CLIMATE RISK COUNTRY PROFILE

BENIN

THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP

COPYRIGHT

RIGHTS AND PERMISSIONS

Graphic Design: Circle Graphics, Reisterstown, MD.

ACKNOWLEDGEMENTS

This profile is part of a series of Climate Risk Country Profiles developed by Climate Change Group of the World Bank Group (WBG). The country profiles aim to present a high-level assessment of the climate risks faced by countries, including rapid-onset events and slow-onset changes in climate conditions, many of which are already underway, as well as summarize relevant information on policy and planning efforts at the country level.

The country profile series are designed to be a reference source for development practitioners to better integrate detailed climate data, physical climate risks and need for resilience in development planning and policy making.

This effort is managed and led by MacKenzie Dove (Technical Lead, CCKP, WBG) and Pascal Saura (Task Team Lead, CCKP, WBG).

This profile was written by Balsher Singh Sidhu (Climate Change Consultant, CCKP, WBG).

Unless otherwise noted, data is sourced from the WBG's Climate Change Knowledge Portal (CCKP), the WBG's designated platform for climate data. Climate, climate change and climate-related data and information on CCKP represents the latest available data and analysis based on the latest Intergovernmental Panel on Climate Change (IPCC) reports and datasets. The team is grateful for all comments and suggestions received from climate and development specialists, as well as climate research scientists and institutions for their advice and guidance on the use of climate related datasets

CONTENTS

FOREWORD

Development progress has stalled in many countries amid low growth, increased fragility and conflict, pandemic-related setbacks, and the impacts of climate change. Droughts, extreme heat, flooding and storms push millions into poverty annually, causing unemployment and risking unplanned internal and cross-border migration. Every year, an estimated 26 million people fall behind due to extreme weather events and natural disasters. These shocks have the potential to push a total of 130 million into poverty by 2030.

The World Bank Group (WBG) is supporting countries to meet these challenges. As part of our vision to end poverty on a livable planet, we are investing in development projects that improve quality of life while creating local jobs, strengthening education, and promoting economic stability. We are also helping people and communities adapt and prepare for the unpredictable and life-changing weather patterns they are experiencing, ensuring that limited development resources are used wisely and that the investments made today will be sustainable over time.

Having access to data that is accurate and easily understandable is of course critical to making informed decisions. This is where the report you are about to read comes in.

Climate Risk Country Profiles offer country-level overviews of physical climate risks across multiple spatiotemporal scales. Each profile feeds into the economy-wide Country Climate and Development Reports and draws its insights from the Climate Change Knowledge Portal, the WBG's 'one-stop-shop' for foundational climate data.

Guided by World Bank Group data and analytics, developing countries can conduct initial assessments of climate risks and opportunities that will inform upstream diagnostics, policy dialogue, and strategic planning. It is my sincere hope that this country profile will be used to inform adaptation and resilience efforts that create opportunities for people and communities around the world.

Valerie Hickey, PhD
Global Director
Climate Change Group
World Bank Group

KEY MESSAGES

Seasonal Climate Modes

Southern Benin has a tropical climate with two rainy seasons (March–July and September–November) and two brief dry spells, while the north features a single rainy season (May–October) followed by a pronounced harmattan-driven dry period (December–March).

Warming Trends

Since 1971, mean temperatures have climbed by 0.26 °C per decade, with nighttime lows rising 0.29 °C per decade (nearly double daytime warming), threatening heat-sensitive crops like rice.

Heat Extremes

Under SSP3-7.0, hot days (Tmax > 35 °C) will increase from 97 days/year today to 147 days/year by 2050, and tropical nights (Tmin > 23 °C) from 163 to 273 nights/year, intensifying heat stress and soil moisture loss.

Rainfall Decline & Variability

Annual precipitation has fallen by 20 mm per year since 1971, especially in coastal departments, and while total rainfall may not change significantly in the future, more intense one-day downpours and mid-season dry spells heighten both flood and drought risks.

Sea-Level Rise

Mean sea level in Benin's Exclusive Economic Zone (EEZ) rose 0.11 m between 1993–2024; under SSP3-7.0, a further 0.68 **m** median rise is projected by 2100 (0.5 m by 2080; 1 m by 2125), exacerbating coastal inundation and salinization.

Agricultural Implications

Staple crops (cassava, yam, maize, rice) rely on reliable June–November rains and moderate temperatures; increased heat, erratic rainfall, and higher seas threaten planting, growth, and harvest cycles.

Adaptation Priorities

To protect yields and nutrition, Benin must adjust planting calendars, adopt heat- and drought-tolerant varieties, improve irrigation and drainage, and strengthen coastal defenses.

COUNTRY OVERVIEW

Benin is a small tropical country in West Africa, covering about 114,763 km^2 (reference). It borders Togo to the west, Nigeria to the east, and Burkina Faso and Niger to the north. Benin's population is approximately 14 million people, the majority of whom reside in the low-lying southern coastal plain (including major urban centers like Cotonou and Porto-Novo)[1] (**Fig. 1b**). The country is divided into 12 departments or administrative divisions.

Although a small country with generally low elevation (most below 400 m), Benin has varied topography (**Fig. 1a**). The coastal area in the south is flat and sandy, with lagoons and marshes. Further inland is a fertile, mostly flat plateau with a few hills. The Atakora Mountains occupy the northwest, while the Niger plains lie in the northeast. This diverse landscape, together with an economy that heavily depends on agriculture and coastal commerce, makes Benin particularly susceptible to the adverse impacts of climate change from rising temperature, changing sea levels, and shifts in precipitation patterns.

Benin's diverse terrain and varied topography influences regional climate patterns. The south has a tropical climate with two rainy seasons (March–July and September–November) and two drier intervals, governed by the north-south movement of the Inter-Tropical Convergence Zone. The northern half of Benin has a tropical savanna climate with a single rainy season roughly May–October and a pronounced dry season during boreal winter, influenced by the Saharan harmattan winds.

Agriculture is the backbone of Benin's economy and rural livelihoods, employing roughly 70% of the workforce,contributing significantly to GDP and export earnings. It is heavily dominated by only a few crops. Five major crops (cassava (35%), yam (32%), maize (10%), rice (8%), and cotton (5%)) together account for nearly 90% of Benin's agricultural production value (as of 2022)[2]. Cassava and yam (root/tuber crops) and maize are primary staples for domestic consumption, while cotton is a critical cash crop for export.

The country's food security and nutrition are closely tied to climate-sensitive agricultural production. Climate change thus presents a direct threat to nutrition through its impacts on crop yields, food availability, and stability of supply.

1 https://www.britannica.com/place/Benin/Plant-and-animal-life
2 FAO. 2025. *FAOSTAT Statistical Database*. Food and Agriculture Organization of the United Nations. Rome, Italy. Available at: https://www.fao.org/faostat [Accessed: 5 February 2025].

FIGURE 1A. Topography of Benin (in meters)[3] and Subnational Boundaries (World Bank cartography). The Country's Topography Plays a Crucial Role in Shaping Regional Climate Patterns.

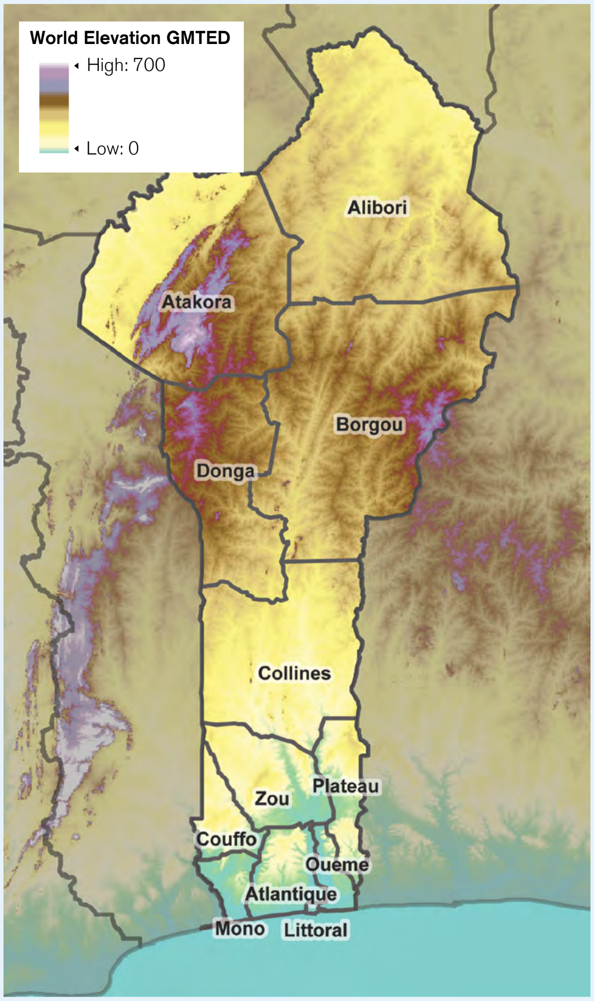
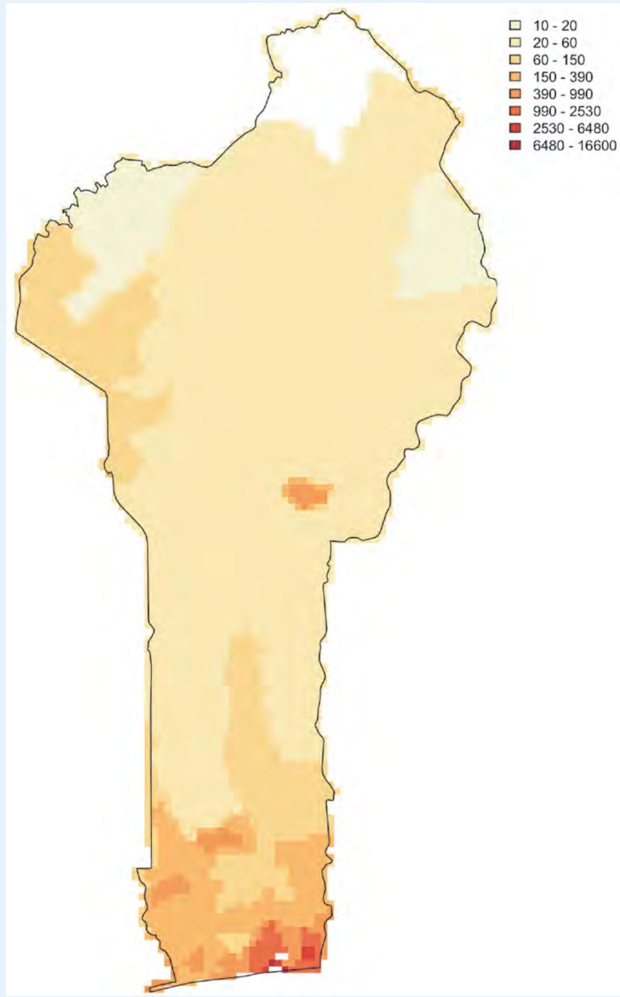


FIGURE 1B. Population Density (population per square km), 2020[4]



3 Global Multi-resolution Terrain Elevation Data GMTED2010 https://pubs.usgs.gov/of/2011/1073/

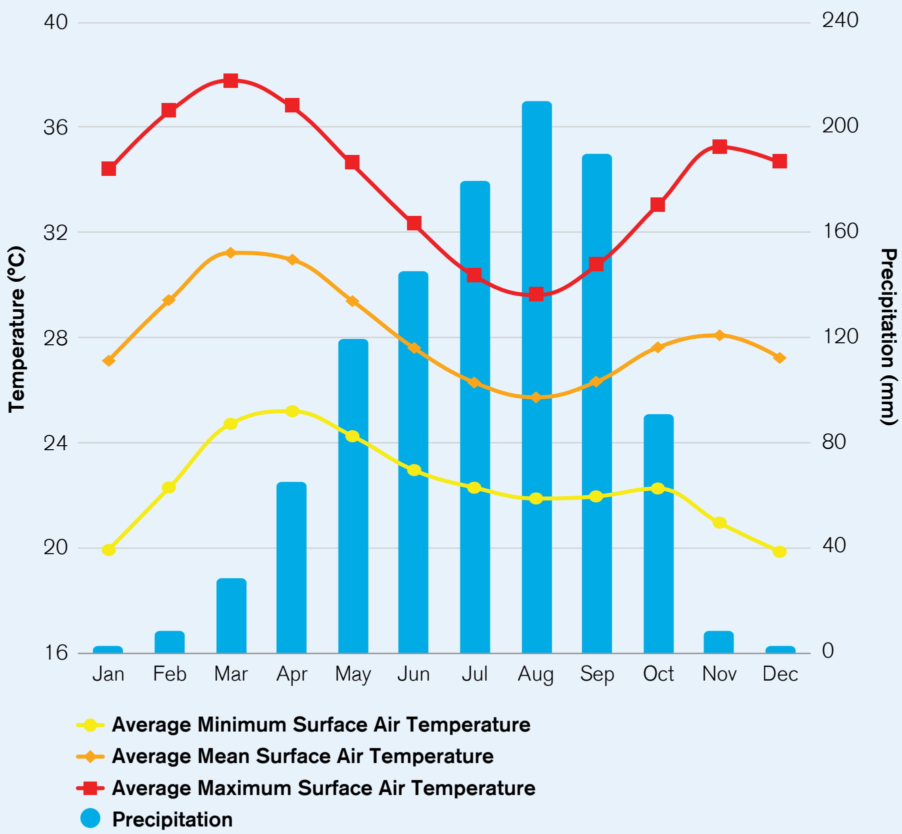
4 Center for International Earth Science Information Network-CIESIN-Columbia University. 2018. Gridded Population of the World, Version 4 (GPWv4): Administrative Unit Center Points with Population Estimates, Revision 11. Palisades, New York: NASA Socioeconomic Data and Applications Center (SEDAC). Accessed 15 April 2025.

CLIMATE OVERVIEW

Data overview: Historically, observed data is derived from the Climatic Research Unit, University of East Anglia (CRU), CRU TS version 4.08 gridded stations dataset (1901–2023), and from the ERA5 reanalysis collection from ECMWF (1950–2023).

Benin's climate is broadly hot and humid year-round, with mean annual temperatures of about 28 °C (**Fig. 2**) (historically ranging from roughly 27.5 °C along the southern coast to 28.5 °C in the far north departments of Alibori and Atakora over the 1991–2020 period). Coastal areas benefit from maritime moderation and are slightly cooler, while the northern interior, free from oceanic influence, tends to be hotter. The hottest interval falls in the late dry season (March–April in the south; April–May in the north), immediately preceding the onset of rains, whereas the coolest conditions occur coincides the peak of the wet season (July–September).

FIGURE 2. Monthly Historical Climatology of Average Temperature (minimum, average, and maximum) and Total Precipitation (1991–2023) for Benin (CRU dataset)



Rainfall and seasonality in Benin are governed by the north-south oscillation of the Inter-Tropical Convergence Zone and, in the north, by the Sahara-origin harmattan winds. Nationally, annual precipitation averages around 1050 mm (Fig. 2; CRU data), but there is a gradient from the wetter coast (as high as 1240 mm/year in Oueme) to the drier north (as low as 935 mm/year in Alibori). The southern region experiences two rainy seasons, March through July and September through November, separated by two briefer dry spells. In contrast, the tropical savanna zone of northern Benin has a single rainy season from May to October and a pronounced dry season from December to March, when dust-laden harmattan winds prevail.

TEMPERATURE AND PRECIPITATION HISTORICAL AND PROJECTED TRENDS

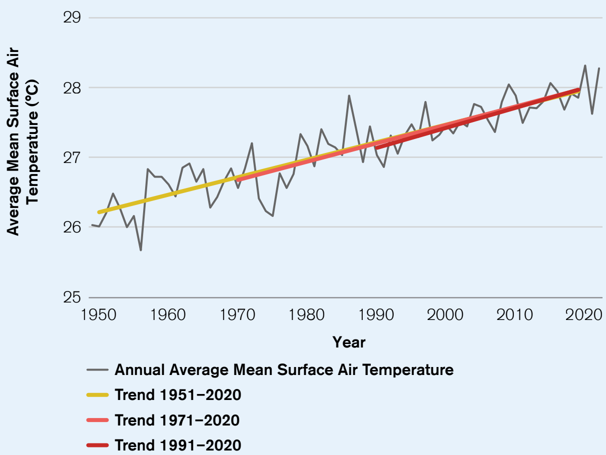
Data overview: Historical observed data is derived from the ERA5 reanalysis collection from ECMWF (1950–2023). Modeled climate data is derived from CMIP6, the Coupled Model Intercomparison Project, Phase 6. This risk profile focuses primarily on SSP3-7.0[5], which projects a doubling of CO_2 emissions by 2100, a global temperature change of approximately 2.1°C by mid-century (2040–2059) and 2.7°C (likely 2.1°C to 3.5°C) by the end of the century (2080–2099), with respect to pre-industrial conditions (1850–1900).

Historical Temperature Changes

Like much of West Africa, Benin has experienced significant warming over the past 50 years. Between 1971 and 2020, the country's average temperature increased by 0.26°C per decade (**Figure 3**). Nighttime temperatures rose by 0.29°C per decade (almost twice the daytime rate of 0.16°C per decade). This differential warming (more nighttime warming) is a concerning trend for agriculture, as certain crops (for example, rice) are particularly sensitive to higher night-time temperatures which can impact crop yields[6].

All regions of Benin are warming, but some spatial variation is observed. Central departments (such as Zou, Plateau, and Couffo) and the southern coastal departments (e.g. Atlantique and Mono) have seen slightly faster increases in extreme daytime temperatures compared to the northern departments. Even so, the northern areas remain hotter in absolute terms.

FIGURE 3. Benin's Annual Mean Surface Air Temperature Time Series and Decadal Trends for Different Periods Between 1951 and 2020; ERA5 Data



[5] Climate scientists may prioritize SSP2-4.5 and SSP5-8.5 to cover a range of potential futures, but SSP5-8.5 is frequently avoided in policy discussions due to its extreme nature. SSP3-7.0 is understood as a balanced compromise, sufficiently pessimistic yet in line with current policies. Note that patterns of change are generally consistent across scenarios, differing only in timing and impact intensity. For example, impacts projected under SSP3-7.0 by 2070 (2.8°C warming) are projected to occur by 2060 under SSP5-8.5, given the same level of warming. This approach allows scenarios to be translated by focusing on the warming signal rather than specific timelines.

[6] Peng, Shaobing, et al. "Rice yields decline with higher night temperature from global warming." *Proceedings of the National Academy of Sciences* 101.27 (2004): 9971–9975.

Benin experiences no ice or frost days, nor is it expected to with climate change. These conditions, often harmful or even restrictive to crop cultivation, are not a concern in the region.

Projected Temperature Changes[7]

Benin's climate will continue to warm considerably in coming decades (**Fig. 4(a)**). Under SSP3-7.0, mean annual temperature is projected to increase by 0.28°C per decade (0.15°C, 10th percentile, 0.46°C, 90th percentile) per decade by mid-century, with the northern departments (Atakora, Alibori, Donga, Borgou) warming slightly faster (up to 0.29°C (0.15°C, 0.46°C) per decade) compared to the southern coastal regions (Mono, Atlantique, Littoral, Ouémé), which are expected to see increases of around 0.27°C (0.15°C, 0.46°C) per decade. Despite minor spatial differences, every part of Benin will face substantially higher temperatures.

In addition, extreme heat indicators such as tropical nights (with minimum temperatures above 23°C) and hot days (with maximum temperatures over 35°C) are anticipated to become more frequent, particularly in the northern and South Centre departments (including areas like Zou and Plateau), highlighting the growing need for adaptive measures to address these changes.

The warming is mostly uniform across seasons (**Fig. 4(b)**): all months are projected to be warmer, with no strong seasonal variation in the magnitude of warming (**Table A7**).

FIGURE 4A. Projected Average Mean Surface Air Temperature for Different Climate Change Scenarios, Along with the 10th–90th Percentile Dispersion Across Models

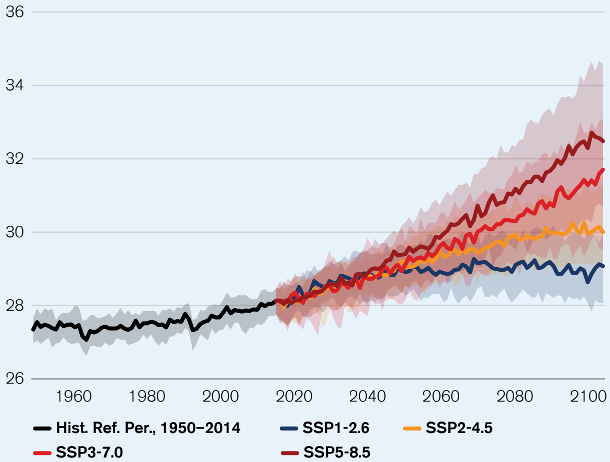
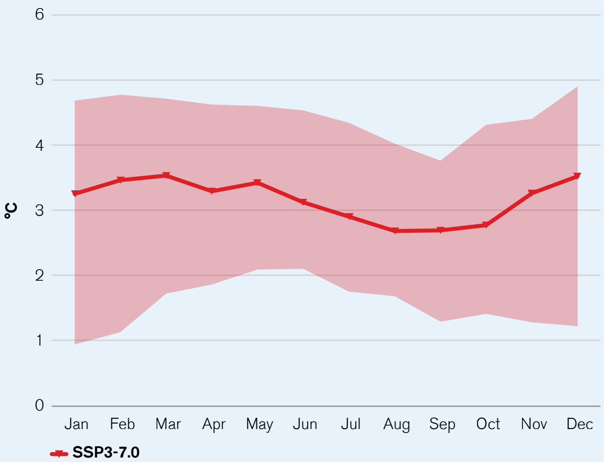


FIGURE 4B. Projected Monthly Anomaly of the Average Mean Surface Air Temperature for 2040–2059 (relative to the reference period 1995–2014) Under SSP3-7.0, Along with the 10th–90th Percentile Dispersion Across Models



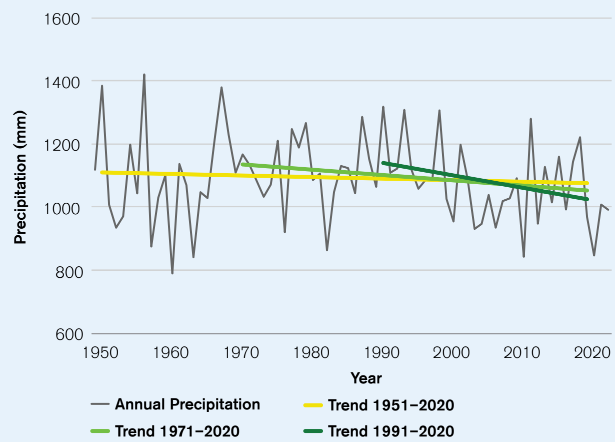
7 The projections in this profile primarily discuss a medium-high emissions scenario (SSP3-7.0). This scenario reflects a future with continued high population growth and moderate economic development, where global CO2 concentrations roughly double by 2100. In terms of climate outcomes, SSP3-7.0 is characterized by global warming of approximately 2.1°C by mid-century and 2.7°C by late century relative to pre-industrial times. For Benin, we consider multi-model ensemble projections under SSP3-7.0, focusing on the mid-21st century (around 2050) when climate change impacts become more pronounced. All projections are compared against a late 20th-century baseline (1995–2014, unless otherwise noted). Ranges represent the spread (10th–90th percentile) across climate models, illustrating uncertainties.

Historical Precipitation Changes

Rainfall trends in Benin over time are more complex. Benin's rainfall is highly variable year-to-year, influenced by regional weather patterns (such as monsoon dynamics and Atlantic sea-surface temperatures). Benin has a tropical climate with an average annual rainfall of around 1050 mm, with coastal areas receiving slightly more. However, between 1971 and 2020, the country experienced a notable decline of 20.3 mm per year on average (**Fig. 5**).

This national trend masks regional differences. The coastal areas have experienced notable drying: southern departments like Mono, Atlantique, Littoral, and Ouémé recorded rainfall declines up to 3–4 times the national average rate. In contrast, parts of the north-central region had relatively smaller downward trends: for instance, Alibori (3.9 mm/decade decline) and Borgou (7.9 mm/decade decline) in the north show minimal long-term declines (**Table A2**).

FIGURE 5. Annual Precipitation Time Series and Decadal Trends for Different Periods Between 1951 and 2020 as Indicated, ERA5 Data

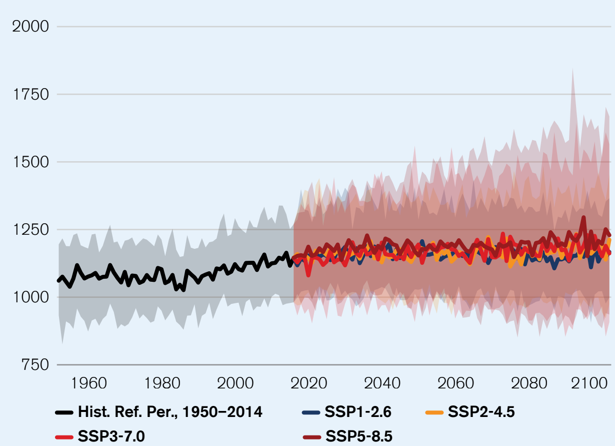


Projected Precipitation Changes

Projecting rainfall in West Africa remains challenging due to complex monsoon dynamics and model uncertainties. Under the SSP3-7.0 scenario, ensemble projections suggest that total annual rainfall nationally might increase slightly (10.5 mm/decade increase by 2050 over the 1123 mm/year baseline) by mid-century, but this increase is within the range of natural variability and is not statistically significant. This uncertainty is present at regional results as well: Alibori is the only department where the projected rainfall increase (17.6 mm per decade) is large enough to be statistically significant by mid-century (**Table A4**). All other departments show changes that are small relative to year-to-year variability. Note that even where mean rainfall increases, this does not necessarily translate to improved water availability, since higher temperatures increase evapotranspiration demands.

As the atmosphere warms and can hold more moisture, indicators of extreme precipitation such as the maximum one-day rainfall (rx1day) and the frequency of days with rainfall over 20 mm (r20 mm)

FIGURE 6. Projected Annual Precipitation for Different Climate Change Scenarios as Labeled, Along with the 10th–90th Percentile Dispersion Across Models



tend to increase, although this trend is statistically significant only in Alibori. Given that crops like yam and cassava are cultivated in Alibori, any adverse changes in precipitation patterns could adversely impact their yields, which may ultimately affect livelihoods and nutrition regionally and nationally.

At the sub-annual (seasonal) timescale, some interesting trends are expected (**Table A8**). December-January-February (DJF) are generally the dry months across most departments of Benin, and they are expected to become even drier toward the middle of this century, although the magnitude of the change is considerably small compared to the historical baseline and natural variability. Farmers who depend on rainfall during DJF may face reduced crop yields. Note that all trends in Table A8 are statistically insignificant, given the high natural variability in precipitation from one year to the next.

IMPACTS OF A CHANGING CLIMATE

Hot Days

Extreme heat can endanger people and animals by triggering heat-related illnesses. It also worsens wildfire conditions, harms agriculture, depletes water resources, raises irrigation demands, and drives up energy consumption, creating ripple effects that can destabilize infrastructure, ecosystems, food systems, and communities. Under the SSP3-7.0 scenario, Benin is expected to see a sharp rise in hot days (Tmax > 35°C), increasing from 97.42 (83.63, 107.78) days per year currently to 147.26 (88.04, 187.95) days per year by 2050; an increase of roughly 10.94 (3.13, 21.54) days per decade (**Table A3**). Although coastal regions are projected to experience a less marked increase, the central and northern regions, which are key areas for agriculture, will likely follow the national trend.

In warm countries like Benin, extended periods of high temperatures can stress plants, disrupt growth stages, and lead to increased water loss. The overall impact depends on the severity, timing, and duration of these temperature changes, as well as on the specific temperature tolerances of different crops; therefore, targeted crop yield studies are essential to fully understand the effects.

Additionally, an increase in hot days presents challenges for human well-being. High-risk areas here are defined as locations where, at least once every 50 years, a year occurs with more than 30 days characterized by maximum temperatures surpassing 35°C. Nationally, median exposure to dangerous levels of heat is set to rise from 60% during 1975–2024 to over 86% in 2050–2099 (**Table A5**). Not all regions of Benin will experience heat extremes equally. Coastal areas, moderated by the ocean, will remain a bit cooler than the interior. While Littoral, the most densely populated department, is not expected to experience any health risk from hot days, other high-density departments such as Oueme (rising from 3% in 1975–2024 to 22% in 2050–2099), Atlantique (from 1% to 53%), Couffo (from 48% to 100%), and Mono (from 0% to 95%) may not be as fortunate.

This widespread exposure includes rural farming communities; many will face greater difficulty working outdoors and maintaining agricultural outputs. It also has nutrition implications because heat stress can increase human hydration needs and exacerbate conditions like diarrhea, which affects nutrient absorption, particularly in children. Ensuring access to clean water and cooling is thus part of climate resilience for nutrition.

Tropical Nights

Currently, Benin experiences 162.74 (139.52, 186.57) tropical nights each year, defined as nights when the minimum temperature exceeds 23°C. Under the SSP3-7.0 scenario, projections indicate an average increase of 22.69 (14.21, 33.68) nights per decade, with the total expected to reach 273.46 (213.20, 309.87) nights per year by 2050 (Table A3). In the central departments, specifically Collines and Couffo, the increase is projected to be even more pronounced, with an estimated rise of about 30 additional nights per decade.

When evaluating population exposure to tropical nights, high-risk areas are defined as those where, at least once every 50 years, there is a year with more than 30 nights exceeding 26°C. Nationally, the proportion of the population exposed to such dangerous conditions is expected to jump from 47% during the historical period to nearly 100% by 2050–2099 (Table A5). At the regional level, every subdivision in Benin, including high population density departments like Oueme, Atlantique, and Mono, is projected to reach full exposure. This trend poses significant challenges not only to public health but also to agriculture, as certain crops, such as rice, are particularly sensitive to increased nighttime temperatures (Peng et al., 2004).

Heat Index

The Heat Index represents how hot it feels by combining air temperature and humidity, assuming shade and light wind[8]. When both temperature and humidity are high, the Heat Index can rise sharply. This makes outdoor conditions feel much hotter than the actual air temperature. As a result, the risk to human health increases significantly. High humidity slows the evaporation of sweat, which is the body's primary cooling mechanism. When the body can't cool itself effectively, it begins to overheat. This can lead to heat-related illnesses such as heat exhaustion and heat stroke. In severe cases, prolonged exposure can even be fatal, especially for vulnerable groups like the elderly, young children, and those with pre-existing health conditions.

Projections indicate that the dangerous heat index-reflecting humid, high-temperature conditions will become an increasing concern by the end of the century. Population exposure to high heat index conditions is set to rise significantly; high-risk areas are defined as those where, at least once every 50 years, a year experiences more than 20 days with a heat index exceeding 35°C. Historically, over 90% of Benin's population has been exposed to these conditions, a figure projected to reach 100% by mid-century (Table A5). Regionally, departments such as Littoral (48% exposure during 1975–2024) and Donga (22% exposure during the same period) are expected to achieve full exposure by 2050, meaning that every department will face extreme heat conditions that pose a significant risk, especially for outdoor workers.

[8] Heat Index as defined by US-National Weather Service- Steadman R.G., 1979: The assessment of sultriness, Part I: A temperature-humidity index based on human physiology and clothing science. J. Appl. Meteorol., 18, 861–873, doi: http://dx.doi.org/10.1175/1520-0450

Extreme Precipitation

Access to a regular and sufficient supply of water is essential for crop production. Agricultural productivity is affected not only by insufficient water but also by excessive water delivered in short bursts during intense precipitation events. Adequate seasonal rainfall supports healthy crop growth, yet excessive rainfall can lead to waterlogging, nutrient leaching, and an increased risk of crop diseases. Similarly, the intra-seasonal distribution of precipitation is also important. Prolonged periods of low rainfall can trigger drought conditions that harm rainfed crops during sensitive stages such as establishment, flowering, and fruiting, while extended periods of heavy rainfall may result in waterlogging and ponding, particularly affecting root and tuber crops.

In a warming climate, the atmosphere's increased capacity to hold moisture raises the likelihood of heavier precipitation. Despite natural variability in rainfall patterns, there is a consistent though statistically insignificant trend toward higher one-day precipitation levels (rx1day) and more heavy precipitation days (r20 mm) across all departments in Benin (Table A4). These changes indicate a propensity for more intense downpours, raising concerns about flash flooding and soil erosion even if annual totals remain similar. On the other hand, the potential for short-term dry spells within the rainy season could also increase if rains become more concentrated, meaning slightly longer gaps between rainy episodes in some scenarios.

SPEI

The Standardized Precipitation Evapotranspiration Index (SPEI) is a drought index that influences crop yields based on its values: positive SPEI values indicate wetter-than-normal conditions, which are generally associated with higher crop yields, while negative SPEI values signify drier-than-normal conditions that can reduce yields depending on the crop type and region. SPEI12, calculated over a 12-month period, smooths out monthly variations and reflects long-term moisture conditions. In Benin, the SPEI is projected to improve nationally from the historical period to 2041–2060, although some regional variation exists; it is important to note that while an increase in SPEI12 generally has a positive impact on crop production, intra-annual variability such as an increase in extreme precipitation events may in fact have a negative effect.

Floods

High-risk areas are defined as locations where, at least once every 25 years, a year occurs with a 5-day cumulative precipitation above 130 mm. Nationally, these areas are expected to increase from 22% historically to 46% by 2010–2059 and to 58% by 2050–2099 (**Table A6**). Additionally, return period analysis of extreme 1-day precipitation events indicates significant changes under the SSP3-7.0 scenario. Specifically, a 100-year event is projected to become 2.58 (1.14, 7.26) times more likely by 2035–2064 and 5.42 (1.42, 20.13) times more likely by 2070–2099 (**Table 1**). As discussed above, the climate change-induced increase in the frequency of these extreme events is expected to lead to more frequent flooding, which can have detrimental impacts on infrastructure, human safety, and agriculture.

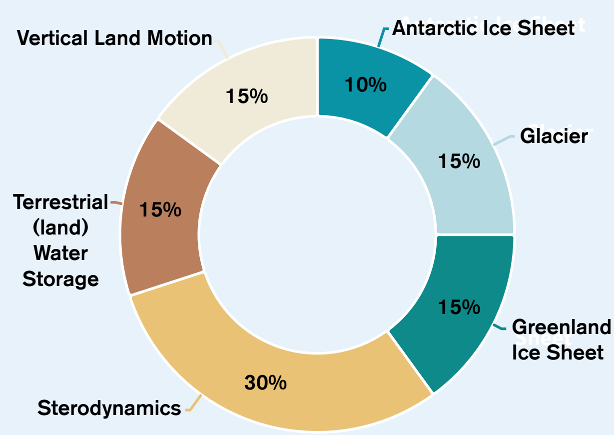
TABLE 1. a) Future (2035–2064 and 2070–2099) Return Period (years) for Extreme Precipitation Events that Correspond to the Return Levels for the Largest Single-Day Event During the Historical Period (1985–2014) for SSP3-7.0; b) Change in Future Exceedance Probability Expressed as Change Factor for Extreme Precipitation Events that Correspond to the Return Levels for the Largest Single-Day Event During the Historical Period (1985–2014). Fractional Change Above 1 Indicates Increased Probability and Decreased Return Period. For Example, a Fractional Change of 1.20 for the 100-Year Event Indicates a 20% Increase in the Probability of Suffering 100-year Extreme Precipitation Events in the Future, or 1.2 More Likely.

Historical Return Period (1985–2014)						
1985–2014	5-yr	10-yr	20-yr	25-yr	50-yr	100-yr
Future Return Period (years)-Median (10th, 90th)						
2035–2064	2.86 (1.56–4.34)	5.23 (2.53–8.55)	9.62 (4.16–16.85)	11.63 (4.91–20.96)	21.13 (7.96–41.49)	39.1 (12.76–82.93)
2070-2099	2.11 (0.95–3.84)	3.46 (1.4–7.27)	5.71 (2.07–13.81)	6.65 (2.34–17.13)	10.91 (3.4–33.16)	18.76 (4.76–63.74)
Change in Future Annual Exceedance Probability (change factor)-Median (10th, 90th)						
2035–2064	1.76 (1.1–2.99)	1.93 (1.12–3.64)	2.1 (1.14–4.46)	2.17 (1.14–4.76)	2.39 (1.16–5.88)	2.58 (1.14–7.26)
2070–2099	2.38 (1.21–5.05)	2.92 (1.26–6.89)	3.55 (1.32–9.42)	3.82 (1.34–10.39)	4.68 (1.39–14.3)	5.42 (1.42–20.13)

Sea Level Rise

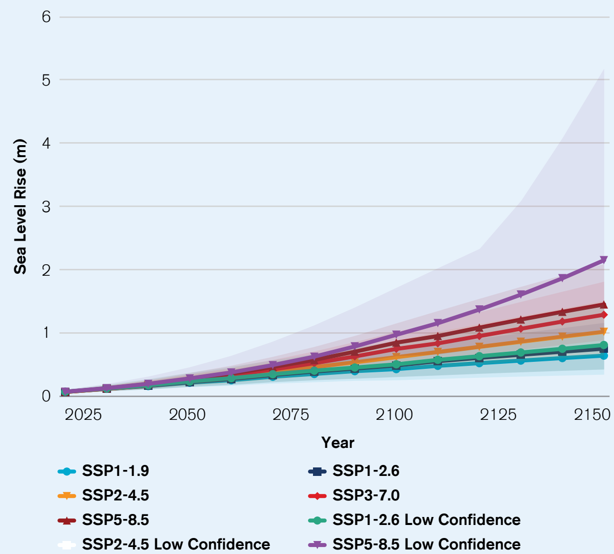
Over one-third of Benin's population resides within the coastal departments of Mono, Atlantique, Littoral, and Ouémé, where livelihoods and infrastructure are highly sensitive to even modest changes in sea level. Between 1993 and 2024, mean sea levels across the Beninese Exclusive Economic Zone (EEZ) rose by 0.11 m. This historical increase has been driven by sterodynamic changes (thermal expansion and altered currents; 0.033 m), melting of glaciers (0.017 m) and the Greenland Ice Sheet (0.017 m), changes in land water storage (0.017 m), and vertical land motion (0.017 m), with the Antarctic Ice Sheet contributing around 0.011 m. These drivers have already exacerbated coastal inundation, accelerated saltwater intrusion into groundwater aquifers, and promoted soil salinization. These threats imperil agriculture, fisheries, and freshwater supplies in low-lying coastal plains.

FIGURE 7. Contribution to Sea Level Change from Various Processes for Beninese Exclusive Economic Zone



Under the SSP3-7.0 scenario, projections indicate that by 2100, relative sea levels in the Benin EEZ are likely to rise an additional 0.68 m (median estimate), with a very likely range (17th–83rd percentile) of 0.50 m to 0.93 m, and an extreme (5th–95th percentile) range of 0.58 m to 1.14 m. By mid-century (2050), the median increase relative to 2020 is about 0.19 m, already enough to submerge critical wetlands and low-elevation settlements during high tides and storm surges. Moreover, a 0.5 m rise is projected around 2080 (likely range 2066–2102), and a full 1 m rise is expected by 2125 (likely range 2100–2168). Continued groundwater pumping and subsidence in some areas may amplify these impacts locally. Such rises will intensify coastal erosion, undermine coastal defenses, and heighten the frequency and severity of flooding, demanding urgent adaptation measures in Benin's hinterland and urban coastal zones.

FIGURE 8. Projected Sea Level Change (relative to 2005) for the Beninese Exclusive Economic Zone for Different Climate Change Scenarios as Labeled, Along with the 17th–83rd Percentile Dispersion Across Models



Natural Hazards

Natural disasters, from floods and droughts to epidemics and wildfires, are catalogued in EM-DAT, a global database covering over 26,000 mass disasters since 1900. Between 1982 and 2022, Benin experienced 20 major floods (3.3 million people affected) and one severe drought (2.1 million people affected), events whose frequency and intensity have been amplified by a warming climate.

Climate change is driving heavier, more erratic rainfall that feeds these floods, already displacing hundreds of thousands in low-lying coastal departments, and deepening drought spells like the one in 1983 that affected over two million people. At the same time, rising seas (0.11 m since 1993; projected to rise further by 0.68 m by 2100 under SSP3-7.0) will exacerbate coastal inundation during storms and high tides, further magnifying flood hazards in vulnerable areas such as Mono and Littoral.

Agriculture Impacts

Agricultural Timing and Heat Stress

Benin's staple crops (cassava, yam, maize, rice, and cotton) are tightly aligned with the June–November growing season, making the reliability of rains and moderate temperatures essential. As highlighted earlier, mean temperatures have risen by 0.26 °C per decade, hot days are set to climb from roughly 97 to 147 days per year by 2050, and tropical nights (Tmin > 23 °C) are projected to exceed 270 nights annually. Such warming shortens effective growing periods by stressing plants during critical stages like flowering and grain filling, while warmer nights impede plant recovery and accelerate soil moisture loss. Heat-sensitive cereals and rice, already cultivated near their thermal limits, face the greatest yield reductions, threatening both calories and nutrient availability.

Rainfall Variability and Water Management

Long-term rainfall has declined by about 20 mm per year, yet climate change is driving both more extreme downpours and sporadic dry spells within the season. Intense one-day rains heighten flood and waterlogging risks, particularly as high-risk flood zones expand from 22% of the country historically to 58% by late century, while mid-season drought breaks can stall maize and vegetable development. This variability disrupts the carefully timed planting, growth, and harvest cycles across Benin's bimodal and monomodal zones. To sustain yields and nutrition, farmers will need to adjust planting dates, diversify crop calendars, and bolster water management through targeted irrigation during dry spells and enhanced drainage to mitigate floods.

ANNEX: HISTORICAL AND PROJECTED CHANGES ACROSS REGIONS

Historical Climate and Changes Across Regions

Tables A1 and **A2** show the variations in historical temperature and precipitation.

TABLE A1. Historical a) Air Surface Temperature Averages (1991–2020), CRU, and b) Trends per Decade (1971–2020), ERA5, for Temperatures (in deg C), Colored According to Intensity. The Decadal Trend is Bolded Whenever Significant at a 90% Level.

Region	Historical Air Surface Temperature Averages (1991–2020) (degrees C)					Trend per Decade (1971–2020) (degrees C/decade)		
	Temp	Min Temp	Max Temp	Coldest Month (usually Aug)	Hottest Month (usually Mar)	Temp	Min Temp	Max Temp
BENIN	28.07	22.36	33.82	25.72	31.22	**0.26**	**0.29**	**0.16**
Alibori	28.78	22.60	35.01	26.02	33.24	**0.26**	**0.31**	**0.15**
Atakora	28.41	22.47	34.40	25.89	32.06	**0.25**	**0.30**	**0.12**
Atlantique	27.68	23.81	31.61	25.67	29.59	**0.25**	**0.26**	**0.24**
Borgou	27.70	21.76	33.69	25.36	31.08	**0.27**	**0.29**	**0.15**
Collines	27.70	22.30	33.16	25.31	30.16	**0.27**	**0.26**	**0.17**
Couffo	27.71	22.99	32.49	25.46	29.81	**0.30**	**0.29**	**0.27**
Donga	27.47	21.61	33.37	25.10	30.55	**0.25**	**0.29**	**0.14**
Littoral	27.54	24.12	31.01	25.65	29.35	**0.18**	**0.20**	**0.16**
Mono	27.64	23.25	32.07	25.55	29.58	**0.26**	**0.28**	**0.25**
Oueme	27.65	23.84	31.51	25.65	29.53	**0.23**	**0.25**	**0.20**
Plateau	27.76	23.28	32.28	25.56	29.84	**0.28**	**0.28**	**0.26**
Zou	27.89	23.06	32.78	25.56	30.08	**0.30**	**0.29**	**0.27**

TABLE A2. a) Historical Data (1991–2020), CRU and b) Decadal Trend (1971–2020), ERA5, for Annual Precipitation (in mm), c) Historical Annual Maximum Number of Consecutive Dry Days (daily accumulated precipitation < 1 mm), ERA5, and d) Historical Annual Number of Consecutive Wet Days (daily accumulated precipitation ≥ 1 mm), ERA5, Color-Coded by Intensity. Interannual Variability is Expressed as the Standard Deviation of Annual Total Values from 1990 to 2020. Significant Decadal Trends, at the 90% Confidence Level, are Highlighted in Bold.

	Historical Precipitation Yearly Averages (mm; 1991–2020)						
Region	Total Precip	Interannual Variability	Monthly Max Precip (J/J/A/S)	Monthly Min Precipt (Dec/Jan)	Trend (mm/decade; 1971–2020)	Max Consecutive Dry Days (1991–2020)	Max Consecutive Wet Days (1991–2020)
BENIN	1049.73	55.75	209.68	2.36	−20.32	66.37	24.53
Alibori	937.10	54.27	261.12	0.02	−3.92	89.90	15.31
Atakora	1033.88	57.78	259.64	0.07	−11.31	74.84	22.36
Atlantique	1124.48	85.71	214.31	9.17	−75.17	19.87	36.34
Borgou	1089.21	64.66	225.03	1.46	−7.83	72.74	25.22
Collines	1075.45	83.25	182.79	4.84	−13.58	48.56	26.49
Couffo	1034.47	83.68	153.91	7.27	−52.51	28.15	31.40
Donga	1154.04	63.95	236.86	2.15	−22.23	62.57	36.59
Littoral	1224.60	86.78	270.23	11.26	−84.25	18.48	36.05
Mono	1056.89	86.08	177.46	8.09	−78.42	18.60	38.20
Oueme	1243.62	86.76	235.53	12.02	−72.31	18.73	38.81
Plateau	1165.27	77.57	181.96	8.16	−48.30	29.11	29.57
Zou	1043.04	78.23	156.78	5.58	−40.10	33.43	24.92

Projected Climate and Changes Across Regions

Tables A3 and **A4** show the variations in CMIP6 historical and projected temperature and precipitation related variables.

TABLE A3. CMIP6 Simulated Historical Averages (1994–2015), Mid-Century SSP3-7.0 Projections (2041–2060), and Decadal Trends (2000–2050) for a) Average Surface Air Temperature, b) Number of Tropical Nights per Year with Tmin > 23°C, c) Number of Hot Days per Year with Tmax > 35°C, and d) Average Maximum Surface Air Temperature

Region	Average Surface Air Temperature (degrees C)			Number of Tropical Nights per Year with Tmin > 23°C (days)			Number of Hot Days per Year with Tmax > 35°C (days)			Average Maximum Surface Air Temperature (degrees C)		
	1994–2015	2041–2060	Trend	1994–2015	2041–2060	Trend	1994–2015	2041–2060	Trend	1994–2015	2041–2060	Trend
BENIN	27.82	29.22	**0.28**	162.74	273.46	**22.69**	97.42	147.26	**10.94**	32.93	34.18	**0.26**
Alibori	28.80	30.27	**0.29**	196.01	277.39	**17.00**	163.43	206.75	**9.77**	34.41	35.70	**0.26**
Atakora	27.86	29.31	**0.29**	143.53	239.97	**19.79**	121.46	170.14	**10.88**	33.30	34.60	**0.27**
Atlantique	27.12	28.41	**0.27**	310.22	361.52	**11.46**	0.82	8.51	**1.75**	30.00	31.22	**0.27**
Borgou	27.47	28.83	**0.28**	108.04	238.72	**25.80**	93.21	149.86	**12.44**	32.88	34.11	**0.26**
Collines	27.68	29.04	**0.27**	165.56	318.89	**30.95**	65.30	129.50	**13.54**	32.47	33.69	**0.25**
Couffo	27.31	28.65	**0.27**	218.78	349.84	**29.33**	11.16	51.63	**8.87**	31.26	32.51	**0.28**
Donga	27.09	28.47	**0.27**	88.48	223.27	**27.30**	72.04	130.11	**12.48**	32.32	33.55	**0.25**
Littoral	26.73	27.96	**0.26**	358.88	364.91	**1.07**	0.00	0.00	**0.00**	28.13	29.34	**0.26**
Mono	27.21	28.50	**0.26**	300.30	360.31	**13.63**	0.43	8.33	**1.78**	30.32	31.54	**0.27**
Oueme	26.99	28.27	**0.27**	317.96	361.67	**9.73**	0.88	7.08	**1.36**	29.67	30.89	**0.27**
Plateau	27.48	28.82	**0.27**	242.00	352.29	**24.17**	19.59	63.26	**9.74**	31.41	32.65	**0.27**
Zou	27.64	29.00	**0.27**	237.36	352.16	**25.19**	27.28	83.66	**12.14**	31.75	33.01	**0.27**

TABLE A4. CMIP6 Simulated Historical Averages (1994–2015), Mid-Century SSP3-7.0 Averages (2041–2060), and Trends per Decade (2000–2050) for a) Precipitation, b) Maximum Number of Consecutive Dry Days (CDD), c) Maximum Number of Consecutive Wet Days (CWD), d) Average Highest Precipitation Amount in a 1-day Period (rx1day), e) Number of Heavy Precipitation Days (precip ≥ 20 mm; r20 mm), and f) Standardized Precipitation Evapotranspiration Index (spei12)

Region	Precipitation (mm)			Max Consecutive Dry Days			Max Consecutive Wet Days		
	1994–2015	2041–2060	Trend	1994–2015	2041–2060	Trend	1994–2015	2041–2060	Trend
BENIN	1123.19	1170.18	10.51	60.42	59.30	−0.11	53.43	48.10	−0.60
Alibori	805.67	880.00	17.57	83.72	81.79	−0.33	34.80	33.15	−0.08
Atakora	1018.15	1078.88	15.19	70.94	71.02	−0.04	49.70	45.62	−0.05
Atlantique	1475.88	1472.00	1.95	12.59	14.09	0.00	69.11	65.03	−0.56
Borgou	1167.46	1235.65	10.88	66.61	65.25	−0.07	57.31	50.28	−0.37
Collines	1283.86	1295.07	4.09	41.81	39.22	0.00	59.66	52.81	−1.66
Couffo	1328.32	1315.93	−0.22	21.13	21.56	0.01	61.46	54.28	−0.42
Donga	1419.72	1455.26	6.80	56.30	54.84	−0.12	75.21	65.46	−1.46
Littoral	1450.69	1459.52	3.80	11.69	12.98	0.00	72.69	63.17	−0.82
Mono	1550.57	1550.88	0.91	12.32	13.65	0.01	72.08	67.09	−0.24
Oueme	1548.22	1546.49	2.19	11.64	12.94	0.00	72.98	68.04	−0.83
Plateau	1313.72	1309.07	1.17	22.11	22.38	0.04	57.67	50.68	−1.45
Zou	1220.23	1207.51	0.22	26.56	26.15	0.06	54.93	48.77	−1.45

Region	Highest Precipitation in a 1-day Period (mm) (rx1day)			Heavy Precipitation Days (≥ 20 mm) (r20 mm)			Standardized Precipitation Evapotranspiration Index (SPEI12)		
	1994–2015	2041–2060	Trend	1994–2015	2041–2060	Trend	1994–2015	2041–2060	Trend
BENIN	27.63	31.11	1.04	4.10	5.60	0.15	−0.14	0.29	0.08
Alibori	24.42	28.35	1.22	3.44	5.31	0.26	−0.28	0.35	0.14
Atakora	29.11	34.35	1.39	4.45	6.08	0.21	−0.22	0.33	0.11
Atlantique	32.26	33.25	0.84	3.05	3.99	0.00	−0.04	0.09	0.03
Borgou	27.83	31.54	1.03	4.93	6.55	0.11	−0.17	0.33	0.09
Collines	26.81	29.27	0.60	3.48	4.72	0.13	0.04	0.24	0.04
Couffo	27.97	29.47	0.74	2.36	3.18	0.00	0.10	0.16	−0.02
Donga	30.97	34.56	0.79	6.23	7.62	0.18	−0.06	0.30	0.06
Littoral	32.61	33.21	0.90	3.68	4.63	0.00	−0.11	0.09	0.04
Mono	33.90	35.59	0.90	3.54	4.57	0.00	−0.04	0.12	0.02
Oueme	33.85	34.50	0.99	3.58	4.63	0.00	−0.07	0.09	0.04
Plateau	28.11	29.10	0.85	2.41	3.35	0.00	0.03	0.16	0.01
Zou	25.49	26.48	0.82	2.01	2.77	0.00	0.09	0.18	−0.01

Population Exposure Across Regions

Tables A5 and **A6** show the variations in CMIP6 historical and projected population exposure to temperature and precipitation related variables.

TABLE A5. For Each Admin1 Department, Percent of the Population[9] at High Health Risk for Three Periods: Retrospective (1975–2024, centered on 2000), Future (2010–2059, centered on 2035), and Distant Future (2050–2099, centered on 2075), Under SSP3-7.0. High-Risk Areas are Defined as Locations where, a) At Least Once Every 50 years, a Year Occurs with More Than 30 Days Characterized by Maximum Temperatures Surpassing 35°C, b) At Least Once Every 50 Years, a Year Occurs with More Than 20 Days Characterized by Heat Index Surpassing 35°C, c) At Least Once Every 50 Years, a Year Occurs with More Than 30 Days Characterized by Night Temperatures Surpassing 26°C.

Region	Hot Days (Tmax>35°C)			Heat Index >35°C			Tropical Nights (Tmin > 26°C)		
	1975–2024	2010–2059	2050–2099	1975–2024	2010–2059	2050–2099	1975–2024	2010–2059	2050–2099
BENIN	59.38	70.41	86.17	91.40	100.00	100.00	46.59	99.17	100.00
Alibori	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Atakora	100.00	100.00	100.00	77.03	100.00	100.00	60.57	100.00	100.00
Atlantique	0.66	4.83	52.89	98.02	100.00	100.00	71.04	100.00	100.00
Borgou	100.00	100.00	100.00	93.09	100.00	100.00	24.27	100.00	100.00
Collines	100.00	100.00	100.00	100.00	100.00	100.00	0.00	100.00	100.00
Couffo	48.22	88.65	100.00	100.00	100.00	100.00	0.00	100.00	100.00
Donga	100.00	100.00	100.00	21.64	100.00	100.00	0.00	86.49	100.00
Littoral	0.00	0.00	0.00	48.03	100.00	100.00	100.00	100.00	100.00
Mono	0.00	30.44	95.10	100.00	100.00	100.00	59.01	100.00	100.00
Oueme	2.66	3.13	21.69	96.99	100.00	100.00	85.18	100.00	100.00
Plateau	42.69	54.36	90.52	100.00	100.00	100.00	29.39	100.00	100.00
Zou	76.62	100.00	100.00	100.00	100.00	100.00	42.48	100.00	100.00

9 Population dataset: Gridded Population of the World, Version 4: GPWv4; Revision 11, Dec 2018

TABLE A6. For Each Admin1 District, Percent of the Population at High Health Risk for Three Periods: Retrospective (1975–2024, centered on 2000), Future (2010–2059, centered on 2035), and Distant Future (2050–2099, centered on 2075), under SSP3-7.0. High-Risk Areas are Defined as Locations where at Least Once Every 25 Years, a Year Occurs with 5-day Cumulative Precipitation Above 130 mm.

Region	Average Largest 5-day Cumulative Precipitation		
	1975–2024	2010–2059	2050–2099
BENIN	22.07	46.06	57.75
Alibori	8.38	100.00	100.00
Atakora	61.42	97.76	100.00
Atlantique	0.00	16.00	33.88
Borgou	55.77	98.34	100.00
Collines	15.52	23.51	46.36
Couffo	0.00	0.00	0.00
Donga	86.78	100.00	100.00
Littoral	0.00	45.98	96.24
Mono	0.00	50.93	49.76
Oueme	23.90	27.32	78.32
Plateau	11.09	9.98	39.61
Zou	0.00	0.00	0.00

TABLE A7. CMIP6 Simulated Historical Averages (1994–2015), Mid-Century SSP3-7.0 Projections (2041–2060), and Decadal Trends (2000–2050) for Seasonal Average Surface Air Temperature over December-January-February (DJF), March-April-May (MAM), June-July-August (JJA), and September-October-November (SON)

Region	1994–2015				2041–2060				Trend			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
BENIN	27.70	30.19	26.39	27.09	29.17	31.70	27.66	28.39	**0.28**	**0.30**	**0.28**	**0.26**
Alibori	27.67	32.31	27.51	27.84	29.20	33.93	28.80	29.18	**0.29**	**0.31**	**0.29**	**0.27**
Atakora	27.44	30.63	26.44	27.00	28.98	32.25	27.73	28.31	**0.30**	**0.30**	**0.30**	**0.27**
Atlantique	27.95	28.22	25.73	26.62	29.27	29.58	26.99	27.82	**0.27**	**0.28**	**0.26**	**0.24**
Borgou	27.24	29.81	26.06	26.85	28.67	31.28	27.28	28.13	**0.27**	**0.29**	**0.27**	**0.25**
Collines	28.43	29.18	26.10	27.08	29.87	30.58	27.38	28.36	**0.29**	**0.29**	**0.25**	**0.26**
Couffo	28.32	28.51	25.78	26.69	29.68	29.91	27.09	27.96	**0.29**	**0.29**	**0.27**	**0.26**
Donga	27.40	28.95	25.55	26.52	28.89	30.42	26.79	27.81	**0.28**	**0.30**	**0.26**	**0.25**
Littoral	27.34	27.82	25.48	26.26	28.61	29.15	26.70	27.38	**0.28**	**0.28**	**0.26**	**0.24**
Mono	28.02	28.32	25.81	26.70	29.36	29.69	27.07	27.89	**0.28**	**0.28**	**0.26**	**0.25**
Oueme	27.70	28.08	25.71	26.51	29.01	29.43	26.97	27.69	**0.27**	**0.29**	**0.26**	**0.24**
Plateau	28.55	28.63	25.95	26.86	29.91	30.02	27.24	28.13	**0.28**	**0.29**	**0.26**	**0.25**
Zou	28.77	28.86	26.02	26.98	30.15	30.27	27.33	28.28	**0.29**	**0.29**	**0.27**	**0.26**

TABLE A8. CMIP6 Simulated Historical Averages (1994–2015), Mid-Century SSP3-7.0 Projections (2041–2060), and Decadal Trends (2000–2050) for Seasonal Total Precipitation over December-January-February (DJF), March-April-May (MAM), June-July-August (JJA), and September-October-November (SON)

Region	1994–2015				2041–2060				Trend			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
BENIN	24.61	229.86	568.29	300.43	24.95	232.79	585.78	326.65	−0.46	0.91	5.40	5.78
Alibori	1.68	105.64	497.48	200.87	2.14	112.71	537.30	227.84	−0.01	1.57	9.58	7.20
Atakora	4.57	176.89	544.90	291.79	5.39	185.89	564.17	323.44	−0.05	2.45	7.02	7.20
Atlantique	148.18	420.30	496.09	411.31	145.00	410.24	495.85	420.92	−2.52	−1.41	−0.39	2.96
Borgou	6.92	219.98	633.81	306.76	7.97	227.64	656.89	343.15	−0.08	1.74	5.38	6.59
Collines	36.46	316.86	587.81	342.73	37.32	310.15	588.81	358.79	−0.73	−0.93	2.77	2.99
Couffo	93.21	369.98	494.04	371.09	90.32	359.30	485.93	380.39	−2.07	−2.31	0.02	2.32
Donga	15.13	308.31	719.98	376.30	16.29	311.99	721.34	405.63	−0.27	1.03	3.34	5.66
Littoral	146.46	408.74	535.11	360.38	143.10	401.54	541.25	373.63	−2.36	−0.60	1.34	3.58
Mono	157.98	442.67	500.67	449.25	155.52	432.53	500.56	462.27	−2.48	−1.83	−0.07	3.35
Oueme	159.62	440.14	530.71	417.75	155.57	429.41	532.04	429.47	−2.92	−1.49	−0.30	4.15
Plateau	94.95	371.91	491.04	355.82	93.21	360.91	488.79	366.16	−2.00	−1.90	0.92	3.86
Zou	69.63	334.92	486.50	329.19	67.84	324.40	478.33	336.95	−1.65	−1.75	0.97	2.37

TABLE A9. Gross Production Value (constant 2014–2016 US$) for Various Crops in Benin in the Year 2022

Item	Value (1000 USD)	Percent	Cumulative Percent
Cassava, fresh	1,598,984	35.1%	35.1%
Yams	1,447,389	31.8%	66.8%
Maize (corn)	461,929	10.1%	77.0%
Rice	345,404	7.6%	84.5%
Seed cotton, unginned	233,276	5.1%	89.7%
Tomatoes	189,138	4.2%	93.8%
Beans, dry	102,112	2.2%	96.1%
Other vegetables	74,655	1.6%	97.7%
Sorghum	36,845	0.8%	98.5%
Okra	36,108	0.8%	99.3%
Sweet potatoes	20,604	0.5%	99.7%
Millet	9,937	0.2%	100.0%
Taro	1,634	0.0%	100.0%
Potatoes	434	0.0%	100.0%

Source: FAOSTAT[10]

[10] FAO. 2025. *FAOSTAT Statistical Database*. Food and Agriculture Organization of the United Nations. Rome, Italy. Available at: https://www.fao.org/faostat [Accessed: 5 February 2025].

CLIMATE RISK COUNTRY PROFILE

BENIN

THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP