CLIMATE CENTRAL

Climate change is heating up West Africa's cocoa belt

Analysis: Climate change is increasing temperatures year-round in West Africa, impacting cacao quantity and quality

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KEY FACTS

- Climate change, due primarily to burning oil, coal, and methane gas, is causing hotter temperatures to become more frequent in the four West African countries responsible for producing approximately 70% of the world's cacao — the key ingredient in chocolate.
- Analysis of daily maximum temperatures during the past decade shows that climate change added at least three weeks above 32°C (89.6°F) annually during the main cacao crop season (October-March) in Côte d'Ivoire and Ghana. Such temperatures are above the optimal temperature range for cacao trees.
- Over the same time period, climate change added just over two weeks above 32°C annually during the main crop season in Cameroon and more than one week in Nigeria.
- In 2024, human-caused climate change added six weeks' worth of days above 32°C in 71% of cacao-producing areas across Côte d'Ivoire, Ghana, Cameroon, and Nigeria.
- While many factors, such as precipitation and insect-borne infections, can affect cacao trees, excessive heat can contribute to a reduction in the quantity and quality of the harvest — potentially increasing global chocolate prices and impacting local economies in West Africa.

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INTRODUCTION

West African countries account for the largest share of global production of cacao — the primary raw ingredient in chocolate. Approximately 70% of the world's cacao is produced in West Africa's cocoa belt, where consistent warm and humid conditions are ideal for plant growth. Côte d'Ivoire and Ghana lead production in this region, supporting the livelihoods of over approximately 9 million farmers and workers, while Cameroon and Nigeria follow as the third and fourth largest producers. Brazil, Indonesia, Peru, Chile, and Ecuador are other major producers of cacao globally.

Warm to hot temperatures up to 32°C are optimal for cacao growth, and temperatures that exceed this threshold can reduce the quality and quantity of the harvest. Cacao trees produce pods during two six-month crop cycles each year: the main harvest, which occurs from October-March, and the smaller mid-crop harvest, from April-September (though the timing of these periods may differ slightly in Cameroon and Nigeria).

Excessive heat can significantly hinder photosynthesis and increase water stress within cacao plants, resulting in shriveled flowers and smaller, rotted pods. In 2024, for example, farmers in Côte d'Ivoire reported that excessive heat caused leaves — which typically provide shade for cacao pods — to fall off the trees, exposing the pods to sunlight and additional heat stress.

Adequate and well-distributed rainfall is also crucial for cacao growth. According to the International Cocoa Organization (ICCO), cacao grows best when annual rainfall totals are between 1,500 and 2,000 millimeters, with a dry spell lasting no longer than three months. In the post-harvest period, excessive rainfall can prevent cacao beans from drying out, leading to mold development and further harvest losses. In July 2024, portions of Côte d'Ivoire received 40% more rainfall than expected, flooding crop fields and damaging cacao plants, while little to no rain fell across the country in December. Inconsistent rainfall patterns impacted all West African cacao-producing countries in 2024 and contributed to lower harvests and higher prices.

Climate Central analyzed how warming temperatures, attributed to climate change, affected the number of days with maximum temperatures above 32°C during the main and mid-crop cycles in Cameroon, Côte d'Ivoire, Ghana, and Nigeria over the past 10 years (2015-2024). The analysis uses observed temperature data as well as estimates of counterfactual temperatures — or temperatures that would have occurred in a world without human-induced climate change — derived from the Climate Shift Index (CSI) system.

Findings indicate that temperatures beyond the optimal range for cacao growth are becoming more common in West Africa's cocoa belt, particularly during the main crop harvest season, compared to a world without climate change.

Beyond intensifying heat, climate change is also altering rainfall patterns in West Africa — an important factor in cacao growth — and contributing to soil degradation, further straining cacao production. However, rising temperatures and changing rainfall patterns are just two of the factors at play. Illegal mining, smuggling, and the spread

of cacao swollen shoot virus through mealybug infestations are also significantly impacting the quantity and quality of cacao harvests, driving up chocolate prices and compounding challenges for farmers.

RESULTS

1. During the past decade, global warming has increased the number of days above the ideal cacao growth temperature range in West African growing regions by two to four weeks annually — mostly during the main crop cycle.

