CLIMATE AND HEALTH VULNERABILITY ASSESSMENT FOR GHANA

REPORT

December 2023

THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP

CLIMATE AND HEALTH VULNERABILITY ASSESSMENT FOR GHANA

THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP

ACKNOWLEDGMENTS

This report was done by: Prof. Mawuli Dzodzomenyo (Lead), University of Ghana, Legon; Dr. Margaret Appiah, University of Environment and Sustainable Development, Somanya; Dr. Naomi Kumi, University of Energy and Natural Resources, Sunyani; Dr. Jeffrey Nii Armah Aryee, Kwame Nkrumah University of Science and Technology, Kumasi; Prof. Duah Dwomoh University of Ghana, Legon; and Prof. Benjamin Delali Dovie, University of Ghana, Legon. Contributions were provided by the World Bank Health, Nutrition and Population team in Ghana: Patrick Mullen, Human Development Program Leader; Enoch Oti Agyekum, Health Economist; Akriti Mehta, Consultant; Pearl Opoku Youngmann, Liaison Officer, Global Financing Facility; and Leila Fall, Human Development Analyst. The report reflects valuable inputs from: the ministries of Health, Agriculture, Science Technology and Environment, and Water and Sanitation; the Atomic Energy Commission; and representatives of civil society. The team acknowledges Mr. Kwakye Kontor, Ministry of Health, and Dr. Carl Osei, Ghana Health Service, for their technical support and advice. The team appreciates the Ghana Health Service, which provided data through the Centre for Health Information Management, and the Ministry of Fisheries and Aquaculture Development, which provided data on sea-level rise.

Finally, the team expresses its thanks to all stakeholders who took the time to provide information and input.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

AFRO	Africa Regional Office
BRT	Bus Rapid Transit
CBEA	Community Based Extension Agents
CCKP	Climate Change Knowledge Portal
CFSVA	Comprehensive Food Security and Vulnerability Analysis
CHAG	Christian Health Association of Ghana
CHIM	Center for Health Information Management
CHPS	Community Health Planning and Services
CHVA	Climate and Health Vulnerability Assessment
CMIP6	Coupled Model Intercomparison Project Phase 6
COPD	Chronic Obstructive Pulmonary Disease
CSM	Cerebro-Spinal Meningitis
CSRPM	Centre for Scientific Research into Plant Medicine
DENV	Dengue Virus
DHMIS	District Health Information Management System
EPA	Environmental Protection Agency
EWS	Early Warning Signs
FEW	Flood Early Warning
GCF	Green Climate Fund
GDP	Gross Domestic Product
GHS	Ghana Health Services
GMet	Ghana Meteorological Agency
GoG	Government of Ghana
GSS	Ghana Statistical Service
HEW	Health Early Warning
HIV	Human Immunodeficiency Virus
HSS	Heath System Strengthening
IDSR	Integrated Disease Surveillance and Response
IgG	Immunoglobulin-G
IHD	Ischemic Heart Disease
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
ITNs	Insecticide Treated Nets
LUSPA	Land Use and Spatial Planning Authority
M&E	Monitoring and Evaluation
MDAs	Ministries Departments Agencies
MMDAS	Metropolitan Municipal District Assemblies
MOFA	Ministry of Food and Agriculture
MOH	Ministry of Health
MRDPs	Migrants Refugees and Internally Displaced Populations
NADMO	National Disaster Management Organisation
NAP	National Adaptation Plan
NDCs	Nationally Determined Contributions
NGOs	Non-Governmental Organizations

NHIS	National Health Insurance Scheme
NMCP	National Malaria Control Program
OPD	Out-Patient Department
PHC	Primary Health Care
PM	Particulate Matter
QGDP	Quarterly Gross Domestic Product
RTI	Road Traffic Injuries
SSP	Shared Socioeconomic Pathways
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USD	United States Dollars
WHO	World Health Organization
WHO-AIMS	World Health Organization Assessment Instrument for Mental Health Systems
WMO	World Meteorological Organization

1. EXECUTIVE SUMMARY

Climate change impacts various aspects of life, including health. Its effects on human health can be direct and immediate or indirect and delayed. Direct effects result from increased frequency and severity of extreme weather events, such as heat, drought, and heavy rain. Indirect and delayed effects may be mediated through alterations in natural systems, such as air pollution and water insecurity, or mediated by human systems, such as malnutrition and mental health.

Ghana is vulnerable to the effects of climate change. Climate change impacts the epidemiology of climate-sensitive infectious diseases such as malaria and diarrhea, which are estimated to be the 1st and 8th most common causes of death in Ghana. Additionally, malnutrition and air pollution, also sensitive to climate change, have been identified as the top two risk factors contributing to death and disability in the country.

Climate and Health Vulnerability Assessments (CHVA) are country-level diagnostic tools used to identify climate risks to health and health systems, the adaptive capacities in place to deal with these risks, and recommendations to meet identified gaps. This report presents the findings from Ghana's CHVA. Accounting for the burden of climate-sensitive infectious diseases in Ghana, this report places greater focus on understanding the impact of climate change on vector and water-borne diseases, particularly the impact at the national and sub-national levels of malaria, diarrhea, meningitis, and schistosomiasis. It also presents an exploratory analysis of the direct health effects of climate change and its impact on mental health and air pollution-related diseases.

The assessment used a multi-pronged methodological approach, including desk review of documents and literature, quantitative analysis of secondary data, and qualitative data collection and analysis. Using the World Health Organization's (WHO) Operational Framework for Building Climate-Resilient Health Systems, it presents the assessment of capacities and gaps along the six Health System Strengthening (HSS) building blocks and identifies recommendations for strengthening each of the ten components of health system climate resilience.

CLIMATE EXPOSURES/HAZARDS

OBSERVED AND PROJECTED CLIMATOLOGY AND SEA LEVEL RISE

An analysis of Ghana's observed climatological trends indicates wide variability in temperature and precipitation across the country, with the Northern region receiving less rainfall and experiencing higher mean and maximum temperatures. Rainfall patterns are unimodal in the north and bimodal in the southern part of the country, with maximum rainfall amounts recorded in the southwestern part. The average air temperature from 1991 to 2020 generally increases with latitude. The mean temperature over Ghana ranges between 26°C and 30°C, with the highest in the country's north. Projections for 2020-2039 and 2040-2059 estimate that monthly rainfall patterns will be unimodal, peaking between June and September. Overall, a substantial decline in rainfall magnitude is expected over the country. Projected temperatures showed bimodal patterns and warmer periods for 2040-2059 compared to 2020-2039. Relative to historical trends, monthly temperature peaks are expected to shift by a month to March-April.

On average, an increase of 3.44 mm in sea levels per year was observed from 1993 to 2016, though recent years exhibit an estimated rise of 50 mm and above. An analysis of projected changes in sea levels under different emission scenarios using the new Shared

Socioeconomic Pathways (SSPs), an indication of climate change projections and Socioeconomic scenarios for evaluating climate impact and adaptation measures, estimated an increasing trend in projected sea level rise. Four SSPs, with varying adaptation and mitigation pathways, were assessed for the 2020-2039 and 2040-2059 periods. 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, the sea level is expected to rise by about 5.3 mm/year within 2020-2039, with an increase of about 5.5 mm/year in 2040-2059.

CLIMATE-RELATED EXTREME EVENTS IN GHANA

In the past 50 years, 22 major hydrometeorological events in Ghana have affected 16 million people, directly causing over 400 deaths. Six climate hazards associated with extreme events can be identified in Ghana: droughts, earthquakes, epidemics, floods, wildfires, and storms. There have been 19 significant flood events in the past five decades; despite declining projected average rainfall, heavy rainfall events are expected to increase in Ghana, resulting in flooding, flash floods, and riverbank erosion. Additionally, sea-level rise in the country is resulting in sea erosion and flooding along the coastal stretch and is pervasive on the eastern coast along the Volta delta, affecting communities along the coast. Three drought events have occurred in Ghana in the past five decades with varying degrees of impact. Both floods and droughts pose a significant threat to the agricultural sector, with the most immediate consequence being a decrease in the production of staple crops and a negative impact on the livelihoods of smallholder farmers.

HEALTH RISKS

VULNERABLE SUB-POPULATIONS

Dimensions of poverty, gender, age, urban-rural residence, occupation, and disability can characterize population sub-groups that are most vulnerable to the impact of climate change. The elderly, women, children, the chronically ill, the socially isolated (for example, disabled, ethnic minorities, and migrants), and at-risk occupational groups are particularly vulnerable to climate change impacts. Relative to other parts of the country, the northern part of Ghana greatly relies on subsistence farming. Thus, it is prone to food insecurity due to the damaging effect of frequent exposure to extreme rainfall and flood events on crop yields. Additionally, poverty rates are higher in the northern region, reducing the ability to adapt to climate change and exacerbating its impact. Women, particularly poor women, are more likely to be victims of direct impacts of extreme climate events and are disproportionately affected by food and water insecurity in households. Pregnant women are also particularly susceptible to malaria, resulting in maternal anemia. In Ghana, the drivers of migration, particularly in rural areas, are linked to the impacts of climate change on the sustainability of agrarian livelihoods. The level of vulnerability is higher in rural areas compared to urban due to fewer resources and lower adaptive capacity. Women are disproportionately affected, particularly within rural communities. Heat stress and high levels of physical labor disproportionately impact farmers and miners.

DIRECT RISKS TO HEALTH OUTCOMES

Extreme climate events like floods and droughts have resulted in injuries and fatalities in Ghana. It is also estimated that about 2 million Ghanaians are vulnerable to food insecurity and in the event of a natural disaster, food availability will be greatly affected, particularly in the Northern region and the country's rural areas. There was little evidence of heat-related mortality and morbidity in Ghana's context. However, the literature describes the health effects of heat waves. Heat strokes, common during heat waves, result in substantial mortality with a rapid progression to death. In survivors, permanent damage to organ systems can cause severe functional impairment and increase the risk of early mortality. Besides an increase in mortality, evidence from other countries depicts an association between heat waves and increased emergency room admissions, particularly in the elderly and particularly for respiratory and renal disease outcomes. Additionally, heat waves are associated with other health hazards, including air pollution, wildfires, and water and electricity supply failures that have health implications.

Available data suggest that air pollution-related diseases have a high mortality rate and high cost of treatment in Ghana. According to the Global Burden of Disease, air pollution remained the second greatest risk factor contributing to the most deaths and disability in Ghana between 2009 and 2019. A report on ambient air pollution and its health impact estimated that in Greater Accra, the 2015 levels of air pollution would be responsible for about 70,000 years of life lost in the adult (25+) population over 10 years. It also estimates that implementing air pollution reduction strategies could prevent 1,790 deaths annually in Greater Accra. Additionally, the report identifies household air pollution as an issue resulting from the significant use of solid fuels.

Though evidence suggests the role of climate change in increasing stress, anxiety, depression, and other mental health issues, there is limited information in the context of Ghana. The literature reflects rapidly expanding evidence on the link between climate change and mental health. Extreme weather events such as heat events, humidity, and flooding have been associated with increased reports of mood and behavioral disorders, including schizophrenia, mania, and neurotic disorders. Post Traumatic Stress Disorder (PTSD) is the most often reported mental health impact of acute climate change-related disasters, though there are increasing reports of suicide and suicidal ideation. Climate change can also result in indirect mental health impacts due to physical and social infrastructure damage, physical health effects, food and water shortages, conflict, and displacement from acute, subacute, and chronic climactic changes. Regarding resource availability, Ghana's health system lacks the infrastructure and human resources to address the burden of mental health issues.

INDIRECT RISKS TO HEALTH OUTCOMES: ANALYSES OF CLIMATE-SENSITIVE INFECTIOUS DISEASES

The study analyzed national and sub-national data on climate-sensitive infectious disease cases. However, there was limited information on the prevalence of dengue in Ghana, partly due to challenges in diagnosing it as distinct from malaria. The Ashanti and Eastern regions of the country reported the maximum absolute number of malaria cases between 2012 and 2021, though cases show a declining trend. As a proportion of total outpatient cases, the northern part of the country had the highest malaria load and the least decline in absolute number of cases over time. Between 2012 and 2021, the absolute number of schistosomiasis cases has been declining nation wide. The number of cases as a proportion of total outpatient cases was <1% across all regions. Across the regions, the number of schistosomiasis cases recorded between 2012 and 2021 ranged from less than 500 to over 10,000, with the highest in the Eastern and Upper East regions.

The study also analyzed national and sub-national incidence data for meningitis and diarrhea. Between 2012 and 2021, the total number of meningitis cases reported across the regions of the country ranged from less than 100 to about 900 cases. All regions reported <1% meningitis cases as a proportion of total outpatient visits. While the upper parts of the country showed a declining trend in reported cases, regions in the middle belt, such as the Ahafo and Ashanti, and the Central Region in the south, have recorded marginal increases. The Ashanti and Eastern regions recorded the highest total number of diarrhea cases between 2012 and 2021. However, as a proportion of total outpatient visits, the northern regions reported the maximum number of cases. Across regions, the total number of cases over the decade ranged from 400,000 to 1.75 million. While the Greater Accra, Eastern, and Upper East Regions have seen the greatest decline in cases over time, cases in the Bono East region seem to be rising by an average of 2,000 cases per year.

In addition, statistical models were constructed to quantify the association of precipitation and ambient temperature with monthly reported diarrhea, malaria, schistosomiasis, and meningitis cases at the national and sub-national levels. An ecological study design was used in which the unit of observation was the national and administrative regions of Ghana using a monthly time series dataset compiled from the routine health management information system and meteorologic estimates between 2012 and 2020.

Nationally, temperature was associated with higher numbers of diarrhea, malaria, and meningitis cases, while precipitation was associated with higher numbers of malaria cases. At the national level, it was estimated that temperature increases were associated with immediate and delayed increases in diarrhea incidence, while the association between precipitation and diarrhea was not statistically significant. Both increases in temperature and in precipitation were associated with immediate and delayed rises in malaria incidence. Temperature increases were associated with immediate and delayed increases in meningitis incidence, while the association between precipitation and meningitis was not statistically significant. Neither increased temperature nor increased precipitation was associated with the incidence of schistosomiasis. In the regional analysis, higher temperature and precipitation were associated with both immediate and delayed effects on the incidence of diarrhea, malaria, and meningitis cases. However, temperature and precipitation were not associated with schistosomiasis, although the number of schistosomiasis cases increased with increasing temperature.

HEALTH SYSTEM RISKS

An affordable and accessible primary health care (PHC) system is integral for early recognition and management of a climate-induced health emergency. A 2018 report by the University of Ghana indicates that Ghana has insufficient health facilities per population density to manage both communicable and non-communicable diseases. Moreover, in 2010 and 2013, the density of health posts per 100,000 people in Ghana declined marginally from 1.18 to 1.11, respectively, while the density of health centers per 100,000 people fell slightly from 9.69 to 9.13.

Despite the expansion of Community Health Planning and Services (CHPS) Zones, various population sub-groups still lack access to PHC services, which may be exacerbated by climate-sensitive health risks. There are gaps in the supply of PHC through government health services, while the National Health Insurance Scheme (NHIS) benefits package largely does not include preventive services. Additionally, strong referral systems across levels of care are lacking. The health infrastructure needs to be strengthened to enhance service availability and readiness. About half of CHPS Zones meet standards in terms of infrastructure and transport, and only a third of CHPS Zones and less than half of Health Centers have the full complement of equipment. Rural and remote districts often report stock-outs of essential medicines.

Human resources for health have increased in Ghana, though there are regional and urban-rural disparities. Over 60% of health facilities and human resources are found in 6 of the 16 administrative regions of the country, with Ashanti and Greater Accra accounting for 40% of infrastructure and human resources. There are shortages in some cadres of health workers, inequities in the distribution and skill configuration of workers, insufficient training, and deficiencies in working conditions. This hampers access to services and achievement of national health objectives.

ADAPTIVE CAPACITY AND IDENTIFICATION OF GAPS

Leadership and governance: Ghana has introduced policies addressing climate change and its health risks across various sectors. For example, the government released the National Climate Change Policy Master Plan for 2015-2020 and initiated the development of a National Adaptation Plan (NAP) in 2020. The NAP aims to adopt an integrated, coordinated, and sustainable approach to resilience building to reduce vulnerability to the negative impact of climate change. Other notable multisectoral policy efforts include the development of a National Climate Change Adaptation Strategy in 2012, spearheaded by the National Climate Change Committee, and the recently updated Nationally Determined Contributions under the Paris Agreement, led by the Ministry of Environment, Science, Technology and Innovation. Notably, most national-level policy documents have emerged from the non-health sectors, with a variable focus on the health impact of climate change. However, the health sector has developed a National Plan of Action for Building a Climate Resilient Health Sector in Ghana for 2015-2025. This plan of action is anchored around the WHO's ten components of climate-resilient health systems and includes sections devoted to health leadership and governance, health workforce, vulnerability, capacity and adaptation assessment, integrated risk monitoring and early warnings, health and climate research, climate resilience and sustainable technology and infrastructure, management of environmental determinants of health, climate-informed health programs, emergency preparedness and management and climate and health financing. The plan outlines activities under each health system building block with measurable outputs and time horizons (ongoing, short, medium, and long-term). It also outlines the lead institutions that can play a key role in the realization of the plans and collaborating institutions such as Development Partners, Non-Governmental Organizations (NGOs), and the private sector. However, there is limited information about the implementation of the Plan of Action or its integration into multisectoral policies and strategies. The only sub-national policy document is the Medium-Term National Development Policy Framework, 2018-2021. The Ministry of Health is establishing a steering committee on climate change and health that will harmonize existing policies and strategies that address the health impact of climate change.

Health workforce: Climate change influences workforce capacity and may put a strain on overall health system performance. Despite an increase in the magnitude of the health workforce in the country, the country faces a shortfall. Additionally, the distribution of the health workforce in the country is unequal. Health workforce training initiatives relevant to climate change and health have largely focused on infectious diseases, particularly malaria.

Health information systems: Currently, the Ghana Health Service collects routine data for health services rendered, morbidity, mortality, and disease burden, which are useful to health managers and used for planning, budgeting, and decision-making. Such information is collected by facilities and districts and submitted through the District Health Information Management System (DHIMS). DHIMS collects information on specific climate-sensitive infections, namely malaria, diarrhea, meningitis, and schistosomiasis. Outside the health system, the Ghana Meteorological Agency tracks temperature, rainfall, and humidity levels across major cities and districts, the National Disaster Management Organization (NADMO) captures data on the effect of extreme heat, and the Environmental Protection Agency (EPA) has a framework for assessing air quality in limited parts of the country.

Essential medical products, technology, and infrastructure: Floods and other extreme weather events damage healthcare facilities and supporting infrastructure. 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. There is an absence of agreed-upon standards and implementation plans. Additionally, no assessments have been conducted to determine the climate resilience of the country's health facilities. This will be particularly imperative for the health infrastructure in the rural areas that may be the only source of health services in the region. Diagnostic tools, vaccines, and treatments at most health facilities do not yet target addressing the health risks of climate change. However, there are examples of interventions utilizing medical products and technologies that target certain climate-sensitive infections, for example, malaria. Ghana's National Essential Medicines List, 2017, includes drugs for various climate-sensitive infections, including malaria, diarrhea, and schistosomiasis; the list also includes meningococcal vaccine. While drug stockouts have been reported at health facilities, there is limited information on the frequency of stockouts of drugs specifically used to prevent and manage common climate-sensitive conditions.

Service delivery: There are gaps in the distribution of health facilities and the health workforce, particularly in rural areas, which affect access to and availability of care to address the burden of climate-related health risks. Moreover, better coordination is needed for service delivery across a range of healthcare and public health programs, including those important to reduce climate change risks. Vertical health programs and interventions, such as for malaria, are in place to address the burden of the climate-sensitive diseases. However, given the wide-reaching impact of climate change on mental health, maternal health, respiratory health, and infectious diseases, to name a few, system-wide integration is needed. Additionally, multisectoral action, as highlighted in the country's health and climate change policies, needs to be implemented.

Health system financing: 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 recurrent costs. Thus, delays in NHIS payments to the facilities limit their ability to render services, particularly in a disaster response situation. Despite the expansion of NHIS, out-of-pocket payments (OOPS) represent the second highest source of financing health services; in fact, the share of OOPS in health facilities' total revenues is increasing. The budget statement of the 2022 financial year estimates that Ghana requires a total of US$9.3 billion in investments to implement the 47 Nationally Determined Contributions programs from 2021 to 2030. To mobilize sufficient financial resources, Ghana is exploring more results-based climate financing options, including carbon markets and climate impact bonds. From 2015 to 2020, the Government of Ghana (GoG) reports having spent a total of GH¢14.5 billion on Climate Relevant Actions, which amounts to an average of 4% of the total government expenditure. The total GoG expenditure between 2015 and 2020 was GH¢ 369 billion, of which GH¢ 14.5 billion was earmarked for Climate Relevant Actions. The recent increase in GoG expenditure is attributed to government interventions in non-health sectors. Among Ministries, Departments, and Agencies (MDAs), agriculture and food security showed the highest expenditure. In contrast, at the Metropolitan, Municipal, and District Assemblies (MMDAs) level, water and sanitation showed the highest expenditure.

Recommendations to reduce climate-related health vulnerabilities and vulnerabilities of the health system

Based on the findings presented in this report, the gaps in adaptive capacity and corresponding recommendations are summarized in Table 1-1. This report is a first, largely exploratory, analysis of the impacts of climate change on health in Ghana so that recommendations are necessarily geared towards further research, monitoring, dialogue, policy development, and building systems and capacities.

TABLE 1-1.
Summary of adaptive capacity gaps and recommendations

HEALTH SYSTEM BUILDING BLOCKS	GAPS IN ADAPTIVE CAPACITY	RECOMMENDATIONS
Leadership and governance	• Little focus on strategies to minimize the health impact of climate change on the most vulnerable sub-populations. • Presence of many national climate change policies with varying focus on its health impact. Most policies have emerged from non-health sectors, except the National Plan of Action for Building a Climate Resilient Health Sector in Ghana, 2015-2025. However, there is limited information about the implementation of the Plan of Action or its integration into multisectoral policies and strategies.	**Leadership and governance** • Undertake dialogue, development, and implementation of the National Plan of Action for Building a Climate Resilient Health Sector in Ghana, 2015-2025. Integrate its objectives and activities into climate change policies emerging from other sectors to allow alignment.
Health workforce	• Despite an increase in the magnitude of the health workforce in the country, the country faces some gaps. The distribution of the health workforce is unequal, with resources concentrated in urban areas. • Health workforce training initiatives relevant to climate change and health have largely focused on infectious diseases, particularly malaria, with little emphasis on the wide-reaching health outcomes and systems implications of climate change.	**Health workforce** • Integrate climate-related impacts into health workforce planning. • Institutionalize climate-related capacity building of the health workforce with buy-in from relevant regulators.

HEALTH SYSTEM BUILDING BLOCKS	GAPS IN ADAPTIVE CAPACITY	RECOMMENDATIONS
Health information systems	• The routine health information and surveillance systems in Ghana collect information on specific climate-sensitive infections, namely malaria, diarrhea, 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.	**Vulnerability, capacity, and adaptation assessment** • Periodically conduct national and sub-national climate and health vulnerability assessments. **Integrated risk monitoring and early warning** • Enhance the coverage of climate-sensitive health conditions in routine health information systems. • Routine integration of weather and disease forecasting. **Health and climate research** • Identify and prioritize knowledge gaps in health and climate research. • Understand the impact of climate change on individuals and communities through research. • Build capacity to use combined health and climate models • Timely analysis and dissemination of surveillance data.

HEALTH SYSTEM BUILDING BLOCKS	GAPS IN ADAPTIVE CAPACITY	RECOMMENDATIONS
Essential medical products, technologies and infrastructure.	• 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 must be taken to further these strategies. • No assessments have been conducted to determine the climate resilience of health facilities in the country. • Availability of diagnostic tools, vaccine, and treatment available at most health facilities is not yet targeted at addressing health risks of climate change. • There is limited information on the frequency of stockouts of drugs used to prevent and manage common climate-sensitive conditions.	**Climate resilient and sustainable technologies and infrastructure** • Undertake vulnerability assessments of health facilities to climate change. • Upgrade public health infrastructure. • Introduce climate-smart health sector infrastructure codes. • Routinely evaluate the availability of drugs and equipment for the prevention and management of climate-sensitive infectious diseases such as malaria.
Service delivery	• There are gaps in health infrastructure and workforce, particularly in rural areas, which limit access to and availability of care to address the burden of climate-related health risks. • There is an absence of institutional mechanisms that integrate strategies for addressing the impact of climate change into all vertical health programs and non-health sectors by utilizing a systems approach.	**Management of environmental determinants of health** • Multisectoral action to improve determinants of health. **Climate-informed health programs** • Continue implementation and strengthening of vector and water-borne infectious disease control programs. • Adopt systems approach to strengthen all health programs towards climate change.

HEALTH SYSTEM BUILDING BLOCKS	GAPS IN ADAPTIVE CAPACITY	RECOMMENDATIONS
		Emergency preparedness and management • Contingency planning. • Build an effective emergency communication system. • Active engagement of communities in emergency response.
Health system financing	• 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 recurrent costs. • Despite the expansion of NHIS, out-of-pocket payments (OOPS) represent the second highest source of financing health services. • Between 2015 and 2020, the GoG reportedly spent an average of 4% of the total government expenditure on Climate Relevant Actions. There is a need to establish sustainable streams of funding to address climate change. • The recent increase in GoG expenditure is largely attributed to government interventions in non-health sectors.	**Climate and health financing** • Sustained and holistic health and climate change financing. • Monitor climate-related health expenditure in line with policy commitments. • Ensure smooth and timely claims payments from NHIS to the health facilities. • Financial protection of vulnerable sub-populations.

Source: Authors

2. INTRODUCTION AND BACKGROUND

Due to global warming, the climate in most regions, especially Africa, is predicted to become more variable, and extreme weather events are expected to be more frequent and severe. These include increasing risks of droughts, flooding, and inundation due to sea-level rise in the continent's coastal areas, potentially reducing economic prospects and national development. It will be imperative for countries to mitigate and adapt to these changing climatic conditions. To succeed,, the potential impacts of climate change and variability must be identified along with the country's capacity to adapt and the means to overcome barriers to successful adaptation.

Climate change impacts various aspects of life, including health. Its effects on health can be direct or indirect. The impacts of climate change on health result from three essential pathways (see Table 2-1): (i) direct and immediate health impacts relating primarily to increased frequency and severity of extreme weather events, including heat, drought, and heavy rain, (ii) indirect and delayed effects mediated through alterations in natural systems such as air pollution and water insecurity that include allergic and infectious diseases, and (iii) indirect and delayed effects heavily mediated by human systems such as malnutrition and mental health[1,2,3]. The pathways and effects of climate change are summarized in Figure 2-1.

Climate change impacts the epidemiology of infectious diseases[4]. It could alter or disrupt natural systems. This disruption could make it possible for diseases to emerge. It could also cause diseases to spread to areas where they were initially limited or did not exist. In other scenarios, some areas could become less hospitable to the vector or the pathogen, causing diseases to disappear. Climate change could also exacerbate existing patterns of ill health by acting on the underlying vulnerabilities of environmental and sociodemographic origin that led to ill health even in the absence of climate change. Studies suggest that children, young people, and the elderly are at increased risk of climate-related illness with adverse effects of malaria, diarrhea, and undernutrition concentrated among children[5].

Ghana is vulnerable to the health impacts of climate change. In Ghana, malaria and diarrhea – both climate-sensitive infectious diseases – are estimated to be the 1st and 8th most common cause of death[6]. Additionally, malnutrition and air pollution, also sensitive to climate change, have been identified as the top two risk factors contributing to death and disability in the country.

Ghana is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and is obligated to carry out national assessments of the potential impacts of climate change, including on the health sector. Vulnerability assessments have typically focused on identifying communities and regions exposed to environmental stressors; they are not designed to examine strategies. Merging vulnerability assessments with adaptation and resilience research provides an opportunity to explicitly link vulnerability assessments with the formulation

1. Costello A. et al. (2009). Managing the health effects of Climate Change. *The Lancet*. *373*(9676):1693–733
2. Jankowska, M. M., Lopez-Carr, D., Funk, C., Husak, G. J., & Chafe, Z. A. (2012). Climate change and human health: Spatial modeling of water availability, malnutrition, and livelihoods in Mali, Africa. *Applied Geography*, *33*, 4-15. doi:10.1016/j.apgeog.2011.08.009
3. Intergovernmental Panel on Climate Change (IPCC). (2014). Climate Change 2014: Summary for policymakers. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, USA: Cambridge University Press.
4. Watts, N., et al. (2018). The 2018 report of the Lancet Countdown on health and climate change: shaping the health of nations for centuries to come. *The Lancet*, *392*(10163), 2479-2514.
5. Xu, Z., Huang, C., Turner, L. R., Su, H., Qiao, Z., & Tong, S. (2013). Is diurnal temperature range a risk factor for childhood diarrhea?. *PLoS One*, *8*(5), e64713.
6. IHME (2019). Global Burden of Diseases. Seattle. Available at: https://www.healthdata.org/ghana

of policies. The Third Intergovernmental Panel on Climate Change (IPCC) Assessment Report suggests that vulnerability is a function of exposure, sensitivity, and coping or adaptive capacity, reporting significantly on the global health impacts of climate change.

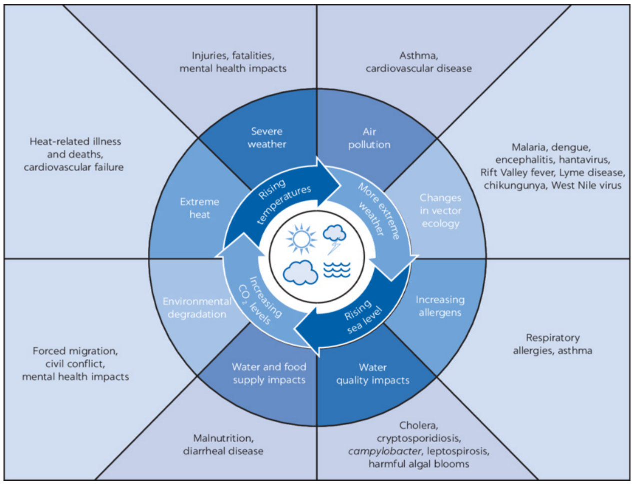
Climate and Health Vulnerability Assessments (CHVA) are a country-level diagnostic tool to identify climate risks to health and health systems, the adaptive capacities that are in place to deal with these risks, and recommendations to meet identified gaps. The tool can be used to assess which populations are most vulnerable to the different climatic stresses and accompanying health effects, identify key weaknesses in human systems that protect vulnerable populations, and propose interventions for critical response. The tool can assist in understanding the direct and indirect impacts of climate change by analyzing the mediating influences, serve as a pathway to improving evidence and understanding of the linkages between climate change and health, and providing a baseline analysis against which changes in disease risk and protective measures can be measured. Despite an increasing understanding of health risks associated with climate change, public health policies and practices globally do not account for climate change-related health impacts. Additionally, existing indicators used to evaluate climate change resilience in the health sector are inadequate and primarily drawn from environmental health perspectives. The CHVA, therefore, is pivotal in differentiating climate change and environmental health outcomes.

TABLE 2-1.
Mediating processes and direct and indirect potential effects of changes in temperature and weather on health.

Mediating process	Health outcome
Direct effects Exposure to thermal extremes	Changed rates of illness and death related to heat and cold
Changed frequency or intensity of other extreme weather events	Deaths, injuries, psychological disorders; damage to public health infrastructure
Indirect effects Disturbances of ecological systems: Effect on range and activity of vectors and infective parasites	Changes in geographical ranges and incidence of vector borne disease
Changed local ecology of water borne and food borne infective agents	Changed incidence of diarrhoeal and other infectious diseases
Changed food productivity (especially crops) through changes in climate and associated pests and diseases	Malnutrition and hunger, and consequent impairment of child growth and development
Sea level rise with population displacement and damage to infrastructure	Increased risk of infectious disease, psychological disorders
Biological impact of air pollution changes (including pollens and spores)	Asthma and allergies; other acute and chronic respiratory disorders and deaths
Social, economic and demographic dislocation through effects on economy, infrastructure, and resource supply.	Wide range of public health consequences: mental health and nutritional impairment, infectious diseases, civil strife

Source: McMichael and Haines, 1997

FIGURE 2-1.
Pathways through which climate change affects human health.



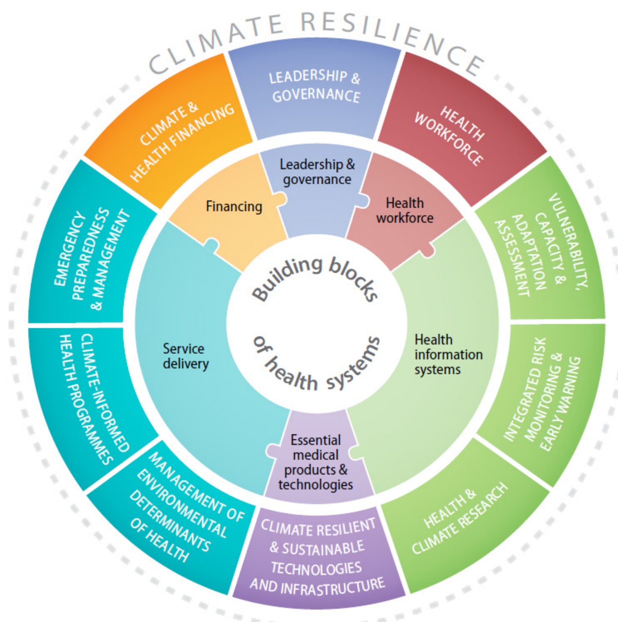
Source: World Bank Group and WHO, 2018

2.1. OBJECTIVE AND CONCEPTUAL FRAMEWORK

This CHVA aims to assist decision-makers in Ghana with planning effective adaptation measures to deal with climate-related health risks. The report identifies the impact of climate risks on health and health systems, the adaptive capacities in place to deal with these risks, and the gaps in the adaptive capacities. It also provides recommendations to close the identified gaps.

The report adopts the World Health Organization's (WHO) Operational Framework for Building Climate-Resilient Health Systems to analyze Ghana's adaptive capacity to adequately deal with current and future identified health risks of climate change. Following this framework (see Figure 2-2), the report assessment is firstly structured around the six Health System Strengthening (HSS) building blocks (inner ring). These six categories encompass the assessment of capacities and gaps, now and into the future. The framework then considers the ten components of health system climate resilience (outer ring), providing recommendations for strengthening each of them.

Figure 2-2.
WHO operational framework for building climate resilient health systems.



Source: WHO, 2015

2.2. APPROACH AND METHODOLOGY

Accounting for the burden of climate-sensitive infectious diseases in Ghana, this report focuses on understanding the impact of climate change on vector and water-borne diseases. In particular, it presents a deep dive into the climate change effects on national and sub-national cases of malaria, diarrhea, meningitis, and schistosomiasis. Due to a paucity of data, the report presents a limited analysis of the direct health effects of climate change and the climate change impact on mental health and air pollution-related diseases.

The assessment used a multi-pronged methodological approach, including a

desk review of documents and literature, quantitative analysis of secondary data, and qualitative data collection and analysis. A desk-based review of published and grey literature was conducted to identify key climate exposures. To summarize current and future climatic patterns, a comprehensive climate-related database comprising temperature, precipitation, and humidity, among others, was used to assess the historical and projected climatologies, as well as, spatiotemporal climate patterns and to assess trends across the country. Climatic Research Unit (CRU) time series data was used for historical assessment, whereas the ensemble mean of Coupled Model Intercomparison Project Phase 6 (CMIP6) data with Shared Socioeconomic Pathways (SSP5.85) were used for the projection assessment. To assess the intersection between climatology and selected health outcomes or risks, the analysis utilized an ecological study design in which the unit of observation was the national and administrative regions of Ghana using a monthly time series dataset compiled from routine health management information systems and meteorologic estimates between 2012 and 2020. We used a negative binomial regression model with robust standard errors that address issues of residual autocorrelation to quantify the association of precipitation and ambient temperature with monthly reported diarrhea, malaria, schistosomiasis, and meningitis cases, from the years 2012 to 2020 in 16 administrative regions of Ghana. To assess adaptation options and the health sector's adaptive capacity towards mitigating the impact of climate change, a desk-based review of policy documents and country-level action plans from Ghana's Ministries, Departments, and Agencies (MDA) were reviewed. Additionally, a stakeholder validation workshop was held with individuals from various sector ministries, wherein the report's findings were validated, and additional information on Ghana's current and planned adaptive capacities was obtained.

3. OVERVIEW OF GHANA COUNTRY CONTEXT

3.1. GEOGRAPHY

FIGURE 3-1.
Ghana's administrative regions and their capitals

Source: The Permanent Mission of Ghana to the UN (n.d)

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 longitudes 3.5^0 W and 1.3^0 E. Ghana has a total land area of 239,460 km^2, and its marine territories reach about 200 nautical miles offshore. Ghana is divided into sixteen central administrative regions, with its capital headed by a politically appointed Regional Minister. Figure 3-1 shows the regions and their capitals[7]. Ghana is divided into 16 regions, each further divided into districts that represent a decentralized local governance system and further represented by zonal committees.

3.2. CURRENT CLIMATE AND ENVIRONMENT

Air temperatures in Ghana have increased over the last few decades with a higher rate of increase in the north compared to the south. The country's tropical climate is 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: the major season from April to July and the minor one from September to November. Several climate models have confirmed that air temperature has increased by 1.0^{O}C between 1960 and 2003, at an average rate of 0.21^{O}C per decade. The rate of increase has generally been more rapid in the northern parts than in the southern parts. Rainfall is highly variable on inter-annual and inter-decadal timescales, suggesting that long-term trends and associated consequences would be 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. An overview of Ghana's current climate context is provided in Table 3-1.

7. The Permanent Mission of Ghana to the UN. Available at: https://www.ghanamissionun.org/map-regions-in-ghana/

TABLE 3-1.
Overview of Ghana's climate context

TEMPERATURE	RAINFALL
The average number of 'hot' days per year has increased by 48, an additional 13.2% of days.	Rainfall variability is higher in the forest regions than in the rest of the country.
The number of hot nights per year increased by 73, an extra 20% of nights.	More than ever before, the high likelihood of wet spells may lead to floods.
The frequency of cold days per year has decreased by 12, 3.3% of days.	The likely increases in dry spells can exacerbate drought conditions.
The number of cold nights per year has reduced by 18.5, 5.1% of days.	

Source: Authors

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 primarily derived from the Coastal, South-Western, and Volta, the latter comprising the Red, Black, and White Volta, as well as the Oti River. The South-Western river systems comprise 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% (Volta), 22% (South-Western), and 8% (Coastal) of the total surface water[8,9]. The finest and worst water quality occurs within the Densu basin[10].

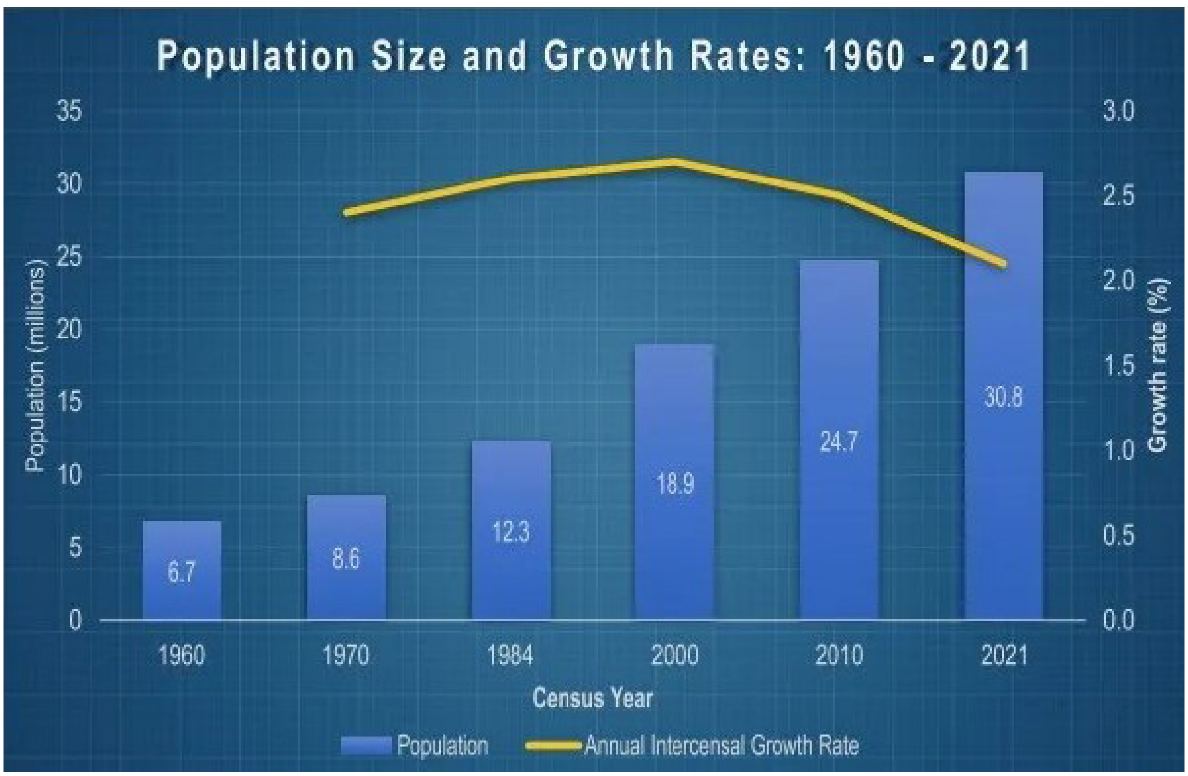
As a measure of Ghana's air quality, the annual mean PM2.5 concentrations are up to six times higher than the WHO recommended limits. These ultra-fine particles, 2.5 micrometers or smaller in diameter, are known to clog human lungs and constitute a health risk[11]. The WHO recommends a PM2.5 yearly guideline of 5 micrograms per cubic meter (g/m3)[12] against Ghana's PM2.5 concentrations of 35 g/m3 in 2017[13]. However, these data are recorded at only a few locations in the Greater Accra Region and are not accessible to the general public. The airflow and circulation over Ghana are dry and dusty northeast trade winds during the Harmattan seasons and the moist and warm southwest 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-fueled cookstoves and pollutants and other aerosols, which are mixed, especially during peak sunshine hours.

8. Ministry of Water Resources, Works and Housing, Ghana. (2007). *Ghana national water policy.*
9. Yeleliere, E., Cobbina, S. J., & Duwiejuah, A. B. (2018). Review of Ghana's water resources: the quality and management with particular focus on freshwater resources. *Applied Water Science*, *8*(3), 1-12.
10. 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.
11. Xing, Y. F., Xu, Y. H., Shi, M. H., & Lian, Y. X. (2016). The impact of PM2. 5 on the human respiratory system. *Journal of thoracic disease*, *8*(1), E69.
12. WHO. (2021). Ambient (outdoor) air pollution. Available at: https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health.
13. The World Bank group. (2017). World Development Indicators.

3.3. POPULATION AND DEMOGRAPHIC TRENDS

Ghana's annual intercensal population growth rate was 2.1% between 2010 and 2021, the lowest observed since independence. Ghana has a total population of 30.8 million, of which 50.7% are females and 49.3% are males. The national sex ratio is 97 males for every 100 females, and the national population density is 129 persons per square kilometer as per the 2021 Population and Housing Census. The average national household size is 3.6 persons. The population has increased by 6.1 million from the 24.7 million recorded in 2010, constituting an annual intercensal growth rate of 2.1%. This rate is less than observed in the previous intercensal period (2000 – 2010: 2.5%) and is the lowest observed since independence. At this rate, the country's population will double within 33 years. And by 2050, the population of Ghana will be over 50 million[14]. Figure 3-2 shows Ghana's population size and growth rate from 1960 to 2021, and figure 3-3 shows the population size distribution by region[15].

FIGURE 3-2.
Ghana's population size and growth rate, 1960-2021.

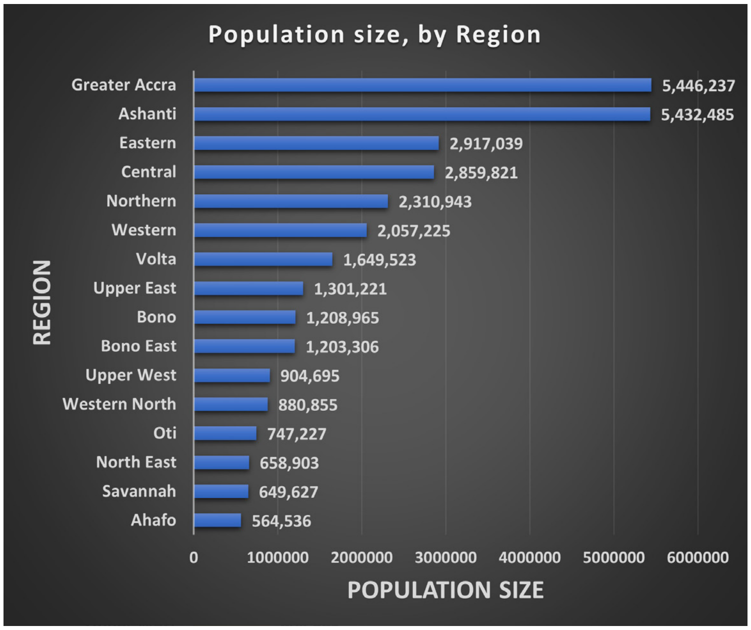


Source: Ghana Statistical Services, 2021

14. Ghana Statistical Service (GSS). (2021). *Population and Housing Census* (PHC). Available at: www.census2021.statsghana.gov.gh/dissemination.

15. Ghana Statistical Service (GSS). (2021). *Population and Housing Census* (PHC). Available at: www.census2021.statsghana.gov.gh/dissemination.

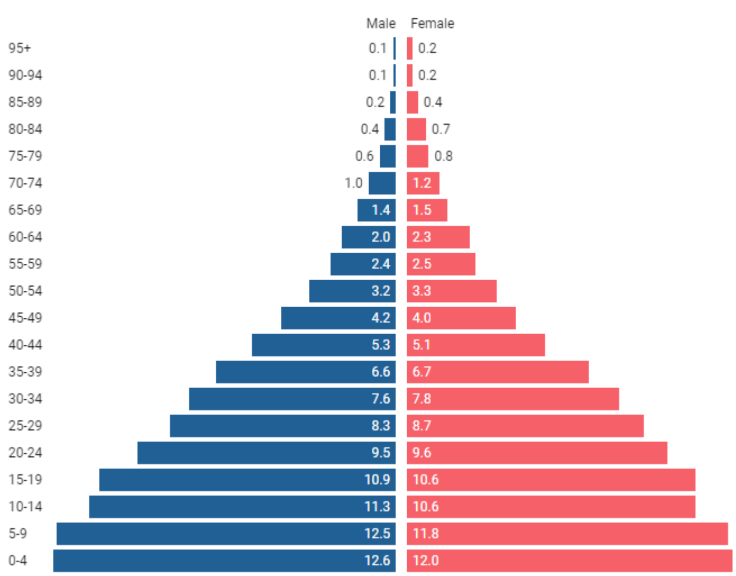
Figure 3-3.
Distribution of population size by region



Source: Ghana Statistical Services, 2021

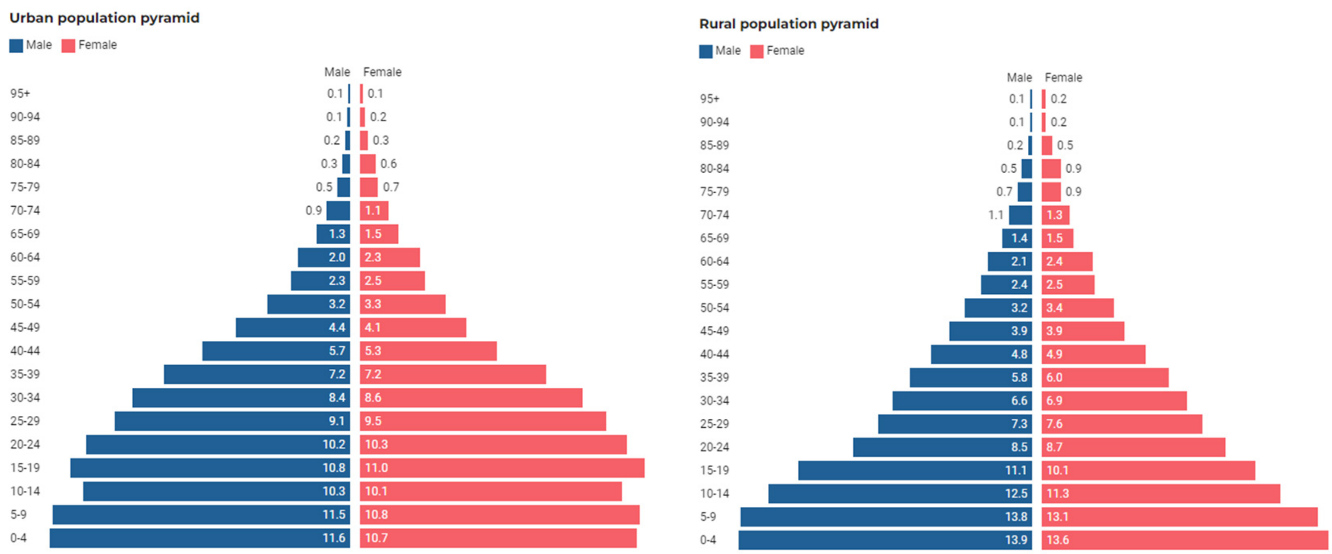
The country's population pyramid is transitioning from one dominated by children aged 0-14 years to that dominated by young people aged 15-35 years, which is evident in all the regions of Ghana though most pronounced in Greater Accra (see Figure 3-4; 3-5). The population pyramid represents the age and 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 34.0% in 2000 to 38.2% in 2021.

FIGURE 3-4.
Population pyramid by gender



Source: Ghana Statistical Services, 2021

FIGURE 3-5.
Population pyramid by location



Source: Ghana Statistical Services, 2021

The life expectancy in Ghana in 2021 was 62 years and 66 years among males and females, respectively[16]. Life expectancy at birth is the average number of years a newborn is expected to live if mortality patterns at the time of its birth remain constant in the future. It reflects a population's overall mortality level and summarizes the mortality pattern across all age groups in a given year. The higher life expectancy among females was evident in urban and rural areas.

3.4. ECONOMIC DEVELOPMENT

Ghana is a lower-middle-income country. Its economy grew at an average of 7% from 2017 to 2019 before contracting sharply in the second and third quarters of 2020[17]. The country has made significant progress towards democracy under a multi-party system in the last two decades, with its independent judiciary gaining public trust. Ghana has routinely ranked among Africa's top three countries for freedom of expression and press. Major economic drivers/sectors of Ghana's economy have been classified under agriculture, industry, and service sectors. In 2022, the share of agriculture in Ghana's Gross Domestic Product (GDP) was 19.57%; industry contributed approximately 31.99%, and the services sector contributed about

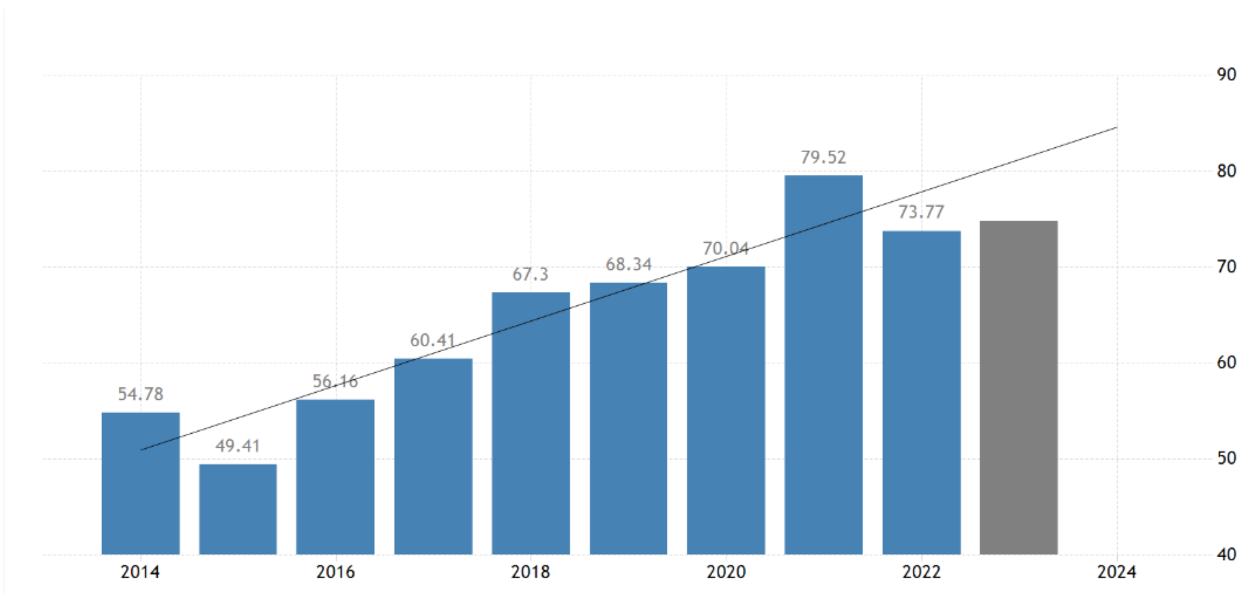
16. Ghana Statistical Service (GSS). (2010) *Population and Housing Census* (PHC). Available at: https://statsghana.gov.gh/gssmain/fileUpload/pressrelease/2010_PHC_National_Analytical_Report.pdf

17. 17. The World Bank Group. (n.d). Ghana Overview. Available at: https://www.worldbank.org/en/country/ghana/overview

42.03%[18]. The current and projected GDP trends (Billions, USD) are presented in Figure 3-6. In 2022, Ghana experienced a decrease in its GDP, which stood at 73.77 billion USD, down from the previous year's GDP of 79.52 billion USD[19]. Crops, education, trade, auto repair, household goods, manufacturing, and information and communication were the primary drivers of GDP growth in the third quarter of 2021 (see Table 3-2).

In 2020, the country's overall fiscal deficit increased to 15.2%, and public debt climbed to 81.1% of GDP, putting the country at risk of debt distress. Despite a significant downturn in mining and the pandemic's second wave, growth accelerated in the first and second quarters of 2021. The fiscal deficit as a percentage of GDP was 5.1%[20]. As the pandemic-induced food price shock subsided, headline inflation stayed low at 7.8% in June 2021, prompting the Bank of Ghana to cut its policy rate by 100 basis points to 13.5 % in May to aid the recovery. However, due to rising food and non-food inflation, inflation increased by 9.7% in August. Imports grew faster than exports in early 2021, fueled by the domestic recovery, while commodity demand remained passive. As a result, the current account deficit increased in the second quarter of 2021, rising from 0.8% to 1.3% of GDP[21].

FIGURE 3-6.
GDP trends, 2014-2022, with projections for 2023 (USD Billion)



Source: Trading Economics, the World Bank Group

18. Data available at: https://www.statista.com/statistics/447524/share-of-economic-sectors-in-the-gdp-in-ghana/
19. Data available at: https://tradingeconomics.com/ghana/gdp
20. Data available at: https://www.statista.com/statistics/447524/share-of-economic-sectors-in-the-gdp-in-ghana/
21. Ghana Statistical Service. (2021). Quarterly Gross Domestic Product (QGDP) Third Quarter 2021 Quarter 2019. 1–11

TABLE 3-2.
Ghana's GDP contributions by sector

Related	Last	Previous	Unit	Reference
GDP	72.35	67.23	USD Billion	Dec/20
GDP per capita	1940.68	1974.29	USD	Dec/20
GDP per capita PPP	5304.98	5396.87	USD	Dec/20
GDP From Utilities	228.56	195.80	GHS Million	Jun/21
GDP From Transport	2386.96	2443.50	GHS Million	Jun/21
GDP From Services	16083.96	18253.10	GHS Million	Jun/21
GDP From Public Administration	1448.38	1486.30	GHS Million	Jun/21
GDP From Mining	4873.71	5018.50	GHS Million	Jun/21
GDP From Manufacturing	4612.31	6772.80	GHS Million	Jun/21
GDP From Construction	3365.57	3558.70	GHS Million	Jun/21
GDP From Agriculture	7548.71	9554.50	GHS Million	Jun/21

Source: Trading Economics, the World Bank Group

Due to rising commodity prices and robust domestic demand, Ghana's economy is expected to gradually recover over the medium term. Ghana recently received $1 billion in Special Drawing Rights (SDR) from the International Monetary Fund (IMF), a portion of which will be used to aid economic recovery. In 2021-23, annual growth is predicted to average 5.1%. Real per capita GDP is expected to rebound to pre-COVID-19 levels in 2021, after dropping by 1.7% in 2020. The fiscal deficit is expected to remain high as the government implements its economic stimulus program. It is expected to fall to 14% of GDP in 2021 and 9.5% in 2023, still exceeding Ghana's 5% cap[22].

The country's economic slowdown has an impact on household poverty rates. It is estimated that the poverty rate in the country will increase from 25% in 2019 to 25.5% in 2020[23]. The country's northernmost regions are expected to remain the poorest.

