Report

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Scorching Reality

Rising Heatwaves in India
The Case of Jharkhand

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About CEED

Center for Environment and Energy Development (CEED), an environment and energy group, is involved in creating sustainable solutions to maintain a healthy, rich and diverse environment. CEED primarily works towards climate resilience, energy transition, decarbonisation, circular economy, air quality, and sustainable mobility by creating an ecosystem that can scaleup investments in low-carbon development pathways. CEED engages with industries, think tanks, stakeholders and the public to create environmentally responsible and socially just solutions. CEED is the Technical Partner of the Task Force Sustainable Just Transition, Jharkhand.

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1. Introduction

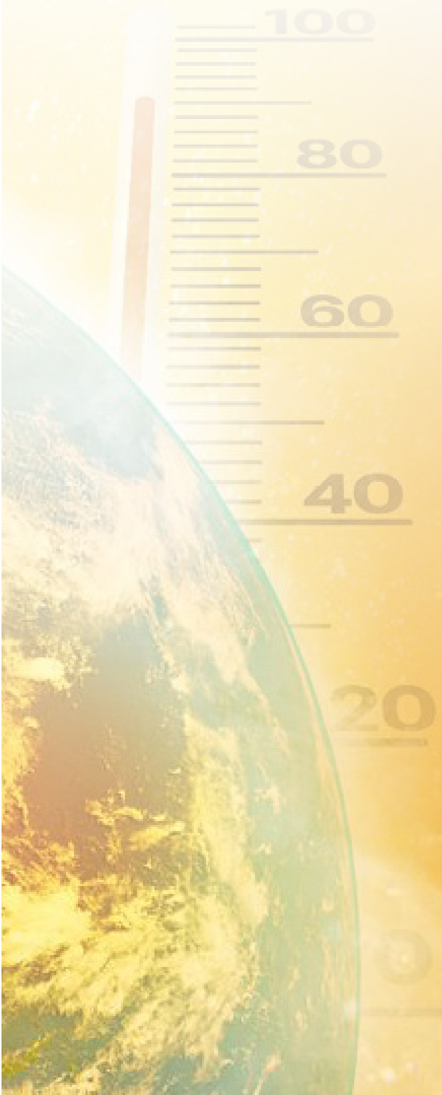
A heatwave, defined by an extended period of unusually high temperatures, presents a significant environmental and public health challenge. This phenomenon is characterized not only by extreme daytime highs but also by elevated nighttime temperatures, which hinder the body's ability to recover from the heat accumulated during the day.

The increasing frequency of heatwaves, their expansion into regions previously unaffected, and their occurrence at atypical times of the year signal a growing concern. Projections by the Intergovernmental Panel on Climate Change (IPCC) suggest that these events will become more frequent as global warming continues.

The effects of heatwaves are often compounded by other extreme events, such as droughts, wildfires, flash floods, and air pollution. These overlapping risks create complex, cascading consequences that affect both human health and ecosystems.

Heatwaves across Globe : Trends & Impacts

Heatwaves pose a growing threat to global health, economic stability, and environmental integrity. Their impacts are vast, including increased mortality rates, reduced water quality and availability due to droughts, higher wildfire risks, disruptions to power supplies, and considerable agricultural damage. Certain populations, such as the elderly, pregnant women, infants, outdoor workers, and athletes, are especially at risk. The urban heat island effect, where cities experience temperatures 5°C to 10°C higher than surrounding areas, further exacerbates the risks.



In recent years, several extreme heatwave events have occurred around the world, for instance:

China experienced its longest and most severe heatwave in 2022, lasting more than 70 days.

In **India** and Pakistan, the heatwaves in 2022 were found to be 30 times more likely due to human-induced climate change.

In the **United Kingdom**, the 2022 heatwaves exceeded previous temperature records, reaching a peak of 40.3°C (World Meteorological Organization).

Globally, over **220 million** people were identified as vulnerable to heatwave exposure in 2018 (World Meteorological Organization).

A study conducted in 2022 in **Europe** linked heat-related stress to over 62,862 deaths, highlighting the serious consequences of these events (Ballester et al., 2023).

2. Indian Context: Extreme Temperatures & Heatwaves

In the summer of 2024, India witnessed a significant milestone as temperatures surpassed the critical 50°C threshold, nearly breaking the all-time national record. The Mungeshpur weather station in Delhi recorded a temperature of 52.9°C, potentially surpassing the previous national record of 51°C set in Rajasthan's Phalodi in 2016. This temperature, recorded on May 28, 2024, is approximately four degrees lower than the world's highest recorded temperature of 56.7°C, recorded in California's Death Valley in 1913.

In India, heatwaves are defined as prolonged periods of unusually high temperatures, surpassing typical maximum temperatures, usually occurring between March and June. On average, five to six heatwave events occur annually across the northern regions of the country. These events can persist for several weeks, often occurring consecutively, and can impact large populations.

In 2016, states such as Bihar, Jharkhand, Gangetic West Bengal, Odisha, Punjab, Haryana, Chandigarh & Delhi, Rajasthan, Maharashtra, West Madhya Pradesh, and Gujarat were severely affected by heatwaves (World Health Organization).

Climate Change and Heatwaves

Since the 1950s, human-driven climate change has led to an increase in both the frequency and severity of heatwaves, and this trend is expected to continue as global temperatures rise, according to the IPCC's Sixth Assessment Report. The report also highlights that human activities have likely made extreme weather events, like heatwaves and droughts, more common. These compound events, where multiple extreme conditions occur simultaneously, have become more frequent on a global scale since the mid-20th century.

As the planet continues to warm, the intensity and frequency of extreme weather events are expected to increase. For example, with every additional 0.5°C rise in global temperatures, heatwaves become more intense and occur more often. Heatwaves not only bring unbearable heat but also worsen droughts, heightening the risks of wildfires, poor air quality from smoke, water shortages, power outages, and crop failures.