- The impact of human-caused climate change on temperature was most pronounced in cacao-growing regions of Côte d'Ivoire and Ghana, where the analysis found that climate change added, on average, nearly 40 days per year with temperatures above 32°C during the past decade (2015-2024) (Figure 1).

- Over this same 10-year period, Cameroon experienced, on average, at least 18 additional days each year where temperatures exceeded 32°C because of climate change, while Nigeria saw around two weeks' worth of additional excessive heat.

- The majority of days above 32°C added by climate change were experienced during the main crop cycle (October-March) across all four countries: Côte d'Ivoire (26 days), Ghana (25), Cameroon (15), and Nigeria (9) (Table 1).

Country	Average annual days above 32°C (2015-2024)	Average annual days above 32°C added by climate change during the main crop cycle (2015-2024)	Average annual days above 32°C added by climate change during the mid-crop cycle (2015-2024)
Côte d'Ivoire	80	26	13
Ghana	105	25	14
Cameroon	31	15	3
Nigeria	73	9	5

Table 1. Days each year that exceed optimal cacao growing temperatures (32°C) during the main and mid-crop cycles in West Africa's cocoa belt, added by human-caused climate change. Averaged over the past decade (2015-2024).

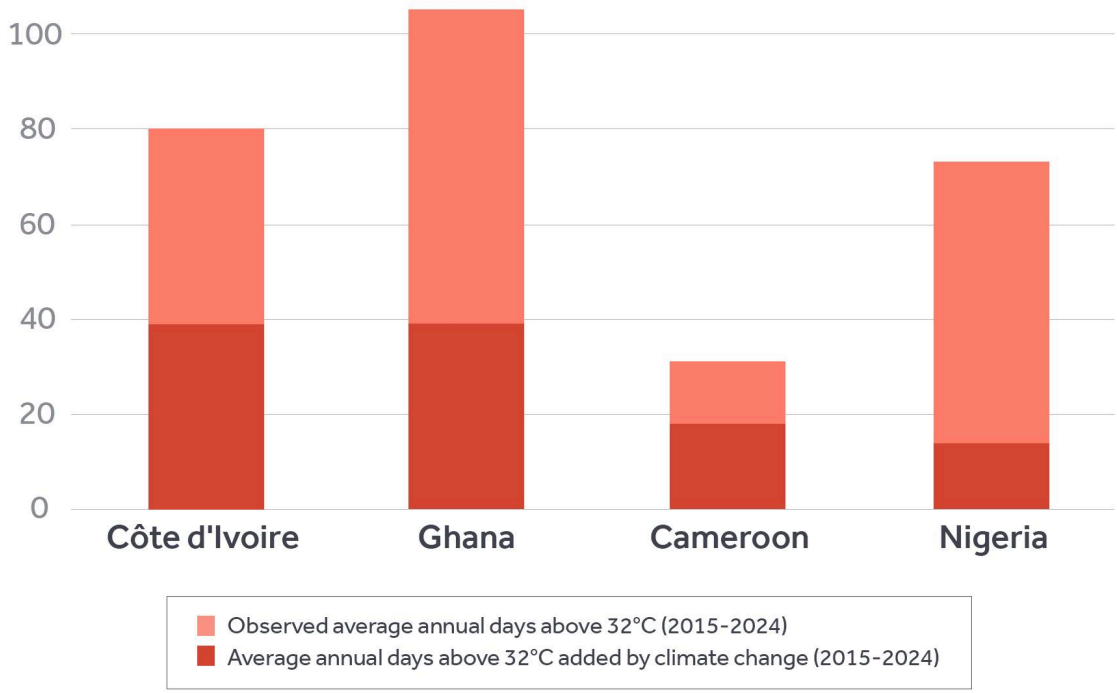

Figure 1. Days each year that exceed optimal cacao growing temperatures (32°C) in West Africa's cocoa belt, added by human-caused climate change. Averaged over the past decade (2015-2024).

2. Nearly all the analyzed cacao-producing areas in West Africa saw at least three additional weeks' worth of days above 32°C added by climate change each year during the past decade — but many experienced much more.

