**Down To Earth**

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# INDIA 2023

## AN ASSESSMENT OF EXTREME WEATHER EVENTS

JANUARY - SEPTEMBER

India saw extreme
weather events on **86%**
of the days in the first
nine months of the year

All **36** Indian states and
Union Territories experienced
extreme weather events

Extreme weather events have
killed **2,923** people, affected
**1.84** million hectares of crop area

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# INDIA
# 2023

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## EXTREME WEATHER EVENTS

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**Scan to access India's Atlas on Weather Disasters**

# EXECUTIVE SUMMARY

The UN Intergovernmental Panel on Climate Change defines extreme weather events as occurrences that are "rare at a particular place and time of year". While India does not have an official definition, the India Meteorological Department (IMD), in its annual "Statement on Climate of India" reports, classifies lightning and thunderstorms, heavy to very, and extremely heavy rainfall, landslides and floods, coldwaves, heatwaves, cyclones, snowfall, dust and sandstorms, squalls, hailstorms and gales as extreme weather events. The agency defines each of these weather events on its website, "Climate Hazards and Vulnerability Atlas of India", launched in January 2022, and in other documents (see 'How IMD defines extreme weather events').

"India 2023: An assessment of extreme weather events", prepared by the Centre for Science and Environment and *Down To Earth* (CSE/DTE), attempts to build an evidence base on the frequency and expanding geography of extreme weather events in India. It has sourced its data on extreme events from two key government sources: IMD and the Disaster Management Division (DMD) of the Union Ministry of Home Affairs. In addition, it has scanned media reports to track the events—particularly in the pre-monsoon period when official data is inadequate. The media reports have also provided further information on the extent of loss and damage.

## SOURCE USED: INDIA METEOROLOGICAL DEPARTMENT

Information on extreme weather events in the past 24 hours and forecasts and warnings are published in IMD's All India Weather Summary and Forecast bulletins and daily press releases. CSE/DTE has downloaded each day's report from the IMD website and mapped out the events by state and Union Territory (UT), and by event type.

On loss and damage due to extreme weather events, IMD uses media reports and publishes the number of human deaths and livestock losses in its "Climate Summary for the Month". Till March 2023, the loss and damage data was provided state-wise. Starting in April, the IMD changed its reporting method to provide only the national loss and damage numbers. In June 2023, IMD did not provide the loss and damage numbers for the month.

## SOURCE USED: HOME MINISTRY'S DISASTER MANAGEMENT DIVISION

The department under the Union Ministry of Home Affairs issues a "Situation report regarding flood/Heavy rainfall in the country" as and when the event happens. It includes the forecast from IMD and the Central Water Commission (on floods). It also has a section on damages reported by the states/Union Territories in the past 24-hour period.

From June 23, 2023, the situation reports have provided the "Cumulative loss and damage data for the monsoon season". The cumulative datasheet provides information on human deaths during this period because of drowning, lightning, landslides and other reasons. It also provides information about the damage to houses, crops and livestock during this period in the affected states.

DMD needs to define the category "others" so that there is a better understanding of the reasons for the loss of human life.

The situation reports are primarily for floods, heavy rainfall and cyclones; India needs similar daily assessment for all weather-related disasters and the loss and damage they cause—given the frequency of these events.

One of the key indicators to establish the extent of damage is "people affected". It

# How IMD defines extreme weather events

### Lightning and storms

Lightning is an electrical discharge caused by imbalances between storm clouds and the ground or within the clouds themselves. Storms include duststorms (caused by thunderstorms or strong pressure gradients associated with cyclones which increase wind speed over a wide area), hailstorms (an outgrowth of a severe thunderstorm in which balls or irregularly shaped lumps of ice fall with the rain), thunderstorms and gales (a very strong wind).

### Heavy rains, floods and landslides

Heavy rainfall happens when a region receives 64.5-115.5 mm rain in 24 hours. In the case of very heavy rainfall, the threshold increases to 115.6-204.4 mm and in the case of extremely heavy rainfall it is 204.5 mm or more. The report has considered all very heavy and extremely heavy rainfall events, and heavy rainfall events only when they have caused damages.

### Heatwaves

Heatwave conditions signify a certain amount of rise in temperature at a given place with respect to the normal climatological value. The report has considered heatwaves (4.5°C to 6.4°C departure of the maximum temperature from normal), and severe heatwaves (departure of more than 6.4°C).

### Cold day/coldwave

Cold day conditions occur when the maximum temperature drops by 4.5°C to 6.4°C than average. If the deviation is more than 6.4°C, then it is considered severe cold day. Cold wave conditions occur when the minimum temperature drops by 4.5°C to 6.4°C than normal. Similarly, severe coldwave occurs when the minimum temperature drops by more than 6.4°C than normal. The report has considered all the four categories.

### Snowfall

Snowfall is a hydrological hazard where a large amount of snow can affect transport, crops and people. The "Annual Disaster Weather Report" by IMD reports the snowfall cases over India that caused human deaths. The report has considered only those snowfall events that caused deaths.

### Cloudbursts

Cloudburst is very heavy rainfall (100 mm per hour) over a localised area. It is accompanied with strong winds and lightning.

### Cyclones

Cyclones are intense vortex or whirls in the atmosphere with very strong winds circulating around them in anti-clockwise direction in the Northern Hemisphere and in clockwise direction in the Southern Hemisphere.

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is also a target under the Sendai Framework for Disaster Risk Reduction (target B-1), by the UN Office for Disaster Risk Reduction. While DMD's daily situation report provides information on this globally accepted parameter of population affected, it is not included in the cumulative loss and damage datasheet. DMD needs states to provide this data at the end of each weather disaster so that it can be included in the cumulative data that is issued for the monsoon period.

In addition, each state has its down disaster management authority (SDMA), which reports on the events on its websites. However, the data is at best sketchy and not released regularly. There are signs of change. During this flood season, Assam's SDMA released daily situation reports with details on the extent of loss and damage. But, in this CSE/DTE report, SDMA data has not been considered as it is not uniformly available for the country.

In the case of any discrepancy in the three sources—IMD, DMD and media reports—the source with the highest reported number has been considered. Also, as DMD does not provide data on crop area affected during the pre-monsoon period, CSE/DTE has sourced it from media reports (which are also used by IMD for compiling its loss and damage data).

### GAPS IN THE DATA

While a realistic estimate can be made about the number of days the country recorded extreme weather events from IMD releases, major gaps remain when it comes to loss and damage assessment. DMD provides data as received by the states and this is mainly for the monsoon season. It does not include all extreme events as defined by IMD. Moreover,

the data is not comprehensive. For instance, DMD data indicates that 831,269 hectares of crop area across 16 states and Union Territories (UTs) were affected between April and September 2023. Our database, which incorporates media reports, suggests that the actual area affected was 847,532.85 hectares, spread across at least 18 states and UTs. The absence of a robust public database on extreme weather events in the country poses difficulties in the evaluation of disaster situations and their impacts.

It is also clear that now, given the intensity and frequency of these events, the country no longer needs to count just the disasters; it needs credible numbers on the loss and damage.

### WHY THIS REPORT?
India recorded extreme weather events on 235 of the 273 days from January 1 to September 30, 2023. This means that in 86 per cent of the first nine months of this year, India had an extreme weather event breaking in one or more parts of the country. It also experienced record-breaking temperatures for several months, and regions across the country were deluged because of very heavy and extremely heavy rainfall. This led to floods and the loss of life and livestock. This speaks of the increased frequency and intensity of the extreme events that we are seeing in our rapidly warming world.

What the country has witnessed so far in 2023 is the new abnormal in a warming world. A 2020 report by the UN Office for Disaster Risk Reduction says globally, there has been "a sharp increase [in disasters] over the previous twenty years".

The CSE/DTE report is an attempt to build an evidence base on the frequency and expanding geography of extreme weather events in India. This is extremely important as currently fragmented data on extreme weather events is publicly available and fails to provide the overall picture. It provides season-wise, month-wise and region-wise analysis of extreme weather events and their associated loss and damage. Along with this report, DTE also maintains "India's Atlas on Weather Disasters", an open-access online public interactive database on extreme weather events that is updated every month.

### HIGHLIGHTS AND KEY FINDINGS
India has seen a disaster nearly every day in the first nine months of this year—from heat and cold waves, cyclones and lightning to heavy rain, floods and landslides. These disasters have claimed 2,923 human lives, affected 1.84 million hectares (ha) of crop area, destroyed over 80,563 houses and killed close to 92,519 livestock. This calculation of loss and damage is probably an underestimate as data for each event is not collated, nor are the losses of public property or crop calculated.

With an event every second day, Madhya Pradesh saw the highest number of days with extreme weather events; but Bihar saw the highest number of human deaths at 642, followed by Himachal Pradesh (365 deaths) and Uttar Pradesh (341 deaths).

Himachal Pradesh reported the highest number of damaged houses (15,407) and Punjab reported the highest number of animal deaths (63,649).

Madhya Pradesh has experienced an extreme weather event on 138 days since the beginning of 2023. Despite this, official records indicate no crop area damage. However, media reports suggest that at least 45,000 hectares of crop area were affected. This discrepancy could be due to gaps in loss and damage reporting.

While January remained slightly warmer than average (1981-2010), February exceeded all previous records to become the warmest in 122 years. Northwest India was especially hot, with a 2.78°C temperature anomaly above average (1981-2010). March was modestly warmer for India once again, however, the average minimum temperature

in Northwest India was 1.34ºC above usual. The country's mean temperature stayed near average in April and May, with the exception of the South Peninsula, which had the third highest average maximum temperature for April, with an anomaly of 0.77ºC. This June was the sixth warmest on record for the country, with the South Peninsula reporting its warmest June on record. In July, the country had its second-warmest minimum temperature in 122 years. August and September were again the warmest ever for the country.

India also recorded its sixth driest February and its driest ever August in 122 years. Meanwhile, March remained unusually wet for Central India and the South Peninsula, with the two regions receiving 206 per cent and 107 per cent of the long-term average (1971-2020) rainfall, respectively.

This is the watermark of climate change. It is not about the single event but about the increased frequency of the events—an extreme event we saw once every 100 years has now begun to occur every five years or less. Worse, it is now all coming together—each month is breaking a new record. This, in turn, is breaking the backs of the poorest, who are worst impacted and are fast losing their capacities to cope with these recurring and frequent events.

In terms of the "nature" of the event, all types of extreme weather have been seen in the past nine months—lightning and storms were reported in all 36 states and Union Territories and claimed 711 lives. Then, every day of the three months of monsoon—from June to August—shows heavy to very heavy and extremely heavy rainfall in some parts of the country. This is why the flood devastation has not sparred any region—in Himachal Pradesh, for instance, vast parts of the state were submerged and people lost lives, homes and sources of livelihood.

This is why the extreme weather report card is important to understand. It tells us of the number of such events; the fact that this will lead to cumulative and extensive damage. And that fact that we need systems to better account for the losses so that climate change and its impact have the human face of their victim.

It speaks of the need to do much more to manage these extreme events—we have to move beyond the management of the disaster to reducing risks and improving resilience. This is why we need more than words to improve the systems for flood management—deliberately building drainage and water recharge systems on the one hand and investing in green spaces and forests so that these sponges of water can be revitalised for the coming storms.

This also speaks of the need to demand reparations for the damage from the countries that have contributed to the emissions in the atmosphere and are responsible for this damage. The models that explain the impacts of climate change are clear that extreme weather events will increase in frequency and intensity. This is what we are seeing today. This report card is not good news. But it needs to be read so that we understand the revenge of nature that we are witnessing today and also understand that it will get worse tomorrow if we do not combat climate change at the scale that is needed.

# DISASTER A DAY

India experienced extreme weather events on 235 of the 273 days, or a little over 86% of the days from January 1 to September 30, 2023. These events claimed 2,923 human lives, affected 1.84 million hectares (ha) of crop area, damaged 80,563 houses and killed over 92,519 animals.

### Region-wise extreme weather events (January 1- September 30, 2023)

📅 Number of days  ☠ Human deaths  🌾 Affected crop area (ha)  🏠 Houses damaged (fully and partially)  🦌 Total animal deaths (big and small)

## Central region

It recorded extreme weather events on 198 of the 273 days, which claimed 755 human lives, damaged 141,123.65 ha of crop area, 24,070 houses, and killed 2,144 animals.

| | 📅 | ☠ | 🌾 | 🏠 | 🦌 |
|---|---|---|---|---|---|
| Madhya Pradesh | 138 | 249 | 45,000 | 2,626 | 376 |
| Maharashtra | 106 | 173 | 62,052 | 467 | 197 |
| Odisha | 89 | 61 | 15,576 | 3,651 | 29 |
| Chhattisgarh | 77 | 115 | 18,179.65 | 1,820 | 245 |
| Gujarat | 69 | 148 | 0 | 14,971 | 1,297 |
| Goa | 44 | 7 | 0 | 265 | 0 |
| DN&DD* | 1 | 2 | 316 | 270 | 0 |

*Dadra & Nagar Haveli and Daman & Diu
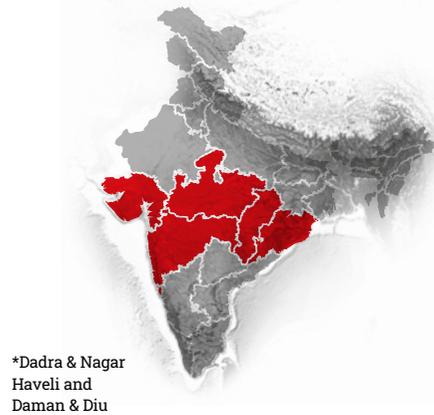
## South Peninsula region

It recorded extreme weather events on 143 of the 273 days, which claimed 232 human lives, damaged 93,077.43 ha of crop area, 20,035 houses and killed 1,053 animals.

| | 📅 | ☠ | 🌾 | 🏠 | 🦌 |
|---|---|---|---|---|---|
| Kerala | 67 | 60 | 9,463 | 2,066 | 0 |
| Telangana | 52 | 33 | 62,811.43 | 5,193 | 645 |
| Karnataka | 47 | 38 | 11,788 | 11,917 | 252 |
| Andhra Pradesh | 45 | 45 | 9,015 | 14 | 0 |
| Tamil Nadu | 29 | 56 | 0 | 836 | 156 |
| Puducherry | 26 | 0 | 0 | 9 | 0 |
| Andaman & Nicobar | 14 | 0 | 0 | 0 | 0 |
| Lakshwadeep | 1 | 0 | 0 | 0 | 0 |
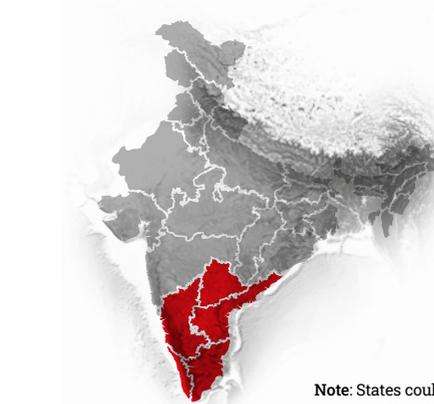
**Note**: States could not be ascertained for 74 human deaths. Cropped area worth 478,000 ha were damaged across Uttar Pradesh, Rajasthan and Madhya Pradesh. As state-wise break-up is not available, these figures are added to the total but not reflected in the region-wise break-up.

## Northwest region

It recorded extreme weather events on 204 of the 273 days, which claimed 1,080 human lives, damaged 1,074,868.02 ha crop area, 31,478 houses and killed 88,906 animals.

| | 📅 | ☠ | 🌾 | 🏠 | 🦌 |
|---|---|---|---|---|---|
| Uttar Pradesh | 113 | 341 | 0 | 1,231 | 0 |
| Himachal Pradesh | 112 | 365 | 75,760 | 15,407 | 21,025 |
| Punjab | 102 | 79 | 348,554 | 6,578 | 63,649 |
| Uttarakhand | 94 | 104 | 44,882 | 3,120 | 1,121 |
| Rajasthan | 89 | 80 | 42,165 | 362 | 119 |
| Haryana | 53 | 48 | 563,507 | 4,686 | 2,982 |
| Jammu and Kashmir | 38 | 38 | 0 | 83 | 0 |
| Delhi | 24 | 18 | 0 | 11 | 10 |
| Chandigarh | 14 | 0 | 0 | 0 | 0 |
| Ladakh | 10 | 7 | 0 | 0 | 0 |
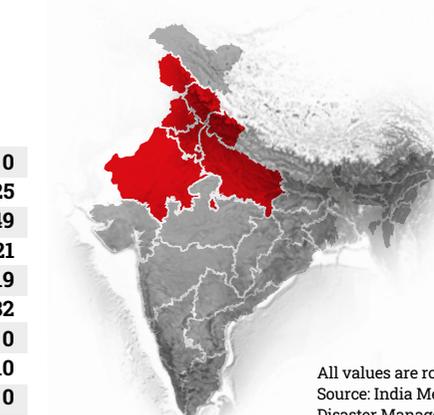
All values are rounded off to nearest two decimal
Source: India Meteorological Department, Pune, Disaster Management Division under the Union Ministry of Home Affairs and media reports

📅 Number of days  ☻ Human deaths  🌾 Affected crop area (ha)  🏠 Houses damaged (fully and partially)  🦌 Total animal deaths (big and small)

## East and Northeast region

It recorded extreme weather events on 180 of the 273 days, which claimed 782 human lives, damaged 48,317 ha crop area, 4,980 houses and killed 231 animals.

| | 📅 | ☻ | 🌾 | 🏠 | 🦌 |
|---|---|---|---|---|---|
| Assam | 102 | 51 | 48,029 | 1,633 | 159 |
| Sikkim | 88 | 8 | 8 | 390 | 56 |
| West Bengal | 86 | 14 | 0 | 0 | 0 |
| Bihar | 81 | 642 | 0 | 250 | 0 |
| Meghalaya | 58 | 7 | 111 | 215 | 0 |
| Arunachal Pradesh | 45 | 5 | 9 | 93 | 11 |
| Jharkhand | 44 | 23 | 0 | 0 | 0 |
| Tripura | 30 | 18 | 0 | 266 | 0 |
| Nagaland | 19 | 11 | 105 | 1,927 | 5 |
| Mizoram | 10 | 3 | 55 | 206 | 0 |
| Manipur | 6 | 0 | 0 | 0 | 0 |

## Day-wise extreme weather events in India

(January 1 - September 30, 2023)
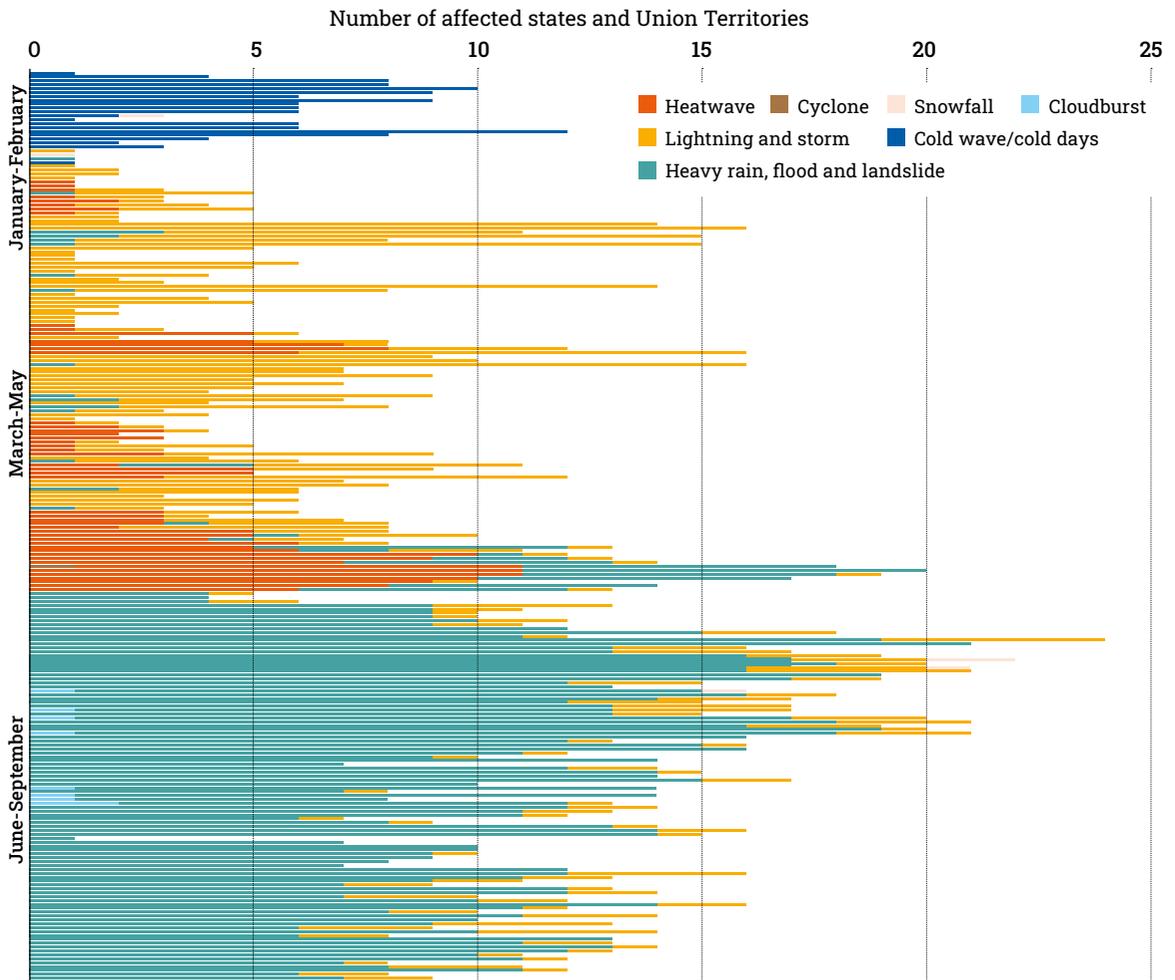
Number of affected states and Union Territories

Legend:
- Heatwave
- Cyclone
- Snowfall
- Cloudburst
- Lightning and storm
- Cold wave/cold days
- Heavy rain, flood and landslide

(Rows grouped by period: January-February, March-May, June-September)

All values are rounded off to nearest two decimal points

Source: India Meteorological Department, Pune, Disaster Management Division under the Union Ministry of Home Affairs and media reports

# SEASON-WISE

# WINTER

**January - February 2023**
**59 Days**

While January experienced mildly warmer temperatures than average (1981-2010), February remained extremely hot with daytime and mean temperatures 1.86ºC and 1.36ºC warmer than average, respectively. The two months also remained drier than usual with an average rainfall deficit of 13 per cent in January and 68 per cent in February.