These consequences can cause significant harm to communities worldwide. If no further actions are taken, the global population will be increasingly exposed to heatwaves as global temperatures continue to rise, with vulnerable groups facing the most severe health impacts due to heat-related illnesses and deaths.

Research also shows how El Niño, a natural climate phenomenon, influences heatwaves in countries like India. During El Niño years, the delay in the start of the Indian Summer Monsoon and weaker winds in the Arabian Sea often lead to more frequent and intense heatwaves.

Forecasts of Soaring Temperature

As per IMD maximum temperatures across India suggest that above-normal temperatures are likely during the hot weather season, particularly in most parts of the country. However, some areas in eastern and northeastern India, as well as pockets in northwest India, are expected to experience normal to below-normal maximum temperatures (Figure 1).

The forecast for the number of heatwave days across the country during the April to June 2025 season indicates that above-normal heatwave days are likely in most parts of South Peninsula, Central India, East India, and the plains of Northwest India.

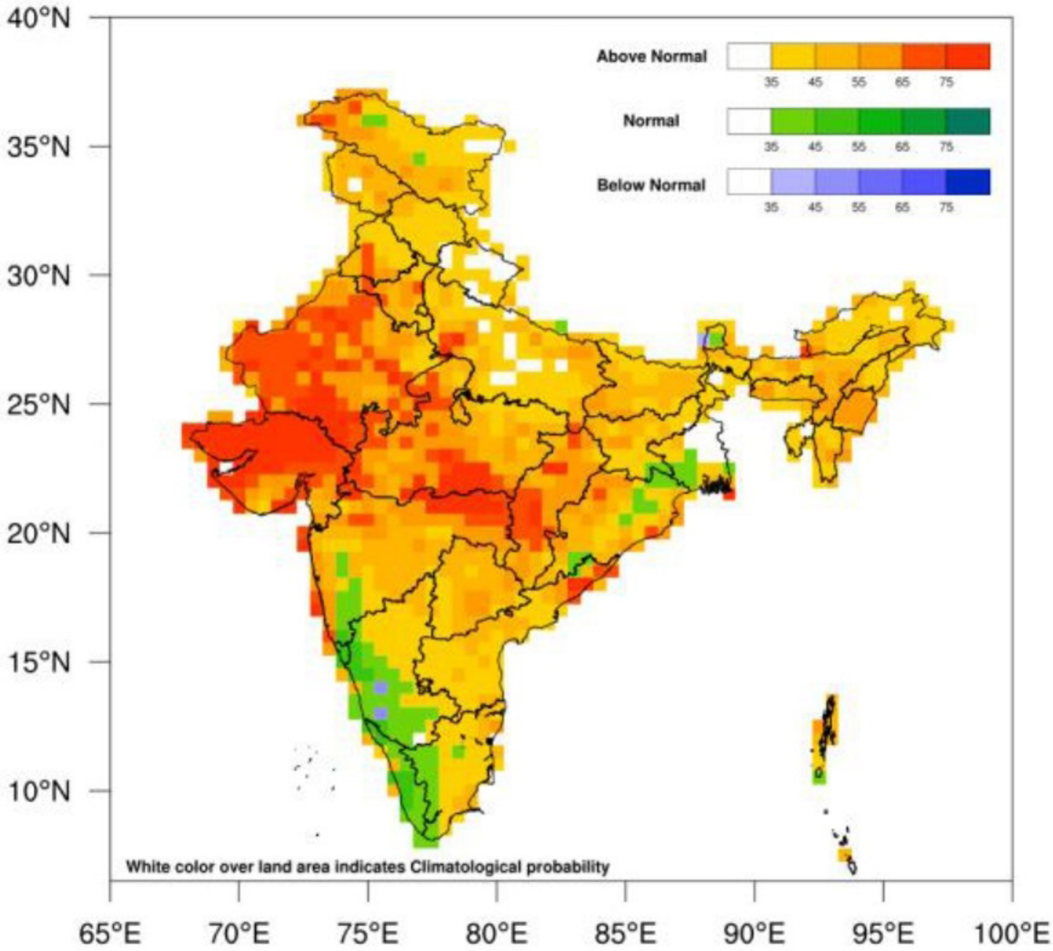


Figure 1: *Probability Forecast of Maximum Temperature for April to June 2025.*
Source: IMD

The anomaly of heat wave duration (in days) over India during the April–June (AMJ) season of 2025, as derived from IMD data, reveals notable spatial variability. Positive anomalies (shaded in red) represent regions with above-normal heat wave durations, while negative anomalies (in blue) indicate durations below the climatological mean.

Substantial positive anomalies, reaching up to 8 days, are observed over central, eastern, and parts of northwestern India, particularly across Telangana, Madhya Pradesh, Odisha, and Bihar. In contrast, localized negative anomalies are evident over regions such as Gujarat and coastal Andhra Pradesh. These patterns collectively suggest a widespread intensification of heat wave conditions over large parts of the country during the pre-monsoon season of 2025 as shown in Figure 2.