- Climate Central analyzed temperature data in 44 cacao-producing districts, regions, or states across West Africa in Cameroon, Côte d'Ivoire, Ghana, and Nigeria.

- Over the past decade (2015-2024), around two-thirds (28) of cacao-producing areas experienced at least six additional weeks' worth of days with above 32°C added by climate change each year, while one-third (15) saw at least eight additional weeks' worth of days with excessive heat (Table 2).

- Nearly all areas (43) saw at least three weeks' worth of days above the optimal temperature range for growing cacao added each year due to human-caused warming.

Country	District/Region/State	Days above 32°C (2015-2024)	Days above 32°C added by climate change (2015-2024)
Côte d'Ivoire	Yamoussoukro	136	80
Côte d'Ivoire	Sassandra-Marahoué	120	77
Côte d'Ivoire	Lacs	145	75
Ghana	Ahafo	119	72
Ghana	Western North	99	72
Côte d'Ivoire	Gôh-Djiboua	87	70
Ghana	Eastern	110	69
Ghana	Ashanti	128	67
Côte d'Ivoire	Lagunes	82	66
Côte d'Ivoire	Montagnes	90	63
Ghana	Central	67	61
Ghana	Bono	143	60
Ghana	Volta	80	59
Côte d'Ivoire	Comoé	82	55
Nigeria	Imo	129	55
Nigeria	Abia	120	54
Côte d'Ivoire	Bas-Sassandra	51	48
Nigeria	Cross River	112	48
Nigeria	Delta	89	48
Nigeria	Edo	122	48
Nigeria	Rivers	80	47
Nigeria	Akwa Ibom	78	45
Ghana	Bono East	155	45
Ghana	Oti	118	45
Ghana	Western	49	45
Côte d'Ivoire	Abidjan	39	43
Nigeria	Ogun	99	42
Nigeria	Ondo	93	42

Table 2. Analyzed cacao-producing districts, regions, and states in West Africa's cocoa belt that experienced at least six additional weeks' worth of days with a temperature above 32°C annually due to human-caused climate change. Averaged over the past decade (2015-2024).

3. In 2024, more than two-thirds of cacao-producing states or regions analyzed in West Africa saw at least six additional weeks' worth of days above 32°C.

- Around 70% (31) of analyzed cacao-producing regions in West Africa experienced six additional weeks' worth of days when the temperature exceeded the optimal cacao growing conditions, compared to what they would have experienced in a world without human-caused climate change (Table 3).

- Every region analyzed experienced at least an additional three weeks' worth of temperatures hotter than the optimal growth range due to global warming in 2024 (Figure 2).

Country	District/Region/State	Days above 32°C (2024)	Days above 32°C added by climate change (2024)
Côte d'Ivoire	Gôh-Djiboua	149	75
Côte d'Ivoire	Montagnes	154	73
Ghana	Central	122	72
Ghana	Eastern	176	72
Ghana	Western North	171	69
Côte d'Ivoire	Sassandra-Marahoué	189	66
Côte d'Ivoire	Lagunes	137	63
Cameroon	Centre	104	62
Ghana	Volta	130	59
Ghana	Western	96	59
Côte d'Ivoire	Yamoussoukro	204	58
Ghana	Ashanti	202	58
Côte d'Ivoire	Bas-Sassandra	92	57
Cameroon	Est	84	56
Côte d'Ivoire	Comoé	139	54
Côte d'Ivoire	Lacs	215	54
Côte d'Ivoire	Abidjan	74	53
Nigeria	Cross River	188	53
Ghana	Ahafo	193	53
Nigeria	Bayelsa	90	50
Cameroon	Littoral	71	50
Nigeria	Delta	152	49
Nigeria	Rivers	139	48
Ghana	Oti	177	48
Nigeria	Abia	195	47
Nigeria	Akwa Ibom	132	47
Cameroon	Sud-Ouest	84	45
Ghana	Bono	218	45
Ghana	Bono East	238	45
Nigeria	Ondo	153	43
Nigeria	Ogun	164	42

Table 3. Analyzed cacao-producing districts, regions, and states in West Africa's cocoa belt that experienced at least six additional weeks' worth of days with a temperature above 32°C in 2024 due to human-caused climate change.