22. International Trade Administration. (2022). Ghana - Country Commercial Guide. Available at: https://www.trade.gov/country-commercial-guides/ghana-healthcare
23. The World Bank Group. (n.d). Ghana Overview. Available at: https://www.worldbank.org/en/country/ghana/overview

3.5. DISEASE BURDEN

Malaria, a climate-sensitive vector-borne disease, is the leading cause of death in the country and is the second leading cause of death and disability combined[24]. Despite a nearly 34% decrease in its contributions towards total deaths in the country between 2009 and 2019, it still causes the most deaths (see Figure 3-7). Estimates suggest that the country's burden of deaths and disability due to malaria is much higher than the average of similar countries with low-middle social-demographic indicators. Lower respiratory infections, HIV/AIDS, tuberculosis, and diarrhea are the other major infectious diseases causing deaths and disability in the country (see Figure 3-8). The proportion of deaths and disability due to non-communicable diseases (NCD) like stroke, ischemic heart disease, and diabetes are on the rise, while road injuries are increasingly causing more disability.

FIGURE 3-7.
Causes of deaths in Ghana

Communicable, maternal, neonatal, and nutritional diseases
Non-communicable diseases

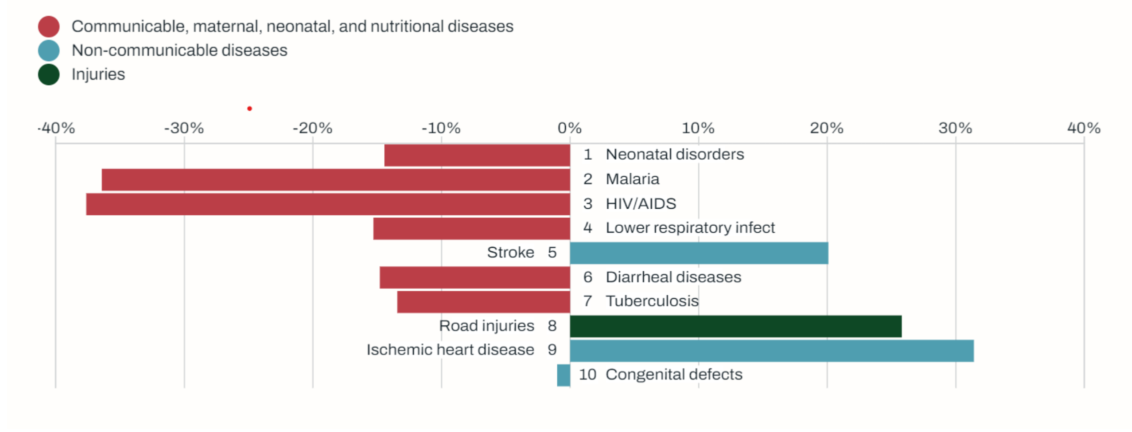
Cause	2009 rank	2019 rank	Change in deaths per 100k, 2009–2019
Malaria	1	1	−64.3
Stroke	5	2	−1.2
Lower respiratory infect	4	3	−14.9
Neonatal disorders	3	4	−29.1
Ischemic heart disease	7	5	+3.5
HIV/AIDS	2	6	−41.7
Tuberculosis	6	7	−14.8
Diarrheal diseases	8	8	−9.9
Diabetes	10	9	−0.6
Cirrhosis liver	9	10	−2.7

Source: IHME, 2019

24. IHME. (2019). Global Burden of Diseases, Seattle. Available at: https://www.healthdata.org/ghana

FIGURE 3-8.

Causes of deaths and disability in Ghana



Source: IHME, 2019

Malnutrition and air pollution are two leading risk factors causing the most fatalities and disability combined, both climate-sensitive (see Figure 3-9). In Ghana, there are various environmental, health, and safety issues arising from the burning of used lorry tires to extract copper wires for sale, improper land reclamation in the mining industry, open defecation, the dismantling and burning of used electronic gadgets to extract valuable metals for sale, inappropriate human liquid waste disposal and inappropriate disposal of plastic bottles and bags. Lifestyle-related risk factors like high blood pressure, high body mass index, and high fasting blood glucose are increasingly contributing to more deaths and disability.

FIGURE 3-9.

Risk factors causing deaths and disability in Ghana

Metabolic risks
Environmental/occupational risks
Behavioral risks

Risk	2009 rank	2019 rank	Change in DALYs per 100k, 2009–2019
Malnutrition	1	1	↓ –4,116.7
Air pollution	2	2	↓ –1,314.3
Unsafe sex	3	3	↓ –1,497.1
High blood pressure	5	4	↑ +8.2
High body-mass index	6	5	↑ +266.1
WaSH	4	6	↓ –913.9
High fasting plasma glucose	7	7	↓ –57.2
Alcohol use	8	8	↓ –144.0
Dietary risks	9	9	↓ –9.7
Kidney dysfunction	10	10	↑ +18.5

Source: IHME, 2019

3.6. HEALTH SYSTEM

In Ghana, the Ministry of Health (MOH) and Ghana Health Services (GHS) oversee health care infrastructure and service delivery. The Ghana Health Service and the Teaching Hospitals Act (ACT 525), passed in 1996, separated governance and policy from the operational and service aspects of health service delivery. The Ministry is mandated to formulate policies and design appropriate measures for implementation, while the GHS implements the policies and is in charge of providing health services.

The mission statement of the Ministry of Health (MOH) is to promote "health and vitality for all individuals living in Ghana via access to quality health care provided by motivated employees"[25]. However, cultural and religious convictions, poor physical infrastructure, and limited resources collectively contribute to significant service discrepancies between North and South, affluent and poor. All these factors combine to make it difficult for planners and politicians to provide universal access to healthcare services. Furthermore, the Ghana National Health Policy 2007, dubbed "Creating Wealth through Health," was developed to help realize the country's vision[26]. The strategy acknowledges that poor health is both a cause and a result of poverty and that environmental factors impact health. It provides a sector-wide strategy for improving population health and reducing access disparities based on preventative and curative treatment.

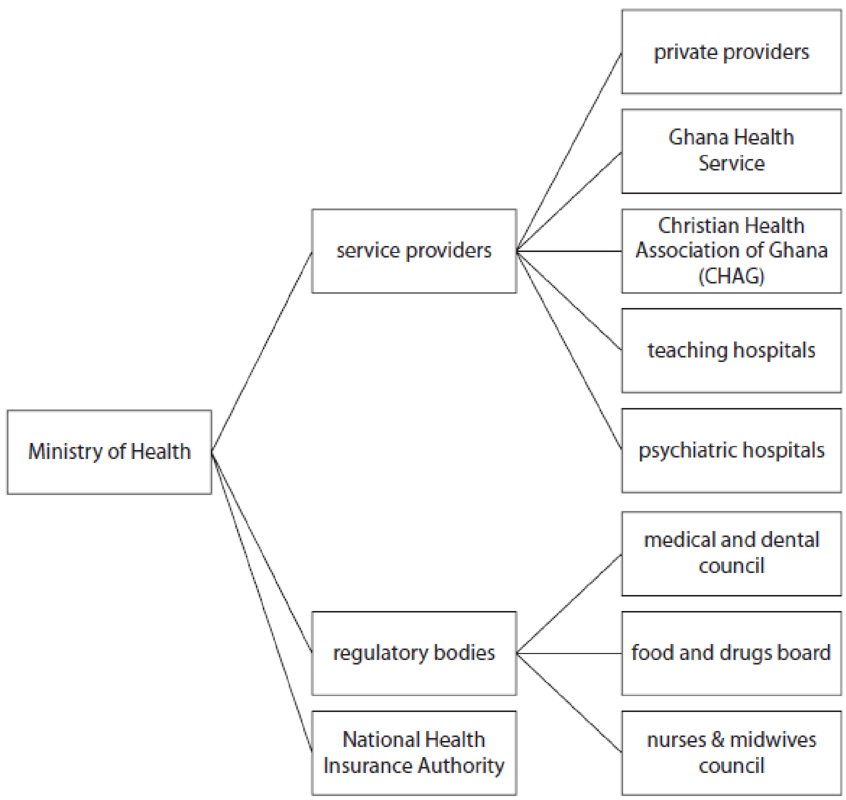
Ghana's health service delivery system is plural and decentralized. Service providers include public, private, faith-based, and traditional medicine sectors (see Figure 3-10). The public sector is organized into primary, secondary, and tertiary levels of care. These levels of care include Community-Based Health Planning and Services (CHPS) compounds, community health centers, and polyclinics; followed by district hospitals at the district health center level that are the primary referral facilities for health centers and clinics at the sub-district level; regional hospitals; and finally, referral hospitals that are usually teaching hospitals. Private health facilities include clinics and hospitals. Available data show that as of May 2020, the total number of health facilities countrywide was 2,773, of which 1,625 were government hospitals. Private hospitals and health facilities from the Christian Health Association of Ghana (CHAG) were 928 and 220 respectively[27].

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 (OOPS). The National Health Insurance Scheme (NHIS) was established in 2003 to eliminate imbalances in service provision between 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 government revenues[28]. The NHIS is financed by a national health insurance fund. The fund has three main sources: first, tax revenue of a 2.5% Valued Added Tax (VAT) on goods and services which contributes to about 70% of the fund; second, 2.5% of contributions of Social Security and National Insurance Trust (SSNIT) contributors who are largely formal sector workers and which contributes to about 20% of the fund; and third, income adjusted premiums which range from between GH7 to GH48 for non-SSNIT contributors which contribute to about 5% or less to the fund. Funding for health care services, administration of the NHIS, and

25. Ministry of Health, Government of Ghana. Available at: www.moh-ghana.org
26. Ministry of Health (2007). National Health Policy 2007, Government of Ghana. Available at: https://www.moh.gov.gh/wp-content/uploads/2016/02/NATIONAL-HEALTH-POLICY.pdf
27. Data available at: https://www.statista.com/statistics/1238760/number-of-health-facilities-in-ghana-by-ownership/
28. Schieber, G., Cashin, C., Saleh, K., & Lavado, R. (2012). Health financing in Ghana. The World Bank. doi:10.1596/978-0-8213-9566-0

premium exemptions for specific categories of people, including people with low incomes, are financed by the National Health Insurance Fund (NHIF). The NHIS was established through the National Health Insurance Law (Act 650 of Parliament) in 2003 and had a legal framework in 2004 through the National Health Insurance Regulations (L.I. 1809)[29].

FIGURE 3-10.
Organization of the health system in Ghana



Source: George Joseph Schieber, 2012

29. Government of Ghana, 2003; 2004.

Box 1. Summary of Ghana country context

Ghana lies close to the equator and is listed among the 19 “climate hotspots” in Africa.

Air temperatures in Ghana have increased over the last few decades with a higher rate of increase in the north compared to the south. There is pronounced temperature and climate variability across the country.

Surface water resources are restricted. 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.

As a measure of Ghana’s air quality, the annual mean PM2.5 concentrations are up to six times higher than the WHO recommended limits, which constitute a health risk.

The total population of the country in 2021 stands at 30.8 million, though the annual inter-censal population growth rate was 2.1% between 2010 and 2021, which is the lowest since independence. Additionally, the country’s undergoing a demographic shift, transitioning from one dominated by children aged 0-14 years to that dominated by young people aged 15-35 years. It also faces rapid urbanization.

Diseases and risk factors like malaria, diarrhea, malnutrition and air pollution are some of the leading causes of deaths and disability in the country.

Photo: © Jonathan Ernst / World Bank

4. CLIMATE EXPOSURES / HAZARDS

This section describes observed, historical climatic changes (1991-2020) and projected climatic changes in rainfall and temperature (mean, minimum, maximum) across Ghana for 2020-2039 and 2040-2059. Climate data were retrieved from the World Bank Group's 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.

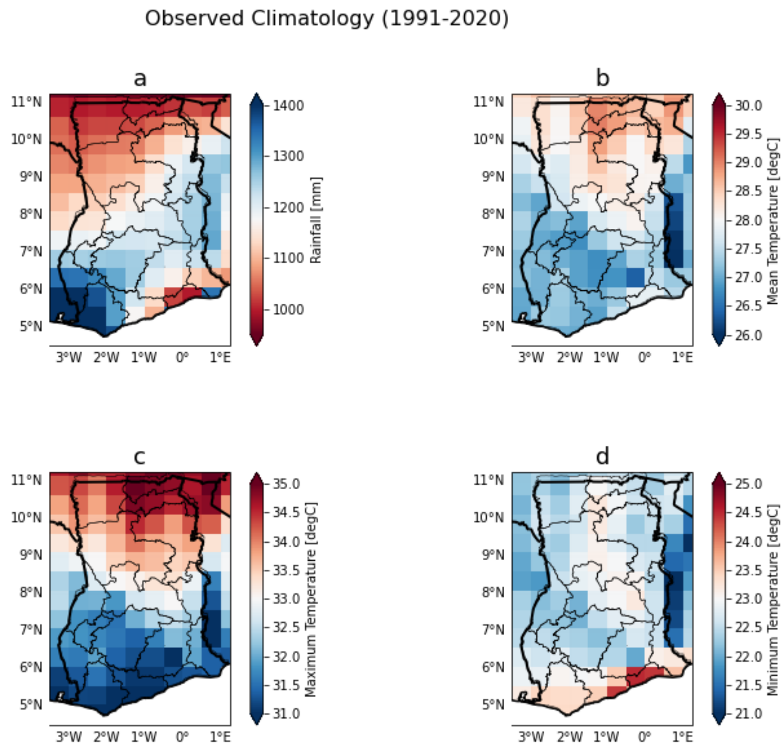
The data were assessed temporally (on different resolutions: monthly and annually) and spatially for the spatiotemporal patterns and trends and the short to medium-term changes. Also presented are observed and projected changes in sea level rise between 2020-2039 and 2040-2059 using the new Shared Socioeconomic Pathways (SSPs) that are an indication of climate change projections and socioeconomic scenarios for evaluating climate impact and adaptation measures. The five SSPs consist of SSP1 ("Sustainability"; low challenges to mitigation and adaptation), SSP2 ("Middle of the Road"; middle challenges to mitigation and adaptation), SSP3 ("Regional Rivalry"; high challenges to mitigation and adaptation), SSP4 ("Inequality"; low challenges to mitigation, high challenges to adaptation), and SSP5 ("Fossil-fueled Development"; high challenges to mitigation, low challenges to adaptation).

4.1. ANNUAL AND MONTHLY OBSERVED TRENDS IN CLIMATOLOGY: TEMPERATURE, PRECIPITATION, HUMIDITY/HEAT INDEX

There is wide variability in the annual temperature and precipitation across the country, with the northern region receiving less rainfall and experiencing higher mean and maximum temperatures. On an annual basis, less rainfall is received in the northern part and many areas in the southeast of the country (see Figure 4-1a). 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[30,31,32,33]. 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 (see Figure 4-1b), ranging from 26^{0}C to 30^{0}C, the highest in the north, and characteristic of climatic conditions within the tropics. The climatological maximum temperature (see Figure 4-1c), which indicates the mean daytime temperature recorded during peak solar insolation, mimicked the mean temperature pattern (see Figure 4-1b) with magnitudes ranging from 31 to 35^{0}C. On the other hand, a reverse pattern is observed with the minimum temperature (usually an indication of mean night-time temperature), where higher values are recorded along the coast and the Volta basin.

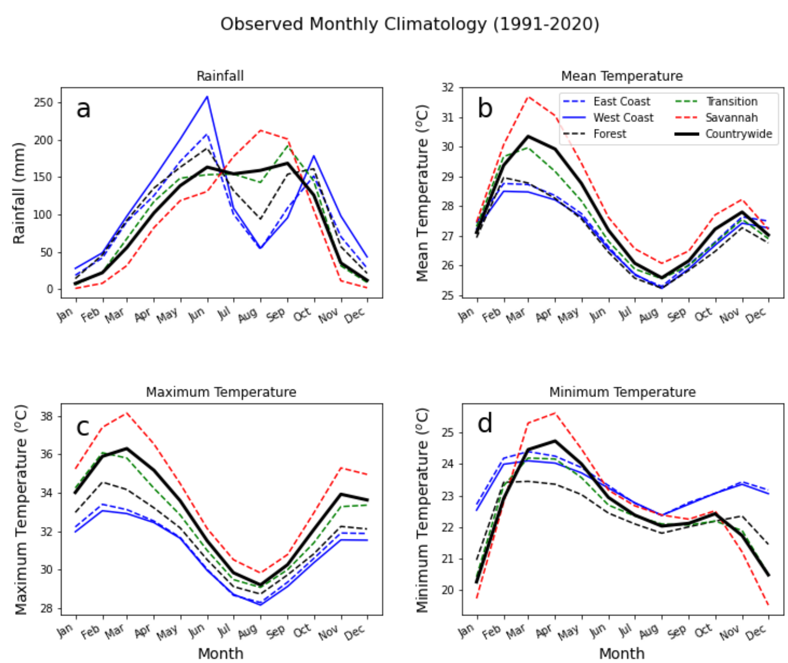
30. Kumi, N., & Abiodun, B. J. (2018). Potential impacts of 1.5 C and 2 C global warming on rainfall onset, cessation and length of rainy season in West Africa. *Environmental Research Letters*, *13*(5), 055009
31. Omotosho, J. B., & Abiodun, B. J. (2007). A numerical study of moisture build-up and rainfall over West Africa. *Meteorological Applications: A journal of forecasting, practical applications, training techniques and modelling*, *14*(3), 209-225.
32. 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.
33. 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 4-1.
Observed annual climatology of (a) rainfall (b) mean- (c) maximum- (d) minimum-temperatures over Ghana, 1991-2020



Source: Authors using Climatic Research Unit (CRU) data

FIGURE 4-2.
Observed monthly climatology of (a) rainfall (b) mean- (c) maximum- (d) minimum-temperature, averaged over the defined agroecological zones, 1991-2020



Source: Authors using Climatic Research Unit (CRU) data

The monthly rainfall patterns vary by region though 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, with a "little dry season"[34] in August (see Figure 4-2a). 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 savanna 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^{0}C and 28 – 38^{0}C, respectively (see Figures 4-2b, 4-2c) with their peaks recorded within February and March. Following the rainfall pattern in Figure 4-2a, low-temperature values are recorded in July – September, with August registering 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 (see Figure 4-2d). The low values are recorded in June – August, with the lowest from November to January coinciding with the dry season.

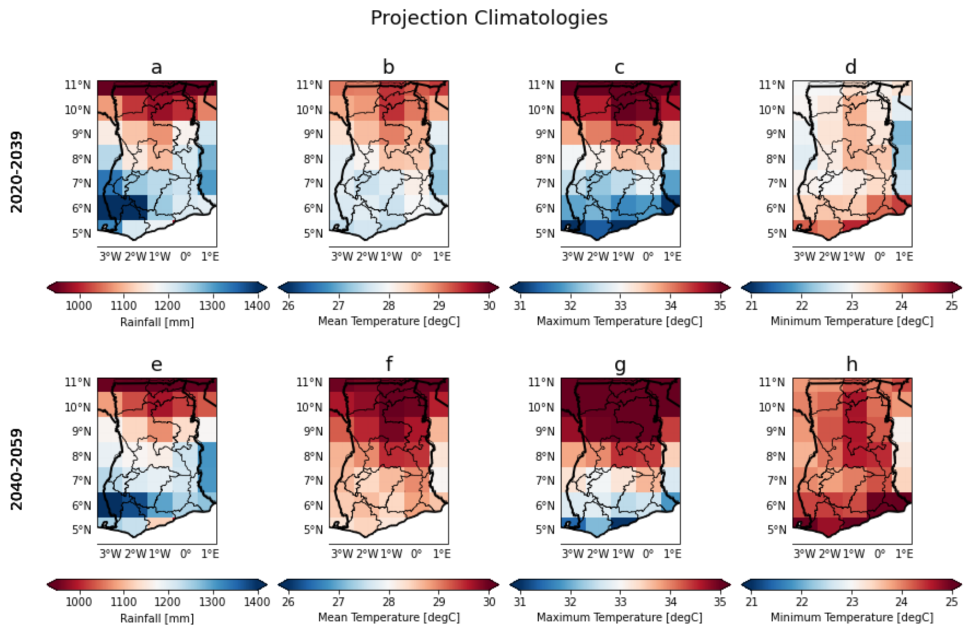
4.2. ANNUAL AND MONTHLY PROJECTED TRENDS IN CLIMATOLOGY: TEMPERATURE, PRECIPITATION, HUMIDITY/HEAT INDEX

While rainfall is predicted to decline in the middle belt of the country, it is likely to increase along the coast. Mean, maximum, and minimum temperatures are expected to increase. Projected climatology of rainfall and temperature (mean, minimum, maximum) were undertaken across the country for the periods 2020 - 2039 and 2040 - 2059 informed by the CMIP6. Rainfall projections were similar to the historical data (baseline), with reduced magnitude and patterns of rainfall in the northern parts of the country, increasing south-westwards (see Figure 4-3a), projected in the order of 1000 - 1400 mm for both 2020 - 2039 and 2040 - 2059. However, marginal declines are expected in the 2040 - 2059 period, particularly in the middle belt of the country. On the contrary, rainfall along the Coast is projected to increase marginally within the 2040 - 2059 period, except for the Central Region (see Figure 4-3e). Mean temperatures are projected to range from 26 to 30^{0}C for the 2020 - 2039 period over the entire country (see Figure 4-3b), with maximum and minimum temperatures from 31 to 35^{0}C and 22 to 25^{0}C, respectively. The peak values decreased gradually along a northern-southern gradient of the country, with projections for the 2040 - 2050 period showing a substantial increase in the mean >28^{0}C (see Figure 4-3f), maximum >31^{0}C (see Figure 4-3g), and minimum >23^{0}C (see Figure 4-3h).

34. 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.

FIGURE 4-3.

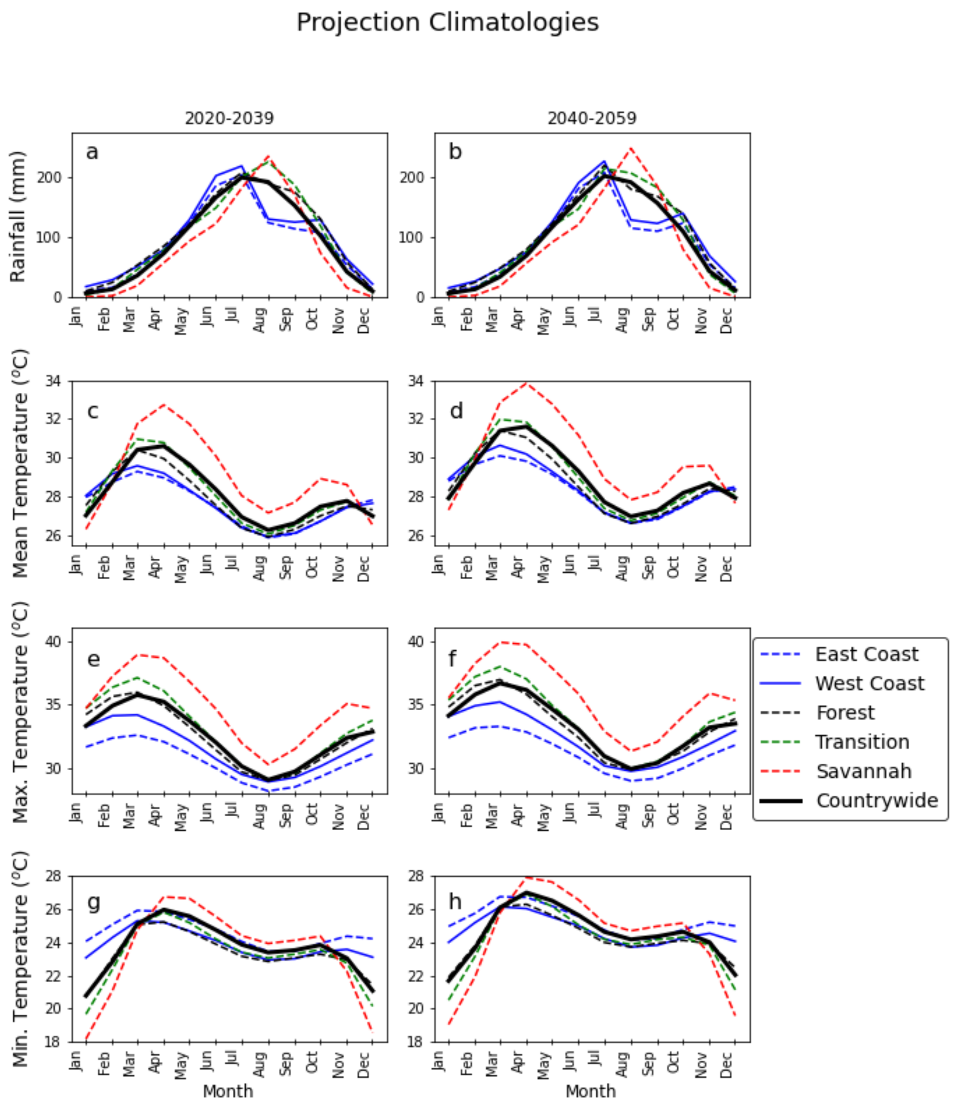
Projected climatology of (a) rainfall (b) mean- (c) maximum- (d) minimum-temperatures over Ghana (2020-2039) and (e) rainfall (f) mean- (g) maximum- (h) minimum-temperatures over Ghana (2040-2059)



Source: Coupled Model Intercomparison Project Phase 6

The projected monthly rainfall will peak between June and September, yet with substantial expected decline in magnitude, except for August, across most parts for all periods (see Figure 4-4). Monthly rainfall patterns are expected to be unimodal over the entire country. On average, rainfall amounts are projected to remain approximately the same for 2020 - 2039 and 2040 - 2059. The projected temperature shows similar bimodal patterns as the historical data over the entire country (see Figures 4-4c-h). For 2020 - 2039, the magnitudes of mean temperatures are expected to be between 27 and 31^{0}C; maximum and minimum temperatures are expected to be between 30 - 36^{0}C and 21 - 26^{0}C respectively. The monthly temperature patterns will deviate from the historical observation within a month with the peaks expected in March and April. The lowest mean and maximum temperatures are projected to be in August, and the lowest minimum is expected in January.

FIGURE 4-4.
Projected monthly climatology of (a, b) rainfall (c, d) mean- (e, f) maximum- (g, h) minimum-temperature averaged over the defined agroecological zones, 2020-2039 and 2040-2059

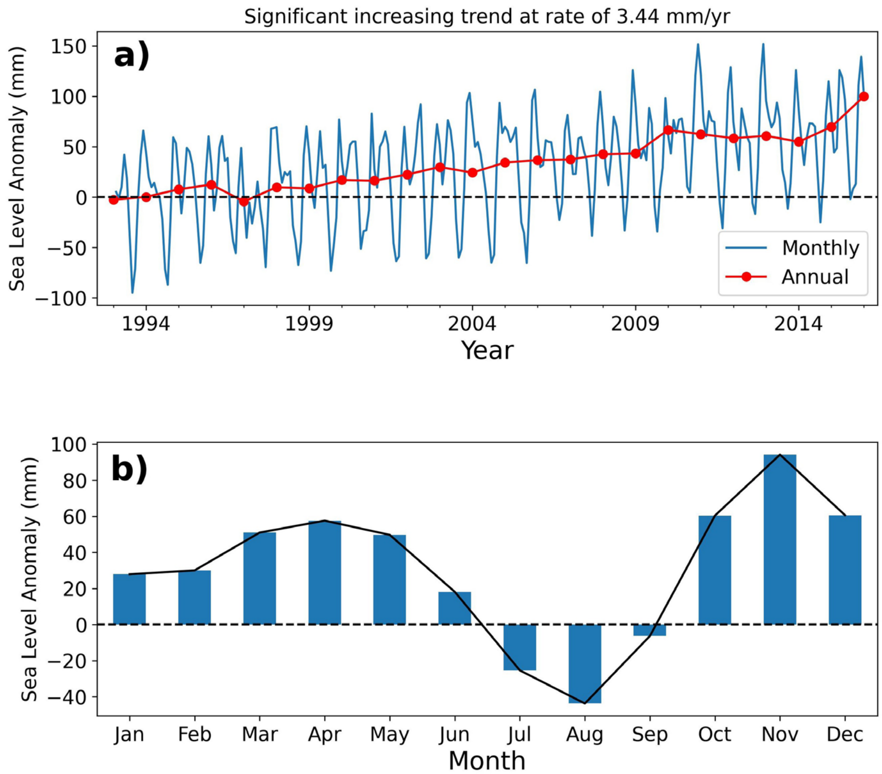


Source: Coupled Model Intercomparison Project Phase 6

4.3. OBSERVED AND PROJECTED CHANGES IN SEA-LEVEL RISE

On average, there has been a 3.44 mm rise in sea levels per year from 1993 to 2016, yet current years exhibit an estimated rise of 50 mm and above. This estimated increase in sea levels is a significant upward shift/ trend in the yearly and long-term anomaly signals in Ghana's coastal waters (see Figure 4-5). There are monthly anomalies with heightened or reduced levels, with the highest in November, approximately 90 mm above mean sea level (see Figure 4-5b), as opposed to August's shallowest observed level at around 40 mm below mean sea level.