The country experienced an extreme weather event on 28 of 59 days in the winter months of 2023. The events were spread across 21 states/ Union Territories.

Punjab and Haryana were the worst hit as they experienced extreme weather events on 15 days. They were followed by Uttar Pradesh and Bihar which experienced extreme weather events on 14 days.

# INDIA 2023
## JANUARY

### TEMPERATURE

January was marginally warmer than usual. The day temperature was 0.19ºC above the average (1981-2010), night temperature was 0.38ºC above the average and mean temperature was 0.29ºC above the average for the country as a whole. East and Northeast India was 0.94ºC warmer than average in January 2023.

**In 2023, South Peninsula recorded its 8th hottest day temperature in January since 1901**

■ Average maximum/day temperature      ■ Mean temperature
■ Average minimum/night temperature      **00** Anomaly from 1981-2010 average

All figures in ºC

| | India | Northwest | East & Northeast | Central | South Peninsula |
|---|---|---|---|---|---|
| Average maximum/day | 25.79 | 17.53 | 24.23 | 27.6 | 30.59 |
| Average minimum/night | 14.07 | 5.9 | 10.64 | 13.97 | 20.85 |
| Mean | 19.93 | 11.71 | 17.44 | 20.78 | 25.72 |
| Anomaly (max) | 0.19 | -0.8 | 1.19 | -0.2 | 0.59 |
| Anomaly (min) | 0.38 | 0.28 | 0.68 | 0.41 | 0.27 |
| Anomaly (mean) | 0.29 | -0.26 | 0.94 | 0.1 | 0.43 |

### RAINFALL

India experienced a dry January (14.8 mm) this year, with rainfall levels 13 per cent lower than the Long Period Average (1971-2020). Rainfall over East and Northeast region (1.9 mm) was fourth lowest since 1901 (89 per cent deficit rainfall). Northwest was the only region that remained wetter than average.

**In 2023, East and Northeast India experienced the fourth driest January in 122 years**
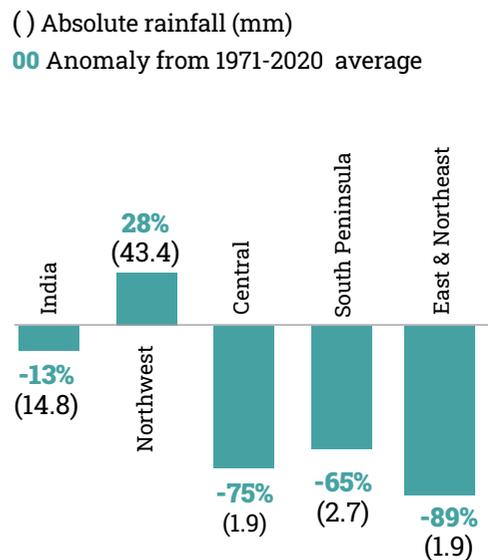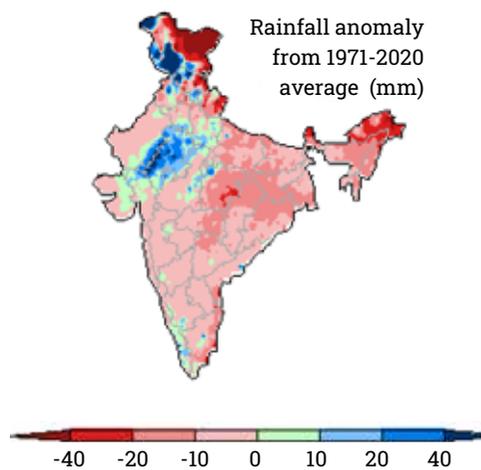
Rainfall anomaly from 1971-2020 average (mm)

-40  -20  -10  0  10  20  40

Source: India Meteorological Department, Pune

( ) Absolute rainfall (mm)
**00** Anomaly from 1971-2020 average

| Region | Anomaly | Absolute rainfall (mm) |
|---|---|---|
| India | -13% | (14.8) |
| Northwest | 28% | (43.4) |
| Central | -75% | (1.9) |
| South Peninsula | -65% | (2.7) |
| East & Northeast | -89% | (1.9) |

## EXTREME WEATHER EVENTS

India experienced extreme weather events on 22 out of 31 days in January. These were spread across 18 states/UTs. Punjab and Haryana were the worst hit with extreme weather events on 15 days of the month.

State-wise number of days with extreme weather events



0  6  12  18  24  30

### NUMBER OF STATES/UTS THAT EXPERIENCED EXTREME WEATHER EVENTS EACH DAY

January 2023

| | |
|---|---|
| 01 | 1 |
| 02 | 4 |
| 03 | 8 |
| 04 | 8 |
| 05 | 10 |
| 06 | 9 |
| 07 | 6 |
| 08 | 9 |
| 09 | 6 |
| 10 | 6 |
| 11 | 6 |
| 12 | 2  1 |
| 13 | 1 |
| 14 | 6 |
| 15 | 6 |
| 16 | 12 |
| 17 | 8 |
| 18 | 4 |
| 19 | |
| 20 | |
| 21 | |
| 22 | |
| 23 | |
| 24 | |
| 25 | |
| 26 | |
| 27 | 2 |
| 28 | 3 |
| 29 | 1 |
| 30 | 1 |
| 31 | |

■ Cold wave/ cold day **(20 days)**   ■ Snowfall **(2 days)**   ■ Lightning and storms **(1 day)**
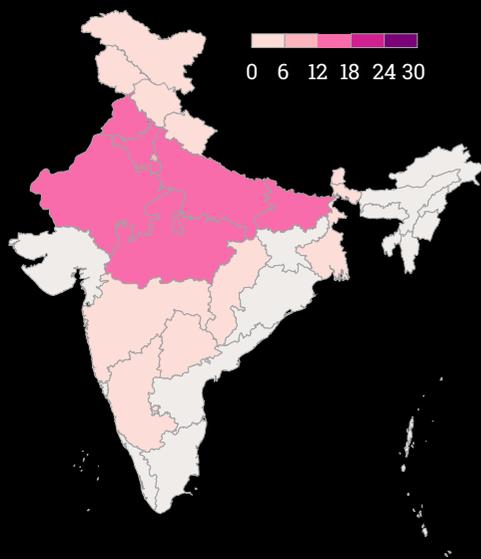
## LOSS AND DAMAGE

**8**

people died due to extreme events in January, in Uttar Pradesh (4), Jammu & Kashmir (2) and Ladakh (2)

**389,127 hectares**

of crop area affected, in Haryana (347,117 ha), Rajasthan (42,000 ha) and Punjab (10 ha)

All values are rounded off to nearest two decimal points
Source: India Meteorological Department, Pune, Disaster Management Division under the Union Ministry of Home Affairs and media reports
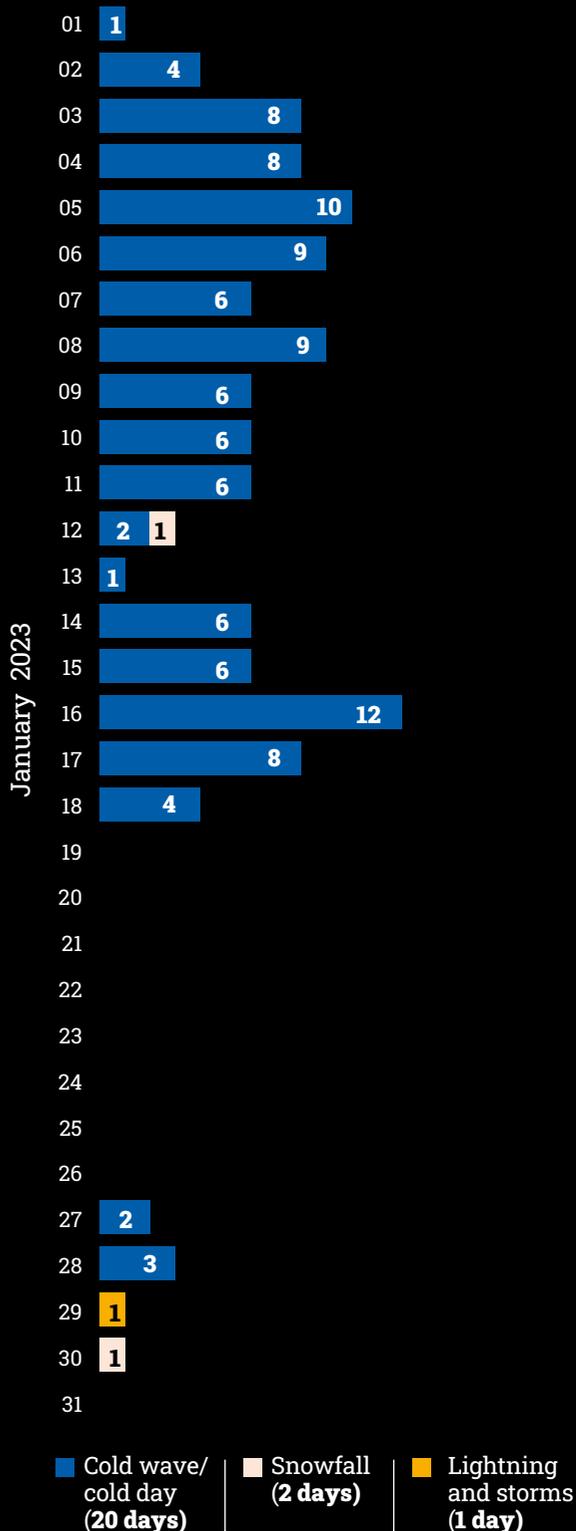
## TEMPERATURE

India endured its second hottest February on record, with the mean temperature soaring 1.36°C above the average (1981-2010). The year also witnessed the hottest ever day temperature for the month, with the mercury rising to an uncomfortable 1.86°C above average.

**In 2023, India saw its hottest day temperature for February in 122 years**

■ Average maximum/day temperature     ■ Mean temperature
■ Average minimum/night temperature    00 Anomaly from 1981-2010 average

All figures in ºC

| | India | Northwest | East & Northeast | Central | South Peninsula |
|---|---|---|---|---|---|
| Max | 29.66 | 25.04 | 27.52 | 32.04 | 32.04 |
| Min | 16.37 | 10.16 | 14.04 | 16.13 | 21.49 |
| Mean | 23.01 | 17.6 | 20.78 | 24.08 | 26.76 |
| Anomaly Max | 1.86 | 3.58 | 1.51 | 2.16 | 0.68 |
| Anomaly Min | 0.87 | 1.99 | 1.72 | 0.49 | -0.01 |
| Anomaly Mean | 1.36 | 2.78 | 1.62 | 1.32 | 0.34 |
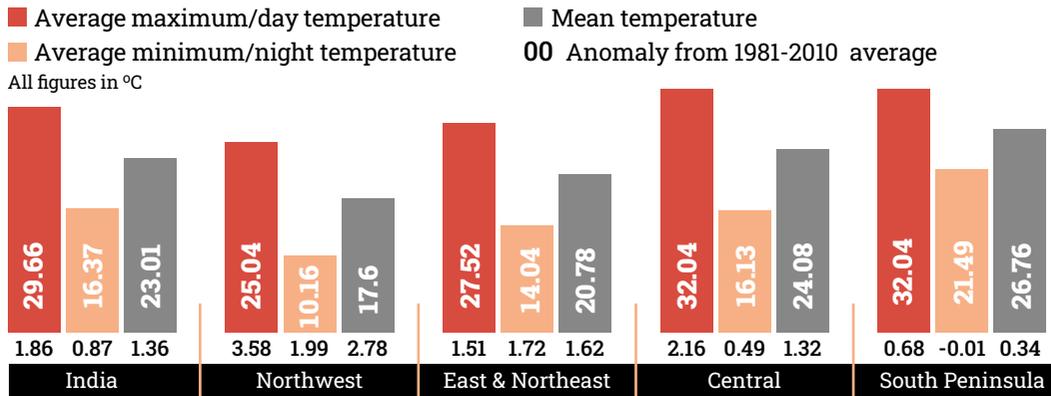
## RAINFALL

India experienced a remarkably dry February, with overall rainfall plummeting 68 per cent below the Long Period Average (1971-2020) of 22.7 mm. This made it the sixth driest February since 1901. Central India bore the brunt of the dryness, recording an unprecedented 99 per cent deficit, the worst in 122 years. Northwest India, South Peninsula, and East and Northeast India also suffered significant rainfall shortfalls, with deficits of 76 per cent, 54 per cent, and 35 per cent, respectively.

**In 2023, Central India experienced its driest February in 122 years**
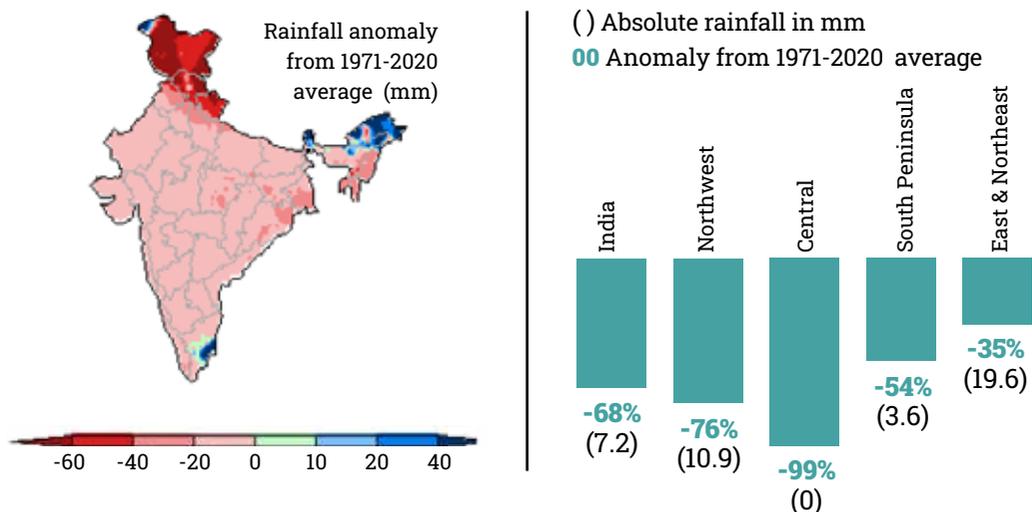
Rainfall anomaly from 1971-2020 average (mm)

( ) Absolute rainfall in mm
00 Anomaly from 1971-2020 average

-60  -40  -20  0  10  20  40

| India | Northwest | Central | South Peninsula | East & Northeast |
|---|---|---|---|---|
| -68% (7.2) | -76% (10.9) | -99% (0) | -54% (3.6) | -35% (19.6) |

Source: India Meteorological Department, Pune

## EXTREME WEATHER EVENTS

India experienced extreme weather events on 6 out of 28 days in February. These were spread across six states/UTs. Himachal Pradesh and Uttarakhand were the worst hit with extreme weather events on two days in the month.

State-wise number of days with extreme weather events

0 6 12 18 24 30

**NUMBER OF STATES/UTS THAT EXPERIENCED EXTREME WEATHER EVENTS EACH DAY**

01  **1**

02

03

04  **1**

05

06

07

08  **1**

09

10

11  **2**

12

13

February 2023

14

15

16

17

18

19

20

21  **2**

22

23

24

25

26

27

28  **1**

### LOSS AND DAMAGE

**0**

No deaths due to extreme weather events were recorded across India

**0**

No crop area loss was recorded across India

■ Lightning and storms **(4 days)**

■ Cold wave/ cold day **(1 day)**

■ Heavy rains, floods and landslides **(1 day)**

All values are rounded off to nearest two decimal points

Source: India Meteorological Department, Pune, Disaster Management Division under the Union Ministry of Home Affairs and media reports

# PRE MONSOON

**March-May 2023**
**92 Days**

While the season recorded near normal temperatures, there were substantial regional aberrations. At the same time, rainfall remained on the higher side along with unusually high incidence of lightning and storms, particularly hailstorms, spread across almost the entire country.

India experienced extreme weather events on 85 out of 92 days. The events were spread across 33 states/UTs. Lightning and storms were reported on 79 days, heatwaves on 28 days, followed by heavy rains, floods and landslides on 16 days.

Maharashtra was the worst hit with extreme weather events on 41 days. It was followed by Rajasthan (33 days).

## TEMPERATURE

March commenced with unusually warm days, and saw temperatures soaring over 2°C above the normal on nine of the first 15 days. The narrative shifted dramatically following thunderstorms that brought the average day temperature for the month to a marginal 0.13°C above normal.

**In 2023, Northwest India recorded its 9th hottest night temperature for March in 122 years**

■ Average maximum/day temperature　　■ Mean temperature
■ Average minimum/night temperature　　**00** Anomaly from 1981-2010 average

All figures in °C

| | India | | | Northwest | | | East & Northeast | | | Central | | | South Peninsula | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Max/Mean | 31.37 | 19.46 | 25.41 | 27.36 | 14.07 | 20.71 | 30.16 | 17.47 | 23.81 | 33.21 | 20.12 | 26.67 | 33.29 | 23.34 | 28.32 |
| Anomaly | 0.13 | 0.59 | 0.36 | 0.54 | 1.34 | 0.94 | -0.05 | 0.89 | 0.42 | -0.37 | 0.5 | 0.07 | 0.21 | 0.004 | 0.11 |
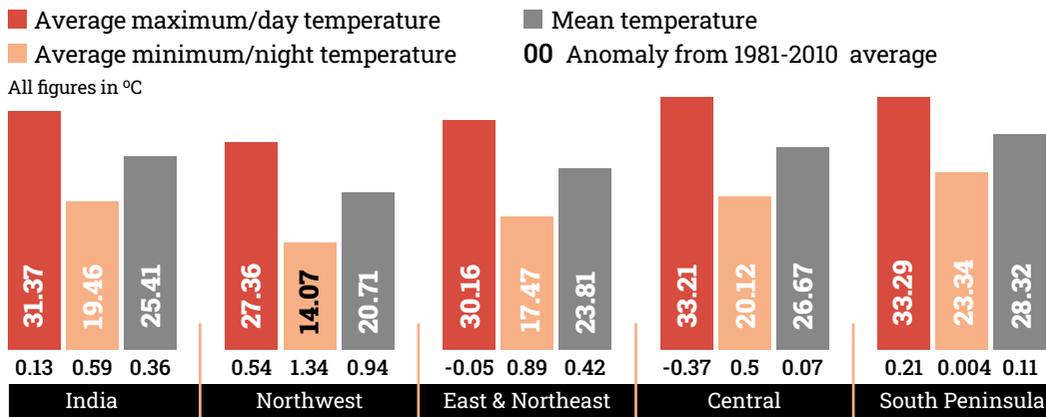
## RAINFALL

Central India and South Peninsula experienced unusually wet March this year, with surplus rainfall of 206 per cent and 107 per cent, respectively. These aberrations pushed the overall rainfall for the country to a surplus of 26 per cent, compared to the Long Period Average (1971-2020) of 29.9 mm.

**In 2023, South Peninsula saw its 7th wettest March in 122 years**
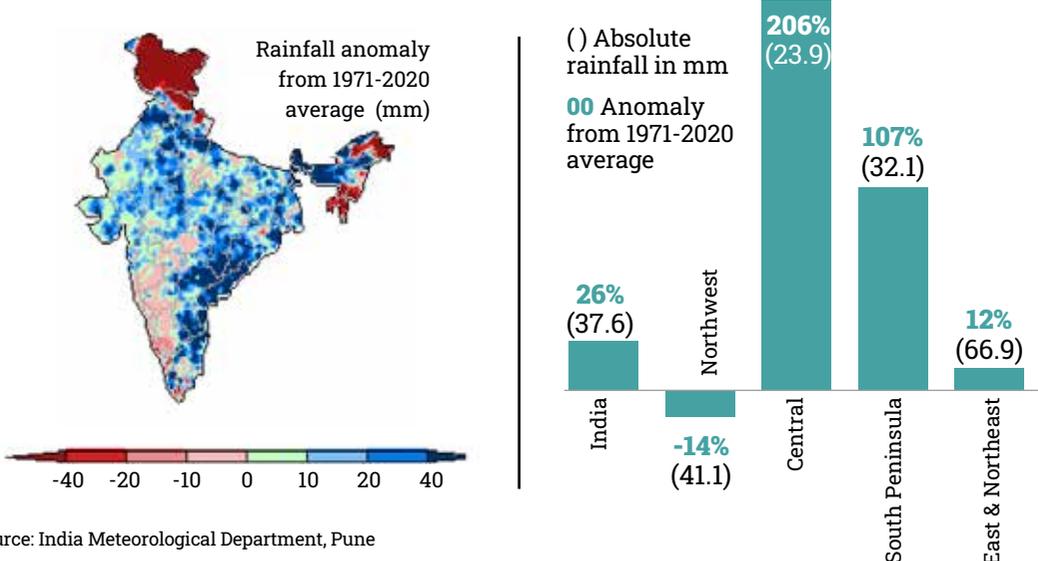
Rainfall anomaly from 1971-2020 average (mm)

-40  -20  -10  0  10  20  40

( ) Absolute rainfall in mm

**00** Anomaly from 1971-2020 average

India: **26%** (37.6)
Northwest: **-14%** (41.1)
Central: **206%** (23.9)
South Peninsula: **107%** (32.1)
East & Northeast: **12%** (66.9)

Source: India Meteorological Department, Pune

## EXTREME WEATHER EVENTS

India experienced extreme weather events on 28 out of 31 days in March. These were spread across 33 states/UTs. Uttarakhand was the worst hit with extreme weather events on 11 days in the month, followed by Rajasthan (10 days). Lightning and storms were recorded on 26 days in the month.