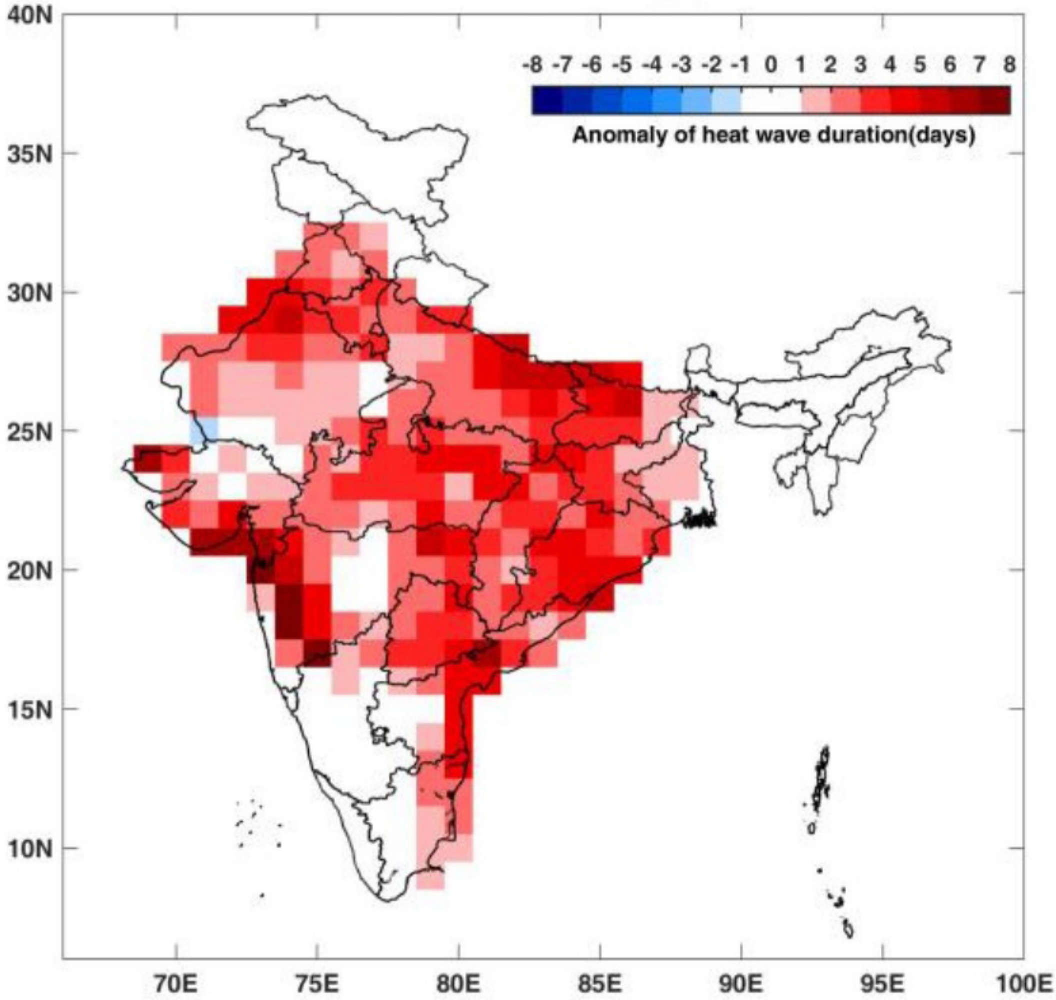


Figure 2: *Anomaly of Heat Wave Duration (in days) for the season April to June (AMJ) 2025. Source: IMD*

Indian Meteorological Department Criteria for Declaring Heat Wave in India

According to the India Meteorological Department (IMD), a heat wave is considered when the maximum temperature at a station reaches at least 40°C for plains regions and at least 30°C for hilly regions.

A temperature increase of 5 to 6°C above the standard temperature is considered a heat wave condition if the station's maximum temperature does not exceed 40°C.

A severe heat wave is defined as an increase in temperature of 7°C or more from the average.

In regions where the maximum temperature typically exceeds 40°C, an increase of 4 to 5°C above the standard is regarded as a heat wave condition. For such regions, an increase of 6°C or more is classified as a severe heat wave.

Additionally, a heat wave is declared if the actual maximum temperature reaches 45°C or more, irrespective of the normal maximum temperature for that region.

3. Heatwave Impacts in India

These "silent disasters" often develop gradually but have severe consequences for both human and animal welfare. The increasing frequency of heatwaves in India aligns with the global trend of rising temperatures.

A 2022 study by the University of Cambridge, published in PLOS Climate, highlighted that climate change-induced heatwaves have significantly increased the vulnerability of around 90% of the Indian population to public health crises, food shortages, and higher mortality rates.

The study also pointed out a critical gap in India's national Climate Vulnerability Indicator (CVI), the absence of a specific indicator for heatwave risk. This omission results in an underestimation of the true impact of heatwaves, hindering efforts to identify the most vulnerable regions, including major urban areas like Delhi, and to implement effective Heat Action Plans at the state level (Debnath et al., 2023).

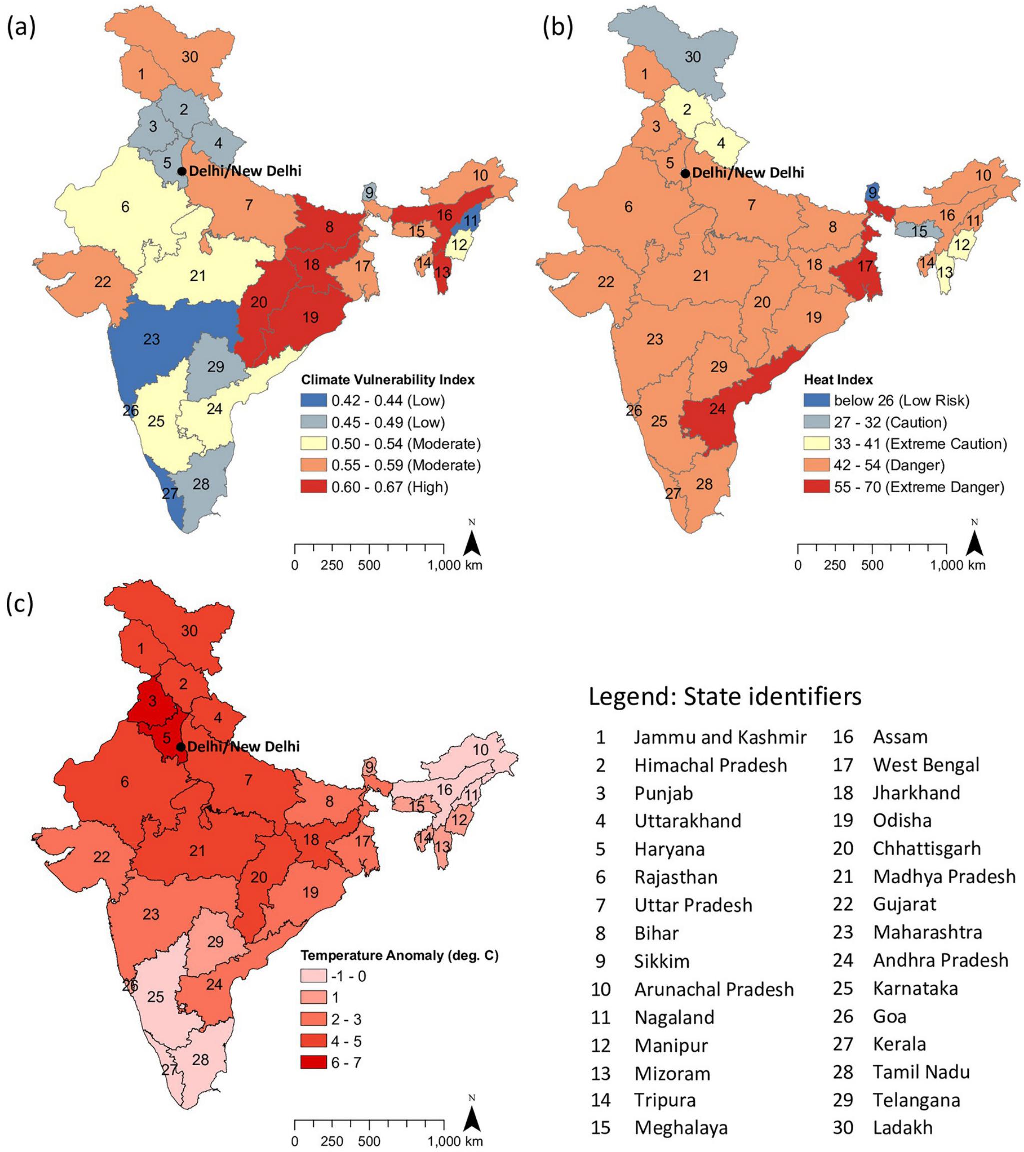


Figure 3: *India's Climate Vulnerability Index (CVI) and Heat Index (HI) estimation. (A) CVI illustrated as Low, Moderate and High levels across states.; (B) Estimated heatwave impact (HI) in April 2022, (C) Temperature anomaly caused in India due to heatwaves in April 2022. (source: (Debnath et al., 2023)).*

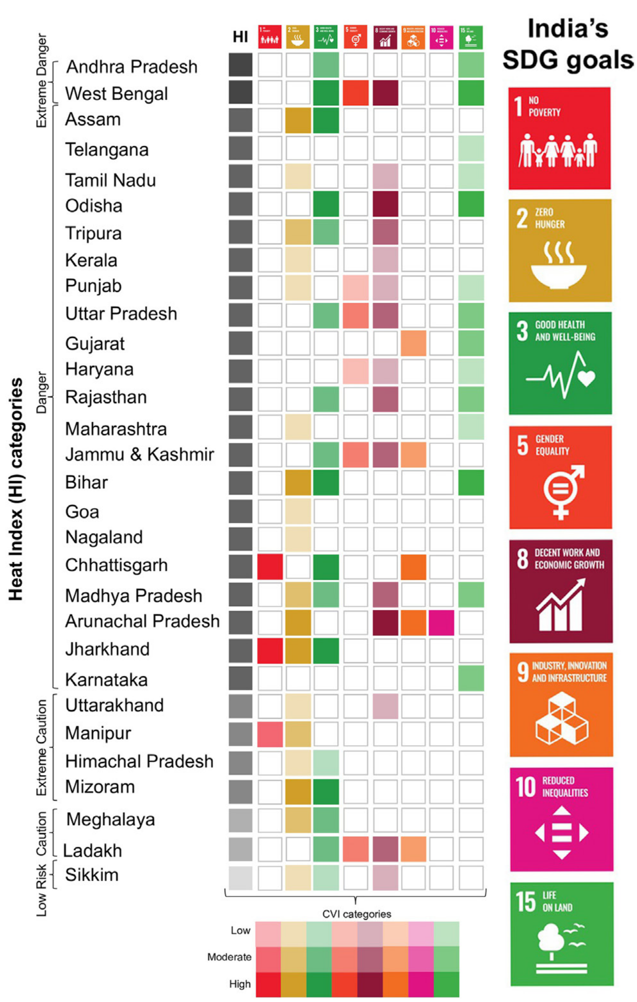
Health impacts: India also witnessed a **34 percent rise** in deaths due to heat waves between 2003-2012 and 2013-2022, **according to IMD data**.

Economic losses: Up to **4.5% of India's GDP** could be at risk by 2030 due to lost labour hours from extreme heat and humidity conditions. This translates to potential losses of around **$250 billion, according to a 2020 McKinsey study**. A report by the **Climate Vulnerability Monitor** indicates that India suffered an income loss of **5.4% of GDP** due to the heatwave in 2021

Labour productivity loss: According to the **Climate Transparency Report 2022**, in 2021, **Indians lost 167.2 billion potential labour hours** due to heat exposure with income losses equivalent to about 5.4% of the national GDP.

Impact on livestock: In March 2022, a **study published in Lancet** estimated that increasing temperatures could reduce milk production in India's arid and semi-arid regions by **25 per cent** by the end century in 2085.

Rising Heatwaves Pose Barrier to India's SDG Goals



Moreover, the study suggested that this gap in the CVI could obstruct India's progress in achieving several Sustainable Development Goals (SDGs), including SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-Being), SDG 5 (Gender Equality), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure), SDG 10 (Reduced Inequalities), and SDG 15 (Life on Land).

Projections indicate that by 2050, more than 300 million Indians could be affected by heatwaves, with nearly 600 million experiencing a diminished quality of life by 2100, further underscoring the need for comprehensive, targeted interventions (Debnath et al., 2023).

Figure 4: *The Heat Index (HI) identifies more of India's vulnerabilities than the Climate Vulnerability Index (CVI). The y-axis represents the state-wise HI categories (extreme danger, danger, extreme caution, caution and low risk). The x-axis represents the state-wise CVI categories per UN SDGs. States with blank CVI scores for corresponding SDGs are due to missing data (source: (Debnath et al., 2023)).*

The growing intensity and frequency of heatwaves are also contributing to increased energy demand, particularly for cooling. As temperatures rise, the reliance on air conditioning and other cooling methods intensifies, leading to greater strain on energy infrastructure. This surge in demand places significant pressure on power grids, often resulting in supply shortages, blackouts, and rising energy prices, thus exacerbating the socio-economic impacts of heatwaves.

Key Highlights From Jharkhand

590 heatwave days recorded in Jharkhand over 35 years (1990–2024).

May accounts for the highest number of heatwave days (275), followed by April (183) and June (132).

300% increase in annual heatwave frequency observed from 1990 to 2024.

Heatwaves are increasing at a rate of +0.13 days/year, showing significant intensification.

Mean summer temperature (Apr–Jun) increased by 0.017°C/year, totaling a 7.69% rise over the study period.

2024 saw the highest intensity with 21 heatwave days, up from just 2 days in 2020.

Western & central districts like Garhwa (1,188 days) and Palamu (993 days) recorded the highest heatwave occurrences.

Eastern districts like Godda and Sahibganj reported the lowest heatwave days (87-297).

Dry westerlies and poor moisture retention in lateritic soils fuel intense heating in western Jharkhand.

4. Trend Analysis of Extreme Heat & Heatwaves in Jharkhand:

Jharkhand has witnessed a significant rise in extreme heat events over the past three and a half decades, with heatwaves becoming more frequent and intense between 1990 and 2024. Although Jharkhand was officially carved out of Bihar in the year 2000, this analysis considers the geographical extent of present-day Jharkhand throughout the entire 35-year period. The state experienced a total of 590 heatwave days between 1990 and 2024, out of which 431 days occurred during the 25-year period from 2000 to 2024, reflecting a sharp rise in recent decades. A clear seasonal concentration of heatwave events is observed, with May contributing the highest number (275 days), followed by April (183 days) and June (132 days). This seasonal clustering is consistent with the regional climatology, where pre-monsoon months typically experience high solar insolation, low humidity, and suppressed convective activity-factors conducive to extreme heating of land surfaces.

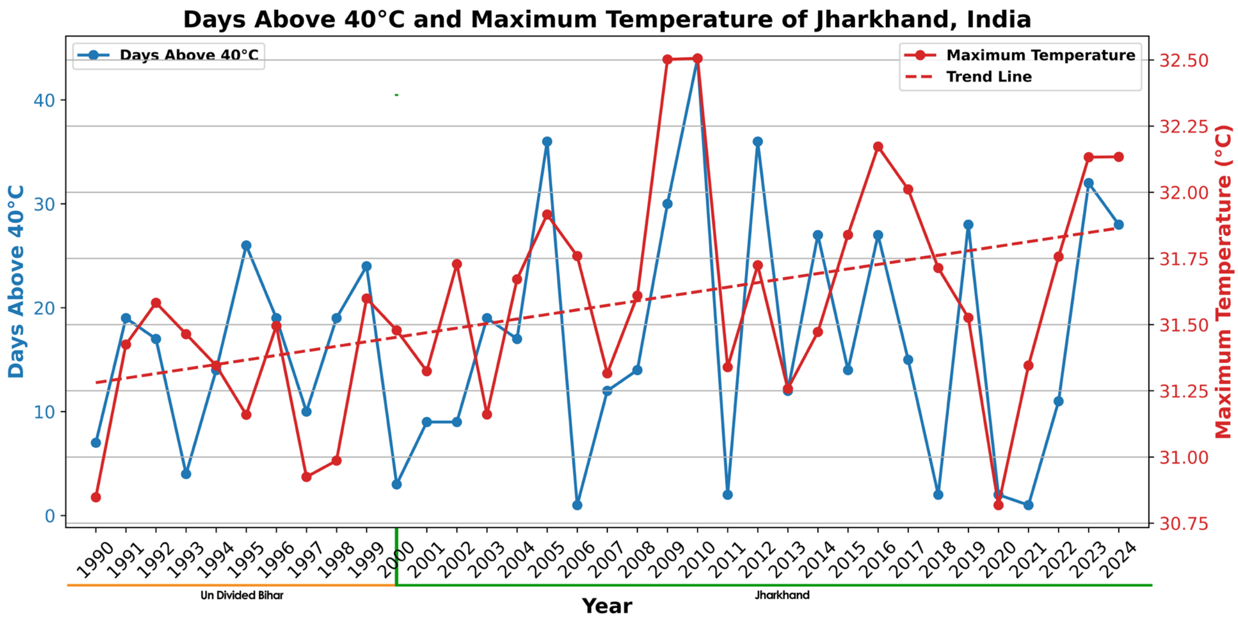


Figure 5: *Yearly mean temperature trend and number of heatwaves from 1990 to 2024 over Jharkhand. Data Source: IMD*

A trend analysis of annual heat wave days reveals a 300% increase in frequency from 1990 to 2024, indicating a statistically significant intensification of extreme temperature events. The estimated linear trend slope suggests an annual increase of 0.13 heat wave days per year (Figure 5).