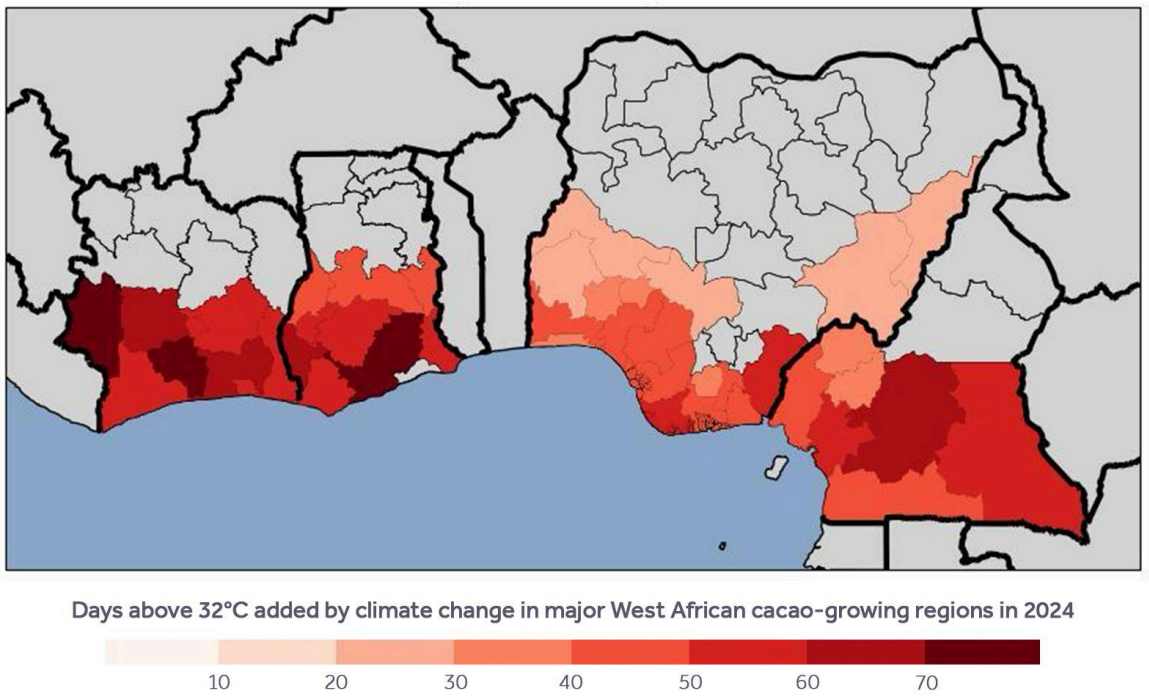

Figure 2. Days with a temperature above 32°C in 2024 added due to human-caused climate change in analyzed cacao-producing districts, regions, and states in West Africa's cocoa belt.

4. Climate change added more days above the optimal temperature range during the main crop cycle than during the mid-crop cycle across nearly all cacao-growing regions in 2024.

- Human-caused climate change added more days above 32°C during the main crop cycle than the mid-crop cycle in 87% (39) of cacao-producing regions analyzed in 2024 (Table 4).
    - The number of days above 32°C added by climate change during the mid-crop cycle was greater than the days added in the main crop cycle in only five areas: **Imo**, **Oyo**, **Kogi,** and **Kwara** in Nigeria; and **Bono East** in Ghana.
    - Even without the influence of climate change, the main crop cycle would likely experience more days above 32°C than the mid-crop cycle across most regions analyzed, reflecting inherent seasonal differences. While climate change often adds a higher percentage of days above 32°C to the mid-crop cycle, the main crop cycle remains the hotter season overall and was more impacted in absolute terms in most regions.

- Climate change added two to four weeks' worth of days above the optimal temperature threshold to the mid-crop cycle in all cacao-growing districts of Ghana and Côte d'Ivoire.

    - Climate change contributed at least two weeks' worth of additional days above 32°C during the mid-crop cycle in all but three regions of Nigeria: Adamawa (6 days), Lagos (9), and Taraba (11).
    - Only one region of Cameroon (**Centre**) experienced at least an additional two weeks above the optimal growing threshold (15 days)**.**

- Climate change accounted for at least half of the observed days above 32°C in 12 states during the main crop cycle and 19 states during the mid-crop cycle across all analyzed countries.

Country	District/Region/State	Days above 32°C added by climate change during the main crop cycle (2024)	Days above 32°C added by climate change during the mid-crop cycle (2024)
Côte d'Ivoire	Montagnes	50	23
Ghana	Central	48	24
Côte d'Ivoire	Gôh-Djiboua	47	28
Cameroon	Centre	47	15
Ghana	Western North	45	24
Ghana	Eastern	44	28
Cameroon	Est	44	12
Côte d'Ivoire	Sassandra-Marahoué	40	26
Côte d'Ivoire	Lagunes	40	23
Ghana	Western	39	20
Côte d'Ivoire	Bas-Sassandra	39	18
Ghana	Volta	38	21
Cameroon	Littoral	38	12
Cameroon	Sud-Ouest	36	9
Côte d'Ivoire	Yamoussoukro	35	23
Côte d'Ivoire	Abidjan	35	18
Nigeria	Bayelsa	35	15
Ghana	Ashanti	34	24
Côte d'Ivoire	Comoé	34	20
Nigeria	Cross River	34	19
Ghana	Ahafo	33	20
Nigeria	Akwa Ibom	33	14
Nigeria	Rivers	32	16
Côte d'Ivoire	Lacs	31	23

Nigeria	Delta	31	18
Ghana	Oti	29	19
Cameroon	Sud	29	12
Nigeria	Abia	28	19
Nigeria	Ondo	28	15
Nigeria	Lagos	27	9
Cameroon	Ouest	27	8
Nigeria	Ogun	26	16
Cameroon	Nord-Ouest	25	6
Ghana	Bono	24	21
Nigeria	Edo	22	19
Ghana	Bono East	21	24
Nigeria	Ekiti	19	14
Nigeria	Osun	18	15
Nigeria	Imo	17	19
Nigeria	Taraba	16	11
Nigeria	Adamawa	16	6
Nigeria	Kogi	11	17
Nigeria	Oyo	11	16
Nigeria	Kwara	9	15

Table 4. Comparison of the number of days above 32°C during 2024 that were added by climate change across cacao-producing regions of Côte d'Ivoire, Ghana, Nigeria, and Cameroon in the main and mid-crop cycles.

Other factors impacting cocoa production in West Africa

Temperature is only one of the factors that play a role in the growth of cacao. Other important influences on cacao growth include mealybug infestations, rainfall patterns, smuggling, and illegal mining.

- **Inconsistent rainfall patterns.** Sufficient rainfall is important for the growth of cacao, but more important is how that rainfall is distributed throughout the year. Uneven rainfall patterns can stress cacao trees and disrupt flowering. Too much rainfall over a short period can waterlog fields and prevent roots from taking up oxygen, which is vital for physiological growth processes in cacao trees. Heavy rainfall can cause flowers to fall off trees, reducing the quantity of the harvest. Excessive moisture also creates an environment ideal for the growth of black pod disease, or pod rot, which was responsible for a 25% loss in Ghana's annual cocoa bean output in 2012. On the other hand, drought can reduce the efficiency of photosynthesis in trees leading to fewer flowers,

producing smaller and underdeveloped beans, and causing trees to shed leaves in an attempt to conserve water. High temperatures in conjunction with prolonged dry periods can drastically increase water stress in cacao trees.

In 2024, erratic rainfall patterns early in the year were linked to climate change and El Niño.

- **Mealybugs and CSSV**. Mealybugs are insects that can be found worldwide but thrive in especially warm and humid conditions. There are over 2,000 species of mealybugs, but there are 14 types of mealybugs that have been identified as vectors of the cacao swollen shoot virus (CSSV). Mealybugs acquire CSSV when they feed on the sap of infected trees and transmit it to healthy trees as they move and feed again. The disease can cause symptoms such as swollen stems and roots, yellowing of leaves, and reduced leaf and pod size, eventually leading to the death of the infected trees. According to the Ghana Cocoa Board, CSSV is responsible for an estimated 17% annual loss in cacao production. Nearly 600,000 hectares of land in Ghana were found to be infested with CSSV in 2023.