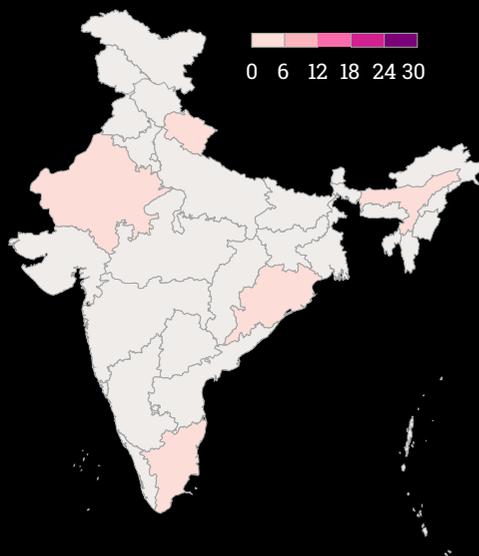State-wise number of days with extreme weather events

0  6  12  18  24  30

### NUMBER OF STATES/UTS THAT EXPERIENCED EXTREME WEATHER EVENTS EACH DAY

March 2023

| Day | Heatwave | Heavy rains, floods and landslides | Lightning and storms |
|---|---|---|---|
| 01 | | | |
| 02 | | | |
| 03 | 1 | | |
| 04 | 1 | | |
| 05 | 1 | | 2 |
| 06 | | 1 | 4 |
| 07 | | | |
| 08 | 1 | | 2 |
| 09 | 2 | | 1 |
| 10 | 1 | | 3 |
| 11 | 2 | | 3 |
| 12 | 1 | | 1 |
| 13 | | | 2 |
| 14 | | | 2 |
| 15 | | | 14 |
| 16 | | | 16 |
| 17 | | 3 | 8 |
| 18 | | 2 | 13 |
| 19 | | 1 | 7 |
| 20 | | 1 | 14 |
| 21 | | | 5 |
| 22 | | | 1 |
| 23 | | | 1 |
| 24 | | | 1 |
| 25 | | | 6 |
| 26 | | | 5 |
| 27 | | | 1 |
| 28 | | 1 | 3 |
| 29 | | | 2 |
| 30 | | | 3 |
| 31 | | | 14 |

■ Heatwave **(8 days)**  ■ Heavy rains, floods and landslides **(6 days)**  ■ Lightning and storms **(26 days)**

### LOSS AND DAMAGE

# 125
people died due to extreme weather events with Madhya Pradesh (42), Bihar (24) and Chhattisgarh (15) accounting for 65% of the deaths

# 598,726.25 hectares
of crop area affected on the back of unusually high hailstorm events across the country

All values are rounded off to nearest two decimal points
Source: India Meteorological Department, Pune, Disaster Management Division under the Union Ministry of Home Affairs and media reports
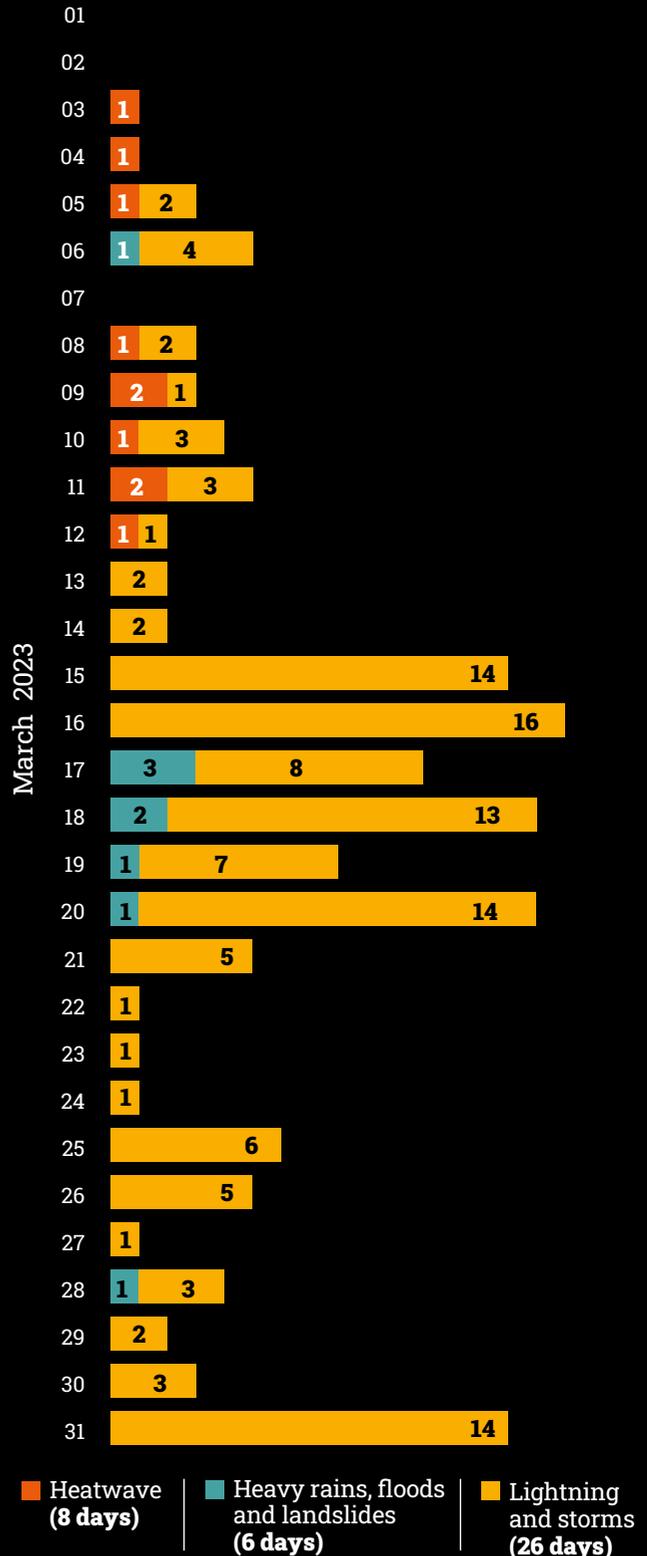
## TEMPERATURE

April remained close to average (1981-2010) this year, but saw substantial daily aberrations. On seven days, the day temperature varied by more than 2°C, and on three days, it was 2°C below normal.

**In April 2023, South Peninsula saw its 7th warmest day temperature in 122 years**

■ Average maximum/day temperature     ■ Mean temperature
■ Average minimum/night temperature     00 Anomaly from 1981-2010 average

All figures in °C

| | India | Northwest | East & Northeast | Central | South Peninsula |
|---|---|---|---|---|---|
| Max | 34.19 | 31.73 | 33.5 | 35.83 | 35.03 |
| Min | 22.08 | 17.2 | 20.64 | 22.96 | 25.28 |
| Mean | 28.14 | 24.46 | 27.07 | 29.39 | 30.15 |
| Anomaly Max | 0.26 | -0.82 | 1.5 | -0.47 | 0.77 |
| Anomaly Min | -0.07 | -0.49 | 0.5 | -0.36 | 0.094 |
| Anomaly Mean | 0.1 | -0.65 | 1 | -0.41 | 0.43 |
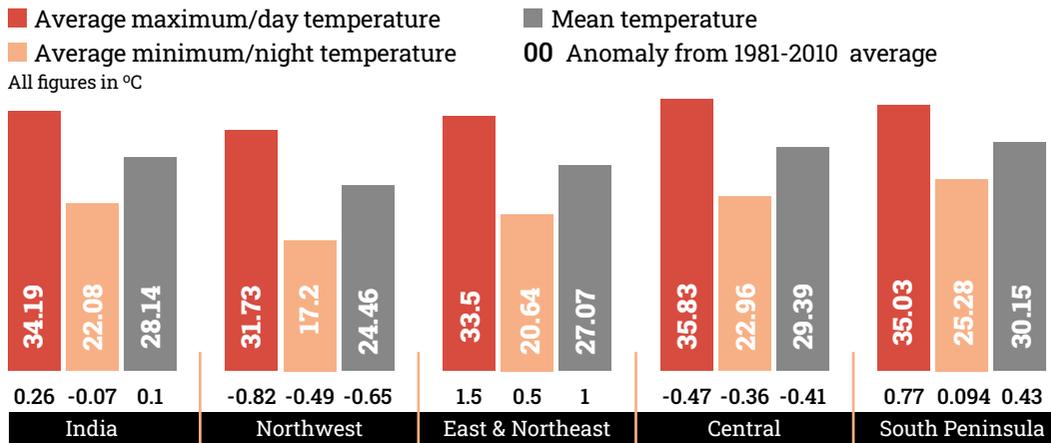
## RAINFALL

India April rainfall was slightly above the Long Period Average (1971-2020), though there was substantial regional variation. While Northwest India, Central India and South Peninsula received a surplus rainfall, East and Northeast India experienced 48 per cent deficit rainfall.

**In 2023, Central India experienced its 4th wettest April in 122 years**
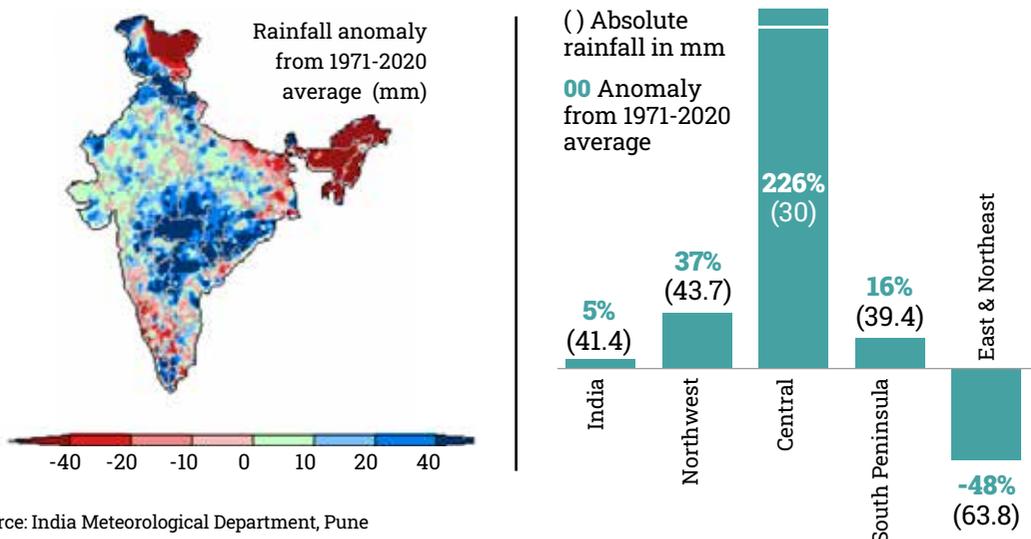


Rainfall anomaly from 1971-2020 average (mm)

-40   -20   -10   0   10   20   40

( ) Absolute rainfall in mm

00 Anomaly from 1971-2020 average

| India | Northwest | Central | South Peninsula | East & Northeast |
|---|---|---|---|---|
| 5% (41.4) | 37% (43.7) | 226% (30) | 16% (39.4) | -48% (63.8) |

Source: India Meteorological Department, Pune

## EXTREME WEATHER EVENTS

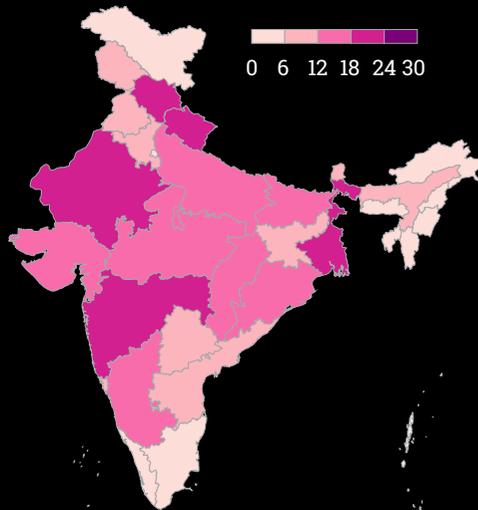India experienced extreme weather events on 28 out of 30 days in April. These were spread across 30 states/ UTs. Maharashtra experienced lightning and storms on 20 days in the month, followed by Odisha (14 days), and West Bengal and Himachal Pradesh (13 days each).

State-wise number of days with extreme weather events



0  6  12  18  24  30

**NUMBER OF STATES/UTS THAT EXPERIENCED EXTREME WEATHER EVENTS EACH DAY**

April 2023

| Day | Heatwave | Heavy rains, floods and landslides | Lightning and storms |
|-----|----------|-----------------------------------|----------------------|
| 01 | | 1 | 7 |
| 02 | | 1 | |
| 03 | | | 4 |
| 04 | | | 5 |
| 05 | | | 2 |
| 06 | | | |
| 07 | | | 1 |
| 08 | | | 2 |
| 09 | | | |
| 10 | | | 1 |
| 11 | | | 1 |
| 12 | 1 | | |
| 13 | 1 | | 2 |
| 14 | 5 | | 1 |
| 15 | | | 2 |
| 16 | 5 | | 3 |
| 17 | 7 | | 1 |
| 18 | 8 | | 4 |
| 19 | 6 | | 10 |
| 20 | | | 9 |
| 21 | | | 10 |
| 22 | | 1 | 15 |
| 23 | | | 7 |
| 24 | | | 7 |
| 25 | | | 9 |
| 26 | | | 5 |
| 27 | | | 7 |
| 28 | | | 5 |
| 29 | | | 4 |
| 30 | | 1 | 8 |

**Heatwave (7 days)** · **Heavy rains, floods and landslides (3 days)** · **Lightning and storms (27 days)**

## LOSS AND DAMAGE

### 100
people died due to extreme events in April

### 2,336.85 hectares
crop area affected across Telangana (2,023.43 ha), Maharashtra ( 312 ha) and Punjab (1.42 ha)
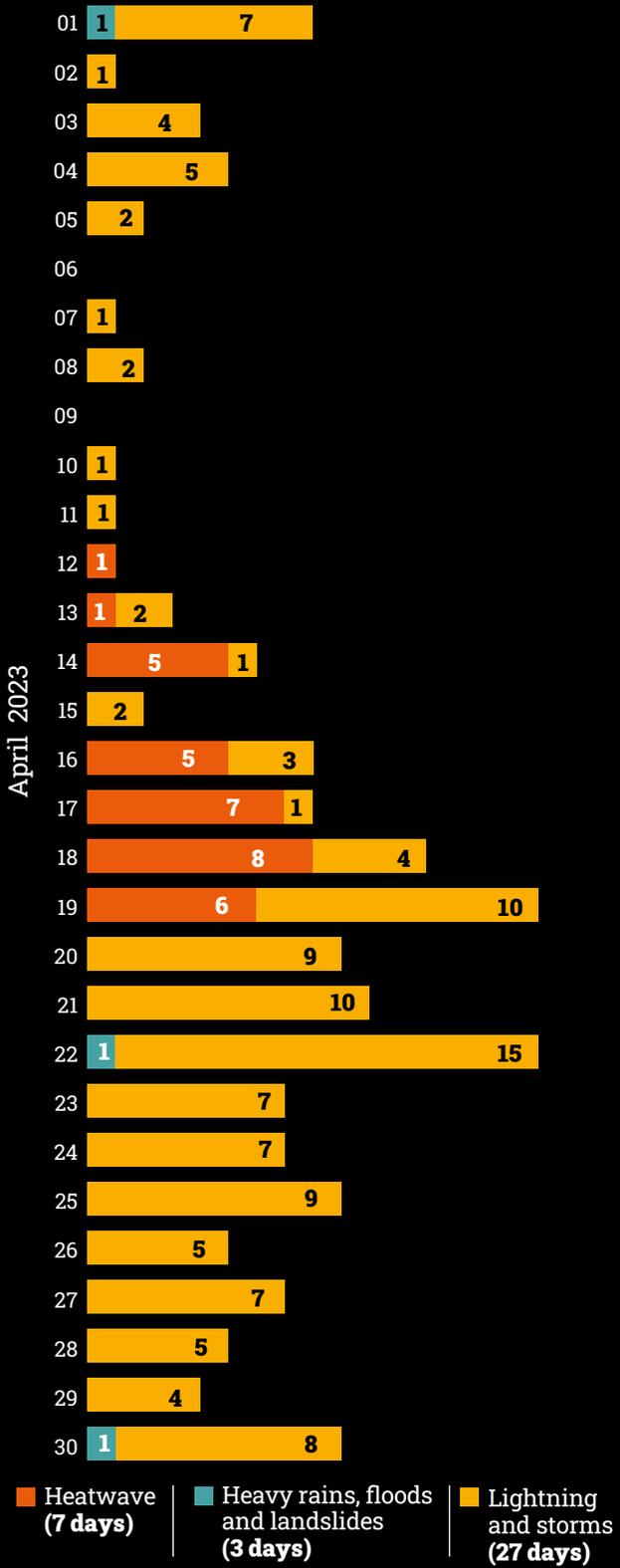
### TEMPERATURE

May 2023 remained cooler than average (1981-2010), with the night temperature almost half a degree below average. This resulted in subdued heatwave conditions across the country.

**In 2023, Central India experienced sixth coldest night temperature for May in 122 years**

■ Average maximum/day temperature   ■ Mean temperature
■ Average minimum/night temperature  **00** Anomaly from 1981-2010 average

All figures in °C



| | India | Northwest | East & Northeast | Central | South Peninsula |
|---|---|---|---|---|---|
| Max | 35.03 | 33.53 | 34.33 | 37 | 35.03 |
| Min | 23.92 | 20.09 | 22.61 | 25.2 | 26.12 |
| Mean | 29.47 | 26.81 | 28.47 | 31.1 | 30.58 |
| Anomaly Max | -0.14 | -2.06 | 1.3 | -0.43 | 0.58 |
| Anomaly Min | -0.4 | -1.37 | -0.03 | -0.74 | 0.241 |
| Anomaly Mean | -0.27 | -1.71 | 0.63 | -0.58 | 0.41 |
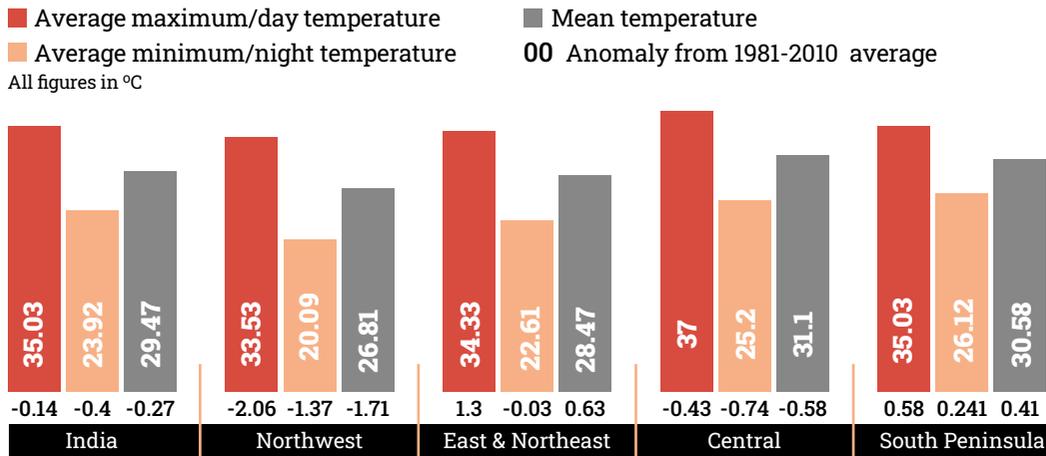
### RAINFALL

India's rainfall in May was slightly higher than the Long Period Average (1971-2020), but regional variations were observed. Three regions—Northwest India, Central India, and South Peninsula—received surplus rainfall, while East and Northeast India received a deficit of 41 per cent.

**In 2023, Northwest India experienced its 3rd wettest May in 122 years**
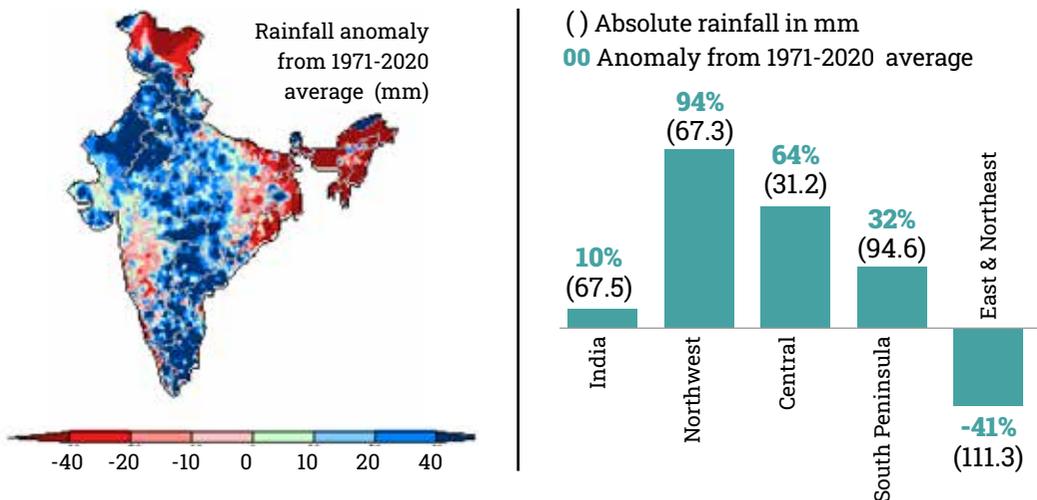


Rainfall anomaly from 1971-2020 average (mm)

( ) Absolute rainfall in mm
**00** Anomaly from 1971-2020 average

India **10%** (67.5)
Northwest **94%** (67.3)
Central **64%** (31.2)
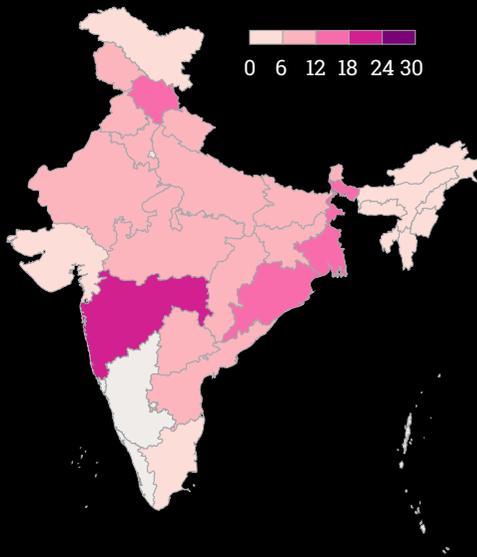South Peninsula **32%** (94.6)
East & Northeast **-41%** (111.3)

Source: India Meteorological Department, Pune

## EXTREME WEATHER EVENTS

India experienced extreme weather events on 29 out of 31 days in May. These were spread across 27 states/UTs. Rajasthan experienced heavy rainfall, floods and landslides on 16 days. Madhya Pradesh recorded extreme weather events on 14 days, followed by Maharashtra (12 days).

