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Climate and Health Vulnerability Assessment



SIERRA LEONE



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LIST OF ABBREVIATIONS

AR6	IPCC Assessment Report 6
CCKP	Climate Change Knowledge Portal [World Bank]
CD	Communicable Disease
CFSVA	Comprehensive Food Security and Vulnerability Analysis
CHVA	Climate and Health Vulnerability Assessment
CHE	Current Health Expenditure
CMIP5	Coupled Model Inter-comparison Project Phase
COVID-19	Coronavirus disease 2019
CRU	Climatic Research Unit [University of East Anglia, UK]
CVD	Cardiovascular Disease
DALYs	Disability Adjusted Life Years
DHIS	District Health Information System
DHS	Demographic Health Surveys
DRM	Disaster Risk Management
EPA	Environmental Protection Agency
EWS	Early Warning System(s)
FHCI	Free Health Care Initiative
FSMS	Food Security Monitor System
GCHA	Global Climate and Health Alliance
GCM	General Circulation Model
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas [emissions]
GIS	Geographic Information Systems
GFDRR	Global Facility for Disaster Reduction and Recovery
HARPIS-SL	Hazard And Risk Profile Information System – Sierra Leone
HISS	Health Information Systems Strategy
HRH	Human Resources for Health
HSS	Health System Strengthening
IHR	International Health Regulations
INDC	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
LULC	Land Use Land Change

MoH	Ministry of Health
MoHS	Ministry of Health and Sanitation
MOU	Memorandum of Understanding
NAP	National Adaptation Plan
NCD	Non-Communicable Disease
NDC	Nationally Determined Contribution
NDMA	Sierra Leone National Disaster Management Agency
NDP	National Development Plan
NHIS	National Health Information Systems
NGO	Non-Governmental Organization
NSCC	National Secretariat for Climate Change
OOP	Out of Pocket (spending on health)
PHC	Primary Health Care
PHU	Peripheral Health Unit
PM_{2.5}	Fine Particulate Matter
RCP	Representative Concentration Pathway
SLMet	Sierra Leone Meteorological Agency
SLR	Sea-Level Rise
SOPs	Standard Operating Procedures
SPEI	Standardized Precipitation Evapotranspiration Index
TBA	Traditional Birth Attendant
TtT	Train-the-Trainer
UHC	Universal Health Coverage
UNFCCC	United Nations Framework Convention on Climate Change
VBD	Vector-Borne Disease
WASH	Water Sanitation and Hygiene
WBD	Water-Borne Disease
WBGt	Wet Bulb Globe Temperature
WHO	World Health Organization
YLDs	Years of Health Lost Due to Disabilities

EXECUTIVE SUMMARY

Sierra Leone is among the most vulnerable countries in the world to the adverse effects of climate change such as extreme heat, droughts, wildfires, and floods.

High population densities and inadequate housing, substantial economic dependence on agriculture, and poverty and lack of socioeconomic basic needs in the population, increases the risks in the face of climate change. The objective of the Climate and Health Vulnerability Assessment (CHVA) is to provide recommendations to enhance health system resilience to climate change, including health interventions and strategies for adaptation in Sierra Leone as well as assist decision makers in the country with planning effective adaptation measures to reduce climate-related health risks.

Climate-related hazards and changes in the near- and mid-term temperature and precipitation affect the population in Sierra Leone. Sea level rise (SLR) threatens more than 2 million Sierra Leones in coastal communities and the low-lying coast. Catastrophic **floods** are increasing in frequency, having around 10 percent of Freetown's population residing in high-risk zones, and around 28 percent of the population in the Western Area's rural district and 34 percent of its urban district exposed to flood risks as well. **Landslides** are responsible for significant damage to homes and infrastructure and estimated to cause around USD 350,000 average annual direct loss to buildings by the 2050s under RCP 8.5. **Wildfire** events in the country are accelerating, most often affecting the northwest and eastern areas of the country, and the impact of future wildfires are likely to be exacerbated, given the projected declines in precipitation and increases in temperatures. The interior provinces of Sierra Leone have been, and will continue to be, especially vulnerable to **drought** conditions during the dry season due to erratic rainfall, coupled with increasing temperatures.

Temperature and precipitation changes affect directly and indirectly health risks in Sierra Leone, especially food security and nutrition, vector-borne diseases, water-borne diseases, heat-related morbidity and mortality, and air quality risks.



Nutrition risks: Food insecurity is a chronic and worsening problem throughout Sierra Leone, with nearly 5 million people without adequate access to food. In the absence of adaptation, climate variability will substantially aggravate food insecurity and nutrition outcomes especially for populations in the Southern and Eastern Provinces, where demonstrated food insecurity and malnutrition rates already exceed those of other parts of the country.



Vector-borne Diseases: Malaria has been the leading cause of premature mortality for over a decade, despite ongoing efforts to curb transmission. Malaria prevalence is nearly twice as high in rural areas (49 percent) than in urban areas (25 percent). The population in the Western Area will have the highest risk of malaria by the 2050s.



Water-borne Diseases: Waterborne and water-related diseases occur throughout Sierra Leone because of inadequate water and sanitation systems, intense precipitation, drought conditions, and specific water contaminants. Coastal communities can be impacted through saline intrusions, as sea levels rise due to climate impacts, thus affecting the local groundwater.



Heat-related Morbidity and Mortality: The health impacts of extreme heat are a growing concern in Sierra Leone, particularly in urban centers such as Bo and the capital Freetown. The whole of the country is exposed to medium to high levels of extreme heat index.



Air Quality: In 2019, 98.8 percent of the urban population and 100 percent of rural populations had primary reliance on polluting fuels and technologies for cooking. Solid fuels are used in 97 percent of households, with 64 percent using wood.

Sierra Leone has been developing policies that aim at addressing climate-related risks, having health risks and healthcare adaptation strategies being prioritized in national policies and plans, to strengthen its adaptive capacity. However, these strategies are diverse and lack specific details for implementation. Moreover, there is limited engagement of the health sector with coordination mechanisms to facilitate cross-sector action. Challenges in implementation are linked to lack of budgets that incorporate climate and health related risks, as well as not having resource allocation mechanisms for an integrated climate-resilient approach in the health sector. Regarding health workforce, the country faces an imbalance in number, skill mix and deployment, having an absent systematic approach for the capacity building of the workforce on climate-related health risks. On the other hand, health information and disease surveillance systems are not integrated with weather data or other environmental factors, likewise, there are no comprehensive climate-informed early warning systems in place.

Furthermore, the health system's facilities are under-resourced and hard to reach in rural areas, especially during extreme weather events, hindering the delivery of health services. Overall, Sierra Leone has not conducted a health infrastructure assessment, and has limited integration of climate-resilient features in health facilities' infrastructure. Moreover, strengthened disaster contingency plans are needed, especially at the community level, and climate change and associated impacts need to be mainstreamed into the operations of health programs at all levels. Additionally, laboratory capacities and other health technologies in Sierra Leone need further assessment to better understand the ability to manage current and projected climate-sensitive diseases, as well as guide allocation of resources.

Recommendations for Strengthening the Resiliency of the Health System in Sierra Leone include:

- Develop a Climate Change and Health National Strategy and action plan. This strategy should account for climate-related health risks and be closely aligned with the National Adaptation Plan to facilitate integration and enable multisectoral mechanisms for implementation.
- Train health sector policy makers and planners to use climate information to inform the design of health sector programs and policies.
- Support hospitals in updating their admissions and emergency case records to track heat-related morbidity and mortality, as well as other climate-sensitive diseases, starting with the Eastern and Northern Provinces, which are projected to experience significant temperature increases.
- Develop and implement Standard Operating Procedures for drinking water and sanitation provision and launch a public awareness-raising campaigns on hygiene, particularly handwashing.
- Develop and implement national building codes/permits for healthcare facilities, including to retrofit, refurbish, and maintain existing health infrastructure.
- Enhance contingency planning for deployment and response at national, provincial, district, and community levels.
- Improve laboratory capabilities for testing and diagnosis of endemic, as well as novel and reemerging diseases; develop a list of essential medicines needs for VBD outbreaks.
- Facilitate the use of on-site renewable energy sources (for example, solar photovoltaic) in health care facilities, as well as promote the use of low-cost air quality sensor network to monitor dangerous air pollution levels.



INTRODUCTION

COUNTRY CONTEXT

1. **Sierra Leone is a developing country working to attain middle-income status, despite an undiversified, volatile economy.** Fundamental to Sierra Leone's economic growth is agriculture: it contributed to more than 60 percent of the country's annual Gross Domestic Product (GDP) in 2020 [1]. Another significant sector of Sierra Leone's economy is mineral production: it constituted approximately 7 percent of the GDP in 2019 [2].

However, Sierra Leone faced three major shocks between 2014 and 2021: the sharp decline in the price of iron ore, the Ebola epidemic, and the Coronavirus disease 2019 (COVID-19) pandemic. The economic and fiscal impact of the Ebola epidemic was very significant, with the country's real GDP contracting by 20.6 percent in 2015. Although the country was in the process of rebuilding slowly and recovering economically by 2019, the occurrence of the COVID-19 pandemic nearly doubled its fiscal deficit in 2020 [3]. The cumulative output lost from 2020–2021 is SLL1.5 trillion (USD146.5 billion). While the economy is projected to recover (with the GDP rising by 3 percent in 2021), it is likely that the growth will be slower than prior to COVID-19 [4].

2. **Despite the significant strides made in poverty reduction, Sierra Leone suffers from rising chronic poverty.** In 2020, 58.9 percent of the population was impoverished, compared with 56.8 percent in 2018 [5]. Urban areas, in particular the capital city of Freetown, have experienced the largest increases in poverty,

as a result of the COVID-19 pandemic. Poverty rates in Freetown rose from approximately 18 percent in 2018 to 29 percent in 2020. Even so, rural poverty (74 percent) is still substantially higher than urban poverty (35 percent). In terms of geographical distribution, the Northern Region has the highest incidence of poverty (74.2 percent), while the Western Area has the lowest (30.8 percent) [5]. Finally, income inequality is quite high throughout the country, as evidenced by the Gini index of 34 [5].

3. **Population growth in Sierra Leone, which is accelerating rapidly, is projected to increase to 8.8 million by 2025 [6].** In 2020, the population was over 7.9 million [6]. The population is disproportionately young: 40.9 percent are under 15 and only 3.5 percent are above 65 years [7]. Persons of working age (15–64 years) represent 76.3 percent of the total population [8]. The most recent completed census, conducted in 2015,¹ shows

¹ At the time of publication, results from the 2021 *Mid-term Population and Housing Census* were unavailable.

an average annual growth rate of 3.2 percent between 2004 and 2015 (see [7]). In terms of population distribution, the Northern Province² is the most populated province (over 2.5 million inhabitants); however, it has the lowest population density (69.3/km²). The Southern Province is the least populated, with approximately 1.4 million inhabitants and a population density of 71.0/km² [7, 9]. Most of Sierra Leone's population reside in rural areas (59 percent) [7]. However, the rate of urban population growth has been steadily increasing since the 1960s [10].

- 4. Sierra Leone is among the most vulnerable countries in the world to the adverse effects of climate change, although it is among the lowest contributors to greenhouse gas emissions (GHGs).** Coupled with human-induced health stressors, climate change has exacerbated existing health burdens and created new health risks in the country. Compounding these challenges is the reality that the impacts of climate change on health and economic inequalities are not uniformly distributed, in terms of demographic, socio-economic, geographical, and environmental factors, thereby further heightening population health risks.

Sierra Leone's vulnerabilities are the result of several factors:

- a. The country's geography renders the population vulnerable to a wide range of extreme, climate-related events.
- b. High urban population densities and population growth, coupled with inadequate housing, increase the likelihood of disease

outbreaks and susceptibility to natural hazards.

- c. Substantial economic dependence on agriculture increases the country's sensitivity to climate change and climatic shocks, which affect agricultural productivity and food security.
- d. Socioeconomic progress has recently been substantially hindered by the 2014–2016 Ebola outbreak and COVID-19, leaving Sierra Leone in a weakened position to address the impacts of climate change.
- e. Poverty and the lack of socioeconomic necessities make it harder for the population to cope with climate change-related risks.

- 5. Sierra Leone is committed to meeting the climate challenge through both adaptation and mitigation measures.** Sierra Leone ratified the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC) on September 22, 2016: it aims to limit the global mean temperature increase to well below 2°C, compared with pre-industrial levels. Moreover, the Government of Sierra Leone submitted two rounds of intended nationally determined contributions (INDCs), first in 2016 (see [2]) and then in 2021 (see [3]). They set out the measures Sierra Leone will take to respond to the climate crisis. Section IV of this assessment highlights the key steps adopted to meet its climate aspirations.

AIMS OF THIS ASSESSMENT AND CONCEPTUAL FRAMEWORK

- 6. The objective of this Climate and Health Vulnerability Assessment (CHVA) is to assist decision-makers with planning effective adaptation measures to deal with climate-related health risks.** Where available, these measures are provided at a subnational level

² Statistics reported are from the most recent recorded census (2015), prior to the re-drawing of provincial and district borders to include the Northwestern Province, along with the Falaba and Karene districts.

The objective of this Climate and Health Vulnerability Assessment (CHVA) is to assist decision-makers with planning effective adaptation measures to deal with climate-related health risks.

to assist regional health planners. The recommendations of this CHVA are primarily aimed at the health sector, but they are also targeted at other sectors that affect climate-related health risks, such as disaster risk management (DRM).

7. Adaptation priorities need to be accompanied by fundamental and urgent action to mitigate climate change. It is important to illuminate the complexity of the climate challenge and the difficulty of predicting with accuracy the severity of climate exposures populations will face in the future. There are many factors that could slightly slow or significantly speed up rates of change, including positive feedback effects and cascading climatological tipping points, which are the most worrisome. For this reason, mitigating existing GHGs, along with developing and implementing measures to protect human health from the changing climate, is of paramount importance.

8. Investing in adaptation strategies to proactively address the effects of climate change on health outcomes is critical. This assessment outlines climate risks to health and health systems, the adaptive capacities in place to deal with these risks, and recommendations to meet identified gaps. The primary focus of this assessment is, therefore, on climate adaptation and resilience measures.

However, as the Assessment Report Six (AR6) of the Intergovernmental Panel on Climate Change (IPCC) makes clear, “Global surface temperature will continue to increase until at least the mid-century under all emissions

scenarios considered” [13]. Mitigation alone is no longer a sufficient strategy, regardless of the pace with which governments and communities around the world act. Adaptation is now as critical a part of climate action as mitigation. Therefore, while this report is focused on adaptation measures, it also includes recommendations for reducing GHGs or facilitating the decoupling of emissions from progress toward human health goals, where possible.

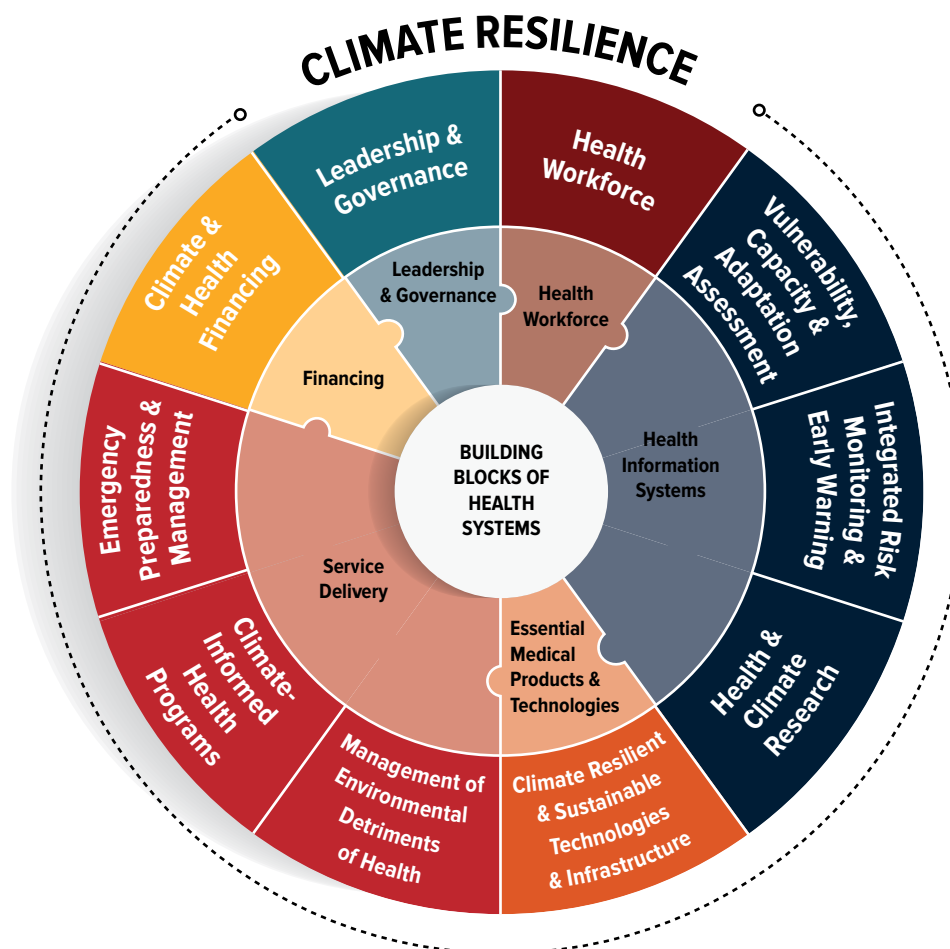
9. The World Health Organization’s (WHO) operational framework to build climate-resilient health systems [14] has been adopted to analyze the adaptive capacity for adequately dealing with current and future identified risks.

In accordance with this framework (**Figure 1**), this CHVA is structured around the six Health System Strengthening (HSS) building blocks. These six categories encompass the assessment of current and future capacities and gaps. The CHVA then moves on to consider the 10 components of health system climate resilience.

10. This CHVA follows a stepwise linear approach. The first step characterizes the *climatology* in Sierra Leone, highlighting the observed and future climate exposures relevant to health. The second step examines *climate-related health risks*, including identifying vulnerable populations most at risk. The third and final step assesses the *adaptive capacity of the health system* by identifying gaps in order to manage current and future climate-related

FIGURE 1.

World Health Organization's (WHO) Operational Framework for Climate-Resilient Healthcare Systems



Source: [14].

health risks. Together, these steps inform a series of **recommendations** to reduce climate-related health vulnerability in Sierra Leone. The CHVA is based on a review of the published literature, national statistics, and consultations with key counterparts in the government including the Ministry of Health and Sanitation (MoHS).

11. The CHVA incorporates subnational considerations for health-related climate action. Sierra

Leone is administered through five administrative units, four provinces, and one area. The provinces are the Eastern Province, Northern Province, Southern Province, Northwest Province, and Western Area (**Figure 2**). These provinces are further subdivided into 16 districts. Freetown, the capital, is in the Western Area. New provincial and district borders were drawn in 2017, leading to the creation of the Northwest Province and the districts of Falaba and Karene.

FIGURE 2.

Administrative boundaries of Sierra Leone



Source: World Bank Cartography Unit



CLIMATE CHANGE: OBSERVED TRENDS AND PROJECTIONS

12. This section describes observed climatic changes and projected climate trends, highlighting priority climate-related exposures of human health risks in Sierra Leone. Climate information is taken from the World Bank Group's Climate Change Knowledge Portal (CCKP; see [15]), while historical, observed data is derived from the Climatic Research Unit, University of East Anglia (CRU). Observed changes in the mean annual temperature, mean maximum temperature, as well as the mean minimum temperature and precipitation from CCKP, are derived from the CRU's TS version 4.05 gridded dataset of the 1901–2020 period.

In addition, model-based, climate projection data is obtained from the Coupled Model Inter-Comparison Project Phase 5 (CMIP5) collection. CMIP5 is a standard framework for analyzing coupled atmosphere-ocean general circulation models (GCMs) and providing estimates of future temperature and precipitation scenarios. Projected changes are explored under the IPCC representative concentration pathway (RCP) 8.5³ for the short (2030s; 2020–2039) and medium (2050s; 2040–2059) terms.

SIERRA LEONE'S GEOGRAPHY

13. Sierra Leone, situated on the west African coast, has a complex mosaic of landscapes (Figure 3). There are four major physiographic regions: the interior plateau and mountain range; interior lowland plains; the Sierra Leone

Peninsula; and coastal swamps. The coastline stretches for approximately 500 km along the Atlantic Ocean [16]. There are nine major river systems throughout the country that range in length from 160 km to 430 km, and whose mean annual runoff is in the order of 160 km [17].

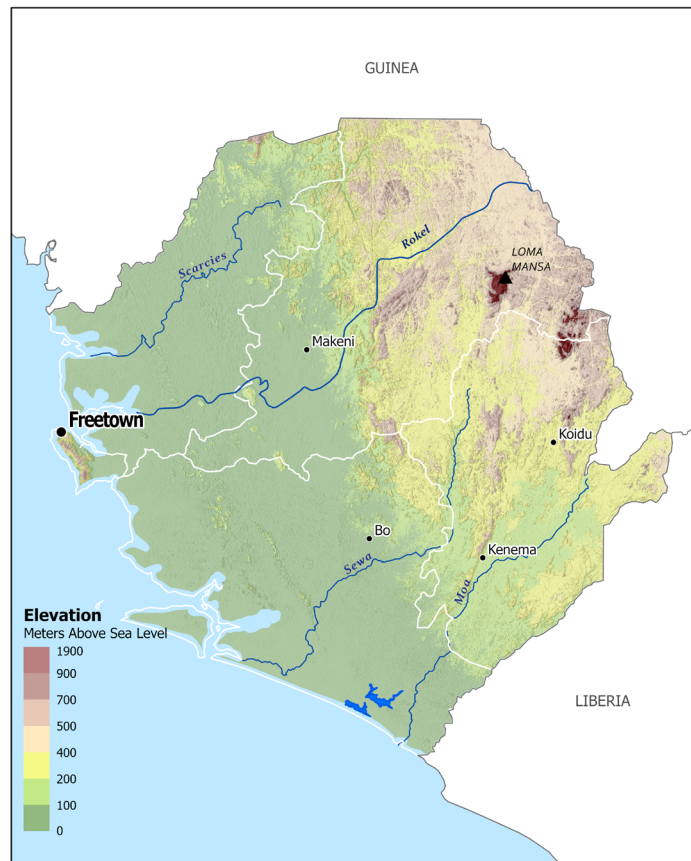
OBSERVED AND PROJECTED CLIMATOLOGY AND SEA-LEVEL RISE

14. Sierra Leone has a tropical climate that is predominately hot and humid. As a function of topography, temperature increases, and precipitation decreases as one moves inland from the coast. Mean annual temperatures range from 25°C to 28°C (Figure 4). There are two distinct seasons — rainy and dry. The rainy season occurs from May to November, driven by the movement of the Inter-Tropical Convergence Zone (ITCZ). Average rainfall during the rainy season exceeds 2,300 mm (1991–2020), with the Western Area experi-

³ Raw data is provided for RCP 4.5 in Annex A of this report. For additional indicators, see *The World Bank's Climate Knowledge Portal Data*. Download at <https://climateknowledgeportal.worldbank.org/download-data>.

FIGURE 3.

