GRMA Country Insight Series

Global Risk Modelling Alliance

CLIMATE AND DISASTER RISK ASSESSMENT LANDSCAPE: GHANA

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ACRONYMS

ARC	African Risk Capacity
CCKP	Climate Change Knowledge Portal (World Bank)
CCRA	Climate Change Risk Assessment
CCVA	Climate Change Vulnerability Assessment
CCDR	Country Climate and Development Report
CMIP5	Coupled Model Intercomparison Project Phase 5
CORDEX	Coordinated Regional Climate Downscaling Experiment
DRM	Disaster Risk Management
EM-DAT	Emergency Events Database
EPA	Environmental Protection Agency (Ghana)
FAO	Food and Agriculture Organization of the United Nations
GCA	Global Center on Adaptation
GAIN	Global Agricultural Information Network
GARID	Greater Accra Resilient and Integrated Development Project
GCF	Green Climate Fund
GFDRR	Global Facility for Disaster Reduction and Recovery
GHSL	Global Human Settlement Layer
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GMET	Ghana Meteorological Agency
GSS	Ghana Statistical Service
GRMA	Global Risk Modelling Alliance
HAND	Height-Above-Nearest-Drainage
IFPRI	International Food Policy Research Institute
IWMI	International Water Management Institute

JRC	Joint Research Centre (European Commission)
MESTI	Ministry of Environment, Science, Technology and Innovation (Ghana)
MOF	Ministry of Finance (Ghana)
MMDA	Metropolitan, Municipal and District Assembly
NADMO	National Disaster Management Organisation (Ghana)
OSM	OpenStreetMap
RCP	Representative Concentration Pathway
SRID	Statistics, Research and Information Directorate (Ministry of Food and Agriculture, Ghana)
SIFT	UNOPS Sustainable Infrastructure Fund Tool
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNOPS	United Nations Office for Project Services
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
VU	Vrije Universiteit (Amsterdam)
WACA	West Africa Coastal Areas Resilience Investment Project
WHO	World Health Organization
WMO	World Meteorological Organization

INTRODUCTION

The Climate and Disaster Risk Assessment Landscape Series by the Global Risk Modelling Alliance (GRMA) aims to provide a summary of available climate and disaster risk analysis and information in the chosen country, covering global and local sources of data, risk models and hazard maps, and examining by individual major perils.

The review of Ghana was conducted as part of the GRMA programme in Ghana. In 2023, the Ministry of Finance of Ghana submitted a joint letter of interest in receiving support from the Global Shield against Climate Risks initiative and GRMA. The GRMA is providing EUR2.0 million in support for climate risk analytics and capability development based on priorities that were co-defined in partnership with MOF and Ghana's GRMA Technical Working Group.

In partnership with MOF and its cross-institution Technical Working Group, the GRMA programme includes models, data and capability development in the following areas:

- **Agricultural Risk Assessment**: Drought, Flood and Pest: Analysis of agricultural hazards in Northern Ghana, focusing on drought, fluvial and pluvial flooding, and pest infestations such as Fall Army Worm. The project covers key food crops including maize, rice, soybean, and sorghum, and develops crop and hazard datasets to model the frequency and intensity of risks to production.
- **Urban Flood Risk Assessment**: Study of fluvial and pluvial flood patterns in Kumasi, Tamale, Sekondi-Takoradi, and Cape Coast. The project examines flood hazard extent, exposure of built-up areas and populations, and variability in risk across different parts of each city, with special attention to low-lying and densely populated areas.
- **Coastal Flood Risk Assessment**: Investigation of coastal flooding in the Volta Delta Region, with a focus on Keta, Anloga, and Ketu. The project considers the combined effects of sea level rise, coastal erosion, and land subsidence, and maps flood hazard characteristics in relation to settlements, ecosystems, and critical infrastructure along the shoreline.

A more detailed description of GRMA's work with Ghana can be found in the project brief here.

This work was also included in the Global Shield Stocktake and Gap Analysis report [1], reaffirming the critical importance of climate risk analytics in laying the foundation for climate and disaster risk finance and management in a country. The GRMA is a key expert resource and partner initiative to the Global Shield.

[1] More information on the Global Shield against Climate Risks initiative and its in-country programme, including the full stocktake and gap analysis of the CDRFI landscape in Costa Rica, can be found on the respective country page here. This country brief may include supplemental information to the Global Shield Stocktake due to subsequent work undertaken in the GRMA programme.

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Published January 2026. Unless otherwise indicated, all data and analysis presented in this report are up-to-date as of October 2025.

COUNTRY CONTEXT

Ghana's climate is largely tropical, influenced by its location along the Gulf of Guinea and its varied topography, which includes coastal plains, forested hills, and savannah regions. The country experiences two main seasons: a rainy season and a dry season, with rainfall patterns varying across ecological zones. The southern coastal and forest zones typically have two rainy seasons (April–June and September–November), while the northern savannah experiences a single rainy season from May to October, followed by a prolonged dry season dominated by the Harmattan winds from December to March. Climate variability is further influenced by global phenomena such as the El Niño Southern Oscillation (ENSO), which can lead to droughts or flooding depending on the phase.

Ghana faces multiple natural hazards, primarily floods, droughts, and coastal erosion, with occasional earthquakes in the southern regions. Flooding is the most frequent hazard, often linked to intense rainfall and inadequate drainage infrastructure, particularly in urban areas like Accra. Droughts predominantly affect the northern savannah, impacting agriculture and water availability. Coastal erosion poses a growing threat to communities along the Gulf of Guinea, exacerbated by sea-level rise and human activities. While Ghana is not located in a major seismic zone, minor earthquakes have been recorded, especially around Accra.

