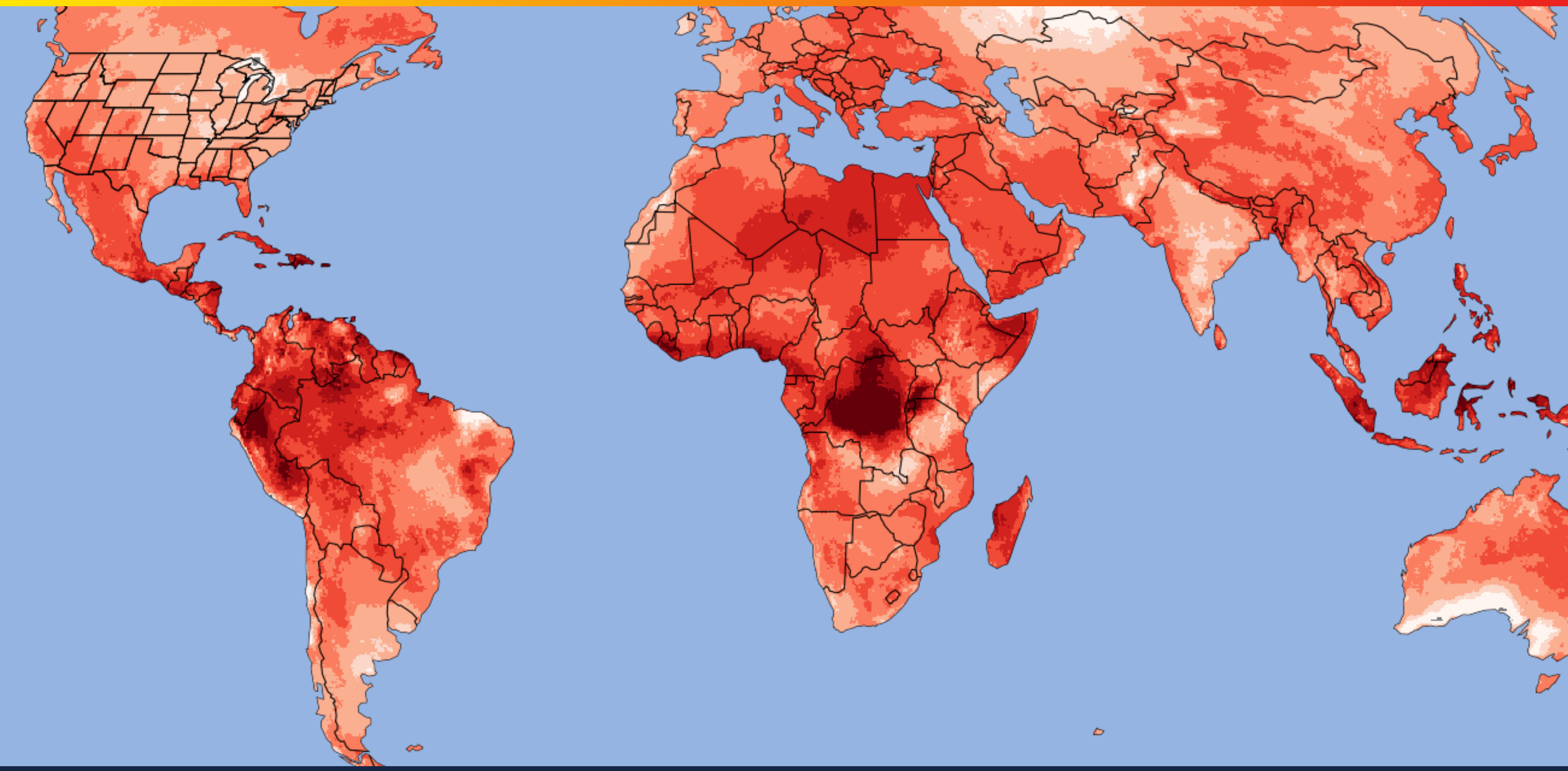
Climate Change and the Escalation of Global Extreme Heat: Assessing and Addressing the Risks

A global review of extreme heat over the past 12 months (May 2024 to May 2025), climate change's influence on that heat, and strategies to prevent increasingly frequent and intense heat from claiming lives worldwide.

May 30, 2025



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Climate Change and the Escalation of Global Extreme Heat: Assessing and Addressing the Risks

A global review of extreme heat over the past 12 months (May 2024 to May 2025), climate change's influence on that heat, and strategies to prevent increasingly frequent and intense heat from claiming lives worldwide.

What's inside the report:

Ahead of Heat Action Day, this new report from scientists at World Weather Attribution, the Red Cross Red Crescent Climate Centre, and Climate Central assesses the influence of human-caused climate change on dangerous heat waves over the past 12 months (May 1, 2024, to May 1, 2025).

The period of analysis spans Earth's hottest year and hottest January ever recorded. The report found that human-caused climate change is boosting dangerous extreme heat for billions of people, and making heat events longer and more likely.

Key findings from the analysis include:

- Over the 12-month period, **4 billion people — about 49% of the global population — experienced at least 30 additional days of extreme heat** (hotter than 90% of temperatures observed in their local area over the 1991-2020 period) **due to human-caused climate change**.
- **In 195 countries/territories, climate change at least doubled the number of extreme heat days**, as compared to a world without climate change.
- All 67 extreme heat events — identified as significant based on record-setting temperatures or major impacts to people or property — **were found to be influenced by climate change**.

This report also demonstrates the crucial role of tracking and reporting on extreme heat impacts and offers actionable solutions to heat risk.

➢ **Download data:** data for 247 countries over May 1, 2024, to May 1, 2025, and 67 extreme heat events

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INTRODUCTION

The year 2024 was, once again, the hottest year on record, surpassing the previous year (2023). It also marked the first year in which global temperatures were clearly 1.5°C or more above the pre-industrial average for the whole year. Each month from January to June 2024 was the hottest ever recorded for that respective month, while the rest of the year was only marginally cooler than the record-breaking period of July to December 2023.

The year 2025 started with the hottest January ever recorded and the lowest amount of Arctic sea ice that a Northern Hemisphere winter has ever seen.

This is not a surprise or an accident — the causes are well known and the impacts are devastating. The continued burning of coal, oil, and gas has released and accumulated enough greenhouse gases to warm the planet by 1.3°C (over a 5-year average) — and by more than 1.5°C in 2024 alone — compared to pre-industrial times. In 2024, as in recent years, human-induced climate change drove more intense and frequent extreme weather events, with heat waves clearly and dramatically affected. One illustration of this is the March 2025 heat wave in Central Asia, which was up to 10°C warmer than it would have been without human-induced climate change.

Such assessments are now routinely possible. In the past decade, climate science has made significant progress in understanding how climate change fuels extreme temperatures. Thanks to developments in attribution science and climate modeling, scientists can now quantify how much heat climate change has added to an extreme temperature event and predict how heat waves will grow more frequent and intense unless emissions are cut drastically. Research can also show how many people have died because of extreme heat driven by human-induced climate change.

One of the most consistent climate attribution science findings is that every heat wave today is made more likely, more intense, and longer-lasting due to humans burning fossil fuels (Clarke et al., 2022). In the last few years, researchers have identified many deadly extreme heat events that would have been virtually impossible without human-induced climate change. Although floods and cyclones often dominate headlines, heat is arguably the deadliest extreme event, with thousands of extreme heat-related deaths reported each year and many more that go unreported or unrecognised as linked to heat.