- **Smuggling and illegal mining.** Among the non-temperature-related impacts on cacao production and losses are smuggling and illegal mining. During the 2023/2024 cacao season, the director of the Ghana Cocoa Board and leader of the anti-smuggling task force estimated that at least 160,000 tons of cacao were lost to smuggling. This is more than three times higher than the previous season. Smuggling rings became more common during Ghana's economic crisis in 2022 because they offered farmers higher prices for cacao, providing incentives to sell through unofficial channels. Similar activities were reported in Cameroon in 2023 when the country's Trade Ministry revealed that they lost approximately CFA70 billion (USD 111.7 billion) to smuggling. For similar reasons, illegal mining has also become more common in Ghana. Farmers will lease their land to miners for payments that are often higher than their profits from cacao farming. However, mining activities contribute to soil degradation and can prevent the land from being used in cacao farming in the future. These challenges, along with widespread child and forced labor practices in the region, reflect a long-term undervaluation of the work of cacao farmers that could grow worse as more extreme heat increasingly threatens the health of farmers.

Adapting cacao farming for a warming world

Investing in diverse and nature-friendly agriculture practices could be key to food system adaptation — especially in a warming world. For example, planting other crops and taller trees (such as mango, cashew, and banana) between the cacao plants creates healthy fertile soils that can hold onto moisture, reduces the risk of pest and disease outbreaks, and provides protective shade for cacao plants from extreme temperatures and water loss. This can mean more consistent cocoa yields for farmers.

While such adaptations are important, they cannot fully protect cacao production from the impacts of climate change. Cacao farmers will still face significant challenges, especially as some of these strategies can be slow to implement, costly, or difficult for small-scale farmers to adapt to. Extreme weather events, such as drought and flooding, could exacerbate existing challenges and undermine the progress made through adaptation strategies. Uncertainty and variability in future climates make it difficult to plan the right combination of adaptations.

METHODS

Calculating days with temperatures above 32°C

We analyzed observed global temperatures using ERA5 reanalysis temperature data. The data is available at a resolution of 0.25° (31 km). Additionally, the analysis utilized counterfactual temperatures, or the temperatures that would have occurred in a world without human-induced climate change. These are estimated using Climate Central's Climate Shift Index (CSI) system. The system uses the latest peer-reviewed attribution science to quantify the influence of climate change on daily temperatures around the world.

We typically express this influence as a change in the likelihood of the observed temperature due to climate change. However, it is also possible to use the CSI system to estimate the temperature without climate change. To do this, we find the probability of exceeding the observed temperature in the modern climate. We then find the temperature with the same probability in a climate with no global warming (global mean temperature change of 0°C relative to the preindustrial period). We estimate these counterfactual temperatures using each of the observation and model-based methods in the CSI system and then average.

For this analysis, we split each year from 2015-2024 into two seasons corresponding to cacao production: the main crop cycle (October-March) and the mid-crop cycle (April-September). We then counted the number of days each crop cycle when the daily maximum temperature exceeded 32°C over the ERA5 and counterfactual temperatures from 2015-2024 and calculated the difference to determine how many additional days above 32°C were caused by climate change.

We used 10-meter resolution raster data for Côte d'Ivoire and Ghana to identify cacao farms and matched the data with level-1 administrative shapefile boundaries from the database of Global Administrative Boundaries (GADM) to identify the regions/districts that grow cacao. We identified cacao-producing states in Nigeria using data from the National Bureau of Statistics for the 2011/2012 production season, and in Ghana using data available from the National Cocoa and Coffee Board.

Numbers in this report are typically rounded to the nearest significant figure. During the analysis, numerical values for observed and counterfactual data were calculated to high precision, but for reporting and presentation purposes, the number of decimal

places was reduced. As a result, rounding may lead to small discrepancies when performing arithmetic operations on the presented values. These discrepancies are an artifact of rounding and do not affect or reflect the underlying precision of the analysis.

REPORT CONTRIBUTIONS

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