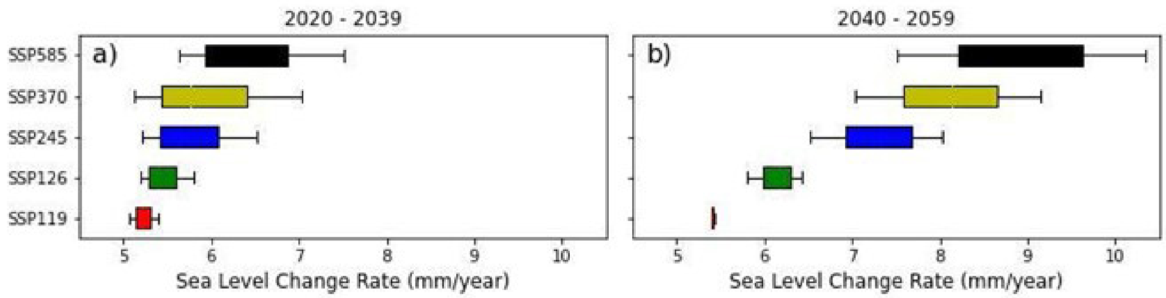
FIGURE 4-5.
(a) Time series analysis of sea-level anomaly and (b) monthly climatology of sea-level anomaly



Source: Authors using the World Bank Climate Change Knowledge Portal Data

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 implemented. The new Shared Socioeconomic Pathways (SSPs) that indicate climate change projections and socioeconomic scenarios for evaluating climate impact and adaptation measures were assessed with a keen consideration of regional sea level change rate. Four SSPs, with varying adaptation and mitigation pathways, were assessed (see Figure 4-6) 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, the sea level is expected to rise by about 5.3 mm/year within 2020-2039, with a marginal increase to about 5.5 mm/year in 2040-2059. Conclusively, the influence of emissions on sea level rise is projected to 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 and could also lead to the development of novel water-related diseases, coastal floods, submergence of habitable lands, etc.

FIGURE 4-6.
Sea level change for (a) 2020-2039 and (b) 2040-2059 under 5 Shared Socioeconomic Pathways (SSPs)



Source: Authors using the World Bank Climate Change Knowledge Portal Data

Box 2. Summary of historic observations and projected changes in temperature, precipitation, and sea level rise

Rainfall patterns are unimodal in the north and bimodal in the southern part of the country, with maximum rainfall amounts recorded in the country's southwestern part.

Climatological mean temperature shows that average air temperature from 1991 to 2020 generally increases with latitude. Mean temperature over Ghana ranges between 26^{0}C and 30^{0}C, with the highest in the country's north.

Monthly rainfall patterns are projected to be unimodal, peaking between June and September for the periods 2020 - 2039 and 2040 – 2059. Overall, substantial decline in rainfall magnitude is expected over the country.

At the countrywide level, rainfall amounts are not expected to be significantly altered between the periods 2020 -2039 and 2040 - 2059.

Projected temperature revealed bimodal patterns, and warmer periods for 2040 - 2059 than for 2020 - 2039. There is an expected shift in the monthly temperature peaks by a month to March and April.

On average, there has been a 3.44 mm change in sea level per year between 1993 and 2016.
Sea level is expected to rise by 6 – 7 mm/year in 2020-2039 and 8.5 – 9.7 mm/year by 2040-2059 under SSP 5.85 (high challenges to mitigation, low challenges to adaptation). Under SSP 1.19 (sustainable SSP with low challenges to mitigation and adaptation), sea level will rise by 5.3 mm/year in 2020-2039, with a marginal increase to about 5.5 mm/year in 2040-2059.

Photo: © Arne Hoel / World Bank

4.4. CLIMATE-RELATED EXTREME EVENTS

In the past 50 years, 22 major hydrometeorological events in Ghana have affected 16 million people, resulting in over 400 deaths[35]. The World Bank identifies six different yet interrelated hazards associated with extreme events in Ghana. They are droughts, earthquakes, epidemics, floods, wildfires, and storms[36]. This section focuses on the three extreme events that predominantly confront the country: heavy rainstorms/ floods, sea-level rise, and droughts.

Over 19 significant flood events have occurred 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 patterns are anticipated during the wet season, accompanied by overall lower precipitation levels. Floods are 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,

35. EM-DAT(2016). Disaster List for Ghana. The International Disaster Database.
36. Climate Risk Profile: Ghana (2021). The World Bank Group.

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[37]. 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. This event claimed 56 lives, damaged approximately 500 km of roads, destroyed 69 bridges and displaced around 332,000 people[38]. In 2010, floods in the White Volta River Basin affected hundreds of thousands of people and destroyed many livelihoods. Urban floods also regularly impacted key cities, with the last major event occurring in Accra in June 2015[39]. The flood event experienced in Accra in June 2015 caused extensive harm to human life, infrastructure, and businesses[40].

Climate change is precipitating sea-level rise in the country, resulting in sea erosion and flooding along the coastal stretch[41, 42], and is pervasive on the eastern coast along the Volta Delta, affecting communities along the coast. The coastal Ramsar sites in the Muni-Pomadze lagoon experienced an average coastal retreat of 0.22 m/year between 1972 and 2014[43], while 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).

Three drought events have occurred in Ghana in the past five decades with varying degrees of impact (EPA 2020). Drought exposes smallholder farmers to significant climate risk when seasonal changes and droughts occur. Given Ghana's reliance on rain-fed agriculture, drought poses a considerable 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 a 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 extreme hunger and the deaths of hundreds of people, primarily children. The most affected regions of the 1983 drought were the Upper East, Upper West, and Northern regions, southern Brong-Ahafo, and northern Ashanti[44]. Table 4-1 presents the extreme climate events and their impact on the country between 1968 and 2017.

37. Armah, F. A., Yawson, D. O., Yengoh, G. T., Odoi, J. O., & Afrifa, E. K. (2010). Impact of floods on livelihoods and vulnerability of natural resource dependent communities in Northern Ghana. *Water*, *2*(2), 120-139. 368.
38. 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.
39. According to the Environmental Protection Agency (2020).
40. Amoako, C., & Inkoom, D. K. B. (2018). The production of flood vulnerability in Accra, Ghana: Re-thinking flooding and informal urbanisation. *Urban Studies*, *55*(13), 2903-2922.
41. 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.
42. 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).
43. 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*, 515-525.
44. Agency for International Development. (1984). Disaster Case Report: Ghana – Food Shortage. Office of U.S. Foreign Disaster Assistance. Washington D.C. Available at: https://pdf.usaid.gov/pdf_docs/PBAAB318.pdf

TABLE 4-1.
List of extreme climate events and their impacts in Ghana between 1968 and 2017

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	8	9,674
2011	Flood	Eastern	6	12,571
2011	Flood	Greater Accra. Eastern, Volta14	81,473	-
2013	Flood	Northern, Volta	5	25,000
2015	Flood	Greater Accra	25	5,000
2016	Flood	Greater Accra	10	-

Source: EM-DAT.be, 2016

Overall, 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 waves, drought/aridity. Projected increases in dry spells can exacerbate drought conditions, especially in the Savannah region. Second, the country comprises mostly low plains to a low elevation of between zero meters 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. An estimated 50% of the 540 km shoreline of Ghana is vulnerable to sea-level rise[45]. 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[46]. Fifth, the severe effects of land use and land cover changes, including deforestation, loss of biodiversity, soil erosion, and disruption of soil structure, play a pivotal role in land degradation. This degradation tends to modulate the impacts of extreme events. Sixth, weak social and environmental determinants of human well-being, including extreme poverty in some parts, predispose populations to the impacts of extreme events. Finally, heat stress is a recently emerging phenomenon and can exacerbate or magnify the impacts of other extreme events.

Box 3. Summary of climate related extreme events

Rainfall variability will trigger frequent dry spells and potentially result in intensified drought conditions over the northern parts of the country, whilst wet spells may lead to more floods across the country.

Ghana will continue to be warm with temperatures projected to rise by 2080, increasing the risk of droughts. The impact of droughts may be compounded by heat stress , resulting in detrimental effects on food systems.

The impacts of climate risks are likely to magnify the uneven social and spatial distribution of risk in Ghana, and possibly amplify poverty in the Northern regions.

The regions are likely to record more extreme weather events with projected increases in dry spells exacerbating drought conditions.

45. 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.
46. Conway, G. (2009). The science of climate change in Africa: impacts and adaptation. *Grantham Institute for Climate Change Discussion Paper*, *1*, 24.

5. HEALTH RISKS

This section assesses climate-related health risks that impact Ghana. It is divided into two sub-sections. It begins with identifying population sub-groups most impacted by the poverty dimensions and health impacts of climate change. The second sub-section assesses the intersection between climatology and selected health outcomes and health system risks. It presents the findings of an ecological study design in which the unit of observation was the national and administrative regions of Ghana using a monthly time series dataset compiled from routine health management information systems and meteorologic estimates between 2012 and 2020. In doing this, a negative binomial regression model with robust standard errors was constructed.

The model addresses issues of residual autocorrelation to quantify the association of precipitation and ambient temperature, with monthly reported diarrhea, malaria, schistosomiasis, and meningitis cases, from 2012 to 2020 in the 16 administrative regions of Ghana. Three main considerations inform the selection of these diseases: i) the disease is a known climate-sensitive condition, ii) the burden of the disease is high in Ghana, and iii) disease cases are reported so incidence data were readily available. We did not assess other climate-related health risks, such as air quality in relation to respiratory health, the crosscutting risks of ongoing climate change on mental health, and direct injuries and mortality associated with natural hazard events. The second sub-section also presents findings from a desk review of the direct and indirect health outcome and health system risks of climate change in Ghana.

5.1. VULNERABLE POPULATION GROUPS

Besides the risk of infectious diseases, key climate risks in Ghana include droughts, coastal erosion, floods, and landslides that are exacerbated by the current development dynamics and demographic changes in the country. Many 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. Vulnerabilities to climatic impacts on health are determined by physical exposures and a range of socioeconomic, demographic, biological, and geographical factors[47]. Floods and droughts are among Ghana's most devastating climate-induced disasters, with far-reaching consequences on food security[48,49]. 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 the 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[50]. Though poverty rates ($1.90

47. World Health Organization. (2021). Climate change and health: vulnerability and adaptation assessment.
48. Asumadu-Sarkodie, S., Owusu, P. A., & Rufangura, P. (2015). Impact analysis of flood in Accra, Ghana. *Advances in Applied Science Research*, *6*(9):53-78
49. Atanga, R. A., & Tankpa, V. (2021). Climate change, flood disaster risk and food security nexus in Northern Ghana. *Frontiers in Sustainable Food Systems*, *5*, 706721.
50. 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

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 country's three northern regions (Northern, Upper East, and Upper West Regions) and the Volta Region[51], which has the potential to exacerbate climate-related health risks. Additionally, these regions depend primarily on subsistence agriculture for livelihood, which is adversely affected by perennial floods and droughts, limiting food security, incomes, and access to health care [52]. 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 affect about 70,500 hectares of land, resulting in the loss of 144,000 metric tonnes of maize, sorghum, millet, groundnuts, yam, cassava, and rice[53]. 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 km2 of farmland in northern Ghana[54]. 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[55].

Gender: Climate change magnifies existing gender inequalities, reinforcing the disparity between women and men in their vulnerability and capability to cope with climate change[56, 57]. As the majority of the world's poor, women are the most vulnerable to the effects of climate change[58]. Poor women are more likely to become direct victims (mortalities and injuries) of climate change disasters, such as hurricanes and flooding[59]. Additionally, during natural disasters, women die more often than men because they are not warned, cannot swim, or cannot leave the house alone. 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 usually control decision-making around land use and agricultural assets such as livestock. Under varied climate scenarios, cholera, diarrhea, malaria, malnutrition, and heat-related deaths are likely to increase. Pregnant women and children are particularly susceptible to malaria, contributing to prenatal mortality, low birth weight, and maternal anemia[60]. Climate change can also affect the availability of certain medicinal plants used by most 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

51. The World Bank Group. (n.d). Ghana Overview.
52. 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.
53. Armah, F. A., Yawson, D. O., Yengoh, G. T., Odoi, J. O., & Afrifa, E. K. (2010). Impact of floods on livelihoods and vulnerability of natural resource dependent communities in Northern Ghana. *Water*, *2*(2), 120-139.
54. Atanga, R. A., & Tankpa, V. (2021). Climate change, flood disaster risk and food security nexus in Northern Ghana. *Frontiers in Sustainable Food Systems*, *5*, 706721
55. Nti, F. K. (2012). *Climate change vulnerability and coping mechanisms among farming communities in Northern Ghana* (Doctoral dissertation, Kansas State University).
56. UNDP. (2011). http://content-ext.undp.org/aplaws_publications/3253640/AAP_Discussion_Paper1_English.pdf
57. Mitchell, T., Tanner, T., & Lussier, K. (2007). 'We know what we need': South Asian women speak out on climate change adaptation.
58. Women's Environment and Development Organization. (2008). Changing the Climate: Why Women's Perspectives Matter.
59. Neumayer, E., & Plümper, T. (2007). The gendered nature of natural disasters: The impact of catastrophic events on the gender gap in life expectancy, 1981–2002. *Annals of the association of American Geographers*, *97*(3), 551-566.
60. Amegah, A. K., Damptey, O. K., Sarpong, G. A., Duah, E., Vervoorn, D. J., & Jaakkola, J. J. (2013). Malaria infection, poor nutrition and indoor air pollution mediate socioeconomic differences in adverse pregnancy outcomes in Cape Coast, Ghana. *PloS one*, *8*(7), e69181.

particularly vulnerable during water scarcity, as they often prioritize their husbands, ensuring that the man's water needs are met before theirs[61]. In addition, recent studies on adaptation planning have revealed that the major constraints to mitigating climate change impacts in Ghana include the lack of money and inadequate access to labor among women, as well as inadequate access to extension and old age/poor health among men. These studies recommend the integration of gender needs in climate change adaptation planning and intervention development to help build resilient farm households in many communities[62].

Photo: © Curt Carnemark /World Bank

61. Buor, D. (2004). Water needs and women's health in the Kumasi metropolitan area, Ghana. *Health & Place*, *10*(1), 85-103.
62. Assan, E., Suvedi, M., Olabisi, L. S., & Bansah, K. J. (2020). Climate change perceptions and challenges to adaptation among smallholder farmers in semi-arid Ghana: A gender analysis. *Journal of Arid Environments*, *182*, 104247.

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)[63]. 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[64]. 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 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[65]. Generally, very few age-related studies ascribe 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 a majority of participants rightly linked CSM infections to very dry, hot, and dusty conditions experienced during the dry season, a few elderly participants ascribed spiritual causes (disobedience to gods, ancestors, and evil spirits) to CSM infections[66].

Disability: People with disabilities are a heterogeneous group who share living experiences with significant functional restrictions and are often excluded from full community engagement. The number of persons with a disability is growing due to increased chronic health issues and population aging. When persons with disabilities seek health care, they may face stigma, prejudice, and poor-quality treatment[67]. 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 and 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 behaviors than those without impairments, such as poor nutrition and tobacco use[68]. 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[69]. 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. Overweight and obesity can have detrimental effects on one's health.

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

63. World Health Organization. (2020). Children: new threats to health https://www.who.int/news-room/fact-sheets/detail/children-new-threats-to-health
64. Reiner, R. C., et al. (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-e190337.
65. Pecora, P. J., Whittaker, J. K., Barth, R. P., Borja, S., & Vesneski, W. (2018). *The child welfare challenge: Policy, practice, and research*. Routledge.
66. Codjoe, S. N. A., & Nabie, V. A. (2014). Climate change and cerebrospinal meningitis in the Ghanaian meningitis belt. *International journal of environmental research and public health*, *11*(7), 6923-6939.
67. World Health Organisation. Disability and health. (2021). Disability and health. Available at: https://www.who.int/news-room/fact-sheets/detail/disability-and-health
68. Australian Institute of Health and Welfare. (2022). Health of people with disability. Available at: https://www.aihw.gov.au/reports/australias-health/health-of-people-with-disability
69. According to the 2016 Annual Disability Statistics Compedium Available at: https://disabilitycompendium.org/sites/default/files/user-uploads/2016_AnnualReport.pdf

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[70]. Temporary migration is apparent in many areas; however, the most vulnerable to climate change are not necessarily the most likely to migrate[71]. 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 is expected to rise[72]. The effects of climate change on water stress and agriculture are potential drivers of rural-urban migration. Population movement through rural-urban migration, due to crop failure and other climate-induced shocks, can cause health problems because of overcrowding, psychological stress, and the increased pressure on health and social services in destination areas[73]. In Ghana, the drivers of migration, particularly in rural areas are linked to climatic impacts as climate change has threatened the sustainability of agrarian livelihoods. In the Northern semi-arid regions and coastal areas, for example, migration is influenced by drought. Coastal communities face additional challenges of coastal sea erosion, flooding, soil salinization, and the destruction of critical habitats such as mangroves[74]. Other studies in Ghana, however, indicate that though flood and drought are more likely to trigger migration among people in communities with savanna characteristics, when other sociodemographic and economic factors are controlled, a similar experience is less likely in communities with forest characteristics. This paper concludes that climate-related environmental events alone may not trigger migration if it is not linked to other socioeconomic issues[75]. The linkages between climate, migration, and health outcomes have not been explored.

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 particular nation[76]. The word "ethnic minority" refers to ethnic or racial groups in a nation subordinate to the main ethnic population[77]. Indigenous peoples have distinct social, economic, and political systems, languages, traditions, and beliefs and are adamant about preserving and developing their unique identities[78]. Studies about indigenous peoples' health have shown that, to date, indigenous peoples have a life expectancy at birth that is more than five years shorter than the non-indigenous population[79]. Discrimination is a significant factor in the social isolation of indigenous peoples and ethnic minorities. 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 healthcare institutions, has resulted in a dearth of culturally appropriate health treatments. In Ghana, there is no known evidence of ethnic-related climate

70. United Nations High Commissioner for Refugees (2015). Global Trends Forced Displacement in 2015. Available at: http://www.unhcr.org/statistics/unhcrstats/576408cd7/unhcr-global-trends-2015.
71. International Organization for Migration. (2008). Migration and Climate Change. Available at: https://publications.iom.int/system/files/pdf/mrs-31_en.pdf
72. International Organization for Migration. (2020). Health and Migration, Environment, Climate Change. Available at: https://environmentalmigration.iom.int/health-and-migration-environment-climate-change
73. Toole, M. J., & Waldman, R. J. (1990). Prevention of excess mortality in refugee and displaced populations in developing countries. *Jama*, *263*(24), 3296-302.
74. Prosper, A., & Khan, A. (2018). Migration in climate change hotspots: opportunities and challenges for adaptation.*CARIAA*.
75. Abu, M. (2011, December). Migration as an Adaptation Strategy to Climate Change: evidence from Buoku and Bofie-Banda in the Wenchi and Tain Districts of Ghana. In *Paper for the Sixth African Population Conference, held in Ouagadougou, Burkina Faso* (pp. 5-9).
76. Hall, G. H., & Patrinos, H. A. (Eds.). (2012). Indigenous peoples, poverty, and development. Cambridge University Press.
77. Ferrer, A., & Retis, J. (2019). Ethnic minority media: Between hegemony and resistance. *Journal of Alternative & Community Media, 4*(3), 1-13.
78. Wiessner, S. (2011). The cultural rights of indigenous peoples: achievements and continuing challenges. *European Journal of International Law*, *22*(1), 121-140.
79. Tjepkema, M., Bushnik, T., & Bougie, E. (2019). Life expectancy of First Nations, Métis and Inuit household populations in Canada. *Health Reports*, *30*(12), 3-10.

change and health vulnerability, though socioeconomic variability exists among the diverse ethnic groups.

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 makes impoverished people more vulnerable by hurting their health and livelihoods, limiting their possibilities for economic progress[80,81,82]. 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[83]. In a study by Owusu et al. (2019), the authors 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[84]. A general observation is that Ghana's rural and urban areas 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. Furthermore, women, especially those in rural communities, are disproportionately affected by this issue. This is often attributed to their limited access to resources, lack of control over them, and their limited involvement in decision-making related to crisis management and control, both at the household, community, and national levels. These challenges also hinder rural communities from fully participating in income-generating activities essential for poverty reduction and enhancing adaptive capacities. Urban communities face additional stresses and challenges stemming from populations migrating from rural to urban areas [85, 86].

Occupation-related vulnerabilities: Climate change adversely affects various working groups and occupations in the country. Ghana's socioeconomic growth and development primarily depend on the various formal and informal sectors. With the advent of the 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, the heavy physical workload for long hours, and increasing workplace heat exposure due to rising temperatures stemming from climate change, especially in situations with inadequate prevention and

80. Hulme, M., Doherty, R., Ngara, T., New, M., & Lister, D. (2001). African climate change: 1900-2100. *Climate research*, *17*(2), 145-168.
81. Davidson, D. J., Williamson, T., & Parkins, J. R. (2003). Understanding climate change risk and vulnerability in northern forest-based communities. *Canadian Journal of Forest Research*, *33*(11), 2252-2261.
82. Fields, S. (2005). Continental divide: why Africa's climate change burden is greater. *Environmental Health Perspectives, 113*(8), 534–537.
83. Christensen, J. H., Hewitson, B., Busuioc, A., Chen, A., Gao, X., Held, I., Jones, R., Kolli, R. K., Kwon, W. T., Laprise, R., Magana Rueda, V., Mearns, L., Menendez, C. G., Raisanen, J., Rinke, A., Sarr, A, Whetton, P. (2007). Regional Climate Projections. Chapter 11. United Kingdom. Available at: http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter11.pdf
84. Owusu, M., Nursey-Bray, M., & Rudd, D. (2019). Gendered perception and vulnerability to climate change in urban slum communities in Accra, Ghana. *Regional environmental change*, *19*, 13-25.
85. Twumasi-Ankrah, K. (1995). Rural-urban migration and socioeconomic development in Ghana: some discussions. *Journal of social development in Africa*, *10*, 13-22.
86. Dumenu, W. K., & Obeng, E. A. (2016). Climate change and rural communities in Ghana: Social vulnerability, impacts, adaptations and policy implications. *Environmental Science & Policy*, *55*, 208-217.

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 significantly influence the health of the local population and agriculture, which is the people's main source of income. In a related study[87] 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. Still, the variation in heat-related 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.

5.2 HEALTH RISK

5.2.1. National and regional level analyses of climate-sensitive infectious diseases: An ecological study

National analysis of diarrhea

Increase in temperature was linked to both immediate and delayed rises in diarrhea incidence, while the relationship between precipitation and diarrhea was not statistically significant. At the country level, 13,091,680 cases of diarrhea were recorded from 2012 to 2020, with a monthly median value of 6,825. It was found that temperature had both immediate and delayed effects on diarrhea, as a unit

Box 4. Summary of vulnerable population groups

Dimensions of poverty, gender, age, urban-rural residence, occupation and disability drive which population sub-groups are most vulnerable to the impact of climate change.

The elderly, women, children, the chronically ill, the socially isolated (for example, disabled, ethnic minorities, and migrants) and at-risk occupational groups are particularly vulnerable to climate change impacts.

Relative to other parts of the country, the northern part of Ghana relies on subsistence farming. Thus it is prone to food insecurity due to the damaging effect of frequent exposure to extreme rainfall and flood events on crop yields. Additionally, poverty rates are higher in the northern region, reducing the ability to adapt to climate change and exacerbating its impact.

Women, particularly poor women, are more likely to be victims of direct impacts of extreme climate events and are disproportionately affected by food and water insecurity in households. Pregnant women are also particularly susceptible to malaria, resulting in maternal anemia.

In Ghana, the drivers of migration, particularly in rural areas are linked to climatic impacts as climate change has threatened the sustainability of agrarian livelihoods.

The level of vulnerability is higher in the rural areas compared to urban, due to less adaptive capacity and lack of resources. Women are disproportionately affected, particularly within the rural communities.

Heat stress coupled with high levels of physical labor disproportionately impact farmers and miners.

87. Nunfam, V. F., Oosthuizen, J., Adusei-Asante, K., Van Etten, E. J., & Frimpong, K. (2019). Perceptions of climate change and occupational heat stress risks and adaptation strategies of mining workers in Ghana. *Science of the total environment*, *657*, 365-378.

increase in monthly ambient temperature was associated with an 8.0% increase in the instantaneous incidence rate of diarrhea cases reported at the health facilities. The individual temperature lags of one and two months were each also associated with a higher incidence rate of diarrhea (see Appendix 1). Nationally, an increase of 1°C in temperature across the three months before diarrhea cases was associated with a 32% higher incidence rate of diarrhea reported, corresponding to 2,459 direct cases. Nationally, the overall effect of precipitation on diarrhea was not significant, despite an observed instantaneous marginal effect.

National analysis of malaria

An increase in temperature was associated with both immediate and delayed increases in malaria incidence; precipitation was associated with an increase in malaria incidence. A total 65,828,883 malaria cases were recorded for 2012-2020, with a monthly median value of 32,730. A unit increase in monthly ambient temperature was associated with a 6.3% increase in the instantaneous incidence rate of malaria cases (see Appendix 2). The two-month temperature lag was associated with a higher incidence rate of malaria, as an increase of 1°C in temperature across the three months before malaria cases was associated with a 14% higher incidence rate, corresponding to 5,509 direct cases. The precipitation for the index month and one and two-month lags were each associated with a higher incidence rate of malaria (see Appendix 2). The overall effect of precipitation was associated with a 0.39% increase in the malaria cases reported, corresponding to a marginal increase of 165 cases per every 1 – 3 month period.

National analysis of meningitis

An increase in temperature was associated with both immediate and delayed increases in meningitis incidence; the association between precipitation and meningitis was not statistically significant. A total of 4,810 meningitis cases were recorded for 2012-2020, with a monthly median value of 30 cases. Nationally, a unit increase of three months' cumulative temperature had an associated incidence rate of 2.4 meningitis cases. Temperature exhibited both instantaneous and delayed effects on the rise in cases. However, incidence appeared to decline as the lag-temperature effect decreased. Thus, instantaneous temperature and temperature at lag months 1 and 2 were each associated with higher incidence rates (see Appendix 3). There was no association between precipitation and reported meningitis cases.

National analysis of schistosomiasis

Neither temperature nor precipitation was associated with the incidence of schistosomiasis. A total of 51,288 cases of schistosomiasis disease were recorded during the 2012-2020 period, with a monthly median value of 373 cases. At the national level, temperature and precipitation do not influence the number of schistosomiasis cases reported (see Appendix 4).

Sub-national / regional level analysis

The association of temperature and precipitation with the incidence of diarrhea, malaria, meningitis and schistosomiasis was determined at a regional level. For each of the four outcome measures, the region with the highest number of cases per 1,000 Out-Patient Department (OPD) visits for malaria and diarrhea was selected, and per 100,000 OPD cases for meningitis and schistosomiasis was selected. The North East region recorded the highest number of diarrhea cases for 2012-2020, and the Savannah region recorded the highest number of malaria cases. The Upper West and the Upper East recorded the highest number of meningitis and schistosomiasis, respectively (see Appendix 5). For diarrhea cases reported in the North East region, a two-month lag effect of monthly ambient temperature was associated with an 8.6% increase in the instantaneous incidence rate of reported diarrhea cases (see Appendix 5) corresponding to 239 direct cases of diarrhea. The overall effect of precipitation on diarrhea in the region was not observed. While there seems to be an increase in the incidence of malaria in the Savannah region associated with higher index temperatures and ambient temperatures after one month, this effect did not reach statistical significance. The higher temperature at the index month and temperature after one month appeared to increase meningitis incidence by 21.7% in the Upper West region, but the impact was not statistically significant. Precipitation at lag month two was associated with a marginal reduction of 0.99% in the incidence of meningitis in the region. Monthly ambient temperature was not associated with the incidence rate of schistosomiasis cases reported in the Upper East region. Precipitation at index month was associated with a minimal reduction in the incidence of schistosomiasis but not with the overall three-month effect of precipitation.

5.2.2. Direct and indirect health outcome risks of climate change

Direct risk 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 more people at risk of heat-related conditions. Several studies in Ghana have found both direct and indirect impacts of climate variability and change on the health of the population[88]. In recent times, there has been exposure to temperature

Box 5. Summary of national and regional analysis of infectious diseases: an ecological study

Nationally, increase in temperature was associated with immediate and delayed increase in diarrhea incidence; the association between precipitation and diarrhea was not statistically significant.

Nationally, increase in temperature was associated with immediate and delayed increase in malaria incidence; precipitation was associated with an increase in malaria incidence.

Nationally, increase in temperature was associated with immediate and delayed increase in meningitis incidence; the association between precipitation and meningitis was not statistically significant.

Nationally, neither temperature nor precipitation was associated with the incidence of schistosomiasis.

In a regional analysis, higher temperature and precipitation were associated with both instantaneous and delayed effects on the incidence of , malaria, and meningitis cases. Temperature and precipitation were not associated with schistosomiasis, although the number of schistosomiasis cases increased with increasing temperature.

88. 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.

extremes; there is also a higher frequency of climatic hazards, an intensity of climatic hazards, or both. 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[89, 90]. Victims of flood events and their immediate families suffer from long-term mental health conditions[91].

Heat-related morbidity and mortality

There is little evidence of the burden of heat-related morbidity and mortality in the context of Ghana. Biologically, high temperatures cause heat stroke, heat exhaustion, heat syncope, and heat cramps[92]. Severe heat stroke occurs when the core body temperature exceeds 103°F, leading to multiple organ dysfunction. Heat stroke results in substantial mortality, with rapid progression to death, as evidenced by documented global experiences. The heat wave in France in August 2003 caused 14,802 deaths in 20 days, while another in Athens in 1987 was associated with more than 2,000 deaths. In survivors, the permanent damage to organ systems can cause severe functional impairment and increase the risk of early mortality. Besides an increase in mortality, evidence from other countries depicts an association between heat waves and increased emergency room admissions, particularly in the elderly and particularly for respiratory and renal disease outcomes. Additionally, heat waves are associated with other health hazards, including air pollution, wildfires, and water and electricity supply failures that have health implications. Nunfam et al. (2019) found that perceptions of climate change impact the health of mining workers in Ghana[93]. The mining workers reported experiencing varying heat–related morbidities.

VECTOR-BORNE DISEASES

Malaria

Evidence suggests a correlation between climate-related hazards such as rainfall, flooding, humidity, warmer temperatures, and malaria in Ghana. Ghana has made significant strides in malaria control, yet malaria remains a major health burden since it affects many people, especially pregnant women and children[94]. The suitability of the climate for Anopheles mosquitoes and Plasmodium parasite development largely influences malaria transmission. As climatic conditions continue to change, shifts in geographic locations suitable for transmission and lengths of seasons of suitability are expected to occur. Ankamah et al. (2018) noted that climatic conditions alone explain about 12.5% of the variability in the trend of malaria in Ghana[95]. At the national level, the total number of rainy days and humidity have been found to predict malaria incidence[96]. Analyses of the impact of climatic variability on malaria in Ghana revealed the highest positive effect of maximum temperature, relative humidity, and rainfall on malaria for September, March, and October,

89. Asumadu-Sarkodie, S., Owusu, P. A., & Rufangura, P. (2017). Impact analysis of flood in Accra, Ghana. *Advances in Applied Science Research*, *6*(9):53-78
90. Amoako, C., & Inkoom, D. K. B. (2018). The production of flood vulnerability in Accra, Ghana: Re-thinking flooding and informal urbanisation. *Urban Studies*, *55*(13), 2903-2922.
91. Dziwornu, E., & Kugbey, N. (2015). Mental health problems and coping among flood victims in Ghana: A comparative study of victims and non-victims. *Current Research in Psychology*, *6*(1), 15-21.
92. Kovats, R. S., & Hajat, S. (2008). Heat stress and public health: a critical review. *Annu. Rev. Public Health*, *29*, 41-55.
93. Nunfam, V. F., Oosthuizen, J., Adusei-Asante, K., Van Etten, E. J., & Frimpong, K. (2019). Perceptions of climate change and occupational heat stress risks and adaptation strategies of mining workers in Ghana. *Science of the total environment*, *657*, 365-378.
94. IHME. (2019). Global Burden of Diseases. Seattle. Available at: https://www.healthdata.org/ghana
95. Ankamah, S., Nokoe, K. S., & Iddrisu, W. A. (2018). Modelling trends of climatic variability and malaria in Ghana using vector autoregression. *Malaria Research and Treatment*, *2018*.
96. Akpalu, W., & Codjoe, S. N. A. (2013). Economic analysis of climate variability impact on malaria prevalence: the case of Ghana. *Sustainability*, *5*(10), 4362-4378.

respectively. Simulation of seasonal malaria incidence shows that malaria transmission follows rainfall peaks, with the intensity and duration of malaria transmission being controlled predominantly by rainfall[97]. According to Amekudzi et al. (2014), the prevailing shift in the peak rainfall patterns in the coastal cities in Ghana will lead to a shift in malaria transmission season (May-July) by around 1-2 months between 2020 and 2080[98]. In addition, projected changes in climatic conditions are also expected to lead to the reduction of malaria prevalence in these areas since temperatures above 35^{0}C degrees and reduced rainfall patterns negatively influence malaria transmission.

Photo: © Arne Hoel / World Bank

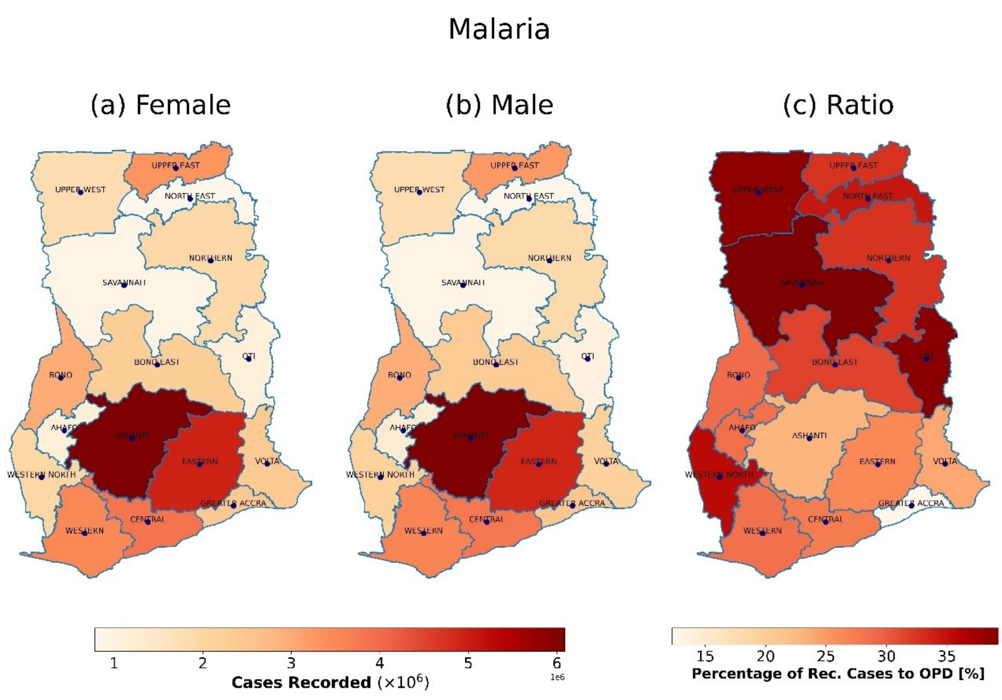
97. Asare, E. O., & Amekudzi, L. K. (2017). Assessing climate driven malaria variability in Ghana using a regional scale dynamical model. *Climate*, *5*(1), 20.
98. Amekudzi, L., Codjoe, S. N. A., Sah, N. A., & Appiah, M. (2014). Impact of climate change on malaria in coastal Ghana. International Development Research Center.

Between 2012 and 2021, the Ashanti and Eastern regions of the country recorded the highest number of malaria cases. Figure 5-1 highlights the total reported malaria cases within the 2012 - 2021 period, grouped by gender across the region (Figure 5-1a – b) and also as a fraction of total attendance from the Out Patient Departments (OPDs) in each region (Figure 5-1c). The reported cases were over million each for males and females over the review decade. The Upper East, Bono, Western, and Central regions follow suit, with reported cases exceeding 2.5 million persons for the reviewed decade. The lowest reported malaria cases were recorded in the North East, Savannah, Ahafo, and Oti regions.

As a ratio of total OPD attendance, the most prevalent regions with reported malaria cases were in the northern parts of the country and the upper parts of the middle regions, with proportions exceeding 30%. The Greater Accra region recorded the lowest disease density, with malaria cases below 10%. The Ashanti Region also recorded less than 25% malaria disease density.

FIGURE 5-1.

Region-wise reported malaria cases, 2012-2021 (a) among females (b) among males and (c) as % of total OPD attendance (disease density)

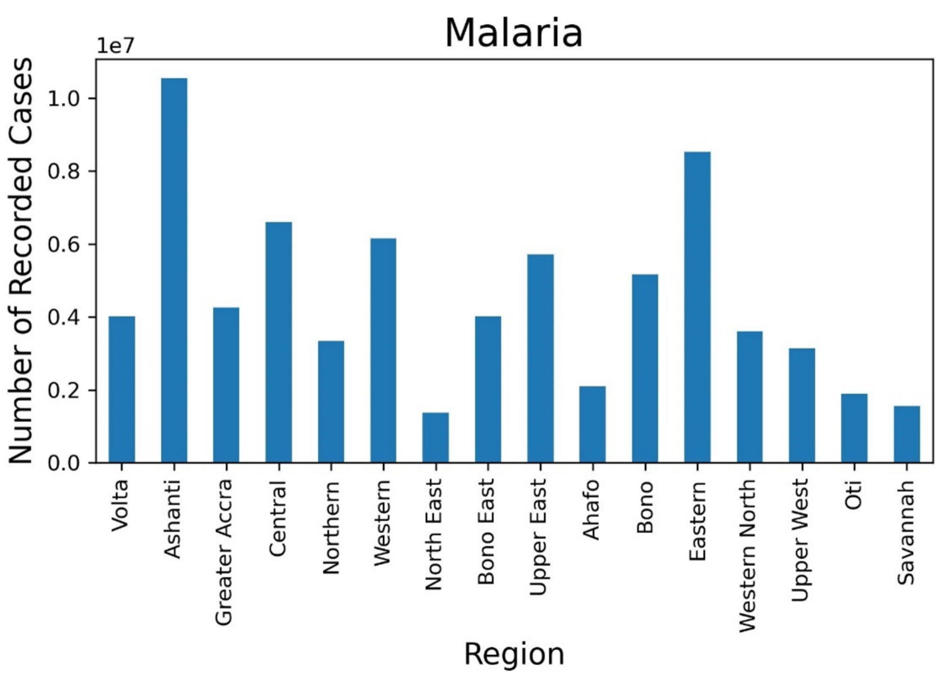


Source: Authors retrieved OPD data from Ghana Health Service

The malaria cases recorded over the decade are more than a million for each region across the country. Figure 5-2 highlights the accumulated number of individual malaria cases reported within the 2012 - 2021 decade from all 16 regions nationwide. By numbers, the Ashanti region has recorded over 10 million individual malaria cases, followed by the Eastern region with more than 8 million cases. The North East, Ahafo, Savannah, and Oti regions have the lowest numbers with recorded cases on the order of a million.

The Greater Accra and Ashanti regions, over the years, have seen a reduction of more than 60,000 reported malaria cases, followed by the Eastern region with an approximate reduction of 48,000 cases. On the other hand, relatively lower declines (on the order of 10,000 to 20,000 cases) have been observed in the upper

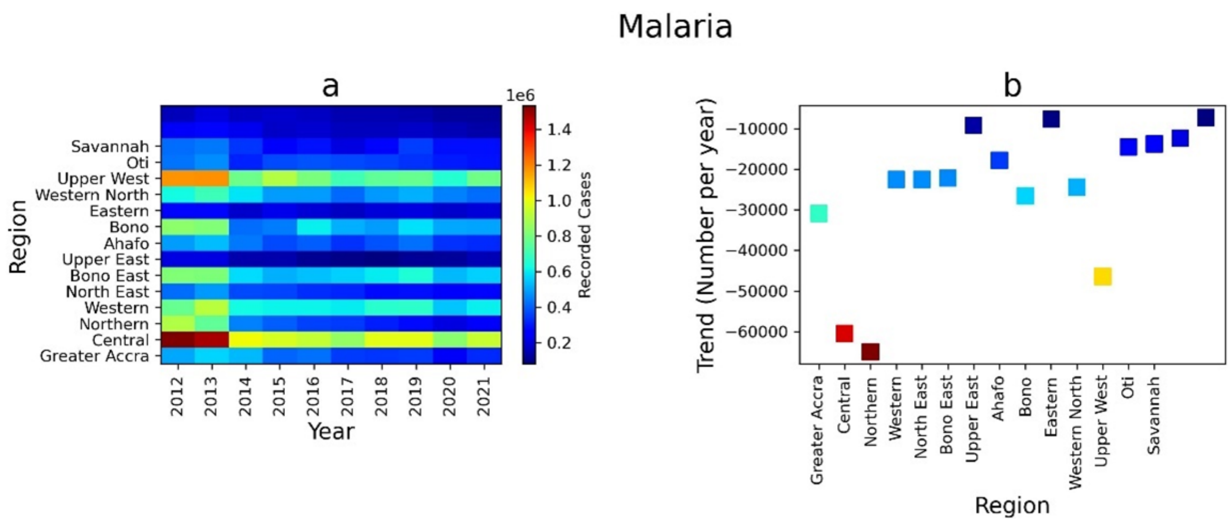
FIGURE 5-2.
Total reported malaria cases by region, 2012-2021



Source: Authors retrieved OPD data from Ghana Health Service

parts of the country. Figure 5-3 provides a time series analysis of the reported malaria cases per region (a) and the regional trends in reported malaria cases for the review decade (b). The time series data offers insights into annual reported cases and observed changes over the years. Notably, there has been a nationwide decline in malaria cases, likely attributed to comprehensive education and interventions implemented to combat malaria, including the distribution of treated nets and mosquito breeding ground clearance.

FIGURE 5-3.
(a) Annual region-wise reported malaria cases (b) trends



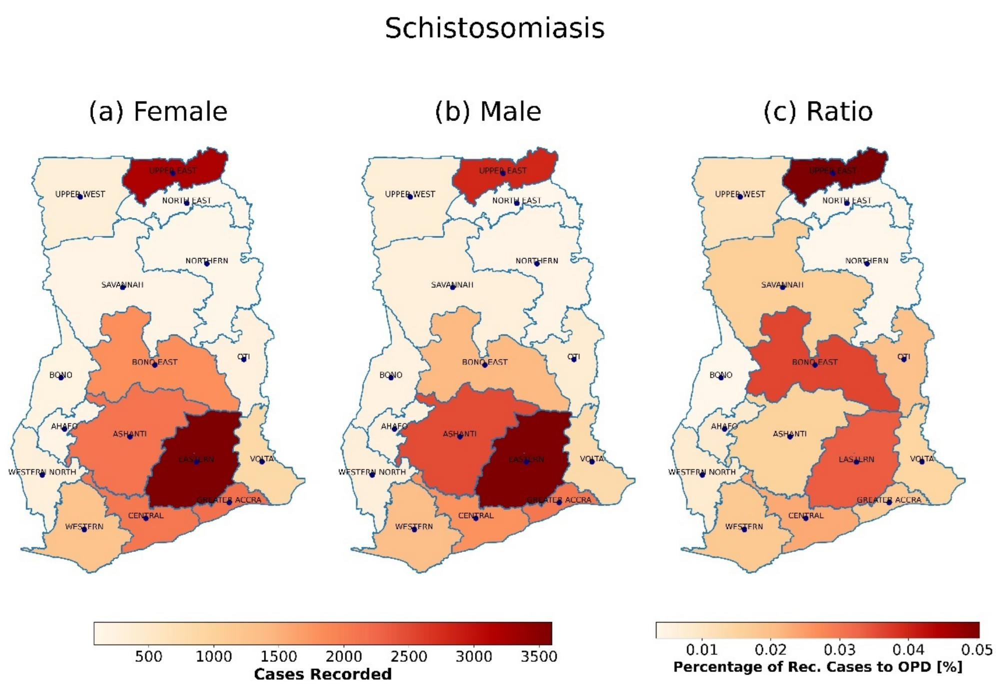
Source: Authors retrieved OPD data from Ghana Health Service

Schistosomiasis

Between 2012 and 2021, the Eastern and Upper East regions recorded the highest number of schistosomiasis cases. Figure 5-4 provides information on the total reported schistosomiasis cases within the 2012 - 2021 period, categorized by gender across the region (Figure 5-4a – b) and as a fraction of total OPD attendance in each region (Figure 5-4c). Reported cases exceeded 3,000 for both males and females. The Bono East, Ashanti, Greater Accra, Upper East, and Central and Eastern regions each had over 3000 reported cases for the decade, female and male combined. Schistosomiasis cases in other regions were generally below 1000 and the Volta and Western Region reported between 1000 and 1500 cases, female and male respectively.

As a ratio to total OPD attendance, the prevalence of schistosomiasis was low (but more prevalent than meningitis), with disease densities below 1%. However, from the assessment, the most schistosomiasis-prevalent regions are in the Upper East, Bono East, and Eastern regions, with proportions exceeding 0.035%. The least prevalent regions are the Bono, North East, and Northern Regions.

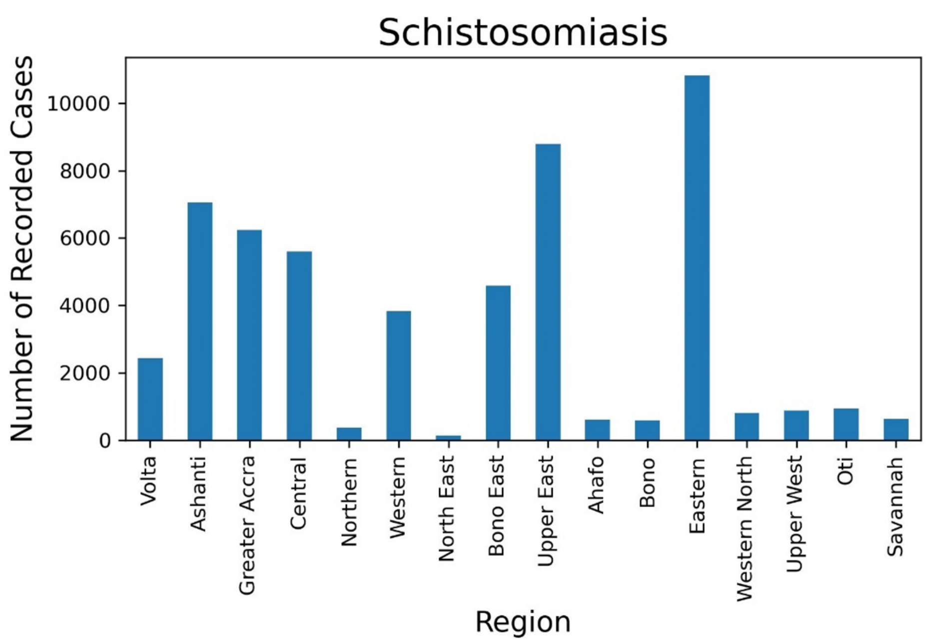
FIGURE 5-4.
Region-wise reported schistosomiasis cases, 2012-2021 (a) among females (b) among males, and (c) as % of total OPD attendance (disease density)



Source: Authors retrieved OPD data from Ghana Health Service

Across the regions, the total schistosomiasis cases recorded between 2012 and 2021 ranged from less than 500 to over 10,000. Figure 5-5 presents the accumulated number of individual schistosomiasis cases reported within the 2012 - 2021 decade from all 16 regions of the country. The highest cases have been recorded in the Eastern region with magnitudes slightly above 10,000, followed by the Ashanti, Greater Accra, Central, and Upper East regions with more than 5,000 reported cases over the period. The Northern, North East, Ahafo, Bono, Western North, Upper West, Savannah, and Oti regions recorded the lowest numbers of schistosomiasis cases with less than 500 cases over the decade.

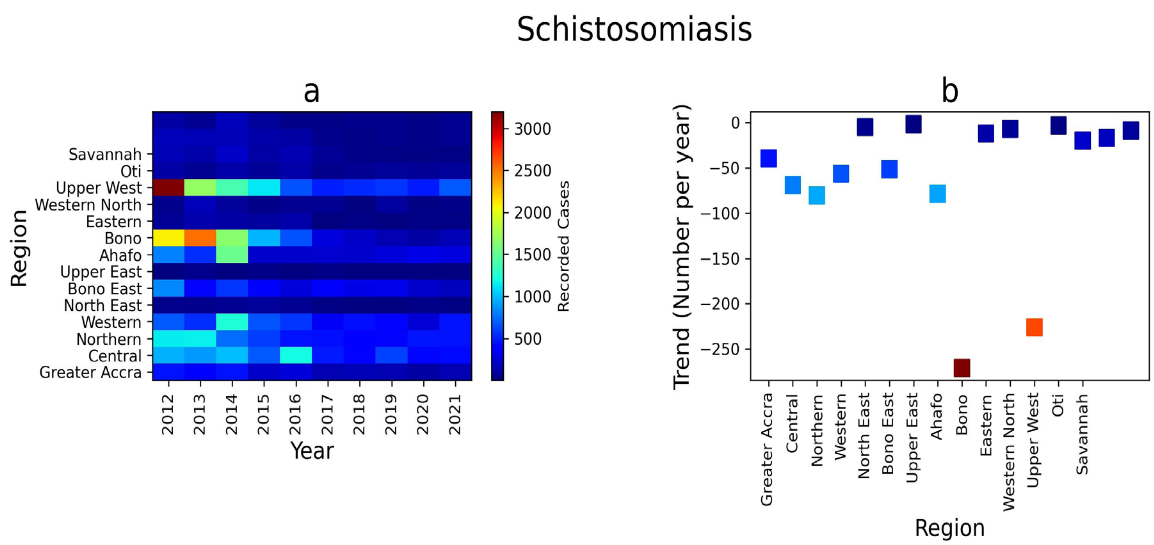
FIGURE 5-5.
Total reported schistosomiasis cases by region, 2012-2021



Source: Authors retrieved OPD data from Ghana Health Service

A general decline in schistosomiasis cases is observed in most parts of the country between 2012 and 2021. Figure 5-6 provides (a) a time series analysis of the reported schistosomiasis cases per region and (b) the regional trends in reported schistosomiasis cases for the review decade. Generally, the time series data offers insights into annual reported cases and observed changes over the years, reflecting the impact of interventions and public education efforts. Figure 5-6b shows that the Upper East and Eastern regions have experienced the most significant reduction, with more than 200 fewer reported schistosomiasis cases over the years. In contrast, other parts of the country have seen relatively smaller declines, typically below 100 cases.

FIGURE 5-6.
(a) Annual region-wise reported schistosomiasis cases and (b) trends



Source: Authors retrieved OPD data from Ghana Health Service

Dengue Haemorrhagic 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[99, 100, 101]. In spite of 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. At the same time, drought conditions promote household water storage and consequently increase the number of suitable breeding sites for the vector[102]. The first dengue virus infection was reported in Ghana in 2008. Although cases of dengue have been reported in Ghana over the 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 infections[103]. This similarity has contributed immensely to the over-diagnosis of malaria and the under-recognition of dengue[104]. A study conducted among 218 febrile-ill children clinically diagnosed with malaria from Accra, Navrongo, and Kintampo showed a DENV IgG seroprevalence of 21.6% collectively[105]. Other Studies have shown 87.2% of dengue prevalence among 236 HIV-infected individuals[106] and 3.6% dengue IgG seroprevalence among 360 yellow fever suspect individuals across all regions in Ghana[107]. Pappoe-Ashong et al. (2020) 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[108]. However, the Upper East and the Volta regions had a significantly higher seroprevalence than the overall seroprevalence in Ghana. In spite of the existing evidence of the prevalence of dengue in Ghana, its linkage with climatic conditions is yet to be explored.

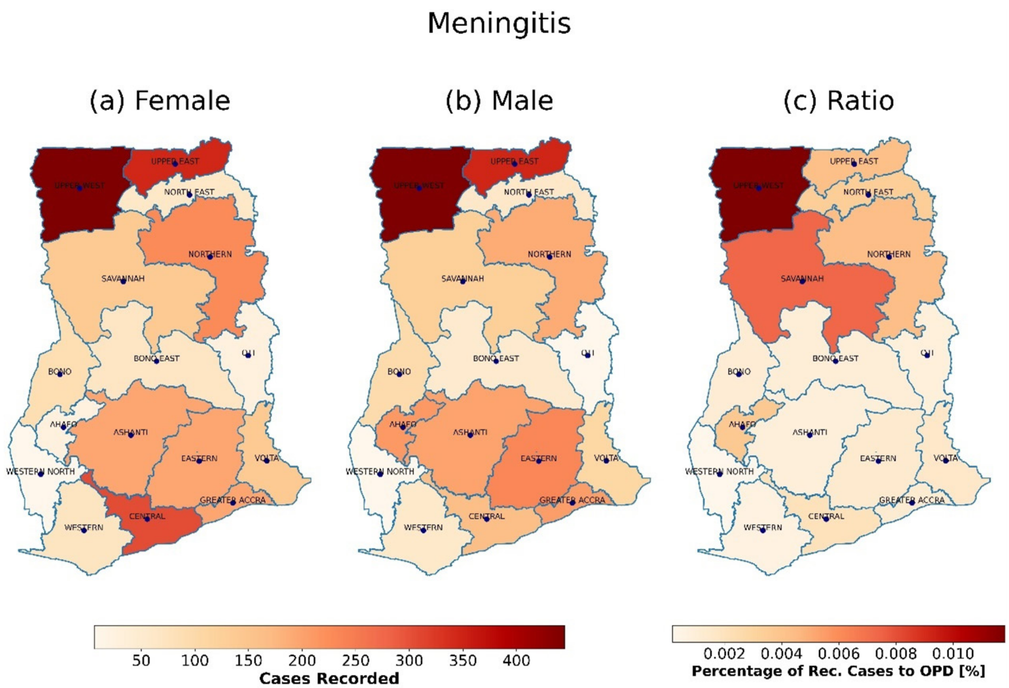
WATER-BORNE AND WATER-RELATED DISEASES

Meningitis

Between 2012 and 2021, the Upper West and Upper East regions recorded the highest number of meningitis cases. Figure 5-7 provides information on the reported meningitis cases within the 2012 - 2021 period, grouped by gender across the region (Figure 5-7a – b) and as a fraction of total OPD attendance in each region (Figure 5-7c). Reported cases exceeded 300 for both males and females. The Northern, Ashanti, Eastern, Greater Accra, and Central regions had reported cases exceeding 170 for the decade. Central region also had high reported cases in females, exceeding 300 cases. In contrast, the Ahafo region had lower reported cases

99. Hales, S., De Wet, N., Maindonald, J., & Woodward, A. (2002). Potential effect of population and climate changes on global distribution of dengue fever: an empirical model. The Lancet, 360(9336), 830-834.
100. Corwin, A. L., Larasati, R. P., Bangs, M. J., Wuryadi, S., Arjoso, S., Sukri, N., Listyaningsih, E., Hartati, S., Namursa, R., Anwar, Z., Chandra, S., Loho, B., Ahmad, H., Campbell, J.R. & Porter, K. R. (2001). Epidemic dengue transmission in southern Sumatra, Indonesia. Transactions of the Royal Society of Tropical Medicine and Hygiene, 95(3), 257-265.
101. Cazelles, B., Chavez, M., McMichael, A. J., & Hales, S. (2005). Nonstationary influence of El Nino on the synchronous dengue epidemics in Thailand. PLoS medicine, 2(4), e106.
102. Pontes, R. J., Freeman, J., Oliveira-Lima, J. W., Hodgson, J. C., & Spielman, A. (2000). Vector densities that potentiate dengue outbreaks in a Brazilian city. *The American journal of tropical medicine and hygiene*, *62*(3), 378-383.
103. 103. Stoler, J., Delimini, R. K., Bonney, J. K., Oduro, A. R., Owusu-Agyei, S., Fobil, J. N., & Awandare, G. A. (2015). Evidence of recent dengue exposure among malaria parasite-positive children in three urban centers in Ghana. The American journal of tropical medicine and hygiene, 92(3), 497
104. Delimini, R. K. (2014). Investigation of dengue exposure and infection in Ghanaian children with malaria (Doctoral dissertation, University of Ghana).
105. Webster, J., Baiden, F., Bawah, J., Bruce, J., Tivura, M., Delmini, R., ... & Owusu-Agyei, S. (2014). Management of febrile children under five years in hospitals and health centres of rural Ghana. Malaria journal, 13(1), 1-13.106.
106. Sherman, K. E., Rouster, S. D., Kong, L. X., Shata, T. M., Archampong, T., Kwara, A. et al. (2018). Zika virus exposure in an HIV-infected Cohort in Ghana. JAIDS Journal of Acquired Immune Deficiency Syndromes, 78(5), e35-e38.
107. Ofosu-Appiah, L., Kutame, R., Ayensu, B., Bonney, J., Boateng, G., Adade, R., et al. (2018). Detection of Dengue Virus in samples from suspected yellow fever cases in Ghana. Microbiology Research Journal International, 24(1), 1-10.
108. Pappoe-Ashong, P., Ofosu-Appiah, L., Mingle, J., & Jassoy, C. (2018). Seroprevalence of dengue virus infections in Ghana. East African Medical Journal, 95(11), 2132-2140.