Although Jharkhand was officially separated from Bihar in the year 2000, this assessment considers the geographical extent of present-day Jharkhand for the entire study period to ensure spatial consistency. Mean summer temperatures (April–June) within this boundary show an upward trend of 0.017°C per year, amounting to an overall 7.69% temperature rise over the 35-year period (Figure 6). This reflects a warming rate slightly higher than global averages, emphasizing regional climate sensitivity.

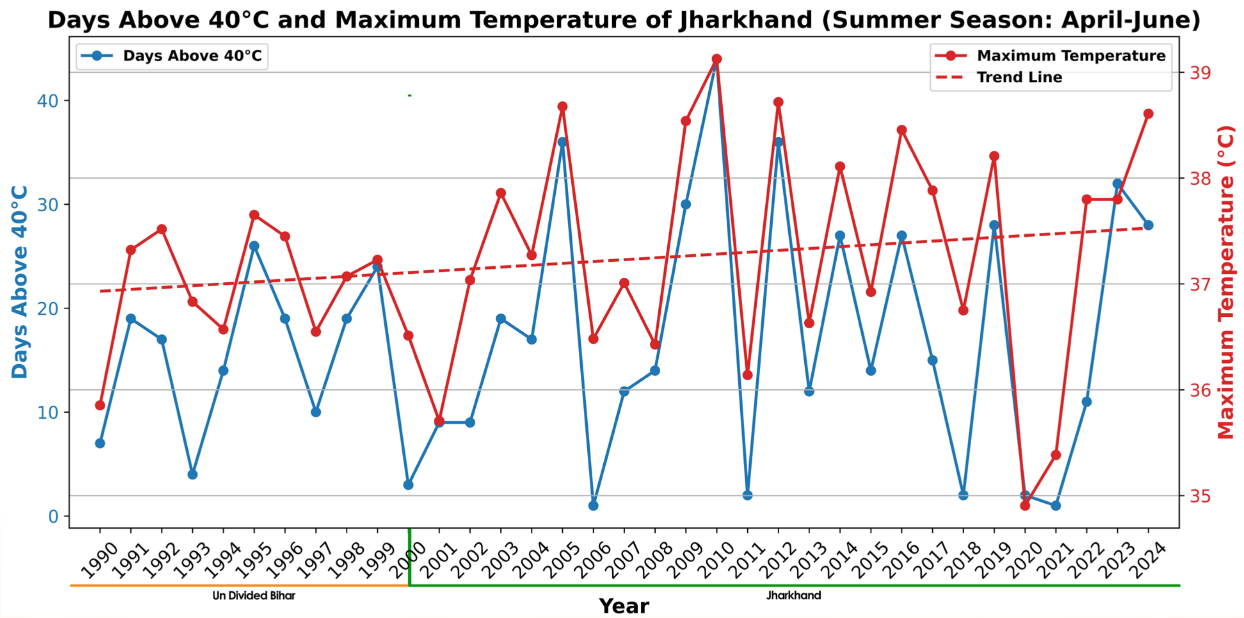


Figure 6: *April, May and June (Summer Season) mean Yearly temperature trend and number of heatwaves from 1990 to 2024 over Jharkhand. Data Source: Indian Meteorological Department*

Heat Wave Frequency and Intensity from 2020 to 2024

A clear escalation in the frequency and intensity of heat waves from 2020 to 2024. In 2020, heat waves were minimal, with only two days in late May exceeding significant temperature thresholds. However, each subsequent year saw an increase in both the number and severity of heat waves. By 2022, there were seven notable heat wave events in April and May, with temperatures frequently surpassing previous years' peaks.

This trend intensified in 2023, with twelve prolonged periods of extreme heat, particularly in the summer months. The year 2024 marked the most severe activity, with twenty-one days of sustained high temperatures from April to June, indicating a sharp rise in heat wave frequency and intensity over the five-year period (Figure 7).

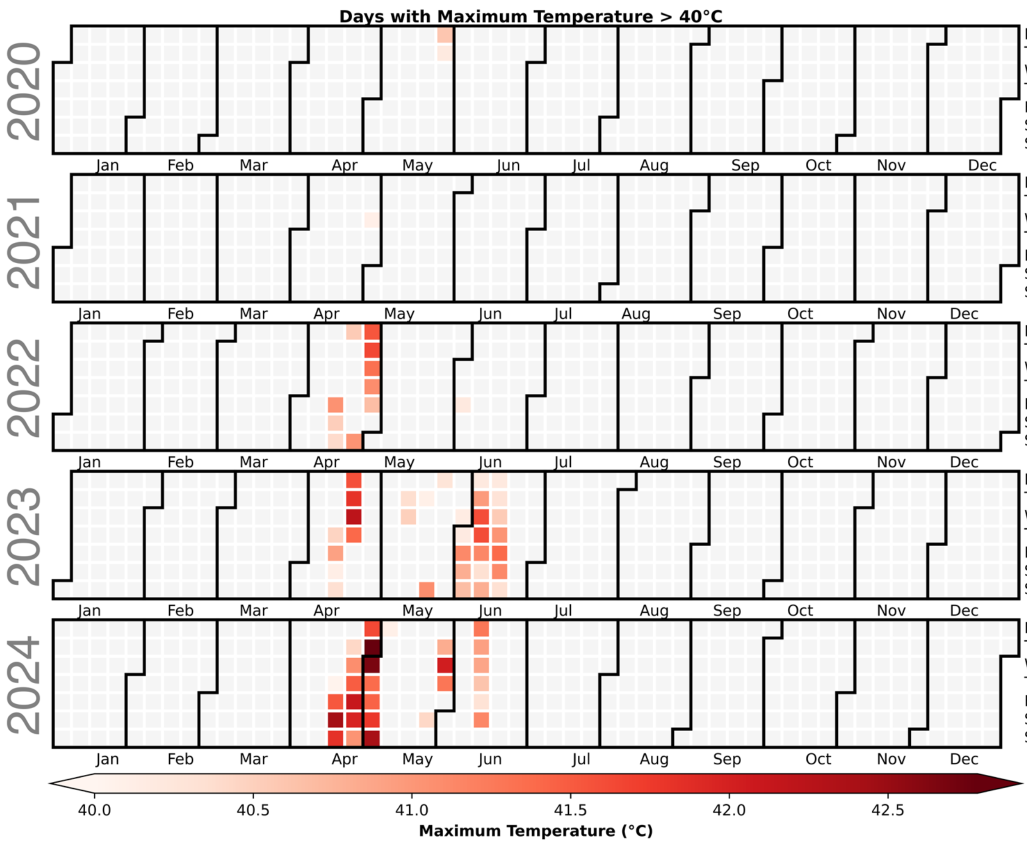


Figure 7: *Daily Maximum Temperature from 2020 to 2024 over Jharkhand.*
Data Source: Indian Meteorological Department

5. Regional Heatwave Trend in Jharkhand

Western and central districts of Jharkhand - including **Garhwa**, **Palamu**, **Latehar**, and **Simdega** - have consistently reported the highest frequencies of heatwave occurrences over the past 35 years, based on spatially averaged IMD gridded maximum temperature data. Among them, **Garhwa** recorded the highest number of heatwave days at 1,188, averaging approximately 34 days per year, followed by **Palamu** with 993 days (29 days/year), **Latehar** with 935 days (27 days/year), and **Simdega** with 827 days (24 days/year)[1].

These regions are predominantly characterized by rocky terrain, lateritic soils, and sparse moisture retention capacity, which contribute to rapid surface heating. Their western inland location exposes them to hot, dry westerly winds from central and northwestern India during pre-monsoon months, intensifying daytime temperatures. The continental climatic setting of this zone far from moderating influences like large water bodies results in greater diurnal temperature variation and prolonged periods of high heat.

In contrast, **Godda** and **Sahibganj** recorded the lowest number of heat wave days (87 days each), likely due to their proximity to the Santhal Pargana plateau and the Rajmahal Hills, which are marked by undulating terrain and elevated landforms.

These physical features contribute to more efficient convective cooling and wind circulation, thereby reducing the accumulation of heat near the surface. Their location in the eastern part of the state also ensures earlier onset and stronger influence of the humid southwesterly monsoon winds, which bring in moisture-laden air and help lower ambient temperatures during peak summer months.

The intensification of heat waves in Jharkhand aligns with broader climate change patterns observed across South Asia. IPCC reports have highlighted that the frequency and duration of heatwaves are expected to increase under continued greenhouse gas emissions scenarios.

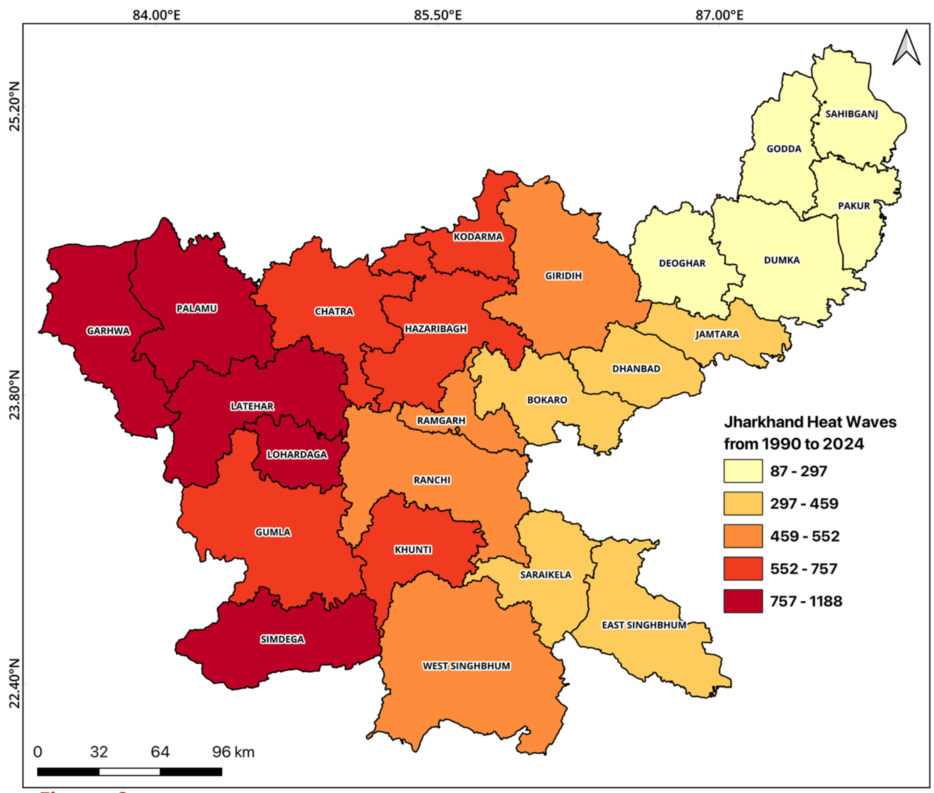


Figure 8: *District-Wise Number of heat waves from 1990 to 2024 in Jharkhand, India.*
Data Source: Indian Meteorological Department

[1] *Figures are based on daily IMD gridded maximum temperature data, spatially averaged over each district boundary using the standard IMD heatwave definition.*

Probable Causes:

Inland Location: Jharkhand lacks the moderating effect of sea breezes due to its distance from big bodies of water, which results in extended dryness and decreased moisture.