ABOUT THIS REPORT

Ahead of Heat Action Day on June 2, 2025, this new report from scientists at World Weather Attribution, the Red Cross Red Crescent Climate Centre, and Climate Central assesses the influence of human-caused climate change on dangerous heat waves over the past 12 months (May 1, 2024, to May 1, 2025). The report also highlights the crucial role of tracking and reporting on impacts in extreme heat assessment and actionable solutions to reduce heat risk.

World Weather Attribution (WWA) is an international group of scientists that investigates how climate change influences the intensity and likelihood of extreme weather events, such as heat waves, floods, and droughts. WWA uses weather observations and climate models, and prioritizes events to analyze based on fixed

criteria, such as the humanitarian impact, observed impacts, and team capacity. All WWA studies also consider how vulnerability and exposure shape the impacts.

Climate Central is an independent group of scientists and communicators who research and report the facts about our changing climate and how it affects people's lives. Climate Central is a policy-neutral 501(c)(3) nonprofit.

The Red Cross Red Crescent Climate Centre is a climate reference center supporting the global Red Cross Red Crescent Movement and its partners to reduce the impacts of extreme weather events on the most vulnerable people.

ABOUT THE ANALYSIS

To understand the extent of climate change-driven extreme heat in the past year, Climate Central scientists analyzed daily temperatures in 247 countries and territories between May 1, 2024, and May 1, 2025, using two primary mechanisms:

1. **Extreme heat days:** We focused on days with temperatures that people would consider hot based on their local experience. For each location in our dataset, we look at the temperature that is warmer than 90% of temperatures observed at that site over the 1991-2020 period (also referred to as temperatures above the 90th percentile). We define these as "extreme heat days."

2. **The Climate Shift Index (CSI) system**: Using our peer-reviewed CSI system (Gilford et al., 2022), we calculated the number of extreme heat days that would have occurred in a world without human-caused climate change (i.e., a counterfactual scenario) and compared that to the total number observed. This allowed us to count how many extreme heat days were added by climate change in the past year.

We also looked at 67 extreme heat events identified as notable between May 1, 2024, and May 1, 2025, using World Weather Attribution criteria. For each event we estimated how much climate change increased the likelihood of the heat event (see ***Methodology***).

We defined the length of the heat events using start and end dates identified by WWA. When WWA only identified a start date, we defined the length as the five days following the identified onset of the heat wave (for a total of 6 days). For each identified event, we used the geographic regions identified by WWA, which include both entire countries and sub-regions of countries. It is important to highlight that this analysis uses a consistent definition of heat waves for each country based on temperature metrics, rather than observed impacts as done in WWA studies (van

Oldenborgh et al., 2021). As a result, the changes in likelihood differ quantitatively from other studies by WWA. However, the qualitative conclusion remains the same: human-induced climate change strongly increased the likelihood of these heat waves.

These 67 events occurred in 232 different countries and territories across all inhabited continents. For most events outside of Europe and North America, available data only included generic population data, with limited impact data such as deaths, morbidity, infrastructure, or agricultural failures. However, where impact information exists, it is clear that these events were often dire and affected both the most vulnerable and privileged individuals in every country.

Out of the 67 triggered extreme heat events, the WWA team studied four in depth:

- The extraordinary heat in Central Asia in March 2025
- The extreme heat — and its impacts on women and girls — in South Sudan in February 2025
- The deadly Mediterranean heat wave in July 2024
- The extreme heat in Mexico, the U.S. Southwest, and Central America in June 2024

In all of these studies, human-induced climate change was found to be the key driver of the extreme heat. In many cases — including in Central Asia, South Sudan, and the Mediterranean — the observed high temperatures would not have occurred without climate change.

RESULTS

Extreme heat days added by climate change

Within the past 12 months, no part of the world was spared from dangerous extreme heat (Figure 1). In every country, human-caused climate change added more extreme heat days (Figure 2).

- Four billion people across the world experienced at least one additional month (30+ days) of extreme heat days because of climate change.
- In 195 countries/territories, climate change at least doubled the number of extreme heat days, as compared to a world without climate change.
- Of all countries/territories, Aruba experienced the most days with extreme heat — 187 days. Without human-induced climate change, the average person in Aruba would have experienced only 45 such days.

