Federal Ministry
for Economic Cooperation
and Development

Climate Risk Profile: Ghana

Summary

This profile provides an **overview of projected climate parameters and related impacts** on different sectors in Ghana until 2080 **under different climate change scenarios** (called Representative Concentration Pathways, RCPs). RCP2.6 presents the low emissions scenario in line with the Paris Agreement; RCP6.0 represents a medium to high emission scenario. **Model projections do not account for effects of future socioeconomic impacts**.

Agro-ecological zones might **shift**, **affecting ecosystems**, **biodiversity** and **crop production**. Models project only small changes in species richness and tree cover in response to climate change.

Agriculture, biodiversity, health, infrastructure and water are highly vulnerable to climate change. The **need for adaptation in these sectors should be represented in the German development cooperation portfolio** in Ghana.

Per capita water availability will decline by 2080 mostly due to population growth as almost no change is expected in overall precipitation levels. Model projections indicate that **water saving measures will become especially important after 2050 in the north** of Ghana.

Depending on the scenario, **temperature** in Ghana is projected to **rise between 1.7 and 3.7 °C by 2080**, compared to pre-industrial levels, with higher temperatures and more temperature extremes projected for the north of Ghana.

The **population affected** by at least one **heatwave** per year is projected to **rise** from 5 % in 2000 to 19 % in 2080. This is related to 94 more very hot days per year over this period. As a consequence, **heat-related mortality** is estimated to **increase by a factor of five** by 2080.

Precipitation trends are highly uncertain and project either no change or a **slight decline** in mean annual precipitation amounts over the country. Future dry and wet periods are likely to become **more extreme**.

Under RCP6.0, the **sea level** is expected to **rise by 39 cm** until 2080. This threatens Ghana's coastal communities and may cause saline intrusion in coastal waterways and groundwater reservoirs.

Climate change is likely to cause **severe damage to the infrastructure sector** in Ghana. A study from 2014 estimates the cost for repair and adaptation to climate change for road infrastructure alone to amount to USD 678.47 million by the end of the century [27].

Models project an **increase in crop land exposure to drought**. Yields of heat- and drought-sensitive crops such as maize are projected to decline while yields of less sensitive crops such as cassava are projected to benefit from CO_2 fertilisation. Farmers will need to adapt to these changing conditions.

Context

Ghana is a lower-middle income country in Western Africa with a **population of 29 million people**. According to UN projections, the population is expected to more than double in the next half century, **reaching a total of 76 million people by 2100** [1], [2]. Ghana's economy is dominated by the services sector, accounting for 46 % of Ghana's GDP in 2017, followed by industry with 33 % and agriculture with 21 % of GDP [3]. Its long-term economic development strategy relies heavily on strengthening the country's energy supply. In 2015, almost half of Ghana's electricity (43 %) was provided by the hydropower sector [4], [5]. The reliance on hydropower raises concerns about the effects of climate change on river flows, especially through rising temperatures, droughts and storms [6]. In fact, model calculations project a **decline in Ghana's GDP between 2 % and 17 % beyond 2100 for a warming of 1 °C and 4 °C**, respectively [7]. Insufficient infrastructure and **limited access to services, such as water supply, sanitation and healthcare make large shares of the population highly vulnerable to disruptive events** triggered by climate extremes, such as storms, floods or extreme heatwaves, which can cause severe health challenges especially for the poor [8]. The agricultural sector provides employment to 40 % of Ghana's active labour force, making it a key source of livelihoods for the population [9]. **Ghana's strong economic dependence on agriculture and livestock, and the sector's limited adaptive capacity underlines the country's high vulnerability to climate change**, especially as less than 1 % of the national crop area is irrigated [10]. Staple crops, such as maize, millet and cassava are traditionally rainfed, yet are of great importance for food security, as are livestock, such as cattle and poultry. Cocoa is Ghana's most important cash crop, accounting for 11 % of total exports in 2017 [11], [12]. Other cash crops include oil palm, groundnut, cotton and tobacco.

Quality of life indicators [13]–[16]

Human Development Index (HDI) 2017	ND-GAIN Vulnerability Index 2017	GINI Coefficient 2016	Real GDP per capita 2018	Poverty headcount ratio 2016	Prevalence of undernourishment 2016–2018
0.592 **140 out of 189** (0 = low, 1 = high)	**45.1** **107 out of 181** (0 = low, 100 = high)	**43.5** (0–100; 100 = perfect inequality)	**1807 USD** (constant 2010 USD)	**13.3 %** (at 1.9 USD per day, 2011 PPP) [1]	**5.5 %** (of total population)

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[1] Poverty headcount ratio for the year 2016 adjusted to 2011 levels of Purchasing Power Parity (PPP). PPP is used to compare different currencies by taking into account national differences in cost of living and inflation.

Topography and environment

Ghana is located in the tropical savannah climate zone and is divided into **six agro-ecological zones with two different precipitation regimes** (see Figure 1). The Tropical Rainforest, the Coastal Savannah, the Moist Semi-deciduous Forest and the Transitional Zone in **the southern part are characterized by bimodal precipitation creating a major and a minor growing season**, while the Guinea Savannah and the Sudan Savannah in **the north experience unimodal precipitation distribution and only one growing season** [17]. Ghana's stretch over three bio-geographical zones (southern Guineo-Congolian zone, transitional Guineo-Congolian/Sudanian middle belt, northern Sudanian zone) makes the country **rich in biological diversity** [18]. Yet, illegal logging practices often driven by agricultural expansion have contributed to irreversible changes to the forest ecosystem and impacted flora and fauna. According to official estimates by the Ghanaian Ministry of Environment, logging is about four times higher than would be sustainable for forest recovery [19]. Climate change adds to these existing threats through **rising temperatures and changing precipitation patterns**, ultimately leading to the reduction of (agro-) ecological productivity, including loss of indigenous species. It is reported that some 295 indigenous crop varieties are endangered and are potentially close to extinction due to an increased shift towards improved varieties as a form of climate change adaptation by Ghana's farmers [19]. Population growth puts additional stress on Ghana's biological diversity with the majority of the population depending on ecosystem services, e.g. for income generation, as sources of food security or as physical shelter. Climate change, as an additional stressor puts ecosystems under threat, highlighting the **need for adaptation measures to protect biodiversity and maintain fragile ecosystems and their services**.

Present climate

Ghana has a tropical climate with average mean annual temperature of 28.2 °C in the north and 27.3 °C in the south.

The country has a single rainy season (modal precipitation regime) in the north, and two rainy seasons (bimodal precipitation regime) in the south.

Mean annual precipitation ranges from 900 mm in the north to an average of 1500 mm in the south. In the tropical rainforest agro-ecological zone in the south-west, annual precipitation can reach over 1800 mm.

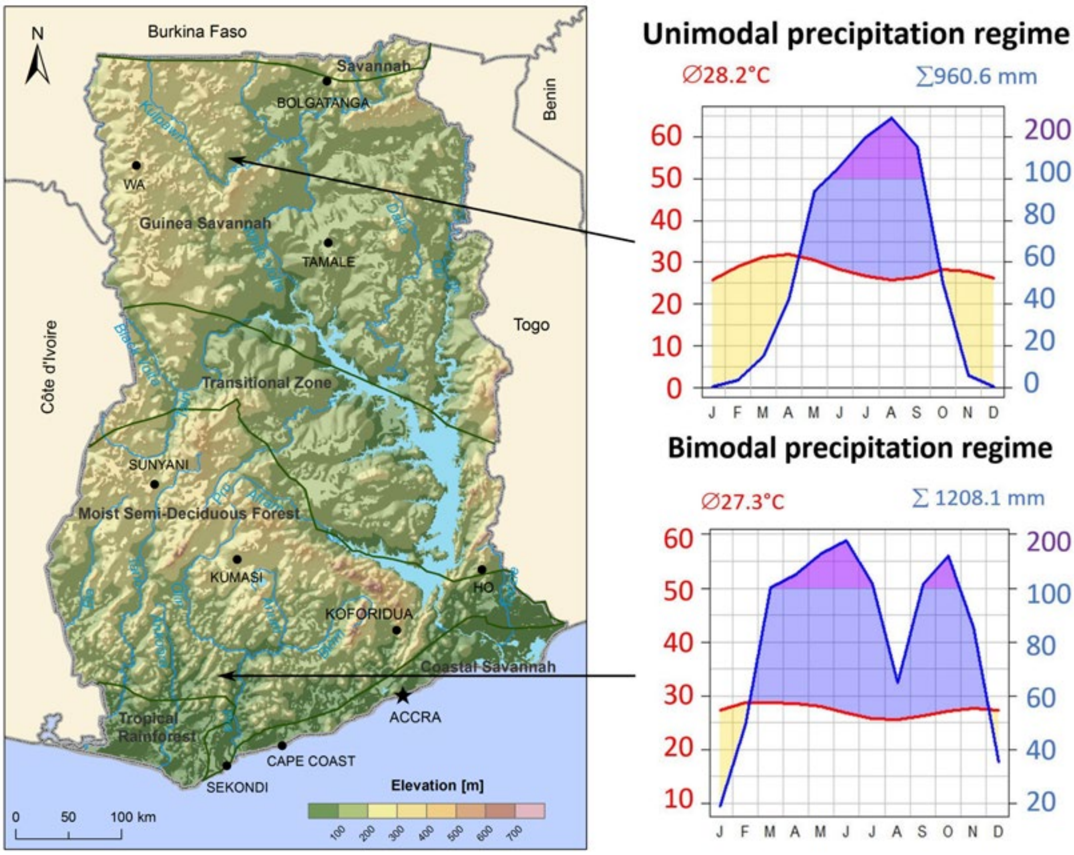


Figure 1: Map of Ghana with agro-ecological zones and precipitation regimes.

Projected climate changes

How to read the line plots

historical — best estimate
RCP2.6 — likely range
RCP6.0 — very likely range

Lines and shaded areas show multi-model percentiles of 31-year running mean values under RCP2.6 (blue) and RCP6.0 (red). In particular, lines represent the best estimate (multi-model median) and shaded areas the likely range (central 66 %) and the very likely range (central 90 %) of all model projections.

How to read the map plots

Colours show multi-model medians of 31-year mean values under RCP2.6 (top row) and RCP6.0 (bottom row) for different 31-year periods (central year indicated above each column). Colours in the leftmost column show these values for a baseline period (colour bar on the left). Colours in the other columns show differences relative to this baseline period (colour bar on the right). The presence (absence) of a dot in the other columns indicates that at least (less than) 75 % of all models agree on the sign of the difference.
For further guidance and background information about the figures and analyses presented in this profile kindly refer to the supplemental information on how to read the climate risk profile.

Temperature

In response to increasing greenhouse gas (GHG) concentrations, **air temperature over Ghana is projected to rise by 1.7to 3.7 °C (very likely range) by 2080** relative to year 1876, depending on the future GHG emissions scenario (Figure 2). Compared to pre-industrial levels, median climate model temperature increases over Ghana amount to approximately 1.8 °C in 2030, 2.2 °C in 2080, and 1.2 °C in 2080 under the low emissions scenario RCP2.6. Under the medium/high emissions scenario RCP6.0, median climate model temperature increases amount to 2.0 °C in 2030, 2.5 °C in 2050, and 3.3 °C in 2080.

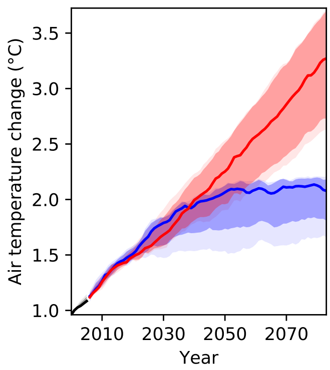
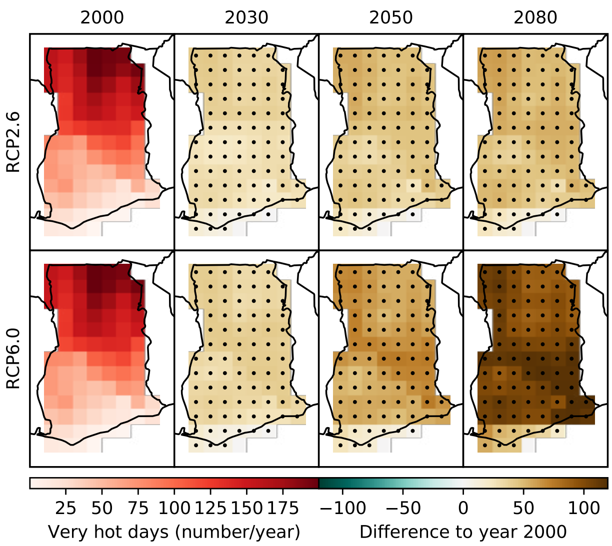


Figure 2: Air temperature projections for Ghana for different GHG emissions scenarios, relative to the year 1876.



Very hot days

In line with rising annual mean temperatures, the annual number of very hot days (days with daily **maximum temperature greater than 35 °C**) is projected to rise substantially in particular over northern Ghana (Figure 3). Under the medium/high emissions scenario RCP6.0, on average over all of Ghana, the median climate model projects **34 more very hot days per year in 2030 than in 2000, 55 more in 2050, and 94 more in 2080**. In some parts, especially in the north of Ghana, this amounts to about 300 days per year by 2080.

Figure 3: Projections of the annual number of very hot days (daily maximum temperature greater than 35 °C) for Ghana for different GHG emissions scenarios.

Sea level rise

In response to globally increasing temperatures, the sea level off the coast of Ghana is projected to rise (Figure 4). Until 2050, very similar sea levels are projected under different GHG emissions scenarios. Under RCP6.0 and compared to year 2000 levels, the median climate model projects **a sea level rise by 11 cm in 2030, 20 cm in 2050, and 39 cm in 2080**. This threatens Ghana's coastal communities and may cause saline intrusion in coastal waterways and groundwater reservoirs.

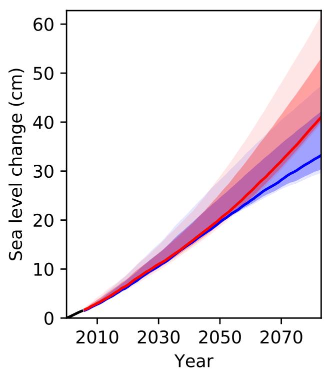


Figure 4: Sea level rise projections for the coast of Ghana for different GHG emissions scenarios, relative to the year 2000.

Precipitation

Future projections of precipitation are substantially more uncertain than projections of temperature or sea level rise. Detecting trends in annual mean precipitation projections is complicated by large natural variability at multi-decadal time scales and **considerable modelling uncertainty** (Figure 5). Of the four climate models underlying this analysis, one projects a decline in annual mean precipitation over Ghana. According to the other three models, there will be no change. Therefore, our best estimate is that there will be **almost no change in total precipitation per year until 2080 irrespective of the emissions scenario**, yet this result is highly uncertain.

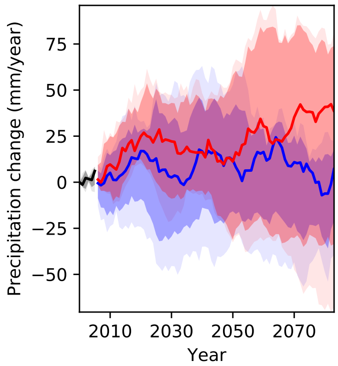


Figure 5: Annual mean precipitation projections for Ghana for different GHG emissions scenarios, relative to the year 2000.

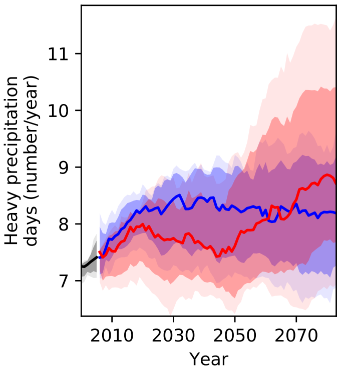


Figure 6: Projections of the number of days with heavy precipitation over Ghana for different GHG emissions scenarios.

Heavy precipitation events

In response to global warming, extreme precipitation events are expected to become more intense in many parts of the world due to the increased water vapour holding capacity of a warmer atmosphere. At the same time, the number of days with heavy precipitation events is expected to increase. This tendency is also found in climate projections for Ghana (Figure 6), with climate models projecting **a slight increase in the number of days with heavy precipitation events**, from 7 days/year in 2000 to 8 days/year under RCP2.6 or 9 days/year under RCP6.0 by 2080.

Soil moisture

Soil moisture is an important indicator for drought conditions. In addition to soil parameters, it depends on both precipitation and evapotranspiration and therefore also on temperature as higher temperature translates to higher potential evapotranspiration. **Annual mean top 1-m soil moisture projections for Ghana show a decreasing tendency** (Figure 7). This tendency is stronger than the corresponding precipitation change projections, which reflects the influence of temperature rise on evapotranspiration.

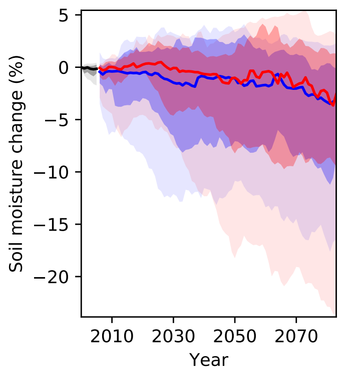


Figure 7: Soil moisture projections for Ghana for different GHG emissions scenarios, relative to the year 2000.

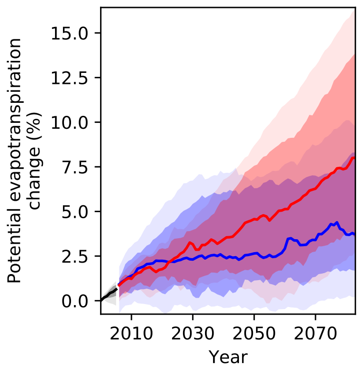


Figure 8: Potential evapotranspiration projections for Ghana for different GHG emissions scenarios, relative to the year 2000.

Potential evapotranspiration

Potential evapotranspiration is the amount of water that would be evaporated and transpired if sufficient water were available at and below the land surface. Since warmer air can hold more water vapour, **it is expected that global warming will increase potential evapotranspiration in most regions of the world**. In line with this expectation, hydrology projections for Ghana indicate a stronger rise of potential evapotranspiration under RCP6.0 than under RCP2.6 (Figure 8). Specifically, under RCP6.0, compared to year 2000 levels, **potential evapotranspiration is projected to increase by 3.2 % in 2030, 4.6 % in 2050, and 7.4 % in 2080**.

Sector-specific climate change risk assessment

a. Water resources

Current projections for water availability in Ghana display high uncertainty under both GHG emissions scenarios. Assuming a constant population level, multi-model median projections suggest a slight decline in per capita water availability over Ghana by the end of the century under both RCP2.6 and RCP6.0 (Figure 9). Yet, when accounting for population growth according to SSP2 projections[2], **per capita water availability for Ghana is projected to decline by about 70 % by 2080** relative to year 2000 (Figure 9, B). While this decline is not primarily driven by climate change but population growth, it highlights the urgency to invest in water saving measures and technologies for future water consumption.

Looking at the spatial distribution of future water availability projections within Ghana, it becomes evident that **water saving measures will become especially important after 2050 in the north of the country** (Figure 10). For all other parts of Ghana, water availability projections are too uncertain to make any such statement.

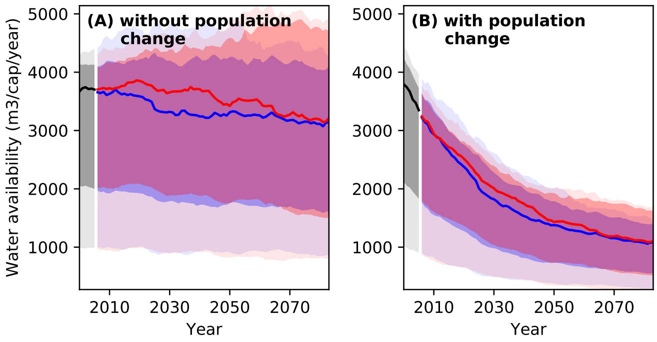


Figure 9: Projections of water availability from rainfall per capita and year with national population held constant at year 2000 level (A) and changing according to SSP2 projections (B) for different GHG emissions scenarios, relative to the year 2000.

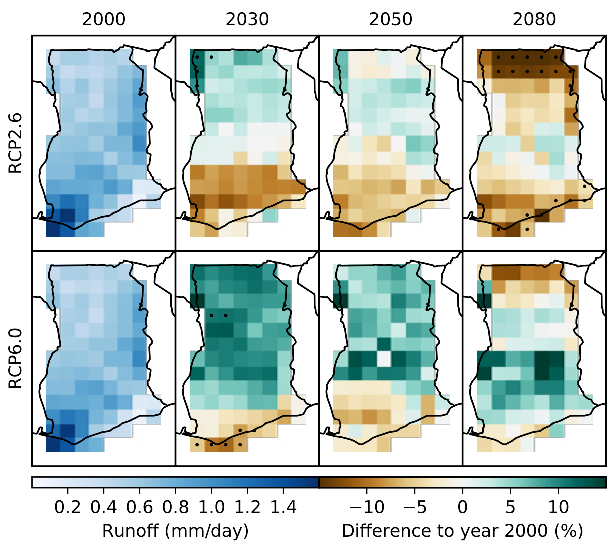


Figure 10: Water availability from precipitation (runoff) projections for Ghana for different GHG emissions scenarios.

A significant number of households (~40 %) depend on groundwater especially in the north [20], [21]. In particular after mid-century, **climate change will reduce the recharge into groundwater reservoirs** (aquifers), while increased requirements for agricultural water use under dry periods can lead to water scarcity. This risk is significant for closed basins such as Lake Bosomtwi, which has a small catchment [22]. In the south, sea level rise and storm surges will also increase the risk of salt water intrusion in freshwater especially in aquifers. Model results from the literature for the impacts of climate change on the Volta river basin in Ghana indicate that extreme flows will be more frequent [23], [24]. **This means there is a likely increase of periods with either relatively higher or lower mean annual discharge than in the past**, sometimes in consecutive years, affecting availability of fresh water for agriculture, sanitation, generation of hydropower and other economic activities.

[2] Shared Socio-economic Pathways (SSPs) outline a narrative of potential global futures, including estimates of broad characteristics such as country-level population, GDP, or rate of urbanisation. Five different SSPs outline future realities according to a combination of high and low future socio-economic challenges for mitigation and adaptation. SSP2 represents the “middle of the road”-pathway.

b. Agriculture

Agriculture is amongst the sectors most exposed to climate change. Smallholder farmers in Ghana are increasingly challenged by the uncertainty and variability of weather that climate change causes, particularly in the northern regions of Ghana. Since crops are predominantly rainfed (as less than 1 % of the national crop area is irrigated), crop yields depend on water availability and are susceptible to drought. **The impacts of climate change on the agricultural sector will be crop-specific and also site-specific with major negative impacts expected for maize in the central to northern parts of the country** [24]. Yet, the high uncertainty of water availability projections (Figure 10) translates to high uncertainty in drought projections (Figure 11). According to the median over all models employed for this analysis, **the national crop land area exposed to at least one drought per year will hardly change in response to global warming. However, there are models that project an increase in drought exposure**. Under RCP6.0, the likely range of drought exposure of the national crop land area per year widens from 0.3–8.8 % in 2000 to 0.5–21.0 % in 2080. The very likely range widens from 0.1–25.0 % in 2000 to 0.1–53.0 % in 2080. This means that **some models project more than a doubling of drought exposure over this time period, while others project no change**.

In terms of yield projections, model results indicate a clear **negative yield trend for maize and millet** under both RCP2.6 and RCP6.0. As a best estimate, compared to year 2000, yields are projected to decline by 9 % for maize and 10 % for millet by 2080 under RCP6.0, and by 4 % and 5 % under RCP2.6, respectively.

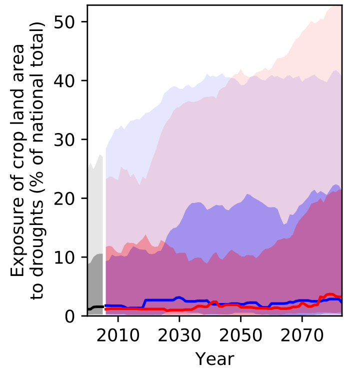


Figure 11: Projections of at least once per year exposure of crop land area to drought for Ghana for different GHG emissions scenarios.

Yields of cassava, groundnuts and field peas, on the other hand, are projected to significantly gain from climate change. Under RCP6.0, yield increases by 2080 relative to year 2000 are projected to amount to 33 % for cassava, 14 % for field peas, and 3 % for groundnuts. A possible explanation for the positive results under RCP6.0 is that cassava, groundnuts and field peas are so-called C3 plants, which follow a different metabolic pathway than maize and millet (C4 plants), and thus benefit more from the CO_2 fertilisation effect under higher concentration pathways. Cassava and groundnuts are also more tolerant to both low and high rainfall extremes.

Overall, adaptation options such as switching to improved varieties in climate change sensitive crops need to be considered, yet should be carefully weighed against adverse outcomes, such as resulting decline of agro-biodiversity and loss of local crop types.

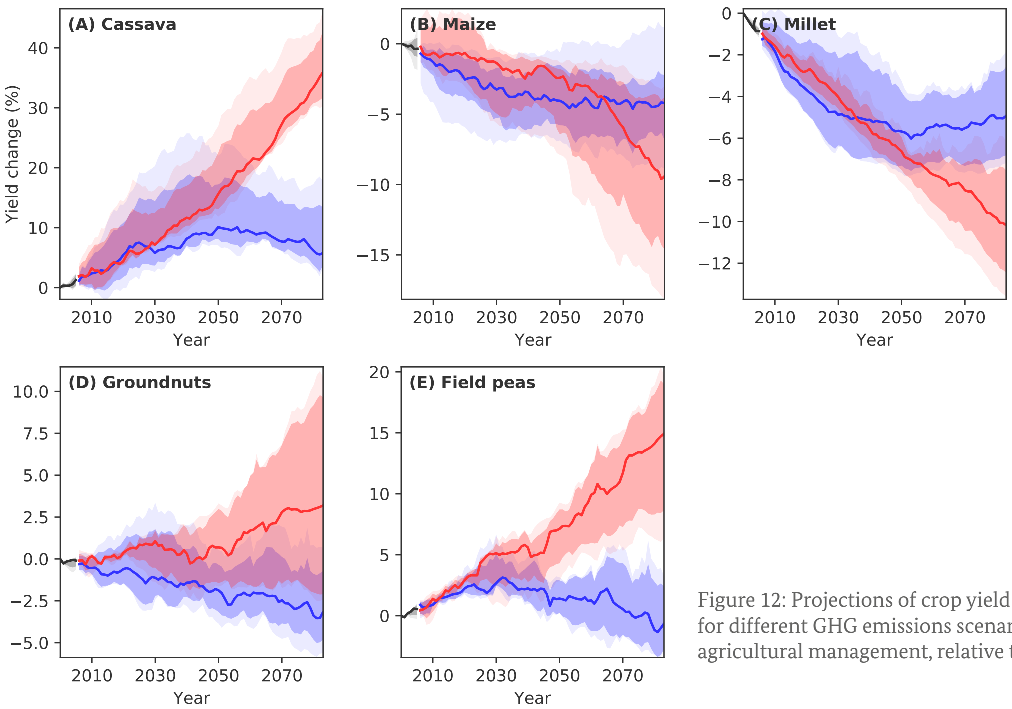


Figure 12: Projections of crop yield changes for major staple crops in Ghana for different GHG emissions scenarios assuming constant land use and agricultural management, relative to the year 2000.

c. Infrastructure

Extreme weather events have been the cause of major **damage to the infrastructure sector in Ghana in the past**. A study by Twerefou et al. [25] from 2014, for example, states that within one year, **1016 km of roads were destroyed, 13 bridges collapsed and 442 sewers damaged in the northern region of Ghana in 2007 alone through climate-related events**. In general, high temperature can cause roads to develop cracks, while high precipitation rates may create potholes or deepen existing ones. [26]. Transport infrastructure is very vulnerable to extreme weather events and yet very important for social, economic and agricultural livelihoods. Roads allow communities to trade their goods and access healthcare, education, credit, as well as other services, especially in rural and remote areas of Ghana.

Storms, extreme rainfall and floods can also have devastating effects on economic production sites as well as settlements, especially in areas where large populations reside, such as Accra, Kumasi and Tamale. Informal settlements are particularly vulnerable to these events, as structures are generally weak and dwellers have low adaptive capacity to respond to disruptive events. Hydropower generation plants are affected by both droughts and floods, whereas sea level rise is already beginning to erode coastal roads [27]. **Overall, climate change will make the life span of infrastructure shorter than planned while maintenance costs will increase significantly to keep them functioning** [27], [28].

Under climate change, extreme weather events are likely to become more frequent, and temperatures are projected to rise. Accordingly, the risk for infrastructure damage in the country is likely to increase. However, precise predictions of the location and extent of exposure are difficult to make. For example, projections of river flood events are subject to substantial modelling uncertainty, largely due to the uncertainty of future projections of precipitation amounts and their spatial distribution, affecting affecting flood occurrence (see also Figure 5). According to this analysis, flood projections show a decrease in exposure for one climate model, no change for another, a slight increase for the third and a strong increase for the fourth. Thus, **no reliable estimates on river flood occurrence in the future can be made**. While median model trends suggest an approximate doubling of road exposure to floods under RCP6.0 (Figure 13) from 2000 to 2080, the very likely range of model results indicates a **possibility of up to a fivefold increase in road exposure to floods by 2080** (from 0.2 % of the national road network exposed in 2000 to 1.1 % in 2080). Also **urban land area exposed to floods is projected to increase** (Figure 14), with a very likely range of 0–0.6 % of the urban area exposed by 2080 under RCP 6.0.

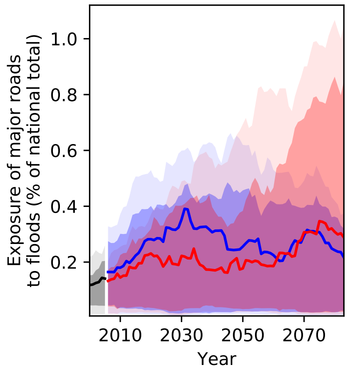


Figure 13: Projections of at least once per year exposure of major roads to river floods for Ghana for different GHG emissions scenarios.

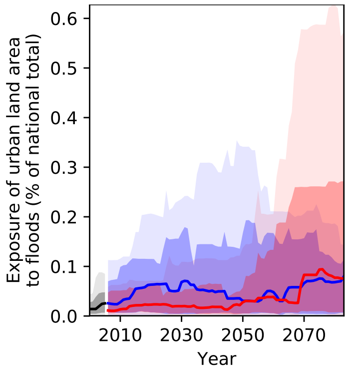


Figure 14: Projections of at least once per year exposure of urban land area to river floods for Ghana for different GHG emissions scenarios.

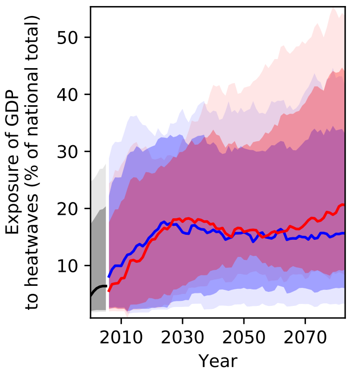


Figure 15: Exposure of GDP in Ghana to heatwaves for different GHG emissions scenario.

Twerefou et al. [27] estimate that the future (2020-2100) cost of climate change-related damage on road infrastructure will amount to USD 473 million if no adaptation actions are taken, and USD 678.47 million if pricing in the costs for adaptation efforts in designing and constructing new road infrastructure. They estimate that **the highest adaptation costs will incur in the northern region and the lowest in the greater Accra region.**

With the impact to GDP from heatwaves projected to increase from around 5 % in 2000 to 15 % (RCP2.6) and 20 % (RCP6.0) by the end of the century, it is recommended that policy planners start identifying heat-sensitive economic production sites and activities, and integrating climate adaptation options, such as improved, solar-powered cooling systems or switching of operation times from day to night.

d. Ecosystems

Climate change is anticipated to have a significant influence on the ecology and distribution of tropical ecosystems, though the magnitude, rate and direction of these changes are uncertain [29]. Under rising temperatures, increased frequency and intensity of droughts and shorter growing periods, **wetlands and riverine systems become at risk of being converted to other ecosystems** with plants being succeeded and animals losing habitats. Increased temperatures and droughts can also affect succession in forest systems while concurrently increasing the risk of invasive species, all of which affect the ecosystems. In addition to these climate drivers, reduced agricultural productivity and population growth might motivate further agricultural expansion resulting in increased deforestation, forest degradation and in return in increased forest fires, all of which will impact animal and plant biodiversity [30]. While ecosystems in the northern areas of Ghana are expected to be particularly affected given the higher expected temperature increase and mounting pressure from human land use, the challenges are prevalent throughout the entire country.

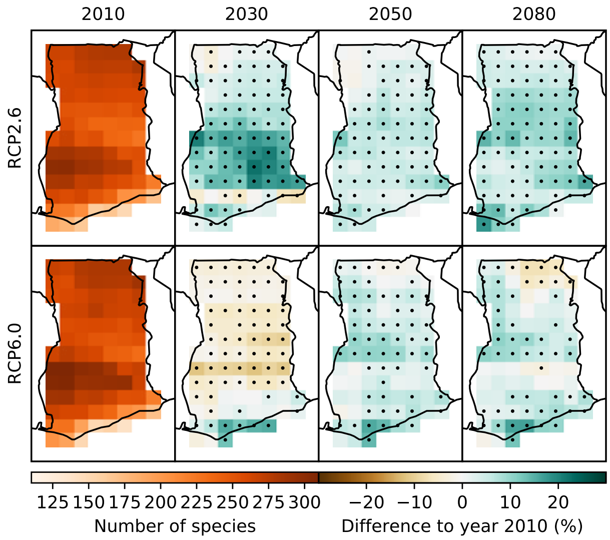


Figure 16: Projections of the aggregate number of amphibian, bird, and mammal species for Ghana for different GHG emissions scenarios.

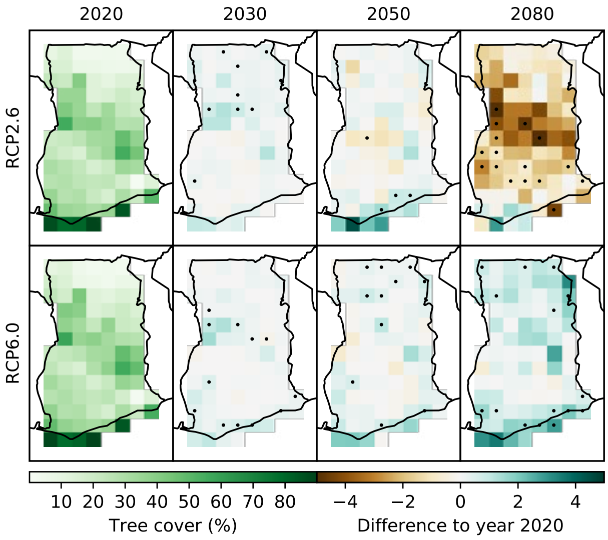


Figure 17: Tree cover projections for Ghana for different GHG emissions scenarios.

Model projections of species richness (including amphibians, birds, and mammals) and tree cover for Ghana are shown in Figure 16 and 17, respectively. The volatility in species richness between 2030 and 2050 under RCP6.0 suggest a high sensitivity of species survival and population recovery to natural climate variability. Overall, however, **model results indicate a slightly positive long-term impact of climate change on species richness under both RCPs** (Figure 15), with the majority of models (at least 75 %) agreeing on this trend. With regards to tree cover shifts, model results are highly uncertain. Until mid-century, tree cover is projected to not change significantly in most parts of Ghana. Towards the end of the century, the average model projects slight decreases of tree cover under RCP2.6 and slight increases under RCP6.0, yet model agreement about these trends is low in most parts of the country (Figure 16).

Although these results paint an overall positive picture for climate change impacts on ecosystems and biodiversity, it is important to keep in mind that the **model projections exclude any impacts on biodiversity loss from human activities such as land use**, which have been responsible for significant losses of global biodiversity in the past, and are expected to remain the main driver of biodiversity loss in the future [31].

e. Human health

Climate change threatens the health and sanitation sector through more frequent incidences of heatwaves, floods, droughts and dry winds [32]. Climate change impacts on health can be direct, e.g. via increasing exposure to heatwaves or floods, or indirect, e.g. via more frequent incidences of vector-borne diseases, such as malaria, as well as via increasing food insecurity or malnutrition.

Rising temperatures will result in more frequent heatwaves in Ghana, which **will increase heat-related mortality**. Under RCP6.0, the **population affected by at least one heatwave per year is projected to rise from 5 % in 2000 to 19 % in 2080** (Figure 17). Furthermore, under RCP6.0, heat-related mortality will likely increase from about 1 to about 5 deaths per 100 000 people per year, which translates to an increase by a factor of more than five towards the end of the century compared to year 2000 levels, provided that no adaptation to hotter conditions will take place (Figure 18). Under RCP2.6, heat-related mortality is projected to increase to about 2 deaths per 100 000 people per year.

Among the key health challenges in Ghana are also communicable diseases, such as malaria, tuberculosis, and HIV, maternal and children's health as well as malnutrition, many of which are expected to become increasingly severe under climate change. Studies show that Malaria, diarrhea, and Cerebro Spinal Meningitis are being aggravated by impacts of climate change in Ghana [33].

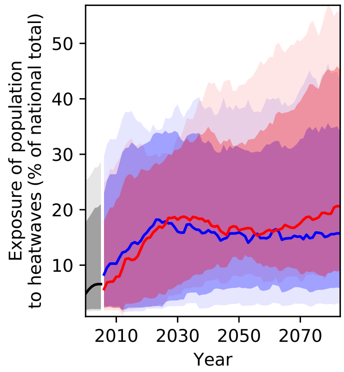


Figure 18: Projections of at least once per year exposure of population to heatwaves for Ghana for different GHG emissions scenarios.

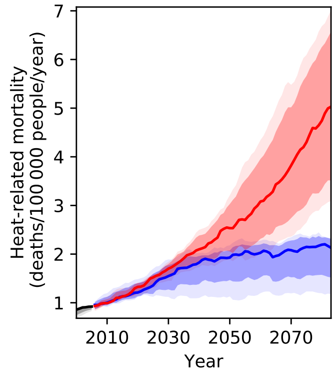


Figure 19: Projections of heat-related mortality for Ghana for different GHG emissions scenarios assuming no adaption to increased heat.

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