FIGURE 5-7.
Region-wise reported meningitis cases, 2012-2021 (a) among females, (b) among males, and (c) as % of total OPD attendance (disease severity)



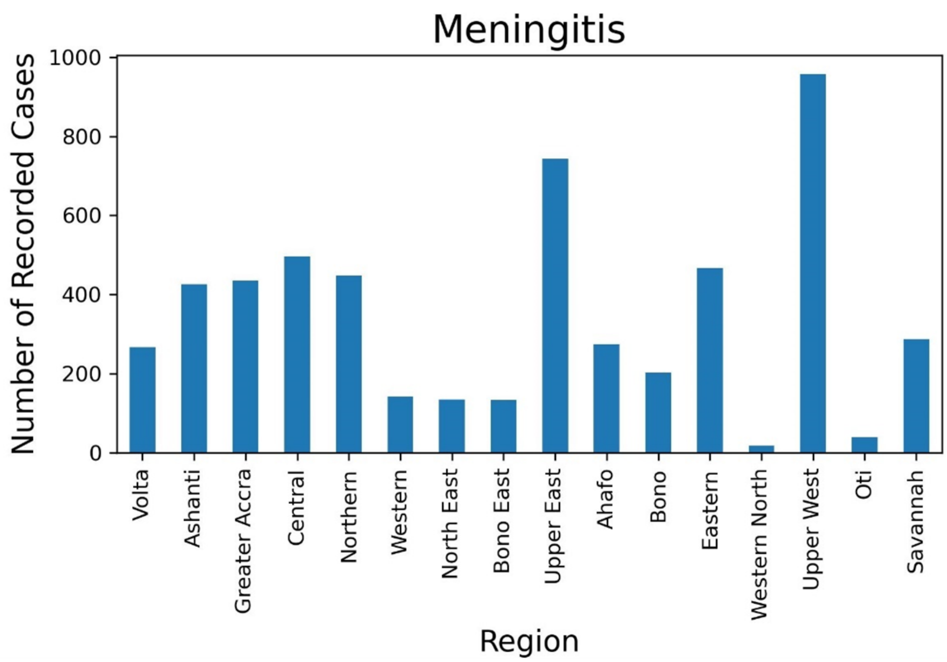
Source: Authors retrieved OPD data from Ghana Health Service

in females (less than 100 cases). The lowest reported meningitis cases were in the Oti and Western North regions, with less than 100 cases each.

As a ratio to total OPD attendance, meningitis was found to have low prevalence with disease densities below 1%. However, from the assessment, the most meningitis-prevalent regions are in the north-western parts of the country (North West and Savannah regions), with proportions exceeding 0.008%.

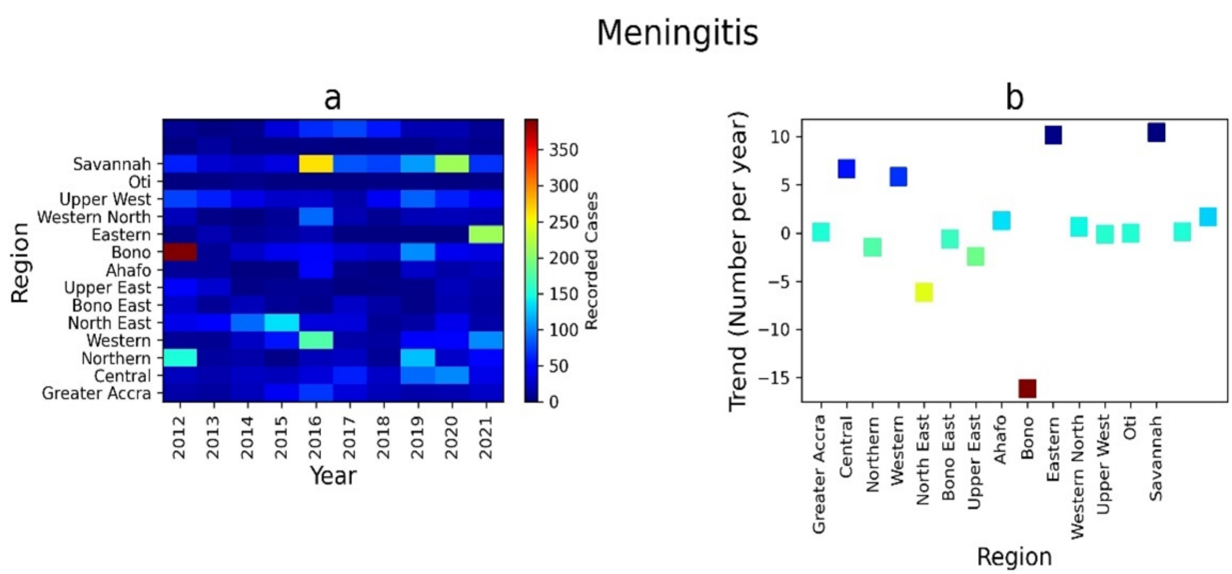
Meningitis cases recorded over the decade were less than 1,000 per region across the country, and, in terms of absolute numbers, meningitis was the least prevalent compared to malaria, diarrhea, and schistosomiasis. Figure 5-8 presents the accumulated number of individual meningitis cases reported within the 2012 - 2021 decade from all 16 regions across the country. By numbers, the highest cases have been recorded in the Upper East and Upper West regions, with magnitudes greater than 600 and 900, respectively. The least reported meningitis cases are from the Western North and Oti regions, with less than 100 cases over the decade.

FIGURE 5-8.
Total reported meningitis cases by region, 2012-2021



Source: Authors retrieved OPD data from Ghana Health Service

FIGURE 5-9.
(a) Annual region-wise meningitis cases and (b) trends



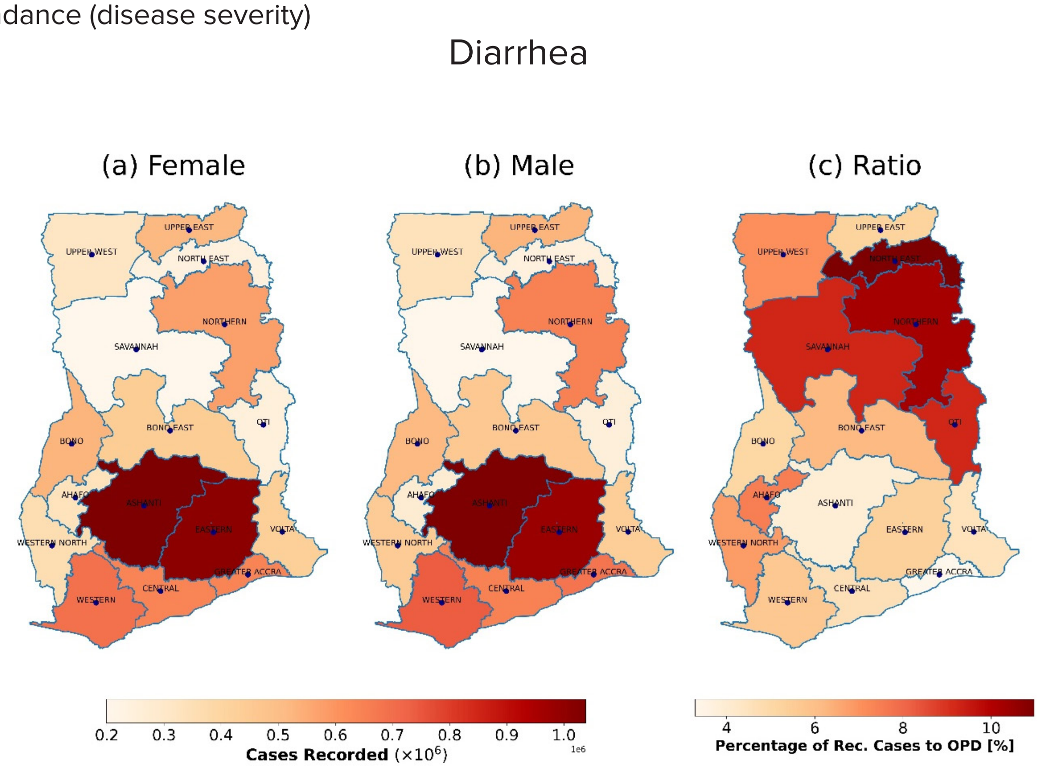
Source: Authors retrieved OPD data from Ghana Health Service

There was an observed decrease in meningitis cases over the upper parts of the country. However, regions in the middle belt such as Ahafo and Ashanti, along with the Central Region in the south, have recorded marginal increases in reported cases**.** Figure 5-9 provides a time series analysis of the reported meningitis cases per region (a) and the regional trends in reported diarrhea cases for the review decade (b).

Diarrhea

Between 2012 and 2021, the Ashanti and Eastern regions recorded the highest diarrhea cases, with the reported cases being more than 1 million each for males and females. Studies in urban Accra show households linking the incidence of diarrhea to flood experience in their community[109]. Figure 5-10 provides information on the total reported diarrhea cases within the 2012 - 2021 period, grouped by gender across the region (Figure 5-10a – b) and as a fraction of total OPD attendance in each region (Figure 5-10c). The Upper East, Northern, Bono, Western, Greater Accra, and Central regions followed with reported cases exceeding 500,000 for the decade. The lowest reported diarrhea cases were recorded in the North East, Savannah, Ahafo, and Oti regions with magnitudes below 300,000 cases.

FIGURE 5-10.
Region-wise reported diarrhea cases, 2012-2021 (a) among females, (b) among males and (c) as % of total OPD attendance (disease severity)



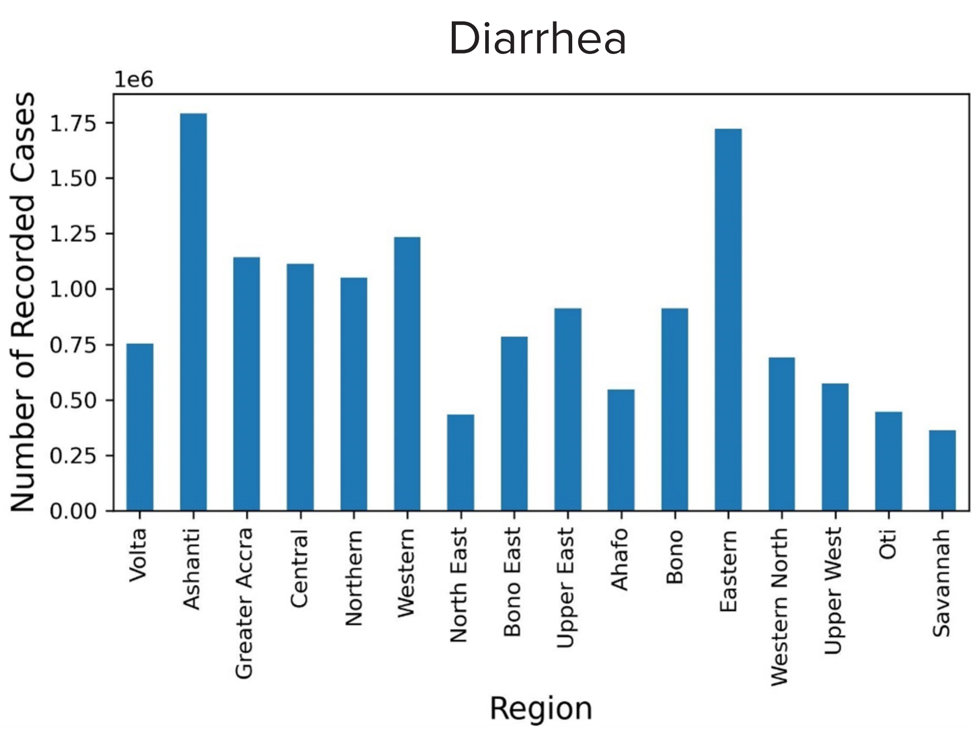
Source: Authors retrieved OPD data from Ghana Health Service

109. Abu, M., & Codjoe, S. N. A. (2018). Experience and future perceived risk of floods and diarrheal disease in urban poor communities in Accra, Ghana. *International Journal of Environmental Research and Public Health*, *15*(12), 2830.

As a ratio to total OPD attendance, the most diarrhea-prevalent regions were predominantly in the northern parts of the country, particularly the North East, Northern, Savannah, and Oti regions, with proportions exceeding 8.5%. Meanwhile, the proportion in the Greater Accra and Ashanti regions was the least, at less than 4%.

Across the regions of the country, the diarrhea cases recorded over the decade ranged from about 400,000 to 1.75 million. Figure 5-11 highlights the accumulated number of individual diarrhea cases reported within the 2012 - 2021 decade from all 16 regions nationwide. In terms of numbers, the Ashanti and Eastern regions have reported more than 1.5 million individual diarrhea cases. Conversely, the North East and Savannah regions have the lowest reported diarrhea cases, with less than 500,000 cases over the decade.

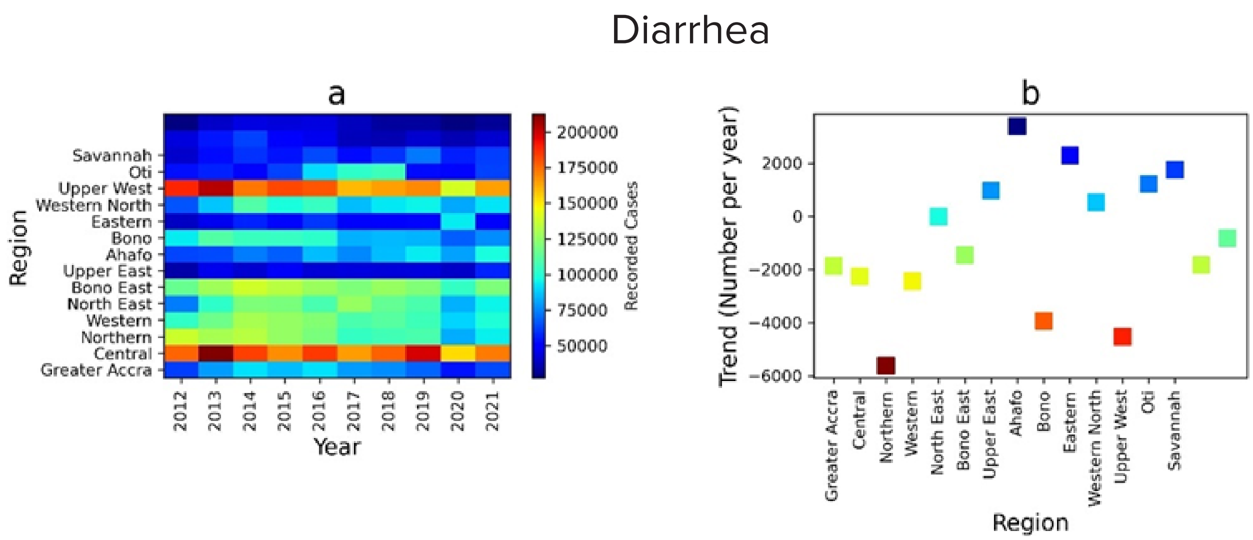
Figure 5-11.
Total reported diarrhea cases by region, 2012-2021



Source: Authors retrieved OPD data from Ghana Health Service

In regions such as the Volta, Ashanti, Greater Accra, Central, Western, Upper East, Eastern, Oti, and Savannah, although sporadic, there is an observable decline in diarrhea cases, whereas the remaining regions show increasing trends. Figure 5-12 presents a time series analysis of reported diarrhea cases per region (a) and regional trends in reported diarrhea cases over the review decade (b). The most significant declines are observed in the Greater Accra, Eastern, and Upper East Regions, with reductions exceeding 40,000 cases. Conversely, Bono East shows an apparent increase, averaging around 2,000 cases per year.

FIGURE 5-12.
(a) Annual region-wise diarrhea cases and (b) trends



Source: Authors retrieved OPD data from Ghana Health Service

Food security and nutritional deficiencies

Ghana faces food insecurity due to low annual yield, attributable to adverse weather conditions. According to the United Nations, global food security demands that people have physical and economic access to sufficient, safe, and nutritious food that satisfies their food choices and dietary needs to live an active and healthy life. A review of general agricultural trends and challenges in Ghana[110] 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 2009 World Food Programme report indicated that the total number of Ghanaians who are food insecure is about 453,000. The report projected 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, representing 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 are moderately food insecure. Out of the 3.6 million people who are food insecure 2.8 million live in rural areas, and 0.8 million in urban areas. Another report issued by the Ministry of Food and Agriculture, Ghana, indicated that approximately 1.2 million people are food insecure representing about 5% of the country's population.

110. 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.

Air quality and pollution-related illnesses

Available data suggest that air pollution related diseases have a high mortality rate and high cost of treatment in Ghana. The contamination of the 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 as ambient air with a particulate matter with a diameter of 10 µm less than or equal to 50 µg m -3. Also, the Environmental Protection Agency (EPA, Ghana) defines air quality as ambient air with particulate matter less than or equal to 70 µg m -3. The quality of air influences the health and well-being of humans. Air pollution is one of the causes of climate change and is a major threat to 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. Among the health effects of air pollution are respiratory and heart problems. A WHO report on ambient air pollution and its health impact estimated that in Greater Accra, the 2015 levels of air pollution will be responsible for about 70,000 years of life lost in the adult (25+) population over a period of 10 years[111]. It also estimates that implementing air pollution reduction strategies could prevent 1790 deaths annually in Greater Accra. Additionally, the report identifies household air pollution as an issue in Accra due to the significant use of solid fuels. Household air pollution from solid fuel cooking was responsible for 4.3 million deaths worldwide in 2012, according to the World Health Organization[112]. In terms of the economic costs of air pollution, a 2020 report from Accra, Ghana, by the

111. Mudu, P.(2021). Ambient air pollution and health in Accra, Ghana. World Health Organization.
112. WHO. (2004). *Promoting mental health: Concepts, emerging evidence, practice: Summary report*. World Health Organization.

WHO Urban Health Initiative[113] showed that Chronic Obstructive Pulmonary Disease (COPD) patients spent the most amount of time in the hospital, an average of 29 days, followed by lung cancer patients, with 23 days, Road Traffic Injuries (RTI) patients, with 21 day and pneumonia patients who 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 who have lung cancer paying as much as US$2135, stroke patients paying US$351 and Ischemic heart disease (IHD) patients paying US$638, on average.

Mental health and well-being

A 2017 report by the American Psychological Association found that climate change triggers stress, anxiety, and depression and causes relationship strain[114, 115]. The literature reflects rapidly expanding evidence on the link between climate change and mental health. Mental health impacts may be direct or indirect. Extreme weather events such as heat and humidity have been associated with increased hospital admissions for mood and behavioral disorders, including schizophrenia, mania, and neurotic disorders[116]. There is some evidence from Ghana on adverse physical and mental health impacts of flooding in the Old-Fadama community in Accra[117]. Post Traumatic Stress Disorder (PTSD) is the most often reported mental health impact of acute climate change-related disasters, though there are increasing reports of suicide and suicidal ideation. The indirect mental health impact of climate change can be due to climate change-related damages to physical and social infrastructure, physical health effects, food and water shortages, conflict, and displacement from acute, subacute, and chronic climactic changes. Mental illness is a primary cause of disability worldwide, with significant negative consequences, especially in low-income nations. However, data on the prevalence of mental health conditions and their linkages to climate change are limited in these settings, notably in Africa and specifically, Ghana. People with mental illnesses are frequently subjected to severe human rights breaches, discrimination, and stigma. Even though many mental health illnesses can be adequately managed at a reasonable cost, the gap between those needing care and those with access to it remains significant. The percentage of people who receive effective treatment is still deficient. Ghana has few resources to manage the burden of mental health illnesses.

According to an article published by the Harvard Global Health Institute website, there are approximately 38 psychiatrists to serve Ghana's entire population, resulting in a startling psychiatrist-to-population ratio of one psychiatrist for every 800,000 Ghanaians[118]. A report based on a survey conducted in 2012 on behalf of the Ministry of Health using the World Health

113. Essel, D., Spadaro, J. V., et al. (2020). Health and economic impacts of transport interventions in Accra, Ghana. World Health Organization
114. American Psychological Association. (2017). Stress in America: Coping with change. American Psychological Association.
115. World Health Organization. (2004). *Promoting mental health: Concepts, emerging evidence, practice: Summary report*. World Health Organization.
116. Hayes, K., Blashki, G., Wiseman, J., Burke, S., & Reifels, L. (2018). Climate change and mental health: risks, impacts and priority actions. *International journal of mental health systems*, *12*(1), 1-12.
117. 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.
118. MindIT Mental Health Service Story - Ghana. (2022). Harvard Global Health Institute. Available at: https://globalhealth.harvard.edu/mindit-mental-health-service-story-ghana

Organization Assessment Instrument for Mental Health Systems (WHO-AIMS) by the Kintampo Project highlighted that, as of 2011, there were no national or regional mental health organizations to offer the government guidance on mental health policies and legislation. The total amount spent by the Government of Ghana on

Box 6. Summary of change related health risks

In the past, extreme climate events like floods and droughts have resulted in injuries and fatalities in Ghana. There is little evidence on heat-related mortality and morbidity.

Vector borne diseases:
The Ashanti and Eastern regions of the country reported the maximum absolute number of malaria cases between 2012 and 2021, though cases show a declining trend. As a proportion of total OPD cases, the northern part of the country had the highest malaria load and the least decline in absolute number of cases over time.

Between 2012 and 2021, the absolute number of schistosomiasis cases has been declining across the country.The number of cases as a proportion of total OPD cases are <1% across all regions. Across the regions, the total schistosomiasis cases recorded between 2012 and 2021 ranged from less than 500 to over 10,000, with the highest in the Eastern and Upper East regions.

There is limited information available on the prevalence of dengue in Ghana, partly due to challenges in diagnosing it as distinct from malaria.

Water borne diseases:
Between 2012 and 2021, the total number of meningitis cases reported across the regions of the country ranged from less than 100 to about 900 cases. All regions reported <1% meningitis cases as a proportion of total OPD visits. While the upper parts of the country showed a declining trend in reported cases, regions in the middle belt such as the Ahafo and Ashanti, as well as, Central Region in the south have recorded marginal increases.

The Ashanti and Eastern regions recorded the highest number of total cases between 2012 and 2021, though as a proportion of total OPD visits the northern regions reported the maximum cases. Across regions, the total cases over the decade ranged from 400,000 to 1.75 million. While the Greater Accra, Eastern and Upper East Regions have seen the maximum decline in cases over time, cases in Bono East region seem to be rising by an average of 2000 cases per year.

It is estimated that about 2 million Ghanaians are vulnerable to food insecurity and that should any natural disaster occur food availability will be greatly affected, particularly in the Northern region and the rural areas of the country.

Available data suggest that air pollution diseases, like respiratory illness, stroke and heart disease, have a high mortality rate and high cost of treatment in Ghana.

Though evidence suggests the role of climate change in triggering stress, anxiety, depression, and other mental health issues, there is limited information in the context of Ghana. In terms of resource availability, Ghana's health system lacks the infrastructure and human resources to address the burden of mental health issues.

health in 2011 was GH¢ 398,857,000, and the spending on mental health was 1.4% of the total health budget[119]. Moreover, in 2011 the patient-to-bed ratio in inpatient mental health facilities was 5.5 beds per 100,000 population, with three facilities offering 1,322 beds. In the same year, however, more patients were admitted than there were beds. Statistics show that about 77% of mental health patients spend at least three months in inpatient facilities for treatment, 11% spend about 12 to 48 months, and 13% spend 50 to 120 months[120]. All these metrics point to the fact that, should the causes of mental health be carefully researched and mitigated, its impact on the country's economy can be reduced.

5.2.3. Health system risks

Health infrastructure

A report by the University of Ghana in 2018 on the state of the nation's health suggests that Ghana has insufficient health facilities per population density to manage both communicable and non-communicable diseases[121]. Moreover, the report observes that for 2010 and 2013, the density of health posts per 100,000 people in Ghana declined marginally from 1.18 to 1.11, respectively, while the density of health centers per 100,000 people fell slightly from 9.69 to 9.13. However, between 2010 and 2013, the density of provincial or regional hospitals per 100,000 people in Ghana remained constant at 0.03. In addition, the density of district and rural hospitals per 100,000 people increased from 0.8 to 1.41 during that period. In the capital region, each sub-metro is expected to have one polyclinic, but this is currently not the case. The recent subdivision of four districts into ten new sub-metro regions makes it more challenging to meet the infrastructure requirements.

Despite the expansion of CHPS Zones, various population sub-groups still lack access to primary health care (PHC) services[122, 123], which may be exacerbated by climate-sensitive health risks. An affordable and accessible PHC system is integral for early recognition and management of a climate-induced health emergency. A key factor limiting access to PHCs is the exclusion of PHC services within the benefits package of NHIS. Additionally, robust referral systems across levels of care are lacking.

The health infrastructure needs to be strengthened to enhance service availability and readiness. About half of CHPS Zones meet standards in terms of infrastructure and transport, and only a third of CHPS Zones and less than half of Health Centers have the full complement of equipment. Rural and remote districts often report stockouts of essential medicines[124].

Health workforce

The number of human resources for health has increased in Ghana, though

119. Roberts, M., Mogan, C., & Asare, J. B. (2014). An overview of Ghana's mental health system: results from an assessment using the World Health Organization's Assessment Instrument for Mental Health Systems (WHO-AIMS). *International journal of mental health systems*, *8*, 1-13.
120. Roberts, M., Asare, J. B., Mogan, C., Adjase, E. T., & Osei, A. (2013). The mental health system in Ghana. *Ghana: The Kintampo Project*. WHO-AIMS.
121. University of Ghana, School of Public Health. (2018). Available at: https://publichealth.ug.edu.gh/sites/publichealth.ug.edu.gh/files/docs/state_of_the_nations_interior_final_compressed-compressed_2.pdf
122. Braimah, J. A., Sano, Y., Atuoye, K. N., & Luginaah, I. (2019). Access to primary health care among women: the role of Ghana's community-based health planning and services policy. *Primary Health Care Research & Development*, *20*, e82.
123. Acquah-Hagan, G., Boateng, D., Appiah-Brempong, E., Twum, P., Atta, J. A., & Agyei-Baffour, P. (2021). Access Differentials in Primary Healthcare among Vulnerable Populations in a Health Insurance Setting in Kumasi Metropolis, Ghana: A Cross-Sectional Study. *Advances in Public Health*, *2021*, 1-14.
124. Republic of Ghana. (2020). Ghana's Roadmap for Attaining Universal Health Coverage, 2020-2020. Ministry of Health.

there are regional and urban-rural disparities. Over 60% of health facilities and human resources are found in 6 of the 16 administrative regions of the country, with Ashanti and Greater Accra accounting for 40% of resources. A chronic shortage of health workers, inequities in their distribution and skill configuration, inadequate training, deficient working conditions, and suboptimal physician-to-patient relationships restrict access to services and hinder the achievement of national health objectives. Investments in the capacities of Health Centers, which can be characterized as the "missing middle," are needed to strengthen their essential role at the sub-district level. A 2017 assessment found that three of 37 Health Centers had a doctor on staff, while nine had a medical assistant[125]. On average, the rural areas are poorly served compared to urban areas. The government has introduced various schemes to address this challenge; these include the Deprived Area Incentive Scheme, which provides an extra 20 – 35% of the basic salary as an allowance to motivate the even distribution and placement of health staff. Other such schemes include the Health Staff Vehicle Hire Purchase Scheme and various housing schemes, but none has proved particularly successful.

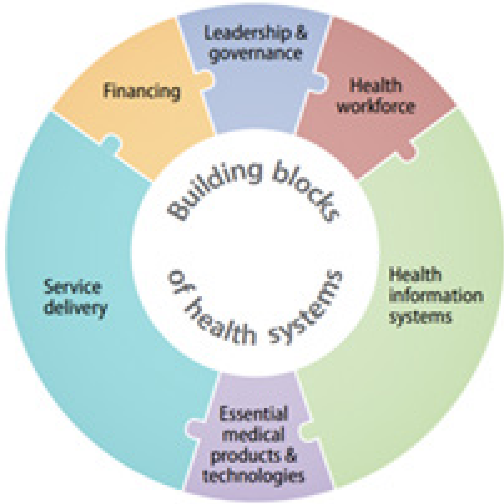
Photo: © Curt Carnemark / World Bank

125. World Bank. (2017). Baseline Report for the Impact Evaluation of the Ghana Community Performance Based Financing (CPBF) Pilot

6. ADAPTIVE CAPACITY AND IDENTIFICATION OF GAPS

Ghana is highly vulnerable to adverse implications of climate change. Despite the government's efforts to expand PHC services to cover most of the population, capacity is limited, leading to an overreliance on higher levels of care and the private sector, particularly in urban areas. The extent to which Ghana's health system is prepared for and can respond to climate-related changes is a key modifier of climate-related health risks. This assessment examines Ghana's adaptive capacity to prevent and manage climate-related health risks according to the WHO's six health system building blocks, as outlined in Figure 6-1. These building blocks are further elaborated upon in the remainder of this section.

FIGURE 6-1.
Health system building blocks



Source: WHO, 2010

6.1. LEADERSHIP AND GOVERNANCE

Across various sectors, Ghana has introduced policies addressing climate change with varying focus on its health impact. Ghana has released several national climate change policy documents across various sectors that are relevant for health (Table 6-1), national health sector-specific policy documents (Table 6-2), and sub-national-level policy documents on climate change and health (Table 6-3).