See Table 1 for a list of the 12 countries/territories with the most days of extreme heat, and **download the data** to see data for 247 countries and territories.

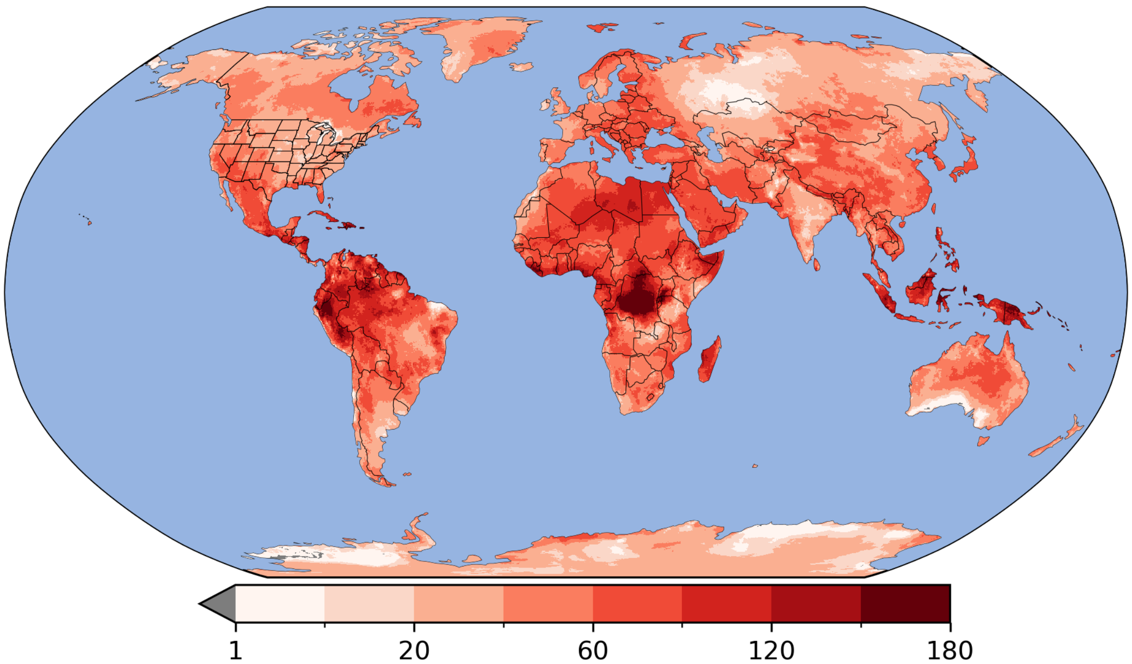

Figure 1. Number of extreme heat days (days when maximum temperatures are hotter than 90% of local historic temperatures) between May 1, 2024, and May 1, 2025. Analysis based on ECMWF ERA5 data and the Climate Shift Index (CSI) system. Produced May 6, 2025.

Country	Number of extreme heat days (observed)	Number of extreme heat days added by climate change
Aruba	187	142
Dominica	184	143
Saint Vincent and the Grenadines	180	151
Grenada	177	145
Guadeloupe	175	136
Montserrat	174	131
Barbados	171	155
Antigua & Barbuda	167	119
Micronesia (Federated States of)	166	157
Saint Kitts and Nevis	164	119
Martinique	163	135
Puerto Rico	161	113

Table 1. Countries and territories with the most extreme heat days (days when maximum temperatures are hotter than 90% of local historic temperatures) from May 1, 2024, to May 1, 2025.