Tropic of Cancer: As Jharkhand is situated along the Tropic of Cancer, there is a lot of solar insolation, or sunlight that strikes the ground almost exactly perpendicularly, raising

The Chhota Nagpur Plateau: This Plateau acts as a heat absorber, trapping and enhancing surface heat, and it encompasses a significant portion of the state.

Mining and Deforestation: The region's natural ability to regulate temperature is weakened by extensive mining operations and deforestation, which increases heat accumulation.

Urbanization and Pollution: As cities get more populated and polluted, they become urban heat islands, where heat-absorbing surfaces and pollutants raise the temperature much higher than in rural areas.

6. Best Practices: Mitigating Heatwaves

Heat wave mitigation measures are essential to reduce the health, economic, and environmental impacts of extreme heat, especially in urban and vulnerable rural settings. These measures are generally categorized into short-term (emergency response) and long-term (planning and policy) strategies. Below is a summary of key mitigation measures along with relevant case examples from India.

1. Heat Action Plans (HAPs): Strategic frameworks developed to reduce heat-related mortality and morbidity through early warning systems, public awareness, and capacity building.

Case Example: Ahmedabad Heat Action Plan (India, 2013)

India's first HAP developed after the deadly 2010 heat wave that killed over 1,300 people.

Components included: early warning system, inter-agency coordination, public outreach, and training for healthcare professionals.

Resulted in a 25–40% drop in heat-related mortality over subsequent years.

2.Water Security Measure: Ensuring availability of drinking water at public places, especially for marginalized communities, and restoring water bodies.

Case Example: Churu District (Rajasthan)

Extreme heat-prone area with proactive tanker-based water supply to rural hamlets during summer months.

"Jal Mitra" Water Stations- Setting up temporary shade shelters with drinking water points in bus stands, markets, Road junctions etc.

3.Urban Greening & Nature-Based Solutions: Planting trees, developing green spaces, urban forests, and restoring water bodies to reduce urban heat island effect. heat-related mortality and morbidity through early warning systems, public awareness, and capacity building.

Case Example: Delhi's City of Trees Campaign

Massive tree plantation along roads and parks.

Provided shade and lowered ambient temperatures in the locality.

4.Cool Roofs and Reflective Surfaces: Applying reflective materials or white paint on rooftops to reduce indoor temperatures.

Case Example: Hyderabad Cool Roof Program (2021)

Aimed at installing cool roofs in low-income settlements.

Indoor temperature reduction by 2–5°C.

Mandatory cool roofs for government buildings from 2023.

5.Temporary Shading Structures: Installing temporary tents and shading umbrellas at major traffic intersections.

Case Example: Bhubaneswar, Odisha

The Commissionerate Police of Bhubaneswar-Cuttack, in collaboration with Odisha State Disaster Management Authority (OSDMA) and corporate sponsors, installed temporary tents and shading umbrellas at major traffic intersections.

UV-resistant fabric canopies.

Provision of drinking water bottles and ORS sachets at intersections.

Implemented in 50+ high-traffic locations across Bhubaneswar and Cuttack.

6.Health System Preparedness: Training health professionals, stocking oral rehydration solutions (ORS), and setting up cooling wards.

Case Example: Nagpur Heat Preparedness Program

Health professionals trained on heatstroke symptoms and treatment.

Cooling wards established in primary hospitals.

7. Everyday Action to Minimise Heatwaves

Water Conservation: Implement water-saving techniques at home, such as fixing leaks, using water-efficient fixtures, and collecting rainwater for gardening.

Home Insulation: Improve home insulation to reduce the need for air conditioning. This can involve using reflective materials on roofs or planting trees around the house for natural cooling.

Energy Conservation: Reduce energy use by turning off lights and appliances when not in use, and opt for energy-efficient appliances. Lowering energy consumption reduces the heat generated by power plants.

Reflective Materials: Use light-colored or reflective materials for rooftops and pavements to reduce heat absorption.

Cool Spaces: Create and promote the use of cool spaces in homes and communities, such as shaded areas, parks, and community centers equipped with cooling systems.

Collaborative Efforts:

Community Workshops: Hosting workshops on sustainable living practices, heat wave preparedness, and the importance of urban greenery.

Partnerships: Collaborating with NGOs, businesses, and schools to organize joint activities and projects aimed at reducing heat wave impacts.

Innovation Challenges: Organizing competitions or challenges for innovative solutions to mitigate heat waves, such as new cooling technologies or community projects.

8. The Way forward

To effectively address the growing threat of heat waves in Jharkhand, it is essential to implement a comprehensive strategy that includes strengthening public awareness campaigns in local languages, enhancing health system preparedness with adequate resources and staff training, and improving urban planning through increased green spaces and reliable water and power supply.

Special attention should be given to protecting vulnerable groups such as outdoor workers, the elderly, and children by adjusting work hours, providing cooling shelters, and ensuring access to hydration.

Intra-state variability in heat wave exposure underscores the need for localized heat action plans, incorporating early warning systems, community awareness campaigns, and infrastructural interventions (e.g., cool roofs, shaded public spaces). Future studies may benefit from integrating satellite-derived land use dynamics, urban heat island (UHI) effects, and socio-economic vulnerability layers to develop a comprehensive risk assessment framework.

Regularly updating and enforcing local heat action plans, fostering collaboration among government, NGOs, and communities, and integrating lessons from recent heat events will be crucial for building long-term resilience and minimizing the health and economic impacts of extreme heat in the state.

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