Rating	Trend	Comment
Heat waves and stress	7	Upward	Excessive heat is experienced during the dry season in all districts in the region.
Forced migration / displacement	7	Upward	Is a problem in coastal areas due to periodic tidal wave increase. The problem can be described as non-permanent displacement. In recent times, we have displacement of people due to spillage of Akosombo dam. Affected areas are Keta, Angloga, Ketu South and the 3 Tongus i.e., South, Central and North Tongu.
Low crop yield	6	Upward	Is a widespread problem in the region. The rains are not coming the way they used to come and when the rain comes, it comes too much and cause flooding. The problem of low crop yield can be looked at in two (2) ways, namely the area put under production and yield from production. Yield is increasing due to application of technology. In addition, more people are farming leading to increase production. Climate is however generally affecting crop yield.
Bushfires	6	Upward	Bushfires are widespread in the region. Affected areas are Kpado Municipality, Hohoe, South and North Dayi, Adaklu, Ho and Ho West, the 3 Tongus i.e., South, Central and North Tongu and Akatsi North and South.
Sand winning	6	Upward	Is a problem in the region. Affected areas are Ho, Ho West, the 3 Tongus, i.e., South, Central and North Tongu, South Dayi, Ketu South and North, and Keta districts.
Storms / Floods	6	Upward	Flooding is a problem especially in coastal districts due to periodic tidal wave increase. Also affects communities along water bodies such as rivers and dams. In recent times, we have displacement of people due to spillage of Akosombo dam. Storms occur occasionally in some districts in the region. Affected areas are Ketu South, Angloga, Keta, South and North Dayi, Gemeni area, Kpando Torko and the 3 Tongus i.e., South, Central and North Tongu.
Vulnerable shelter / Haphazard built environment	6	Upward	Haphazard built environment is a challenge in the region since development is faster than planning due to lack of local plans. The problem can be described as widespread especially in the rural area. Most affected areas are along the coast i.e., Ketu South, Keta, Angloga and the 3 Tongus i.e., South, Central and North Tongu.
Unsafe drinking water	5	Upward	Most places in the region have Ghana water company provision of water. 60% of the population in the region have been covered with regards to potable water. The remaining 40% of the population are not covered. Ghana water is rationed sometimes. Dzodze area do not have water at all.
Logging / Charcoal production	5	Upward	Charcoal production is a problem in the region. Affected areas are Adaklu, Agotime Ziokpli, North and South Dayi, Hohoe, Ho municipal, Ho West, Kpando and Afadzato South districts. The problem logging is not common in the region. The problem is common in the Oti region.
Drought	5	Upward	Occurs in the region especially along the coast. Rainfall pattern is changing. Now we cannot differentiate between the rainy season and the minor season. Affected areas are Ketu North, the 3 Tongu's i.e., South, Central and North Tongu and Akatsi areas / districts.
Sea level rise	5	Upward	Coastal districts are affected. They include Ketu South and North, Angloga and Keta districts.
Poor sanitation	4	Downward	Is a widespread problem in the region. There is 56% sanitation coverage and 32% coverage for exclusive households.

Overgrazing/ destruction by livestock	4	Unchanged	Overgrazing / destruction by cattle is a challenge in some parts of the region. Affected areas are Central and North Tongu, Adaklu and Ketu North districts. The problem is increasing in Central and North Tongu districts. However, the problem is decreasing in Adaklu and Ketu North districts.
Poor mining practices	3	Upward	Mining for minerals such as gold etc are not carried out in the region. However, there is mining for clay (geophagic clay) which is eaten especially by pregnant women. Affected area is North Dayi district.
Conflicts/fighting	2	Unchanged	Conflicts / fighting related to climate risk factors are not common in the region.

Western North Region

Climatic risk factors	Rating	Trend	Comments
Lumbering	8	Upward	There are a lot of timber processing companies in the region. Logging for timber is widespread in the region.
Poor mining practices	7	Upward	Poor mining practices is widespread. The problem has negative impact on crop production. In addition, there is concern of chemicals associated with mining potentially getting into food crops (chemical residue in food) and other parts of the environment.
Floods	6	Upward	The problem is widespread in almost all the 9 districts. Situatiom worse in Aowin, Kontombra, Bai West and Suaman districts. Duration of rainfall is shortening but intense. Rains come heavy but in a short time. Rice fields are flooded in Wiawso, Bibiani, and Aowin. Development activities is also affecting flooding. Proper channels and gutters for water flow are not being built.
Storms	6	Upward	Rain now comes with increasing wind and lots of storm, uprooting trees and collapsing structures. Some farming fields are now being flooded. 32 houses roof riffed off this year – Kontombra, Bodi
Heat waves and stress	6	Upward	Heat waves are widespread, especially during the dry season in the months of March and April. The forest cover is being lost gradually.
Unsafe drinking water	6	Upward	Everybody gets drinking water through boreholes and ground water in the region. The borehole water is tested. Water quality test is conducted twice a year and then water is treated by treatment plants if there are issues with the water quality. Water coverage is 64% in the region. Floods are affecting borehole water quality by causing contamination. Manganese and iron are now found in water in the region. Runoff water is also disturbing water quality from pipelines. Some boreholes also get dried these days. Surface waters are coloured. Flooding occurs at Wiawso and Dzoabuso. Dryness of boreholes occurred at Bia West district. Borehole extraction is not controlled in Ghana. Borehole extraction needs to be regulated.
Poor sanitation	6	Downward	Access to good sanitation services is about 40%. Water table is generally high in most places so there is over reliance on community facilities compared to private sanitation facility. Open defaecation is widespread in the region, around 20%. Population in the region is however low, about 1 million. Open defaecation is reducing. Region has no place to dispose of liquid waste. Final disposal of liquid waste is not known. Potentially, liquid waste management is a problem. Waste treatment plant is located at Bekwai.
Sand winning	5	Upward	Those who carry out sand winning activities are now moving to galamsay sites to collect sand and gravel left behind after galamsay work. Gravel and sand combined is considered as a very good material for the building and construction industry. The problem can be described as widespread in the region. Severely affected areas are however, Awuwi, Bibiani and Suaman.
Drought	4	Upward	Drought is also a problem widespread in the region.
Low crop yield	4	Upward	Rains come in short time but with high intensity. Low crop yield is a problem at Awawi district due to flooding and a problem in Bibiani and Wiawso districts due to use of farmlands for estate development. Low yield of Cocoa crop production problem in the region is however due to swollen shoot disease. But personally believe the forest cover is also declining.