To put policies in action and facilitate climate change adaptation, the government released the National Climate Change Policy Master Plan for 2015-2020 and initiated the development of a National Adaptation Plan (NAP) in 2020. The NAP aims to adopt an integrated, coordinated, and sustainable approach to resilience building to reduce vulnerability to the negative impact of climate change. It is envisaged that developing future climate scenarios and conducting vulnerability assessments for the different sectors of the economy can generate evidence for planning[126]. Other notable multisectoral policy efforts include the development of a National Climate Change Adaptation Strategy in 2012, spearheaded by the National Climate Change Committee, and the recently updated Nationally Determined Contributions under the Paris Agreement, led by the Ministry of Environment, Science, Technology and Innovation.

Notably, Ghana has developed a draft National Plan of Action for Building a Climate Resilient Health Sector in Ghana for 2015-2025. However, there is limited information about the implementation of the Plan of Action or its integration into multisectoral policies and strategies. This plan of action is anchored around the WHO's

126. United National Environment Programme. 2021. Adaptation Gap Report 2020. Available at: https://www.unep.org/resources/adaptation-gap-report-2020#:~:text=The%20UNEP%20Adaptation%20Gap%20Report%202020%20that%20finds%20while%20nations,floods%20and%20sea%2Dlevel%20rise.

ten components of climate-resilient health systems and includes sections devoted to health leadership and governance, health workforce, vulnerability, capacity and adaptation assessment, integrated risk monitoring and early warnings, health and climate research, climate resilience and sustainable technology and infrastructure, management of environmental determinants of health, climate-informed health programs, emergency preparedness and management and climate and health financing. The plan outlines activities under each health system building block with measurable outputs and time horizons (ongoing, short, medium, and long-term). It also outlines the lead institutions that can play a key role in the realization of the plans, and collaborating institutions such as Development Partners, NGOs, and the private sector.

Ghana's Ministry of Health is establishing a steering committee on climate change and health that will harmonize existing policies and strategies that address the health impact of climate change. The steering committee is envisaged to be multisectoral, involving various stakeholders, and will allow the alignment of existing efforts in the country pertaining to climate change and health.

Photo: Weija floods. © Resolution / World Bank

TABLE 6-1.
National climate change policies and plans relevant for health

POLICY / ACTION PLAN	PRINCIPLES / GOALS / STRATEGIC AREAS	RELATED PUBLIC SECTOR
National Climate Change Adaptation Strategy 2012	Policy Goal: To enhance Ghana's current and future development by strengthening its adaptive capacity concerning climate change impacts and building the resilience of the society and ecosystems 1. Reduce the incidence of water and airborne disease 2. Health worker capacity improvement 3. Increase and upgrade existing health facilities	GHS MOH
Ghana National Climate Change Policy 2013	Focus Area 6: Addressing Impacts of Climate Change on Human Health 1. Identify and improve data recording, reporting, analysis, and storage of at all climate-sensitive diseases at levels of service delivery. 2. Enhance knowledge and sensitize the health sector on the impacts of climate change, including issues for vulnerable groups like the aged, women, and children. 3. Minimize the impacts of climate change on health in communities while strengthening public healthcare delivery and preventive care.	Ghana Health Service, Teaching hospitals

POLICY / ACTION PLAN	PRINCIPLES / GOALS / STRATEGIC AREAS	RELATED PUBLIC SECTOR
Ghana National Climate Change Master Plan 2015–2020	Policy Focus Area 6: Impact of Climate Change on Human Health 1. Improvements in the capacity-building of healthcare providers and groups to include strengthening disease surveillance and response systems. 2. Climate-related Health Research. 3. Strengthen Climate-sensitive Disease Surveillance and Response Systems. 4. Improved public health measures (immunization). 5. Partnerships with other agencies and NGOs. 6. Emergency Health Preparedness and Climate-proof Health Infrastructure. 7. Social Protection and Improved Access to Health Care. 8. Indigenous traditional knowledge and practices in health.	MOH, GHS, Teaching hospitals, CHIM, Ghana Public Records & Archives Administration Dept, GMet, CSRPM, MoFA, All Research Institutions
Ghana's Fourth National Communication, 2020	Policy Goal: Communicate to the COP the status of Ghana's effort to implement the Convention up to 2020 by highlighting the pertinent achievements and constraints. 1. Improved health care access 2. Surveillance and response system 3. Improve Collaboration and Partnership	GHS MOH MMDAS

POLICY / ACTION PLAN	PRINCIPLES / GOALS / STRATEGIC AREAS	RELATED PUBLIC SECTOR
Ghana's Nationally Determined Contribution (NDC) 2021	Policy action: Managing climate-induced health risks 1. Strengthening disease surveillance 2. Improve health information systems 3. Traditional knowledge of health risk management.	GHS MOH

Source: Authors retrieved OPD data from Ghana Health Service

TABLE 6-2.
National health sector policies and plans relevant to climate change: The National Plan of Action for Building a Climate-Resilient Health Sector, 2015-2025 (draft)

POLICY / ACTION PLAN	PRINCIPLES / GOALS / STRATEGIC AREAS	RELATED PUBLIC SECTOR
National Plan of Action for building a climate-resilient health sector in Ghana (2015-2025—Draft document)	Human resource capacity building for health sector adaptation to climate change 1. Health workforce capacity building 2. Climate leadership and governance 3. Organizational capacity development 4. Gender-sensitive climate change communication and awareness raising 5. Vulnerability and adaptation assessment of crucial climate change-related issues 6. Conduct M&E information sharing/exchange and validation workshops 7. Analysis of data from M&E surveillance systems and timely dissemination of outputs (risk maps,	MOH GHS

POLICY / ACTION PLAN	PRINCIPLES / GOALS / STRATEGIC AREAS	RELATED PUBLIC SECTOR
	reports, EWS, etc to relevant stakeholders 8. Updating the DHIMS-2 to capture data for monitoring the health impact of CC 9. Design a multi-hazard EWS to predict infectious disease epidemics, with identified key focus areas 10. Improve and implement early detection tools (rapid diagnostic, syndromic surveillance) 11. Conduct periodic supplementary surveys to complement IDSR	
	Develop and implement a national research agenda on climate change and health with stakeholder participation 1. Identify ongoing and past Health and climate-related research 2. Conduct studies to improve energy efficiency and access within the health sector	

Source: Authors retrieved OPD data from Ghana Health Service

TABLE 6-3.
Sub-national policies and plans relevant to climate change and health: The Medium-Term National Development Policy Framework

POLICY / ACTION PLAN	PRINCIPLES / GOALS / STRATEGIC AREAS	RELATED PUBLIC SECTOR
Medium-Term National Development Policy Framework: An Agenda For Jobs: Creating Prosperity And Equal Opportunity For All, 2018-2021	8.1 Promote proactive planning for disaster prevention and mitigation 8.1.1 Educate public and private institutions on natural and man-made hazards and disaster risk reduction 8.1.2 Strengthen early warning and response mechanisms for disasters 8.1.3 Implement gender sensitivity in disaster management	MDAs GHS
	14.1 Address recurrent devastating floods 14.1.3 Intensify public education on indiscriminate disposal of waste 14.1.4 Prepare and implement adequate drainage plans for all MMDAs	MDAs GHS NADMO
	20.1 Improve quality of life in slums, Zongos, and inner cities 20.1.4 Encourage the participation of slum dwellers in improving infrastructural facilities 20.1.6 Upgrade inner cities, Zongos, and slums and prevent the occurrence of new ones	LUSPA MDAs

Source: Authors retrieved OPD data from Ghana Health Service

6.2. HEALTH WORKFORCE

Climate change influences workforce capacity and may put a strain on overall health system performance. Firstly, climate-related changes in population health needs may increase health system demands, thus altering the required staff. Similarly, climate-related health burdens may influence case mix, thus altering the skill requirements of the health workforce. Finally, climate-related extreme events can impact both the health and productivity of those working in the sector[127].

Despite an increase in the magnitude of the health workforce in the country, the country faces a shortfall. The State of the Nation's Health Report shows that the total health workforce in Ghana, across all cadres, increased from 28,662 in 1999 to 94,696 in 2015[128] (see Table 6-4). The density of physicians, nurses, and midwives has increased from 1.07 per 1,000 population in 2005 to 2.65 per 1,000 population in 2017, which, however, is still well below the WHO recommendation of 4.45 skilled health professionals per 1,000 population[129]. Estimates suggest a 42% gross deficit in the availability of the health workforce, which is exacerbated among specialized groups of health professionals[130].

The distribution of the health workforce in the country is unequal. In terms of absolute numbers, across all cadres, the health workforce is largely concentrated in the Ashanti and Greater Accra regions of the country, where most teaching hospitals are located, and specialist care is offered (see Table 6-5). However, these regions also have the maximum proportion of the country's population. The Upper West and Upper East regions have the fewest health workers.

127. Salas, R. N. (2020). The climate crisis and clinical practice. *New England Journal of Medicine*, *382*(7), 589-591.
128. University of Ghana. (2018). State of the Nation's Health Report. School of Public Health Available at: https://publichealth.ug.edu.gh/sites/publichealth.ug.edu.gh/files/docs/state_of_the_nations_interior_final_compressed-compressed_2.pdf
129. GHS. (2018). Human Resource Directorate Annual Report for 2017. Ghana Health Service, Human Resource Directorate.
130. Asamani, J. A., Chebere, M. M., Barton, P. M., D'Almeida, S. A., Odame, E. A., & Oppong, R. (2018). Forecast of healthcare facilities and health workforce requirements for the public sector in Ghana, 2016–2026. *International journal of health policy and management*, *7*(11), 1040.

TABLE 6-4.
Distribution of health workforce by cadre, 2015

Occupational categories/ cadres	Number	% HW	HW/1000 population
General Medical Practitioners**	2438	2.57	0.09
Specialist Medical Practitioners	726	0.77	0.03
Medical/Physician Assistants *	1729	1.83	0.06
Nursing Associate Professionals	32077	33.87	1.15
Nursing Professionals*	19093	20.16	0.68
Midwifery Professionals	5582	5.89	0.20
Dental Assistants and Therapists	533	0.56	0.02
Pharmacist*	666	0.70	0.02
Pharmaceutical Technicians and Assistants**	877	0.93	0.03
Environmental, Occupational and Hygiene Workers**	115	0.12	0.00
Physiotherapist and Physiotherapy Assistant	279	0.29	0.01
Optometrists and opticians	131	0.14	0.00
Medical Imaging &Therapeutic Equipment Operators	1439	1.52	0.05
Medical and Pathology Laboratory Technicians*	849	0.90	0.03
Medical and Dental Prosthetic Technicians	111	0.12	0.00
Community Health Workers**	3451	3.64	0.12
Health management Workers/Skilled administrative Staff*	215	0.23	0.01
Other Health Support Staff*	24385	25.75	0.87
Total	**94696**	**100.00**	**3.37**

** Highly relevant to climate change and health

*Relevant to climate change and health

Source: IPPD, Dec, 2015

TABLE 6-5.
Distribution of health workforce by region, 2015

Region	Medical Officer (%)	Nurse (%)	Midwife (%)	Pharmacist (%)
Ashanti	760 (24.0)	6200 (18.7)	1281 (22.9)	160 (24.0)
Brong Ahafo	166 (5.2)	2513 (7.6)	483 (8.7)	45 (6.8)
Central	136 (4.3)	3005 (9.1)	383 (6.9)	34 (5.1)
Eastern	183 (5.8)	2580 (7.8)	600 (10.7)	64 (9.6)
Greater Accra	1468 (46.4)	6524 (19.7)	973 (17.4)	204 (30.6)
Northern	154 (4.9)	4222 (12.7)	408 (7.3)	45 (6.8)
Upper East	46 (1.5)	1904 (5.7)	311 (5.6)	15 (2.3)
Upper West	25 (0.8)	1331 (4.0)	219 (3.9)	11 (1.7)
Volta	130 (4.1)	2086 (6.3)	465 (8.3)	41 (6.2)
Western	96 (3.0)	2760 (8.3)	459 (8.2)	47 (7.1)
Total	**3164 (100)**	**33125 (100)**	**5582 (100)**	**666 (100)**

Source: IPPD, Dec, 2015

Health workforce training initiatives relevant to climate change and health have focused mainly on infectious diseases, particularly malaria, with little emphasis on the wide-reaching health outcomes and systems implications of climate change. For example, the GHS has conducted various training programs for health institutions on malaria prevention and case management. Workshops have been held to involve MoH staff in developing a sustainability plan for the Neglected Tropical Diseases program in 2021. Additionally, MoH staff have participated in internal capacity development programs related to the National Malaria Control Programme (NMCP), including partnerships with the private sector on larval source management and indoor residual spraying, supported by USAID Ghana. However, it is worth noting that climate-change related training is not currently integrated into pre-service or in-service training and curricula.

6.3. HEALTH INFORMATION SYSTEMS

The routine health information and surveillance systems in Ghana collect information on specific climate-sensitive infections, namely malaria, diarrhea, meningitis, and schistosomiasis. Currently, the Ghana Health Service collects routine health services, morbidity, mortality, and disease, which are useful to health managers and used for planning, budgeting, and decision-making. The collection of such information is currently done by facilities and districts and submitted through the District Health Information Management System (DHIMS) structure. In this system, data is organized from the facility level, through subdistricts, districts, and regions, eventually reaching the national level. The system does not separate the information gathered specifically for climate change though it includes information about climate-sensitive diseases such as diarrhea, malaria, CSM. The WHO/AFRO Integrated Disease Surveillance and Response (ISDR) strategy was adopted as the guidelines for

Ghana's surveillance system. The system covers 23 priority diseases across the country, of which four have been identified as climate-sensitive diseases. They are Diarrheal diseases, Malaria, Meningococcal meningitis, and Schistosomiasis. The country has three Demographic Surveillance Sites (DSS) in Navrongo, Kintampo, and Dodowa that provide surveillance on vector-borne diseases, especially Malaria.

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. The Ghana Meteorological Agency tracks temperature, rainfall, and humidity levels across major cities and the districts assemblies, and the National Disaster Management Organization (NADMO) captures data on the effect of extreme heat. The Environmental Protection Agency (EPA) has a framework for assessing air quality at monitoring stations, on Bus Rapid Transit (BRT) routes, and in some residential, commercial, and industrial areas in Accra.

6.4 ESSENTIAL MEDICAL PRODUCTS, TECHNOLOGIES, AND INFRASTRUCTURE

Floods and other extreme weather events are known to damage hospitals and other health care facilities. These events may also damage critical non-health infrastructure, including transportation, energy, and water supplies, which can adversely affect health service delivery. Remote healthcare facilities often lack access to safe running water and sanitation, and extreme heat events can significantly disrupt hospital and healthcare facility power supply, leading to overheating.

Various national policy documents mention the need to strengthen health facilities and "climate-proof" existing health infrastructure, though concrete steps must be taken to further these strategies. There is an absence of agreed-upon standards or a plan of implementation to achieve the same. Additionally, no assessments have been conducted to specifically determine the climate resilience of health facilities in the country. This will be particularly imperative for the health infrastructure in the rural areas that may be the only source of health services in the region.

The availability of diagnostic tools, vaccines, and treatment at most health facilities is not yet targeted at addressing health risks of climate change. However, there are examples of siloed interventions utilizing medical products and technologies that target certain climate-sensitive infections. For example, the GHS implements a seasonal malaria chemoprevention exercise, mass drug administration to prevent yellow fever and lymphatic filariasis-elephantiasis, mosquito bed net distribution, and larviciding for larval source management. The percentage of children under five years of age sleeping under Insecticide Treated Nets (ITN) has increased gradually from 28% in 2005 to 53% in 2013[131]. In 2012, to increase household access and use of ITNs, a nationwide door-to-door campaign distributed more than 12.4 million long-lasting ITNs to protect against mosquito bites.

While drug stockouts have been reported at health facilities, there is limited information on the frequency of stockouts on drugs specifically used to prevent and manage common climate-sensitive conditions. Ghana's National Essential Medicines List, 2017, includes drugs for climate-sensitive infections such as malaria, diarrhea, schistosomiasis, and the meningococcal vaccine.

131. According to the National Malaria Control Programme of Ghana (2018).

6.5. SERVICE DELIVERY

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. Moreover, adequate coordination for service delivery across a range of healthcare and public health programs, including those important to reduce climate change risks, are lacking in Ghana.

There is an absence of institutional mechanisms that integrate strategies for addressing the impact of climate change into all vertical health programs and other non-health sectors by utilizing a systems approach. Siloed health programs and interventions, such as for malaria, are in place to address the burden of the climate-sensitive disease. However, given the wide-reaching impact of climate change on mental health, maternal health, respiratory health, and infectious diseases, to name a few, a health system-wide integration is needed. Additionally, multisectoral action, as highlighted in the country's health and climate change policies, needs to be implemented to maximize efficiency and effectiveness.

6.6. HEALTH SYSTEM FINANCING

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. Between 2014 and 2018, Domestic General Government Health Expenditures per capita doubled from $32 to $65[132]. Likewise, the share of government spending on Current Health Expenditure increased from 35.1% to 38.9%. The national budget covers health worker remuneration, while meeting non-salary costs of primary health care service delivery depends largely on external financing from Development Partners (which has averaged about 10% of total health spending over the past decade). Especially crucial are payments for services by the NHIS, which represent 80% of financial resources managed at the level of front-line service providers[133]. Any delays in NHIS payments to the facilities would limit their ability to render services, particularly in a disaster response situation.

Despite the expansion of NHIS, out-of-pocket payments (OOPS) represent the second highest source of financing health services[134]; in fact, the share of OOPS in health facilities' total revenues is increasing. Data analysis of health facilities' revenues from the Ghana Health Service shows that the OOP share in total health facilities' revenues has consistently been above 40% and increased by 11 percentage points between 2017 and 2021. A year before the COVID-19 pandemic in 2019, the share of OOPS on total health facilities' revenues reached its highest level at 53%[135].

The budget statement of the 2022 financial year estimates that Ghana requires a total of US$9.3 billion in investments to implement the 47 NDC programs from 2021 to 2030. Out of this amount, US$3.9 billion will be required to implement the 16 unconditional programs over the next ten years. The remaining US$5.4 billion for the 31 conditional NDC programs will be mobilized from public, international, and private sector sources and climate markets. To mobilize sufficient financial resources, Ghana is exploring more results-based climate financing options, including carbon markets and climate impact bonds. For example, Ghana has submitted 18 proposals to seek funding from the Green Climate Fund (GCF) and co-financiers. Nine proposals were approved, totaling US$106.9 million.

132. World Health Organization. (2018). Global Health Expenditure Database.

133. According to the Ministry of Health, 2015-2020 expenditure and 2021-2022 budget data.
134. World Health Organization. (2018). Global Health Expenditure Database.
135. Ghana Health Services (2021).

From 2015 to 2020, the Government of Ghana (GoG) spent GH¢14.5 billion on Climate Relevant Actions, which amounts to an average of 4% of the total government expenditure. There is a need to establish sustainable streams of funding for climate change. The total GoG expenditure between 2015 and 2020 was GHS 369 billion, of which GHS 14.5 billion was earmarked for Climate Relevance Actions. Percentage variations have been noticed over these years, starting with 5.6%, reducing to 2.29% in 2018 and rising marginally to 3.8 % in 2020[136].

The recent increase in GoG expenditure is largely attributed to government interventions in non-health sectors. At the level of Ministries, Departments and Agencies (MDAs), agriculture and food security showed the highest expenditure. In contrast, water and sanitation showed the highest expenditure among the Metropolitan, Municipal and District Assemblies (MMDAs).

TABLE 6-6.

Summary of adaptive capacities and gaps by health system building blocks

HEALTH SYSTEM BUILDING BLOCK	GAPS IN ADAPTIVE CAPACITY
Leadership and governance	• Little focus on strategies to minimize the health impact of climate change on the most vulnerable sub-populations. • Presence of many national climate change policies with varying focus on its health impact. Most policies have emerged from non-health sectors, except the National Plan of Action for Building a Climate Resilient Health Sector in Ghana, 2015-2025. However, there is limited information about the implementation of the Plan of Action or its integration into multisectoral policies and strategies.
Health workforce	• Despite an increase in the magnitude of the health workforce in the country, the country faces a shortfall. • The distribution of the health workforce is unequal, with resources concentrated in the urban areas of the country. • Health workforce training initiatives relevant to climate change and health have largely focused on infectious diseases, particularly malaria, with little emphasis on the wide-reaching health outcomes and systems implications of climate change.

136. Mensah, L. (2021). Climate Public Expenditure and Institutional Review. Available at: https://www.cabri-sbo.org/uploads/files/Documents/September-14-Session-1-Ghana.pdf

HEALTH SYSTEM BUILDING BLOCK	GAPS IN ADAPTIVE CAPACITY
Health information systems	• The routine health information and surveillance systems in Ghana collect information on specific climate-sensitive infections, namely malaria, diarrhea, 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.
Essential medical products, technologies and infrastructure	• 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. • Availability of diagnostic tools, vaccine, and treatment available at most health facilities is not yet targeted at addressing health risks of climate change. • There is limited information on the frequency of stockouts of drugs used to prevent and manage common climate-sensitive conditions.
Service delivery	• 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. • There is an absence of institutional mechanisms that integrate strategies for addressing the impact of climate change into all vertical health programs and non-health sectors by utilizing a systems approach.
Health system financing	• 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. • Despite the expansion of NHIS, out-of-pocket payments (OOPS) represent the second highest source of financing for health services; in fact, the share of OOPS in health facilities' total revenues is increasing. • Between 2015 and 2020, the GoG reportedly spent an average of 4% of the total government expenditure on Climate Relevant Actions. There is a need to establish sustainable streams of funding for climate change. • The recent increase in GoG expenditure is largely attributed to government interventions in non-health sectors.

Source: Authors

7. RECOMMENDATIONS TO REDUCE CLIMATE-RELATED HEALTH VULNERABILITIES AND VULNERABILITIES OF THE HEALTH SYSTEM

7.1. LEADERSHIP AND GOVERNANCE

- **Undertake dialogue, development, and implementation of the National Plan of Action for Building a Climate Resilient Health Sector in Ghana, 2015-2025:** Integrate its objectives and activities into climate change policies emerging from other sectors to allow alignment.

7.2. HEALTH WORKFORCE

- **Integrate climate-related impacts into health workforce planning:** Includes planning for the size of the health workforce, the skill mixes, and the geographical distribution, particularly urban-rural disparities, to meet expected health needs. The Community Based Extension Agents (CBEA) is a rural agricultural extension model based on the idea of providing specialized and intensive technical training to identified people in rural communities to promote various technologies and offer technical services with support and review from an extension organization. The community-based extension model can be explored to determine the potential to contribute to climate change adaptation through training service providers in climate data collection, analysis, and dissemination within their areas of operation to enable communities to select appropriate response strategies.

- **Institutionalize climate-related capacity building of the health workforce with buy-in from relevant regulators:** Develop guidelines for roles and responsibilities of various health cadres to respond to the health impact of climate change, identify associated competencies, develop pre-service or in-service training to meet competency gaps, and develop tools to assess knowledge and competencies post-training. Obtain buy-in from health professionals training and regulatory institutions to institutionalize issues related to climate health vulnerability in pre-service or in-service training.

7.3. VULNERABILITY, CAPACITY, AND ADAPTATION ASSESSMENT

- **Conduct national and sub-national climate and health vulnerability assessments:** Identify interventions and their impact over time, share findings with stakeholders, and obtain stakeholder buy-in for interventions. Assess the vulnerabilities and capacities of the health system to respond to climate change in different regions of the country. Additionally, analyze local climate-related risk factors for infectious disease outbreaks and the capacity to manage epidemics.

7.4. INTEGRATED RISK MONITORING AND EARLY WARNING

- **Enhance the coverage of climate-sensitive health conditions in routine health information systems**: Besides the four climate-sensitive infectious diseases, namely malaria, diarrhea, meningitis, and schistosomiasis, expand coverage of other high-priority climate-sensitive health conditions in routine health information systems to enable estimation of disease burden and allow evidence-based decision-making to manage the same.

- **Mainstreaming weather and disease forecasting:** To mitigate the impact of extreme weather events like floods on health, it is necessary to integrate platforms supporting various early warning systems, including flood early warning (FEW) and health early warning (HEW).

7.5. HEALTH AND CLIMATE RESEARCH

- **Identify and prioritize knowledge gaps in health and climate research:** Conduct stakeholder consultations to identify and prioritize data and knowledge gaps that hinder evidence-based decision-making regarding climate change and its health impacts. This will also facilitate prioritization for resource allocation.

- **Understand the impact of climate change on individuals and communities through research:** Conduct regional and district-level research to identify sub-populations most vulnerable to the various effects of climate change. The findings can inform sub-national adaptation of climate change policies to best protect the most vulnerable.

- **Build capacity to use combined health and climate models:** Once the knowledge gaps have been identified, build research capacity in methods and models that link climatic variables with climate-sensitive diseases. This will allow in-depth analyses of country-level and sub-national-level data to inform decisions and policy formulations. Access to data for climate change and health assessment is challenging since the two data systems are not linked at all levels but are generated separately and would require some integration. Combining this with research partnerships would produce evidence for health decision-making.

- **Timely analysis and dissemination of surveillance data:** Enhance capacities for data analysis from surveillance systems and timely dissemination of outputs (risk maps, reports, EWS, etc.) to relevant stakeholders. This can contribute to establishing a multi-hazard Early Warning System (EWS) to predict and detect infectious disease epidemics in identified/targeted hotspot areas, building upon disease surveillance systems strengthened in response to the COVID19 pandemic.

7.6. CLIMATE RESILIENT AND SUSTAINABLE TECHNOLOGIES AND INFRASTRUCTURE

- **Undertake vulnerability assessments of health facilities to climate change:** This will form the basis of planning and implementation of facility upgrades that can withstand the impact of climate change.

- **Upgrade public health infrastructure:** Based on findings from vulnerability assessments, strengthen health facilities and infrastructure, including laboratory facilities, to help identify and assess climate-related health risks and the effectiveness of mitigating actions. This includes evaluation of "sick" health facility buildings and retro-fitting them to make them "climate-proof". It will be critical to engage with regulators of facilities, drugs, and services as well as Quality Management Units for successful implementation.

- **Introduce climate-smart health sector infrastructure codes:** There is a need to establish climate-smart infrastructure codes for the health sector to complement the existing national codes, especially in the management of buildings and energy facilities for lighting, refrigeration, and incineration.

- **Routinely evaluate the availability of drugs and equipment for the prevention and management of climate-sensitive infectious diseases such as malaria.**

7.7. MANAGEMENT OF ENVIRONMENTAL DETERMINANTS OF HEALTH

- **Multisectoral action to improve determinants of health:** Improve public health and environmental measures, including immunization, improved drainage, sanitation and hygiene, food and water security, and air pollution in climate-vulnerable communities through multisectoral action plans that have a foundation in policy documents.

7.8. CLIMATE-INFORMED HEALTH PROGRAMS

- **Continue roll-out and strengthening of vector and water-borne infectious disease control programs:** Continue health workforce capacity-building for implementing malaria and other infectious disease control programs, particularly in regions with high disease burdens. Strengthen both supply and demand side program components and processes to enable access to care for these diseases.

- **Adopt a systems approach to strengthen all health programs towards climate change:** With buy-in from health system stakeholders, incorporate climate change considerations in the planning and implementation of all health programs.

7.9. EMERGENCY PREPAREDNESS AND MANAGEMENT

- **Contingency Planning:** This is a forward-planning process in a state of uncertainty and revolves around scenario-building and objectives that are agreed upon, and the managerial and technical aspects defined, with actions in place to prevent or better respond to an emergency. Key components of any contingency plan are a well-established inventory of resources that can be accessed and action plans with agency/sector-wise responsibilities of stakeholders.

- **Building strong and effective emergency communication apparatus:** Strong and reliable communication linkages to storm warning and forecast centers so that the emergency response actions taken are appropriate to the magnitude of the probable event.

- **Active engagement of communities in emergency response:** There is a need for emergency response that must include input from the community and political levels, having clear lines of authority, even if the lead agency changes, depending on the type and magnitude of the event.

7.10. CLIMATE AND HEALTH FINANCING

- **Sustained and holistic health and climate change financing:** The health sector adaptation strategy must be gazetted to enable it to obtain the relevant financial investment required to implement the programs. Besides non-health (though health-related) sectors such as agriculture and water and sanitation, financing the health sector must also be a priority to ensure early identification and management of climate-related health emergencies.

- **Monitor climate-related health expenditure in line with policy commitments:** Establish monitoring mechanisms to enable tracking of climate-related health expenditure in line with policies and action plans (such as the Nationally Determined Contributions).

- **Ensure smooth and timely claims payments from NHIS to the health facilities:** Ensure uninterrupted functioning of the health facilities, particularly during climate and health emergencies. Enhance the capacity of facilities to utilize Internally Generated Funds (IGF) for climate change-related needs based on each facility's vulnerability assessment.

- **Financial protection of vulnerable sub-populations:** Expand the NHIS to provide financial protection for the most vulnerable sub-populations affected by the health impacts of climate.

8. APPENDICES

8.1. APPENDIX 1: NATIONAL ANALYSIS OF DIARRHEA CASES: FINDINGS FROM AN ECOLOGIC STUDY

TABLE 8-1.
Distribution of monthly diarrhea cases in Ghana, 2012-2020

Distribution of monthly diarrhea cases (2012-2020)							
Month	Total	Mean	Minimum	Maximum	Median	25th percentile	75th percentile
Jan	1108510	7697.986	1868	20883	6937.5	4559	10020
Feb	1105485	7676.979	1766	17805	7053.5	4266	10155
Mar	1085332	7537.028	1814	20816	6394	4218.5	9668.5
April	1065467	7399.076	1514	37549	6450	4092.5	9033
May	1070291	7432.576	1963	19063	6672	4349	9760
Jun	1149674	7983.847	2162	19723	6962	4295.5	10593.5
Jul	1129473	7843.563	2372	20837	6980	4543	10468.5
Aug	1079108	7493.806	2253	18020	6722.5	4293	10258
Sep	1024721	7116.118	1510	15783	6441.5	4356	9390
Oct	1197380	8315.139	2289	53134	7509.5	4510.5	10540.5
Nov	1089820	7568.194	2154	17132	7212	4220	9741
Dec	986419	6850.132	1953	16268	6411.5	4001.5	9321
Total	**13091680**	**7576.204**	**1510**	**53134**	**6824.5**	**4313**	**9931.5**

Source: Authors based on OPD data from Ghana Health Service

TABLE 8-2.
Effect of temperature and precipitation on diarrhea cases in Ghana

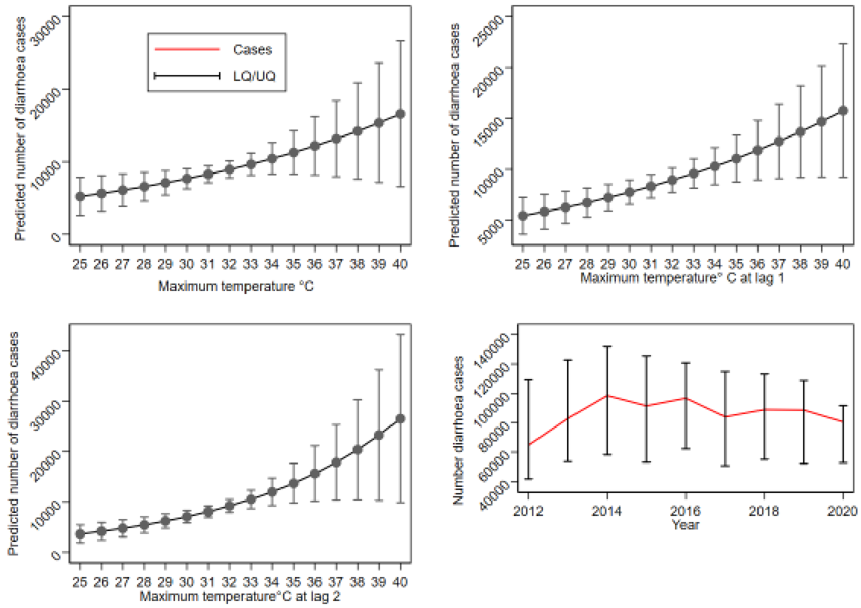
Diarrhea cases		
	aIRR [95% CI]	Predictive ME [95% CI]
Overall effect of temperature	**1.3241 [1.1046, 1.5873]****	**2459 [760, 4157]****
Temperature at lag 0	1.0805 [1.0055, 1.1611]*	678 [48, 1308]*
Temperature at lag 1	1.0737 [1.0247, 1.1250]**	623 [202, 1043]**
Temperature at lag 2	1.1414 [1.0619, 1.2269]***	1158 [510, 1806]***
Overall effect of precipitation	**1.0008 [0.9991, 1.0026]**	**7 [-12, 26]**
Precipitation at lag 0	1.0001 [1.0003, 1.0016]**	8 [3, 14]**
Precipitation at lag 1	1.0002 [0.9998, 1.0006]	2 [-2, 5]
Precipitation at lag 2	0.9997 [0.9985, 1.0008]	-3 [-13, 7]

Source: Authors based on OPD data from Ghana Health Service

Abbreviation: aIRR: adjusted incidence rate ratio, ME: Marginal effect. P-value notation:*p<0.05, **p<0.01, ***p<0.05.

FIGURE 8-1.

Effect of temperature on diarrhea cases nationally (LQ: lower quartile UQ: upper quartile)



Source: Authors based on OPD data from Ghana Health Service

8.2. APPENDIX 2: NATIONAL ANALYSIS OF MALARIA CASES: FINDINGS FROM AN ECOLOGIC STUDY

TABLE 8-3.

Distribution of monthly malaria cases in Ghana, 2012-2020

Distribution of monthly malaria cases (2012-2020)							
Month	Total	Mean	Minimum	Maximum	Median	25th percentile	75th percentile
Jan	4970002	34513.90	5862	130906	28081.5	16753.5	46533.5
Feb	4466561	31017.78	4968	117786	25447	15304	42951.5
Mar	4382164	30431.69	3176	118609	25043.5	13884	42548
April	4490459	31183.74	2792	123708	23418	12917.5	44584
May	5223782	36276.26	3060	134157	30769.5	15447	50314
Jun	6035349	41912.15	3691	143083	35739	20332.5	57432
Jul	6439675	44719.97	6698	145160	38854	23567	58274
Aug	6194762	43019.18	7833	133420	38327.5	22800	55113.5
Sep	5685050	39479.51	9786	128554	36505.5	21358	48254
Oct	6584530	45725.9	14841	132915	41421.5	24002	56867
Nov	6237025	43312.67	6837	131412	38329	23031	58336
Dec	5119524	35552.25	4164	127784	30612	18804	48742.5
Total	**65828883**	**38095.42**	**2792**	**145160**	**32730**	**18640**	**50198**

Source: Authors based on OPD data from Ghana Health Service

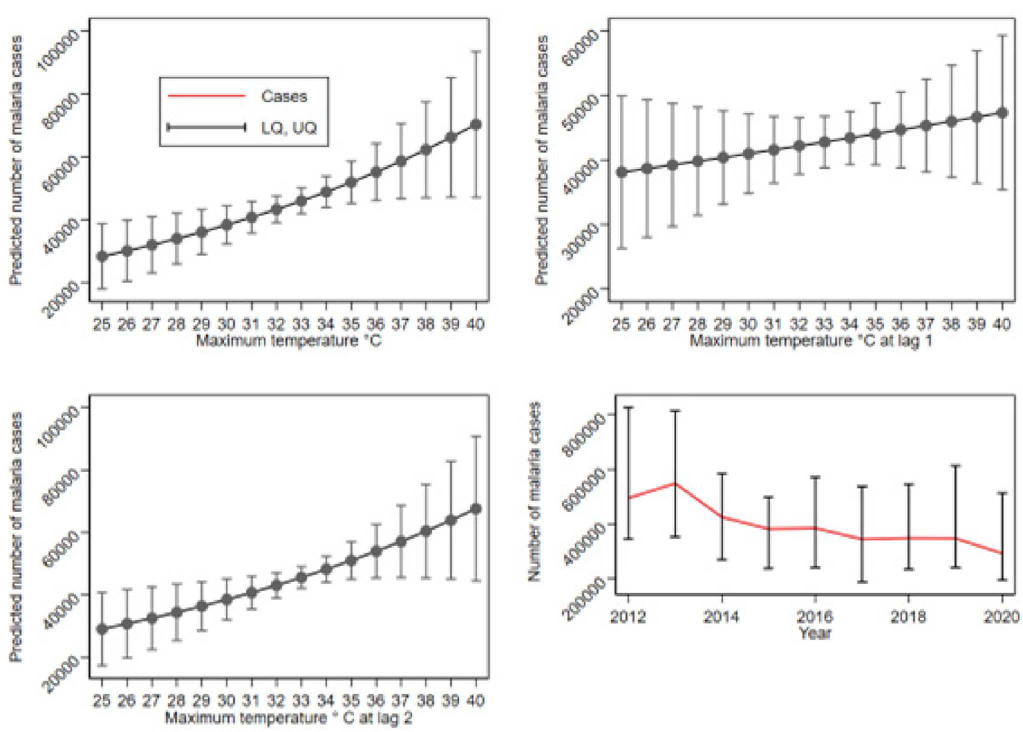
TABLE 8-4.
Effect of temperature and precipitation on malaria cases in Ghana

	Malaria cases	
	aIRR [95% CI]	Predictive ME [95% CI]
Overall effect of temperature	**1.1405 [1.0074, 1.2912]***	**5509 [495, 10527]***
Temperature at lag 0	1.0626 [1.0159, 1.1113]**	2542 [823, 4260]**
Temperature at lag 1	1.0145 [0.9793, 1.0511]	605 [-834, 2049]
Temperature at lag 2	1.0580 [1.0076, 1.1109]*	2362 [506, 4218]*
Overall effect of precipitation	**1.0039 [1.0026, 1.0053]*****	**165 [113, 216]*****
Precipitation at lag 0	1.0012 [1.0007, 1.0018]***	52 [32, 71]***
Precipitation at lag 1	1.0011 [1.0007, 1.0015]***	46 [31, 61]***
Precipitation at lag 2	1.0016 [1.0011, 1.0021]***	67 [50, 84]***

Source: Authors based on OPD data from Ghana Health Service

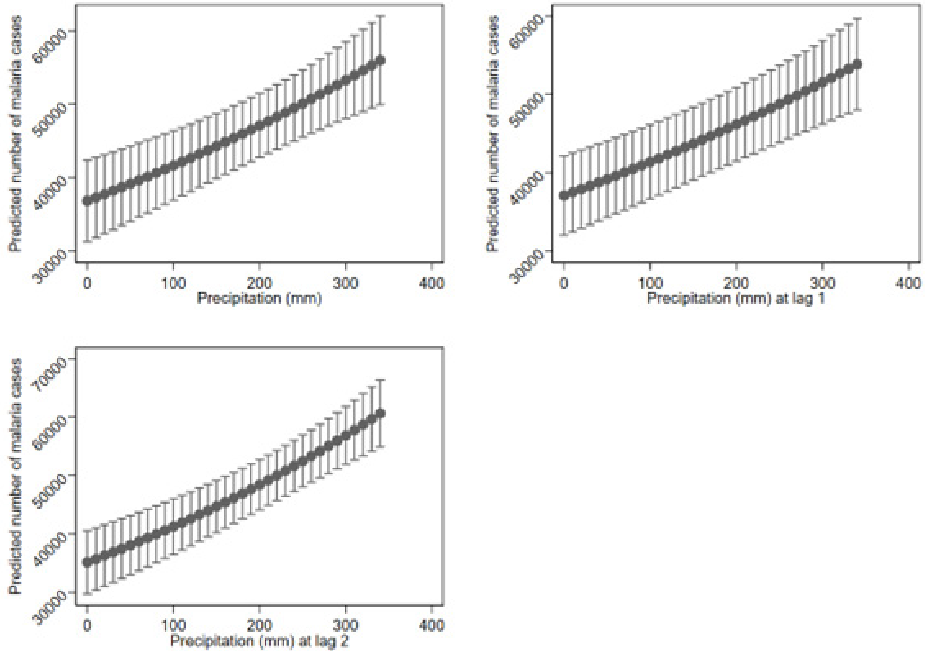
Abbreviation: aIRR: adjusted incidence rate ratio, ME: Marginal effect. P-value notation:*p<0.05, **p<0.01, ***p<0.05.

FIGURE 8-2.
Effect of temperature on malaria cases (LQ: lower quartile, UQ: upper quartile)



Source: Authors based on OPD data from Ghana Health Service

FIGURE 8-3.
Marginal effect of precipitation on malaria cases in Ghana



Source: Authors based on OPD data from Ghana Health Service

8.3. APPENDIX 3: NATIONAL ANALYSIS OF MENINGITIS CASES: FINDINGS FROM AN ECOLOGIC STUDY

TABLE 8-5.
Distribution of monthly meningitis cases in Ghana, 2012-2020

Distribution of monthly meningitis cases (2012-2020)							
Month	Total	Mean	Minimum	Maximum	Median	25th percentile	75th percentile
Jan	565	62.78	25	154	53	48	60
Feb	938	104.22	30	274	83	45	108
Mar	807	89.67	31	215	73	58	107
April	352	39.11	15	123	30	21	41
May	296	32.89	16	48	31	25	44
Jun	242	26.89	7	59	23	22	30
Jul	451	50.11	16	157	30	18	51
Aug	229	25.44	11	70	22	13	27
Sep	194	21.56	9	38	20	18	22
Oct	174	19.33	10	29	18	15	24
Nov	193	21.44	7	37	18	16	29
Dec	369	41.00	10	143	25	20	43
Total	**4810**	**44.54**	**7**	**274**	**29.5**	**18**	**49.5**

Source: Authors based on OPD data from Ghana Health Service

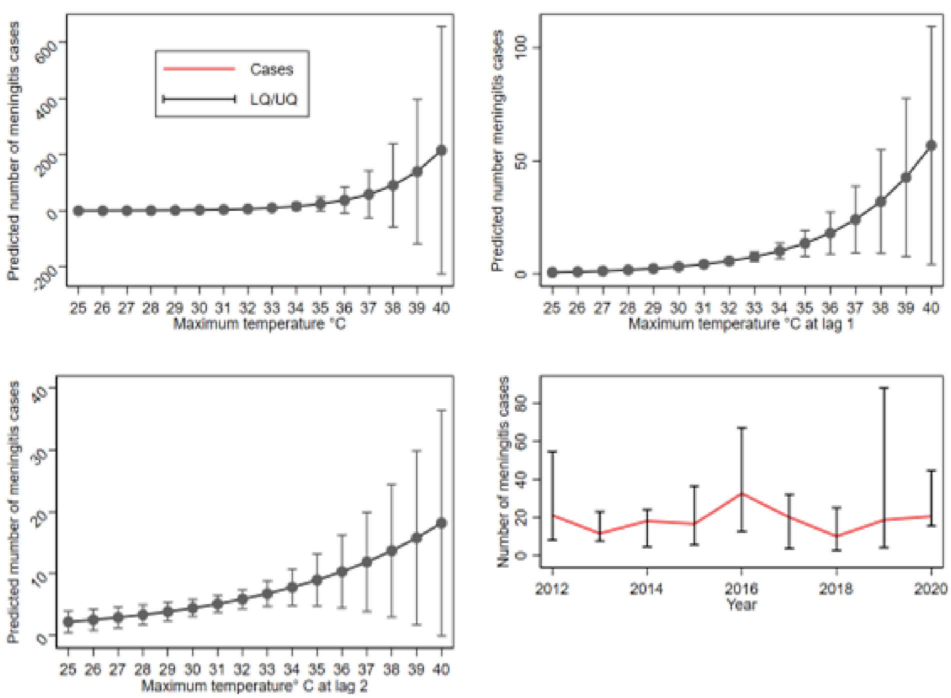
TABLE 8-6.
Effect of temperature and precipitation on meningitis cases in Ghana

	Meningitis cases	
	aIRR [95% CI]	Predictive ME [95% CI]
Overall effect of temperature	**2.3658 [1.7542, 3.1907]*** **	**6.0 [2.3, 9.7]*** **
Temperature at lag 0	1.5426 [1.2553, 1.8955]***	3.0 [1.0, 5.0]**
Temperature at lag 1	1.3311 [1.1913, 1.4874]***	2.0 [1.0, 3.0]***
Temperature at lag 2	1.1522 [1.0269, 1.2928]*	1.0 [0.1, 1.7]*
Overall effect of precipitation	**0.9984 [0.9926, 1.0044]**	**-0.009 [-0.062, 0.043]**
Precipitation at lag 0	1.0003 [0.9962, 1.0044]	0.002 [-0.024, 0.028]
Precipitation at lag 1	0.9946 [0.9982, 1.0007]	-0.003 [-0.011, 0.004]
Precipitation at lag 2	0.9987 [0.9959, 1.0015]	-0.008 [-0.026, 0.010]

Source: Authors based on OPD data from Ghana Health Service

Abbreviation: aIRR: adjusted incidence rate ratio, ME: Marginal effect. P-value notation:*p<0.05, **p<0.01, ***p<0.05.

FIGURE 8-4.
Effect of temperature on meningitis cases in Ghana. (LQ: lower quartile, UQ: upper quartile)



Source: Authors based on OPD data from Ghana Health Service

8.4. APPENDIX 4. NATIONAL ANALYSIS OF SCHISTOSOMIASIS CASES: FINDINGS FROM AN ECOLOGIC STUDY

TABLE 8-7.
Distribution of monthly schistosomiasis cases in Ghana, 2012-2020

Distribution of monthly schistosomiasis cases (2012-2020)							
Month	Total	Mean	Minimum	Maximum	Median	25th percentile	75th percentile
Jan	4296	477.33	222	859	417	271	692
Feb	4204	467.11	185	1036	397	250	594
Mar	5106	567.33	218	1523	456	267	566
April	4096	455.11	181	951	464	255	635
May	4576	508.44	173	957	424	288	856
Jun	4194	466.00	216	1130	369	267	608
Jul	4138	459.78	154	882	311	232	862
Aug	5113	568.11	181	1268	542	288	781
Sep	4163	462.56	194	815	376	238	798
Oct	4215	468.33	219	1047	349	288	601
Nov	3842	426.89	240	881	346	265	521
Dec	3345	371.67	188	694	257	232	503
Total	**51288**	**474.89**	**154**	**1523**	**372.5**	**249.5**	**673**

Source: Authors based on OPD data from Ghana Health Service

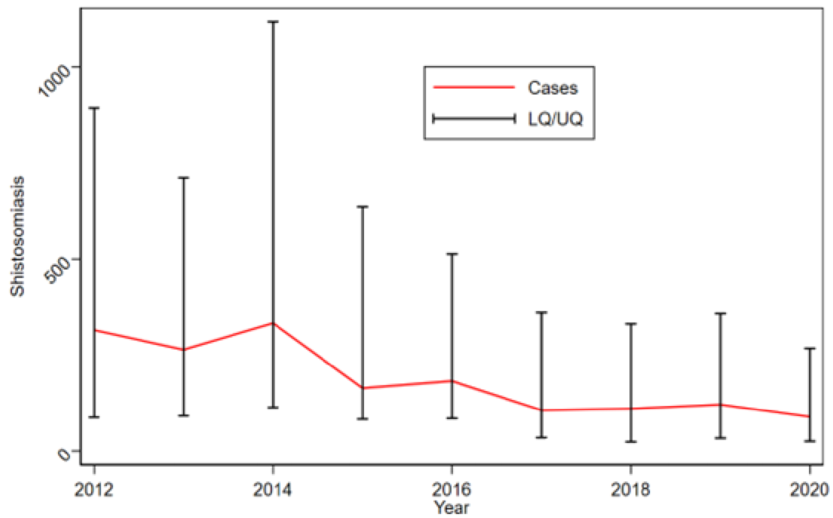
TABLE 8-8.
Effect of temperature and precipitation on schistosomiasis cases in Ghana

	Schistosomiasis cases
	aIRR [95% CI]
Overall effect of temperature	**1.0835 [0.7497, 1.5660]**
Temperature at lag 0	0.9867 [0.8747, 1.1131]
Temperature at lag 1	1.0425 [0.9141, 1.1889]
Temperature at lag 2	1.0534 [0.9002, 1.2327]
Overall effect of precipitation	**1.0005 [0.9970, 1.0041]**
Precipitation at lag 0	1.0006 [0.9987, 1.0025]
Precipitation at lag 1	0.9987 [0.9977, 0.9965]*
Precipitation at lag 2	1.0013 [0.9999, 1.0027]

Source: Authors based on OPD data from Ghana Health Service

Abbreviation: aIRR: adjusted incidence rate ratio. P-value notation:*p<0.05, **p<0.01, ***p<0.05.

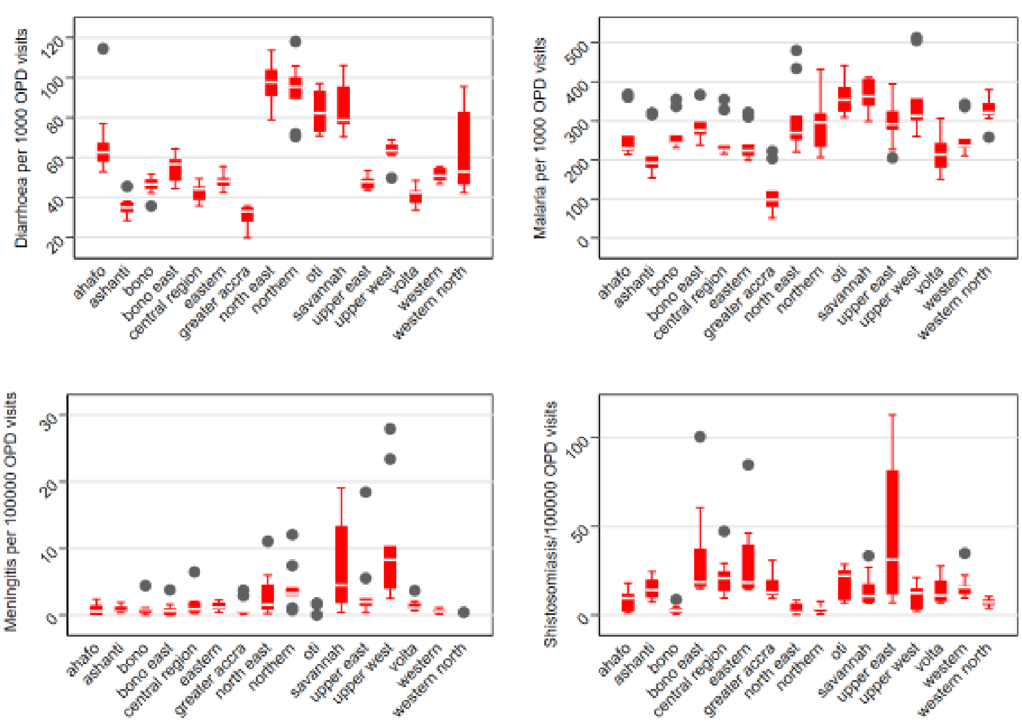
FIGURE 8-5.
Distribution of schistosomiasis cases in Ghana (LQ: lower quartile, UQ: upper quartile)



Source: Authors based on OPD data from Ghana Health Service

8.5. APPENDIX 5. SUB-NATIONAL/REGIONAL LEVEL ANALYSIS: FINDINGS FROM AN ECOLOGIC STUDY.

FIGURE 8-6.
Distribution of climate-induced conditions by region



Source: Authors based on OPD data from Ghana Health Service

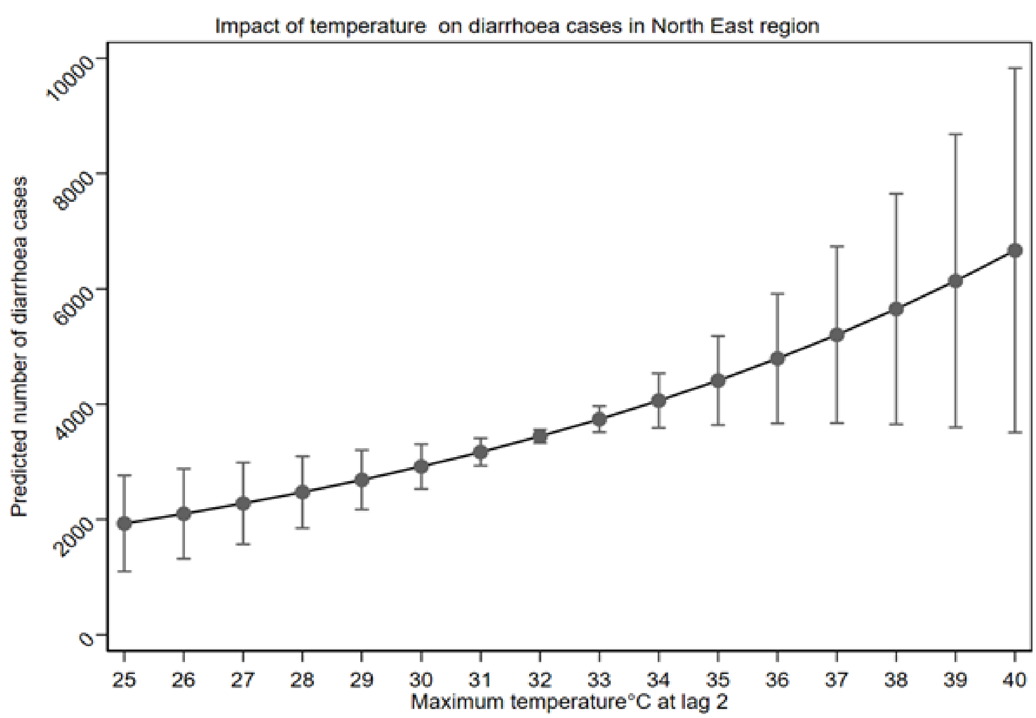
TABLE 8-9.
Effect of temperature on diarrhea in the North East region of Ghana

	Diarrhea cases	
	aIRR [95% CI]	Predictive ME [95% CI]
Overall effect of temperature	**1.1074 [0.9916, 1.2368]**	**362.00 [-260.00, 984.00]**
Temperature at lag 0	1.0115 [0.9550, 1.0715]	41.00 [-164.00, 245.00]
Temperature at lag 1	1.0079 [0.9520, 1.0672]	28.00 [-175.00, 231.00]
Temperature at lag 2	1.0861 [1.0227, 1.1536]**	293.00 [79.00, 508.00]**
Overall effect of precipitation	**0.9997 [0.9977, 1.0017]**	**-1.03 [-12.10, 10.04]**
Precipitation at lag 0	1.0006 [0.9996, 1.0017]	2.00 [-2.00, 6.00]
Precipitation at lag 1	0.9999 [0.9989, 1.0008]	-0.49 [-3.82, 2.84]
Precipitation at lag 2	0.9992 [0.9981, 1.0003]	-2.81 [-6.80, 1.19]

Source: Authors based on OPD data from Ghana Health Service

Abbreviation: aIRR: adjusted incidence rate ratio. P-value notation:*p<0.05, **p<0.01, ***p<0.05.

FIGURE 8-7.
Effect of temperature on diarrhea in the North East region of Ghana



Source: Authors based on OPD data from Ghana Health Service

TABLE 8-10.
Effect of temperature and precipitation on malaria cases in Savannah region of Ghana

	Malaria
	aIRR [95% CI]
Overall effect of temperature	1.0003 [0.9187, 1.0891]
Temperature at lag 0	1.0217 [0.9711, 1.0750]
Temperature at lag 1	1.0175 [0.9667, 1.0709]
Temperature at lag 2	0.9622 [0.9125, 1.0145]
Overall effect of precipitation	**0.9998 [0.9986, 1.0011]**
Precipitation at lag 0	1.0002 [0.9995, 1.0009]
Precipitation at lag 1	1.0002 [0.9993, 1.0011]
Precipitation at lag 2	0.9994 [0.9986, 1.0002]

Source: Authors based on OPD data from Ghana Health Service

Abbreviation: aIRR: adjusted incidence rate ratio. P-value notation:*p<0.05, **p<0.01, ***p<0.05.

TABLE 8-11.
Effect of temperature and precipitation on meningitis cases in Upper West region of Ghana

	Malaria
	aIRR [95% CI]
Overall effect of temperature	1.3955 [0.6879, 2.8310]
Temperature at lag 0	1.2170 [0.8904, 1.6635]
Temperature at lag 1	1.2619 [0.8467, 1.8807]
Temperature at lag 2	0.9086 [0.6315, 1.3074]
Overall effect of precipitation	**0.9814 [0.9638, 0.9993]***
Precipitation at lag 0	0.9929 [0.9843, 1.0016]
Precipitation at lag 1	0.9983 [0.8995, 1.0073]
Precipitation at lag 2	0.9901 [0.9821, 0.9981]*

Source: Authors based on OPD data from Ghana Health Service

Abbreviation: aIRR: adjusted incidence rate ratio. P-value notation:*p<0.05, **p<0.01, ***p<0.05.

TABLE 8-12.
Effect of temperature and precipitation on schistosomiasis cases in Upper East region of Ghana

	Schistosomiasis
	aIRR [95% CI]
Overall effect of temperature	0.9793 [0.7189, 1.3341]
Temperature at lag 0	0.8913 [0.7575, 1.0486]
Temperature at lag 1	1.0433 [0.8941, 1.2174]
Temperature at lag 2	1.0532 [0.9083, 1.2211]
Overall effect of precipitation	**0.9962 [0.9899, 1.0024]**
Precipitation at lag 0	0.9959 [0.9923, 0.9995]*
Precipitation at lag 1	0.9988 [0.9954, 1.0022]
Precipitation at lag 2	1.0015 [0.9980, 1.0050]

Source: Authors based on OPD data from Ghana Health Service

Abbreviation: aIRR: adjusted incidence rate ratio. P-value notation:*p<0.05, **p<0.01, ***p<0.05.

GLOBAL FINANCING FACILITY

KWPF
Korea-World Bank Partnership Facility

THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP