Global Water Security Center

28 Jun 2024
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Environmental Insight Brief: Africa - Gulf of Guinea

Extremes Intensify North of the 10th Parallel by 2035

Over the past 40 years, global warming has driven changes in weather extremes over Gulf of Guinea countries at a much faster rate than the rest of the world. Floods, droughts, and heatwaves are now the norm.

While extreme weather is projected to continue in the region, models show the rate of intensification will slow. However, the changes that are forecast for the next 10 years fall disproportionately north of the 10th Parallel, which generally divides Muslim and Christian populations.

Changes will more heavily impact Muslim populations in areas with heavy ISIS and Boko Haram presence.

Research has shown that government assistance following disaster can ameliorate citizens discontent. Conversely, if increases in damaging weather events are not met with a reasonable increase in government disaster response, citizen could shift toward illicit activities and insurgent groups to support their livelihoods.

Moreover, historic cases from around the globe where one social or religious group perceived that another was treated more favorably in the wake of disaster have caused political unrest.

01 **Heat and Drought:** Temperatures are rising, most particularly in the north and northeast of the region. Recent unprecedented heatwaves will become much more common.

02 **Rain and flooding:** While annual average rainfall is projected to shift only slightly, rain will fall in shorter, more intense bursts that increase the risk of flooding and damage to property and infrastructure.

03 **Sea level rise:** Rising seas and rapid urban development are combining to destabilize coastal cities. Impediments to market and industrial activity in these economic engines may diminish central government revenues.

Supplement

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Gulf of Guinea, 2035: Heat and Drought

Impacts from rising temperatures will be more pronounced north of the 10th Parallel, which could aggravate Muslim-Christian tensions

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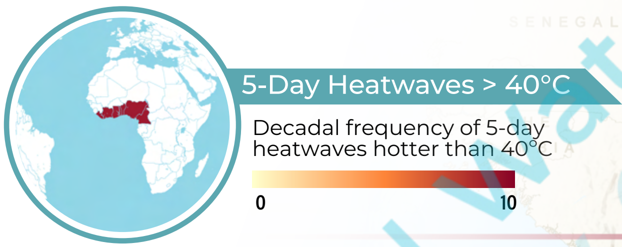
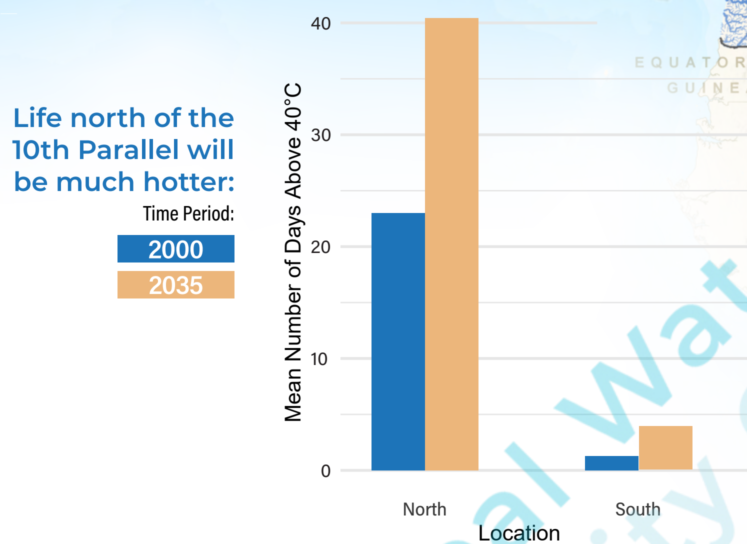


Deadly heatwaves will occur more frequently north of the 10th Parallel. Events like the unprecedented 5-day 40°C heatwave that hit the Sahel and West Africa in 2024 will likely occur every year or two by 2035 in northern regions.

Hotter temperatures will diminish electricity transmission while increasing electricity demand. Weakened transmission lines combined with power demand spikes for cooling will cause blackouts like those in Nigeria in March 2024.

Rising temperatures have already caused tropical forest fires to double over the last 20 years. Heat will drive more frequent, larger fires along the coast that could divide military personnel between firefighting efforts in the south and patrolling sensitive regions in the north.



Pathway to Impact

The difference in magnitude of heat impacts north of the 10th Parallel may compel more people to move to the less-affected south, which may lead to integration problems.

As drought negatively impacts agriculture and livestock, farmers and pastoralists may be compelled to join insurgent groups who offer stability in exchange for loyalty.

Heat stress on one part of the West African Power Pool can have repercussions across the networked grid and cause difficulties in electricity management and regional relations internal to West African countries.

Gulf of Guinea, 2035: Rain and Flooding

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Heavy rainfall and floods will damage the transportation infrastructure required to move troops and patrol politically sensitive regions and illicit activities.

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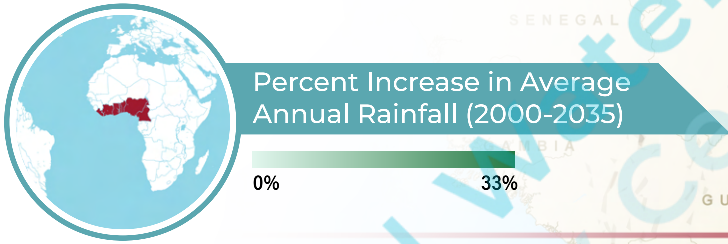


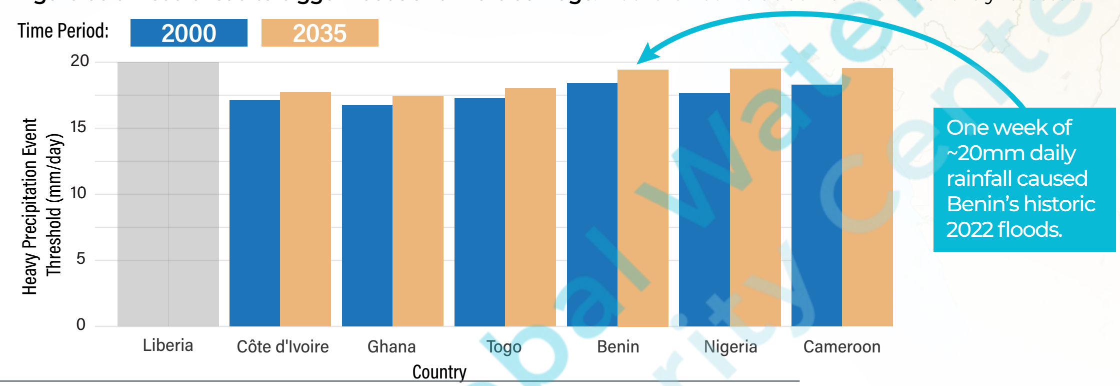
Climate change is already intensifying heavy rain and floods. Climate change made 2022's floods in Nigeria, Cameroon, and Benin 80 times more likely and 20% more intense. That flooding killed hundreds and displaced millions.

Flooding will increase more dramatically north of the 10th Parallel. Average annual rainfall across dry northern border regions is projected to increase up to 33% above the 2000 average by 2035. Heavy rain on hot, parched earth will worsen flooding.

Roads cross rivers ~2,400 times in the region; washed out transportation infrastructure can have far-reaching effects. Damaged roads can limit troop access to illegal mines, wildlife trafficking routes, and protected areas occupied by insurgent groups.

Small increases in rainfall can have massive consequences:

The magnitude of extreme rain events over grasslands is increasing, which means a storm must be bigger to count as extreme. But those grasslands' ability to absorb floods remains the same. **Even the small increases depicted in the figure below could lead to bigger floods and more damage.** Liberia is not included here as it is entirely forested.



Pathway to Impact

Storms that impact government forces more than opposing insurgent groups can tip the scales of power in a region.

Research has shown that, if citizens perceive their government has not offered adequate assistance in disaster, they are more likely to protest and riot.

An increase in rainfall over the Niger River coincides with the Alliance of Sahel States moving away from the Economic Community of West African States, which may make transboundary river sharing more challenging.

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Gulf of Guinea, 2035: Sea Level Rise

Sea level rise will damage economically robust coastal cities and erode the Central Government revenues required to fund militaries and repair damaged infrastructure.

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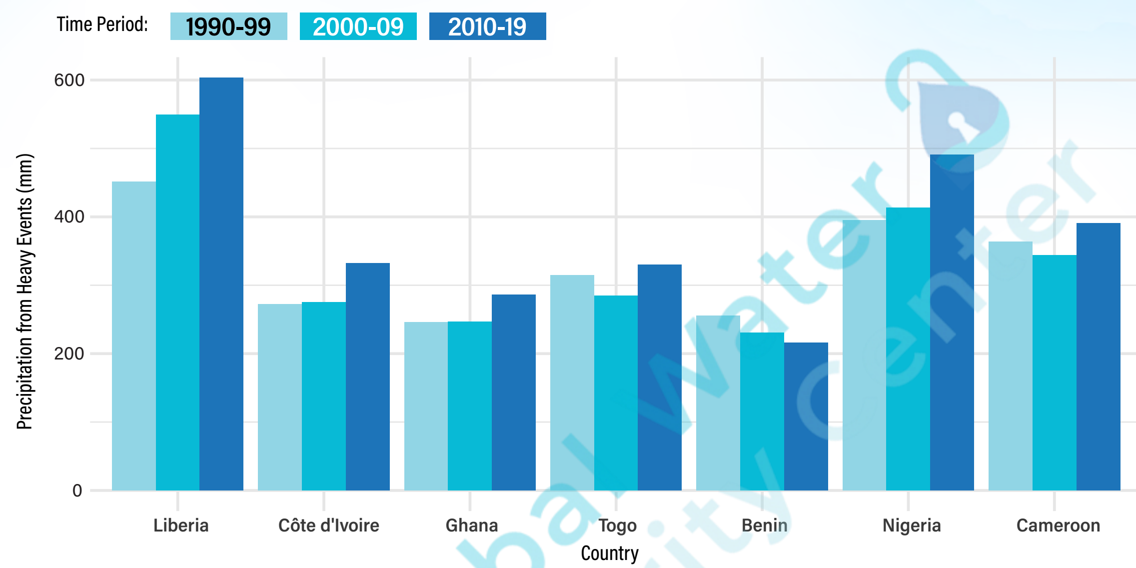
The coastline between Abidjan and Lagos is at high to very high risk of erosion. Some regions, particularly those around ports, see up to 10 meters of horizontal coastal retreat a year.

Global warming and deforestation are generating stronger coastal storms, which exacerbates impacts in urban areas. Inland rainfall combines with powerful waves to wash more coastland out to sea.

Storm surges have been growing in height and frequency over the past 20 years, and sea level rise will make them worse. Washouts, re-routed highways, and costly repairs can disrupt industrial productivity and trade.

In coastal forests, more rain already comes from big storms. That trend will increase:

Heavy rain accompanied by storm surges compounds damage to coastal regions.



Pathway to Impact

Floods and sea level rise threaten the 1000 kms of transportation infrastructure being built for the USD $318 million Corridor Trade and Transport Facilitation Program between Abidjan and Lagos.

Sea level rise and storms will continue to damage oil infrastructure in the Niger Delta, increasing the costs of operation and reducing the economic benefits.

In 2022, 92% of the transit through Lomé's deep water port came from Alliance of Sahel States (AES) countries. Climate damage to the port could complicate relations between Togo, the AES, and the Economic Community of West African States.

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Gulf of Guinea, 2035: Benin

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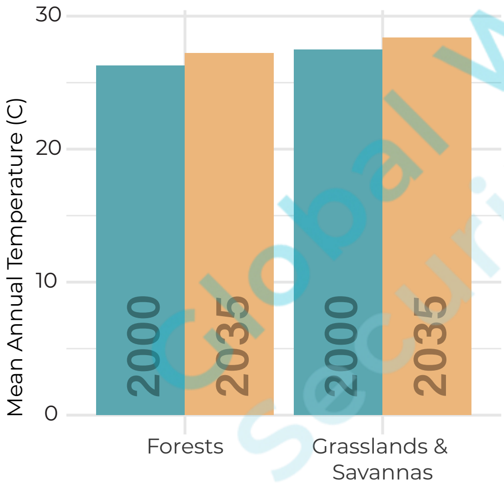
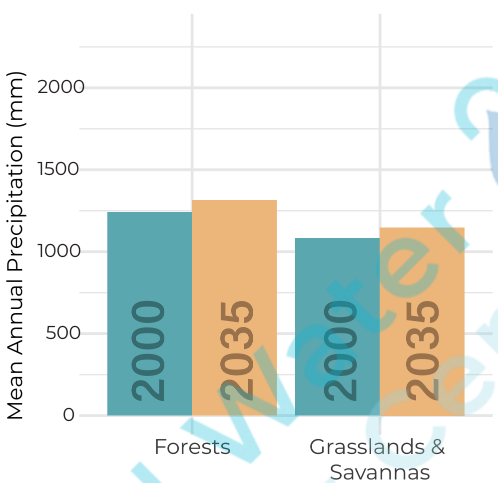
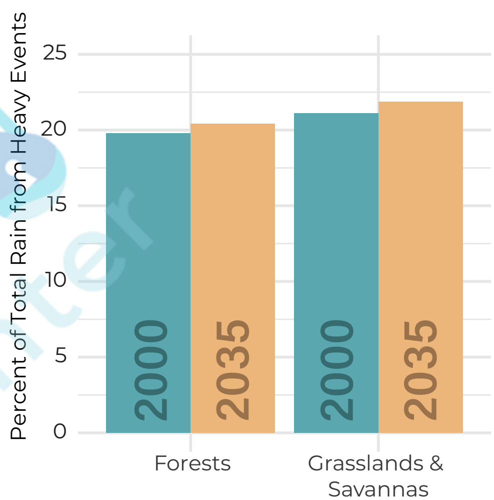


Precipitation Projections



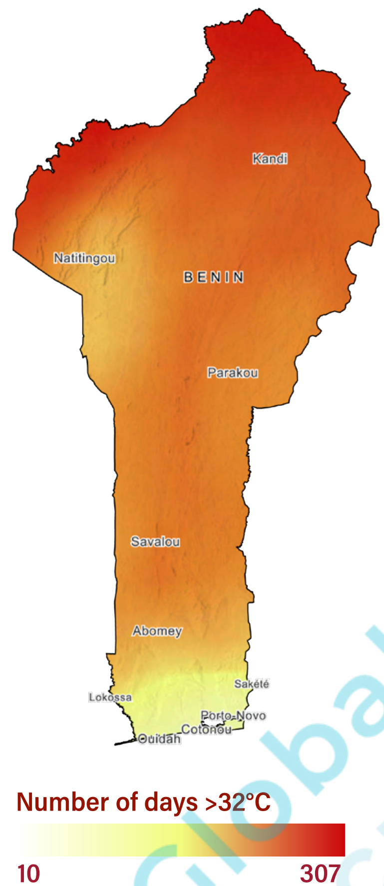


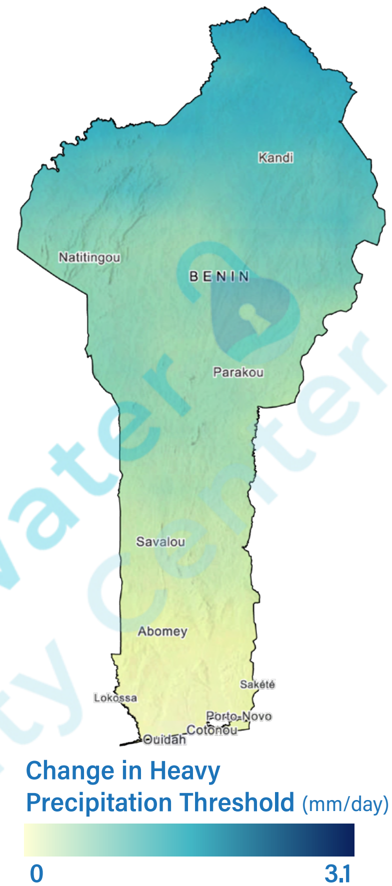
Temperature and Precipitation in 2035

Based on NASA downscaled CMIP6 SSP285

Days >32°C: the US Military considers such days "Black Flag Days." All outdoor physical activities are halted on its own bases when temperatures reach this threshold.

Extreme precipitation threshold: the amount of daily precipitation required to be considered extreme. Here, we define extreme as the top 5% of daily precipitation events.





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Gulf of Guinea, 2035: Cameroon

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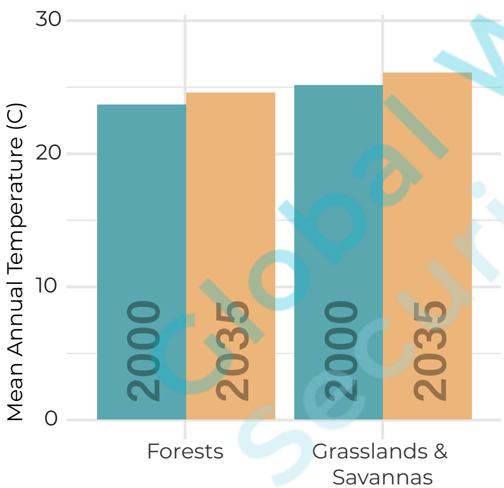

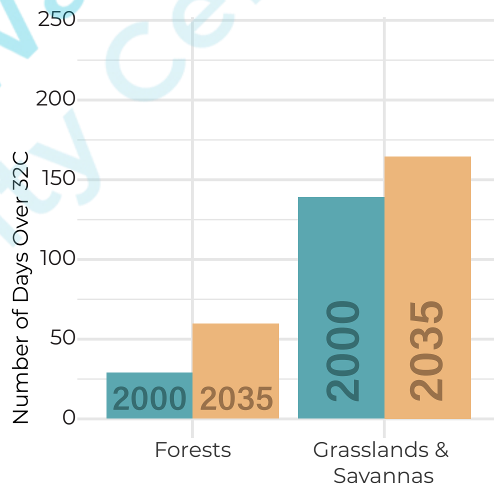

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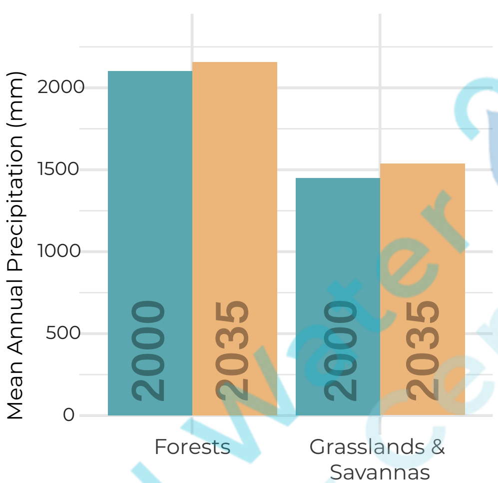

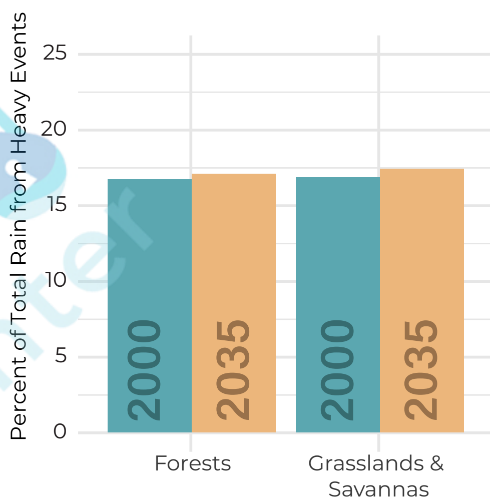

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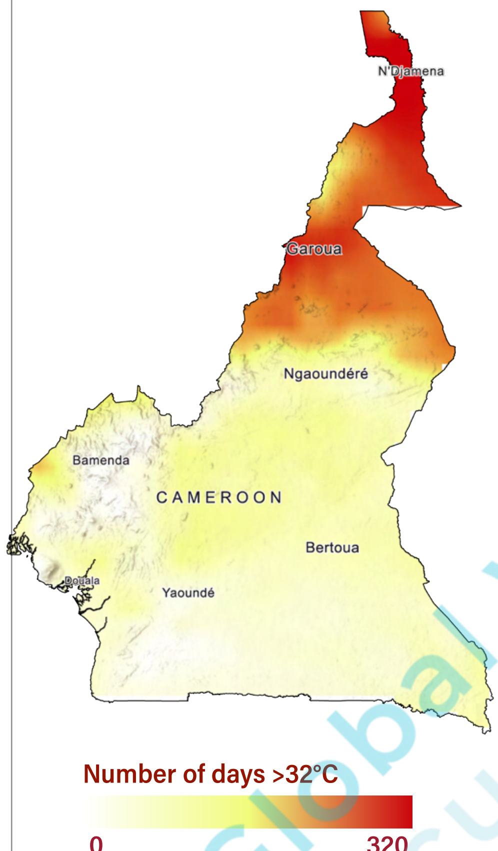

Gulf of Guinea, 2035: Côte d'Ivoire

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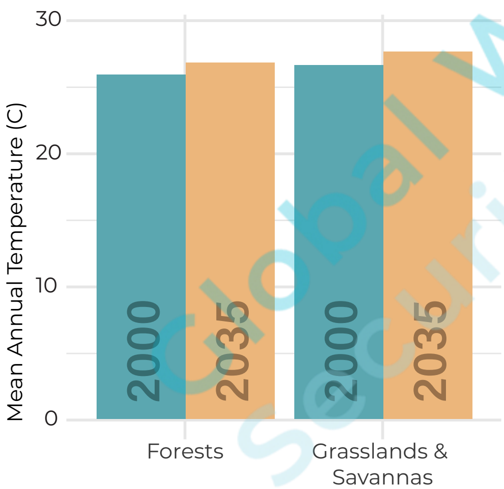

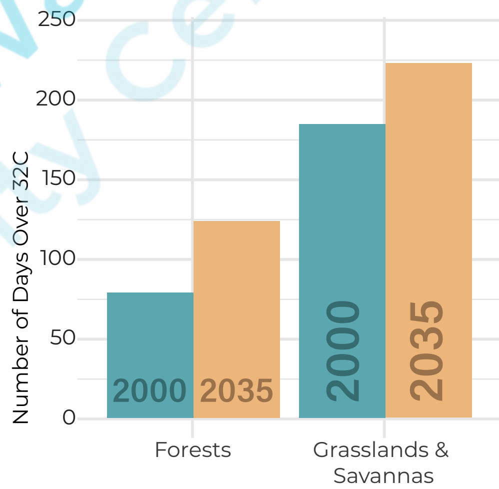

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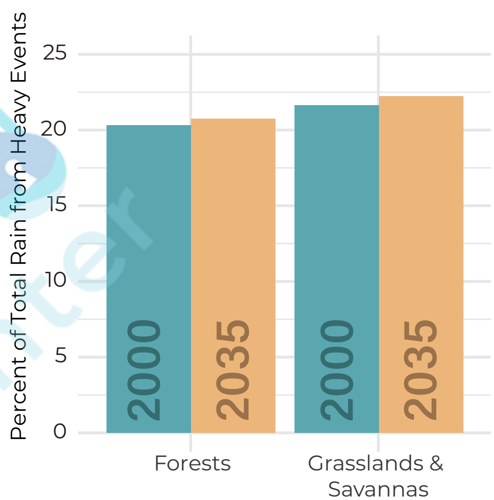

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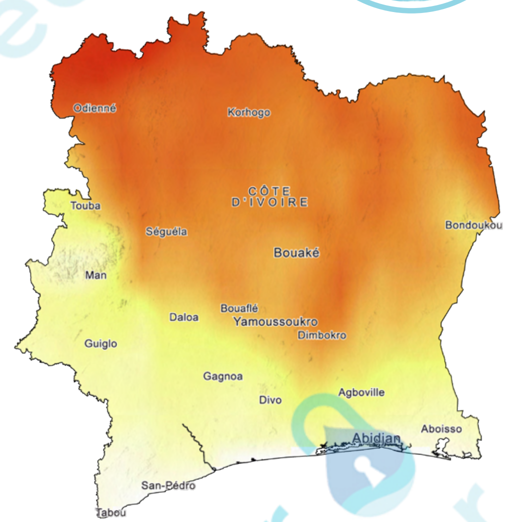
Number of days >32°C

9 280



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Change in Heavy Precipitation Threshold (mm/day)

0 1.5

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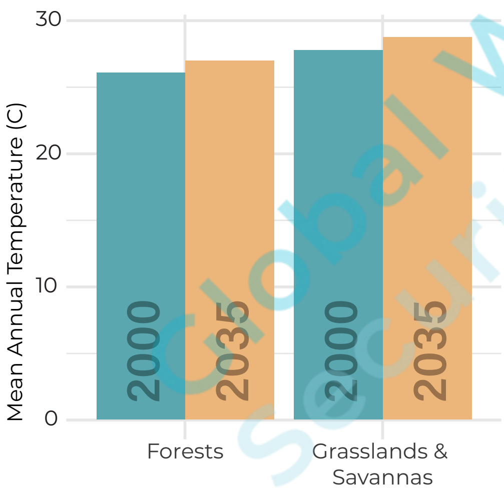

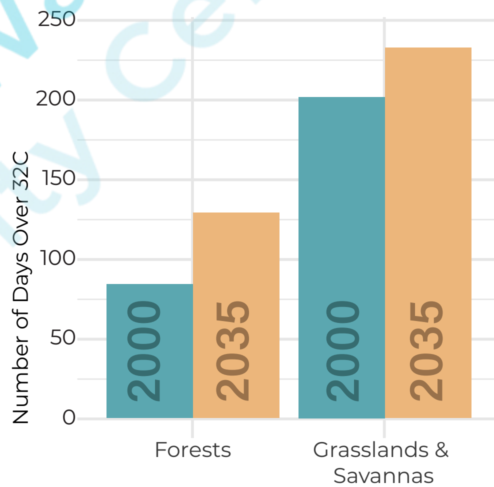

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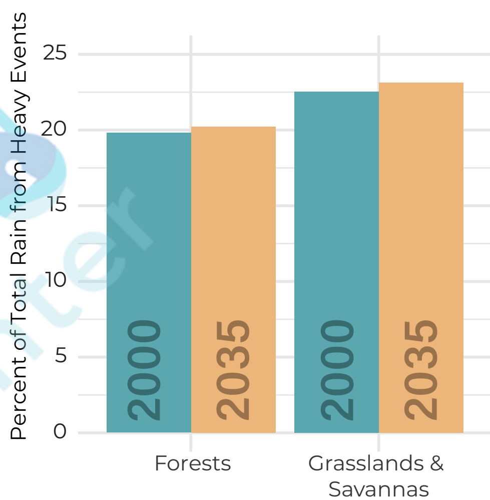

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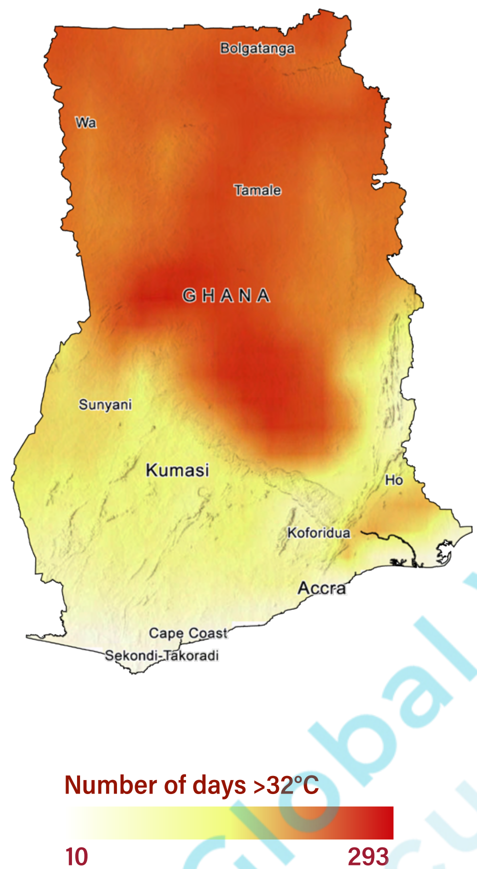

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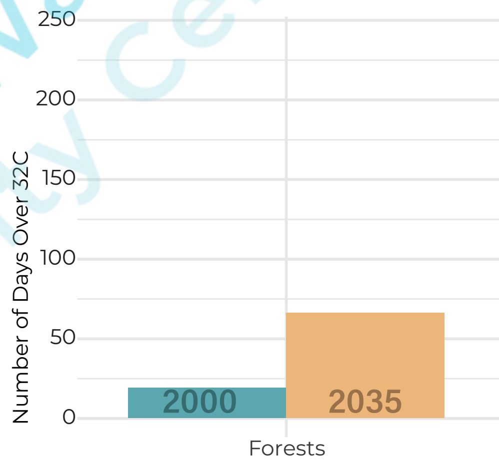
Gulf of Guinea, 2035: Liberia

Temperature Projections



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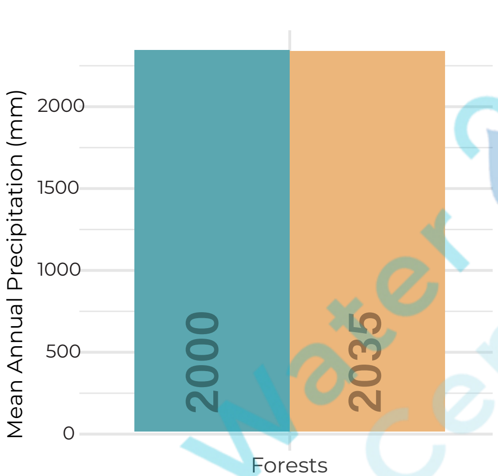

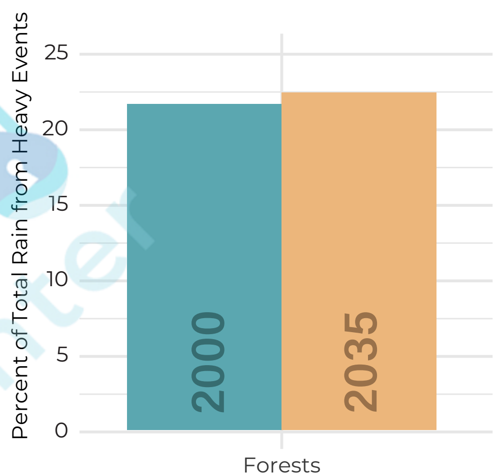

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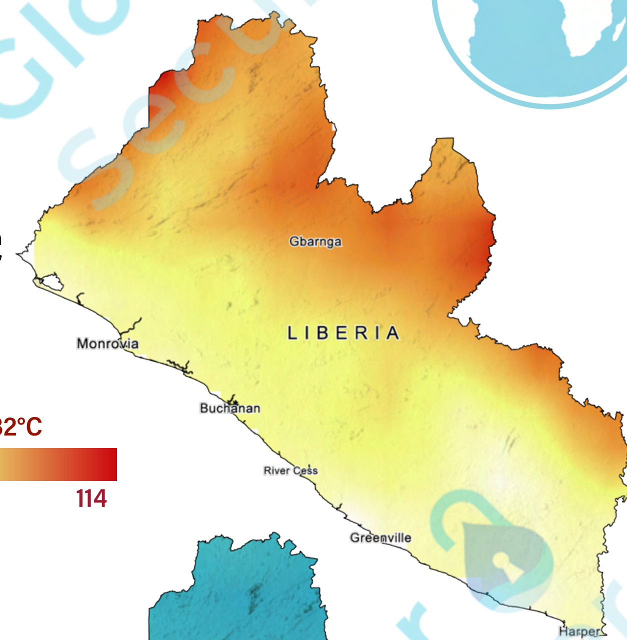

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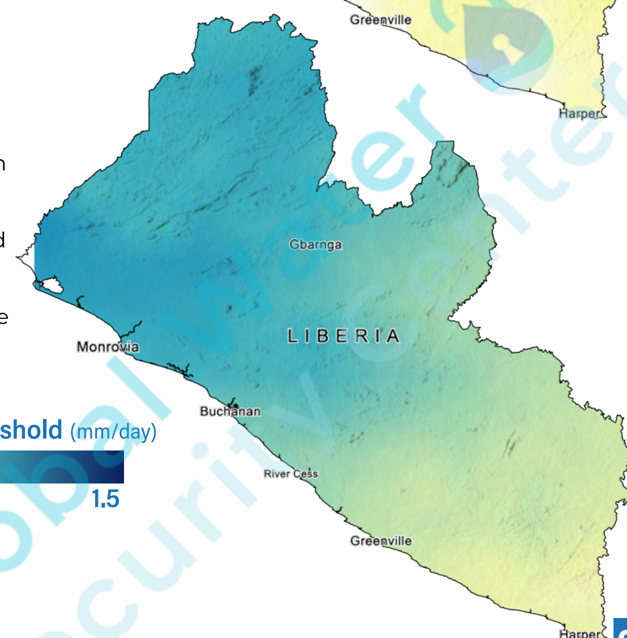
Number of days >32°C

9 — 114



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Change in Heavy Precipitation Threshold (mm/day)

0 — 1.5

Gulf of Guinea, 2035: Nigeria

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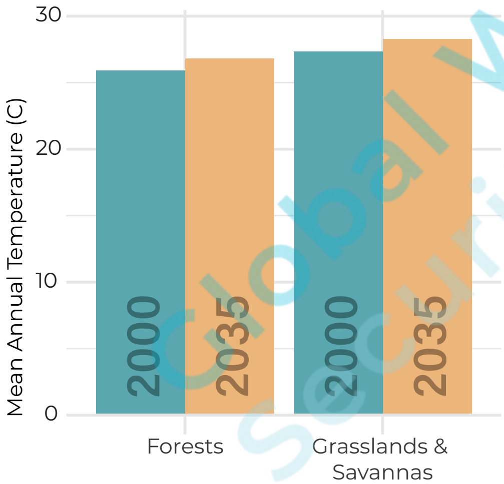

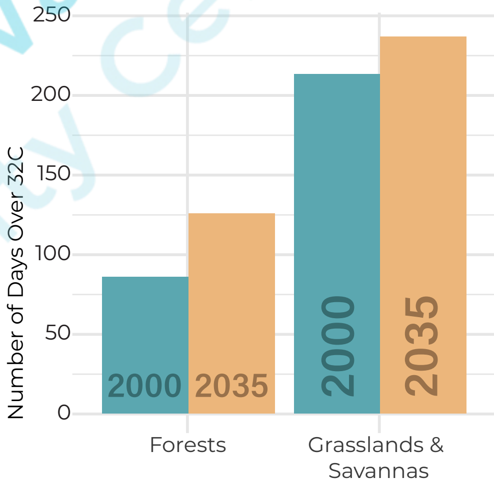

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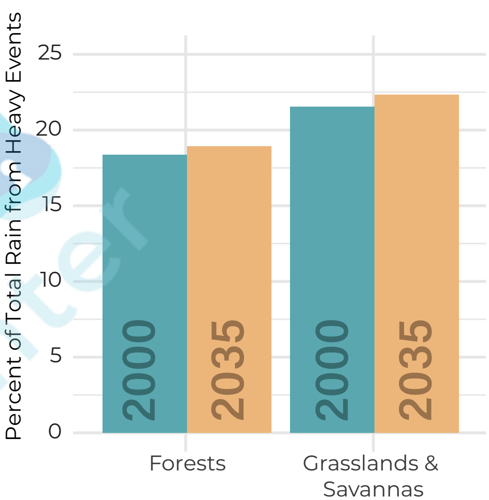

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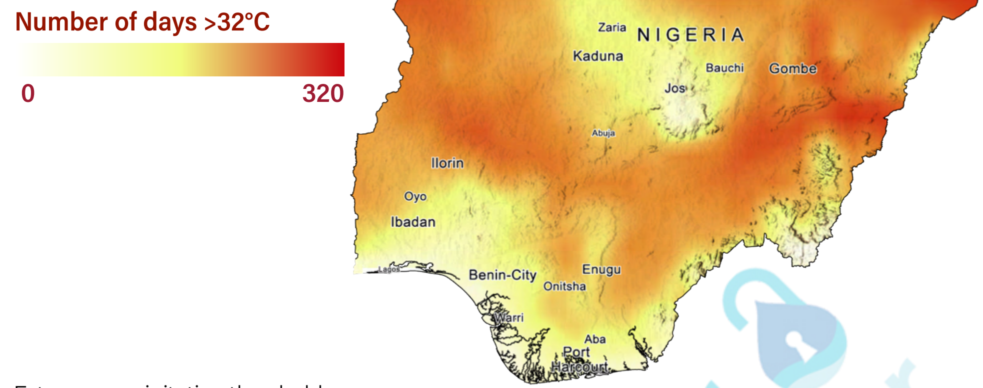

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Change in Heavy Precipitation Threshold (mm/day)

Gulf of Guinea, 2035: Togo

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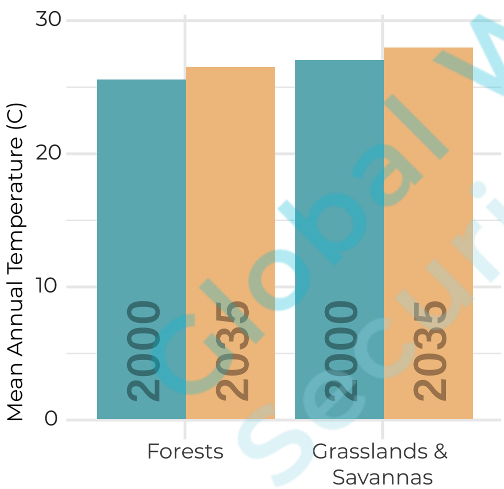

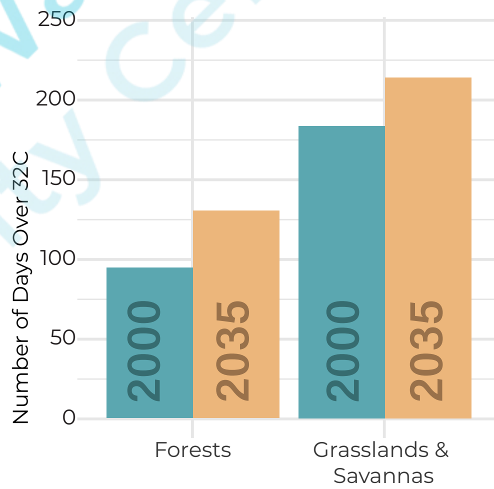

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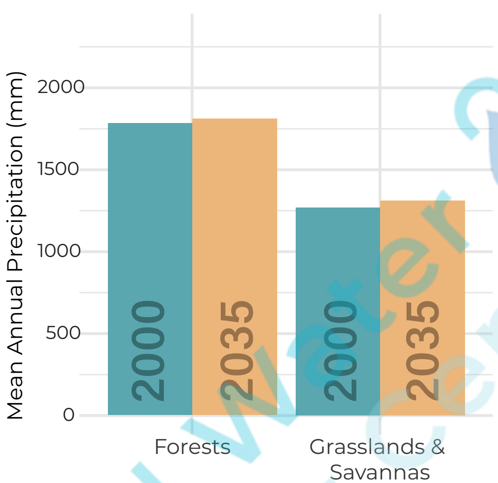

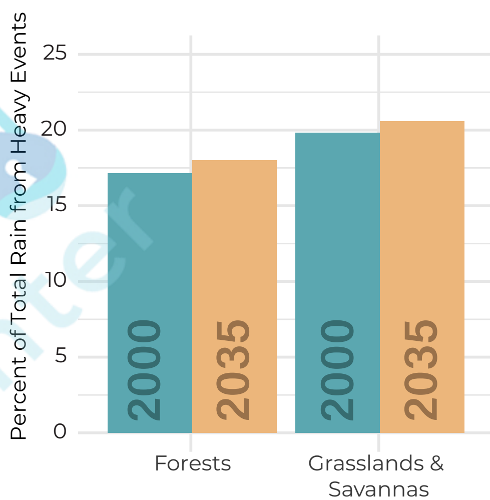

Temperature and Precipitation in 2035

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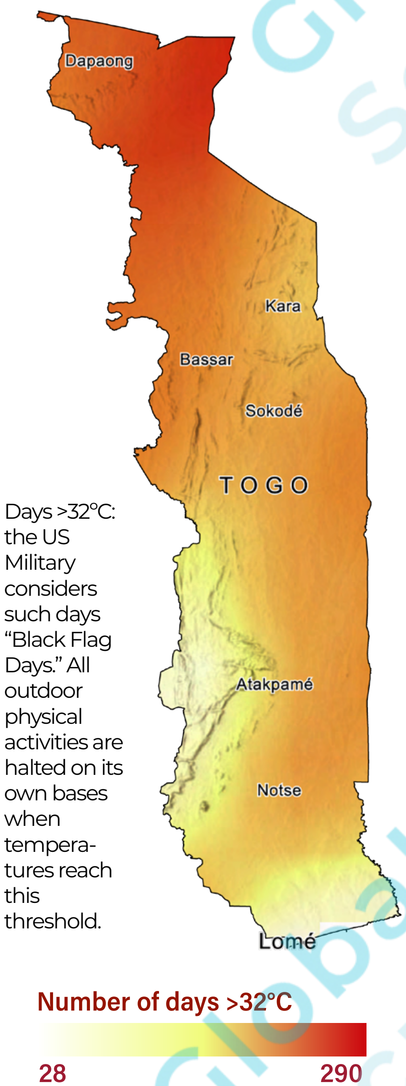

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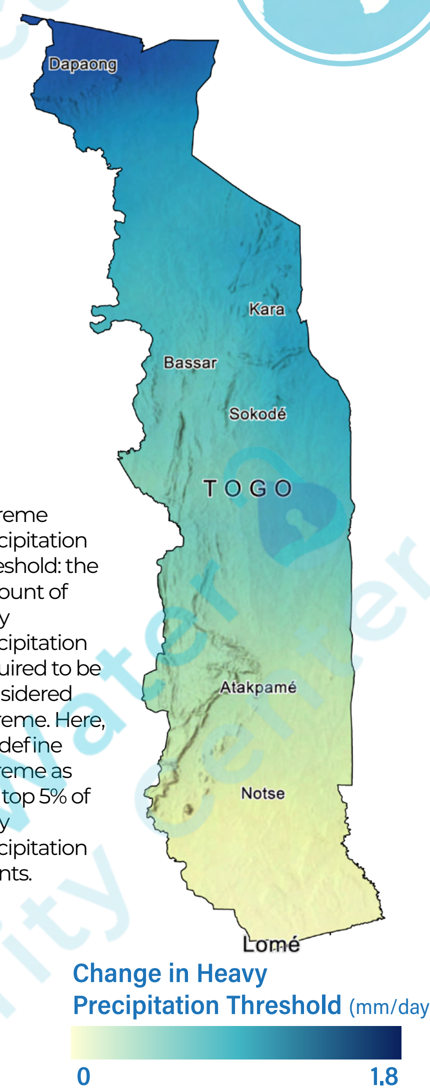

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Supplemental Materials

Data and Methods

Data Sets:

- ERA5 Historical Weather Data [1985-2014] – monthly precipitation, monthly average temperature, daily precipitation
- NASA Earth Exchange Global Daily Downscaled Projection CMIP6. SSP245 2025 – 2035 & 2040-2060. Historical 1985-2014. 17 models were used: ACCESS-ESM1-5, BCC-CSM2-MR, CanESM5, CMCC-ESM2, FGOALS-g3, GISS-E2-1-G, MIROC-ES2L, MPI-ESM1-2-HR, MRI-ESM2-0, NESM3, NorESM2-MM, CNRM-ESM2-1, EC-Earth3-Veg-LR, GFDL-ESM4, INM-CM5-0, IPSL-CM6A-LR, KIOST-ESM

Metric Calculation:

Each metric was calculated for the ERA5 historical range (1990-2010) to get an approximate '2000' value. They were also calculated for CMIP6 historical range ('2000') and the two future time periods ('2035' & '2050'). The CMIP6 future time periods were compared to the CIMP6 historical time period to calculate the projected difference. These differences were then added back to the ERA5 historical values to get future projections.

We grouped results based on two biomes – Tropical and Subtropical Moist Broadleaf Forest (this included the Mangrove biome) and Tropical & Subtropical Grassland, Savannas, and Shrublands (this included the Flooded Grasslands and Savannas biome). Biome data were sourced from the Regional Centre for Mapping of Resource for Development Africa Ecoregions shapefile. Results were also grouped by country so that they are often presented as country by biome.

Precipitation

- Yearly Total Precipitation: The summed total precipitation in mm within a given year over a defined area (by pixel or aggregated to a larger region).
- Mean Annual Precipitation: The average of the yearly total precipitation over a specified time period over a defined areas (by pixel or aggregated to a larger region).
- CV of mean annual precipitation: The standard deviation divided by the mean for a given time period over a defined area. The ratio of CMIP future to CMIP historic was used to determine precipitation interannual variability.
- Heavy rain event size: Heavy events are defined as the 95th percentile daily precipitation events excluding days with less than 1 mm of rain. This was calculated on a yearly basis and then aggregated over the appropriate time period and area.
- Heavy rain event quantity: The quantity of precipitation that falls from heavy rain events within a year over a defined area.
- Proportion of precipitation from heavy events (precipitation irregularity): Heavy rain quantity within a year divided by total annual precipitation for that year over a defined region.
- Precipitation intensity (mean wet day volume): Annual precipitation divided by the number of days with > 1 mm of rain within a year.

Temperature

- Mean Annual Temperature: The mean of the yearly average temperature over a given time range and spatial extent.
- Extreme Heat Days: We looked at three categories for extreme heat days – 32, 40, and 50 C. For each category, we calculated the number of days within a calendar year that met or exceeded the temperature threshold.
- 5-day heatwaves: Heatwaves were defined two ways – (1) as days where the maximum temperature exceeded 40C for five days and (2) as days where the minimum temperature was at least 25 C for five days. We present the 10-year frequency of 10-day heatwaves – to calculate this frequency within a city, we took the maximum frequency of any pixel within the biome and country for a given year, then averaged over the timespan (including years with a frequency of 0) to get a yearly frequency. The yearly frequency was multiplied by 10 to get the 10-year frequency.

Supplemental Materials

Data and Methods

Statistical Analysis:

We ran two linear regressions to determine if there were trends in historical annual precipitation and mean annual temperatures. Each regression was run on the annual values averaged over the entire country. There was no significant trend in precipitation through time, but there was a significant positive increase in temperature between 1950 and 2023.

We looked at historic trends through time for annual temperature, annual precipitation, precipitation intensity, heavy rain event size, and heavy rain event quantity. For each of these metrics, we used values averaged over the country by biome division to not get an inflated sample size.

We started by considering a linear model with a three-way interaction between year, country, and biome. For models where there were no three-way interactions, we looked at a model with all two-way interactions.

For precipitation intensity, we noticed the scatter plot seemed to have a quadratic fit, so we included year2 in a model as well. We compared this to the model with a linear fit for year with AIC and found that the quadratic coding of year had a lower AIC value.

The final models were for each metric were:

- Annual temperature: model with all two-way interactions and main effects
- Precipitation intensity: model with all two-way interactions and all main effects plus an effect of year2
- Heavy event size: model with all two-way interactions and main effects
- Heavy event quantity: model with three-way interaction and all lower combinations of interactions and main effects

We initially looked at annual precipitation but found no effect of year.

Sources:

Bichet, A., & Diedhiou, A. (2018). Less frequent and more intense rainfall along the coast of the Gulf of Guinea in West and Central Africa (1981-2014). Climate Research, 76(3), 191-201. https://doi.org/10.3354/cr01537

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