State-wise number of days with extreme weather events



0  6  12  18  24  30
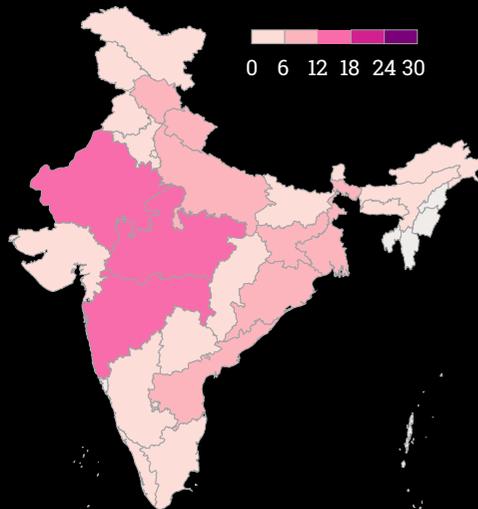
### LOSS AND DAMAGE

**96**
people died due to extreme events. Rajasthan (15), Jharkhand (14) and Gujarat (9) accounted for almost 40% of these deaths

**35,617** **hectares**
of crop area affected in Uttarakhand

**NUMBER OF STATES/UTS THAT EXPERIENCED EXTREME WEATHER EVENTS EACH DAY**
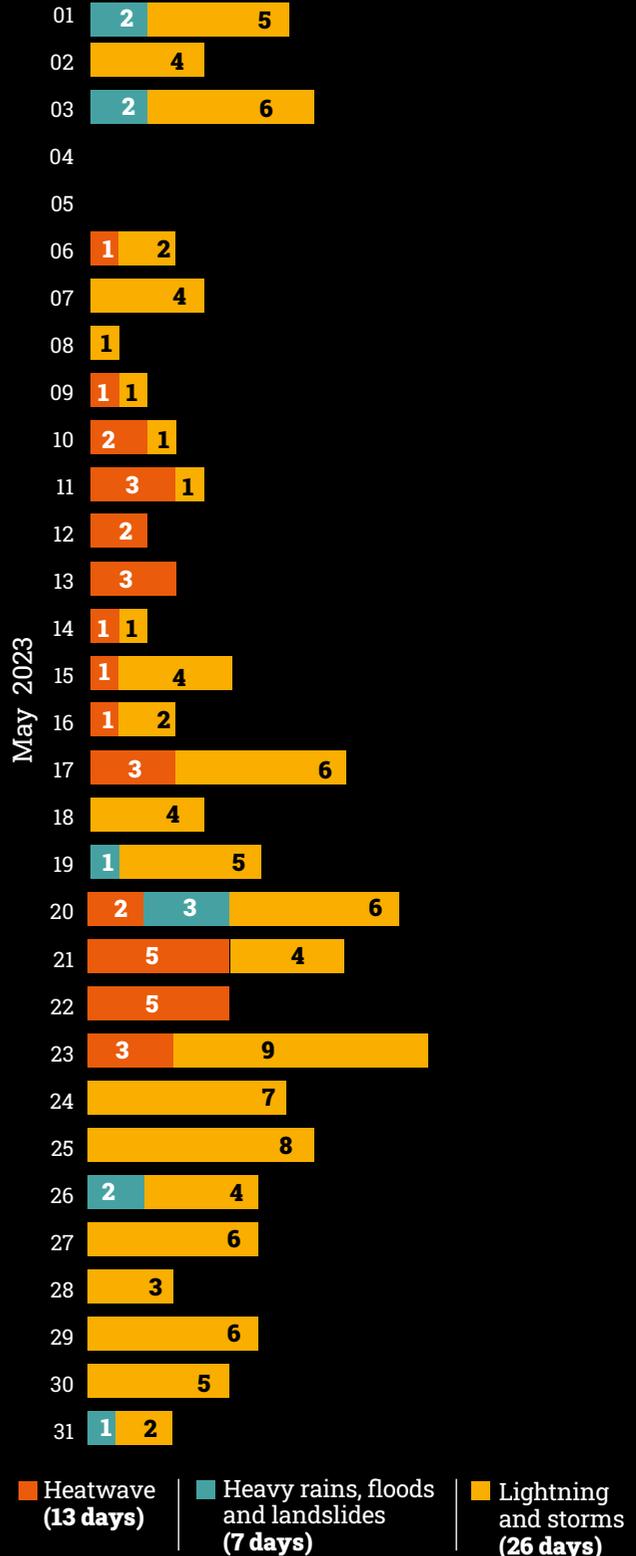
May 2023

| Day | Heatwave | Heavy rains, floods and landslides | Lightning and storms |
|---|---|---|---|
| 01 | | 2 | 5 |
| 02 | | | 4 |
| 03 | | 2 | 6 |
| 04 | | | |
| 05 | | | |
| 06 | 1 | | 2 |
| 07 | | | 4 |
| 08 | 1 | | |
| 09 | 1 | | 1 |
| 10 | 2 | | 1 |
| 11 | 3 | | 1 |
| 12 | 2 | | |
| 13 | 3 | | |
| 14 | 1 | | 1 |
| 15 | 1 | | 4 |
| 16 | 1 | | 2 |
| 17 | 3 | | 6 |
| 18 | | | 4 |
| 19 | | 1 | 5 |
| 20 | 2 | 3 | 6 |
| 21 | 5 | | 4 |
| 22 | 5 | | |
| 23 | 3 | | 9 |
| 24 | | | 7 |
| 25 | | | 8 |
| 26 | | 2 | 4 |
| 27 | | | 6 |
| 28 | | | 3 |
| 29 | | | 6 |
| 30 | | | 5 |
| 31 | | 1 | 2 |

■ Heatwave **(13 days)** | ■ Heavy rains, floods and landslides **(7 days)** | ■ Lightning and storms **(26 days)**

All values are rounded off to nearest two decimal points
Source: India Meteorological Department, Pune, Disaster Management Division under the Union Ministry of Home Affairs and media reports

# MONSOON

**June-September 2023**
**122 Days**

Arriving seven days late on June 8, the
2023 South West Monsoon season initially
progressed slowly. However, it gained
momentum and covered the entire country
by June 30, some 15 days earlier than
normal. Cyclone Biparjoy caused extreme
rainfall in some western states, while a
rare interaction with a western disturbance
led to flash floods in Himachal Pradesh
in July. August saw heavy rainfall in the
mountainous regions and northeast India,
while the rest of the country remained dry.
Despite some monsoon rainfall in September,
the overall deficit was 6 per cent, making it a
near-normal monsoon year for India.

Extreme weather events were reported on all
122 days during the season, and claimed over
2,594 human lives and damaged
0.81 million hectares of crop area and
80,563 houses.

## TEMPERATURE

June was warmer than average (1981-2010) with deviation of more than half a degree in day, night and mean temperatures. South Peninsula saw its warmest June in 122 years along with its third warmest night temperature

### In 2023, India recorded its 7th warmest June in 122 years

■ Average maximum/day temperature  ■ Mean temperature
■ Average minimum/night temperature  **00** Anomaly from 1981-2010 average
All figures in °C

| | India | Northwest | East & Northeast | Central | South Peninsula |
|---|---|---|---|---|---|
| Average maximum/day | 34.6 | 34.93 | 33.87 | 35.62 | 34.05 |
| Average minimum/night | 25.39 | 23.52 | 25.11 | 26.4 | 26.04 |
| Mean | 29.99 | 29.22 | 29.49 | 31.01 | 30.05 |
| Anomaly (day) | 0.87 | -0.85 | 1.73 | 0.81 | 1.58 |
| Anomaly (night) | 0.62 | 0.07 | 1 | 0.47 | 0.868 |
| Anomaly (mean) | 0.75 | -0.39 | 1.37 | 0.64 | 1.22 |

## RAINFALL

India's rainfall in June was slightly lower than the Long Period Average (1971-2020),  with the exception of the South Peninsula, which recorded an unusually dry spell (45 per cent deficit rainfall), and Northwest India, which reported an unusually wet spell (42 per cent surplus rainfall).

### In 2023, South Peninsula recorded its driest June in 122 years
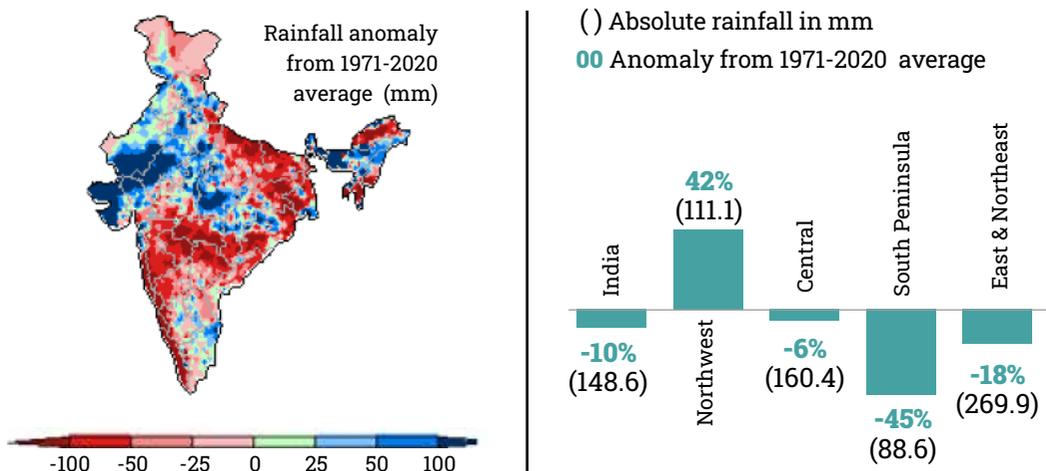
Rainfall anomaly from 1971-2020 average (mm)

( ) Absolute rainfall in mm
**00** Anomaly from 1971-2020 average

-100  -50  -25  0  25  50  100

| Region | Anomaly | Absolute rainfall (mm) |
|---|---|---|
| India | -10% | (148.6) |
| Northwest | 42% | (111.1) |
| Central | -6% | (160.4) |
| South Peninsula | -45% | (88.6) |
| East & Northeast | -18% | (269.9) |

Source: India Meteorological Department, Pune

## EXTREME WEATHER EVENTS

India experienced extreme weather events on all 30 days of the month. These were spread across 31 states/UTs. West Bengal experienced extreme weather events on 22 days, followed by Bihar (21 days) and Madhya Pradesh (20 days)

State-wise number of days with extreme weather events



0 6 12 18 24 30

## NUMBER OF STATES/UTS THAT EXPERIENCED EXTREME WEATHER EVENTS EACH DAY

June 2023

| Day | Heatwaves | Heavy rains, floods and landslides | Lightning and storms | Cyclone |
|-----|-----------|-----------------------------------|----------------------|---------|
| 01 | 3 | | 3 | |
| 02 | 3 | | 1 | |
| 03 | 3 | | 4 | |
| 04 | 3 | 1 | 4 | |
| 05 | 2 | | 6 | |
| 06 | 5 | | 3 | |
| 07 | 5 | 1 | 4 | |
| 08 | 4 | 1 | 2 | |
| 09 | 6 | | 2 | |
| 10 | 5 | 7 | 1 | |
| 11 | 6 | 2 | 3 | |
| 12 | 10 | | 1 | 1 |
| 13 | 9 | 3 | 1 | |
| 14 | 7 | 6 | 1 | |
| 15 | 10 | 7 | | 1 |
| 16 | 11 | 9 | | |
| 17 | 11 | 7 | 1 | |
| 18 | 10 | 7 | | |
| 19 | 9 | | 1 | |
| 20 | 8 | 6 | | |
| 21 | 6 | 6 | 1 | |
| 22 | | 4 | 1 | |
| 23 | | 4 | | |
| 24 | | 4 | 2 | |
| 25 | | 9 | 4 | |
| 26 | | 9 | 2 | |
| 27 | | 9 | 1 | |
| 28 | | 9 | 1 | |
| 29 | | 10 | 2 | |
| 30 | | 9 | 2 | |

**Legend:**
- Heatwaves **(21 days)**
- Heavy rains, floods and landslides **(23 days)**
- Lightning and storms **(25 days)**
- Cyclone **(1 day)**

## LOSS AND DAMAGE

### 322
people died due to extreme weather events across 16 states/UTs in June

### 10,592 hectares
of crop area affected in Assam
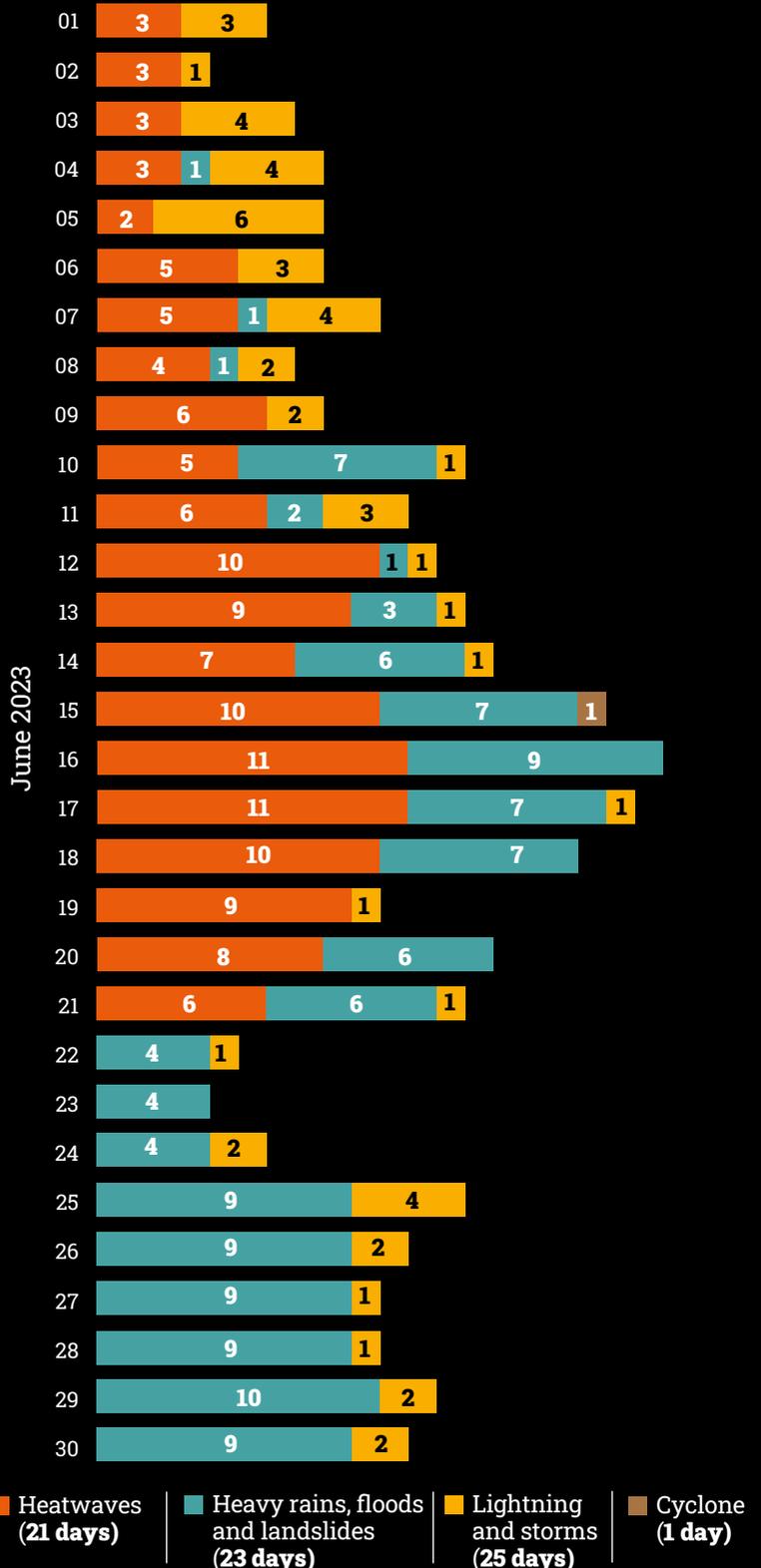
All values are rounded off to nearest two decimal

Source: India Meteorological Department, Pune, Disaster Management Division under the Union Ministry of Home Affairs and media reports

## TEMPERATURE

India experienced its seventh warmest July on record, along with the second highest night temperature. The maximum, minimum, and mean temperatures were all above average (1981-2010) by 0.29°C, 0.57°C, and 0.43°C, respectively, for the country as a whole.

**In 2023, East and Northeast India experienced the second warmest July in 122 years**

■ Average maximum/day temperature    ■ Mean temperature
■ Average minimum/night temperature  00 Anomaly from 1981-2010 average
All figures in ºC

| | India | Northwest | East & Northeast | Central | South Peninsula |
|---|---|---|---|---|---|
| Average maximum/day | 31.91 | 32.13 | 33.23 | 31.28 | 31.56 |
| Average minimum/night | 24.9 | 23.98 | 25.53 | 25.09 | 25.06 |
| Mean | 28.4 | 28.06 | 29.38 | 28.19 | 28.31 |
| Anomaly (max) | 0.29 | -0.72 | 1.78 | 0.09 | 0.36 |
| Anomaly (min) | 0.57 | 0.42 | 1.13 | 0.37 | 0.52 |
| Anomaly (mean) | 0.43 | -0.15 | 1.45 | 0.23 | 0.44 |

## RAINFALL

Rainfall across the country in July was slightly above the Long Period Average (1971-2020), with the exception of the South Peninsula, which recorded an unusually wet spell (45 per cent surplus rainfall), and East & Northeast India, which reported an unusually dry spell (32 per cent deficit rainfall).

**In 2023, East and Northeast India received the fourth lowest rainfall in July in 122 years**
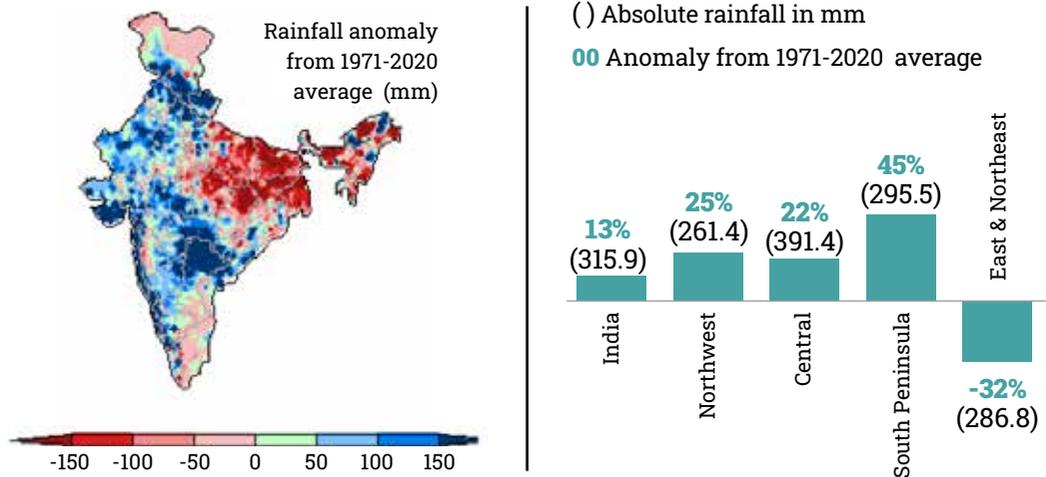
Rainfall anomaly from 1971-2020 average (mm)



( ) Absolute rainfall in mm

00 Anomaly from 1971-2020 average

| Region | Anomaly | Absolute rainfall |
|---|---|---|
| India | 13% | (315.9) |
| Northwest | 25% | (261.4) |
| Central | 22% | (391.4) |
| South Peninsula | 45% | (295.5) |
| East & Northeast | -32% | (286.8) |

-150  -100  -50  0  50  100  150

Source: India Meteorological Department, Pune

## EXTREME WEATHER EVENTS

India experienced heavy rains, floods and landslides and lightning and storms on all 31 days of the month. The extreme weather events were spread across 35 states/UTs.

State-wise number of days with extreme weather events

0 6 12 18 24 30

**NUMBER OF STATES/UTS THAT EXPERIENCED EXTREME WEATHER EVENTS EACH DAY**

July 2023

| Day | Heavy rains, floods and landslides | Lightning and storms | Cloudburst | Snowfall |
|---|---|---|---|---|
| 01 | 12 | | | |
| 02 | 15 | 3 | | |
| 03 | 11 | 1 | | |
| 04 | 19 | 5 | | |
| 05 | 21 | | | |
| 06 | 13 | 3 | | |
| 07 | 13 | 4 | | |
| 08 | 16 | 3 | | |
| 09 | 17 | 3 | | 2 |
| 10 | 18 | 2 | | |
| 11 | 16 | 4 | | 1 |
| 12 | 16 | 5 | | |
| 13 | 19 | | | |
| 14 | 17 | 2 | | |
| 15 | 12 | 3 | | |
| 16 | 13 | | | |
| 17 | 14 | | 1 | 1 |
| 18 | 16 | 2 | | |
| 19 | 14 | 3 | | |
| 20 | 12 | 3 | | |
| 21 | 13 | 4 | | |
| 22 | 12 | 4 | 1 | |
| 23 | 13 | 2 | | |
| 24 | 16 | 3 | 1 | |
| 25 | 18 | 3 | | |
| 26 | 16 | 3 | | |
| 27 | 19 | 1 | | |
| 28 | 17 | 3 | 1 | |
| 29 | 16 | | | |
| 30 | 12 | 1 | | |
| 31 | 15 | 1 | | |

- Heavy rains, floods and landslides **(31 days)**
- Lightning and storms **(25 days)**
- Cloudburst **(4 days)**
- Snowfall **(3 days)**

## LOSS AND DAMAGE

**1,489**
people died due to extreme weather events across 28 states/UTs in July

**405,532 hectares**
of crop area affected across 12 states/UTs
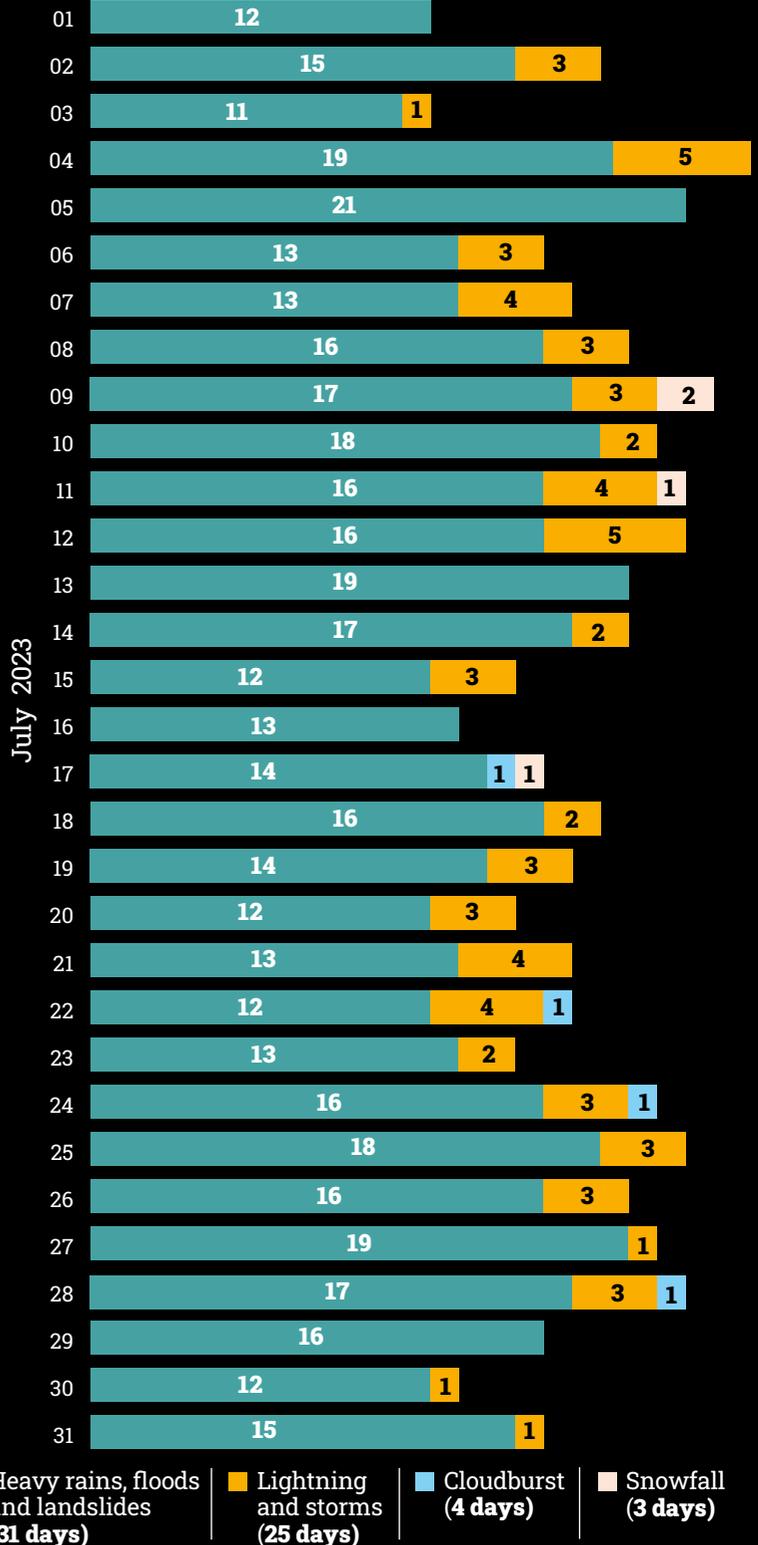
All values are rounded off to nearest two decimal

Source: India Meteorological Department, Pune, Disaster Management Division under the Union Ministry of Home Affairs and media reports
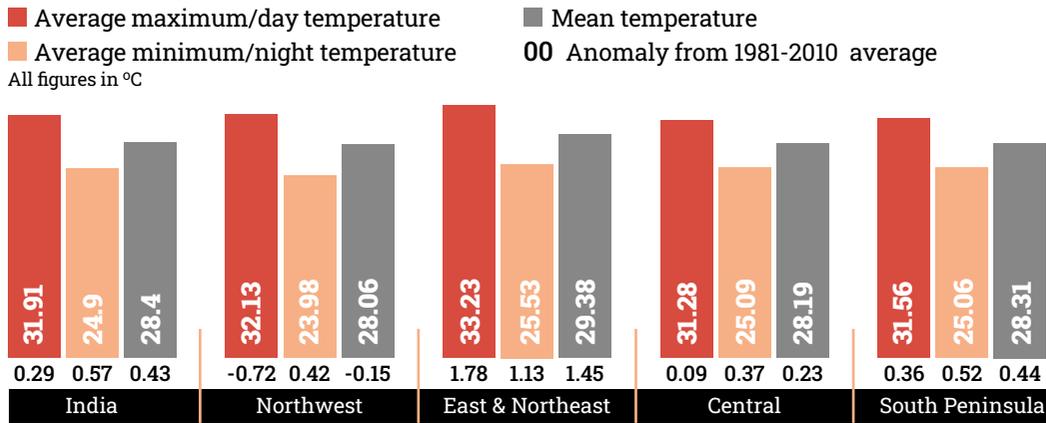
### TEMPERATURE

India recorded its hottest ever August in 122 years, with the mean temperature nearly 1°C warmer than average (1981-2010). The country also recorded its highest-ever day temperature (anomaly of 1.1°C) and second-highest night temperature (anomaly of 0.69°C).

**In 2023, South Peninsula reached its highest mean, day and night temperatures in 122 years**

■ Average maximum/day temperature  ■ Mean temperature
■ Average minimum/night temperature  **00** Anomaly from 1981-2010 average
All figures in °C

| | India | | | Northwest | | | East & Northeast | | | Central | | | South Peninsula | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 32.19 | 24.7 | 28.45 | 32.48 | 23.61 | 28.04 | 32.33 | 25.15 | 28.74 | 31.05 | 24.58 | 27.82 | 32.66 | 25.26 | 28.96 |
| Anomaly | 1.1 | 0.69 | 0.9 | 0.7 | 0.7 | 0.7 | 0.57 | 0.67 | 0.62 | 0.84 | 0.4 | 0.62 | 1.73 | 0.864 | 1.3 |

### RAINFALL

India recorded its driest August in India in 122 years, with rainfall 36 per cent below the Long Period Average (1971-2020) of 254.9 mm. Rainfall over Central India (165 mm) and South Peninsular India (76.4 mm) was also the lowest since 1901.

**In 2023, Central India and South Peninsula recorded its driest August in 122 years**



Rainfall anomaly from 1971-2020 average (mm)

-200 -100 -50 0 50 100 200

( ) Absolute rainfall in mm
**00** Anomaly from 1971-2020 average

| India | Northwest | Central | South Peninsula | East & Northeast |
|---|---|---|---|---|
| -36% (162.7) | -37% (123.8) | -47% (165) | -60% (76.4) | 2% (339.3) |

Source: India Meteorological Department, Pune
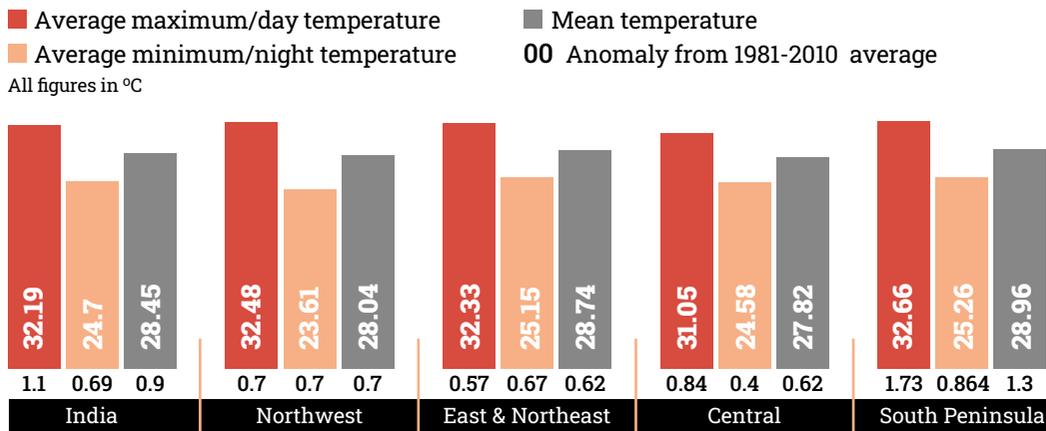
## EXTREME WEATHER EVENTS

India experienced heavy rains, floods and landslides on all 31 days of the month. They were spread across 31 states/UTs. Assam was the worst hit with extreme weather events on 28 days. It was followed by Himachal Pradesh and Punjab with 26 days each

State-wise number of days with extreme weather events

0  6  12  18  24  30
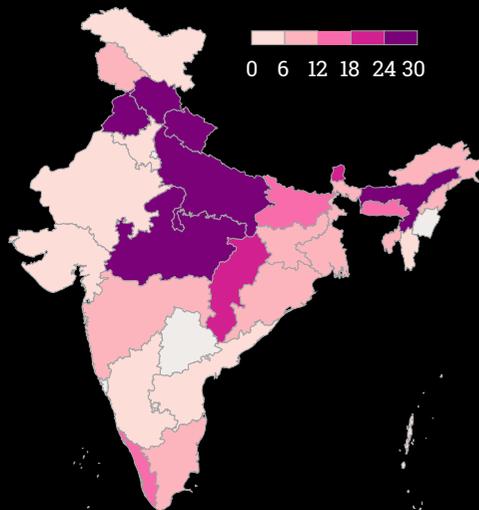
### LOSS AND DAMAGE

## 399
people died due to extreme weather events across 22 states/UTs in August

## 119,130 hectares
of crop area affected across 13 states/UTs

**NUMBER OF STATES/UTS THAT EXPERIENCED EXTREME WEATHER EVENTS EACH DAY**

August 2023

| Day | Heavy rains, floods and landslides | Lightning and storms | Cloudburst |
|-----|-----|-----|-----|
| 01 | 16 | | |
| 02 | 11 | 1 | |
| 03 | 9 | 1 | |
| 04 | 14 | | |
| 05 | 7 | | |
| 06 | 12 | 2 | |
| 07 | 14 | 1 | |
| 08 | 14 | | |
| 09 | 15 | 2 | |
| 10 | 10 | | |
| 11 | 13 | | 1 |
| 12 | 7 | 1 | |
| 13 | 13 | | 1 |
| 14 | 7 | | 1 |
| 15 | 10 | 1 | 2 |
| 16 | 12 | 2 | |
| 17 | 11 | 2 | |
| 18 | 11 | 1 | |
| 19 | 6 | 1 | |
| 20 | 8 | 1 | |
| 21 | 13 | 1 | |
| 22 | 14 | 2 | |
| 23 | 14 | 1 | |
| 24 | 1 | | |
| 25 | 7 | | |
| 26 | 10 | | |
| 27 | 10 | | |
| 28 | 9 | 1 | |
| 29 | 9 | | |
| 30 | 8 | | |
| 31 | 7 | | |
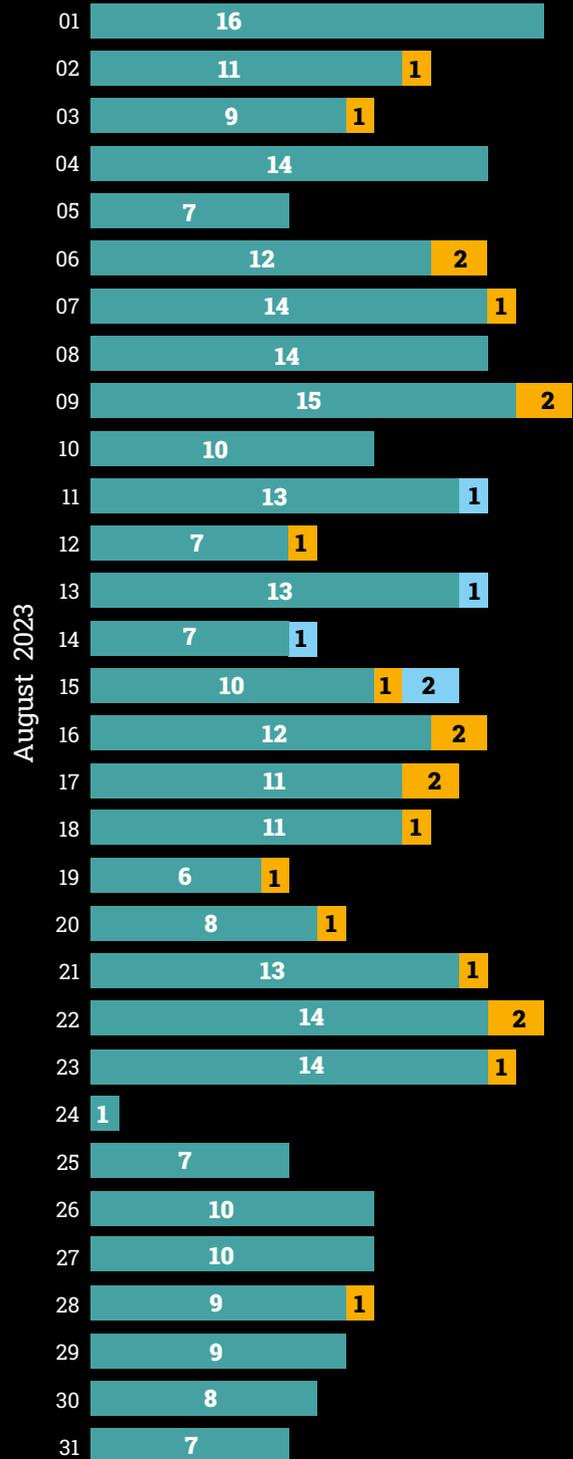
■ Heavy rains, floods and landslides **(31 days)**   ■ Lightning and storms **(16 days)**   ■ Cloudburst **(4 days)**

All values are rounded off to nearest two decimal points
Source: India Meteorological Department, Pune, Disaster Management Division under the Union Ministry of Home Affairs and media reports

## TEMPERATURE

India recorded its hottest ever September in 122 years, with the mean temperature close to 1ºC warmer than average (1981-2010). The country also recorded its highest-ever night temperature (anomaly of 0.9°C) and second-highest day temperature (anomaly of 0.86°C).
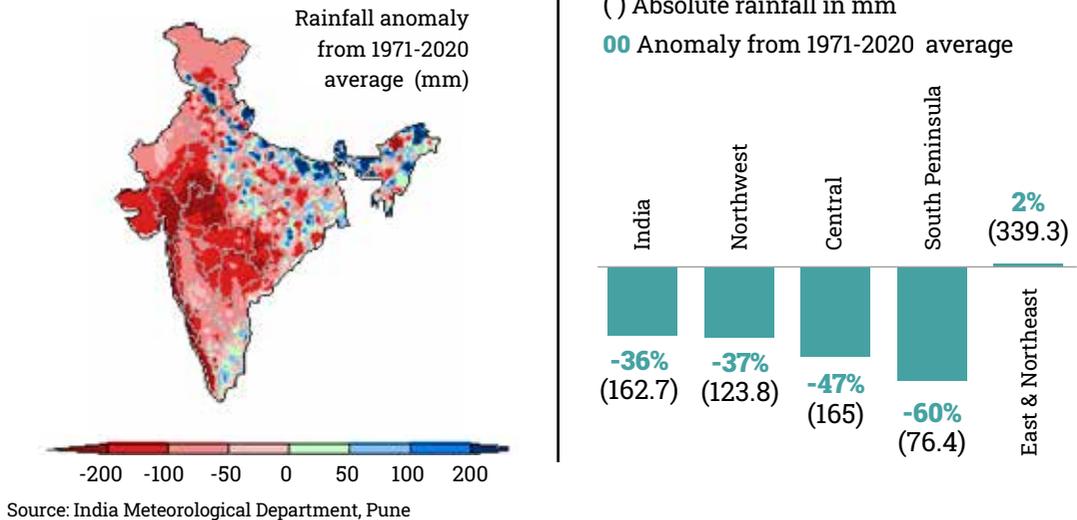
**In 2023, East and Northeast India and Northwest saw their warmest September in 122 years**

■ Average maximum/day temperature   ■ Mean temperature
■ Average minimum/night temperature   **00** Anomaly from 1981-2010 average
All figures in ºC

| | India | Northwest | East & Northeast | Central | South Peninsula |
|---|---|---|---|---|---|
| Average maximum/day temperature | 32.22 | 32.99 | 33.42 | 31.78 | 31.47 |
| Average minimum/night temperature | 24.22 | 22.66 | 25.12 | 24.44 | 24.65 |
| Mean temperature | 28.23 | 27.82 | 29.27 | 28.11 | 28.06 |
| Anomaly (max) | 0.86 | 1.23 | 2.25 | 0.37 | 0.28 |
| Anomaly (min) | 0.96 | 1.67 | 1.34 | 0.73 | 0.467 |
| Anomaly (mean) | 0.91 | 1.45 | 1.8 | 0.55 | 0.37 |

## RAINFALL

India's rainfall in September was slightly above the Long Period Average (1971-2020). Central India and South Peninsula experienced 49 per cent and 24 per cent surplus rainfall, respectively. East and Northeast India recorded a rainfall deficit of 26 per cent.

**In 2023, Kerala, experienced its 4th driest September in 122 years**



Rainfall anomaly from 1971-2020 average (mm)

-150  -100  -50  0  50  100  150

( ) Absolute rainfall in mm
**00** Anomaly from 1971-2020 average

| Region | Anomaly | Absolute rainfall in mm |
|---|---|---|
| India | 13% | (190.0) |
| Northwest | -11% | (91.6) |
| Central | 49% | (264.8) |
| South Peninsula | 24% | (198.9) |
| East & Northeast | -26% | (210.7) |

Source: India Meteorological Department, Pune

## EXTREME WEATHER EVENTS

India experienced extreme weather events on all 30 days of the month. These were spread across 30 states/UTs. Punjab experienced extreme weather events on 28 days, followed by Kerala (25 days) and Maharashtra (23 days).

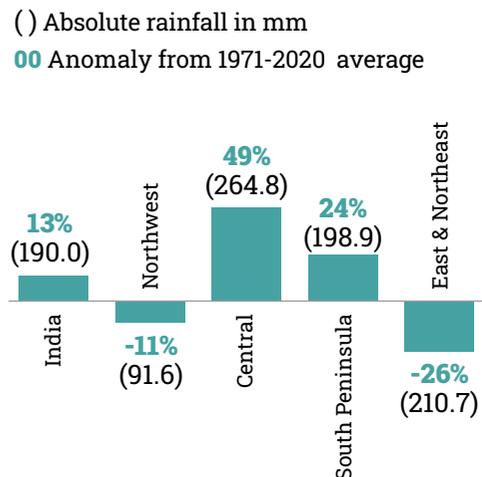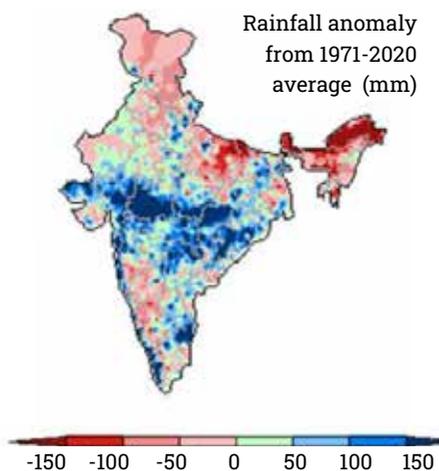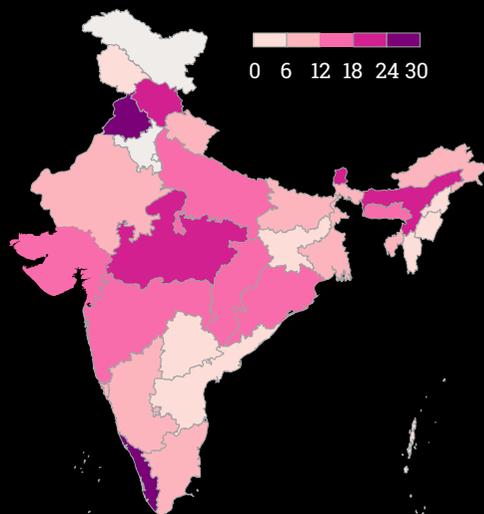### State-wise number of days with extreme weather events
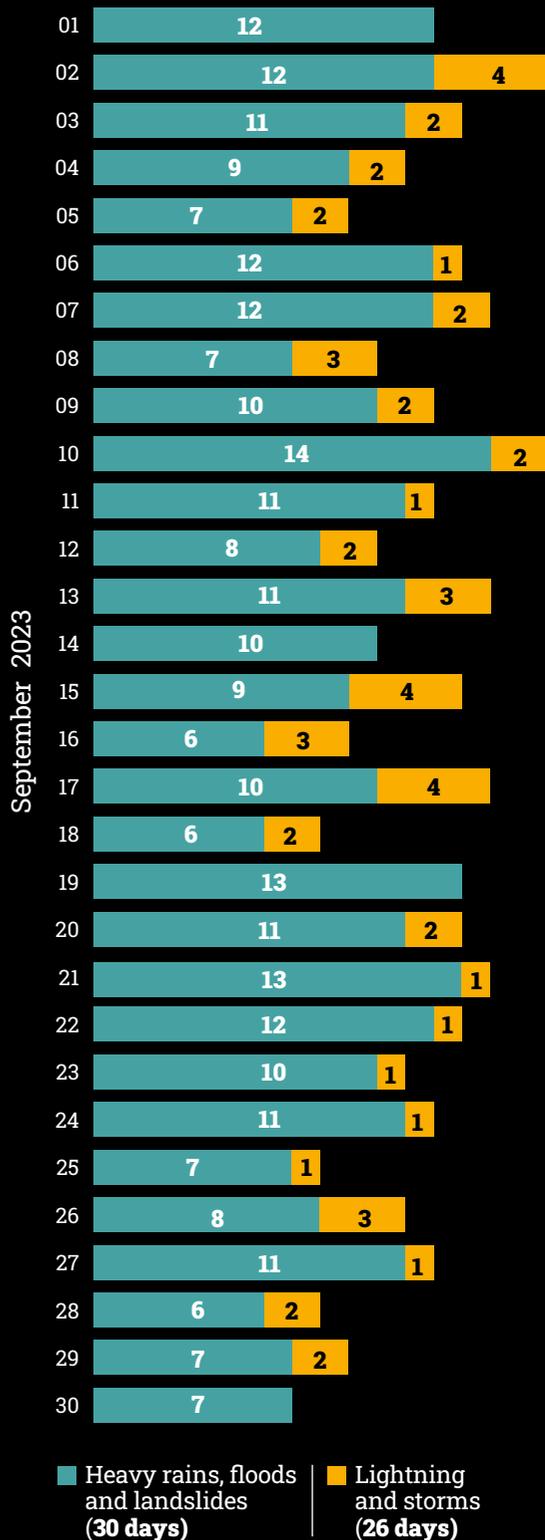


0  6  12  18  24  30

### LOSS AND DAMAGE

**384**
people died due to extreme weather events across 23 states/UTs in September

**274,325 hectares**
of crop area affected across eight states

### NUMBER OF STATES/UTS THAT EXPERIENCED EXTREME WEATHER EVENTS EACH DAY

**September 2023**

| Day | Heavy rains, floods and landslides | Lightning and storms |
|-----|-----|-----|
| 01 | 12 | |
| 02 | 12 | 4 |
| 03 | 11 | 2 |
| 04 | 9 | 2 |
| 05 | 7 | 2 |
| 06 | 12 | 1 |
| 07 | 12 | 2 |
| 08 | 7 | 3 |
| 09 | 10 | 2 |
| 10 | 14 | 2 |
| 11 | 11 | 1 |
| 12 | 8 | 2 |
| 13 | 11 | 3 |
| 14 | 10 | |
| 15 | 9 | 4 |
| 16 | 6 | 3 |
| 17 | 10 | 4 |
| 18 | 6 | 2 |
| 19 | 13 | |
| 20 | 11 | 2 |
| 21 | 13 | 1 |
| 22 | 12 | 1 |
| 23 | 10 | 1 |
| 24 | 11 | 1 |
| 25 | 7 | 1 |
| 26 | 8 | 3 |
| 27 | 11 | 1 |
| 28 | 6 | 2 |
| 29 | 7 | 2 |
| 30 | 7 | |

■ Heavy rains, floods and landslides **(30 days)**   ■ Lightning and storms **(26 days)**

All values are rounded off to nearest two decimal points
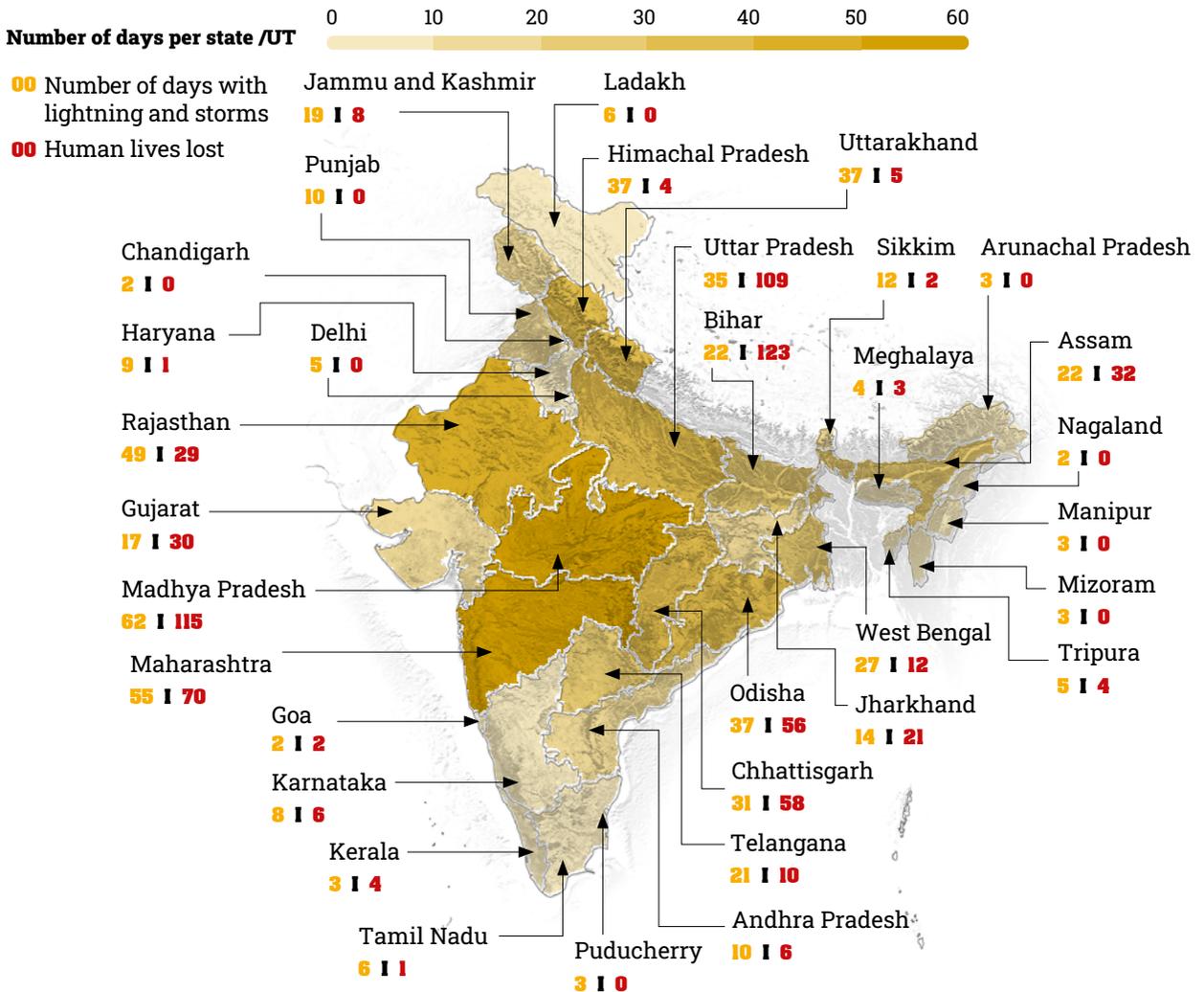Source: India Meteorological Department, Pune, Disaster Management Division under the Union Ministry of Home Affairs and media reports

# DISASTER-WISE

## LIGHTNING AND STORMS

On 176 of 273 days, India experienced lightning and storms. They claimed 711 human lives.

Number of days per state /UT

0   10   20   30   40   50   60

**00** Number of days with lightning and storms

**00** Human lives lost

Jammu and Kashmir
**19 I 8**

Ladakh
**6 I 0**

Himachal Pradesh
**37 I 4**

Uttarakhand
**37 I 5**

Punjab
**10 I 0**

Uttar Pradesh
**35 I 109**

Sikkim
**12 I 2**

Arunachal Pradesh
**3 I 0**

Chandigarh
**2 I 0**

Bihar
**22 I 123**

Meghalaya
**4 I 3**

Assam
**22 I 32**

Haryana
**9 I 1**

Delhi
**5 I 0**

Nagaland
**2 I 0**

Rajasthan
**49 I 29**

Manipur
**3 I 0**

Gujarat
**17 I 30**

Mizoram
**3 I 0**

Madhya Pradesh
**62 I 115**

West Bengal
**27 I 12**

Tripura
**5 I 4**

Maharashtra
**55 I 70**

Odisha
**37 I 56**

Jharkhand
**14 I 21**

Goa
**2 I 2**

Chhattisgarh
**31 I 58**

Karnataka
**8 I 6**

Telangana
**21 I 10**

Kerala
**3 I 4**

Andhra Pradesh
**10 I 6**

Tamil Nadu
**6 I 1**

Puducherry
**3 I 0**

**IMD definition/criteria**

Lightning is an electrical discharge caused by imbalances between storm clouds and the ground or within the clouds themselves. Storms include duststorms (caused by thunderstorms or strong pressure gradients associated with cyclones which increase wind speed over a wide area), hailstorms (an outgrowth of a severe thunderstorm in which balls or irregularly shaped lumps of ice fall with the rain), thunderstorms and gales (a very strong wind).
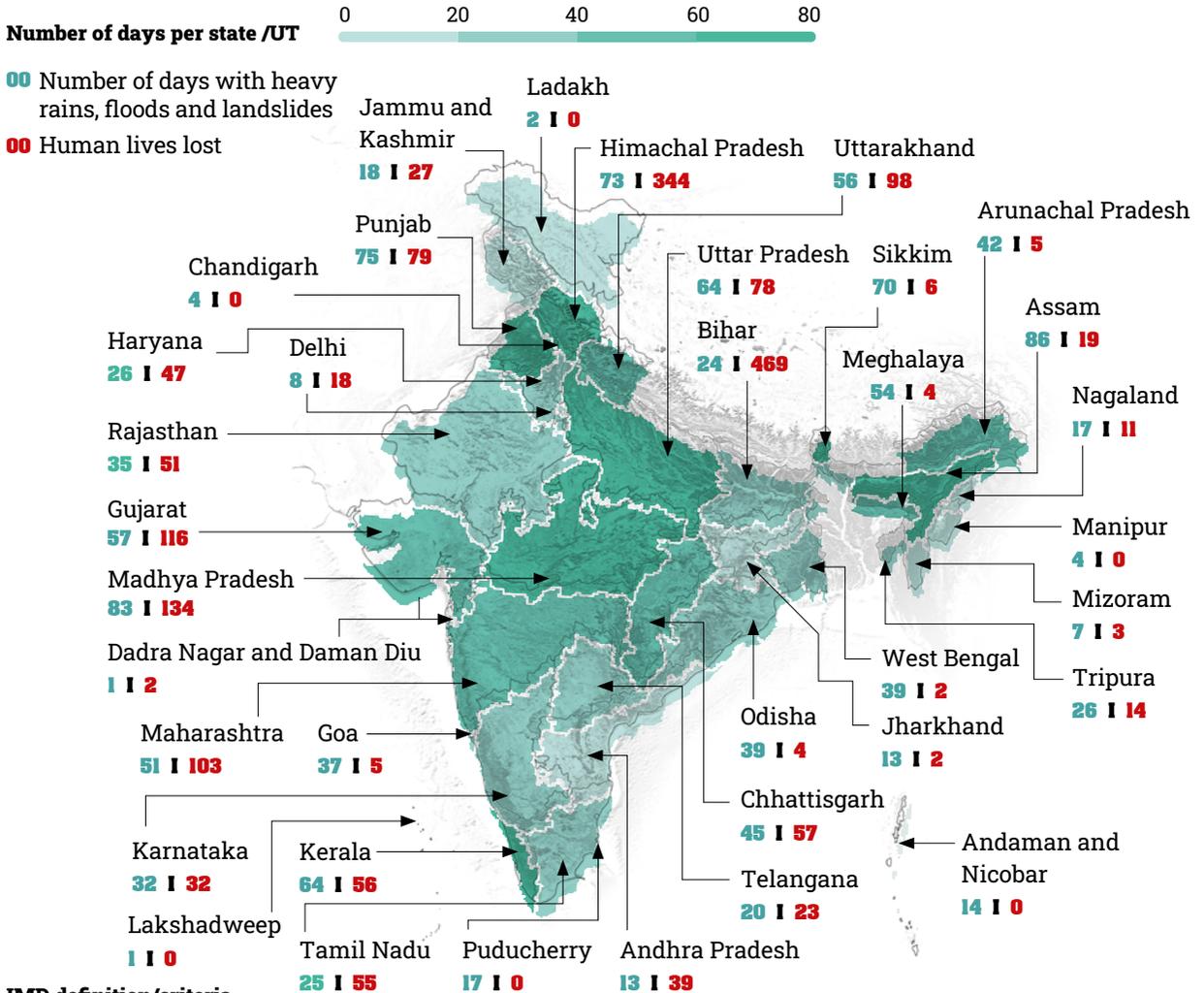
## FREQUENCY TRACKER

The number of days lightning and storms were recorded in India

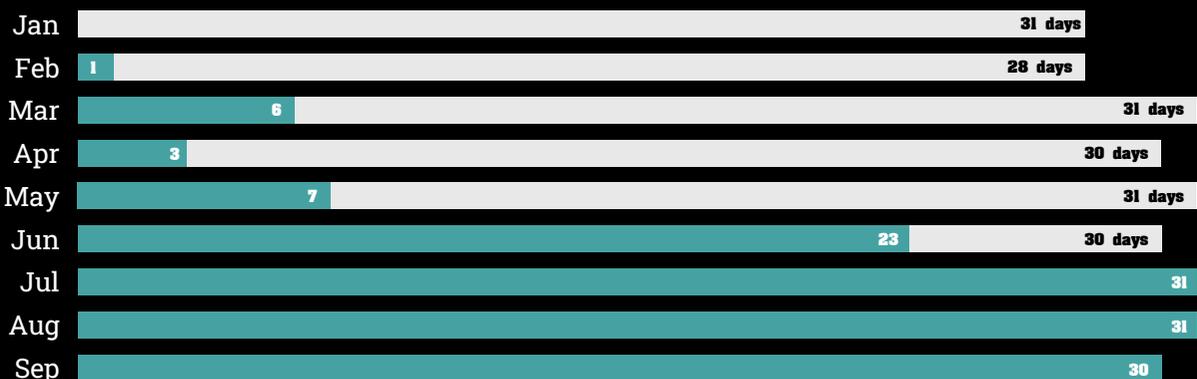| Month | Days with lightning | Total days |
|-------|--------------------:|-----------:|
| Jan | 1 | 31 days |
| Feb | 4 | 28 days |
| Mar | 26 | 31 days |
| Apr | 27 | 30 days |
| May | 26 | 31 days |
| Jun | 25 | 30 days |
| Jul | 25 | 31 days |
| Aug | 16 | 31 days |
| Sep | 26 | 30 days |

# INDIA 2023

## HEAVY RAINS, FLOODS AND LANDSLIDES

On 132 of 273 days, India experienced heavy rains, floods and landslides.
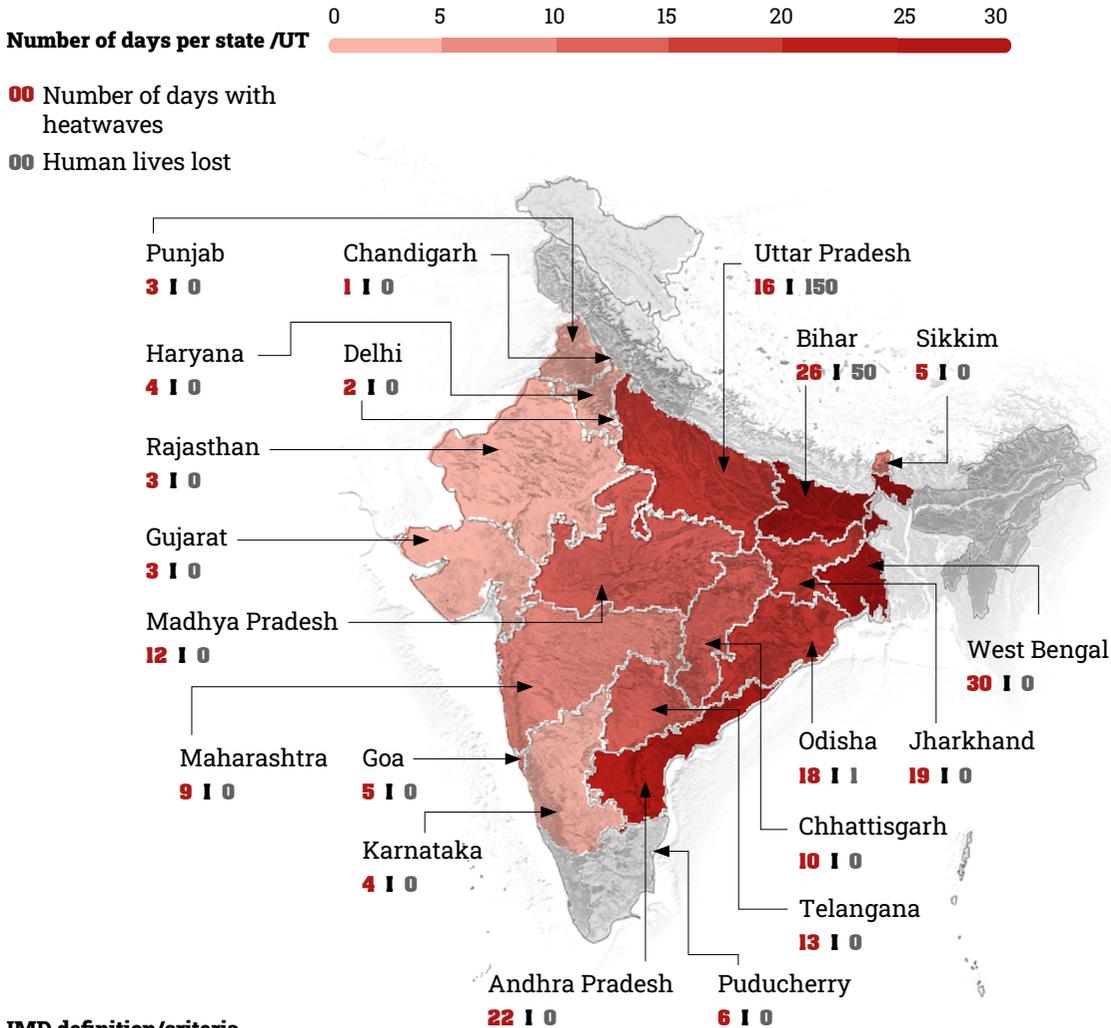They claimed 1,903 human lives.

**Number of days per state /UT**

0    20    40    60    80

**00** Number of days with heavy rains, floods and landslides

**00** Human lives lost

Ladakh
**2** | **0**

Jammu and Kashmir
**18** | **27**

Himachal Pradesh
**73** | **344**

Uttarakhand
**56** | **98**

Arunachal Pradesh
**42** | **5**

Punjab
**75** | **79**

Chandigarh
**4** | **0**

Uttar Pradesh
**64** | **78**

Sikkim
**70** | **6**

Assam
**86** | **19**

Haryana
**26** | **47**

Delhi
**8** | **18**

Bihar
**24** | **469**

Meghalaya
**54** | **4**

Nagaland
**17** | **11**

Rajasthan
**35** | **51**

Manipur
**4** | **0**

Gujarat
**57** | **116**

Mizoram
**7** | **3**

Madhya Pradesh
**83** | **134**

West Bengal
**39** | **2**

Tripura
**26** | **14**

Dadra Nagar and Daman Diu
**1** | **2**

Jharkhand
**13** | **2**

Maharashtra
**51** | **103**

Goa
**37** | **5**

Odisha
**39** | **4**

Chhattisgarh
**45** | **57**

Andaman and Nicobar
**14** | **0**

Karnataka
**32** | **32**

Kerala
**64** | **56**

Telangana
**20** | **23**

Lakshadweep
**1** | **0**

Tamil Nadu
**25** | **55**

Puducherry
**17** | **0**

Andhra Pradesh
**13** | **39**

**IMD definition/criteria**

Heavy rainfall happens when a region receives 64.5-115.5 mm rain in 24 hours. In the case of very heavy rainfall, the threshold increases to 115.6-204.4 mm and in extremely heavy rainfall it is 204.5 mm or more. The report has considered all very heavy and extremely heavy rainfall events, and heavy rainfall events only when they have caused damages.

## FREQUENCY TRACKER

The number of days heavy rains, floods and landslides were recorded in India

| Month | Days recorded | Total |
|---|---|---|
| Jan | | 31 days |
| Feb | 1 | 28 days |
| Mar | 6 | 31 days |
| Apr | 3 | 30 days |
| May | 7 | 31 days |
| Jun | 23 | 30 days |
| Jul | | 31 |
| Aug | | 31 |
| Sep | | 30 |

## HEATWAVES

On 49 of 273 days, India experienced heatwaves. They were spread across 20 states/UTs and claimed 201 human lives.

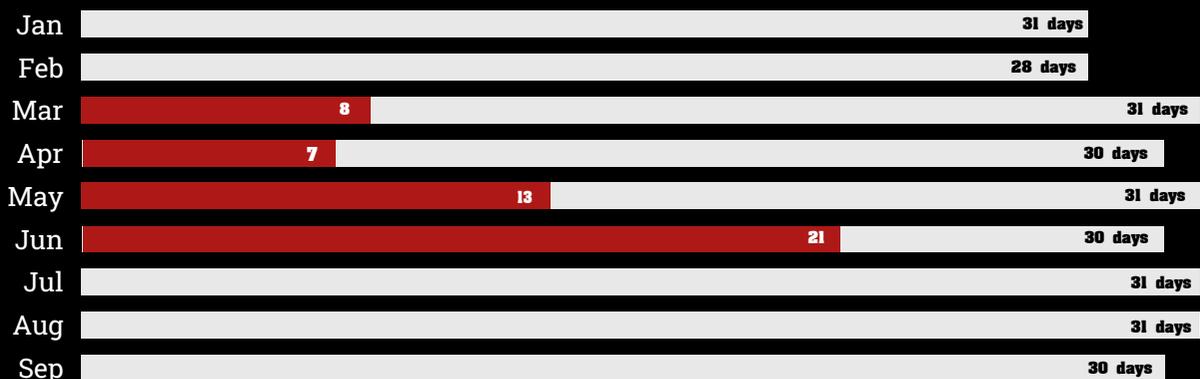**Number of days per state /UT**

0    5    10    15    20    25    30

**00** Number of days with heatwaves

**00** Human lives lost

Punjab
**3 I 0**

Chandigarh
**1 I 0**

Uttar Pradesh
**16 I 150**

Haryana
**4 I 0**

Delhi
**2 I 0**

Bihar
**26 I 50**

Sikkim
**5 I 0**

Rajasthan
**3 I 0**

Gujarat
**3 I 0**

Madhya Pradesh
**12 I 0**

West Bengal
**30 I 0**

Maharashtra
**9 I 0**

Goa
**5 I 0**

Odisha
**18 I 1**

Jharkhand
**19 I 0**

Karnataka
**4 I 0**

Chhattisgarh
**10 I 0**

Telangana
**13 I 0**

Andhra Pradesh
**22 I 0**

Puducherry
**6 I 0**

**IMD definition/criteria**

Heatwave conditions signify a certain amount of rise in temperature at a given place with respect to the normal climatological value. The report has considered heatwaves (4.5ºC to 6.4ºC departure of the maximum temperature from normal), and severe heatwaves (departure of more than 6.4ºC).

## FREQUENCY TRACKER

The number of days heatwaves were recorded in India

| Month | Heatwave days | Total days |
|---|---|---|
| Jan | | 31 days |
| Feb | | 28 days |
| Mar | 8 | 31 days |
| Apr | 7 | 30 days |
| May | 13 | 31 days |
| Jun | 21 | 30 days |
| Jul | | 31 days |
| Aug | | 31 days |
| Sep | | 30 days |

## COLD WAVES/COLD DAYS

On 21 of 273 days, India experienced cold wave/cold day. They were spread across 17 states/UTs.

**Number of days per state /UT**

0   2   4   6   8   10   12   14

**00** Number of days with cold waves/cold days

**00** Human lives lost

Himachal Pradesh
**4 I 0**

Uttarakhand
**5 I 0**

Punjab
**15 I 0**

Chandigarh
**7 I 0**

Uttar Pradesh
**14 I 4**

Bihar
**14 I 0**

Sikkim
**1 I 0**

Haryana
**15 I 0**

Delhi
**9 I 0**

Rajasthan
**11 I 0**

Gujarat
**2 I 0**

Madhya Pradesh
**12 I 0**

Maharashtra
**1 I 0**

Karnataka
**4 I 0**

Odisha
**1 I 0**

West Bengal
**2 I 0**

Chhattisgarh
**1 I 0**

Telangana
**2 I 0**
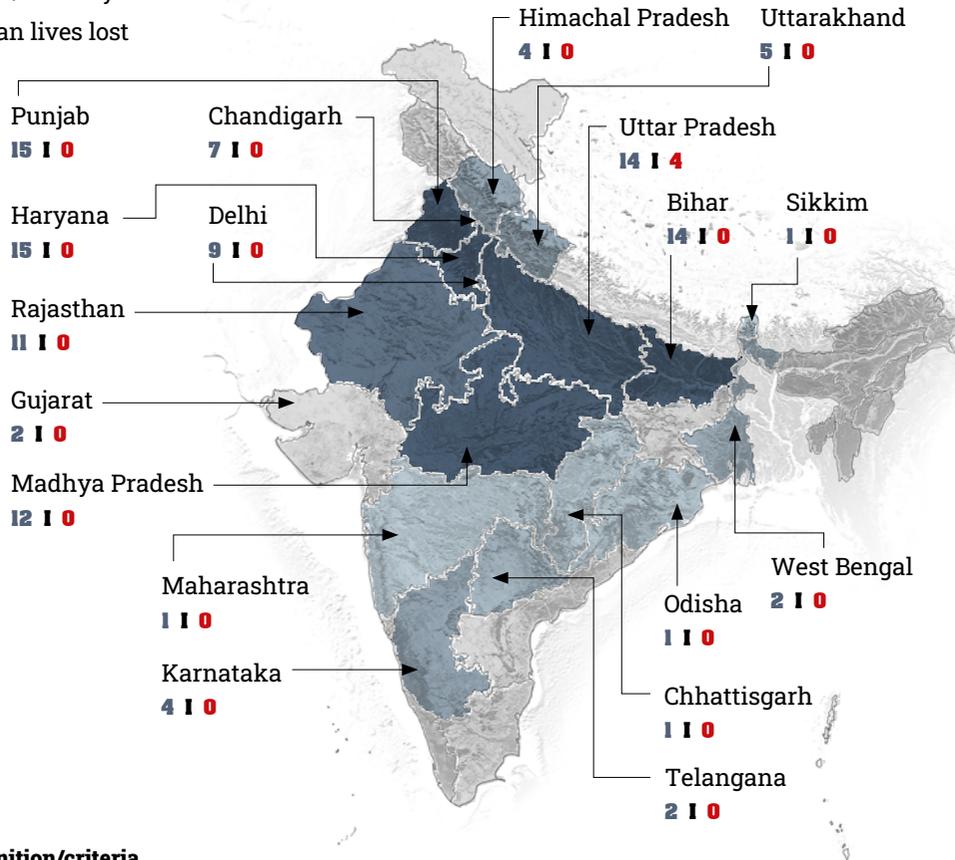
**IMD definition/criteria**
Cold day conditions occur when the maximum temperature drops by 4.5°C to 6.4°C than average. If the deviation is more than 6.4°C, then it is considered a severe cold day. Cold wave conditions occur when the minimum temperature drops by 4.5°C to 6.4°C than normal. Similarly, severe cold wave occurs when the minimum temperature drops by more than 6.4°C than normal. The report has considered all the four categories.

## FREQUENCY TRACKER

The number of days cold waves/cold days were recorded in India

| | | |
|---|---|---|
| Jan | 20 | 31 days |
| Feb | 1 | 28 days |
| Mar | | 31 days |
| Apr | | 30 days |
| May | | 31 days |
| Jun | | 30 days |
| Jul | | 31 |
| Aug | | 31 |
| Sep | | 30 |
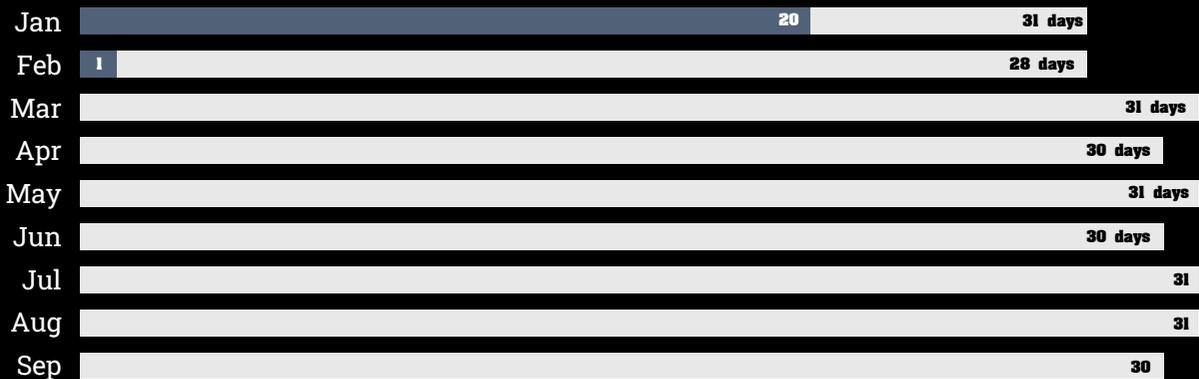
## SNOWFALL

On 5 of 273 days, India experienced snowfall. They were spread across
3 states/UTs and claimed 9 human lives.

**Number of days per state /UT**

0    0.5    1.0    1.5    2.0    2.5    3.0

**00** Number of days with snowfall

**00** Human lives lost

Ladakh
**3 I 7**

Himachal Pradesh
**2 I 0**

Jammu and Kashmir
**1 I 2**
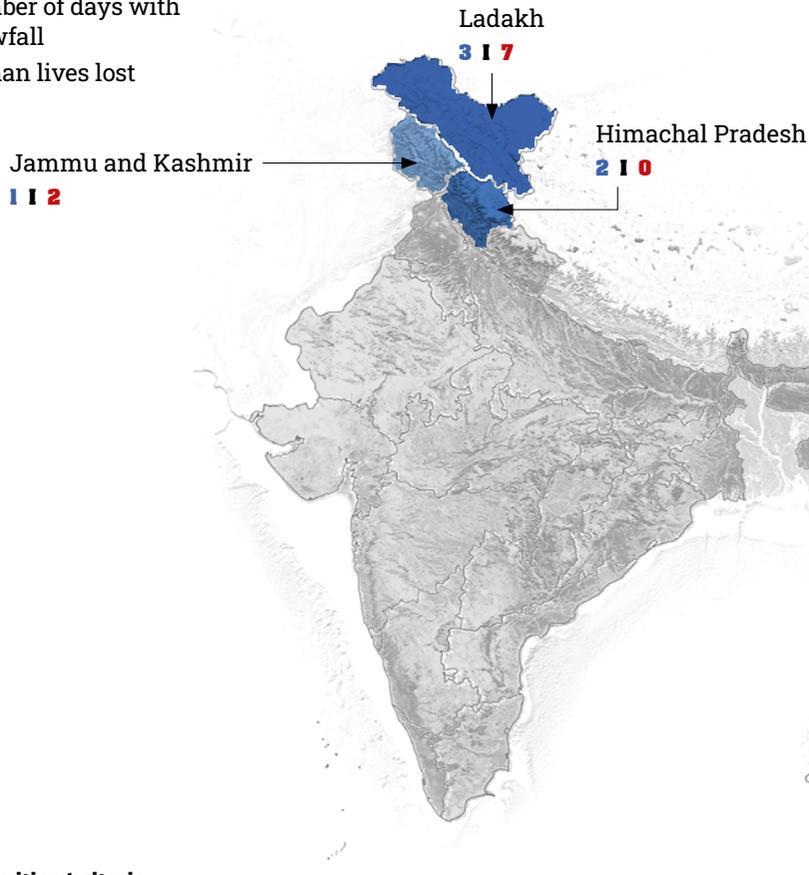
**IMD definition/criteria**
Snowfall is a hydrological hazard where a large amount of snow can affect transport, crops and people.
Annual Disaster Weather Report by IMD reports the snowfall cases over India that caused human deaths.
This report has also considered only those snowfall events that caused human deaths.

## FREQUENCY TRACKER

The number of days snowfall were recorded in India

Jan    **2**                              31 days
Feb                                       28 days
Mar                                       31 days
Apr                                       30 days
May                                       31 days
Jun                                       30 days
Jul    **5**                              31
Aug                                       31
Sep                                       30
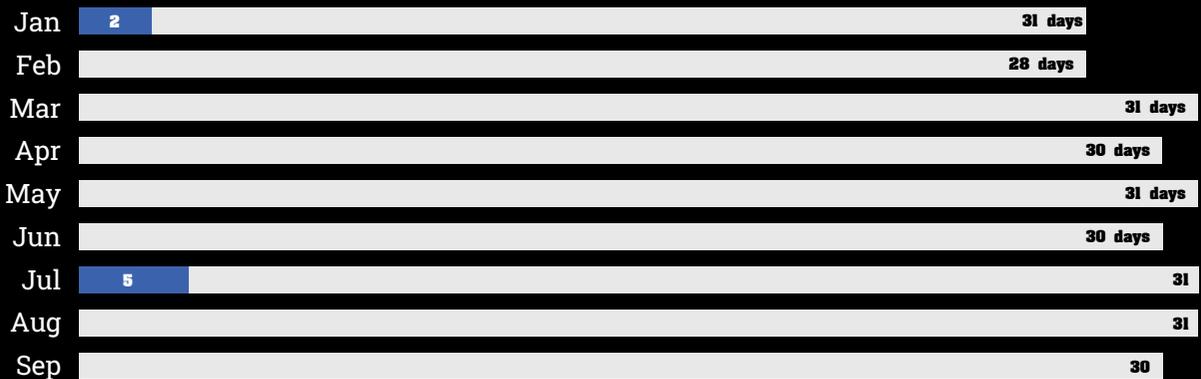
# INDIA 2023

## CLOUDBURSTS

On 8 of 273 days, India experienced cloudbursts. They claimed 19 human lives across three states/UTs.

Jammu and Kashmir
1 I 1

Himachal Pradesh
7 I 17

Uttarakhand
1 I 1
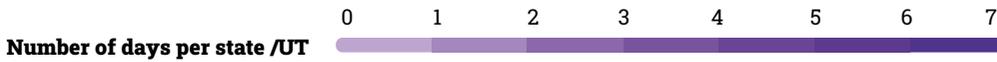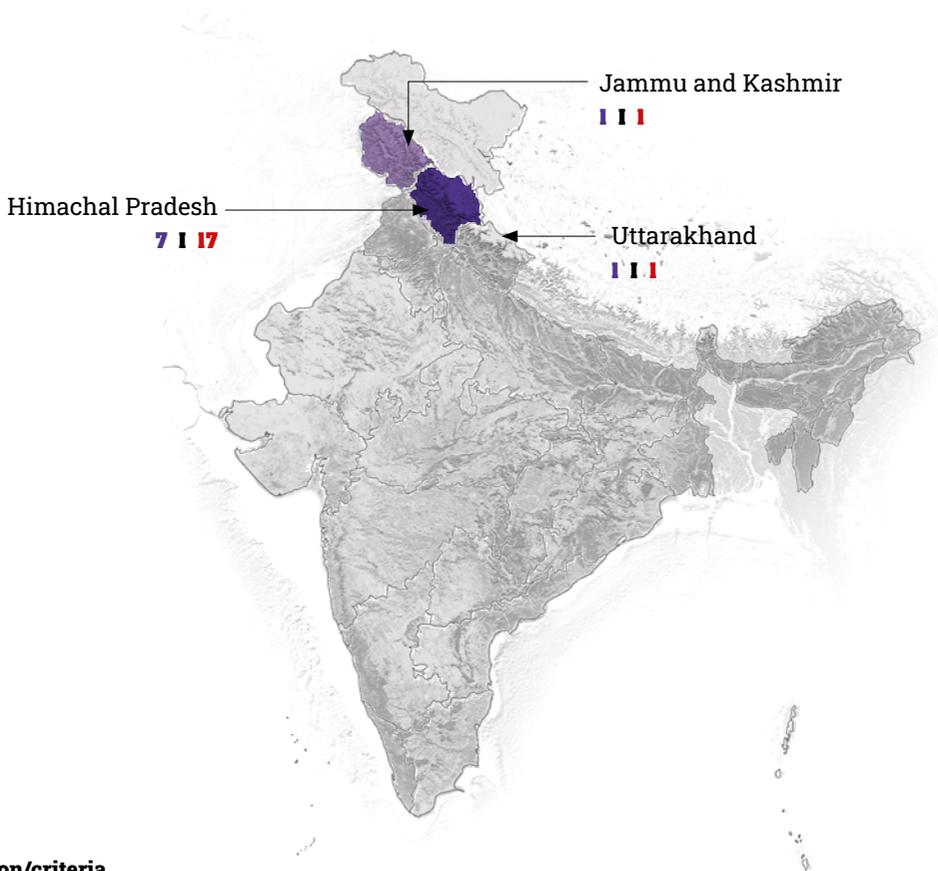
**IMD definition/criteria**
Cloudburst is very heavy rainfall (100 mm per hour) over a localised area.
It is accompanied with strong winds and lightning.

## FREQUENCY TRACKER
### The number of days cloudbursts were recorded in India

| Month | | Days |
|---|---|---|
| Jan | | 31 days |
| Feb | | 28 days |
| Mar | | 31 days |
| Apr | | 30 days |
| May | | 31 days |
| Jun | | 30 days |
| Jul | 4 | 31 days |
| Aug | 4 | 31 days |
| Sep | | 30 days |
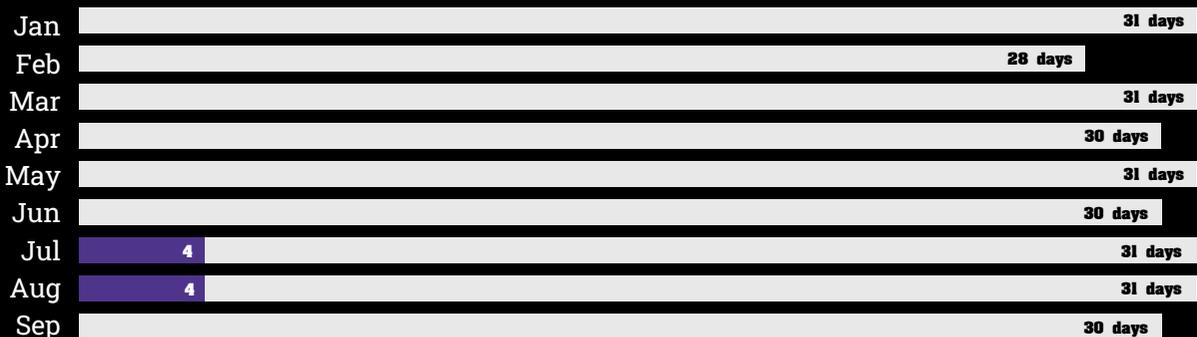
## CYCLONES

On 1 of 273 days, India experienced cloudbursts. It claimed two human lives in one state.

**Number of days per state /UT**

0          0.5          1.0

**00** Number of days with cyclones

**00** Human lives lost

Gujarat

1 I **2**
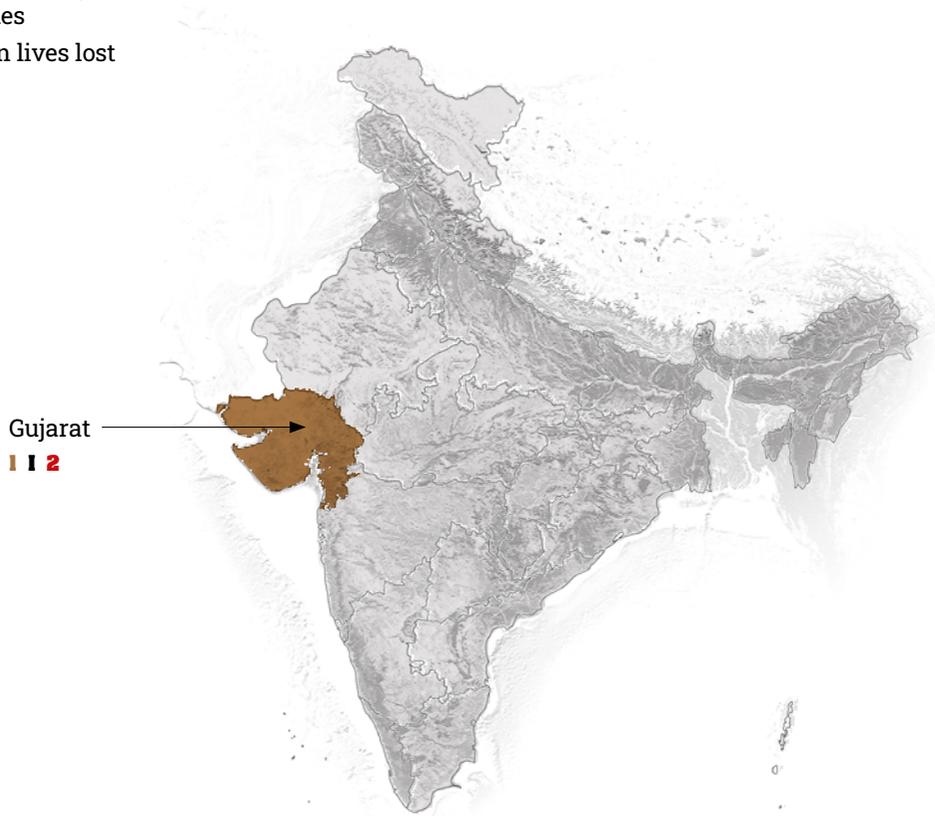
### IMD definition/criteria

Cyclones are intense vortex or whirls in the atmosphere with very strong winds circulating around them in anti-clockwise direction in the Northern Hemisphere and in clockwise direction in the Southern Hemisphere.

**Please note**: Extreme weather events claimed 2,755 lives in January-September 2022. The event type is not known for 498 of the deaths.

### FREQUENCY TRACKER
## The number of days cyclones were recorded in India
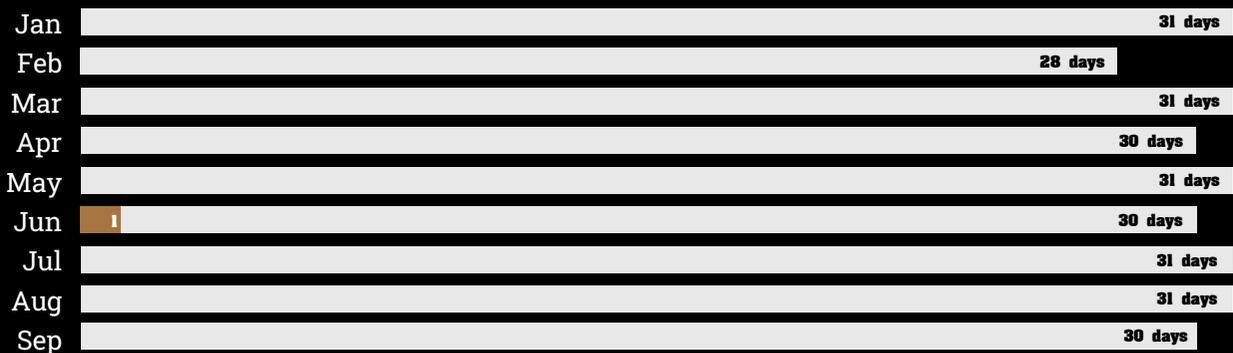
| Month | | Days |
|---|---|---|
| Jan | | 31 days |
| Feb | | 28 days |
| Mar | | 31 days |
| Apr | | 30 days |
| May | | 31 days |
| Jun | 1 | 30 days |
| Jul | | 31 days |
| Aug | | 31 days |
| Sep | | 30 days |

# COMPARATIVE ANALYSIS
## (2023 vs 2022)

INDIA EXPERIENCED extreme weather events on 235 of 273 days in the first nine months of this year, slightly less than the 241 days recorded in the same period last year. Despite this, all 36 states and Union Territories were affected, compared to 34 last year.

The events caused 2,923 fatalities this year, compared to 2,755 last year. While the total cropland damaged remained similar at 1.84 million hectares, the impact spread across 20 states and UTs this year, compared to 15 last year. The northwest states of Punjab and Haryana bore the brunt of the crop losses. Last year, Karnataka, Uttar Pradesh, and Assam were the most affected. Seasonal analysis reveals substantial variations.

### WINTER (JANUARY-FEBRUARY)

The season that is usually associated with cold waves/cold days was warmer than usual this year. As a result, India recorded extreme weather events on 28 days, or 10 days fewer than what was recorded during the same period last year. In the first two months of the year, India recorded 21 days of cold days and cold waves, a decrease of nine days from the same period last year. There were also lightning and storms (5 days), snowfall (two days) and heavy rains, floods and landslides (one day).

While the number of human deaths associated with extreme weather events decreased from 21 to eight, the area of crop damage saw a 12-fold increase, from 0.03 million hectares in 2022 to 0.39 million hectares this year.

### PRE-MONSOON (MARCH-MAY)

The season that recorded historic heatwaves last year remained mildly cooler than normal due to the high incidence of hailstorm events in most states/Union Territories.

India experienced a surge in extreme weather events this pre-monsoon season, with 85 days of extreme weather events compared to 81 days last year. This increase was driven by a significant rise in lightning and storms (primarily hailstorms), which occurred on 79 days this year, nearly double the 42 days recorded last year. Heatwaves, on the other hand, were less frequent, recorded on 28 days this year compared to 51 days last year. Heavy rainfall, floods, and landslides occurred on 16 days. Despite a marginal rise in human deaths from 318 to 321, the season was marked by a devastating blow to agriculture. The area under crop damage saw a 64-fold increase from 0.01 million hectares last year to 0.64 million hectares this year.

### MONSOON SEASON (JUNE–SEPTEMBER)

While India experienced a near-normal monsoon season, it oscillated between dry and wet spells. As a result, the country recorded extreme weather events on all 122 days, the same as last year.

During the season, India recorded 115 days of heavy rains, floods and landslides, a decrease of seven days from the same period last year. There were also lightning and storms (92 days), heatwaves (21 days), cloudbursts (eight days), snowfall (three days) and a cyclone (one day).

While the number of human deaths associated with extreme weather events increased to 2,594 from 2,431 in 2022, the area under crop damage recorded a decrease from 1.8 million hectares in 2022 to 0.81 million hectares this year.
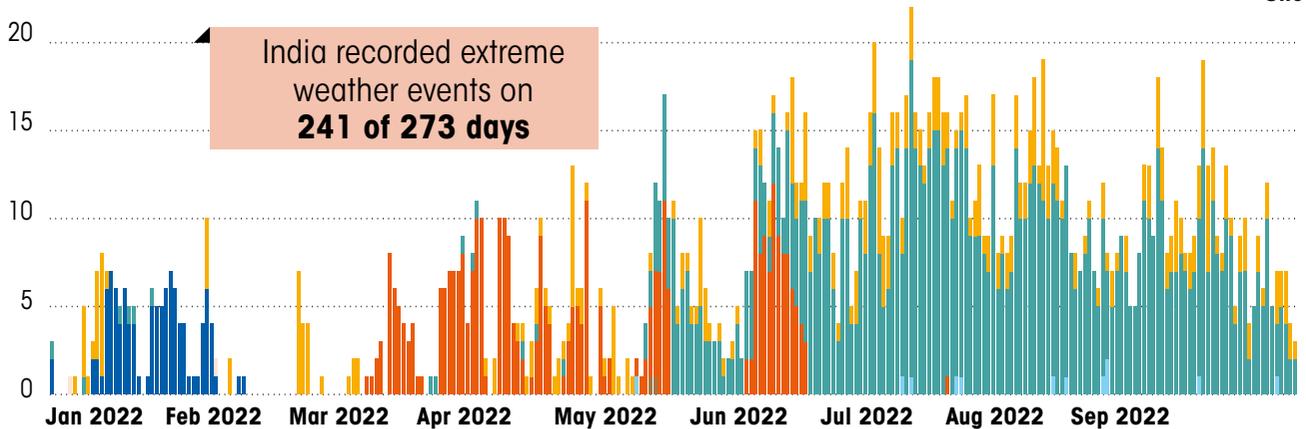
# VISIBLE CHANGE

While the country experienced extreme weather events on 235 of 273 days, a decrease from the 241 days in the same period last year, the number of human fatalities increased from 2,755 to 2,923. Additionally, the area under crop loss remained comparable at 1.84 million hectares, but the crop area loss was spread across a wider range of states and Union Territories (UTs), affecting 20 this year compared to 15 last year.

## JANUARY - SEPTEMBER 2022

**Number of days per extreme weather event**

| Lightning and storms 159 | Heavy rains, floods and landslides 157 | Heatwaves 66 | Cold waves/cold days 30 | Cyclone 2 | Snowfall 2 | Cloudburst 11 |

**Extreme weather events across country, day-wise**

India recorded extreme weather events on **241 of 273 days**



Jan 2022  Feb 2022  Mar 2022  Apr 2022  May 2022  Jun 2022  Jul 2022  Aug 2022  Sep 2022

## JANUARY - SEPTEMBER 2023

**Number of days per extreme weather event**
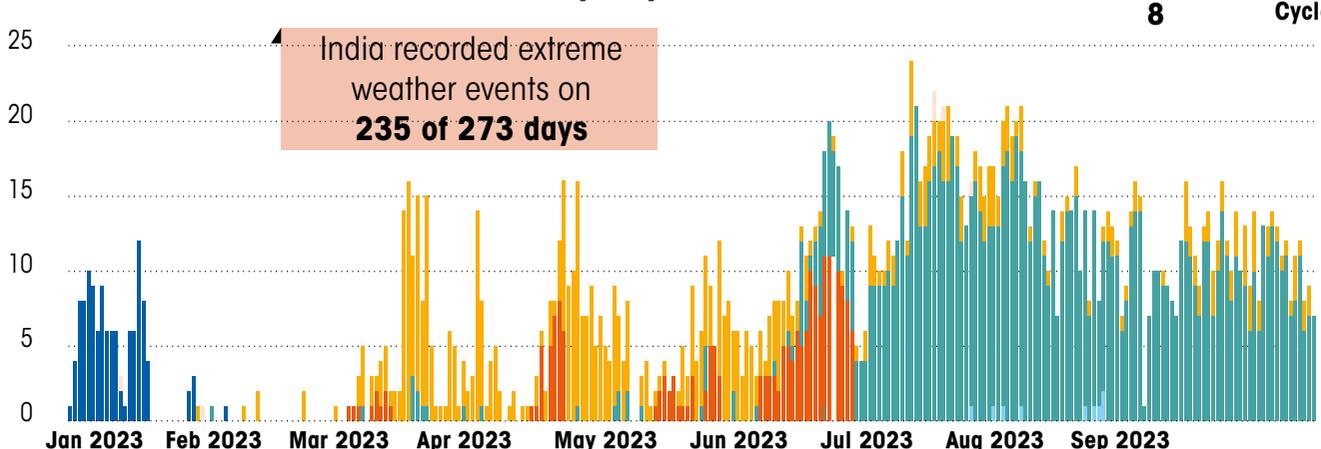
| Lightning and storms 176 | Heavy rains, floods and landslides 132 | Heatwaves 49 | Cold waves/cold days 21 | Cloudburst 8 | Cyclone 1 | Snowfall 5 |

**Extreme weather events across country, day-wise**

India recorded extreme weather events on **235 of 273 days**



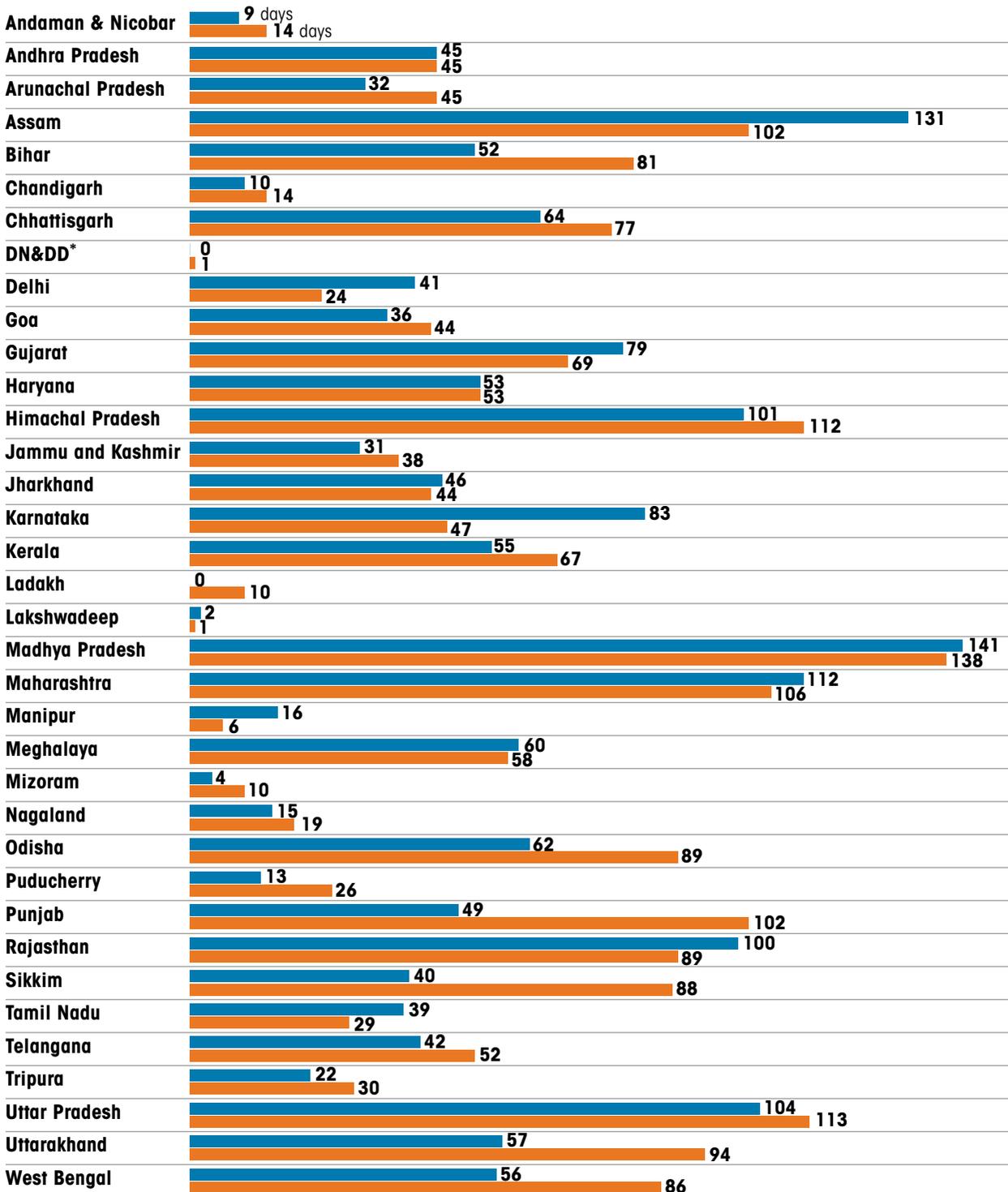Jan 2023  Feb 2023  Mar 2023  Apr 2023  May 2023  Jun 2023  Jul 2023  Aug 2023  Sep 2023

Source: Based on India's database of weather disasters dashboard by CSE-DTE Data Centre. Data sourced from the Disaster Management Division Union Ministry of Home Affairs, India Meteorological Department and media reports

## WIDER SPREAD

In January-September 2023, 26 of the 36 states and UTs had a higher number of extreme weather occurrences than in the same period in 2022.

Number of days with extreme weather events in ■ 2022 and ■ 2023

| State/UT | 2022 | 2023 |
|---|---|---|
| Andaman & Nicobar | 9 days | 14 days |
| Andhra Pradesh | 45 | 45 |
| Arunachal Pradesh | 32 | 45 |
| Assam | 131 | 102 |
| Bihar | 52 | 81 |
| Chandigarh | 10 | 14 |
| Chhattisgarh | 64 | 77 |
| DN&DD* | 0 | 1 |
| Delhi | 41 | 24 |
| Goa | 36 | 44 |
| Gujarat | 79 | 69 |
| Haryana | 53 | 53 |
| Himachal Pradesh | 101 | 112 |
| Jammu and Kashmir | 31 | 38 |
| Jharkhand | 46 | 44 |
| Karnataka | 83 | 47 |
| Kerala | 55 | 67 |
| Ladakh | 0 | 10 |
| Lakshwadeep | 2 | 1 |
| Madhya Pradesh | 141 | 138 |
| Maharashtra | 112 | 106 |
| Manipur | 16 | 6 |
| Meghalaya | 60 | 58 |
| Mizoram | 4 | 10 |
| Nagaland | 15 | 19 |
| Odisha | 62 | 89 |
| Puducherry | 13 | 26 |
| Punjab | 49 | 102 |
| Rajasthan | 100 | 89 |
| Sikkim | 40 | 88 |
| Tamil Nadu | 39 | 29 |
| Telangana | 42 | 52 |
| Tripura | 22 | 30 |
| Uttar Pradesh | 104 | 113 |
| Uttarakhand | 57 | 94 |
| West Bengal | 56 | 86 |

*DN&DD: Dadra Nagar and Daman Diu; Source: Based on India's database of weather disasters dashboard by CSE-DTE Data Centre. Data sourced from the Disaster Management Division of Union Ministry of Home Affairs, India Meteorological Department and media reports

# CLIMATE CHANGE ATTRIBUTION

**T**HE World Meteorological Organization (WMO) has declared that 2023 is on track to be the warmest year on record globally, with a greater than 99 per cent likelihood. This trend is mirrored in India, where the India Meteorological Department (IMD) has reported that 2023 saw its warmest ever August and September in 122 years. The country's warming trend is evident in the consistently above-average temperatures recorded across all seasons.

### WINTER SEASON: UNUSUALLY DRY AND WARM

The winter season, typically India's second-wettest season after the monsoons, has been unusually dry and warm in recent years. In 2023, both January and February, the two months that comprise the winter season, were warmer than average. This pattern has been observed for the past three years, indicating a significant shift in India's winter weather patterns.

This year saw one of the warmest ever February on record since 1901, shattering all previous records. This extreme warmth was accompanied by exceptionally low rainfall. Central India received negligible rainfall, the lowest since 1901, while the Northwest region experienced a 76 per cent rainfall deficit.

Experts attribute the unusual winter seasons and extreme weather events to the evolving Western Disturbances (WDs), a series of cyclonic storms that originate in the Mediterranean and travel over 9,000 km to bring winter rains to Northwest India. WDs play a crucial role in India's weather patterns, particularly in the distribution of winter rainfall. Climate change is disrupting the frequency and intensity of WDs. Studies suggest that the absence of active WDs, reduced rainfall activity, and clear skies over most of the country during February 2023 were key factors contributing to the record-breaking warmth.

### PRE-MONSOON SEASON: EXTREME STORM ACTIVITIES THROUGHOUT THE COUNTRY

In March 2023, the rainfall over Central India and the Southern Peninsula was the highest and 7th highest, respectively, since 1901. The IMD states that several weather systems, including troughs and cyclonic circulations (swirling winds in the middle and upper troposphere, the lowest layer of the atmosphere) connected to two consecutive WDs, were responsible for the rainfall and hailstorms, which peaked during the week of March 16–23, 2023.

In April 2023, the country witnessed hailstorms on 27 of the 30 days. On 7 days (12-19 April), heatwaves were experienced in at least nine states.

These humid heatwaves over India and Bangladesh during April were made 30 times more likely by climate change, according to a study by the World Weather Attribution (WWA) released on May 17, 2023. These heatwave events are expected to affect India and Bangladesh once every five years and would have a heat index that is 2ºC higher than usual.

# CLEAR LINK

In 2023, at least eight attribution studies and reports on India found that climate change made extreme events and related incidences more severe or more likely to occur

### 2015
### Drought in Marathwada

**"The risk of this kind of drought is found to be at least quintupled due to anthropogenic factors"**

Attribution of the 2015 drought in Marathwada, India from a multivariate perspective | Mariam Zachariah, et al | March 2023 | Weather and Climate Extremes

### 1995-2023
### Frequency of heatwaves rising in India due to global warming

**"The frequency of heat waves and their duration over the main heat-prone areas of the country rose by around 2.5 days in the last 30 years due to global warming."**

Meteorological Monograph: Heat and Cold Waves in India: Processes and Predictability| India Meteorological Department | April 2023

### April 2023
### Extreme humid heat in South Asia
**"Human-induced climate change made the April 2023 heat wave across India and Bangladesh 30 times more likely "**

Extreme humid heat in South Asia in April 2023, largely driven by climate change, detrimental to vulnerable and disadvantaged communities | Zachariah, M, et al | 2023 | Imperial College London

### June-August 2023
### Human-driven climate change behind record temperatures in 11 states/UTs
**"During June-August 2023, 11 states/UTs experienced higher temperatures that were made at least three times more likely by climate crisis."**

Climate Shift Index map, Climate Central | September 7, 2023

### 1979-2021
### Climate change is causing more frequent, intense cyclones on India's western coast
**"Changes in the patterns of ocean and atmosphere warming are causing more frequent and severe tropical cyclones in the Eastern Arabian Sea, next to India's west coast."**

Changes in the thermodynamical profiles of the subsurface ocean and atmosphere induce cyclones to congregate over the Eastern Arabian Sea |  C S Abhiram Nirmal,et al | September 22, 2023 | Scientific Reports

### 2022
### Ganga, Mekong basins to see fewer but stronger tropical storms
**"Ganga and Mekong floodplains will see a reduced frequency of tropical storms but the intensity of such events are projected to go up by 2050"**

Fewer, but more intense, future tropical storms over the Ganges and Mekong Basins | Haider Ali, et al |  August 31, 2023 | Geophysical Research Letters

### June 2023
### Climate change made UP heatwave at least two times more likely
**"A three-day extreme heat event over Uttar Pradesh from June 14-16, 2023 was made at least two times more likely by human-caused climate change."**

Climate Shift Index map, Climate Central |  June 2023

### 2041-2080
### Groundwater depletion rates may triple in India because of global warming
**"The rates of net groundwater loss for 2041–2080 could be three times current depletion rates."**

Warming temperatures exacerbate groundwater depletion rates in India |  Nishan Bhattarai, et al | September 1, 2023 | Science Advances

### HEATWAVES EAT INTO MONSOON SEASON

The heatwaves during June 2023 across at least 12 states/UTs have been attributed to human-caused climate change by Climate Central. During June-August 2023 , 11 states/UTs experienced higher temperatures that were made at least three times more likely by the climate crisis as per analysis based on the Climate Shift Index, Climate Central's daily temperature attribution system.

The frequency, duration and intensity of heatwaves over India have shown an increasing trend over the last 50-60 years. Greenhouse gas emissions from fossil fuels are likely the cause of this observed trend in heatwaves, as per a report released by the India Meteorological Department on April 26, 2023.

In the future, greenhouse gas emissions from fossil fuels are likely to increase further, alerted IMD report. The duration of heatwaves in India increased by about 2.5 days between 1961 and 2021 due to global warming.

This is only likely to increase further. By 2060, there will be an increase of about two heatwaves per season; the duration of heatwaves too will rise by 12-18 days by then. Currently, on average, the maximum duration of a heatwave is two to four days.

### THE URGENT NEED FOR ACTION

The escalating climate crisis demands urgent action to mitigate greenhouse gas emissions and adapt to the changing climate. India has taken steps to transition to a cleaner energy future, but more needs to be done. Investing in renewable energy sources, improving energy efficiency and adopting sustainable practices are crucial steps in reducing India's carbon footprint. Additionally, strengthening early warning systems and building resilience to extreme weather events are essential for protecting communities and livelihoods.

India's experience with extreme weather events serves as a stark reminder of the far-reaching impacts of climate change. Addressing this global challenge requires a concerted global effort to reduce greenhouse gas emissions and adapt to the changing climate. By transitioning to a low-carbon economy and building resilient communities, India can play a leading role in shaping a more sustainable future for all.

## ABOUT THE REPORT

All Indian states are significantly climate vulnerable and the gap between the least vulnerable state (Maharashtra) and the most vulnerable state (Jharkhand) is small, as per the Union government's "Climate Vulnerability Assessment for Adaptation Planning in India Using a Common Framework 2019-20". Yet robust data on extreme weather events, which are increasing in frequency and intensity due to climate change, is not available publicly. This happens because government agencies use different definitions and data collection sources, which obscure the bigger picture.

This report, in its second year, is an attempt to build an evidence base on the frequency and expanding geography of extreme weather events in India. It provides season-by-season, month-by-month, and region-by-region analyses of extreme weather events and the loss and damage they caused in the first nine months of 2023.

Scan to access India's Atlas on Weather Disasters