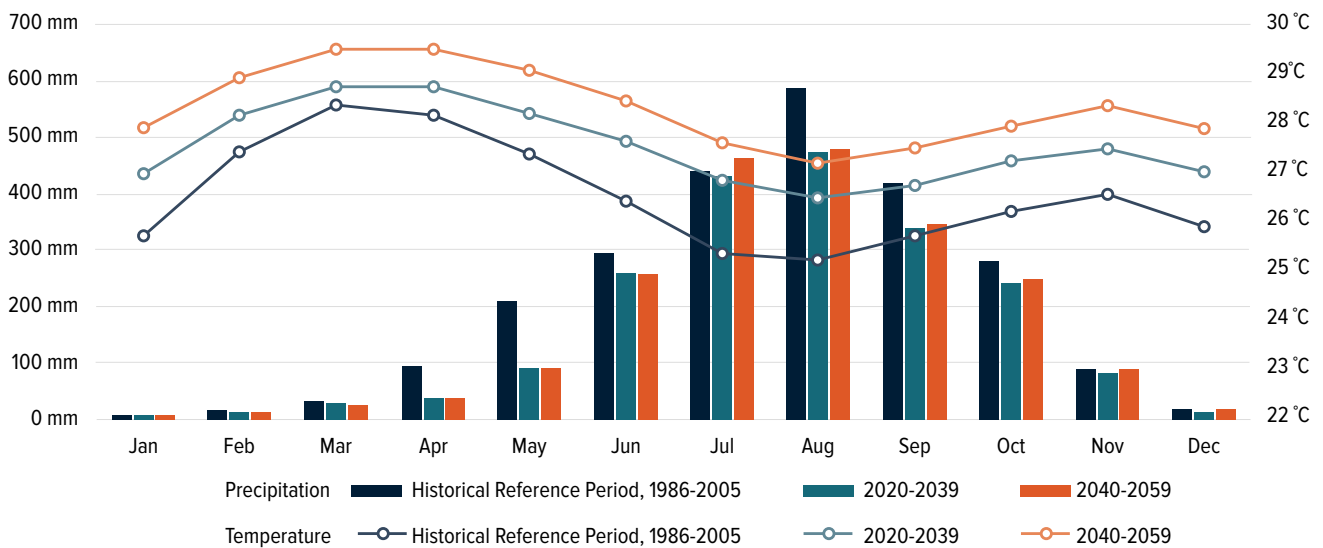
Physical features of Sierra Leone



Source: Natural Earth, ASTER Global Digital Elevation Model Version 3, WB Cartography, and AQUASTAT (FAO).

FIGURE 4.

Projected average monthly temperature and precipitation patterns in Sierra Leone under RCP 8.5



Source: World Bank Climate Change Knowledge Portal

encing more rainfall than any other parts of the country. The dry season is characterized by limited rainfall (less than 200 mm) and hot, dusty conditions from the Harmattan winds blowing in from the Sahara [18].

TEMPERATURE

15. Mean annual temperatures across Sierra Leone have increased by 0.8°C over the past half century, with the rate of increase accelerating more recently.

There is little variation in subnational temperatures. In all provinces, monthly maximum temperatures are at, or exceed, 30°C for nine months of the year. Monthly mean temperatures range from approximately 25°C to 28°C, with interior provinces experiencing higher temperatures than coastal areas.

16. Extreme temperatures will become the new normal for Sierra Leoneans, as temperatures continue to rise.

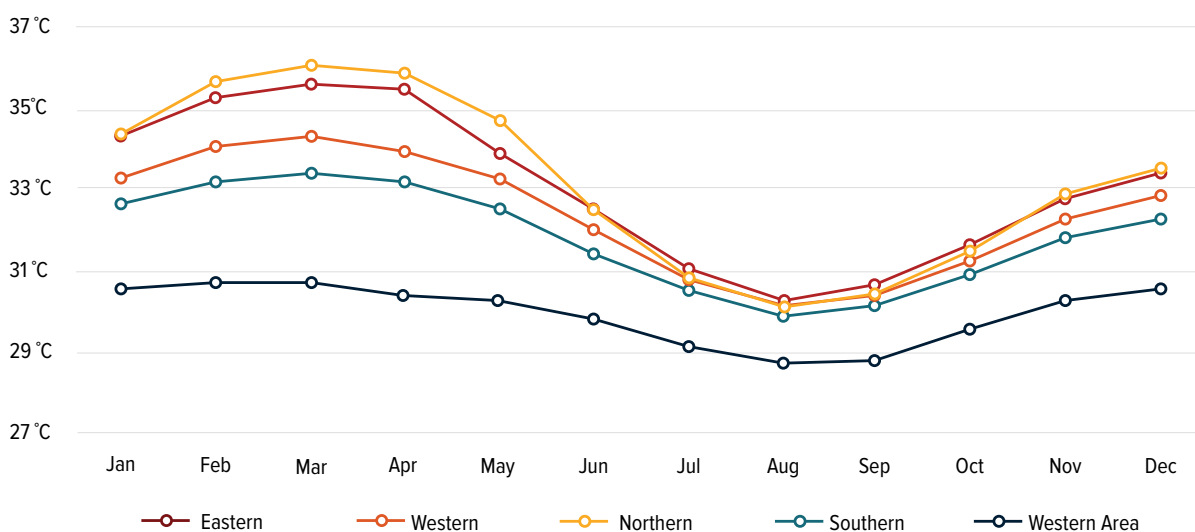
Average monthly temperature increases will range from 0.8°C to 1.1°C across Sierra Leone in the 2030s and 1.4°C to 2.2°C

in the 2050s. As a consequence, average daily maximum temperatures are projected to range from 28°C to 35°C in the 2030s and 29°C to 36°C in the 2050s throughout the country (Figure 5). The Northern and Eastern Provinces will be the most vulnerable to both rising temperatures and heat index. Heat index (that is, the apparent or *feels like* temperature) is a measurement that combines air temperature and relative humidity. By the 2050s, the Northern and Eastern Provinces are projected to experience 98 and 105 days, respectively, each year, during which the heat index will exceed 35°C.

Just as significantly, these increases in daytime temperatures will be compounded by escalating nighttime temperatures (that is, tropical nights). A tropical night is characterized by nighttime temperatures that do not fall below 20°C; this temperature is important, as the human body needs to cool down adequately, especially after experiencing high daytime temperatures. Tropical nights are already routine in Sierra Leone: in the Western

FIGURE 5.

Average daily maximum temperature across Sierra Leone under RCP 8.5 during the 2050s



Source: World Bank Climate Change Knowledge Portal

Area, there has historically been a maximum of just two nights a year with temperatures below 20°C. By the 2050s, the Western Province, the Western Area, and the Southern Province will rarely experience nighttime temperatures below 20°C.

PRECIPITATION

17. Rainfall has become increasingly more erratic throughout Sierra Leone, with a declining trend in mean annual precipitation. Mean annual rainfall from 1991 to 2020 was 2,477 mm, a slight decline from the recorded 2,484 mm during the 1961–1990 period. The most notable change between the two periods is what has been occurring during the month of August: monthly rainfall has increased by approximately 260 mm, nearly half of which has occurred in the Western Area. Over the past half century, stronger winds and more frequent rain and storms have occurred during the pre-monsoon season, coupled with delays at the start of the annual rainy season. In contrast, the September–November period has become calmer and drier, deviating from what is typically a period of heavy rainfall and convective activity [18]. An increase in precipitation intensity and storm surges along the coast has exacerbated flood risk during the rainy season especially in the Western Area.

18. Annual rainfall is projected to continue declining in Sierra Leone through the mid-century, albeit with marked seasonal differences. During 2030–2050, precipitation is projected to increase in all provinces from October to December, coupled with notable declines in precipitation during the first two months of the rainy season — May and June. The overall net annual decline in precipitation will be strongly skewed toward the first half of

the year, thereby encompassing nearly all of the dry season. The dry season is projected to become even drier throughout Sierra Leone by the 2050s, with some slight increases in precipitation during the rainy season. By the mid-century, precipitation in the Western Area during the dry season will decline by 21 percent, amounting to only roughly 60 mm of rainfall. The decline in precipitation will trigger severe prolonged droughts especially in the Western Area.

SEA-LEVEL RISE

19. Sea-Level rise (SLR) is a phenomenon that significantly threatens coastal communities and the low-lying coast of Sierra Leone. More than 2 million Sierra Leoneans are at risk of SLR [19], many with livelihoods that are dependent on coastal resources. SLR not only has implications, in terms of population displacement in coastal communities, but also poses significant risks to water quality, incomes, food security, and nutrition, due to two key reasons. The first is the loss of coastal agricultural lands caused by erosion, inundation, or salinization, and the second is the impact of SLR on coastal fish populations. The erosion of sandy beaches, biodiversity loss, and compromised integrity to rocky coasts have already been attributed to rising sea levels [20]. As of January 2016, the average annual anomaly of coastal Sierra Leone was 126.48 mm.

Just as importantly, Sierra Leone does not have a national sea-level observing system to monitor the mean SLR along the coastline, nor are there country-specific SLR projections. However, global mean SLR is projected to rise between 0.63 and 1.322m by 2100 under RCP 8.5 [21].

CLIMATE-RELATED HAZARDS

20. There are several climate-related hazards linked to changes in baseline temperatures, precipitation, and SLR, which are affecting population health in Sierra Leone. The most common climate-related hazards affecting Sierra Leone are flooding and landslides, but wildfires and droughts also pose additional risks. The overall impacts of such events in Sierra Leone will not merely be attributable to changing environmental conditions, as they will also be compounded by anthropogenic causes including rapid deforestation, coastal degradation, mining, urbanization, and inadequate housing.

FLOODS

21. The frequency of catastrophic flooding events in Sierra Leone is accelerating. Since 1990, 10 major flooding events have been recorded in the international emergency events database (EM-DAT); nine of these events have occurred since 2004 [22]. The most recent catastrophic flooding events occurred in 2019 and 2017, both outside of Freetown. The 2019 event affected over 5,000 residents and claimed six lives, while the successive rainfall in August 2017 led not only to a flooding disaster, but also triggered the Sugar Loaf Mountain landslide (see the following section on landslides) [23].

Flash flooding occurs in urban and coastal areas every rainy season [24], often triggered by heavy or sustained rainfall, high tides, increasing river volumes, and insufficient or blocked drainage infrastructure [25]. Beyond precipitation and rising sea levels, urban development and policy has also contributed to flood risk through a lack of zoning, city planning, and building regulations. The construction of homes on hill tops resulting

in deforestation, stone mining on hills, the destruction of mangroves causing coastal erosion, along with the buildup of wastes in drains and culverts, further compound flooding risks [26].

The Western Area has historically been the region that is the most vulnerable to flood hazards: it has experienced more flooding events over the past decade than any other part of the country. Likewise, the percentage of the population exposed to flooding in the Western Area is higher than elsewhere in Sierra Leone: 28 percent of the population in the Western Area's Rural district and 34 percent of its Urban district are exposed to flooding risk [27]. Other areas most substantially impacted by flooding are the Regent, Port Loko, Kenema, Moyamba, and Kambia districts [28].

22. While annual net precipitation is expected to decline in Sierra Leone, the intensity of rainfall events during the rainy season is projected to increase, which can exacerbate flood risk. By mid-century, the average largest one-day precipitation totals will exceed 100 mm in July and August. Likewise, the average largest cumulative 5-day rainfall will increase by approximately 14 and 12 percent in June and July, respectively, across Sierra Leone. The steep river valleys of the Western Area and the interior mountain region are at the highest risk of flooding due to shorter, intense flooding events during the July–August period. Flatter areas will be more susceptible to flooding from the slower moving storm systems in June and July. Compounding the flooding risk are rising sea levels, which will contribute to the inundation of coastal areas and the increased frequency of flooding events in coastal communities [28].

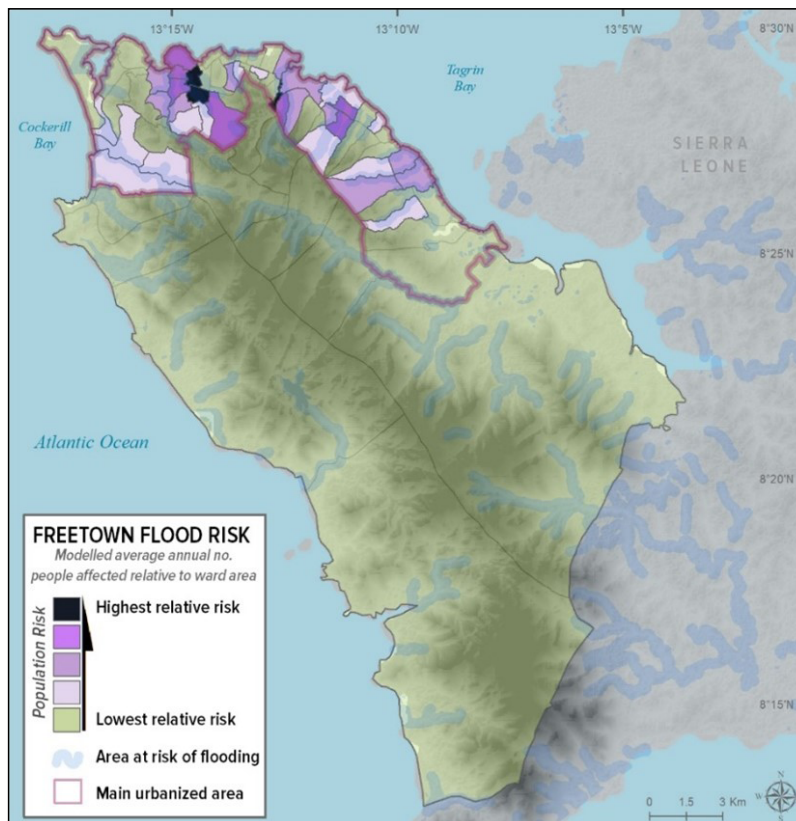
23. Freetown is among the most vulnerable places to future flood risk. The hydraulic modeling of flood risk highlights areas of high-hazard flood zones throughout Freetown (see [28]). Areas of the highest flood risk include the natural river channels within Regent-Lumley in the northwest and Bathurst-Hastings Village area in the southeast; natural channels and tributaries, such as from Thunderhill to Shell and from Gloucester to Cline Bay; as well as bay areas along the coast, including Kroo's Bay, Susan's Bay, and Cline Bay (**Figure 6**).

Approximately 10 percent of Freetown's population reside in high-risk zones, where

deforestation in the upper catchment is expected to exacerbate flooding within these areas. Over 3,000 people are estimated to be affected annually by flooding events with an average of nine fatalities each year [28]. The Lumley, Juba, Susan's Bay, and Regent wards in Freetown are at the highest risk of flood-related fatalities, with Kroo Town and the Brookfield-Congo Market projected to have the highest number of people affected by flood events [28].

By the 2050s, the average annual direct losses to buildings from flooding is estimated to be at more than USD2.5 million.

FIGURE 6.
Population flood risk in Freetown, by ward area



Flood Risk Data Sources: World Bank 2018.

Flood inundation data source: Integrated Geo-information and Environmental Management Services (INTEGEMS), United Nations Development Report (UNDP).

LANDSLIDES

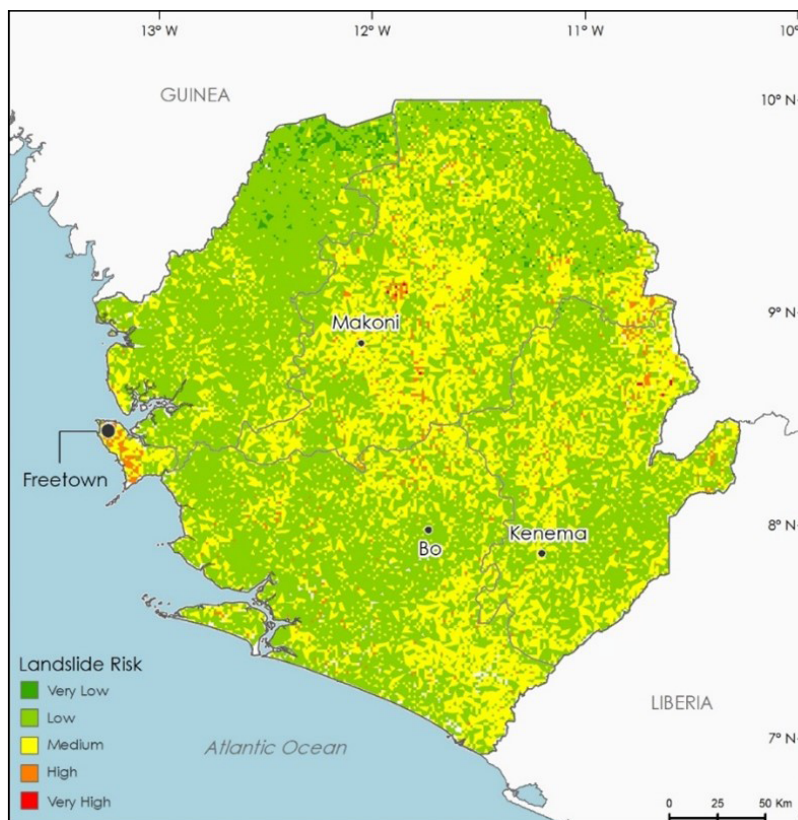
24. Landslides are responsible for significant damage to homes and infrastructure, along with substantial losses of life, in Sierra Leone.

The climate of Sierra Leone, which exacerbates the extensive tropical weathering of the bedrock, in combination with the country's high relief and heavy precipitation during the rainy season, increases the country's vulnerability to landslide events. Landslide and mudslide-prone areas of Sierra Leone include the mountainous Western Area and the high-elevation areas of the central highlands (Figure 7).

The Sugar Loaf Mountain landslide of 2017 was one of the worst disasters to have taken place on the African continent. On August 14, 2017, after three days of heavy rain in the Freetown area, a section of hillside collapsed. Homes were swept away and waterways became blocked. There were more than 1,100 fatalities, including hundreds of children, due to the direct impacts of the mudslide [29]. The extent of the tragedy was further exacerbated by deforestation and the poor planning of the built environment: approximately 15 percent of dense forests in the area had been converted into built-up areas of housing from 1986 to 2015 [30].

FIGURE 7.

Landslide risk in Sierra Leone



Data Source: INTEGEMS, UNDP.

25. Ongoing climate change will aggravate the landslide risk around the steep hills of the Freetown Peninsula and the mountainous areas of the central highlands. While rainfall is the primary trigger of landslide events, deforestation and unmanaged urbanization has weakened slope stability and significantly compounded the risk. Freetown is highly vulnerable to the landslide risk, given the projected increases in the intensity of precipitation events in the Western Area (see discussion on projected precipitation and flooding risk above for further details), deforestation along the area's lower slopes, and ongoing, unregulated construction [31]. Estimates of average annual direct loss to buildings are over USD350,000 as a direct result of landslides in Freetown during the 2050s under RCP 8.5 [28].

WILDFIRES

26. Wildfire events in Sierra Leone are accelerating, most often affecting the northwest and eastern areas of the country [32]. Historically, the wildfire season in Sierra Leone, occurring from January to March, coincides with the dry season [33]. However, climate change, manifested in temperature increases and rainfall variability, can further exacerbate wildfires.

At the same time, attributing the rise in wildfire events in Sierra Leone to climate change is challenging, at best, as information on wildfire incidents throughout the country is scarce, including whether individual wildfire events are natural or human-induced events. Further, fire is often used as a tool in agricultural and hunting practices throughout the region. No studies have been conducted on predicting

the impact of wildfires in Sierra Leone, even as the climate continues to change.

Nonetheless, it is reasonable to assume that the increasing temperatures the country will experience, coupled with a higher likelihood of drought conditions (see below for further information), could exacerbate wildfire risk. Notably, the lengthening of the wildfire season, as has already been documented, can be attributable to climate change [34, 35].

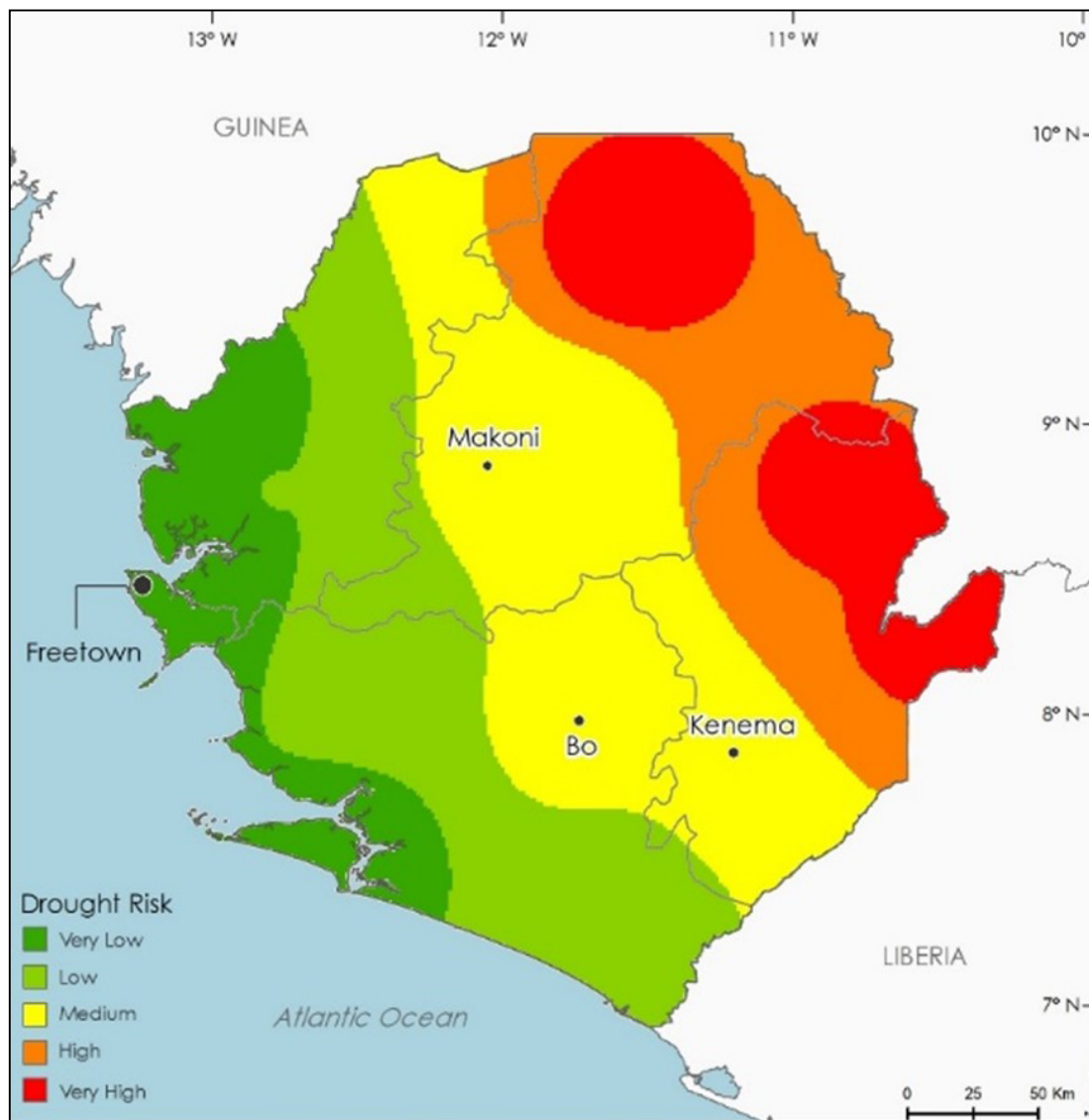
DROUGHT

27. The interior provinces of Sierra Leone are especially vulnerable to droughts due to erratic rainfall, coupled with increasing temperatures. In the northeast, droughts have slowly become prevalent from February to March in recent years, as declining rainfall averages have been attributed to the longer-than-normal dry spells experienced in the region [36]. Long-term patterns and trends of drought occurrences in Sierra Leone are unavailable due to a lack of surveillance data [37].

Projected increases in temperature across Sierra Leone, as well as declining precipitation during the first half of the year, are likely to increase the risk of drought events. The annual Standardized Precipitation Evapotranspiration Index (SPEI) statistics in the 2050s show a predicted negative water balance (-.21), but a very low overall likelihood of severe drought at the national scale. Subnationally, the northeastern districts of Koinadugu in the Northern Province, along with Kono and Kailahun in the Eastern Province, are likely to be the most vulnerable to future drought conditions **(Figure 8)** [36].

FIGURE 8.

Drought risk in Sierra Leone



Data Source: INTEGEMS, UNDP.

KEY MESSAGES



Mean annual temperatures across Sierra Leone have increased by 0.8°C over the past half century. By the 2030s, extreme temperatures will become the new normal for Sierra Leone.



Rainfall has become increasingly more erratic, with a declining trend in mean annual precipitation. Through the mid-century, annual rainfall will continue to decline, most notably from January to June.



SLR threatens coastal communities and the low-lying coast of Sierra Leone significantly. However, without a national sea-level observing system, it is difficult to project and subsequently prepare for the impacts of SLR on coastal communities.



The frequency of catastrophic flooding events in Sierra Leone is accelerating, with the population of Freetown at the greatest risk of future flood-related impacts.



Landslide risk is projected to increase in Freetown and the interior mountainous areas as a result of the increasing intensity of rainfall events, especially during the rainy season.



There has already been a marked lengthening of the wildfire in season in Sierra Leone. The impacts of future wildfires are likely to be exacerbated, given the projected declines in precipitation and increases in temperatures throughout the wildfire season.



The interior provinces of Sierra Leone have been, and will continue to be, especially vulnerable to drought conditions during the dry season due to erratic rainfall, coupled with increasing temperatures.

CLIMATE-RELATED HEALTH RISKS

28. Sierra Leone faces a multitude of health challenges from communicable diseases (CDs) and non-communicable diseases (NCDs), many of which are climate sensitive. In 2019, the crude death (11.5 per 1,000) [38], under-5 mortality (109.2 per 1,000) [39], and neonatal mortality rates (31.18 per 1,000) [40] were higher in Sierra Leone than the regional averages in sub-Saharan Africa. In addition, the maternal mortality ratio is the third-highest in the world (1.1K per 100,00 live births) [41]. Though life expectancy is increasing, it remains low (54.6) [42].

Malaria is the leading cause of morbidity and mortality across the country. In 2020, WHO estimated the incidence of between 1.4 and 4.4 million cases of malaria across the country that resulted in an estimated 6,000–10,000 deaths [43]. CDs, maternal, neonatal, and nutritional diseases constitute seven of the top 10 causes of death [44]. Of these, lower respiratory infections, diarrheal diseases, tuberculosis, and meningitis are climate sensitive.

29. Climate-related risks to health outcomes are not evenly distributed in the population, with some groups at greater risk than others.

The factors that affect a population's vulnerability to climate are often similar to those that affect health more broadly [22]. However, climate-related factors may exacerbate health inequalities, especially among certain vulnerable population groups, including the poor, rural populations, those living in informal urban settlements, women and young children, the elderly, those living with pre-existing conditions and disabilities, and displaced populations. Therefore, investments

in adaptation and mitigation measures must carefully consider groups who would directly benefit from, or may be disadvantaged by, adopted measures.

30. Sierra Leone's CHVA assesses six climate-related health risk categories. They include risks to (a) nutrition, (b) vector-borne disease (VBD), (c) water-borne disease (WBD), (d) heat-related risks, (e) air quality, and (f) mental health. Risk categories were selected from the literature review on climate and health risks to Sierra Leone, including the published literature of Sierra Leone's MoHS.

Each category is assessed in terms of current and future risk, with considerations of both national and subnational peculiarities, wherever possible. It is important to note that these risk categories represent only the most pressing climate-related health risks to the population of Sierra Leone. Other climate-related health risks can include, but are not limited to, direct injuries and mortality associated with natural hazard events.

NUTRITION RISKS

31. Weather and climate are the foundational drivers of healthy and sustainable diets.

The mechanisms by which climate change affects nutrition via the food system are profound, and include the acute and chronic effects on agricultural production, storage, processing, distribution, and consumption (Figure 9). Nutritionally secure and stable diets not only depend on agricultural production, but also on the complex interactions among demand, economics, legislation, conflict, food waste, nutrient losses, food safety, and access [45]. In addition, climate variability is already contributing to increases in global hunger and malnutrition [46].

While a comprehensive analysis of climate change's impact on the food system is beyond the scope of this assessment, this CHVA examines climate and nutrition linkages through a food security lens in Sierra Leone, as it relates to weather and climate impacts on agricultural productivity. Agricultural productivity — a key determinant of food availability — is affected by weather and climate in a multitude of ways, from short-term shocks (for example, natural disasters) to longer-term changes in agro-ecological conditions, which can drastically reduce yields or redefine spatio-temporal patterns of crop suitability.

FIGURE 9.

Stages of the food system that drive healthy and sustainable diets

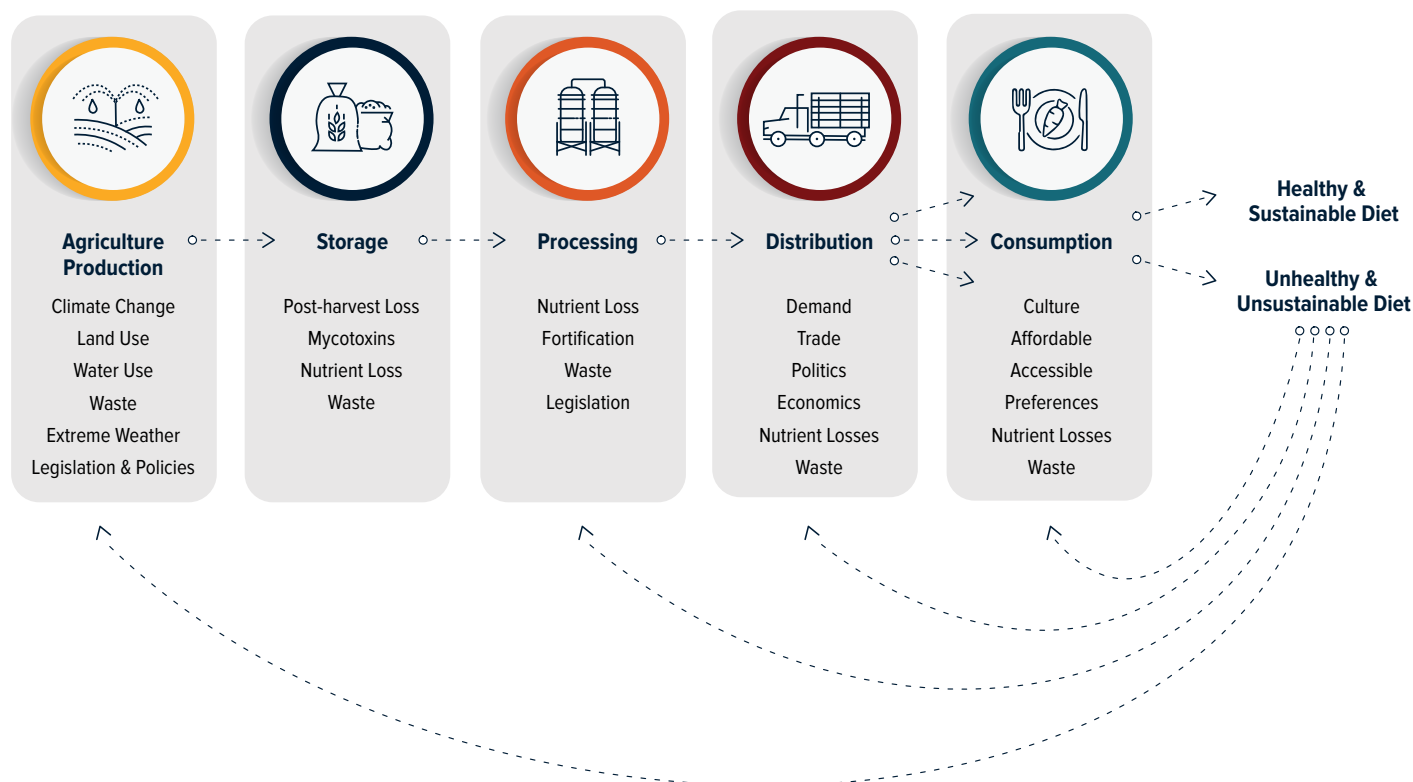
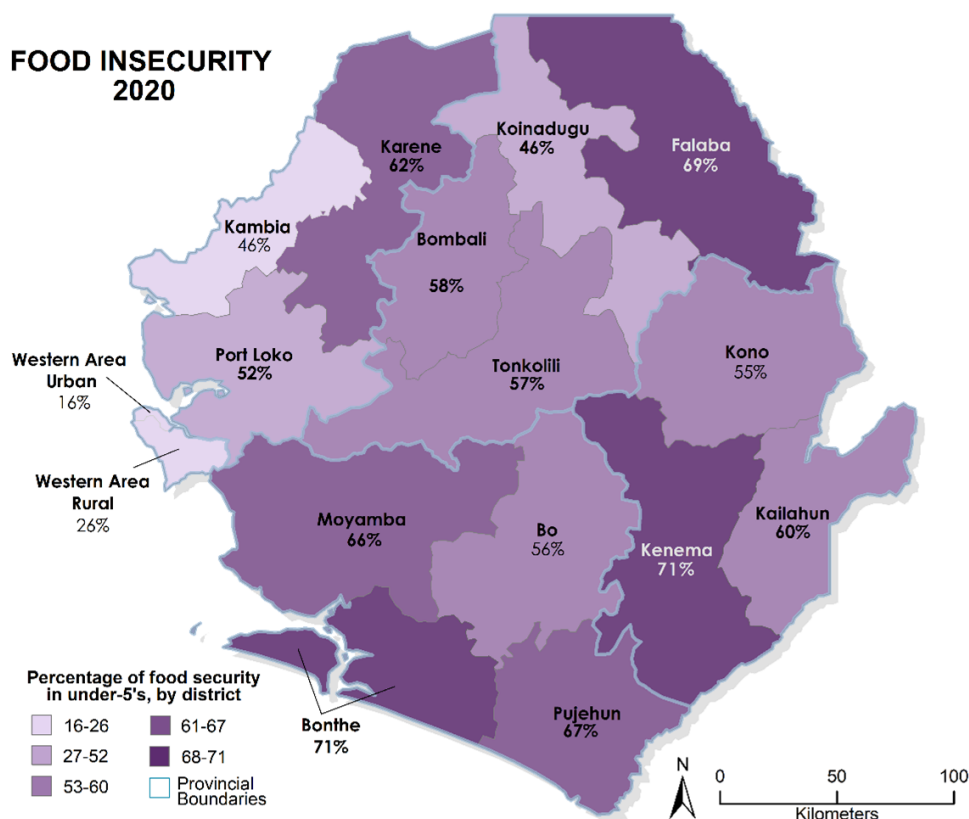


Figure source: [45]

FIGURE 10.

Food insecurity in Sierra Leone in under-5's, by district, in 2020



Source: World Food Programme. 2021. State of Food Security in Sierra Leone: 2020 Comprehensive Food Security and Vulnerability Analysis

32. Food insecurity is a chronic and worsening problem throughout Sierra Leone, with nearly 5 million people without adequate access to food. From 2010 to 2020, the prevalence of food insecurity⁴ increased from 45 percent to 57 percent. Amongst the food-insecure, the proportion of households in severe food insecurity⁵ rose from 7 percent to 12 percent during the same period [47].

The highest rates of food insecurity are in the Southern (65 percent) and Eastern (62 percent) Provinces (**Figure 10**). The districts of Bo, Bonthe, and Moyamba in the Southern Province saw increases in the prevalence of

food insecurity by 19 percent, 18 percent, and 14 percent, respectively, from 2015 to 2020 [47]. Conversely, the largest overall decline in food security during the same period occurred in Western Area Rural (-16 percent). In 2021, 1.7 million people were estimated to need food assistance throughout the lean season from June to August [47].

33. Malnutrition has profound long-term consequences on human capital, which can directly affect economic growth and development. Access, including affordability, is a critical determinant of proper nutrition across Sierra Leone, with food insecurity and malnutrition

4 "Exists when people do not have adequate physical, social, or economic access to food as defined above [110]"

5 Defined as, when a person either feels hungry and does not eat, or does not eat for an entire day, due to a lack of money or other resources

strongly correlated with poverty. Rice, oils, and a limited number of vegetables are the dietary staples in households across the country, though the frequency of their consumption is dependent on the household income [47]. As dietary diversification is linked to purchasing power, it is limited by low income and rising food prices. Micronutrient deficiencies, in particular Vitamin A and iron, are common throughout the country, but are the most prevalent in rural areas. Only 45 percent and 15 percent of rural households consume Vitamin A and iron-rich foods daily, respectively [47].

Children are especially vulnerable to poor health outcomes from malnutrition. Globally, 45 percent of deaths in children under five are attributed to malnutrition [48], and in Sierra Leone, approximately 85 percent of under-5s do not consume a diet that meets minimum dietary diversity. Under-5 mortality in Sierra Leone is already among the highest in the world (109.2 per 1000 live births in 2019 [39]): from 2017 to 2020, the rate of acute malnutrition in under-5s increased from 2.6 percent to 6.7 percent across the country [47]. Further, 14 percent of under-5s were considered underweight and 30 percent stunted, according to the 2019 Demographic Health Survey (DHS) [49]. The prevalence of stunting is highest in the Northwestern and Southern Provinces (32 percent) and the lowest in the Eastern Province (25 percent) [49]. The consequences of ongoing malnutrition to Sierra Leone's economic growth and development could be substantial. Undernutrition in early childhood is associated with decreased physical growth and cognition, workforce productivity and skill attainment, as well as a higher likelihood of developing NCDs. This phenomenon is more pronounced in the case of stunting, which has been shown to have longer-term, intergenerational impacts [50].

34. In the absence of adaptation, climate variability may substantially aggravate food insecurity and worsen nutrition outcomes in Sierra Leone.

While there is uncertainty on the precise number of Sierra Leoneans who will be at risk of food insecurity or rates of malnutrition because of climate change, recent findings suggest that globally, between 2010 and 2050, the population at risk of hunger is projected to change by -91 percent to +30 percent [51]. In Sierra Leone, the most vulnerable populations to climate-related food insecurity and poor nutrition outcomes are those in the Southern and Eastern Provinces, where demonstrated food insecurity and malnutrition rates already exceed those of other areas.

Impacts to rice and wheat production will be especially important to future nutrition outcomes on a national scale. Rice is the staple food throughout the country, regardless of income level, with per capita consumption among the highest in sub-Saharan Africa [52]. Despite being cultivated throughout the country, rice production is insufficient to meet the existing needs of Sierra Leone's population. By 2020, rice produced in Sierra Leone was available in only 52 percent of markets, with most households dependent on imported rice [53].

Rice self-sufficiency is a core priority of Sierra Leone's Ministry of Agriculture and Forestry now; this will likely be the case, as climate continues to change [54]. Rice development is directly affected by increases in ambient temperature and the availability of water resources. Likewise, warmer temperatures will encourage pests and disease, which will negatively impact yield. Despite these concerns, no empirical studies on the impact of climate change on the current rice production system in Sierra Leone have been conducted.

Nonetheless, if findings from nearby Côte D'Ivoire are any indication, irrigated and rainfed rice yields will decline from -0.13 to -0.28 [55].

VECTOR-BORNE DISEASE RISKS

35. Climate is a critical driver of vector-borne disease (VBD) distribution and transmission dynamics. Climate variability causes vector and host ranges to expand or contract, thereby shifting disease distribution and seasonality, and/or facilitating the emergence or re-emergence of VBDs. Investigating species distribution and the seasonality of vectors is valuable to understanding plausible VBD distributions and planning efficient, spatially-targeted methods of control. VBDs in Sierra Leone include malaria, dengue, chikungunya,⁶ lymphatic filariasis (LF), onchocerciasis, and schistosomiasis (SCH).

36. This assessment focuses on malaria, in light of its significance for morbidity and mortality in Sierra Leone. The country's vast swampland and irrigated rice agriculture provide ideal breeding sites for these Anopheline vectors. The predominant malaria vectors in Sierra Leone are *Anopheles gambiae sensulato* (s.l.) mosquitoes [57]; of these mosquitoes, the *Anopheles gambiae* s.s. are highly efficient malaria vectors, given their preference for feeding on human blood, tendency for indoor feeding behavior, and susceptibility to the Plasmodium parasite [58].

37. Spatial models were constructed to demonstrate the plausible distributions

of *Anopheles gambiae* s.l.⁷ mosquitoes according to environmental suitability during the primary malaria transmission season in Sierra Leone (May–November). Here, suitable areas are defined as those that facilitate the development of malaria mosquitoes through the production and persistence of oviposition sites and where temperatures do not exceed or fall below thermal tolerances for the species. It can be assumed that where the suitability for malaria vector species is the greatest, so too is the malaria transmission risk, in the absence of interventions. For further information on the modeling methodology and inputs, see Annex A.

MALARIA

38. Malaria is endemic in Sierra Leone, posing significant risks of morbidity and mortality. The disease has been the leading cause of premature mortality for over a decade, despite ongoing strides to curb transmission [44]. The most recent DHS Malaria Indicator Survey (MIS) demonstrated that prevalence is nearly twice as high in rural areas (49 percent) as compared with urban areas (25 percent). Prevalence according to microscopy was 40.1 percent at the national level in children aged 6–59 months, ranging from 6.3 percent in the Western Area Urban to 58.5 percent in Port Loko district in the North West Province [56]. By DHS region, malaria prevalence is the highest in the Northern Region (52 percent), compared with the Eastern and Southern Regions (40 percent in both) and the Western Region (21 percent) (Figure 11) [56].

⁶ Reports of Dengue virus (DENV) and Chikungunya virus (CHIKV) in Sierra Leone have been published (see [111–113]). However, these viruses are not often considered in patients presenting with non-specific, febrile illnesses; this may have contributed to their under-reporting in Sierra Leone and the wider region [112].

⁷ *Anopheles gambiae* s.l. refers to a complex of eight sibling species. In the absence of detailed entomological surveillance information that morphologically distinguishes and reports distributions of *Anopheles gambiae* s.l. species throughout Sierra Leone, this assessment focuses on *Anopheles gambiae* s.s. (Giles 1902) and *Anopheles coluzzi*, as reported from entomological surveillance in Freetown by Zhao et al. (2019).

FIGURE 11.

Prevalence of malaria in children aged 6–59 months, by district, in 2016

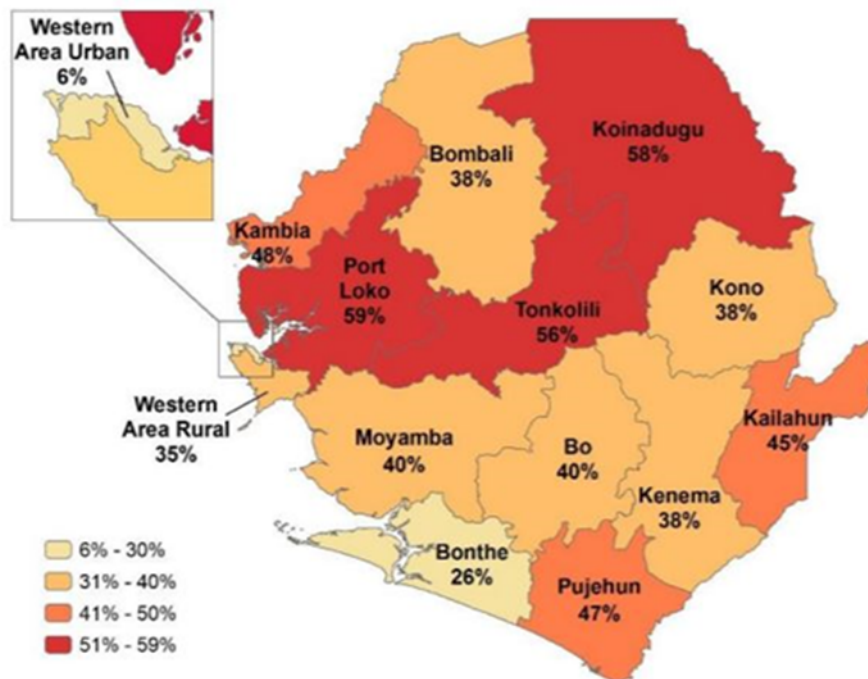


Figure source: [56].

39. The shifting suitability of malaria vector species in Sierra Leone will profoundly change the subnational geography of malaria transmission risk through the mid-century (Figure 12). Suitability for the malaria vector species is likely to decline sharply throughout the country, especially the Eastern Province. Essentially, 4.6 million people are projected to reside in areas that will likely be too warm for these mosquito vectors. These changes are the result of projected increases in the monthly maximum temperatures between the 2030s and 2050s, which will exceed the thermal tolerance of malaria vector species beyond the coastal areas. Regional models also demonstrate the declining suitability for *Anopheles* species across the region under an RCP 8.5 scenario, using the mean temperature (see: [59]). Only the Western Area will increase in suitable area by the

mid-century (**Table 1**); as such, populations residing in the Western Area will be the most vulnerable to transmission risks, in the absence of preventative measures. At the same time, it is important to note that, despite the strong correlation between VBD vectors and climate factors, climate is merely one determinant of the VBD transmission risk. The future risk of these diseases will depend not only on changing climate conditions that define vector suitability, but also on environmental, social, and economic conditions and responses.

WATERBORNE DISEASE RISK

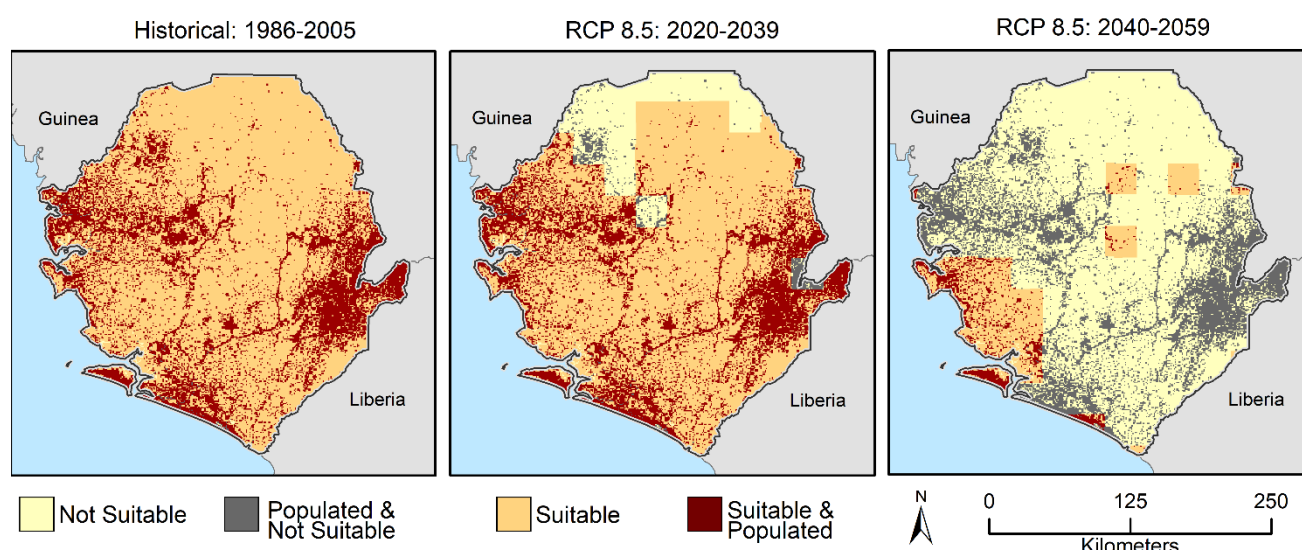
40. Climate change impacts both the availability of water and its quality, with direct effects on water-related illnesses and waterborne infectious diseases. Climate change, including changes in precipitation and temperature, can

impact the quantity and quality of fresh and marine water through urban, rural, and agricultural runoffs. This can lead to the contamination of drinking water, recreational water, as well as fish and shellfish. Contaminated water and poor sanitation are linked to the transmission of diseases, such as cholera, diarrhea, dysentery,

hepatitis A, and typhoid. Drivers of WBDs throughout Sierra Leone are attributable to the consumption of contaminated drinking water, inadequate sanitation facilities, and unhygienic practices, each of which may be affected by weather and climate change.

FIGURE 12.

Comparison of *Anopheles gambiae* s.l. mosquito vector suitability across Sierra Leone under RCP 8.5 across three epochs: 1986–2005 (historical baseline), 2020–2039, and 2040–2059



Note: The maps above were developed by the authors using data from various sources. See Annex A.

TABLE 1.

Percentage of suitable habitat area, by region, for malaria vector species in Sierra Leone, under RCP 8.5, through the mid-century

	PERCENT AREA								
REGION	POPULATED, SUITABLE			OVERALL SUITABILITY			VULNERABLE POPULATION		
	Historic	2030s	2050s	Historic	2030s	2050s	Historic	2030s	2050s
Eastern	42.69	40.12	0.05	100	97.13	1.27	1,435,825	1,364,909	700
North-West	33.30	28.96	2.17	98.34	68.36	6.73	1,078,898	908,124	85,571
Northern	11.11	9.95	0.94	100	78.35	11.55	1,092,166	952,627	82,959
Southern	26.06	26.06	8.31	97.96	97.96	30.18	1,445,068	1,445,068	255,478
Western Area	62.48	62.48	62.57	95.37	95.37	95.51	1,193,931	1,193,931	1,193,931
TOTAL							6,245,888	5,864,659	1,618,639

Note: The table above was developed by the authors using data from various sources. See Annex A.

Diarrheal disease continues to be a leading cause of child mortality in Sierra Leone [60]. Findings from the DHS 2019 showed that among children under five years of age, approximately 7 percent of all participants had diarrhea in the two weeks prior to the survey, with the largest proportion residing in the North West Province (9.2 percent) (Table 2) [60]. The Northern Province had the lowest percentage of under-5 children with diarrhea (4 percent). Prevalence rates were higher for children in rural areas (7.2 percent) as compared with the urban areas (6.9 percent).

41. Water quality is a significant driver of WBD risk in Sierra Leone. Only 2 percent of the population has access to readily available, safe drinking water [61]. Climate change can impact water quality through **temperature increases**, which contribute to the proliferation of water-borne bacteria and algal toxins, and through **flood events** caused by increasing precipitation intensity. Flood waters can be contaminated with human and

animal wastes, along with agricultural and other pollutants. In addition, flood waters lead to the proliferation of flies and other pests, thereby heightening the risk of food contamination. Similarly, under both flooding and drought conditions, bacterial pathogens attach themselves to leafy vegetables, such as lettuce, increasing the risk of food poisoning and bacterial infection outbreaks including Salmonella Escherichia coli (E. coli) [62].

Drought conditions can also affect water quality and limited water quantity, thereby causing WBD outbreaks. This is because limited water supply can force populations to use contaminated water sources for drinking, bathing, and agricultural irrigation. The Northern and Eastern Provinces suffer from extreme heat and drought conditions in the dry season (November–April), with an estimated 40 percent of the recognised “water points” experiencing water shortages [26]. See Annex B for a map of water points across Sierra Leone.

TABLE 2.

Two-week prevalence of diarrhea in children under 5 years in Sierra Leone, 2019

		PERCENTAGE WITH DIARRHEA
Province	Eastern	8.7
	Northern	4.0
	North West	9.2
	Southern	5.9
	Western Area	7.8
Source of Drinking Water	Improved	7.5
	Unimproved	6.3
Type of Toilet Facility	Improved	6.9
	Unimproved sanitation	6.8
	Open defecation	7.9

Data Source: DHS in Sierra Leone 2020.

42. The climate change impacts on algal blooms and eutrophication pose ongoing health risks to the population of Sierra Leone, particularly in the coastal communities. As temperatures increase, algal blooms, which flourish in both coastal waters and inland freshwater sources, will contaminate shellfish and fish. The various types of algae/blooms can cause paralytic and neurotoxic shellfish poisoning, resulting in symptoms of nausea and vomiting, as well as impacting the liver, skin, neurological and digestive systems [63], [64]. In 2011 and 2012, major outbreaks of food poisoning were reported in the Freetown area, where shellfish and fish — a major food source of the region — were contaminated.

An added consideration is the impact of eutrophication on coastal communities. This phenomenon, characterized by the excessive enrichment of minerals and nutrients, specifically nitrogen and phosphorus, has led to the inundation of Sargassum — a floating brown seaweed — on beaches in Sierra Leone since 2011 [65]. It has been damaging the fragile coastal and coral ecosystems [66]. Moreover, hydrogen sulfide gas, a product of the decomposing Sargassum, has been associated with cardiovascular and respiratory impacts, irritation to the upper airways and eyes, as well as neuro-behavioral effects and neurological symptoms [67]. There are additional concerns about Sargassum's carcinogenic properties, and the health risks associated with its accumulation of heavy metals, particularly arsenic and cadmium, although this has yet to be fully proven by evidence [68].

43. Sierra Leone is extremely vulnerable to climate shocks, particularly due to a lack of resilience in its water, sanitation, and hygiene (WaSH) infrastructures and systems, thereby placing its population at increased

risk of water-related illnesses and WBDs.

The country's poor WaSH infrastructure is reflected by the fact that it has one of the highest infant and child mortality rates in the world, along with high rates of malaria, cholera, and typhoid.

In the recent history of Sierra Leone, climate change-related hazards have caused mass mortality and morbidity events. As Section III of this report has shown, Sierra Leone will continue to experience increases in ambient temperatures, which will lead to increased episodes of diarrheal diseases, seafood poisoning, and increases in dangerous pollutants. Warmer waters will contribute to toxic algae blooms and increased cases of food poisoning from affected aquatic foods, thus resulting in outbreaks such as hepatitis A, campylobacter, salmonella, and typhoid. Projected increases in the intensity of rainfall, with consequent floods, landslides, and mudslides, will have the sequelae of WBDs, such as outbreaks of cholera.

Finally, SLR and coastal storm surges have resulted in significant erosion in Konkridee, Lakka, Hamilton, and Plantain Island, with reports documenting 4–6 m of shift in the coastline. Saline intrusions in coastal areas have damaged the quality and quantity of ground water sources, making it unusable, thus exacerbating the shortages of clean water [17]. These occurrences are projected to increase, with climate change rendering these areas highly vulnerable to clean water shortages.

HEAT-RELATED RISKS

44. The health risks of heat are wide-ranging, including effects on mortality, heat-related injuries, mental health, and wellbeing. Several factors influence mortality and morbidity in

relation to extreme heat events: the magnitude of the impacts associated with the timing, duration, and intensity of the temperature event; levels of acclimatization (an individual's adaptive response to a hot environment); the built environment (for example, the urban heat island effect⁸), the adaptive capacity of the affected populations, and the resilience of infrastructure and institutions, among others [69].

Health effects caused by heat include the direct effect of heat stress, as well as heat rash, cramps, exhaustion, and dehydration, along with the acute exacerbation of pre-existing conditions including respiratory and cardiovascular diseases (CVDs). Longer-term mental health risks are also an important effect to consider. In addition to the impacts on individuals, the exposure of the entire population to an extreme heat event can lead to significant increases in hospitalizations, thus putting a strain on health systems [70].

45. The health impacts of extreme heat are a growing concern in Sierra Leone, particularly in urban centers such as Bo and the capital, Freetown. The whole of the country is exposed to medium to high levels of extreme heat (see Section II of this report for a complete discussion on extreme temperatures). However, estimating heat-related mortality and morbidity remains a challenge due to limitations in the availability and quality of vital health statistics [71], as well as the under-reporting of extreme heat events on the continent [72]. In West Africa, the risk of heat-related health effects has been highlighted, especially for children and agricultural workers; yet, in Sierra Leone, heat-related mortality and morbidity have not been quantified. Nonetheless, a global

analysis reported that heat-related non-optimal temperatures in sub-Saharan Africa between 2000 and 2019 were associated with over 18,000 deaths (roughly 4 percent of the total excess deaths) [73]. Moreover, globally, more than one-third of deaths related to heat exposure (nearly 10,000 deaths a year) have been attributed to climate change [74].

46. Both the increases in average seasonal temperatures as well as the frequency and intensity of heatwave events are projected to increase the health risks globally in a changing climate [75–77]. These trends are expected across many countries in Africa, with increasing exposure to dangerous heat projected in cities due to a combination of climate and population factors [78, 79]. Based on the climate change projections described in Section II, the Northern and Eastern Provinces in Sierra Leone are expected to experience the most substantial temperature increases in 2030 and 2050 under RCP8.5, including an increasing number of very hot days (>35°C) and tropical nights (>20°C). Although not as densely populated as other parts of the country, approximately 1.6 million and 2.5 million people in the Eastern and Northern Provinces, respectively, would potentially be exposed to these temperature increases. They include vulnerable groups such as children (ages 0–14), who make up 41 percent and 85 percent, as well as persons over 65 years of age, who make up 3 percent and 4 percent, of the populations in the Eastern and Northern Provinces, respectively. Moreover, as mentioned, urban centers such as Freetown and Bo, may also experience increased risk of extreme heat-related morbidity and mortality, due in part to the urban heat island effect and higher population density.

⁸ An urban heat island is a metropolitan area that's a lot warmer than the rural areas surrounding it.

AIR QUALITY RISKS

47. Ambient and indoor air pollution from wildfires, dust storms, and other air pollutants poses a considerable risk to the health of Sierra Leoneans. Wildfire smoke, for example, contains carbon monoxide, nitrogen oxides, volatile organic compounds, as well as the particulate matter of coarse and fine sizes [80]. The entry of fine particulate matter (PM_{2.5}) and other toxins into the deeper sections of the lungs and the blood stream not only exerts an acute impact on health, but also contributes to the development of severe chronic health conditions. Although the country saw a decrease in PM_{2.5} concentrations to 17.7 micrograms per cubic meter from 2012 to 2014, it rose to 22 by 2015 [82] and remained relatively the same at 21.6 in 2017.

Acute impacts include eye, throat, and lung irritation; shortness of breath and asthma attacks; and precipitation of cardiac symptoms in those at risk (chest tightening and pain due to myocardial infarction). Those who are particularly vulnerable to particulate air pollutants include those with known asthma, chronic obstructive pulmonary disease (COPD), children, and emergency responders such as firefighters of wildfires. Pregnant women are another group who can be adversely impacted, with resultant impacts on the development of babies, such as low birthweight, where the acute damage done could produce adverse long-term effects [81].

48. Projected increases in temperatures, coupled with longer, drier seasons, are likely to result in air quality deterioration in Sierra Leone. In built-up, densely populated areas such as Freetown, increased temperatures will result in ‘heat island’ effects, characterized by the increased risk of smog formation where the air stagnates. The smog contains increased

levels of ozone and particulate matter, thus impacting health acutely and chronically through damage to the cardiovascular and respiratory systems. Moreover, the extended dry season will prolong exposure to coarse particulate matter from dusty roads, industry and dust storms, as there will be no rains to settle the fine and coarse particles to the ground.

MENTAL HEALTH RISKS

49. The association between climate change-related events and mental health can be direct or indirect, short-term or long-term. Acute events (such as floods and other extreme weather events) in the short term can precipitate a psychopathological pattern similar to a traumatic stress experience. Exposure to extreme or prolonged weather-related impacts may result in delayed mental impacts, such as the symptoms of post-traumatic stress in the future or psychological impacts on younger generations. Individuals with lower resilience, including populations such as those in Sierra Leone, are anticipated to be most at risk of negative impacts on their mental health and wellbeing in the face of climatic changes.

50. Globally, research on the effects of mental health outcomes related to climate change lags behind research related to physical health. As such, to evaluate mental health in the context of climate change in this assessment, the full spectrum from “mental illness” to psychological and social wellbeing or “psychosocial health” is considered. Such an approach allows for the incorporation of considerations of wellbeing and resilience [83], which encompasses the diverse psychological and social strains of climate change impacts. Examples include housing, water and income insecurities, as well as living in

physically uncomfortable drought or humid conditions. Adopting such an approach is particularly relevant in Sierra Leone, as the population is experiencing such strains. Moreover, there are limited opportunities for the population to receive psychological or psychiatric assessment and diagnoses in order to inform any potential analyses of climate and health links.

51. Mental health outcomes are byproducts of biological and genetic, psychological, cultural, and social factors. Important societal considerations, with regard to Sierra Leoneans' mental health outcomes, are set out below:

- **Migration — Ongoing, dynamic migration between Sierra Leone, Liberia, and Guinea, predominantly rural to urban.** The migration process itself, coupled with the myriad push and pull factors associated with migration, can negatively impact mental health and wellbeing [84].
- **Ethnicity, Dialects, and Culture.** Sierra Leone has 18 major languages [85], with distinct cultural beliefs and practices that can affect community support networks and relationships among community members. Further, mental health perceptions vary by culture. Mental illness is highly stigmatized in some cultures of Sierra Leone, with the individual and their relatives often viewed as having done something to cause the “curse” [86].
- **Poverty.** Most of the population in Sierra Leone are poor (GDP per capita of USD653), with 53 percent living below the poverty line. Poverty and mental illness have a bidirectional, causal relationship [87].
- **Food Security.** Food security is a chronic and worsening problem throughout the country (see the “Nutrition” subsection of this report). Food insecurity is significantly

associated with higher risks of depression and anxiety [88].

- **Alcohol and Illicit Drug Use.** Figures from 2008 estimated that approximately 90 percent of psychiatric patient admissions were related to drug use in Sierra Leone [89]. It has been reported that the use of marijuana and tramadol had been rising [90]. Alcohol consumption is higher in males than females, with no written national policy or national action plan for alcohol consumption. However, the consumption has been declining at a regionally high level in the period since the civil war [91].
- **Civil War.** Sierra Leone suffered through a violent civil war from 1991 to 2002. A survey conducted by WHO following the end of the civil war revealed that 2 percent of the population was psychotic, 4 percent had severe depression, and 4 percent engaged in substance abuse. Subsequently, WHO advocated for the establishment of community-based mental health services to meet mental health needs, particularly for those living in remote areas [92].
- **Ebola.** Sierra Leoneans are continuing to recover from the socioeconomic devastation and loss of more than 11,000 lives from the Ebola outbreak in 2014–2016 [93].
- **Sugar Loaf Mountain Landslide.** The Sugar Loaf Mountain Landslide of 2017 resulted in the loss of more than 1,100 lives and destroyed hundreds of buildings.
- **COVID-19.** The ongoing COVID-19 pandemic continues to affect Sierra Leone's population, both in terms of morbidity and mortality associated with the infection, along with the economic impacts of the global COVID-19 situation.

52. Climate change is a considerable threat to mental health in the 21st century. Nonetheless, analyzing the link between climate and the

resulting mental health and well-being in Sierra Leone is challenging. A lack of mental health and well-being monitoring, service provision, and assessment, as well as a high level of psychological stressors experienced by the population (see above), makes determining the actual burden of mental health disease challenging, at best.

Estimates have placed the mental health treatment gap in Sierra Leone at 98 percent for those with severe mental disorders. Based on available data, mental diseases contributed to approximately 3 percent of total disability adjusted life years (DALYs) and 21 percent of total years of health lost due to disabilities (YLDs) in 2019 in Sierra Leone (**Table 3**).

The country lacks the capacity to train health workers to meet with the psychosocial needs of the population. Sierra Leone has only 20 mental health nurses and the only facility for patients needing psychiatric care — the Sierra Leone Psychiatric Hospital — has a maximum capacity of just 150 patients. Yet no official budget line has been allocated to mental health according to the MoHS (see [65]). Eighty-eight percent of individuals who do access psychiatric services have previously been seen by an unregulated traditional healer, of which there are estimated to be 37,000 in the country.

TABLE 3.

Burden of mental disease in 2019, both sexes, all ages (percentage)

MENTAL DISEASES	CONTRIBUTION TO TOTAL DALYS (%)	CONTRIBUTION TO TOTAL YLDS (%)	DEATHS PER 100,000
Anxiety disorders	0.59	3.59	Mental disorders are ranked 21st for their contribution to deaths. Even if their impact remains weak compared to other groups of diseases, the burden of mental diseases has strongly increased during the two decades (1990–2019). In 1990: 0.000333 deaths per 100,000 In 2019: 0.000777 deaths per 100,000
Depression	1.01	6.23	
Idiopathic developmental intellectual disability	0.084	0.51	
Schizophrenia	0.18	1.15	
Autism spectrum disorders	0.11	0.65	
Bipolar disorder	0.18	1.08	
Conduct disorder	0.16	0.99	
Headache disorder	0.96	5.84	
Eating disorder	0.036	0.22	
Other mental disorders	0.14	0.85	
Total contribution to the burden of diseases	3.45	21.11	
Even if their impact is relatively weak, in terms of DALYs (3.45 percent), the contribution, in terms of total YLDs, is one of the highest in the world.			

Data Source: [109].

53. It is challenging to project the magnitude of the global, much less country-specific, mental health outcomes in relation to climate change. In Sierra Leone, there is a need for improved surveillance and diagnostics, as well as specialist training and services, to meet the mental health and wellbeing needs of the population.

Many factors can influence mental health and wellbeing, and the nature of resilience is not fully understood. For example, following a climate change-related extreme weather event, trauma may not be an inevitable outcome; rather, it could present an opportunity for post-traumatic growth (PTG), as described by Tedeschi and Calhoun (1995):

significant beneficial changes in cognitive and emotional life beyond levels of adaptation, psychological functioning, or life awareness that occur in the aftermath

of psychological traumas that challenge previously existing assumptions about self, others, and the future

On the other end of the projection spectrum, researchers in China have projected levels of heat-related excess mortality for mental disorders, modeled under different climate change scenarios. Based on the findings that suicide rates increase by 0.7 percent and 3.1 percent, respectively, for a 1°C increase in monthly average temperature, they projected that unmitigated climate change would result in a combined 21,770 (95 percent CI, 8,950–39,260) additional suicides by 2050 [94]. While these estimates may not transfer directly to the context of Sierra Leone, the trends between increasing temperatures and associated mental disorder have also been found with regard to self-harm and suicide rates, using data from the US and Mexico.

TABLE 4.
CLIMATE CHANGE IMPACTS ON HEALTH OUTCOMES

	CURRENT RISK	PROJECTED RISK
Food Security & Nutrition 	- Food security is a chronic and worsening problem throughout Sierra Leone. - From 2010 to 2020, the prevalence of food insecurity⁹ increased from 45 percent to 57 percent; 4.7 million people do not have adequate access to food. - The highest areas of food insecurity are in the Southern and Eastern Provinces. - Malnutrition is primarily attributable to limited access to nutritionally diverse foods.	- The effects of climate change on food security and nutrition, and their impacts on health outcomes for Sierra Leoneans will depend primarily on changes to rice agriculture. Rice is the staple food of Sierra Leoneans, regardless of income level. - No empirical studies of the impact of climate change have been conducted for rice agriculture in Sierra Leone. As a basis of comparison, yield is estimated to decline by 0.13–0.28 in nearby Côte d'Ivoire.

9 “exists when people do not have adequate physical, social, or economic access to food as defined above.”



	CURRENT RISK	PROJECTED RISK
Vector-borne Disease 	• Malaria has been the leading cause of premature mortality for over a decade, despite ongoing strides to curb transmission. • Malaria prevalence is nearly twice as high in rural areas (49 percent) than in urban areas (25 percent). • Prevalence of malaria in children age 6-59 months by microscopy was 40.1 percent in 2016. • Malaria prevalence is highest in the Northern Province (52 percent), as compared with the Eastern and Southern Provinces (40 percent in both) and Western Province (21 percent).	• The shift in the suitability of malaria vector species in Sierra Leone will profoundly change the subnational geography of malaria transmission risk through the mid-century. • By mid-century, approximately 4.6 million people will reside in areas that are too warm for malaria mosquito vectors. • The Western Area will be the most vulnerable area to malaria transmission risk by the 2050s.
Waterborne and Water-Related Diseases 	• Waterborne and water-related diseases occur throughout Sierra Leone as a result of inadequate water and sanitation systems, intense precipitation, drought conditions, and specific water contaminants. • Contaminated water, such as through flooding, results in the transmission of diseases such as cholera, diarrhea, dysentery, hepatitis A, and typhoid, with poor sanitation systems contributing to large and rapid outbreaks of disease. • More intense droughts in the north and east have been linked to the reduced availability of freshwater, a deterioration in water quality, stagnation, and disease outbreaks.	• Coastal communities can be impacted through saline intrusions, as sea levels rise due to climate impacts, thus affecting the local groundwater, as well as toxins from algal blooms that proliferate in response to increases in surface water temperatures on the coast and inland waterways. • Climate change patterns will influence the expanded ecosystem opportunities, the growth and transmission rates, as well as the persistence and virulence of pathogens.
Heat-related Morbidity and Mortality 	• The health impacts of extreme heat are a growing concern in Sierra Leone, particularly in urban centers such as Bo and the capital, Freetown. • The whole of the country is exposed to medium to high levels of extreme heat, as defined by the daily maximum Wet Bulb Globe Temperature (WBGT). • Estimating heat-related mortality and morbidity remains a challenge due to limitations in the availability and quality of vital health statistics,¹⁰ as well as the under-reporting of extreme heat events on the continent.	• Increases in average seasonal temperatures and an increase in the frequency and intensity of heatwave events are projected to increase health risks globally in a changing climate. • Both increases in the average seasonal temperatures and an increase in the frequency and intensity of heatwave events are projected to increase health risks globally in a changing climate. • The Northern and Eastern Provinces are expected to experience the most substantial temperature increases in 2030 and 2050 under RCP 8.5, including an increasing number of very hot days (>35°C) and tropical nights (>20°C).

10 Dann Mitchell, 2021, "Climate Attribution of Heat Mortality," Nature Climate Change 11 (6): 467–8.

Air Quality and Respiratory Health



CURRENT RISK

- Ambient and indoor air pollution poses a considerable risk to the health of Sierra Leoneans. Mean annual PM_{2.5} exposure in 2017 was 21.6 micrograms per cubic meter.
- Deaths attributable to household air pollution are significantly higher in Sierra Leone as compared with other regions, due to the use of unclean cooking fuels and the lack of suitable ventilation.
- In 2019, 98.8 percent of the urban population and 100 percent of rural populations had primary reliance on polluting fuels and technologies for cooking [95]. Solid fuels are used in 97 percent of households, with 64 percent using wood.

PROJECTED RISK

- Northern and Eastern Sierra Leone are projected to experience increasing temperatures and longer, drier seasons that may result in increasing risks of air quality deterioration associated with droughts and wildfires.
- An extended dry season will also result in longer exposures to coarse particulate matter from dusty roads, industry, and dust storms, as there will not be rains to settle the fine and coarse particles to the ground.

Mental Health and Wellbeing



- Important societal considerations with regard to Sierra Leoneans' mental health outcomes include migration, ethnicity, dialects, and culture, poverty, food security, civil war, Ebola, the Sugar Loaf Mountain landslide, and the ongoing COVID-19 pandemic.

- It is challenging to project the magnitude of mental health outcomes in relation to climate change. In Sierra Leone, there is a need for improved surveillance and diagnostics, as well as specialist training and services, to meet the mental health and wellbeing needs of the population.

ADAPTIVE CAPACITY OF THE HEALTH SYSTEM

HEALTH SYSTEM OVERVIEW

54. Sierra Leone's health system is diverse, comprising the government, religious missions, local and international non-governmental organizations (NGOs) and the private sector. The public health delivery system comprises three levels: (a) peripheral health units (PHUs) (community health centers, community health posts, along with maternal and child health posts) for primary health care (PHC); (b) district hospitals for secondary care; and (c) regional/national hospitals for tertiary care. In 2016, the country was served by roughly 19,030 health workers of different cadres (WHO 2017). There are pronounced inequalities in the geographical distribution of clinical health workers between districts with a high 20.28 health workers per 10,000 population in Western Urban and a low 3.75 health workers per 10,000 population in rural Kailahun [98]; however, 9,120 are volunteers [97]. Traditional healers and traditional birth attendants (TBAs) provide a significant amount of healthcare services across the country [96].

55. The health system has been weakened by devastating outbreaks. Among them is the Ebola virus disease outbreak in 2014–2016 that devastated Sierra Leone, severely straining the health system and the ability of the health workforce to deliver services. It resulted in 8,706 laboratory cases and 3,956 deaths [102]. There were 296 infections among frontline health workers and 221 recorded health worker deaths.

56. While there have been significant reforms in the health sector in Sierra Leone since 2010, the efficient financing of the various components of the health system remains a key challenge. Even though the health expenditure is 16.06 percent of the total government expenditure in 2018 [99], significantly over the target of 15 percent in the Abuja Declaration, the government is heavily reliant on donors and partner organizations.

They support its health programs, with funds flowing through budget support or directly to the MoHS and its implementing partners. Out-of-pocket (OOP) expenditure represents 45 percent of the current health expenditure [100].

57. The occurrence of the COVID-19 pandemic has brought with it a focus on the country's health and health systems, specifically the capacity to manage emerging public health risks. Climate change, as with COVID-19, has the potential to disrupt and overwhelm health systems, including healthcare facilities and healthcare staff. This is especially important in settings that may already have weak health systems, including leadership challenges, lack of resources, and/or limited capacity.

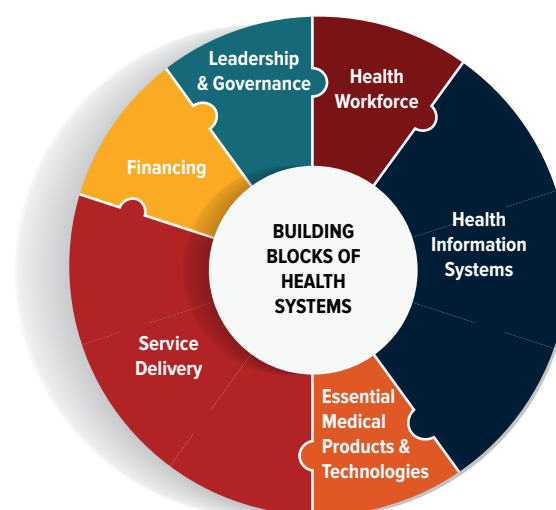
During the first wave of the pandemic (Q1 and Q2 2020), hospital utilization in Sierra Leone decreased by 14.7 percent. According to Sevalie et al. (2021), this development can be attributed to the health systems' inability to maintain the core functions and protection of health services (see [101]). The economic costs of the pandemic have been substantial with significant impacts on growth: -2.3 to -4.0 percent (2020) and 4 percent (2021), as compared with the pre-COVID-19 projected growth rate of 5.4 percent. With the state of emergency, characterized by a partial lockdown and restrictions on movement, the disruption of economic activity has also heightened social tensions, increased poverty and the crime rate.

58. The extent to which the capacity of the health system in Sierra Leone is prepared to manage changes in hazards, exposure,

and susceptibility will determine its resilience in coming decades. In this assessment, Sierra Leone's adaptive capacity¹¹ to prevent and manage climate-related health risks is examined according to WHO's six health system building blocks, as shown in **Figure 13**. See also Annex C for the *Adaptive Capacity Rapid Assessment* and a summarized *Adaptive Capacity and Climate Change-Related Health Risks Gap Analysis* that informs this section.

59. It should be noted that several factors outside the scope of the health sector can also drive reductions in the adaptive capacity of Sierra Leone's institutions and people with regard to managing the health risks of climate change. These factors include the country's economic challenges, changing demographic patterns, and slowly improving social conditions. The promotion of equity as a cross-cutting theme for enhancing the

FIGURE 13.
WHO's Health System Building Blocks



Source: [14]

¹¹ Adaptive capacity is defined by IPCC as "the ability of a system to adjust to climate change, moderate potential damages, take advantage of opportunities, and cope with the consequences" (IPCC AR5). The related term, "resilience," is the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events. People and communities with strong adaptive capacity have greater resilience. [This assessment makes use of the terms, "adaptation" and "adaptive capacity," to encompass both terms]

adaptive capacity and resilience to the health risks of climate change is also critical. Adaptive capacity is likely to be greater when access to resources within a community, nation are more equitably distributed.

LEADERSHIP AND GOVERNANCE

60. The Government of Sierra Leone is acutely aware of the potential negative impacts of climate change, given the country's already dire economic situation. As a result, the government has been actively developing policies and plans to support mitigation and adaptation actions. Among sector policies and plans relevant to climate change and health, there is a special emphasis on community engagement and capacity building at local levels (including the use of community-based volunteers, see “Health Workforce”), which is important for addressing subnational needs. For example, MoHS works closely with district-level stakeholders to develop operational plans that ensure bottom-up approaches for key health programs. A similar district-focused emergency operations model is used for DRM.

61. The evolution of the climate change and health policy landscape in Sierra Leone since 2007 can be summarized as follows (see also Table 5 for a snapshot assessment of climate change and health policies and plans):

- **2007 — Following the development of the National Adaptation Programme Action (NAPA), the Environmental Protection Agency (EPA) was established in Sierra Leone. EPA is responsible for all issues concerning the environment and climate change.** The Meteorological Department of the Ministry of Transport and Aviation is the body responsible for collecting weather data, along with processing and disseminating information and related services to end-users.
- **2012 — Under EPA, the National Secretariat for Climate Change (NSCC) was established and the National Climate Change Policy was developed. NSCC hosts a multistakeholder committee that provides guidance on all national climate change matters, including cross-cutting issues related to DRM, agriculture, infrastructure, and health.** It is the key mechanism for building institutional links across governmental agencies and other actors, such as NGOs and universities, though the extent of the involvement of the MOHS is unclear.
- **2015–2016 — The National Climate Change Strategy and Action Plan was developed in 2015, which includes a section that describes both the impacts and potential adaptation options for human health. This was followed by the submission of the country's INDC to UNFCCC in 2016 (see [11]).** Other existing strategies that are important for specific climate change-related health risks include the Malaria Control Strategic Plan (2016–2020) (see [103]) and the National Environmental Health and Sanitation Strategy (2016–2020) (see [104]). However, for the most part, these plans, while acknowledging the increasing adverse effects of climate change, lack substantial information on potential risk pathways for health, as well as any adaptation activities to improve resilience and reduce vulnerabilities.
- **2017 — The National Health Sector Strategic Plan (2017–2021) is well-informed: it includes sections on climate change-related health issues, such as environmental health and sanitation. However, it lacks adequate information on climate change and health risks and does not identify climate change as a current or future threat to human health.** It outlines the vision of a well-functioning national

health system delivering efficient and high-quality healthcare and ultimately contributing to the socioeconomic development of the country across eight pillars. They mirror the six-health system building blocks, as well as ‘health security and emergencies’, and ‘community engagement, and health promotion’.

→ **2018 — The 3rd National Communication to UNFCCC provides the most comprehensive review of climate change-related health impacts and adaptation options in Sierra Leone. Using a Strengths, Weaknesses, Opportunities, and Threats (SWOT) approach with key stakeholders, the communication review assessed the country’s climate change and health vulnerability and adaptation.** It also included a description of the current climate change-related health impacts, a discussion of future risks, a best practice recommendation specifically for malaria, and the identification of adaptation options. Examples of prioritized actions include the following:

- Adapting to the increased incidence of malaria and rodent-related diseases, particularly in the design and procurement of safe water storage containers and the development of an early warning system (EWS),
- Instituting better water monitoring and management through improvements at the National Water Resources Authority to reduce the risk of WBDs,
- Improving the capabilities of the Disaster Management Department to develop EWS for climate-related hazards,
- Improving the data-gathering capabilities of the Meteorological Office’s technical support staff for monitoring climate variables and warning about climate and health risks, such as flooding and air quality,
- Strengthening collaboration among research institutions involved in pollution control, as well as supporting regional and statistical

downscaling models for environmental and climate change-related health risks.

- 2019 – Sierra Leone’s Medium-Term National Development Plan (NDP) (2019–2023) highlights the building of climate and disaster resilience as a national goal and core element. Although climate risks are outlined throughout the NDP, including the increasing magnitude of extreme weather events, food insecurity, and coastal erosion, they are not explicitly linked to human health.
- 2019 — At the municipality level, Freetown’s three-year plan — the Transform Freetown Strategy (2019–2022) — aims to transform the capital into a productive, livable, and resilient city by improving urban governance and planning and investing in resilient infrastructure and greening. After two years, implementation has begun on several projects relevant for enhancing adaptive capacity for the reduction of climate change and health risks. These projects include tree planting initiatives, flood mitigation measures, climate action planning, strengthening of disaster risks reduction efforts, upgrading of informal settlements, city-wide sanitation improvements, and enhanced water supply in PHUs, as well as numerous COVID-19 response activities.
- 2021 — Sierra Leone provided an update to their Nationally Determined Contributions (NDC). The revision includes a section on the health impacts of climate change and describes the potential of improving population health by building climate resilience in other sectors, such as water, waste management, agriculture, and infrastructure. Additional priority adaptation actions include enhancing health delivery services, improving the supply of safe drinking water and sanitation, increasing funding to the health sector, developing an EWS, strengthening meteorological and hydrological institutions, and providing coastal

infrastructure. However, although identified as a cross-cutting issue, health is not included as a “priority sector.” Moreover, the health-specific adaptation action, described as “mainstream climate change into the health sector” in the NDC, is broad and lacking in adequate detail.

- 2021 — Notably, Freetown appointed the first Chief Heat Officer in Africa. The role involves coordinating across agencies and stakeholders to develop new policies, with a focus on the health impacts of extreme heat and broader climate change and health risks facing Freetown. Freetown is also planning to develop new standard operating procedures (SOPs) for disaster response, as well as establish minimum training requirements for local councilors and disaster managers [105].
- **Forthcoming — Sierra Leone is currently developing a National Adaptation Plan (NAP), although it is unclear how health will be integrated and/or prioritized.** The government is working alongside the Global Environment Facility (GEF)-funded National Adaptation Plan Global Support Programme, being implemented by the United Nations

Development Programme (UNDP) and the United Nations Environment Programme (UNEP) [106].

- The NAP plans to focus on (a) agriculture and food security; (b) water resources and energy; (c) coastal zone management, including fisheries and coastal ecosystems; (d) infrastructure, including water, sanitation, and transportation; along with (e) environment, including tourism, land and forestry, and disaster management.
- Documents to support the development of the NAP have been released recently: they include a Climate Change Communications Strategy Under the NAP (2020) and the National Adaptation Plan Framework (2019), both of which mention human health, albeit with limited details. The NAP will build on the two foundational climate change plans, namely the National Climate Change Policy (2012) and the National Climate Change Strategy and Action Plan (2016), both of which highlight the current and potential impacts of climate change on human health, particularly in relation to WBDs, VBDs, and undernutrition.

TABLE 5.
Assessment of key climate change and health-related policies

DATE	POLICY OR PLAN	RELEVANCE FOR CLIMATE CHANGE AND HEALTH	CLIMATE CHANGE AND HEALTH RISKS
National (Climate Change)			
2007	National Adaptation Programme of Action (NAPA) ^a	Health mentioned throughout in detail, including impacts and priority adaptation measures	Injuries and disruption of health service delivery related to extreme weather events such as flooding, WBDs related to changing rainfall patterns, and VBDs
2012	National Climate Change Policy ^b	Health is mentioned as a key sector, although details are limited.	WBDs, food insecurity, and respiratory diseases
2015	National Climate Change Strategy and Action Plan ^c	Includes sections on health that describe impacts and adaptation actions	WBDs, undernutrition, respiratory illnesses, and NCDs

DATE	POLICY OR PLAN	RELEVANCE FOR CLIMATE CHANGE AND HEALTH	CLIMATE CHANGE AND HEALTH RISKS
2016	Intended Nationally Determined Contributions (INDCs) ^d	Health mentioned under one of seven strategies, in terms of benefits related to improved waste management	Not specified
2018	3rd National Communication to UNFCCC ^e	Completed a health vulnerability and adaptation assessment, which includes recommendations for prioritizing adaptation options for the health sector	Vector-borne (dengue and malaria) and rodent-borne diseases; food and waterborne diseases; health effects of extreme weather events including heat, floods, and droughts; nutrition-related diseases; and NCDs
2019	National Adaptation Plan Framework ^f	Highlights the Ministry of Health and Sanitation (MoHS) as a key stakeholder	Not specified
2020	Climate Change Communications Strategy Under the National Adaptation Plan ^g	Sector-specific messages are described briefly, including for health	WBDs and impacts related to adverse effects on fisheries
2021	Nationally Determined Contributions (NDC) (first submitted in 2016 — updated in 2021) ^h	Includes a section on health impacts and one strategy for implementing adaptation actions in relation to the health sector	Risks mentioned include undernutrition, WBDs, and extreme weather events such as floods, and droughts
Forthcoming	National Adaptation Plan (NAP)	Highlights the Ministry of Health and Sanitation (MoHS) as a key stakeholder	Not specified
National (Health)			
2017-2021	National Health Sector Strategic Plan ⁱ	Impacts of climate change on health and health systems not mentioned	Not specified
Municipality Level			
2019-2022	Transform Freetown Strategy ^j	Prioritizes group in four cluster areas: resilience, human development, healthy city, and urban mobility	Focuses on water- and sanitation-related risks; DRM, including from extreme weather events; food security, NCDs; and maternal health

a Source: Government of Sierra Leone. 2007. National Adaptation Programme of Action (NAPA). <https://faolex.fao.org/docs/pdf/sie175907.pdf>

b Source: Government of Sierra Leone. 2012. National Climate Change Policy.

c Source: Government of Sierra Leone. 2015. National Climate Change Strategy and Action Plan.

d Source: Government of Sierra Leone. 2016. Intended Nationally Determined Contributions (INDCs)

e Source: Government of Sierra Leone. 2018. Third National Communication to UNFCCC. <https://unfccc.int/sites/default/files/resource/FinalThird%20Nat.%20Com.%20document%20111.pdf>

f Source: Government of Sierra Leone. 2019. National Adaptation Plan Framework.

g Government of Sierra Leone. 2020. Climate Change Communications Strategy Under the National Adaptation Plan. <https://napglobalnetwork.org/wp-content/uploads/2020/10/napgn-en-2020-Sierra-Leone-Climate-Change-Communications-Strategy-under-the-NAP.pdf>

h Government of Sierra Leone. 2021. Updated Nationally Determined Contributions. <https://unfccc.int/sites/default/files/NDC/2022-06/210804%20125%20SL%20NDC%20%281%29.pdf>

i Government of Sierra Leone. 2017. National Health Sector Strategic Plan. https://extranet.who.int/countryplanningcycles/sites/default/files/planning_cycle_repository/sierra_leone/sierra_leone_nhssp_2017-21_final_sept2017.pdf

j Freetown City Council. 2019. Transform Freetown. <https://fcc.gov.sl/transform-freetown/>



GAPS IN ADAPTIVE CAPACITY

- 62. The prioritization of climate change and health risks varies across policies, strategies, and plans in Sierra Leone.** For example, key international climate change documents, such as the NDCs and the 3rd National Communication, have highlighted health as a key sector (see **Table 5**). To this end, a recent analysis of NDCs, which assessed the extent to which governments' commitments reflect the linkages between climate change and health, gave Sierra Leone a score of 9 out of 15 — one of the higher scores among African countries (GCHA 2021). Sierra Leone also received high marks for acknowledging the diversity of health impacts related to climate change, as well as the need for adaptation. However, it had gaps in the description on the health co-benefits of climate change mitigation policies, as well as resource mobilization and the costing of adaptation actions.
- 63. Despite health being identified in climate change policies and plans, there seems to be a disconnect with the health sector, including limited engagement from MoHS and ineffective coordination mechanisms for supporting climate change and health actions.** The mainstreaming of climate change into MoHS' strategic planning remains absent, with no national climate change and health-specific strategy or action plan having been developed. Moreover, there is no designated department or focal point designated within MoHS to lead and coordinate climate change activities. The Environmental Health and Sanitation Directorate would be the suggested leading department, but this link has not yet been formally established with EPA or NSCC.
- 64. Coordination and collaboration on climate change and health issues across sectors and agencies have not been assessed.** Although a mechanism for cross-sector stakeholder engagement exists within EPA, the utility of the mechanism and the involvement of MoHS representatives are unclear. In many cases, even though health decision-makers have demonstrated an awareness of the health impacts of climate change, engagement with climate change, DRM, and agriculture counterparts has been slow in general. As a result, progress on the necessary improvements needed to ensure greater level of resilience and preparedness has been limited.
- 65. Although several plans have been developed, including the updating of the NDC, the implementation of the actions identified in the plans remains limited, in part due to resource constraints and continued exposure to climate and non-climate shocks.** A review of the public health adaptation measures in the National Communications of 21 African countries found that Sierra Leone was considering several climate change and health adaptation measures, such as EWS, public awareness, and improved infrastructure; however, few of these have been implemented (Nhamo et al. 2019).
- 66. At the subnational level, the development and implementation of policies and plans to address climate-related health risks are lacking — a situation that is exacerbated by funding resource**

constraints. Although MoHS has developed district-level operational plans, climate change and health in these sub-national plans, so far, have not been well-integrated into local-level planning initiatives. In Freetown, there has been considerable activity related to climate change, but challenges remain, particularly related to sustained funding streams and human resource constraints. Similarly, city councils across Sierra Leone face several barriers related to their fiscal sustainability and investment capacity, thus constraining their ability to deliver services to their residents and undermining the ability to tap into economic growth potential. There is also a need to reinforce national-district coordination for DRM, including for climate change-related hazards. Where progress has been made, as with the appointment of the Chief Heat Officer, it is unclear whether adequate resources will be provided to maintain these positive efforts.

HEALTH WORKFORCE

67. Sierra Leone has made progress in improving its health workforce, but challenges remain, particularly in the public sector. Although the health workforce has increased since the introduction of the National Free Health Care Initiative (FHCI), insufficient staffing levels and other health workforce-related challenges remain.¹² They include urban-rural maldistribution; a lack of proper skill mix; the low quality of education; poor absorption capacity; rural retention issues; international out-migration; as well as insufficient and irregular salary payments.

68. Sierra Leone has a shortage of healthcare personnel. In 2018, the country had an estimated 0.74 medical doctors and 7.525 nurses and midwives per 10,000 population. This number is below the WHO's minimum threshold of 44.5 per 10,000 for achieving universal health coverage (UHC) (WHO 2016). In total, there are an estimated total of 566 registered doctors and 5,757 nurses.

69. Labor conditions for health workers curtail health workforce capacity — a concern that is interrelated with the absence of a unified educational strategy. The unsalaried workforce of approximately 9,120 health workers (48 percent of the health workforce), active in the government health facilities, are the same in number as the formally employed workers. Although there have been efforts to increase salaries for the formal workforce, this remains a challenge for retaining the human capital within the health system.

At the same time, most of the unsalaried workers have limited training and/or are lower-skilled, with no regulations on their education or role within the health workforce. This lack of a unified educational strategy has contributed to the shortage of qualified health professionals, thereby increasing risks for health challenges such as maternal mortality, whose rate is among the highest in the world (HRH 2016).

Moreover, there is a shortage of allied health professionals. For example, in 2011, there were only 183 medical pathologists and laboratory scientists, along with 201 environmental and occupational health and hygiene professionals, who play a vital role in reducing climate

¹² Sierra Leone is one of the 57 Human Resources for Health (HRH) crisis countries (WHO 2006). It is important to note that, in general, data on HRH is scarce, particularly with regard to the private health sector.

change-related health risks. This also includes only 0.041 psychiatrists working in the mental health sector per 100,000 in 2017 (WHO 2017). The shortage is worsened by the out-migration of medical doctors and nurses due to a lack of adequate labor conditions.

70. The health sector’s health education institutions tend to be underfunded, characterized by insufficient qualified educators, materials, and infrastructure. In 2016, Sierra Leone reported the existence of 25 health training institutions that imparted 56 programs, ranging from certificates to master’s level degrees. Large programs like the State Enrolled Community Health Nurse certificate produce around 900 cumulative new graduates per year, while the medical officer program has about 40 recent graduates (HRH 2016). Each institution manages its own curriculum and training program.

71. Climate change can further exacerbate challenges faced by the health workforce due to changes in the frequency and intensity of extreme weather events. Such changes may affect a facility or the workers’ ability to reach the facility. They may also alter the

patterns of climate-sensitive diseases, thereby potentially preventing health professionals from being able to respond to them in a timely manner (WHO 2020).

72. The health workforce and its professional expertise are also affected by uneven distribution, with the level of awareness of climate change and health risks among health workers unknown. The health workforce, particularly doctors and nurses, are more concentrated in urban areas, with 70 percent of medical staff located in urban health facilities, leaving 30 percent of medical staff in rural areas where 62 percent of the population lives (HRH 2016). There is also an uneven distribution of the health workforce across provinces, with the majority of highly skilled professionals stationed in large tertiary hospitals or administrative offices in Freetown (Western area, see **Table 6**). On the other hand, midwives and community health officers are better distributed in more rural districts. Overall, 74 percent of the health workforce is concentrated in 10 percent of the facilities, mainly hospitals (57 percent) and community health centers (21 percent) (HRH 2016).

TABLE 6.

Health workforce distribution per province and cadre

AREA	CADRE	PER 10,000 POPULATION				COMMUNITY HEALTH OFFICERS/ ASSISTANTS
		MEDICAL OFFICERS/ SPECIALISTS	NURSES (HIGHER CADRES)	PHARMACISTS	MIDWIVES	
Northern	Bombali	0.1	0.38	0.03	0.41	0.56
	Kambia	0.06	0.29	0.06	0.44	0.84
	Koinadugu	0.05	0.17	0.05	0.32	0.44
	Port Loko	0.1	0.2	0.03	0.39	0.52
	Tonkolili	0.06	0.11	0.02	0.26	0.68

		PER 10,000 POPULATION				
AREA	CADRE	MEDICAL OFFICERS/ SPECIALISTS	NURSES (HIGHER CADRES)	PHARMACISTS	MIDWIVES	COMMUNITY HEALTH OFFICERS/ ASSISTANTS
Eastern	Kailahun	0.08	0.06	0.04	0.15	0.69
	Kenema	0.08	0.18	0.07	0.34	0.93
	Kono	0.08	0.12	0	0.26	0.42
Southern	Bo	0.1	0.45	0.03	0.47	2.4
	Bonthe	0.2	0.2	0.05	0.3	1.05
	Moyamba	0.13	0.28	0.06	0.5	1.01
	Pujehun	0.06	0.38	0.03	0.35	0.95
Western	Western Area Rural	0.27	0.25	0.02	0.32	0.63
	Western Area Urban	1.1	1.92	0.5	1	0.96

Source: MoHS 2016.



GAPS IN ADAPTIVE CAPACITY

73. Overall, the health sector faces an imbalance in the number, capacities, deployment of the health workforce, and inadequate resource allocation across different levels of health care when compared with global minimum thresholds. Improving workforce capacity would strengthen job satisfaction, human resources retention, salaries, work environment, and resource allocations. Previous experience with the Ebola epidemic has proven to be successful in increasing health workforce absorption capacities and deployment, thus providing a model for the integration of climate change and health training aspects.

74. There are significant disparities in the roles and types of health professionals at subnational levels, including substantial urban-rural divides on which climate change could impact. The presence of a massive unsalaried health workforce, coupled with the lack of a unified health training curriculum, has deepened the disparities and gaps in the workforce distribution and roles. Moreover, the reliance on private initiatives or NGOs, without strengthening and articulating efforts with the public sector, could further increase the vulnerabilities of the health workforce in a changing climate. Finally, the lack of climate change guidelines and tools in capacity-building programs undermines the development of the health workforce.

- 75. The absence of a systematic approach for health workforce capacity development for climate change, as well as for the integration of emergency preparedness and response courses, constitutes a vital bottleneck.** Overall, climate change has not been prioritized in human resource planning mechanisms, starting with the Strategic Planning for the Development of Human Resources in the Health Sector for 2030, which is closely aligned with the WHO Global Health Workforce 2030. Sierra Leone's health education system, which is managed by MoHS and the Ministry of Education, Science and Technology lacks a national training plan and does not prioritize climate change and health. Further, there are no national capacity-building programs in place to address the context of a changing climate and the capabilities of the health workforce to prepare for, prevent, as well as respond and adapt to, climate change-related health risks. International non-governmental organizations (INGOs), which have helped to supplement capacity building in the workforce, have not integrated climate change impacts on health into training programs to date.
- 76. The extent to which Sierra Leone's health workforce possesses the adequate knowledge, technical capacity, and resources to prevent and manage current and future climate change-related health risks remains unknown.** There has been no assessment to establish the baseline understanding, knowledge, and technical needs of the health workforce in relation to climate change. Although climate change policies in the country prioritize climate change impacts on health, there are no programs within MoHS that integrate climate-related risks in the development of the health workforce capacities.

HEALTH INFORMATION AND DISEASE SURVEILLANCE

- 77. Although progress is being made, Sierra Leone lacks a consistently functioning health information and surveillance system infrastructure, as well as clear leadership and reporting mechanisms, thus leading to data quality and availability challenges.** Following the Ebola virus disease outbreak, there were efforts to develop an integrated disease surveillance and response system; however, the maintenance of equipment and continued technical support have been significant barriers.
- 78. Health information and surveillance systems in Sierra Leone collect some information on**

climate-sensitive diseases; however, overall, there are challenges with data completeness and quality. The National Health Information System (NHIS) relies on a combination of paper-based and electronic systems for the collection and management of most of its health data. Routine health information is collected through the District Health Information System 2 (DHIS-2).

A Health Information Systems Strategy (HISS), developed in 2017, focuses on building a user-friendly system for collecting, accessing, and analyzing quality data at all levels of the health system to inform decision-making and improve service quality. Climate-sensitive diseases, such as malaria, malnutrition, and diarrhea, are captured routinely from health facility reports

through DHIS-2, albeit with varying degrees of completeness. Nevertheless, information on emerging VBDs, such as dengue and chikungunya, is still lacking.

79. There are several cross-sectoral and partner-supported initiatives to improve health information and surveillance that could be utilized to build climate resilience.

HISS has mapped out key governmental stakeholders and associated data sources including MoHS; the Ministry of Agriculture, Forestry, and Food Security; and Statistics Sierra Leone (partly in charge of vital statistics). The Directorate of Health Security and Emergencies also supports surveillance efforts by providing leadership, scientific, and technical situational awareness and advice at the national level, including producing weekly epidemiological reports and risk communication materials.

There are also supplementary initiatives to improve health information and surveillance systems in Sierra Leone supported by development partners. For example, the Regional Disease Surveillance Systems Enhancement Project (REDISSE), funded by the World Bank, is designed to strengthen weak human health, animal health, and disaster response systems in West Africa, including Sierra Leone, to guard against future epidemics. Although climate change is not at the center of this project, there are clearly several co-benefits from this investment that is also being expanded in 2022 to support, in part, a more climate-resilient health system.

80. In Sierra Leone, there are other information monitoring systems that are relevant for climate change and health:

- **Meteorological services.** The meteorological infrastructure, largely destroyed during the

civil war, has been slow to be rebuilt. This has limited the country's capacity to engage in the accurate observation and monitoring of weather and climate events, as well as the issuance of predictions and warnings.

To address these challenges, the Sierra Leone Meteorological Agency (SLMet) was established in 2017 to provide comprehensive meteorological services. They include climate services centered around sustainability planning and assessment, as well as the Climate Information, Disaster Management and Early Warning System (CIDMEWS-SL) — a GIS web-based mapping application that enables the exploration of available climate information, disaster management, along with early warning data and information resources. Additionally, there have been ongoing enhancements of early warning capacities, such as strategic investments in new remote sensing, hardware and software packages, as well as the strengthening of the capacity of SLMet to assist in climate and oceanographic monitoring.

- **Disaster management.** Ongoing institutional reforms, as part of the recently approved Sierra Leone National Disaster Management Agency (NDMA) Act (2020), provide an opportunity to strengthen the coordination for an all-hazard EWS, with the capability to promptly gather, process, and communicate disaster information to local stakeholders and vulnerable communities. Key stakeholders involved in the development and implementation of a national EWS have been identified, including potential roles and responsibilities for MoHS (**Table 7**). There have also been investments in data management and information technology (IT) systems, such as open data kits (ODK), phones, and tablets, to improve data collection capacities in the context of DRM (AFRICAB, 2021).

Nevertheless, the current early warning services in Sierra Leone are constrained by the weak technical capabilities and capacity of the hydromet services providers. These challenges restrict the granularity and timeliness of warning provision, thus limiting the effectiveness of the warning services provided.

- **Food security monitoring.** The Ministry of Agriculture, Forestry, and Food Security, MoHS, and Statistics Sierra Leone, in partnership with the Food and Agriculture Organization of the United Nations (FAO) and the United Nations World Food Programme (WFP), are collaborating to strengthen the Food Security Monitoring System (FSMS) aspect of the national EWS. FSMS is implemented twice per year — once in the immediate post-harvest period (January–February) and again during the height of the “lean season” (August–September) — when access to and availability of food is reduced. This is done in order to effectively monitor food security levels in Sierra Leone, better understand their dynamics, and compare the situation with other

West African countries (FSMR 2020). FSMS also acknowledges the potential drivers of food insecurity, including climate change-related shocks and stresses, such as shifting rainfall patterns and flooding events.

Additionally, the 2020 Comprehensive Food Security and Vulnerability Analysis (CFSVA) conducted in Sierra Leone by WFP in partnership with the government of Sierra, provides evidence on food insecurity using a trend analysis. This analysis, conducted every five years, could be used to track climate change-related impacts on food security.

- **Air quality monitoring.** Sierra Leone lacks a robust national air quality monitoring system, despite growing concerns related to outdoor air pollution, especially in urban centers, and the potential impacts of wildfires. In 2015, EPA conducted an ambient air quality study in Freetown to analyze the impact of urban traffic. However, the absence of consistent air quality monitoring data makes evaluating the health implications of air pollution in Sierra Leone a significant challenge (EPA 2015).

TABLE 7.

Key governmental stakeholders involved in Early Warning System Implementation

AGENCY	ACTIVITIES
Sierra Leone Meteorological Agency	• Monitor and forecast the weather conditions in the country in relation to all socio-economic activities requiring meteorological or climatology services • Develop government policy in the field of meteorology, climatology, climate change, and other climate-related issues • Promote the use of meteorology in agriculture; food monitoring; the monitoring of floods, droughts, and desertification; along with other related activities • Establish, organize, and manage surface and upper air observational station networks • Provide meteorological information, advice, and warnings for agriculture; civil and military aviation; surface and marine transport; operational hydrology; management of energy and water resources; as well as search and rescue operations to mitigate the effects of adverse natural events, such as floods, storms, droughts, and disease outbreaks
Ministry of Health and Sanitation	• Monitor and manage disease outbreaks, with a focus on highly contagious and fatal diseases that have the potential of developing into epidemics

AGENCY	ACTIVITIES
Ministry of Agriculture and Forestry	• Monitor and manage pest outbreaks of crop and animal husbandry
Environmental Protection Agency	• Provide information on environment and forestry disaster situations, such as excessive pollution and fire outbreaks
Government Hospitals	• Provide information on the number of beds, nurses, and doctors available for emergency response in disaster situations

Source: World Bank Disaster Risk Management Diagnostic Note Sierra Leone 2020.



GAPS IN ADAPTIVE CAPACITY

81. Health information and surveillance systems are currently not integrated and do not include climate/weather data or other environmental factors. Integrated risk monitoring refers to the use of tools and epidemiological surveillance for early detection, in conjunction with direct and remote sensing technologies for the surveillance of the environmental determinants of health. They include water and air quality, variability in ambient temperature and humidity, or the incidence of extreme weather events. While there are potential monitoring systems (for example, meteorological, all-hazards, and food security) in place that could be useful for better understanding climate change-related health impacts, these systems currently work in silos. Further, there has been no baseline analysis to date of climate change relationships with health outcomes specific to Sierra Leone, in part due to the limitations of the health information and surveillance systems.

82. Sierra Leone has not conducted a comprehensive national assessment of climate change impacts, vulnerability, and adaptation for health. The current assessment helps to fill knowledge gaps, but additional work is needed to conduct more advanced analyses of future climate change-related health risks, explore subnational impacts, and support the prioritization and evaluation of adaptation options. While the 3rd National Communication includes a section on climate change and health-related vulnerabilities and adaptation options, it lacks any analysis of associations between climate and health outcomes, projections of future risks under different climate scenarios, the assessment of targeted vulnerable groups, and a detailed description of interventions across health risks.

83. A comprehensive climate-informed health EWS is also lacking in Sierra Leone. This includes the utilization of current disaster/environmental monitoring systems. Generalized warnings of major climate/extreme weather events are of limited value for effective preparations and response, which require the identification of specific areas and communities likely to be impacted, along with the understanding of when the impacts might occur and the potential impacts, for timely and effective decision-making. Key challenges include limitations in monitoring equipment, technology, administrative and human resources, as well as specialist technical personnel for the analysis and forecasting of hazardous climate/weather events, risk communication, and targeted public health interventions. Building from the improvements within SLMet, there are also opportunities to support climate services targeted at the needs of public health decision-makers and practitioners.

ESSENTIAL MEDICAL PRODUCTS AND TECHNOLOGIES

84. Stock-outs of essential medicines in healthcare facilities remain an issue in Sierra Leone. In 2016, the country reported having no stock-out situations of 75 percent for oral rehydration solutions, 23 percent for zinc, 75 percent for oxytocin injection, and 78 percent for magnesium sulfate. However, data on essential drugs is limited, which has complexified the assessment of the adequacies of drug stocks and resource allocation for health facilities and related planning.

85. Laboratory capabilities in Sierra Leone face several challenges, in relation to testing services, the transport of specimens, quality management, and regulations. There are an

estimated 1,200 laboratory facilities across Sierra Leone. While community health units are able to deliver testing services, including for climate-sensitive diseases like malaria, an assessment done by MoHS in 2016 found that only 13 percent of the 184 lab facilities samples were able to conduct essential basic tests (including rapid diagnostic test for malaria) (MoHS 2016). Further, poor supply chains, including high vulnerability to extreme weather events such as flooding, result in a lack of basic needs (for example, water and electricity) and contribute to stock-outs of laboratory reagents, consumables, and equipment. Lastly, there are no SOPs, accreditation, or registration licensing systems in place for laboratory facilities in Sierra Leone, thus contributing to inadequate quality control measures.



GAPS IN ADAPTIVE CAPACITY

86. Healthcare facilities, including preventive and critical care, along with dispensaries, are ill-equipped, thus increasing health risks and contributing to a lack of management of the health system's needs. Most hospitals are under-resourced, with stock-outs of medications and supplies often affecting rural health centers and PHUs. These gaps and vulnerabilities in equipment and supplies exacerbate the impact of climate-related health risks, such as disease outbreaks. Further, stockpiles of essential medicines and emergency supplies, particularly in rural areas, are needed to adequately prepare for extreme weather events.

87. Laboratory capacities and other health technologies in Sierra Leone need further assessments to better understand their abilities to manage current and projected climate-sensitive diseases. This includes the fundamental strengthening of laboratory capabilities to ensure access to essential medicines, testing, and equipment, as well as specialized protective equipment (for example, insecticide-treated bed nets and rapid diagnostic testing) to reduce climate change-related health risks.

HEALTH SERVICE DELIVERY

88. Sierra Leone suffers from several barriers that impede access to health services, which can be exacerbated by climate change.

At baseline, remote rural areas in Sierra Leone have seen slow change in access to key elements of health coverage. During climate change-related emergencies such as floods (coastal and inland), access to health services and health workers is particularly difficult. Moreover, a lack of access to health services and information has been shown to increase household vulnerability to health risks in flood prone areas. Even as access to services is improving in Sierra Leone, the adequate delivery of quality of health care remains a recurrent challenge (WHO 2017).

89. Low quality of services increases the risk of poor health outcomes.

Sierra Leone's health system is divided into three tiers of health service delivery: PHUs with extended support provided by community health workers; district hospitals; and referral hospitals providing secondary and tertiary patient care. The National Health Sector Strategic Plan (2017–21) pinpointed several key challenges with health service delivery, including inadequacies in the following areas: accessibility to health facilities, often due to geographic reasons and lack of transportation; affordability caused by high OPP expenditures; the availability of basic and specialized services; and quality issues. This reality is further reflected by the 2020 International Health Regulations (IHR) capacity progress indicator of the country's health service provision: implementation status of just 40 percent implementation status compared with 46 percent and 64 percent regionally and globally, respectively (IHR 2020).

90. Health infrastructure in Sierra Leone is impacted by several climate change-related hazards, most notably floods and landslides.

Hazard And Risk Profile Information System – Sierra Leone (HARPIS-SL) (2017) identified 81 out of 1,317 (6.7 percent) health facilities as being at risk of flood inundation. Kailahun and Bombali are the only districts that do not have health facilities at risk of flooding. Floods (coastal and inland) and landslides (notably near urban centers) are unlikely to recede given current projections (GFDRR), with potential damages to health infrastructure including healthcare facilities, especially those in remote areas, likely to be observed in a changing climate.

In Sierra Leone, where most healthcare facilities are public, services are delivered through hospitals and PHUs (see **Table 8** for health facility density per province). They are reported to be understaffed, understocked, and lacking in adequate infrastructure (WHO 2016).

91. Rural access to healthcare infrastructure is complicated by a lack of transportation and the distance patients must travel due to the limited number of health facilities within a 5-mile radius.

For the majority of Sierra Leone's population (67 percent) living in rural areas, it is difficult to access healthcare facilities. As there are no facilities near every community, the distance increases for the patients to get to other communities' healthcare facilities. This results in 15.3 percent of the total population (roughly 1.2 million people) living farther than 5 miles from health facilities.

92. Climate change is not integrated in health sector planning and programming.

When discussed in climate change policies and plans, as in the case of the 3rd National Commu-

TABLE 8.

Number of healthcare facilities by type across provinces (per 10,000 population)

PROVINCE	HEALTH FACILITY DENSITY
Western Area Urban	0.44
Western Area Rural	1.07
Kailahun	1.49
Kono	1.64
Bombali	1.64
Koina Dugu	1.64
Port Loko	1.68
Tonkilili	1.90
Kambia	1.95
Kenema	1.96
Bonthe	2.16
Pujehun	2.17
Bonthe	2.75
Moyamba	3.08
Sierra Leone	1.64

Source: Government of Sierra Leone. 2016. Annual Health Sector Performance Report 2016. <https://www.afro.who.int/sites/default/files/2017-08/Sierra%20Leone%20Health%20Sector%20%20Performance%20Report%202016.pdf>

nication, the only health-related programs being promoted are related to vector control and epidemic disease (Nhamo et al. 2021). As for Sierra Leone's NAP, there are projects and programs that address different needs indirectly affecting health, along with efforts regarding coastal communities and climate risk management, biodiversity conservation and watershed management, and climate-smart agriculture. However, strategies set out for improving nutrition or water and waste management are insufficient, considering Sierra Leone's experiences with waterborne and water-related diseases, as well as under-nutrition (MoHS 2017; NDMA 2020).

93. National environmental quality standards have been defined for air, drinking water, and noise; however, these standards are limited and not up to date, given emerging

health issues in relation to climate change.

For example, Sierra Leone faces a number of barriers regarding environmental health and sanitation due to cultural (for example, open defecation) and resource-dependent factors (for example, its WaSH infrastructure and environmental health officers). The National Environmental Health and Sanitation Strategy (2016–2020) outlines several detailed strategies to manage environmental determinants of health, including integrated waste management, integrated vector control, WaSH, and food safety. Moreover, the One Health National Emergency Risk Communication Strategic Plan similarly outlines important actions that could build resilience to climate change by strengthening collaboration among human, animal, and environmental health sectors.

94. Longer-term strategies on DRM, such as incorporating climate change trends, have been identified as part of a comprehensive approach for some climate-related health risks to reduce the overall burden.

NDMA was launched in 2020 with the mandate to use science, innovation, and data to predict, anticipate, plan for, and report on the full disaster management cycle, including a focus on climate change mitigation and adaptation. The establishment of the NDMA is a result of the NDMA Act that also created the National Disaster Management Fund and the National Platform for Disaster Risk Reduction, reflecting NDMA's consideration of climate change as a critical variable for the country's strategic planning on DRM. NDMA also highlights the need for cooperation among different governmental institutions, regional disaster management committees in each administrative region, the Chiefdom Disaster

Management Committees in each chiefdom, and private initiatives, community organizations, and private initiatives. Moreover, the agency has deepened efforts to evaluate, adapt, and improve EWS and disseminate the information, which could be expanded to the health sector (NDMA 2020).

The creation of these institutional structures stems from the work conducted under the Office of National Security (ONS): it has been mandated to coordinate the management of national disaster mitigation, including the preparation of a Disaster Management Policy (2006) and a National Disaster Management Plan (2006), along with the establishment of a specific Disaster Management Department. An updated National Disaster Risk Management Policy and Emergency Preparedness and Response Plan are currently under development to reflect the new institutional arrangement.



GAPS IN ADAPTIVE CAPACITY

95. Health service delivery in Sierra Leone faces fundamental challenges, in terms of accessibility, affordability, availability, quality, and inefficiency. Given the barriers to quality health service delivery facing Sierra Leone already, additional shocks and stresses related to climate change have the potential to exacerbate existing issues. Health system strengthening is needed to enhance its adaptive capacity and identify further gaps in planning and service delivery.

96. Climate-resilient healthcare facility and health infrastructure assessments lack adaptive retrofitting approaches, long-term construction planning, and opportunities to reduce carbon footprints. This includes adequate coordination across sectors to ensure that climate risks are incorporated into infrastructure planning. Protection from flooding events (coastal and inland) or landslides requires that overall strategies for future climate projection guide existing infrastructure. There is also an urgent need to establish/strengthen/implement national guidelines, standards, zoning, and building codes to support the building of resilience and the strengthening of health technologies and infrastructure for climate change-related events.

97. Essential infrastructure, including for health, should be planned after assessing the relevant quantitative and qualitative information regarding an area's geographical distribution, vulner-

ability, and hazard occurrence to reduce the risk of damage from climate-related phenomena.

Currently, there are initiatives on DRM that are focused on increased awareness, governance, and collaboration among sectors, the improvement of finance mechanisms, and preparation and post-disaster recovery. However, the extent to which infrastructure assessments for the health sector are being conducted, building designs are incorporating projected climate change impacts, and retrofitting measures are being carried out is still unclear (World Bank 2020).

98. There is a lack of access to healthcare facilities in rural areas, which is exacerbated during extreme weather events related to climate change.

Sierra Leone's experience with Ebola management tested the country's health system, leading to improvements in essential healthcare services and infrastructure for addressing the epidemic. However, those efforts have not been long-lasting and they have not incorporated climate change into strategic planning for healthcare facilities, including building long-term resilience, supporting ongoing maintenance, and possible relocation.

99. Climate change and associated impacts are not mainstreamed into the operations of health programs, nationally or subnationally.

Climate change impacts a wide range of health interventions that are important for service delivery, including CDs, maternal and child health, and nutrition; yet, there is no designated unit within MOHS that focuses on climate change and health risks. Although climate change adaptation actions that could improve population health have been identified, notably in climate change planning, they have not been incorporated into health sector planning and operations.

100. Climate change is, and will, likely continue to impact other determinants of health in Sierra Leone, such as water quality and quantity, air quality, nutrition and food security, waste management, and housing.

Programs exist (for example, Environmental and One Health) that would contribute to enhanced adaptive capacity to manage climate change and health risks. However, none of the described interventions considers the effects of climate change on the implementation of these plans now and into the future.

101. Baseline information is lacking in the key environmental determinants of health, including air pollution and WASH coverage in healthcare facilities.

For example, there is a need to build climate-resilient water and sanitation systems and infrastructure in Sierra Leone. This includes efforts to promote education and social awareness in confronting and controlling water pollution, along with waterborne and water-related diseases, and subsequently in improving human health, as well as further policy level actions, particularly at district levels, to create water regulatory authorities.

102. Experience from past disasters and an assessment of the DRM system have highlighted the lack of adequate institutional and policy frameworks for the efficient execution of DRM mandates (World Bank 2020).

This leads to overall inadequate disaster preparedness and response systems, including limited early warning and monitoring capabilities, infrastructure, equipment, and human resources. Further, the link between DRM and climate change adaptation for health, including coordination with MoHS around specific interventions, could be strengthened.

FINANCING

103. Although the healthcare sector has been severely compromised due to flooding (coastal and inland), landslides, as well as the Ebola epidemic and now COVID-19 pandemic, Sierra Leone has increased its expenditure (as a percentage of GDP) in this sector over the last decade.

Public health spending rose from 10.94 percent in 2010 to 16.06 percent as of 2018. According to the National Health Accounts (NHA), public health expenditure was approximately USD590 million in 2013, where 47 percent came from donors, 33 percent from households, 12 percent from NGOs, and 7 percent from the government. In 2013, 52 percent of the total budget went to hospitals and 30 percent to PHUs. From 2014 to 2015, the country increased its health expenditure to respond to the Ebola epidemic, underlining the relevance of health financing within the country's budget. During this time, 63 percent of the total budget was directed to address the epidemic. The last report on health financing was produced in 2016, and it is also included as a relevant topic within the country's National Health Sector Strategic Plan 2017–2021.

104. Despite increases, low public financing on health in Sierra Leone has led to significant OOP payments, thereby increasing poverty, especially in light of ongoing climate-related risks.

By 2018, there was a per capita public expenditure of 85.775 (World Bank 2018). Moreover, OOP expenditure represented 44.77 percent. Most of the funding comes from donors and multilateral cooperation with organizations such as UKAID, the African Development Bank, and Centers for Disease Control and Prevention (CDC) (WHO 2017).

More recently, the government created the FHCI to reduce OOP expenditure for pregnant and lactating mothers and children under 5 years old. The initiative provides funding of approximately USD97 million in 2015 — an amount that is expected to increase to USD136 million by 2025. Most of this budget has been directed to increasing salaries for health workers and drugs procurement.

105. Limited experience with strategic purchasing precludes climate and health results from being appropriately achieved in Sierra Leone.

The prioritization of basic health services and preventative programs are the most effective approach that governments can adopt to strategically purchase health services. The shift from passive budgeting to strategic purchasing can ensure improvements in health outcomes while strengthening governance and accountability mechanisms. Further, it is incumbent upon governments to embrace an equity lens to ensure pro-poor health care service delivery. Selection of providers using public funds should consider capacity, quality, and price. To this end, considerations for different provider payment mechanisms need to be given full attention to incentivize provider behaviors geared toward achieving strategic objectives. Finally, dimensions related to regulation, provider autonomy, and competition are fundamental for successful strategic purchasing arrangements.

106. There is no evident allocation of funding dedicated to addressing climate change's impact on health and health systems within the health sector. To date, the government has prioritized climate-related interventions (EPA 2021) that take into account environmental determinants of health such as adaptation

measures for the agricultural sector and food security, forest management and protection, water and sanitation management (EPA 2021). However, there is no integration of climate change risks into their National Health Sector Strategic Plan 2017–2021, nor are there precise strategic planning for climate-related health finance and resource allocations for climate-related health risks and vulnerabilities. The country is currently developing an updated

NAP; however, it is unclear how or if the health sector will be prioritized, which could hinder climate-related health resource allocations. Thus far, the government has prioritized climate-related interventions that consider environmental determinants of health such as adaptation measures for the agricultural sector and food security, forest management and protection, water and sanitation management).



GAPS IN ADAPTIVE CAPACITY

107. Sierra Leone's health budget is dependent on OOP expenditure and aid or donors' resource allocations. The country needs to prioritize health and increase expenditure (as a percentage of GDP), while building a financial model that is aimed at reducing dependence on aid and donors. Building resilient health systems for climate change requires budget allocations as an integrated component in the overall planning of a national health plan.

108. Guidelines for integrating a climate-resilient approach for health care and public health systems are not available to inform rationalized resource allocations. Raising awareness is needed both within and outside the health sector to communicate the current and projected climate and health risks and the necessary adaptation resources to prevent related mortality and morbidity. Although there are health priorities within the country's climate change policy, there is no integration of climate change events into the health system's budget planning. As a result, no current funds are allocated to climate-related health interventions within MoHS. Further, from a climate change perspective, there are no precise estimations of funding aimed at climate-related adaptation investments, including for the health sector.

109. Risk pooling in Sierra Leone does not account for climate and health-related risks. In general terms, illnesses and health care costs are not evenly distributed, with some population groups facing higher health risks, which may be exacerbated by climate change. Climate change can augment underlying health burdens, while increasing the potential and size of certain catastrophic financial health risks, especially among the most vulnerable.

Risk pooling can address this challenge. Strategies to mobilize health funds will, to a large extent, determine the mechanisms and ability to pool resources to address such risks. General revenues are most suited for pooling risks if health services are accessible to the entire population or for subsidizing premiums of high-risk groups. In Sierra Leone, government-pooled funds for health through general

revenues are limited; moreover, they are characterized by a high level of fragmentation. Non-government pools of funding for health include private health insurance and social security funds. Further, as previously noted, OOP expenditures that constitute the largest share of total health expenditures are not pooled at any level. These arrangements do not take into account the pooling of funds for climate-related risks, thereby falling short of providing any form of financial protection for the poor and vulnerable populations affected by climate- and health-related risks.

110. Health co-benefits of climate change mitigation have not been adequately promoted as cost-effective options. Arguments for implementing climate change mitigation policies often focus on perceived short-term financial gains. However, cost assessments rarely account for the benefits of these policies and the appropriate actions needed to improve human health. Therefore, additional studies are needed to quantify further economic costs and the health co-benefits of climate change mitigation policies in Sierra Leone.

TABLE 9.

Summary of the health system's adaptive capacity gaps for Sierra Leone

HEALTH SYSTEM'S BUILDING BLOCK	SUMMARY OF GAPS IN ADAPTIVE CAPACITY
Leadership and governance	• Prioritization of climate change, along with health risks and adaptation options, in national policies and plans (both health and climate change-focused) remains varied and lacking in specific detail • Limited engagement of health sector with coordination mechanisms to facilitate cross-sector action on climate change • Implementation of policies and plans, particularly at subnational levels, slow and fragmented
Health workforce	• Health sector facing an imbalance in number, skill mix, and deployment of health workforce, including large urban-rural disparities • Absence of a systematic approach for the capacity development of the health workforce in climate change, including the development and integration of training materials • Knowledge, technical capacity, and resources of the health workforce to prevent and manage current and future climate change-related health risks still unknown
Health information and disease surveillance systems	• Health information and disease surveillance systems currently not integrated, with no inclusion of climate/weather data or other environmental factors • No comprehensive climate-informed health EWS • Comprehensive national assessment of climate change impacts, vulnerability, and adaptations for health needing to be conducted
Essential medical products and technologies	• Healthcare facilities under-resourced and hard to reach in rural areas, especially during extreme weather events • Laboratory capacities and other health technologies in Sierra Leone needing further assessment to better understand the ability to manage current and projected climate-sensitive diseases, as well as guide dissemination of resources

HEALTH SYSTEM'S BUILDING BLOCK

SUMMARY OF GAPS IN ADAPTIVE CAPACITY

Health service delivery

- Coordinated approach lacking at multiple levels with multiple stakeholders to address climate-sensitive epidemics and disease outbreaks
- Climate-resilient healthcare facility and health infrastructure assessments lacking, including addressing inadequate coordination across sectors to ensure incorporation of climate risks into infrastructure planning
- Climate change and associated impacts needing to be mainstreamed into the operations of health programs at all levels
- Baseline information lacking on the key environmental determinants of health
- Strengthened disaster contingency plans needed, especially at the community level

Financing

- Guidelines for integrating a climate-resilient approach in health care and public health systems unavailable for informing rationalized resource allocations
- Risk pooling in Sierra Leone needing to account for climate- and health- related risks
- Budgets within the health sector needing to incorporate climate change risks
- Health co-benefits of climate change mitigation inadequately promoted as cost-effective options



RECOMMENDATIONS TO ENHANCE HEALTH SYSTEM RESILIENCE TO CLIMATE CHANGE

This section outlines a set of recommendations to enhance Sierra Leone’s health system resilience and adaptation to climate change, including potential health interventions and strategies that can be put in place. The recommended options are based on an assessment of both the magnitude of the current and projected climate-related health risks and the existing gaps in adaptive capacity to manage and/or prevent these risks.

This section is organized, using the 10 components of climate-resilient health systems (**Figure 14**), and it draws from consultations and reviews of all relevant governmental policies, as well as the World Bank’s Health, Nutrition and Populations (HNP) Climate and Health Guidance Note. See Annex D for a summary of recommendations for building a climate-resilient health system across identified climate change-related health risks.

COMPONENT 1: LEADERSHIP AND GOVERNANCE

Options to strengthen leadership and governance include the following aspects:

NATIONAL (CENTRAL-LEVEL GOVERNMENT AGENCY IN CHARGE OF CLIMATE CHANGE ACTION)

- Integrate health into national-level climate adaptation planning, with the priority being

the NAP, as well as the next round of NDCs. This should include detailed descriptions of priority climate change-related risks, health sector adaptation options, and opportunities to link with non-health sectors. Currently, when health is mentioned, the information is limited and too broad to effectively inform concrete action.

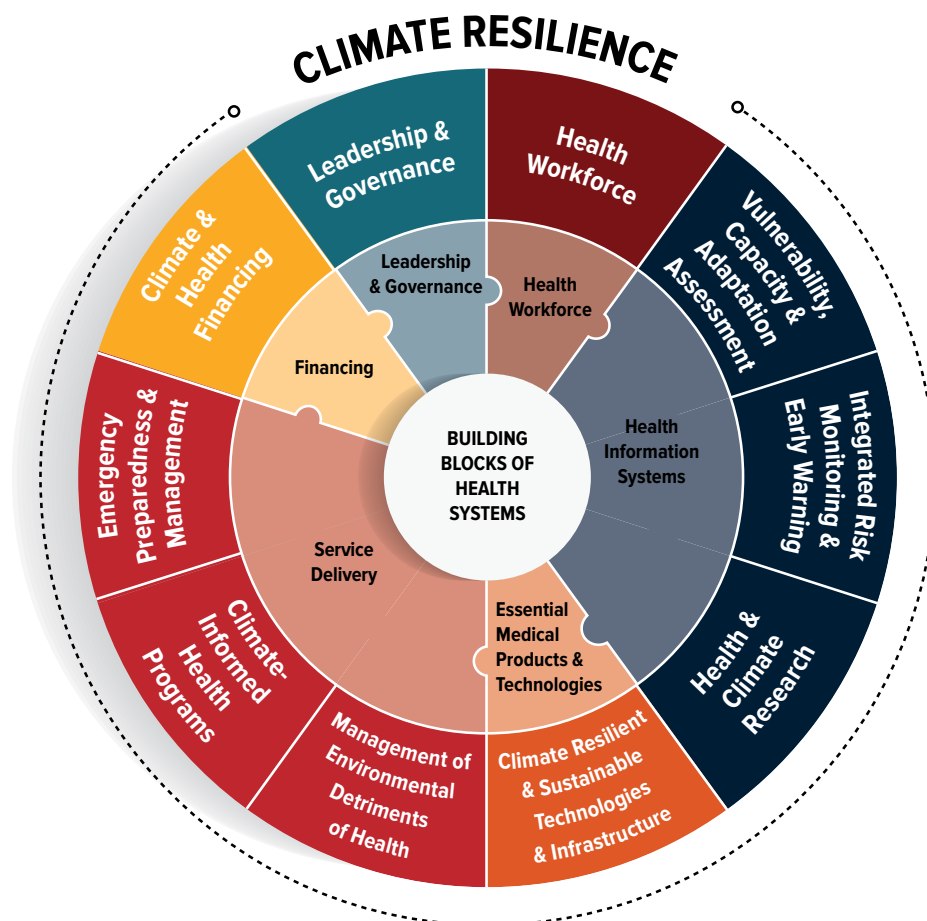
- Facilitate a memorandum of understanding (MOU) between MOHS and other key stakeholders at the national level, including other sectors such as agriculture, planning and development, and transportation. This could link the health sector to the NSCC multistakeholder committee and strengthen their engagement with each other.

NATIONAL (HEALTH SECTOR)

- Develop a Climate Change and Health National Strategy and Action Plan that should incorporate all available evidence and senior en-

FIGURE 14.

WHO's Operational Framework for Building Climate-Resilient Health Systems



Source: World Health Organization, 2015, Operational Framework for Building Climate Resilient Health Systems.

dorsement to facilitate implementation. This should also be closely aligned with the NAP to facilitate integration and enable multisectoral approaches to be implemented.

- Systematically integrate adaptation activities to respond to identified climate-related health risks when updating the National Health Sector Strategic Plan (2017–2021). This could build from the past experience with the Ebola outbreak, mobilizing resources and stakeholders to strengthen health system functions.
- Establish/form a unit on climate change and health in MoHS that includes a team of specialists to plan, coordinate, and monitor action on

climate change in the health sector, including the designation of a national climate and health focal point.

- Develop and deliver climate- and health-related workshops and national policy briefs aimed at senior health sector policymakers, as well as collaborate with other key sectors, to develop climate and health policies and plans and advocate for them at the national level.

SUBNATIONAL

- Develop subnational adaptation plans for climate change and health. This could enable the prioritization of adaptation needs and

ensure the allocation of sufficient financial resources for implementation by local councils at district levels.

- Develop city-level policies and plans for climate-related health risks. This could build from the momentum of the appointment of Africa's first Chief Heat Officer in Freetown, as well as activities highlighted in the Transform Freetown Strategy in relation to urban greening, flood resilience, improved WASH systems, and nutrition interventions. These activities could be replicated in other urban centers such as Bo, as well as the Northern Province that is projected to experience increases in extreme temperatures.

COMPONENT 2: HEALTH WORKFORCE

Options to strengthen the health workforce include the following areas:

- Conduct a specific climate and health workforce needs and knowledge assessment to integrate climate change-related impacts into workforce planning. This would include considerations of the size of the health workforce, the skill mixes, and the geographical distributions of personnel needed to meet expected health needs (for example, addressing urban-rural disparities).
- Train health sector policy makers and planners to use climate information to inform the design of health sector programs and enhance day-to-day service delivery as well as during and after extreme weather events, such as flooding (coastal and inland). This may also include designing protocols to reduce risks to health workers in flood-prone areas (for example, evacuation plans and alerts), particularly in Freetown and coastal communities, which are the most vulnerable to flood risks.
- Create a national curriculum that integrates climate-related health threats into medical

and nursing schools, as well as for all other health professionals, to ensure that the health workforce of tomorrow possesses the knowledge and skills to deliver health care in a changing climate.

- Develop educational and awareness-raising materials and implement training for health-care workers to better understand the health impacts of climate change, including the utilization of train-the-trainer (ToT) models. This may include capacity-building activities, such as targeted training for health personnel to manage changes in VBDs (especially dengue and chikungunya), heat-related illnesses, and food insecurity/undernutrition, particularly at subnational levels, as well as conduct analyses of climate-sensitive diseases, and vulnerability and adaptation assessments.

COMPONENT 3: VULNERABILITY, CAPACITY, AND ADAPTATION ASSESSMENT

Options to strengthen vulnerability, capacity, and adaptation assessments include these areas:

- Conduct additional climate change and health vulnerability and adaptation assessments to capture new information and engage stakeholders, including conducting more advanced analyses and prioritizing adaptation interventions. Assessments should be repeated at least every five years. This could include the exploration of impacts and adaptation at subnational levels, including the evaluation of adaptation interventions.
- Utilize modeling techniques, including climate, disease, and economic scenarios to guide future vulnerability adaptation assessments. This could integrate outputs from tools currently under development by the World Bank, including the Climate and Health Economic Valuation

Tool (CHEVT), as well as others. These tools would make use of information collected in this and other CHVAs.

- Conduct a review of the climate resilience of current healthcare infrastructure, including the impacts of extreme weather events such as flooding (coastal and inland). This should start with the 81 healthcare facilities identified as being at risk of flooding.
- Review the extent to which current health information systems incorporate meteorological variables for climate-sensitive diseases.

COMPONENT 4: INTEGRATED RISK MONITORING AND EARLY WARNING

Options to strengthen integrated risk monitoring and EWS include these aspects:

- Support expanded, enhanced, and electronic coverage of health surveillance for climate-sensitive diseases, for example, in terms of geographic, population, and seasonal aspects. This should build from lessons learned during the Ebola outbreak that would include linking with environmental/meteorological monitoring structures to develop climate-informed EWS and response mechanisms. For example, flood monitoring systems should be linked to public health communication channels that disseminate educational materials and risk messaging to reduce water-related diseases before and after an event.
- Support hospitals in updating their admissions and emergency case records to track heat-related morbidity and mortality, as well as other climate-sensitive diseases, starting with the Eastern and Northern Provinces, which are projected to experience significant temperature increases.
- Develop EWS for extreme weather events, such as heatwaves and flooding (coastal and

inland), to better integrate and disseminate health information (for example, vector-borne and water-related disease outbreaks following flooding events) and link with emergency operations center systems (see [Table 7](#) in Section IV for key stakeholders involved in EWS).

- Review the extent to which human, animal, and plant disease surveillance systems are integrated and incorporate climate factors to ensure that a One Health approach is utilized and strengthened. This should build from the National One Health Strategic Plan (2019–2023) and Communication Strategy that incorporates lessons from the Ebola outbreak to strengthen multisector government coordination, collaboration, and communication for preparedness and response to emergencies and public health threats.
- Collect information to establish and centralize agreed baselines for monitoring vulnerable populations/regions and existing or new health-related human resource, technical, and health services delivery capacity.
- Support the identification and/or development of indicators to measure climate change and health impacts and response capacity for integration into national and subnational monitoring systems. This would also support future climate change and health vulnerability and adaptation assessments.

COMPONENT 5: HEALTH AND CLIMATE RESEARCH

Options to strengthen climate and health research include the following areas:

- Develop research partnerships (for example, national and international academic institutions) to conduct studies and projects on key climate change and health topics, such as the following:

1. Modeling studies to quantify the current and projected burdens of climate-sensitive diseases,
 2. Economic analyses to better understand the healthcare costs related to climate change,
 3. Quantification of the health co-benefits of climate change mitigation actions,
 4. Operational research to test and evaluate the implementation of evidence-based interventions, such as targeted resource deployment for extreme weather events; and
 5. Development and testing of contextualized climate change and health risk communication materials and dissemination approaches.
- Additionally, research priorities for specific climate-related health risks may include studies on climate-resilient crops, analyses of malaria breeding sites related to irrigation systems, and analyses of water demand under different climate scenarios.

COMPONENT 6: CLIMATE-RESILIENT AND SUSTAINABLE TECHNOLOGIES AND INFRASTRUCTURE

Options to strengthen the climate resilience of health technologies and infrastructure include these areas:

- Conduct an assessment of the climate vulnerability of current health infrastructure in Sierra Leone, including closely-linked systems (for example, transportation, coastal/fisheries, energy, along with water and sanitation, systems and infrastructure). This could include agreeing on a minimum threshold for health care infrastructure to be considered climate resilient and environmentally sustainable in Sierra Leone.
- Assess current laboratory capacities to diagnose current and future climate-related diseases, particularly emerging and reemerging CDs, such as VBDs (for example, dengue and chikungunya), as well as NCD burdens.
- Develop and implement national building codes/permits for healthcare facilities, including to retrofit, refurbish, and maintain existing health infrastructure. Importantly, this should include the incorporation of climate risk projections into these codes/permits, for example, to include siting and construction, functioning and operation, energy and water supplies, storm drains and sewers, and sanitation services of health care facilities, as well as a focus on improving the transportation network to ensure access to facilities during extreme weather events.
- Support the integration of new and innovative technologies to monitor environmental change (for example, satellite imagery) to inform measures that will improve the performance of the health system, for example, to directly support local health capacity planning to respond to anticipated increases in water-related diseases and food insecurity due to climate change. Other examples would relate to droughts and nutrition, precipitation, heat and humidity, and VBDs, as well as mapping air quality impacts on health outcomes. Mental health services should also be considered.
- Introduce sustainable cooling measures (for example, increasing natural ventilation, and integrating solar and biomass energy sources) for health care facilities and laboratories to enhance energy efficiency, space cooling, and medical cold chains, and ensure sustainable refrigerant technologies are used. These measures should follow a hierarchy of interventions starting from passive measures, such as building design and vegetative shading, to more active technologies, such as powered air conditioning as a secondary option.

- Development of structures to integrate health and climate considerations into urban design to reduce the threat of urban heat islands, especially in Freetown, with a focus on informal settlements. This could involve strengthening health impact assessments and specific initiatives, such as the continued support of urban tree planting in cities, cool-roof interventions (for example, painting roofs white), and the development of public transport systems, as identified in the Transform Freetown Strategy.

Actions that have also been identified as contributors to enhanced sustainability and reduced GHGs in the health sector include the following:

- Assess the carbon footprint of Sierra Leone's health sector.
- Prioritize sustainability in the selection of health system procurement strategies procedures and products that would include focusing on the incorporation of low-carbon, energy-efficient technologies, such as photovoltaic cells, solar-powered machinery, vaccine chains, and water pumps.
- Promote modern energy cooking solutions (MECS), such as low-emission cookstoves, to reduce solid fuel use and household air pollution.
- Develop regulations that support sustainable healthcare waste management (for example, shifting away from medical waste incineration and promoting the recycling of non-hazardous waste at facility levels where possible).

COMPONENT 7: MANAGEMENT OF ENVIRONMENTAL DETERMINANTS OF HEALTH

Options to strengthen the management of environmental determinants of health include the following areas:

- Develop improved national regulations and policies on key environmental health services and determinants (for example, drinking water, air quality, food system, housing, transport, energy, and waste management).
- Map areas using unsafe drinking water and unimproved sanitation facilities; assess service delivery gaps; and invest in improved drinking water, sanitation, and sewage infrastructure to improve water quality and reduce climate-driven exposures.
- Establish an improved centralized healthcare and medical waste management system in Freetown and other urban centers that can withstand the impacts of extreme weather events.
- Support community-led efforts to improve sanitation practices and controls to prevent water and foodborne diseases, as well as communicate potential climate change-related risks.
- Establish a climate and environmental health database to support the development of national regulations on the management of environmental health services (for example, water supply, sanitation, and food safety).
- Increase support and integration with non-health sector-focused interventions. This could include, for example, the promotion of sustainable/climate-smart agricultural practices by smallholder farmers (for example, alternate wet and dry irrigation for rice), appropriate modeling tools to assist strategic planning of water resources under climate change, and/or technical guidelines that incorporate climate change to increase supportive supervision, along with the monitoring and testing of potable water and sanitation services.

COMPONENT 8: CLIMATE-INFORMED HEALTH PROGRAMS

Options to strengthen climate-informed health programs include these areas:

- Use mainstream and social media to spread awareness and issue warnings related to preventive measures for improving population health literacy concerning climate-sensitive health risks.
- Engage district-level community groups (focusing on youth and women's groups) and leadership structures (for example, chiefdoms disaster management committees) to support dialogues and the development of prospective climate and health programs and policy options, as well as their integration into the planning and support of health promotion programs directed toward climate-related health threats. This could include incorporating climate change risks into existing supplementary and/or emergency feeding programs to reduce undernutrition.
- Strengthen PHC through actions to ensure these systems have improved adaptive capacity, including knowledge and resources to manage current and future climate change-related risks. Activities may include revising public health program SOPs to incorporate responses to climate risks and the delivery of interventions, as well as mainstreaming climate change risks into relevant policies and operational plans for VBDs, water-related diseases, and nutrition programs.

COMPONENT 9: EMERGENCY PREPAREDNESS AND MANAGEMENT

Options to strengthen emergency preparedness and the management of climate change-related disaster risks include these aspects:

- Establish a national risk register that includes climate change-related risks, and if necessary, implement a process of national risk assessment to enable the prioritization of climate-related health risks alongside other national-level threats.
- Enhance contingency planning for deployment and response (at national, provincial, district, and community levels) for acute climate shocks, such as flooding and consequent disease outbreaks, as well as longer-term climate stressors, such as droughts and SLR. This should include integrating climate-related health considerations into district-level and community-level disaster management plans to support stakeholders in organizing activities related to the preparedness of emergency responses.
- Establish seasonal and sub-seasonal climate outlooks (MoHS, in collaboration with the Meteorological Agency) to inform disease control/prevention programs ahead of potential extreme weather events, as well as facilitate multisectoral engagement with first responders, disaster management authorities, and community-based groups to conduct outreach and awareness regarding climate-sensitive diseases.
- Ensure climate-related health risks are integrated into stockpiling and distribution plans to support disaster response supplies (for example, water purifiers and safe water storage containers).
- Conduct scenario-based simulation exercises with subnational health workers to enhance planning and response to health emergencies that are outside the range of historical experience.

COMPONENT 10: CLIMATE AND HEALTH FINANCING

Ultimately, the aim of establishing the recommendations below is to reach a “climate-smart” UHC approach through the lens of health financing. Options to strengthen climate and health financing include the following actions:

- Establish a budget line item at the national level to finance critical preparedness activities and adaptation interventions.
- Initiate pooling health funds to cover climate-related health risks. This could include the consideration of a pre-payment mechanism for providing this financial protection for climate-related health impacts through the pooling of resources. Additionally, this could include expanding the FHCI to reduce OOP expenditure as a subsidy.
- Ensure that strategic purchasing (for example, increasing the equitable distribution of resources) includes climate considerations. This should be tailored to include climate considerations across national and subnational levels. The impact of climate on the utilization of resources needs to be factored into pro-

vincial and district health investment plans for building climate resilience at subnational levels and for supporting continued investments in poverty reduction, health equity promotion, and increased access to essential services. This should also incorporate mitigation activities, such as the solarization of health facilities.

- Explore the financial benefits of the health co-benefits of climate action. The economic benefits of mobilization of financial resources in Sierra Leone seeks to support the health sector in assessing the co-benefits of climate action in other health-determining sectors and to identify climate actions that bring the greatest benefits to health.
- Seek international and external donor funding opportunities and mechanisms. This can include the Green Climate Fund, Global Environment Facility, and the Adaptation Fund for dissemination toward health-based adaptation measures, the control of climate-sensitive diseases, research projects, and mitigation projects, including the NDCs. Additionally, there should be efforts to improve engagement from the health sector with ongoing and/or planned climate change adaptation projects.

ANNEXES

ANNEX A. METHODS FOR THE ESTIMATION OF MOSQUITO SUITABILITY UNDER RCP 8.5 IN SIERRA LEONE

MODEL CONSTRUCTION

Spatio-temporal distributions of *Anopheles gambiae* s.l. mosquitoes were determined, using a raster-based suitability model constructed with the Google Earth Engine. It was adapted from the methodology presented by Frake et al. [107]. This methodology uses abiotic variables specific to the thermal tolerances of vector species and biotic variables that give consideration to species habitat preferences. “Suitable areas” are defined as patches of landscape that facilitate the development of malaria mosquitoes through the production and persistence of oviposition sites and where temperatures do not exceed or fall below thermal tolerances. Parameter thresholds of all input variables were selected, based on a literature review of the *Anopheles gambiae* s.l. habitat: Temperature, Landcover, Precipitation, Flow Accumulation, and Water Resources (Table A1).

The thresholds were then used to create binary maps for each predictor (that is, “suitable” [1] or “unsuitable” [0]) that were combined using Boolean logic to produce suitability maps for Sierra Leone’s historic malaria transmission period (May–November) across three epochs — the historical reference period of 1986–2005), along with 2030–2049 and 2040–2059 [108]. Population vulnerability was demonstrated by spatially overlaying the suitability maps of malaria

mosquitoes in Sierra Leone with population data from the Global Human Settlement Layers (2015) to calculate the number of Sierra Leoneans residing in suitable areas, by region. Population data was held constant in all models in the absence of spatial population projection data. The output spatial resolution of products is 1000 meters this analysis is performed at the landscape, not the microscale, level. Microscale variations in climatological and land use and land cover can and do affect the species’ actual distributions.

SUITABILITY DATA AND PARAMETERS

Temperature

Temperature is critical to mosquito development and life history. Temperatures that are either too low or too high can increase mortality in aquatic or adult stages. Bayoh and Lindsay [109] demonstrated that the upper and lower thresholds for *Anopheles gambiae* s.s. aquatic development are 18°C and 34°C, respectively. The minimum and maximum temperature thresholds for this analysis were set to 18°C and 34°C, respectively. Data was acquired from the NASA NEX-GDDP at a spatial resolution of 0.25 degree.

Land Use and Land Cover

There is a significant relationship between land use and land cover and the distribution of mosquito species, with many species demonstrating strong preferences for specific land cover types. Land Use and Land Cover (LULC) data was acquired from the Copernicus Global Land Service Proba-V-c3 product. To determine whether classifications were suitable for *Anopheles gambiae* s.l. mosquitoes, class descriptions were compared to

the habitat preferences of the species according to the literature review. The mosquito habitats of *Anopheles gambiae* are characterized by open, sunlit pools: they may be associated with human activity including agriculture, which may facilitate water pooling.

In this analysis, M-form and S-form *Anopheles gambiae* s.s. (now known as *Anopheles coluzzi* and *Anopheles gambiae* s.s., respectively) mosquitoes’

habitat preferences were considered. *Anopheles coluzzi* show a preference for forested areas, greater sunlight exposure, higher water vapor pressure, along with lower temperatures and evapotranspiration. S-forms prefer dry savannah and deciduous forests. To account for these species’ preferences, Proba class values — 20, 30, 40, 50, 60, 90, 111, 112, 113, 114, 115, 116, 121, 122, 123, 124, 125, and 126 — were set to “suitable” (**Table A2**).

TABLE A1.

Model parameterization and data sources for habitat characterization

INDICATOR	DATA SOURCE	PRODUCT	SPATIAL RESOLUTION	THRESHOLD
Temperature	NASA	NEX-GDDP	0.25 degrees	<i>Anopheles gambiae</i> s.s. Min: 18°C Max: 34°C
Land Cover	Copernicus Global Land Service	Proba-V-C3	100 m	See Table A2*
Water Resources	JRC	GSW1_0	30 m	>0 percent water occurrence
Flow Accumulation	WWF	HydroSHEDS	500 m	
Population	JRC	GHSL/P2016/POP_GPW_GLOBE_V1		

TABLE A2.

Copernicus Global Land Cover Layers: CG:S-LC100 Collection 2 global landcover map classifications

CLASS VALUE	CLASS DESCRIPTION	SUITABLE ANOPHELES GAMBIAE S.L. LAND COVER
0	Unknown; no or not enough satellite data available	No
20	Shrubs; woody perennial plants with persistent and woody stems and without any defined main stem being less than 5 m tall; shrub foliage either evergreen or deciduous	Yes
30	Herbaceous vegetation; plants without persistent stem or shoots above ground and lacking definite firm structure; tree and shrub cover less than 10%	Yes

CLASS VALUE	CLASS DESCRIPTION	SUITABLE ANOPHELES GAMBIAE S.L. LAND COVER
40	Cultivated and managed vegetation/agriculture; lands covered with temporary crops followed by harvest and a bare soil period (for example, single and multiple cropping systems; note that perennial woody crops will be classified as the appropriate forest or shrub land cover type	Yes
50	Urban/built-up; land covered by buildings and other man-made structures	Yes
60	Bare/sparse vegetation; lands with exposed soil, sand, or rocks, and never with more than 10% vegetated cover during any time of the year	Yes
70	Snow and ice; lands under snow or ice cover throughout the year	No
80	Permanent water bodies; lakes, reservoirs, and rivers; either freshwater or saltwater bodies	No
90	Herbaceous wetland; lands with a permanent mixture of water and herbaceous or woody vegetation; vegetation present in either salt, brackish, or freshwater	Yes
100	Moss and lichen	No
111	Closed forest, evergreen needle leaf; tree canopy >70 %, almost all needle leaf trees remaining green all year round; canopy never without green foliage	Yes
112	Closed forest, evergreen broadleaf; tree canopy >70 %, almost all broadleaf trees remaining green all year round; canopy never without green foliage	Yes
113	Closed forest, deciduous needle leaf; tree canopy >70 %, consisting of seasonal needle leaf tree communities with an annual cycle of leaf-on and leaf-off periods	Yes
114	Closed forest, deciduous broadleaf; tree canopy >70 %, consists of seasonal broadleaf tree communities with an annual cycle of leaf-on and leaf-off periods	Yes
115	Closed forest, mixed	Yes
116	Closed forest, not matching any of the other definitions	Yes
121	Open forest, evergreen needle leaf; top layer — trees 15–70 % and second layer — mix of shrubs and grassland, consisting of almost all needle leaf trees that remain green all year round; canopy never without green foliage	Yes
122	Open forest, evergreen broadleaf; top layer — trees 15–70% and second layer — mix of shrubs and grassland, consisting of almost all broadleaf trees that remain green all year round; canopy never without green foliage	Yes
123	Open forest, deciduous needle leaf; top layer — trees 15–70% and second layer — mix of shrubs and grassland, consisting of seasonal needle-leaf tree communities with an annual cycle of leaf-on and leaf-off periods	Yes
124	Open forest, deciduous broadleaf; top layer — trees, 15–70% and second layer — mix of shrubs and grassland, consisting of seasonal broadleaf tree communities with an annual cycle of leaf-on and leaf-off periods	Yes
125	Open forest, mixed	Yes
126	Open forest, not matching any of the other definitions	Yes
200	Oceans, seas; either freshwater or saltwater bodies	No

Precipitation

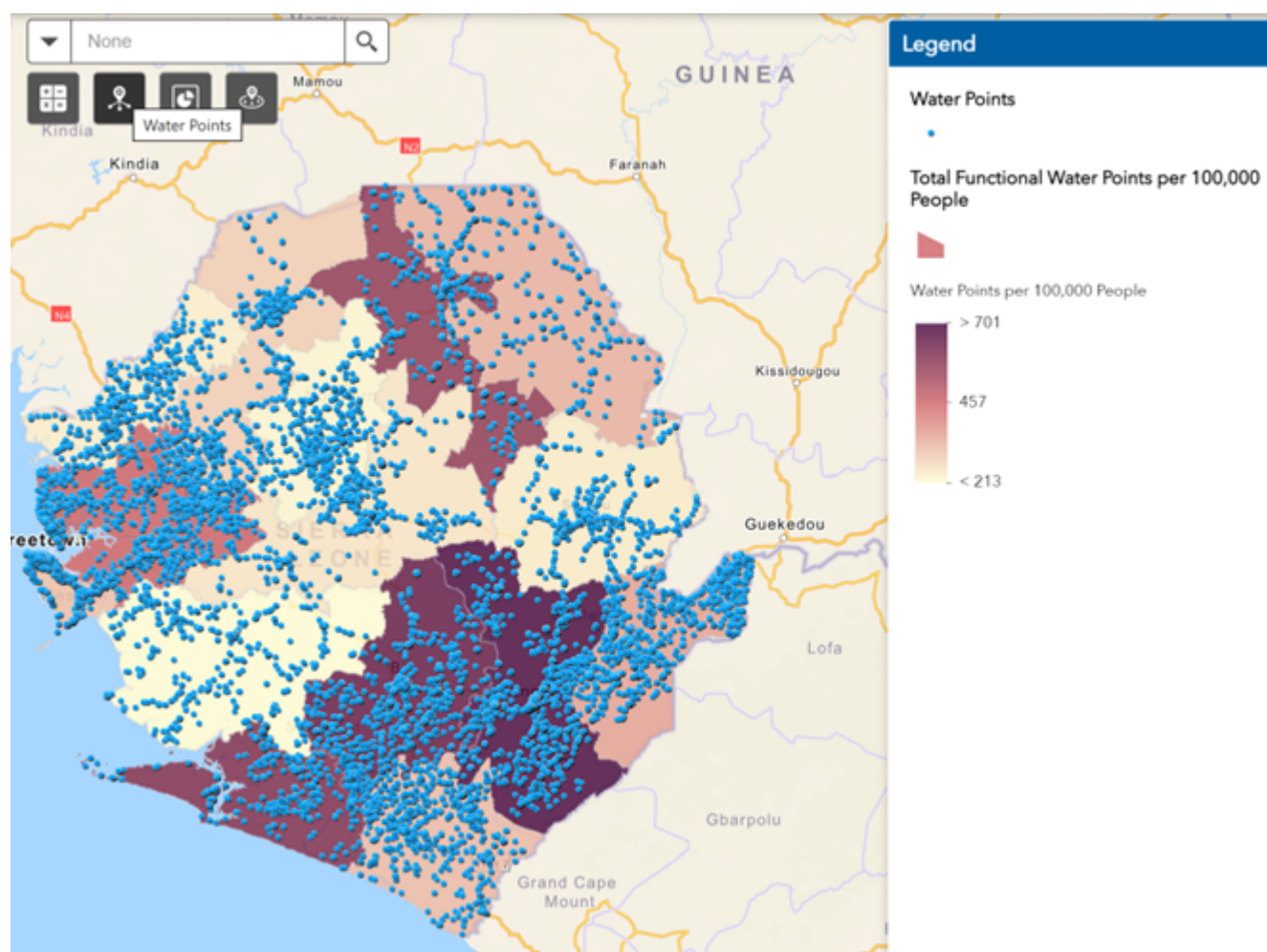
Water is fundamental to mosquito larvae development. To estimate areas likely to become inundated, annual average precipitation was calculated from the Climate Hazards Group InfraRed Precipitation and Station Data (CHIRPS v2.0). Likewise, flow accumulation was derived from the HydroSHEDS Flow Accumulation product to determine the natural drainage from a given pixel to an adjacent, downslope pixel to determine the areas of inundation for larval oviposition sites.

Finally, a water resources layer, derived from the JRC Global Surface Water Bodies Mapping Layer v1.0 product, was developed by buffering water bodies by 250 m to approximate water-rich soils that would support larval development.

ANNEX B. WATER POINTS IN SIERRA LEONE

See **Figure B1** for a map of the water points in Sierra Leone.

FIGURE B1.
Waterpoints in Sierra Leone



Source: Government of Sierra Leone Integrated Geographic Information System (GIS) Portal (<https://gis.dsti.gov.sl/>).

ANNEX C. ADAPTIVE CAPACITY RAPID ASSESSMENT

LEADERSHIP AND GOVERNANCE				
Questions	Assessment			
	Yes	No	Partial	N/A
1.1: Does the country have a national climate change and health plan/strategy?				
1.2: Is health mentioned as a priority in the Nationally Determined Contributions (NDCs)?				
1.3: Is there a designated focal point responsible for health and climate change in the Ministry of Health (MoH)?				
1.4: Is there a multisectoral technical working group/committee focused on climate change and health?				
1.5: Does MoH actively participate in climate change coordination and/or working groups?				
1.6: Is there a MOU between MoH and key climate change-related ministries/ departments (for example, Environment, Meteorological Services, Agriculture, Water)?				
1.7: Are decision-makers (both within MoH and outside) aware of climate change and health risks and potential adaptation options?				
1.8: Does relevant information related to climate change and health risks and adaptation reach key stakeholders across sectors?				
1.9: Is climate change included in health plans at subnational levels?				
HEALTH WORKFORCE				
Questions	Assessment			
	Yes	No	Partial	N/A
2.1: Are there dedicated full-time staff devoted to climate change and health?				
2.2: Are the number of healthcare workers above 4.5 per 1000?				
2.3: Are health workers adequately distributed between urban and rural areas?				
2.4: Is the health workforce aware of the health risks of climate change?				
2.5: Are there capacity-building programs focused on climate change and health within MoH?				
2.6: Have the MoH staff received training on climate change and health over the last two years?				
2.7: Does the health workforce have the technical capacity to interpret and utilize climate change information (for example, scenarios, projections, forecasts) to inform planning/decision-making?				
2.8: Is climate change and health included in the educational curriculum (for example, schools of public health, medicine, nursing)?				
2.9: Are there context- or country-specific climate change and health training/ educational materials for the health workforce?				

HEALTH INFORMATION AND DISEASE SURVEILLANCE SYSTEM

Questions	Assessment			
	Yes	No	Partial	N/A
3.1: Has the country completed a climate change and health vulnerability and adaptation or risk assessment?				
3.2: Do surveillance systems exist for climate-sensitive diseases (for example, heat-related illnesses, VBDs, and WBDs)?				
3.3: Does the country have a centralized monitoring system for climate-related diseases?				
3.4: Do health surveillance systems integrate meteorological and/or environmental information?				
3.5: Are there efforts from MoHS to utilize national climate/meteorological information?				
3.6: Does the country have a climate-informed early warning system (EWS) for any health risks?				
3.7: Are there EWS in place for climate change-related extreme events/hazards? (for example, flooding, drought, and storms)?				
3.8: Does MoH coordinate with disaster/hazard-focused EWS?				

ESSENTIAL MEDICAL PRODUCTS, TECHNOLOGIES, AND INFRASTRUCTURE

Questions	Assessment			
	Yes	No	Partial	N/A
4.1 Has the country's healthcare facilities been assessed for climate resilience?				
4.2 Are health facilities accessible for rural communities?				
4.3: Do healthcare facilities implement measures to remove mosquito breeding sites?				
4.4: Have healthcare facilities employed adaptive measures to protect against climate change related hazards (for example, flood walls and drainage systems)?				
4.5: Does the national laboratory have the capacity to conduct diagnostic tests for climate-sensitive diseases?				
4.6: Are building codes for healthcare facilities designed to protect against climate change-related hazards put in place and enforced?				
4.7: Have healthcare facilities implemented "greening" activities (for example, tree planting and cooling designs)?				
4.8: Are there efforts to incorporate long-term planning (for example, urban design) to reduce climate change and health impacts?				
4.9: Are health facilities adequately equipped for climate change-related hazards and prepared to respond to them (for example, stockpile of medical/emergency supplies)?				

HEALTH SERVICE DELIVERY				
Questions	Assessment			
	Yes	No	Partial	N/A
5.1: Has the country enacted legislation mandated universal healthcare coverage (UHC)?				
5.2: Are there climate change-specific health programs underway in the country?				
5.3: Does health service delivery have contingency measures for extreme weather events (for example, floods, storms, and heatwaves)?				
5.4: Does current public health planning consider climate change information (for example, scenarios, projections, and forecasts)?				
5.5: Has MoH implemented any climate health awareness campaigns to increase public awareness?				
5.6: Is there access to safe WaSH for over 80 percent of the country?				
5.7: Do over 80 percent of healthcare facilities have access to safe WaSH and healthcare waste removal/storage?				
5.8: Have multihazard risk assessments been conducted in the country?				
5.9: If conducted, do multihazard risk assessments include potential health risks?				
FINANCING				
Questions	Assessment			
	Yes	No	Partial	N/A
6.1: Is MoH currently receiving international funds to support climate change and health work?				
6.2: Is there dedicated funding within MoH for climate change and health activities?				
6.3: Is the health expenditure percentage of GDP above the WHO recommendation?				
6.4: Is the national health budget dependent on donors or foreign aid?				
6.5: Are there climate considerations in the national health budget?				

ANNEX D. HEALTH ADAPTATION RECOMMENDATIONS/MENU OF OPTIONS

	Food security and nutrition	Vector-borne diseases	Water-related diseases	Extreme Weather and Climate Hazards Associated Mortality and Morbidity	Heat-Related Morbidity and Mortality	Air quality	Mental health and wellbeing
Component 1: Leadership and Governance	Incorporation of climate change risks into food security and nutrition strategic plans, including sustainable agriculture efforts	Implementation of Malaria Control Strategic Plan	Promotion of subnational-level water regulatory authorities and engagement with communities on policy options	Development and implementation of a health-specific DRM plan to be integrated with national policies and supported by necessary mandates	Development and implementation of a national heat health policy and city-level plans, leveraging the appointment of the Chief Heat Officer in Freetown to raise awareness of the health impacts of extreme heat	Inclusion of the benefits of mitigation actions to health through reducing air pollution into NDCs; establishment of national standards for indoor air pollutants	Development of a national mental health strategy and action plan
Component 2: Health workforce	Incorporation of educational materials on climate change impacts on food security and nutrition into health worker training	Training at subnational levels to enhance the capacity of dengue prevention and control, as well as the knowledge of climate change-related factors	Awareness raising targeted at health workers with regard to climate change impact on WaSH and WBDs	Conducting of simulation exercises with health workers at subnational levels, focusing on service delivery during emergencies, including compounding/cascading climate-induced disasters	Conducting of heat-health training for health workers; management of occupational heat exposures	Health-specific awareness and education materials for health workers on risks of indoor and outdoor air pollution	Training for community health workers on mental health awareness and interventions, especially following extreme weather events
Component 3: Vulnerability, capacity, and adaptation assessment	Vulnerability assessment of nutrition to climate change; assessment of nutritional benefits of climate-smart agricultural interventions	District- and community-level assessments to better understand local risks related to VBDs and capacities for managing outbreaks	Vulnerability assessment to assess water shortages, rainfall extremes, unpredictable river flows, and baseline WaSH coverage in healthcare facilities	Conducting of integrated multihazard vulnerability and risk assessments at local/district levels	Conducting assessments for high-risk groups at the city level, including informal settlements and incorporation into economic analyses	Assessment of indoor and outdoor air pollution levels and health impacts, especially in urban areas	Further exploration of impact of climate change on mental health, as well as community-based resilience-building interventions
Component 4: Integrated risk monitoring and early warning	Development and inclusion of long-term strategies for nutrition interventions into FEWS (famine early warning system)	Building of health information system (HIS) to incorporate climate-informed seasonal outlook	Integration of climate/weather information with WBD surveillance systems to forecast outbreaks	Strengthening of HIS to incorporate emergency preparedness and the use of technology for the monitoring and surveillance of health conditions in emergencies	Heatwave alert systems for urban and rural populations	Development of air quality monitoring systems and public health risk communication	Development of mental health surveillance systems
Component 5: Health and climate research	Analysis of long-term effects of food insecurity on health and economy	Conducting of climate change modeling studies to estimate dengue risk projections and inform adaptation decisions	Modeling of water security/demand projection under different climate scenarios and impact on WBDs	Development and inclusion of extreme weather event attribution studies as evidence of impacts on human health	Studies to further explore impacts of extreme heat on health systems, including urban heat island mapping	Studies on modeling/quantifying the health co-benefits of mitigation policies for air pollution	Studies on the mental health impact of climate change and potential community-level interventions

	Food security and nutrition	Vector-borne diseases	Water-related diseases	Extreme Weather and Climate Hazards Associated Mortality and Morbidity	Heat-Related Morbidity and Mortality	Air quality	Mental health and wellbeing
Component 6: Climate-resilient and sustainable technologies and infrastructure	Improvement of drainage systems in crop fields at risk to floods; exploration of smart-agriculture and crop diversification practices	Improvement of laboratory capabilities for testing and diagnosis of endemic, as well as novel and reemerging diseases; development of a list of essential medicines needs for VBD outbreaks	Improvement of WaSH systems in healthcare facilities to withstand extreme weather events (for example, drainage systems and healthcare waste management)	Revision of specifications to include climate risk projections in siting and construction, functioning and operation, energy and water supplies, and sanitation services of health care facilities	Space cooling in healthcare facilities to prevent overheating and protect IT and equipment; energy-efficient or passive measures of cooling to reduce energy costs	Improvement of energy supply and distribution efficiency and use of on-site renewable energy sources (for example, solar photovoltaic) in health care facilities; promotion of low-cost air quality sensor network	Support of the development of mental health centers to support the distribution of services in rural areas
Component 7: Management of environmental determinants of health	Community-led efforts to map food insecurity and inform interventions to improve the food system in a changing climate	Community awareness campaigns to increase awareness of climate sensitivity of VBDs and engage vulnerable groups in outbreak prevention	Improvement of household water security and sanitation practices	Development and implementation of regulations for disease outbreak response and other climate-related health emergencies to be incorporated into disaster management planning	Housing standards and urban planning (built environment) to reduce heat risks; household water security; and occupational health management	Improvement of healthcare waste management to reduce GHGs and improve local air quality	Engagement with communities to assess and improve mental health and well-being, including reducing stigma and building awareness
Component 8: Climate-informed health programs	Interventions involving the establishment of gardens or food growing opportunities; community-mediated delivery of nutrition services, including screening	Incorporation of climate change information into VBD prevention and outbreak response SOPs	Institution/implementation of SOPs for drinking water and sanitation provision; public awareness-raising campaigns conducted on hygiene, particularly handwashing	Integration of DRM into public health training and implementation of public awareness campaigns focused on the links between disasters, climate change, and health	Incorporation of heat risks into maternal health guidance, guidance for diabetes management, among others	Engagement of high-risk communities to increase understanding of impacts of air pollution, as well as develop community-level response	Mental health program developed in MoHS
Component 9: Emergency preparedness and management	Food production and distribution chain reinforced to withstand impacts of extreme weather events	Inclusion of outbreaks of VBDs in DRM plans at national, provincial, district, and community levels	Development of WaSH-focused emergency preparedness and response plans, including stockpiling and distribution plan for supplies (for example, purifiers and safe water storage)	Conducting of exercises/testing disaster preparedness plans (tabletop and real world), along with evaluations of responses/uses of the plans in the health sector	Heat included into DRM operations	Incorporation of air quality emergencies into DRM plans	Mental health impacts related to extreme weather events incorporated into DRM planning

	Food security and nutrition	Vector-borne diseases	Water-related diseases	Extreme Weather and Climate Hazards Associated Mortality and Morbidity	Heat-Related Morbidity and Mortality	Air quality	Mental health and wellbeing
Component 10: Climate and health financing	Investments in the dissemination of crop varieties and breeds adapted to changing climatic condition	Formation of proposals for external donors to support improved control of VBDs	Allocation of resources to build climate-resilient WaSH district-level operation plans	Resources to support preparedness for extreme weather events and response	Financing of sustainable cities/cool cities to address heat risks; other interventions related to heat-health responses (for example, cool roofs)	Facilitation of access to international funding opportunities and mechanisms (for example, Green Climate Fund) for dissemination toward health-based adaptation measures and mitigation projects	Strengthened resource allocation for improved mental health services

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