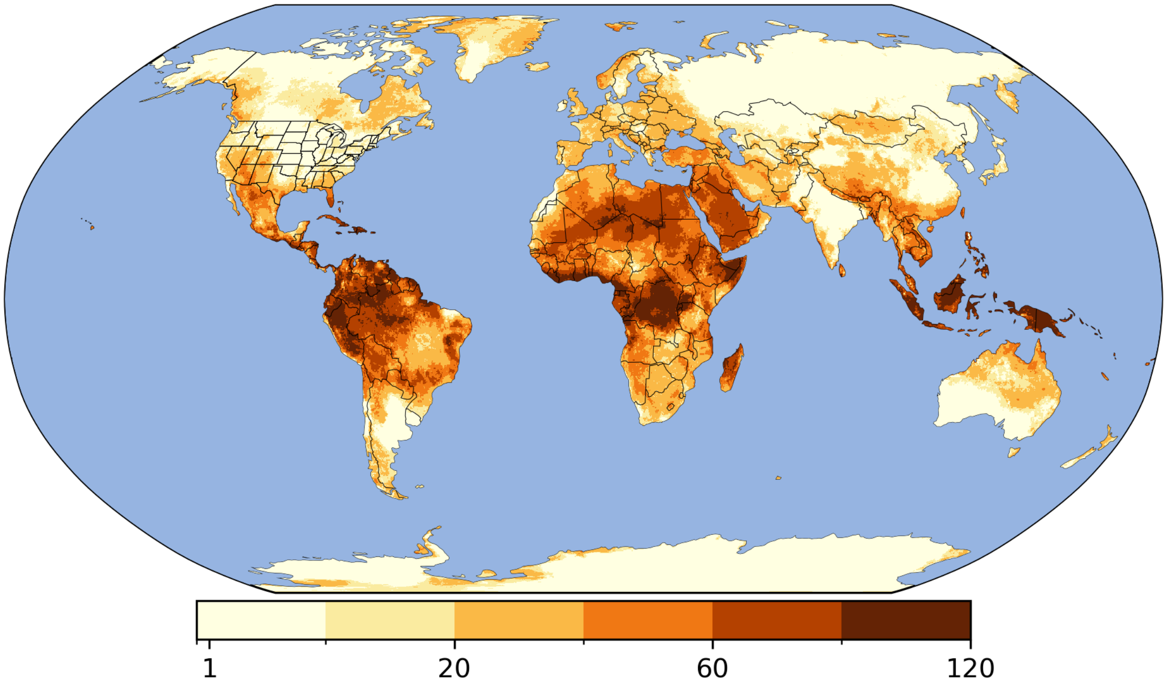

Figure 2. Number of extreme heat days (days when maximum temperatures are hotter than 90% of local historic temperatures) between May 1, 2024, and May 1, 2025 added by climate change. Analysis based on ECMWF ERA5 data and the Climate Shift Index (CSI) system. Produced May 6, 2025.

Climate change influence on significant heat events

WWA identified 67 extreme heat events between May 1, 2024, and May 1, 2025, that were significant due to record-setting temperatures or major impacts to people or property (see ***Methodology*** for details). All 67 events were found to have been made more likely because of climate change.

- The event with the strongest influence of climate change occurred across the Pacific Islands from May 1-30, 2024. It was made at least 69 times more likely because of climate change.
- The next event with the strongest influence of climate change was in Central America and northern South America from Aug. 30 to Sept. 4, 2024, which was made at least 24 times more likely because of climate change.
- In Africa, the event with the strongest influence of climate change stretched across central and western Africa — from Senegal to South Sudan and the Central African Republic — from Dec. 14-30, 2024. It was made at least 15 times more likely because of climate change.
- In Asia, the event with the strongest influence of climate change was in Saudi Arabia, Kuwait, Iraq, and Bahrain from July 11-16, 2024. It was made 14 times more likely because of climate change.

- In Europe, the event with the strongest influence of climate change stretched from Greece to Romania, down into Asia and the Middle East, impacting Egypt, from June 5-10, 2024. It was made at least 11 times more likely because of climate change.

Download the data to see likelihood levels for all 67 events.

DISCUSSION

Underreported impacts

The full extent of extreme heat's impact on human health and wellbeing — as well as its impact on other sectors such as water and agriculture — remains poorly documented, particularly in low- and middle-income countries. Many heat-related deaths are misattributed to comorbid conditions, such as cardiovascular and pulmonary conditions, or renal failure, obscuring the role of elevated temperatures as an aggravating factor (Ebi et al., 2021; The Lancet, 2021).

For example, in the summer of 2022, Europe saw an estimated 61,672 heat-related fatalities (Ballester et al., 2023). However, comprehensive mortality figures are rarely available in most regions (Zhu et al., 2024; Zhao et al., 2021; Murage et al., 2024; IFRC, 2022). This lack of documentation and chronic underreporting significantly impairs global understanding of heat-related health and wellbeing risks, losses, and damages, and undermines adaptation efforts.

Disproportionate and cascading impacts

Vulnerable populations bear the brunt of extreme heat impacts (Benmarhnia et al., 2015). Among older adults and people with pre-existing medical conditions, extreme heat increases the risk of cardiovascular strain, respiratory distress, and premature death (Arbuthnott & Hajat, 2017). Low-income and marginalized communities often lack access to cooling, healthcare, and safe housing, exacerbating their exposure while limiting their ability to recover from heat-related illness and other impacts (Gronlund, 2014). Outdoor workers and people working indoors without cooling face heightened occupational risks, including dehydration, heat stress, and reduced productivity (Gubernot et al., 2015).

Pregnant people also face heightened physiological stress during heat exposure, which can negatively affect both maternal and fetal health (Syed et al., 2022). A recent analysis by Climate Central found that, over the past five years, climate change

at least doubled the number of days considered dangerous for pregnant individuals in nearly 90% of countries and territories, and 63% of cities (Climate Central, 2025).

These health impacts are often compounded by cascading effects across sectors. Heat stress can impair agricultural productivity, reduce water availability, strain health systems, and disrupt energy infrastructure (Figure 3). Heat may also compound with other extremes, such as droughts (Hao et al., 2022), amplifying the overall impact (Rau et al., 2025). Urban areas are especially vulnerable to compounding stressors like power grid failures, water scarcity, loss of productive wage hours (Raju et al., 2024), and increased rates of interpersonal conflict (Lyons et al., 2022). The systemic nature of these impacts reflects the interdependence of infrastructure, public health, and environmental systems under stress from rising temperatures.

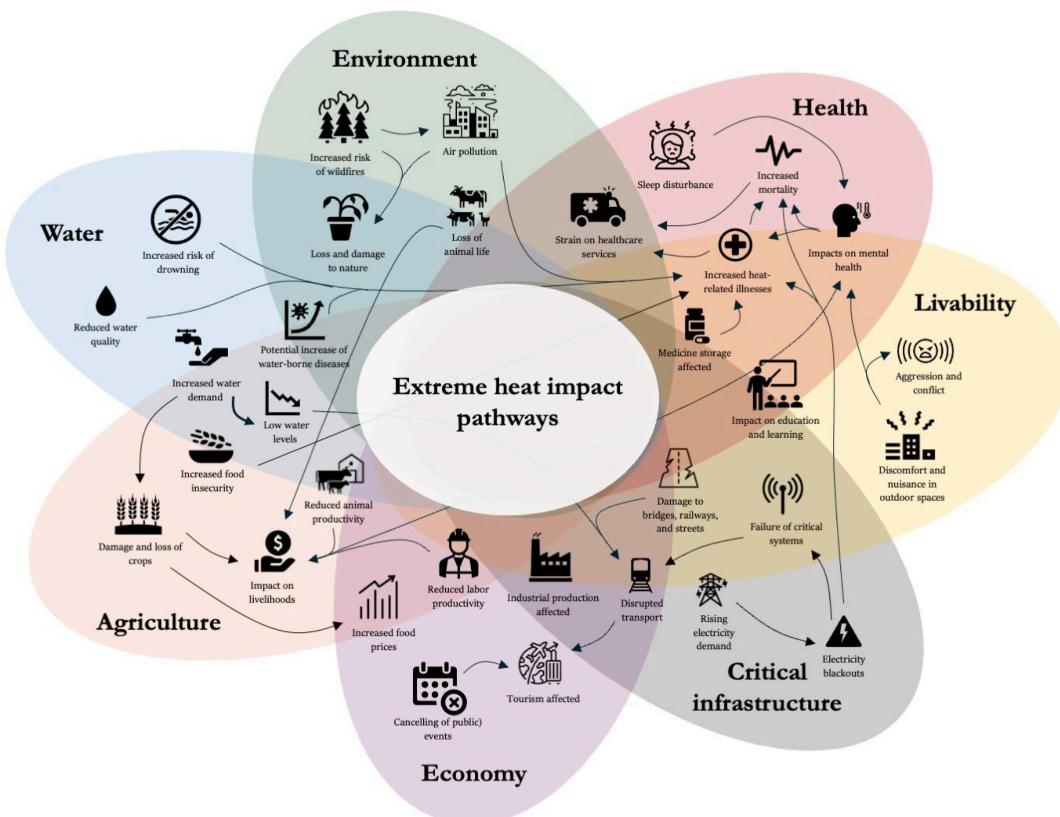

Figure 3. Interrelated and compounding impacts resulting from extreme heat.

Structural barriers to effective monitoring and response

Efforts to monitor and manage heat-related risks are hampered by persistent structural challenges. A lack of accepted definitions for heat waves hinders standardized data collection and the development of effective early warning systems (Awashti et al.,

2022). Where systems do exist, they are often fragmented and rely heavily on emergency department data, which underrepresents the true burden of heat-related illness and mortality (Vaidyanathan et al., 2024; Schramm et al., 2021). Coordination between meteorological, health, and emergency agencies is frequently limited, further undermining preparedness and response (PAHO, n.d.; Murage et al., 2024).

Low public awareness of heat-health risks also weakens preventive action (Eady et al., 2020; WHO, 2018; Howe et al., 2018; Beckmann & Hiete, 2020). Vulnerable groups, particularly in resource-constrained settings, often lack access to critical protections such as cooling, hydration, or timely medical care, exacerbating their vulnerability and exposure.

Evidence-based strategies for risk reduction

Despite persistent challenges, a range of interventions, both individual and systemic, have been shown to reduce the health and societal impacts of extreme heat. At the individual level, adjusting strenuous activity to cooler times of day, resting frequently, staying hydrated, and checking on family, friends, and neighbors can reduce heat impacts (Eyquem & Feltmate, 2022). At the household level, low-cost adaptations such as improved ventilation, shading, reflective roofing, and behavioral changes can significantly lower exposure (Sarihi et al., 2021; Chetan et al., 2020).

City Heat Action Plans (HAPs) have become a key mechanism for coordinating municipal departments, health systems, and emergency responders (Kotharkar and Ghosh, 2021). While these plans are increasingly adopted in cities across South Asia, North America, Europe, and Australia, major gaps remain in Africa, the Middle East, Latin America, and small island states.

Complementary strategies include scaling up heat-health early warning systems, strengthening emergency health services, incorporating cooling support into social protection programs, and reinforcing critical infrastructure such as water, electricity, and transport systems. Legislative actions — such as updating building codes, enforcing occupational heat safety, and implementing heat-resilient urban design — can further institutionalize risk reduction.

The imperative of mitigation

While adaptation is both urgent and necessary, only comprehensive mitigation, through phasing out of fossil fuels, will limit the severity of future heat-related harms. Without sweeping reductions in greenhouse gas emissions, global temperatures will continue to rise, increasing the severity and frequency of extreme heat events.

Adaptation measures alone will become increasingly insufficient to protect communities from the escalating risks. Immediate investment in adaptive capacity, particularly in the most vulnerable regions, must be paired with ambitious global efforts to cut emissions and stabilize the climate system.

METHODOLOGY

WWA heat event criteria

In order for scientists at WWA to consider conducting a study on a heat wave, it must meet one of these two criteria:

1. Record-breaking or unseasonably high temperatures over a large geographic area, for a prolonged period (3+ days), are either forecasted or observed in global data products.
2. Media reports of ≥10 heat-related deaths or major disruptions to critical sectors (notably transportation, energy, and manufacturing) are found.

And it must also meet at least one of these:

3. The heat identified is occurring during the first 3-6 weeks of the hot season (due to heightened vulnerability of early-season extreme temperatures).
4. The heat is occurring in a densely populated area (≥200 people/km^2).
5. The heat is occurring in a highly vulnerable area (using ≥4.8 on the INFORM index as an indicator) and/or one with a high lack of coping capacity (≥6.0 INFORM).

Once an event is triggered, the WWA team then decides whether to undertake an attribution study. Apart from team capacity, providing studies in understudied regions, such as South Sudan or Central Asia, is a key criterion to undertake a detailed WWA study, following the methodology described here.

Calculating the Climate Shift Index (CSI)

Calculating the CSI begins with high-resolution daily temperatures (high, low, and daily average). For this report, Climate Central scientists (we) use ERA5 data from May 1, 2024, to May 1, 2025. We estimate how often the temperature at a particular location is likely to occur in the current climate using both historical observations (ERA5) and 24 climate models. We also estimate the likelihood in a climate without human-caused climate change. The CSI is built from the ratio of these two likelihoods.

Based on the multi-model approach described in Gilford et al. (2022), the CSI combines several different techniques for estimating the frequency of a given temperature occurring in the current climate and in a climate without human-caused climate

change. Two of the techniques use 70 years of historical temperature reconstructions. The other technique uses 24 state-of-the-art global climate models run with and without carbon dioxide emitted by human activities over the historical period.

Calculating days above the 90th percentile

To calculate the number of days with temperatures above the 90th percentile in the modern climate, we calculated the 90th percentile temperature of all average daily temperatures for each ERA5 grid cell from 1991-2020. We then counted how many days between May 1, 2024, and May 1, 2025, had average temperatures above this threshold.

To calculate the number of days with temperatures above the 90th percentile in the counterfactual climate (the climate in a world where climate change hasn't occurred), we calculated the likelihood as a percentile of daily average temperatures occurring from May 1, 2024, to May 1, 2025, in the modern climate. We then applied those percentiles to the counterfactual climate to find the equivalent temperatures. Finally, we counted how many of those days in the counterfactual climate exceeded the 90th percentile threshold from the 1991–2020 period.

To find the number of days above the 90th percentile added by climate change, we subtracted the number of days above the 90th percentile in the counterfactual climate from the number of days above the 90th percentile in the modern climate.

To calculate country-level averages, we took the final number of days and averaged them across each country, weighted by population density in each ERA5 grid cell.

Calculating probability ratios for triggered heat events

For each WWA-identified heat wave between May 1, 2024, and May 1, 2025, we calculated daily climate factors, which reflect how much more likely a given temperature was due to climate change (as used in the Climate Shift Index). To get a single climate factor for the entire event, we adjusted the average daily climate factor using the ratio of daily temperature variance to yearly temperature variance (based on 1991–2020 data). This gave us a variance-scaled climate factor that summarizes the overall influence of climate change. We then averaged these values across the affected countries to get a spatial mean. Finally, we converted the climate factor into an occurrence ratio, showing how many times more likely the event was due to climate change (e.g., a value of 10 means 10 times more likely).