Risk indices such as INFORM and the World Risk Report provide a comparative view of Ghana's disaster risk. INFORM typically ranks Ghana as having medium overall risk, with hazard exposure considered medium, vulnerability medium, and coping capacity low to medium. Hazard-specific risks include flooding and drought as the most significant drivers. Historical disaster data from EM-DAT indicates that floods account for the majority of recorded events and impacts, followed by droughts and storms. Floods have caused substantial economic losses and displacement, while droughts have primarily affected livelihoods and food security in the north.

Although global risk indexes offer useful insights, they have limitations in capturing subnational variations. For Ghana, localised risk assessments are critical, as vulnerability and exposure differ significantly between the coastal, forest, and savannah zones. Urbanisation, deforestation, and climate change continue to amplify these risks, underscoring the need for integrated disaster risk reduction and climate adaptation strategies.

GENERAL OVERVIEW OF AVAILABLE RISK INFORMATION FOR GHANA

Risk information with national coverage

Climate Change Risk Profile for Ghana, USAID, 2017[2]

The climate change risk profile for Ghana, published by USAID in 2017, provides projections of temperature, precipitation and sea level rise, along with sector level climate impacts for agriculture, fisheries, water resources, energy, and human health. Original risk analysis has not been conducted for this fact sheet, but refers to previous analyses by the FAO, Ghana's third National Communication Report to the UNFCCC, University of Ghana papers on managing coastal impact of sea level rise, and previous USAID climate vulnerability profiles for Ghana published in 2011 and 2012.

National Disaster Risk Profile, UNDRR, 2019[3]

In 2019, UNDRR published a national disaster risk profile which used probabilistic modelling of river flood and droughts to estimate losses for multiple sectors of the economy, and the number of people affected was estimated. The study estimated the risk for current conditions and for the 2060s and 2080s using the RCP 8.5 climate scenario (worst case). The analysis was conducted using Cima Foundation global flood hazard maps and drought modelling approaches, with publicly available data to represent exposure.

Climate Risk Profile for Ghana, GIZ, *no date*[4]

The Climate Risk Profile for Ghana, published by GIZ provides projected climate parameters and sector impacts until 2080 under different climate change scenarios: low emissions using RCP 2.6 and medium to high emissions scenarios(RCP 6.0) excluding the effect of socioeconomic impacts. The climate parameters covered are temperature, very hot days, sea level rise, precipitation, heavy precipitation events, soil moisture, and potential evapotranspiration. Sector impacts consider water resources, agriculture (including drought affected crop yield projections for cassava, maize, millet, groundnut and field peas), infrastructure (exposure of urban areas and roads to flood), ecosystems (tree cover and animal species loss), and human health (exposure to heat waves and associated mortality).

Ghana's Fourth National Communication to the UNFCCC, 2021

Downscale climate analysis presented in the Fourth Communication to UNFCCC shows annual rainfall trends and projected average temperature for the country for three 20-year time periods to 2080 as well as for the historical average (1980-2014). Chapter 5 also shows decadal trends in temperature and rainfall for six different ecological / zones.

Highlighted in the report is the increasing attention on climate modelling impact assessment and adaptation in the research community of Ghana, in the last eight years. The report highlights that thousands of research articles have been published in a single year on the topic and that the academic community continues to invest in and deepen this area of research. The report describes the assessment of spatial climate change vulnerability, in which a district level vulnerability index has been developed, which is described later in this section. That assessment finds the Upper West, Northern and Upper East regions to be most vulnerable to climate risks. Greater Accra and Ashanti are estimated to be the least vulnerable regions.

[2] USAID (2017). Climate Change Risk Profile – Ghana. URL. Last accessed 3 November 2023.
[3] UNDRR (2019). United Nations Office for Disaster Risk Reduction and Cima Foundation, Disaster risk profile - Ghana. URL. Last accessed 3 November 2023.
[4] GIZ (no date). Climate Risk Profile – Ghana. URL. Last accessed 3 November 2023.

Climate Risk Country Profile, World Bank, 2021[5]

World Bank Climate Risk Country Profiles (CRCP) are designed to facilitate policy dialogue and strategic planning by presenting a climate baseline of trends and projected changes in key climate parameters, with sector-specific effects and priorities. A large amount of data is summarised from the World Bank's Climate Change Knowledge Portal (CCKP[6]).

CMIP5 projections are presented, indicating that by 2040-2059, the annual temperature is estimated to be 1.2 to 2.7 °C (with a mean of 1.7 °C) warmer than the historical annual average. Estimates of change in annual precipitation is highly uncertain, with CMIP5 ensembles projecting a range of 22.2 mm reduction in annual precipitation to 30.4 mm increase, with a mean estimate of +0.3 mm. The report highlights though that 'more erratic and intense rainfall during the wet season is expected, along with lower precipitation levels during the dry season; larger decreases in the southern regions.'

Sector impacts presented in the CRCP are largely drawn from other diagnostic reports, including USAID (2017 and 2018),IFPRI (2012), Republic of Ghana (2015),and WHO (2015). One of the research gaps identified in the CRCP relevant to risk information is to *'Conduct a comprehensive national assessment of climatechange impacts and existing vulnerabilities for Ghana's population health and the health sector's capability to respond and adapt to climate change impacts'*.

UNDP Inclusive insurance and risk financing in Ghana, 2021[7]

The UNDP 'Diagnostic Report For Inclusive Insurance And Risk Financing In Ghana' (Abaidoo, 2021)[8] highlights 'notable' hazards in Ghana as 'perennial floods, fires, droughts, pest infestation, industrial and domestic accidents, and diseases'. The diagnostic report was not able to use data held on risk assessment by NADMO, so relied on desk review to summarize the risk profile of Ghana. The report includes a short history of floods with a brief description of 26 floods between 1964 and 2020. A general hazard profile with the regions affected by each type of hazard is provided, excerpted in Table 1. The diagnostic report notes that an agricultural sector risk assessment by the World Bank's Agriculture and Environment Services Department indicated a relatively low impact on agricultural output and growth. In particular, the 'diversity of agro-climatic conditions in Ghana's production systems and crops and seeds used within those systems lowers the aggregate risk level for the agricultural sector'.

Regarding pests, the Fall Army Worm is cited specifically, occurring from 2016 in the Eastern region, then spreading to all parts of Ghana, threatening food security. Abaidoo cites significant losses due to Fall Army Worm, totalling over 29,307 hectares of maize (a loss of GH¢ 40 million) destroyed between 2017 and 2019. Analysis presented in the diagnostic report is limited to four years of crop yield data from SRID / Ministry of Food and Agriculture. It does not appear that any quantitative long-term risk analysis of Fall Army Worm impacts on agricultural crops has been conducted.

[5] World Bank (2021) Ghana Country Risk Climate Profile. URL. Last accessed 3 November 2023.
[6] World Bank Climate Change Knowledge Portal. URL. Last accessed 3 November 2023.
[7] UNDP, 2021. Inclusive insurance and risk financing in Ghana Snapshot and way forward 2022, pp21. URL. Last accessed 3 November 2023.
[8] Abaidoo, G., 2021. Diagnostic Report for Inclusive Insurance and Risk Financing in Ghana. Pp94.

Table 1. Hazards and areas of Ghana affected, adapted from Abaidoo, 2021.

Hazards	Type	Area	Impact
Hydro-meteorological	Floods Windstorm Tidal Waves Lightning Droughts	Accra/Kumasi/northern Sector Accra /Eastern Region Northern and Middle Belt Nationwide	Severe Minor Moderate Moderate Severe
Fires	Bush/Wildfires, Domestic and Industrial fires, and Lightning	Nationwide	Moderate to Severe
Geological/ Nuclear Radiological Disasters	Earthquakes, Landslide	Coastal Belt	Moderate
Diseases/Epidemics	Yellow Fever Cerebro -Spinal Meningitis (CSM) Pandemic Influenza, Covid 19	Northern Belt Coaster Belt Nationwide	Severe Severe Severe
Pests and diseases	Fall Army Worm Pest infestation Anthrax, Blackfly, Locust, Larger Grain Borer, etc.	Northern/Middle Belt and Coastal	Severe Severe

Ghana: Roadmap for resilient infrastructure in a changing climate, 2022[9]

The 'Ghana: Roadmap for resilient infrastructure in a changing climate' report was a collaboration between the Government of Ghana (MESTI), the Global Center for Adaptation (GCA), the University of Oxford, the United Nations Office for Project Services (UNOPS) and the United Nations Environment Programme (UNEP). It provides an assessment of climate risk on national infrastructure systems and proposes a roadmap to address those risks through targeted adaptation options. Modelling is performed for inland floods and droughts using the Height-Above-Nearest-Drainage (HAND) approach to estimate inland flood hazard, cumulative rainfall deficit as drought hazard, and landslide susceptibility data from a NADMO hazard assessment. Climate risks are projected using river discharge projections from CORDEX Africa RCP4.5 and 8.5, and the IPCC AB1 scenario, which NADMO uses.

Once the sector impacts of climate risk are estimated, enabling environment needs are defined for adaptation options, including: design, planning, and operation/maintenance needs (common to all sectors). Needs were identified for 35 assets/locations/risks and five adaptation project types were mapped to each project/area. These options were traditionally built environment; nature-based solutions; urban resilience; enabling environments; and gender and inclusivity. Adaptation project sheets were prepared, outlining project concepts, and a UNOPS fund analysis tool (SIFT) was used to identify possible funding for these projects.

[9] Adshead, D., Thacker, S., Fuldauer, L.I., et al. 2022. Ghana: Roadmap for resilient infrastructure in a changing climate. Ministry of Environment, Science, Technology & Innovation, Accra, Ghana. URL. Last accessed 3 November 2023.

Country Climate and Development Report (CCDR), World Bank, 2022[10]

This is a wide-range report examining climate risks, the enabling environment, and pathways to climate resilience and low-carbon development. Generally, the climate risk estimates used in the CCDR are drawn from existing resources, including historical disaster catalogues (EM-DAT and Desinventar), the World Bank's global analysis of exposure to floods, Adshead et al. (2022), and UNDRR (2019). The report includes a macroeconomic analysis of the impact of climate damages under RCP4.5 and RCP8.5, on GDP due to air pollution, crop loss, labour productivity, flooding, energy and tourism (at 2030, 3040, and 2050).

Ghana Climate Change Report, USDA and GAIN, 2023[11]

The United States Department of Agriculture (USDA), Foreign Agricultural Service, and the Global Agricultural Information Network (GAIN) published a short report in 2023, highlighting Ghana's vulnerability sea level rise, droughts, increasing temperatures, and erratic rainfall, with adverse impacts on infrastructure, hydropower production, food security, and coastal and agricultural livelihoods. The climate impacts referenced in this report was derived from the World Bank CCDR (2023), USAID (2017), UNDRR (2019, though they reference the 2018 version) and IFPRI (2012).

Ghana Climate Risk Atlas and Impact-based forecasting, GMET

Bilateral discussion with GMET in October 2022 highlighted two important programs of work being undertaken. The development of a Climate Risk Atlas would present downscaled climate projections for the whole country and should provide a definitive source of climate projection information for subsequent risk analytics. Impact-based forecasting is an area under development by GMET, to communicate early warning in terms of impacts, instead of in terms of what the conditions will be like.

The Ghana Climate Atlas was published in March 2025, with a MapViewer[12] showing historical rainfall and temperature data and several projections.

Risk information with subnational coverage or focus

Enhancing multi-sector planning and capacity for effective adaptation in Ghana, EPA, 2023

In support of National Adaptation Planning, the EPA funded by the Green Climate Fund is conducting Climate Change Risk Assessments (CCRAs) in 10 MMDAs as a pilot. The selected areas represent a range of ecosystems and involve district-level risk assessment and adaptation planning for forestry/agriculture, water energy and transport infrastructure, private sector, disaster risk management and cities, and health. This work will also establish a national climate vulnerability portal.

These assessments review economic vulnerability, physical and environmental vulnerability, social vulnerability, and adaptive capacity, uses national and subnational socio-economic development scenarios, and subnational climate trends. District level flood hazard mapping has been conducted to assess annual expected damage, which may form the basis of further flood risk assessment, but GRMA has to date been unable to review the methodologies used in these risk assessments.

The results of the assessment completed so far have not yet been published, so they are not summarised in this report.

[10] World Bank Group (2022). Ghana Country Climate and Development Report. CCDR Series. URL. Last accessed 3 November 2023.
[11] USDA and GAIN (2023). Ghana Climate Change Report. URL. Last accessed 3 November 2023.
[12] URL.

World Bank West Africa Coastal Adaptation (WACA) program

The objective of this program is to strengthen the resilience of targeted communities and areas in coastal Western Africa. The project aims to achieve this by strengthening regional and national coordination on climate resilience of coastal areas in West Africa, including Ghana. The technical support under the program is wide-ranging and includes capacity building, operationalising coastal observation and monitoring, and use of sustainable management including marine protection and ecotourism. Following bilateral meetings and the in-country workshop, It remains unclear what elements of coastal risk analysis including scenario or probabilistic assessment of damage and loss from coastal flooding in the future given, coastal erosion and sea level rise, will be conducted under the WACA program.

IDF-UNDP Tripartite Project - A (sub-) sovereign parametric insurance solution for the poor & vulnerable in Ghana/Accra

This public-private partnership project[13] seeks to implement parametric flood cover to quickly provide disaster relief in low-income areas and enhance response capacity of NADMO and government in flood events. The risk analytics include analysis of excess rainfall, using 1-day maximum rainfall from ground station observations, and satellite-based estimation of flood extent. Both approaches can be used to trigger parametric pay-outs, with varying degrees of basis risk and scaling capabilities. A decision is yet to be made on which approach will be taken up, but the methods should be replicable if needed to other parts of Ghana.

Climate Risk Analysis for Identifying and Weighing Adaptation Strategies in Ghana's Agricultural Sector in Northern Ghana, GIZ, 2021[14]

This study seeks to deliver the base data for risk-informed and economically sound adaptation decisions for the agricultural sector in the Upper West Region (UWR) of Ghana. It provides information on climate impacts and recommendations for adaptation strategies. To establish current climate conditions at the subnational scale, weather station observation data are used with downscaled climate model data. Recent trends were established and projected into the future, showing a continuation of recent trends: increasing mean annual temperature, increasing number of very hot days and tropical nights, and increasing heavy precipitation intensity and frequency. The analysis showed no trend in mean annual precipitation, rainy season onset, number of dry spells within rainy seasons, and year to year variability of annual precipitation total. Two different crop production models were used to assess the impact of changing climate on agricultural production of cowpeas, groundnut, maize and sorghum. All crops were estimated to slightly decrease or decrease, with medium to very high certainty depending on the crop type and district.

Green Cities Infrastructure and Energy Programme (GCIEP) urban climate risk maps, 2025

Green Cities Infrastructure and Energy Programme (GCIEP) has developed multi-hazard climate risk maps for nine cities across Ghana: Wa, Damango, Nalerigu, Yendi, Bolgatanga, Tamale, Sekondi-Takoradi, Kumasi and Accra. The risk maps are validated with local stakeholders from key institutions, including the municipality and fire services. They identify short-term risks, the location and expected intensity, providing stakeholders with timely, actionable intelligence to inform more resilient urban development planning. A real-time dashboard is being developed to visualise the risks and providing municipality training for full local ownership and application.

[13] URL. Last accessed 3 November 2023.
[14] URL. Last accessed 3 November 2023.

A sample of academic studies

Given the number of academic papers mentioned in the Fourth Communication to the UNFCCC, a thorough literature review of academic studies pertaining to disaster and climate risk in Ghana is not possible here. However, an effort has been to include samples of those that present specific impacts or risk analysis, which have been cited during bilateral meetings and the in-country workshops. Further studies are available in the V20 Climate Vulnerability Monitor scientific coverage dataset[15].

Critical infrastructure network modelling for flood risk analyses: Approach and proof of concept in Accra, Ghana[16]

This paper models critical infrastructure networks for catchment-wide flood risk analyses. It analyses direct and cascading impacts and indirect disruption of services triggered by flood scenarios, quantifying impact as number of disrupted users and disruption time in Accra, as a proof of concept.

The Poverty Impacts of Labor Heat Stress in West Africa Under a Warming Climate[17]

This paper assesses the implications of heat stress-related labour capacity losses by sector and region on poverty, using a global general equilibrium economic model. This is a regional study for West Africa, including Ghana, to estimate changes in real incomes of households near the poverty line. Findings include that unskilled agricultural wages could increase, as loss of productivity and sustained demand for food results in increased labour demand. Neglecting potential increases in mortality and morbidity, poverty increases in Ghana could be around 7%.

Vulnerability of Ghana's Accra Coast to Sea Level Rise[18]

This paper estimates the historical rate of coastal erosion for the coastline of Ghana, at 1.13 metres per year, with the Western section of coastline experiencing 1.86 metres per year. The impact over a 20-year period is likely to be over 13,000 people displaced, while over 50-years this could increase to over 33,000 people. By 2100, over 157,000 people and almost 850 buildings are likely to be vulnerable to permanent inundation. It should be noted these estimates may have increased since 2015.

Available models and data for risk analysis

African Risk Capacity (ARC) models

To support the development and operation of the African Risk Capacity (ARC) risk pool, risk understanding across the continent was required. ARC developed Africa RiskView[19] – its core product for risk analysis. Africa RiskView provides decision-makers with expected and probable maximum costs of drought-related responses before and during agricultural seasons at administrative level 1, for every country in sub-Saharan Africa. The risk estimates can also help countries plan drought response actions and food security investments. The drought model combines operational rainfall-based agricultural drought early warning models with data on vulnerable populations to estimate food insecurity response costs.

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[15] URL.
[16] Schotten, R., & Bachmann, D. (2023). Critical infrastructure network modelling for flood risk analyses: Approach and proof of concept in Accra, Ghana. Journal of Flood Risk Management, 16(3), e12913. URL
[17] Saeed, W., Haqiqi, I., Kong, Q., Huber, M., Buzan, J. R., Chonabayashi, S., et al. (2022). The poverty impacts of labor heat stress in West Africa under a warming climate. Earth's Future, 10, e2022EF002777. URL
[18] Appeaning Addo, K. 2015. Vulnerability of Ghana's Accra Coast to Sea Level Rise. Coastal Resilience Workshop. 3. URL
[19] URL.

ARC have also developed epidemic modelling, a flood hazard product in Africa RiskView, which uses earth observation to assess daily extent of standing water, indicating the extent and duration of floods, to trigger parametric insurance. Historical flood extent data is available back to 1992 and is useful for assessing flood-prone areas. Access to the Africa RiskView software is free and can be requested on the software pages.

District level flood models

Flood hazard models have been employed in the climate risk assessments at MMDA level for EPA. Further information is required to assess the methodology of these models and the availability of the model and hazard data to support further work under the GRMA and Global Shield.

V20 Climate Vulnerability Monitor[20]

The Climate Vulnerability Monitor is an online dashboard containing climate parameters, crop yield data, social vulnerability indicators and relevant scientific studies. It is a useful source of some input data for risk assessment, but does not provide risk information directly, in the form of exposure, hazard and vulnerability for risk modelling.

Exposure data

The Ghana Statistical Service (GSS)[21] holds official census data from 2021, containing information on population demographics, household size, and number and types of residential buildings present at district level with national coverage. A bilateral meeting was held with GSS inOctober 2022 to understand the availability of official information for GRMA projects. The online data portal Statsbank[22] provides open access to an increasing amount of data from GSS, at district level but in future this will be available at 1 km grids under a 'Ghana Gridded Data' program and tool. Progress is being made to include education and healthcare facility data. For limited areas, GSS analysis of mobile phone activity has revealed diurnal trends in population movements. This data is updated quarterly, used by NADMO for their operations and is intended to be expanded to more areas in the future.

Adshead et al. (2022) collated, through a project technical working group and stakeholder consultation, asset data comprising: 29 power plants, 76 substations, 24 dams, 137,047 km of roads, nine airports, and 18 ports (including 14 Volta River ports), 25 land use classes and 86 sub-catchment areas and 297 forest areas. The district level vulnerability index was calculated as the inverse of adaptive capacity from the 4th National Communication. Modelling of future risk uses the current distribution of infrastructure indicating an absence of asset projection data.

A bilateral meeting was held with the lead for OpenStreetMap (OSM) Ghana in Accra during October 2022 to understand the availability of official information for GRMA projects. OpenStreetMap Ghana has an active community of volunteer mappers, with chapters with each university. Through the World Bank Greater Accra Resilient and Integrated Development (GARID) Project and the GFDRR Open Cities Africa program, OSM Ghana has mapped flood-prone neighbourhoods of Accra including the neighbourhood of Nima. The resulting detailed maps of those areas include many individual buildings, their usage and construction materials, while collaborating with GSS, OSM Ghana does not appear to work closely with other government agencies. OSM Ghana has a ready and able body of volunteers capable of adding to high-resolution mapping of assets in Ghana should the need arise.

Additional information is available from global datasets, to complement and address gaps in local exposure information. Such data include, for example, WorldPop or VIIRS night-time lights distribution, World Settlement Footprint, Global Human Settlement Layers (GHSL, JRC), OpenStreetMap, global roads datasets, and global energy database.

[20] URL.
[21] URL.
[22] URL.

Hazard data

NADMO holds earth observation-based flood maps, flood data based on the Height-Above-Nearest-Drainage (HAND) method which indicates areas with a medium or high likelihood of flooding, based on topography and proximity to the river network. These data were used by Adshead et al. (2022) and used to project flood susceptibility to 2050. The flood scenario data are non-probabilistic: no value is given for depth, time, or duration of the hazard; for thorough assessment of flood risk (including frequency and severity of impacts), a more comprehensive flood hazard assessment would be required. Additionally, NADMO data on landslide susceptibility defines areas of medium and high susceptibility under current conditions. Further information is required on the resolution and approach taken to develop the landslide susceptibility dataset.

Additional hazard information is available from global datasets, to complement and address gaps in local hazard information. Such data include commercially available flood hazard maps from e.g., JBA Risk or Fathom, which provide 30m-resolution inland (river and surface) and coastal flood for current and future climate. Global 1-km landslide hazard data (combining susceptibility with annual potential for landslide triggering by precipitation and seismic activity) are available from NASA and GFDRR. Global extreme heat and wildfire (fire weather index) data via GFDRR and coastal flood via VU Amsterdam are also available and could support risk screening but for more comprehensive risk analysis, national scale modelling of these hazards should be undertaken. Regional earthquake risk models are available from the Global Earthquake Model Foundation[23].

Vulnerability data

Ghana's Fourth National Communication to the UNFCCC (2020) includes a Climate Change Vulnerability Assessment (CCVA). The method uses a spatial assessment of exposure, sensitivity to climate change and adaptive capacity to assess vulnerability of each district: CCV = (Exposure x Sensitivity) – Adaptive Capacity. Exposure is assessed based on current mean annual rainfall and seasonal temperature variability. Sensitivity is measured by the proportion of people employed in agriculture in the district. Adaptive capacity includes data on poverty levels, economic activity (night-time lights data) and district governance capacity.

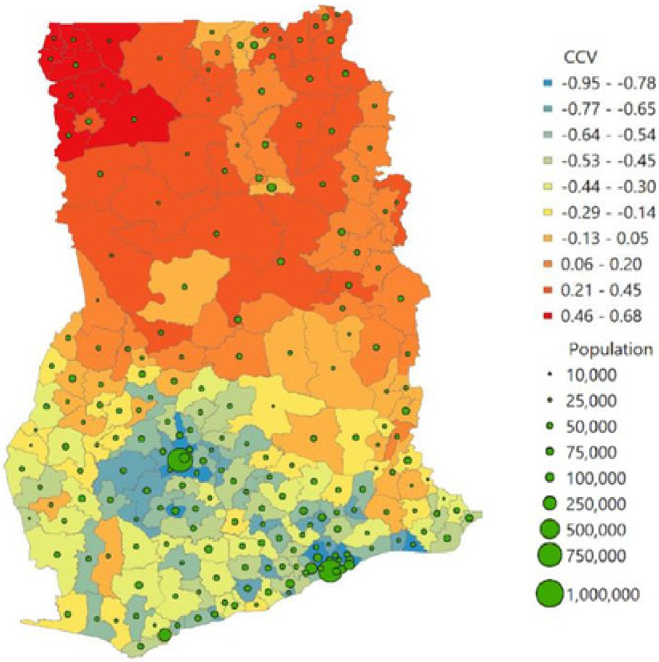
An assessment was conducted to calculate CCV for the administrative districts of Ghana quantitatively. The assessment was built on the workflow and data generated from the study on climate-resilient landscapes for sustainable livelihoods in Northern Ghana. Data for the assessment was obtained from national institutions that have the mandate to publish government data, literature and inter-governmental bodies. The data was processed and used to generate parameters to quantify the variables for exposure, adaptive capacity and sensitivity components of CCV. The resulting distribution of vulnerability is presented in **Figure 1**.

Adshead et al. (2022) use this to derive a district level social vulnerability index for the analysis of risk to people and this would be an appropriate source of information for further analyses, albeit with updates to reflect the 2021 national census results.

[23] URL.

Figure 1
SEQ Figure * ARABIC 1

Climate change vulnerability scores for Ghana's 216 districts



Source: Ghana's Fourth National Communication to the UNFCCC, 2020

There is no information to suggest that physical vulnerability data (to estimate risk to built assets) has been developed or is available for Ghana, whether originating from post-event damage surveys, or analytical methods. In the absence of such information, probabilistic risk assessment would need to rely on existing physical vulnerability relationships that are assessed as being suitable for application to the types of buildings and infrastructure present in Ghana's building stock. This is the usual approach where country-specific vulnerability relationships are not available, though a long-term goal would be to develop such data.

CLIMATE CHANGE ANALYSIS

Ghana's Fourth Communication to the UNFCCC[24] in November 2021 summarises the climate risks faced by Ghana well by citing the impacts of historical disasters – including 22 major hydrometeorological events (floods and droughts) in the last five decades which affected 16 million people and killed at least 400 people. Individual extreme (rare and severe) events can be extremely damaging, frequent events (extensive risk) can be as disruptive to the people's livelihoods and the economy through the disruption caused by frequent, low severity events. High climate risk is already a reality in Ghana, but based on downscaled climate analysis presented in the Fourth Communication, under a future climate:

- Rainfall variability will be high in the forest regions than the rest of the country.
- Ghana will continue to be warm and even get worse by 2080.
- Temperatures are likely to increase by at least 3 C by 2080 nationwide.
- The savanna regions are likely to record temperature above 30 C.
- The high likelihood of wet spells may lead to more floods across the country.
- The projected increases in dry spells may exacerbate drought conditions, especially in the savanna.

Sea level rise is expected to rise by 20 cm by 2050 under Representative Concentration Pathway (RCP) 6 scenario, compared to sea level since the year 2000 (GIZ, no date). This threatens Ghana's coastal communities and may cause saline intrusion in coastal waterways and groundwater reservoirs.

Several climate and disaster risk profiles with national coverage have been published for Ghana. They provide information about climate in the country, estimations of risk from several hazards, and propose potential adaptation options.

> "Climate change is expected to increase the risk and intensity of water scarcity and drought across the country. The primary sectors affected are water, agriculture and forestry, and human health. As extreme rainfall events become more common, riverbank over flow and flash flooding is likely. This may also result in soil erosion and water logging of crops, thus decreasing yields with the potential to increase food insecurity; particularly for subsistence farmers. The frequency and complexity of some of these disaster events are also increasing, especially flooding."

World Bank Climate Risk Country Profile summary for Ghana - key trends in climate impacts.

[24] EPA, 2020. Ghana's Fourth National Communication to the United Nations Framework Convention on Climate Change, May 2020, Environmental Protection Agency (EPA), pp 378.

SUMMARISED QUANTITATIVE RISK ESTIMATES PER MAJOR PERIL

This section summarises available quantitative risk estimates, including from the several climate risk reports introduced above, which quantify risk in terms of population affected or fatalities, economic loss, sector-specific loss and disruption. Changes in climate parameters (rather than risk estimates) are not included in the scope of this section.

Priority Risks

Based on a literature review of previous analyses and information shared in bilateral meetings and country workshops, the priority hazards for Ghana are:

- Coastal flood and sea level rise in coastal areas,
- Inland flood, affecting urban and rural areas nationally,
- Agricultural drought, especially in northern regions,
- Wildfire in the savannah and dry forested areas of northern Ghana,
- Pest infestation, especially Fall Army Worm and a warming climate.

Priority impacts are:

- Food insecurity, and commercial/export crop loss (especially Cocoa),
- Failure of infrastructure, including healthcare, water supply, transport, energy and telecommunications.
- Mortality, loss of homes and livelihoods on the coast due to storms and sea level rise,
- Loss of biodiversity, linking to the introduction of new pathogens of concern to human health (zoonosis) and new invasive pest species,
- Internal migration due to, for example, impact of drought on agricultural livelihoods (crop and livestock) and lack of water ultimately causing rural to urban migration, which can have long-term effects.

Inland flood

UNDRR (2019) estimated that each year 45,000 people are affected by flooding in Ghana, with the majority of those in southwestern and coastal regions. The annual average GDP affected by flood is 100 million USD, or 0.23% of the total GDP of Ghana. Using projections of climate and socio-economic development, GDP affected is estimated to increase to around 550 million USD per year (with climate change alone it would be expected to decrease compared to today).

Direct economic loss estimates currently exceed 80 million USD per year, with the main contribution to that coming from the service sector and housing sector. In a future climate, those estimates reduce in all sectors, to less than 60 million USD overall (UNDRR, 2019). In comparison an extreme event, with a return period of 100-200 years could have result in direct economic loss of almost 500 million USD in today's climate.

GRMA (2021) estimated annual average flood loss due to the building stock in Ghana at 28 million USD but did not analyse the contribution of different sectors to this loss and this was performed using coarse resolution flood data as an initial diagnostic exercise. It was also estimated that 9,000 people per year are affected by flood. Annual loss to the building stock is projected to increase by 24 times for a 1.5C warming scenario and 28 times under 3C warming - in the same scenarios, the number of people affected is expected to increase by 8-9 times.

Adshead et al. (2022) estimated that 35% of districts in Ghana are exposed to high flood hazard in a future climate, however, potential losses have not been quantified. Districts in the Volta region are highly exposed, and also most affected by future deficits in river discharge due to droughts. Central, Ashanti, Volta regions have the greatest areas of high landslide hazard. The study also quantified the km of roads exposed to high flood hazard by 2050, and a large number of ports and airports are also exposed to flood and drought but again monetary losses and risk to these assets and sectors have not been quantified.

Drought

Greater Accra, Northern, Central and Eastern provinces have most people affected by drought currently, which affects 13% of the national population. This is expected to increase to 30% in 2060s, with the greatest increases in Northern and Volta under future climate (UNDRR, 2019).

An increase in crop land exposure to drought is expected in future, and with almost all crops being rainfed and the agricultural sector providing employment to 40% of Ghana's active labour force, this is of huge importance for food security and the economy. Yields of heat- and drought-sensitive crops such as maize (a staple crop) projected to decline. GIZ (2021) estimated that in the Northern region, cow pea yield could decrease by up to 20% under RCP 2.6 and 30% under RCP 8.5, while maize yield could decrease by 15% and 25% respectively. These estimates are for a limited number of farming scenarios in one region, and analysis by GIZ (no date) suggests that yield loss nationally may not reduce by this proportion even for maize (which showed the largest decrease) by 2080; the same analysis also indicates the wide range of uncertainty in these projections. Conversely, less heat/drought sensitive crops such as cassava (also a staple) are projected to benefit from CO_2 fertilisation (GIZ, no date) though.

UNDRR (2019) estimated that yield loss is presently greatest for Yam and Cassava (ton/yr), and that the increase in crop loss relative to the economy will be minor due to climate change (1% of GDP to 1.3% of GDP). The greatest impacts of drought appear to be on livestock, with 13% of livestock units in the current climate affected by drought, increasing to 39% in future climate. Neither the GIZ or UNDRR studies estimate losses to the country's leading cash crop Cocoa, or looks at the impacts on climate on cocoa production, labour force or exports.

Losses in the hydropower sector have also been estimated; low river discharge can prevent energy generation, and annual losses to this sector are expected to increase from 1.6% to 16.3%, or 240mn USD (UNDRR, 2019). IWMI (2012)[25] estimates that drought could lead to up to half of 74% of the total annual irrigation demand and 53% of the average annual hydroelectric potential could be delivered by 2050. Further, water availability per capita could half by the 2050s GIZ (no date). Adshead et al., (2022) assessed the exposure of each of Ghana's dams to drought as well as flood; the East Gonja dam for instance is exposed to a 70% reduction in river discharge.

Coastal flood

The impact of coastal flood over a 20-year period is likely to be over 13,000 people displaced, while over 50-years this could increase to over 33,000 people (Appeaning Addo, 2015). By 2100, over 157,000 people and almost 850 buildings are likely to be vulnerable to permanent inundation.

Ghana's densely populated coastal zone is home to 25% of the population and 80% of industrial activities including oil and gas production, port operations, and thermal hydroelectric power generation as well as agriculture and fishing[25]. Coastal erosion is causing the coastline to recede at about two metres per year on average, with localised coastline recession of up to seventeen metres in a single year. The eastern coastline (Aflao to Prampram) is most vulnerable due to the dynamics of the Volta delta, with strong waves and currents. UNESCO cites face the need for effective

[25] IWMI. 2012. The Water Resource Implications of Changing Climate in the Volta River Basin. URL: Last accessed 6 November 2023

monitoring of erosion and risks for early warning of coastal flooding, and prevention of erosion through a comprehensive coastal erosion management strategy comprising coastal protection and adaptation of human activities and coastal ecosystem restoration.

Extreme heat and human health

Heat-related mortality is expected to increase as more people are exposed annually to heatwaves. Under RCP 6.0, 19% of the population will be exposed annually by 2080, compared to 5% in 2000 (GIZ (no date). Further, it is expected there would be 5-fold increase in mortality in that time, but only a doubling in mortality through the century under a less extreme climate change scenario of RCP 2.6.

Pests

Estimates of the risk of pest infestation such as Fall Army Worm (including estimates of long-term frequency and severity of losses, projected in future climate conditions as well as for present conditions) are not available.

Several years of crop data show reduction in yield where Fall Army Worm have affected crops is available (Abaidoo, 2021 and Bariw, et al., 2020[26]), and this data appears to be the basis for understanding the effect of pests and for strategic planning and policy development. The short duration of data on this risk may not be sufficient for robust decision-making, however.

[26] Bariw, S.A, Kudadze, S. and Adzawla, W., Prevalence, effects and management of fall army worm in the Nkoranza South Municipality, Bono East region of Ghana, Cogent Food & Agriculture, vol. 6, No. 1 (August 2020). URL.

IDENTIFIED GAPS IN DATA, MODELS, AND ANALYSES

This section outlines gaps identified in this review of the risk information landscape in Ghana. This information was used in the co-definition of the GRMA project with local stakeholders, to ensure GRMA adds value in the availability and use of risk information and that projects are aligned with local priorities and needs.

Probabilistic risk modelling

There is a lack of detailed probabilistic modelling to quantify the frequency and severity of direct and indirect losses and risk to specific sectors and the population. Event-based modelling (rather than modelling relying on hazard maps) is needed to support risk financing, especially transfer of risk to international markets. Global models have been used to provide national scale risk estimates including annual average and probable maximum losses at a sector level (UNDRR, 2019). Urban scale flood models (from consultants HKV) have been used to inform urban scale DRM / adaptation interventions and parametric flood insurance in Accra, but not in other areas of the country. Other national scale analysis uses hazard maps (GCA-UNOPS) and qualitative approaches (EPA risk assessments for MMDAs), insufficient to support analysis of risk layering considering specific such as event correlation across large areas. There is a need for high resolution probabilistic event-based modelling incorporating national information on hazard, exposure and vulnerability for sector level risk analysis.

Socio-economic projections in quantitative risk analysis

Aside from UNDRR (2019) no quantitative risk analytics have integrated socio-economic projections to project the frequency and severity of losses (risk). The UNDRR approach used publicly available information which could likely be improved with updated and official data curated by Ghana Statistical Service.

Access to risk analytics

Existing probabilistic risk analysis is not currently accessible to ministries and technical agencies of the Government of Ghana, or to academics in the country. Clearly there is a strong and growing base of expert practitioners and academics working in the field of climate modelling, impact assessment and adaptation, who have contributed to climate vulnerability assessments to date. Experts in Ghana should be able to access quantitative risk models, which is possible through open-source risk modelling such as Oasis for risk financing focussed applications and CLIMADA for assessment of adaptation options. Capability development in this area to raise awareness of such tools and approaches could help to address this gap.

Risk of agricultural pests in a future climate

Understanding of the impact of Fall Army Worm on agricultural crops seem limited to crop yield statistics since about 2016, with no indication that quantitative risk analysis has been conducted to understand long-term risk under current or future climate conditions. Further modelling on their potential impact in a warming climate would be prudent.

Risk to cocoa crop

While several climate risk profiles included here reported on the expected reduction in crop yield for major staple crops including maize, millet and groundnut, there is an apparent gap in risk assessment for the major export crop, cocoa. Bilateral meetings and the in-country workshops highlighted the importance of this crop to the economy and the potential climate risk faced by the cocoa sector, and a sector-focussed assessment of risk would appear beneficial.

Risk quantification for coastal hazards

While the coastal inundation (temporary and permanent) hazard posed by the combined effects of sea level rise, coastal erosion and storms are well recognised, there is an absence of comprehensive risk analysis to estimate the frequency and severity of damage and loss of land. This is well within the reach of existing modelling platforms and academic research on this topic in Ghana shows that data on sea level rise and erosion are available to support risk analysis that can consider future localised conditions. This type of risk analysis could support recommendations on resilience measures as well as financial risk transfer, but an understanding of similar work that may be undertaken in the WACA project needs to be confirmed.

CONCLUSION

Ghana's principal risks stem from flooding, drought and coastal hazards, with additional risks from crop pests, wildfire and seismic activity. Flooding is the most frequent hazard; drought threatens agricultural livelihoods and hydropower. Pest damage (notably fall army worm) has already caused substantial crop losses, while coastal erosion and sea-level rise put dense coastal population and industry at risk. Local stakeholders have highlighted failures of health, water, transport and energy infrastructure are highlighted as priority impacts.

Climate change is expected to amplify these threats: wetter extremes will increase flood frequency and intensity, while more frequent dry spells will worsen drought and stress water and hydropower systems. Overall, warming and changing rainfall patterns are projected to increase the scale and frequency of both coastal and inland hazards, with major implications for food security and infrastructure resilience.

There is substantial available risk information for Ghana but it is uneven across sectors and there is limited maintenance of the information over time. Global models and indices provide national-scale estimates and useful screening, while local sources (GSS, NADMO, GMET, EPA, academic studies, OSM mapping) supply valuable exposure and subnational detail. However, key limitations persist: high-resolution, probabilistic event-based modelling is scarce as most national work relies on hazard maps or global models. Physical vulnerability data for built assets are lacking and socio-economic projections are rarely integrated into quantitative risk analytics. Several hazards of economic importance (long-term pest risk and sector-specific risk to cocoa, comprehensive coastal risk quantification) remain under-analysed. Accessibility is also an issue: existing probabilistic analyses are not readily available to ministries, technical agencies or academics, and some local subnational assessments and datasets lack public documentation or methodological transparency.

The GRMA programme, co-defined with Ghana's Ministry of Finance and the Technical Working Group, is expected to address some of these gaps. GRMA's focus on crop and hazard datasets, subnational modelling and capability development is well aligned with the identified needs for higher-resolution probabilistic analytics, better exposure data and government capacity to apply risk information in decision-making.

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