			Loss of farmlands for estate development can affect crop production negatively. The practice is a problem in Bibiani, Wiawso and Awuwi districts. Bibiani is also losing farmlands due to mining.
Overgrazing/ destruction by livestock	4	Upward	Overgrazing / destruction by livestock is a problem in Bibiani, Bekwai, Bia West and Wiawso.
Forced migration	4	Upward	Forced migration / displacement occurred at Awawi and Bia districts last year due to flooding.
Bushfires	4	Unchanged	Bushfires are not that much in the region. There are only pockets of it.
Vulnerable shelter / Haphazard built environment	3	Downward	Quality of housing is generally of high quality, with resilient structures. Old developments / buildings have the problem of haphazard built environment. However, new buildings are being built according to plans.
Logging / Charcoal production	3	Unchanged	Practices of charcoal production is not a problem in the region. Few pockets of the activity are present in the region. A lot of people use LPG.
Conflicts/fighting	3	Unchanged	Conflicts / fighting because of pressure on farmlands and other resources due to climate risk factors appears to be a minor problem in the region.
Sea level rise	0		Not applicable to region.

Bono East region

Climatic risk factors	Rating	Trend	Comments
Storms / Floods	7	Upward	Is a problem in the region. People settle along the riverbanks such as areas around Akosombo, Black and White Volta and Bui dam). Flooding also affects communities located in low lying areas. There is generally low-lying terrain affecting schools, residential areas and health facilities. Flooding also occurs due to indiscriminate dumping of refuse in gutters. Communities are flooded and affluent gets flooded leading to contamination. The problem is more endemic in the Pru and Sene areas. Seven (7) districts are mostly affected in the region namely Bono East, Kintampo North, Pru West and East, Sene East and West, Techiman municipal, Atebubu, Nkoranza North and South. Certain districts like Pru East and Sene West were badly affected by the Akosombo dam spillage. Pru river & volta overflowed its banks, destroyed crops, - in Sene East, Pru East, blocking access to health facilities Also, communities that are in low lying areas along the black and white volta often get submerged. They include Kintampo South and Twumia Kwanta in Techiman.
Heat waves and stress	7	Upward	All the eleven districts are affected during the dry season.
Poor sanitation	7	Upward	Most communities have the problem of poor sanitation especially in urban areas. Open defecation is a challenge as well as indiscriminate dumping of refuse. Most communities use old latrines. In Sene East, out of 96 communities, only 2 is open defecation free. There are no engineered land fill sites. Similarly, there are no places to treat liquid waste. Toilet dumpers (about 70% for urban areas) are not controlled.
Unsafe drinking water	7	Upward	Both surface water and underground water contamination is a problem in the region. Boreholes are sited at the outskirt of town where open defecation also takes place. Feacal matter contamination has been identified. Chemical contamination by iron and manganese have also been identified. Pesticide pollution is also a problem. Rural and peri urban communities have water from community water and sanitation agency (CWSA). Surface water provision is at Yeji. All districts are affected. Atebubu has problem with the drinking water. The water is salty. Water is being piped from Yeji for Atebubu.
Drought	6	Downward	Kintampo has severe drought during dry season. Drought also promotes insect pest. Affected areas are North and South Mo, Kintampo North, Pru, Sene East, Techiman South and Nkoranza North.
Bushfires	6	Upward	Bushfires are caused by cattle farmers, nomadic herdsmen, hunters and those who cook on the farms. Affected areas are Sene East and West, Kintampo North and South and Techiman North.
Vulnerable shelter / Haphazard built environment	6	Unchanged	Generally, climate resilient shelter is not enough in the region. But the problem appears also not to be a big problem in the region. Atakwame buildings can withstand rainstorms better than modern buildings maybe due to modern design issues. Modern buildings are the ones that are ripped off during rainstorms. Haphazard built environment is a problem in the region due to lack of policy and plans.
Logging / Charcoal production	6	Upward	Is a common phenomenon in the region. Affected areas are Kintampo North and Sene districts. Logging is not a major problem

			currently in the region except some rose woods felling that have taken place some few years ago.
Overgrazing/ destruction by livestock	5	Upward	It's a common phenomenon caused by Fulani herdsmen.
Sand winning	5	Upward	Is common everywhere.
Forced migration / displacement	5	Upward	Occurs due to floods from dam spillage. Affected areas are Pru East and West and Sene East.
Poor mining practices	5	Unchanged	There are no mining activities ongoing in the region. However, there is exploration ongoing recently. Affected areas are Tsingakrom, Banda, Kintampo North and South.
Conflicts/fighting	4	Upward	Occurs between farmers and Fulani / nomadic herdsmen.
Low crop yield	4	Downward	Is a problem in the region. Causes include flooding and decline nutrients of the soil. Bush burning caused by hunters is also affecting crop yield. Affected areas are Nkoranza North and South, Kintampo North and South and Kwame Danso districts.
Sea level rise	0		Not applicable to region.