Down To Earth

CLIMATE INDIA 2022

An assessment of extreme weather events

JANUARY - SEPTEMBER

India saw extreme weather events on 88% of the days in the first nine months of the year

The country recorded its warmest March, 3rd warmest April in over a century

Weather events have killed 2,755 people, affected 1.8 million hectares of crop area

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CSE Down To Earth

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Down To Earth

CSE, founded in 1980, is a public interest research and advocacy organisation based in New Delhi. CSE researches into, lobbies for and communicates the urgency of development that is both sustainable and equitable.
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Down To Earth is a fortnightly on the politics of environment and development. In its 30th year of publication, it continues to adhere to its founder Anil Agarwal's objective of bringing out news, perspectives and knowledge to prepare citizens to change the world.

CONTENTS

06 **Executive Summary**

10 **Regional analysis**

- Central
- South Peninsula
- Northwest
- East and Northeast

12 **Seasonal analysis**

- Winter (January-February)
- Pre-monsoon (March-May)
- Monsoon (June-September)

36 **Disaster-wise analysis**

- Lightning and storms
- Heavy rains, floods and landslides
- Heatwaves
- Cold waves/cold days
- Snowfall
- Cloudbursts

44 **Climate change costs**

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 of 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').

The "India 2022: 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

The 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 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".

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 10, 2022, 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 and 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 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

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 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 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. Annual Disaster Weather Report by IMD reports the snowfall cases over India that caused human deaths. The report has also 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.

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 disaster management authority (SDMA), which reports on the events on their websites. However, the data is at best sketchy and not released regularly. There are signs of change. During this flood season, Assam 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 for the pre-monsoon period, CSE/DTE has sourced it from media reports (which is also used by IMD for compiling its loss and damage data).

GAPS IN 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, media reports suggest widespread crop loss in Haryana, Madhya Pradesh, Rajasthan and Gujarat during the monsoon season (June-September), but the Centre's cumulative loss and damage report for the season claims

that there have been no losses in these states. 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 damages.

WHY THIS REPORT?

India recorded extreme weather events on 241 of the 273 days from January 1 to September 30, 2022. This means that close to 90 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 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 2022 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 are publicly available and they fail 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 has also launched "India's Atlas on Weather Disasters", an open-access online public interactive database on extreme weather events that will be 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, lightning to heavy rain, floods and landslides. These disasters have claimed 2,755 lives, affected 1.8 million hectares (ha) of crop area, destroyed over 416,667 houses and killed close to 70,000 livestock. This estimation 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 loss calculated.

With an event every second day, Madhya Pradesh saw the highest number of days with extreme weather events; but Himachal Pradesh saw the highest number of human deaths at 359 deaths. Madhya Pradesh and Assam saw 301 human deaths each.

Assam reported the highest number of damaged houses and animal deaths.

Karnataka, which experienced an extreme weather event on 82 days since the beginning of the year, accounted for more than 50 per cent of the crop area affected in the country. Madhya Pradesh, as per the official records, did not report any crop area damage. This could be due to gaps in loss and damage reporting.

The Central region reported the highest number of days with extreme weather events at 198, followed by the Northwest (195 days). In terms of human lives lost, Central region saw the highest number of deaths at 887, followed by East and Northeast region (783 deaths).

In 2022, India recorded its seventh wettest January since 1901. This March was also the warmest ever and the third driest in 121 years. It was also the country's third warmest April, 11th warmest August and 8th warmest September since 1901.

Eastern India and Northeast India saw its warmest and driest July in 121 years. The region also recorded its 2nd warmest August and 4th warmest September in 2022.

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 repeated and frequent events.

In terms of the "nature" of the event, all types of extreme weather has been seen in the past nine months—lightening and storms were spread over 30 states and claimed 773 lives. Then, every day of the three months of monsoon—from June to August show heavy to very heavy and extremely heavy rainfall in some part of the country. This is why the flood devastation has not sparred any region—in Assam, for instance, vast parts of the state were submerged and people lost life, homes and sources of livelihoods. DTE reported that the pulses of floods were so frequent that people had shifted "permanently" out of their homes to government shelters.

Heatwaves claimed 45 lives, but what is not captured in the data is the impact of the prolonged high temperatures on people's wellbeing in north India – from farmers to construction workers and how they would have coped (or not) because of the intense and searing heat.

The impact of severe cold episodes and frost is worse for crop damage – this is also not captured in the data that is available. It is clear that farmers must have adequate systems for compensation for weather-related losses. Without this, their livelihoods are threatened; every loss adds to their mounting debt burden and pulls them into the cycle of marginalisation and poverty.

The good news is that fatalities because of cyclones were few—only two lives were lost according to available data from the cyclones that destroyed 95,066 ha in the country. This is because of the laudable work done by IMD for cyclone forecasting so that there is adequate warning to governments. It is also because state governments, particularly from the coastal regions of India, Odisha, Andhra Pradesh and West Bengal, have vastly improved their systems of disaster management so that they can evacuate people quickly and provide them the assistance that is needed in the shelters. But the fact is each cyclone takes away that development dividend that governments work so hard to build—from public schools to water and health facilities and road and communication infrastructure. It also destroys people's ability to cope as they lose livelihoods and resources.

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 has the human face of its victims.

It speaks of the need to do much for managing these extreme events—we have to move beyond 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 241 of the 273 days, or a little over 88% of the days from January 1 to September 30, which claimed 2,755 lives, affected 1.8 million hectares (ha) crop area, 416,667 houses and killed over 69,007 animals

Region-wise extreme weather events (January 1- September 30, 2022)

Number of days | Deaths | Crop area affected (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 887 lives, damaged 136,780 ha crop area, 28,032 houses and killed 7,519 animals

Madhya Pradesh	140	276		6,646	997
Maharashtra	112	230		3,592	4,330
Gujarat	78	152		6,574	1,436
Chhattisgarh	62	91	458	1,439	527
Odisha	62	50	1,36,323	9,693	229
Goa	36			88	

South Peninsula region

It recorded extreme weather events on 125 of the 273 days, which claimed 350 lives, damaged 1.06 million ha crop area, 64,837 houses and killed 4,382 animals

Karnataka	82	117	9,96,190	47,703	1,664
Kerala	53	74		2,215	136
Andhra Pradesh	45	33	25,212	45	9
Telangana	41	27	16,997	14,858	1,574
Tamil Nadu	39	4			
Puducherry	13		9	16	999
Lakshwadeep	2				
Andaman & Nicobar	9				

Northwest region

It recorded extreme weather events on 195 of the 273 days, which claimed 735 lives, damaged 393,726 ha crop area, 5,122 houses and killed 1,707 animals

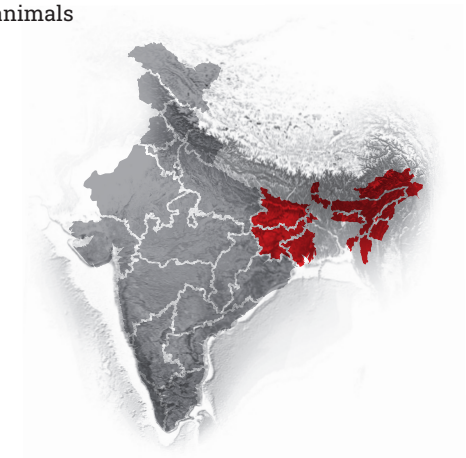
Uttar Pradesh	104	158	2,94,811	805	2
Himachal Pradesh	98	160		1,427	966
Rajasthan	99	70		25	184
Uttarakhand	55	37		977	352
Haryana	53	1	16,187		
Punjab	47	15	28	1,888	203
Delhi	41	3			
Jammu and Kashmir	31	-			
Chandigarh	10	-			

Number of days | Deaths | Crop area affected (ha) | Houses damaged (fully and partially) | Total animal deaths (big and small)

East and Northeast region

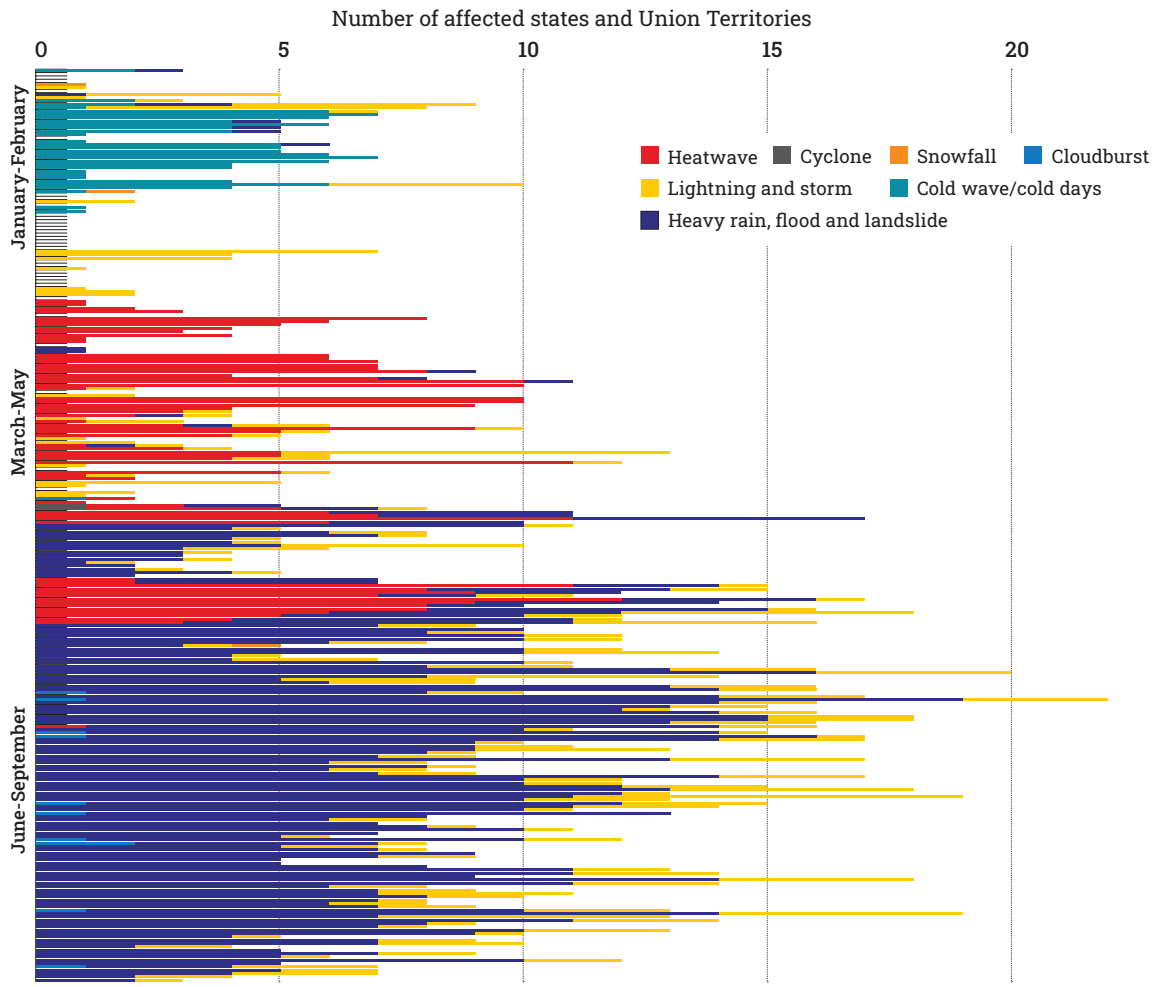
It recorded extreme weather events on 171 of the 273 days, which claimed 783 lives, damaged 256,517 ha crop area, 318,676 houses and killed 55,399 animals

Assam	131	280	243,929	306,362	54,948
Meghalaya	58	41	1,114	4,924	359
West Bengal	56	6			
Bihar	52	246	10,700	140	
Jharkhand	46	23			
Sikkim	40	4	193	3,871	12
Arunachal Pradesh	32	49	96	800	49
Tripura	20	1		1,879	1
Manipur	16	-			
Nagaland	14	30	484	700	30
Mizoram	4				



Day-wise extreme weather events in India

(January 1 - September 30, 2022)



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

EXTREME WEATHER EVENTS

SEASON-WISE

WINTER

January - February 2022

59 Days

While January saw cooler daytime temperatures, February remained almost half a degree colder than normal, resulting in 30 cold wave/cold days and 12 hailstorm days. January was also abnormally wet, while February was drier than normal.

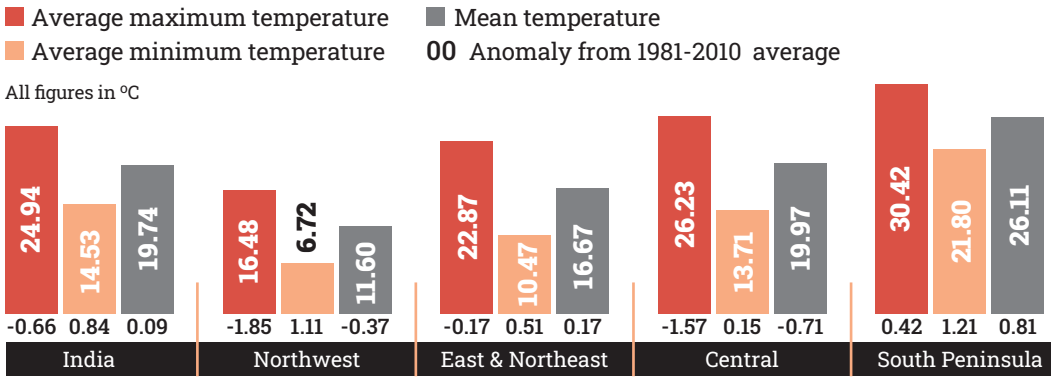
The country experienced an extreme weather event on 39 out of 59 days in the winter months of 2022. The events were spread across 21 states/UTs.

Uttar Pradesh was the worst hit as it experienced extreme weather events on 25 days. It was followed by Madhya Pradesh, which experienced extreme weather events on 24 days.

TEMPERATURE

While the mean temperature for the month was just 0.09°C above the long period average (1981-2010), there were visible variations in the average maximum and average minimum temperatures. January saw cooler daytime temperatures (0.66°C below average maximum temperature) and warmer night-time temperatures (0.84°C above average minimum temperature).

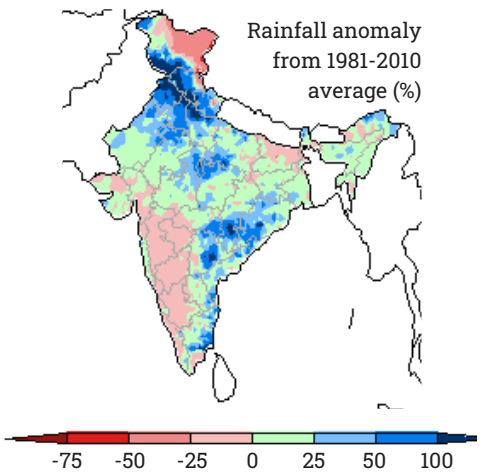
January saw its eighth warmest night-time temperature since 1901

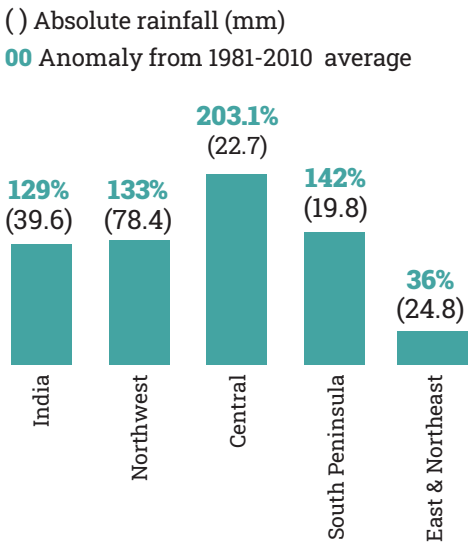


RAINFALL

India experienced a wet January (39.6 mm) this year, with rainfall levels over 129 per cent the long period average (1981-2010). Still most of Maharashtra, Karnataka, Kerala and Ladakh recorded deficit rainfall. At least nine stations reported very heavy rainfall (115.6 to 204.4 mm) and 89 stations reported heavy rainfall (64.5 to 115.5 mm of rainfall).

The month was also seventh wettest since 1901



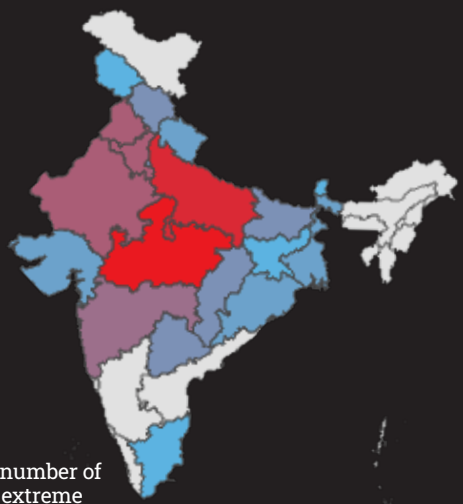


Source: India Meteorological Department, Pune

INDIA 2022
JANUARY

EXTREME WEATHER EVENTS

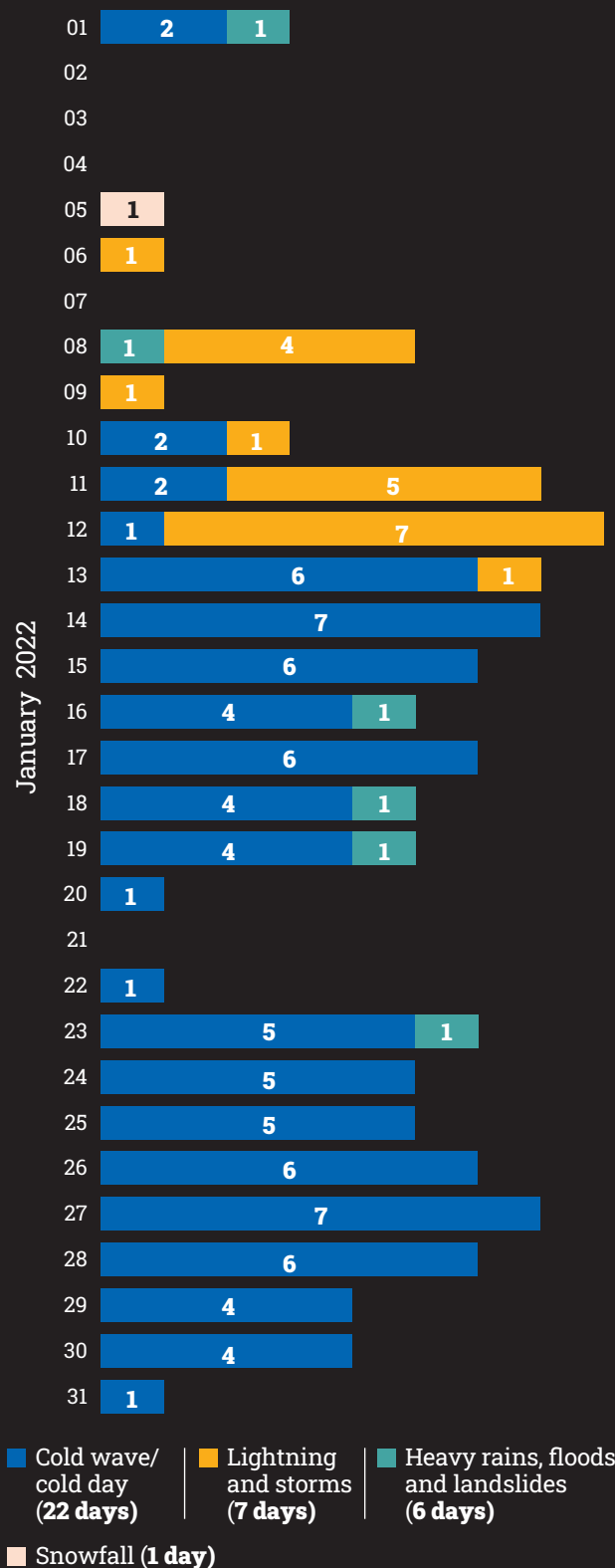
India experienced extreme weather events on 26 out of 31 days in January. This was spread across 20 states/UTs. Madhya Pradesh was the worst hit with extreme weather events on 20 days of the month.



Statewise number of days with extreme weather events

0 2 4 6 8 10 12 14 16 18 20

BARS INDICATE THE NUMBER OF STATES/ UTS THAT EXPERIENCED EXTREME WEATHER EVENTS EACH DAY



LOSS AND DAMAGE

15
people died due to extreme events in January. Himachal Pradesh (13), Jammu & Kashmir (1) and Maharashtra (1)

16,997 hectares
of crop area was affected in Telangana due to hailstorms

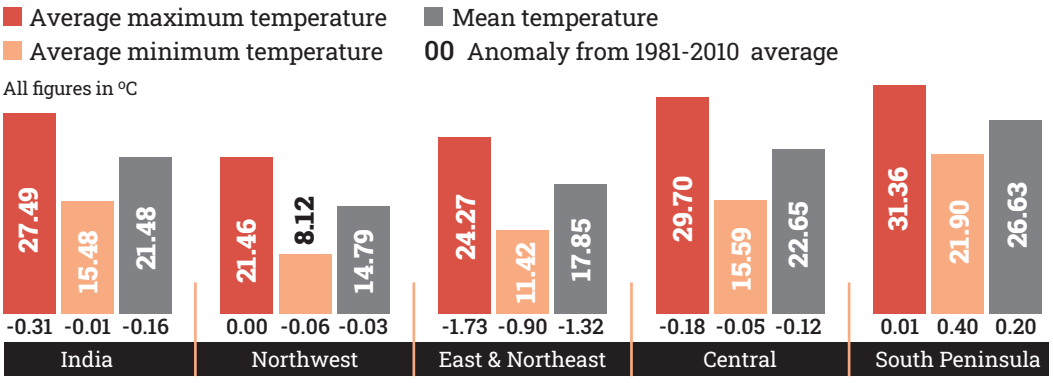
Sources: India Meteorological Department, Pune, Disaster Management Division under the Union Ministry of Home Affairs and media reports

INDIA 2022
FEBRUARY

TEMPERATURE

In February, the country experienced a marginally colder daytime temperature in comparison to the long period average (1981-2010). East and Northeast India experienced an abnormally cold daytime and night-time temperatures.

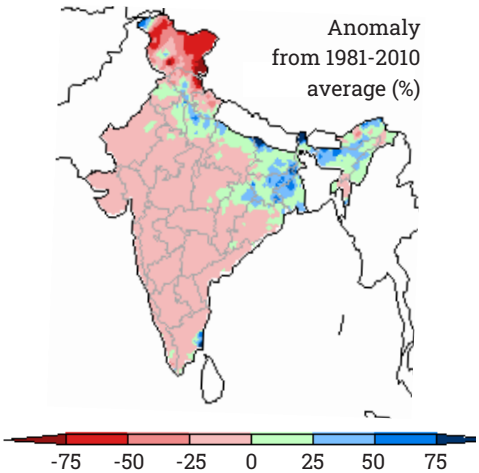
In 2022, East & Northeast India saw its 11th coldest February in 121 years

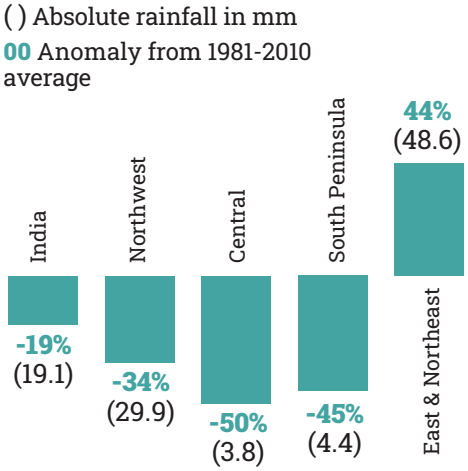


RAINFALL

The overall rainfall was 19 per cent lower than the average, but this masks the variations in the country. The East & Northeast region experienced its second wettest February since 1901, after 2001. Then, Central, South Peninsula and Northwest regions recorded 50, 45 and 34 per cent deficit rainfall respectively.

East & Northeast India saw 44 per cent surplus rainfall



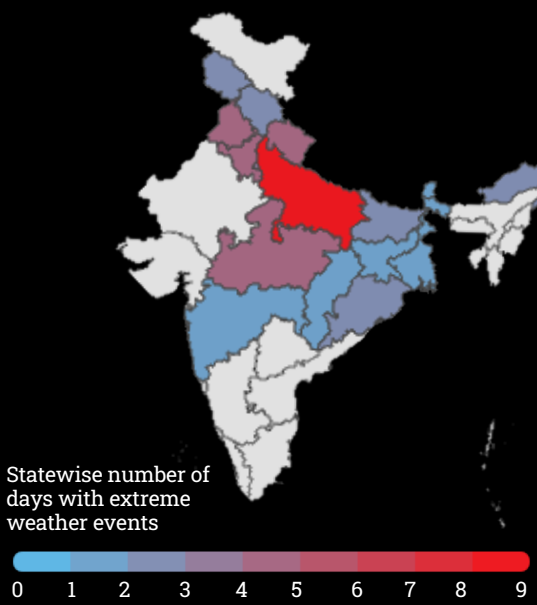


Source: India Meteorological Department, Pune

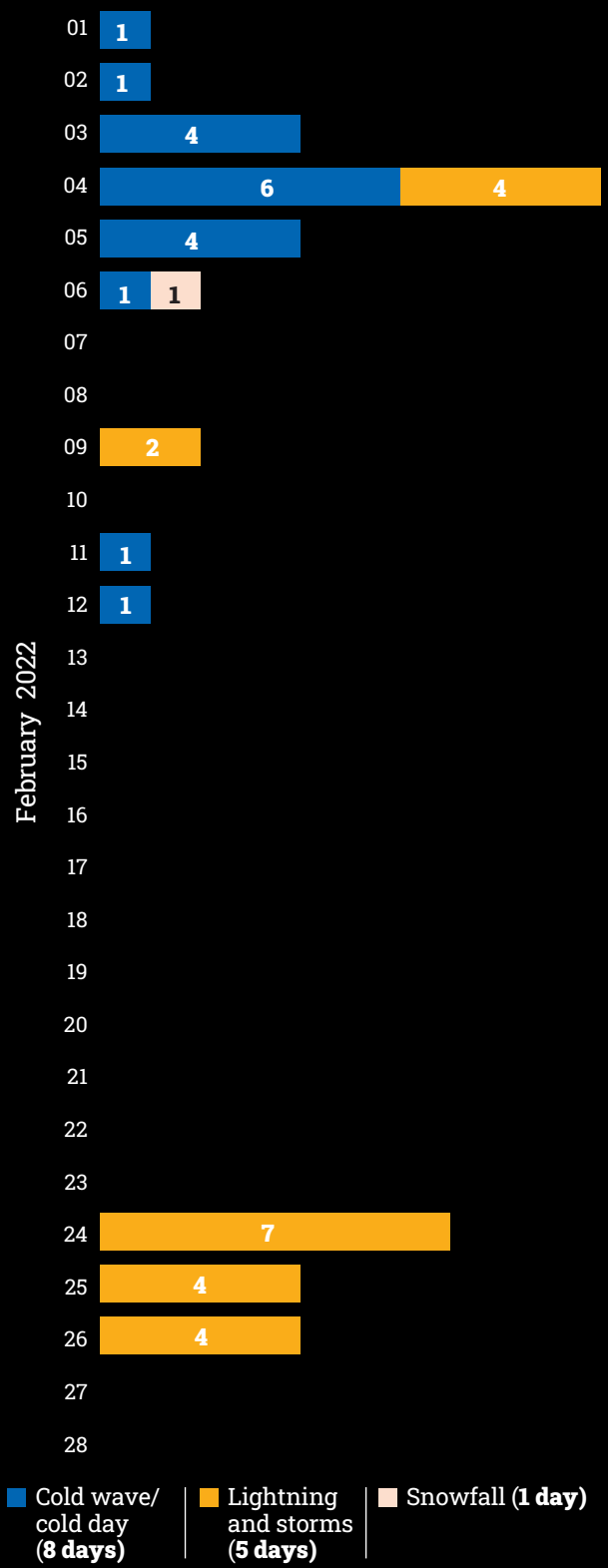
INDIA 2022
FEBRUARY

EXTREME WEATHER EVENTS

India experienced extreme weather events on 12 out of 28 days in February. This was spread across 16 states/UTs. Uttar Pradesh was the worst hit with extreme weather events on 9 days in the month. The state experienced a cold wave/ cold day on six days and hailstorms on three days.



BARS INDICATE THE NUMBER OF STATES/ UTS THAT EXPERIENCED EXTREME WEATHER EVENTS EACH DAY



LOSS AND DAMAGE

7
people died due to extreme events in Arunachal Pradesh in February

16,187 hectares
of crop area was affected in Haryana due to hailstorms

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

PRE MONSOON

March-May 2022

92 Days

Unusually hot March and April led to the early onset of heatwaves this year. While the temperature was largely normal in May, the month saw heavy rainfall triggering floods in Assam and Meghalaya.

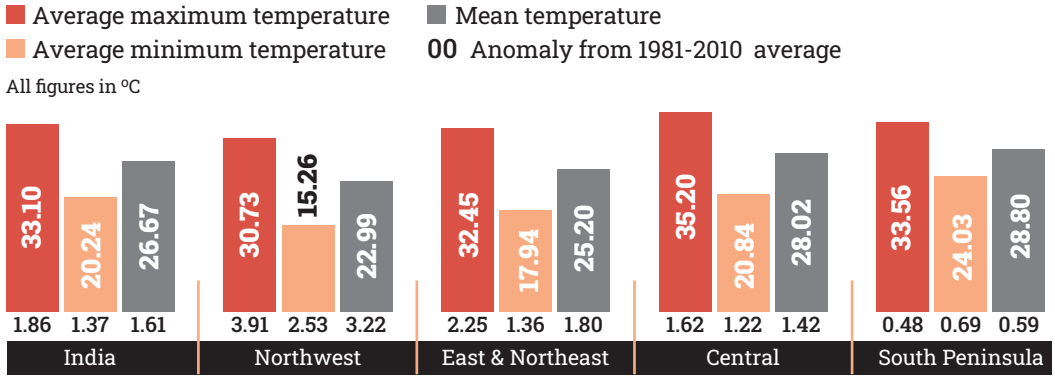
India experienced extreme weather events on 81 out of 92 days in the summer months of 2022. The events were spread across 31 states/UTs. Heatwaves were reported on 51 days, followed by lightning and storms on 43 days and heavy rains, floods and landslides on 29 days.

Rajasthan and Assam were the worst hit with extreme weather events on 36 days. They were followed by Madhya Pradesh (32 days).

TEMPERATURE

India experienced its hottest March on record with the maximum or daytime temperature 1.86ºC higher than long period average (1981 to 2010). The average minimum or night-time temperature was third highest and mean temperature was second highest since 1901.

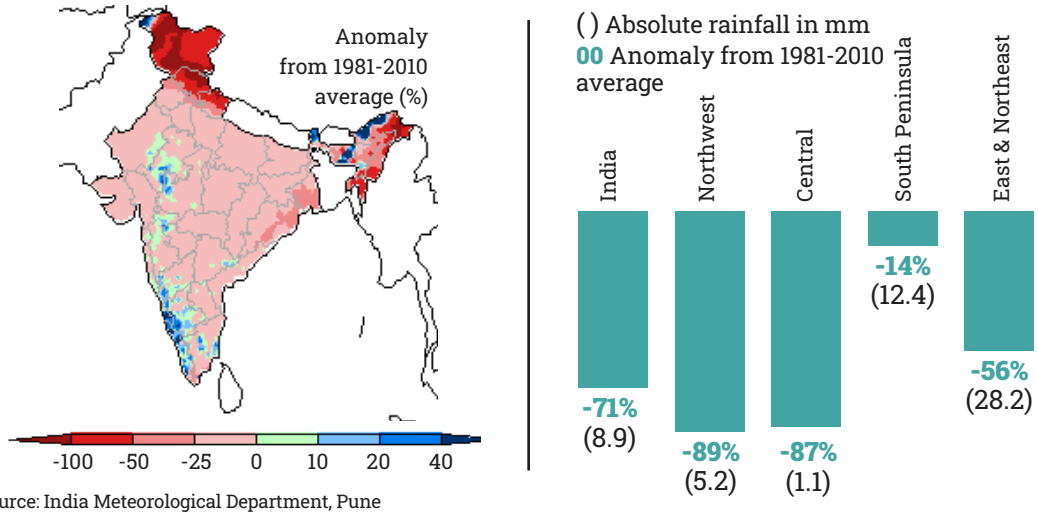
In 2022, India recorded its hottest March in 121 years



RAINFALL

India received only 8.9 mm rainfall through the month, making it the third driest March on record after 1909 (7.2mm) and 1908 (8.7mm). This is 71 per cent lower than the average rainfall levels of 30.4 mm. Northwest India and Central India saw deficit rainfall of 89 and 87 per cent respectively.

The month was also the driest in 112 years

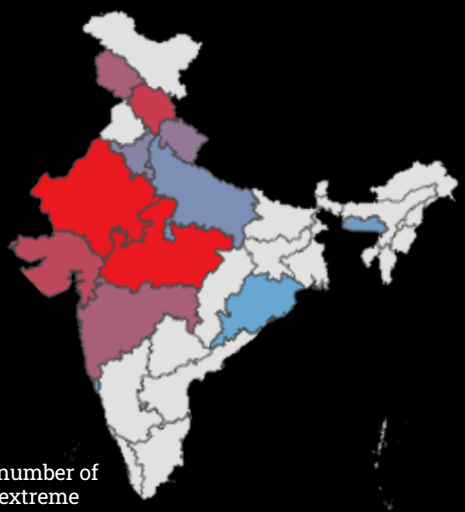


Source: India Meteorological Department, Pune

INDIA 2022
MARCH

EXTREME WEATHER EVENTS

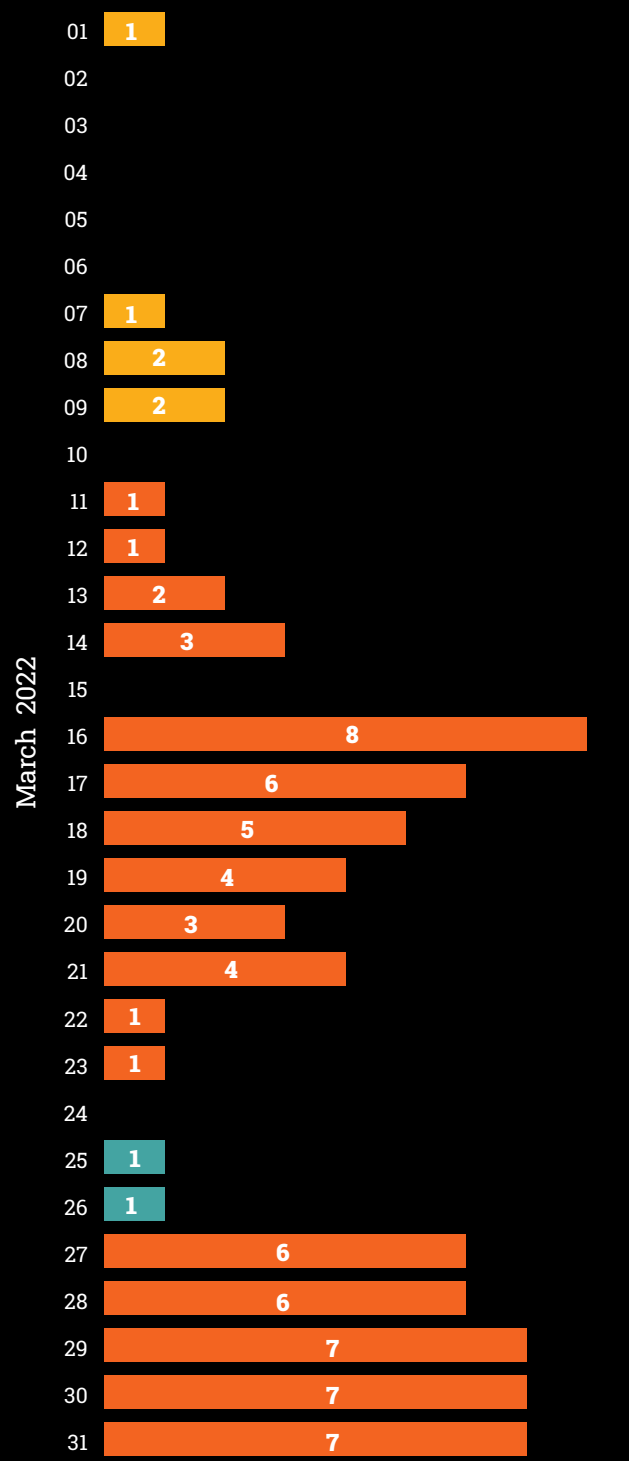
India experienced extreme weather events on 23 out of 31 days in March. This was spread across 13 states/UTs. Rajasthan was the worst hit with extreme weather events on 14 days in the month. The state experienced heatwaves on 12 days and lightning and storms on two days. Madhya Pradesh experienced heatwaves on 13 days.



Statewise number of days with extreme weather events

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

BARS INDICATE THE NUMBER OF STATES/ UTS THAT EXPERIENCED EXTREME WEATHER EVENTS EACH DAY



LOSS AND DAMAGE

3
people died due to extreme events in Maharashtra in March

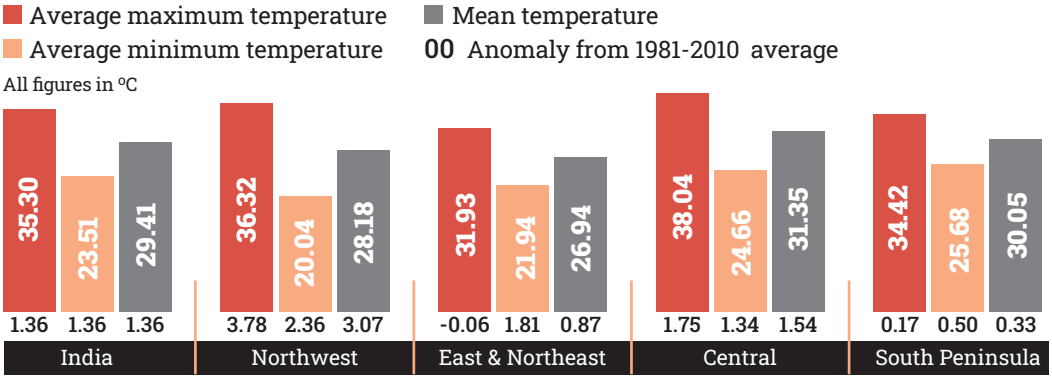
N/A
No crop area was affected across India

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

TEMPERATURE

April was usually warm this year with the average maximum temperature soaring to 35.3°C, the third highest since 1901, after 2010 (35.42°C) and 2016 (35.32°C). India also experienced the second highest mean and average minimum temperatures.

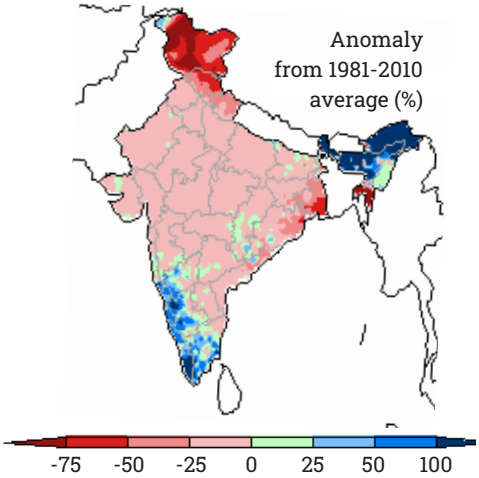
In 2022, Northwest India saw its warmest April in 121 years

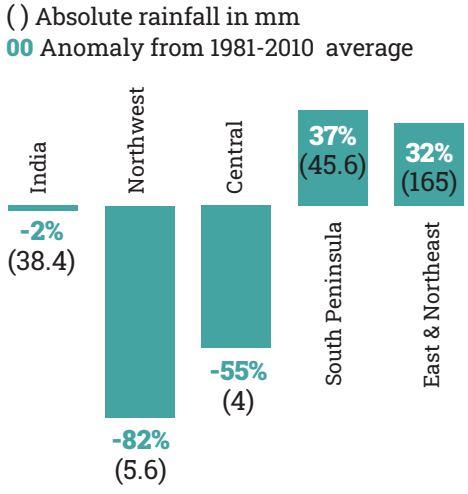


RAINFALL

While India received normal rainfall in the month, there was substantial regional variation. Northwest and Central India received deficit rainfall, and South Peninsula and East and Northeast received surplus rainfall. Rainfall over Northwest India was third lowest since 1901, after 1947 (1.8 mm) and 1954 (4.4 mm).

Northwest region experienced its driest April in 68 years



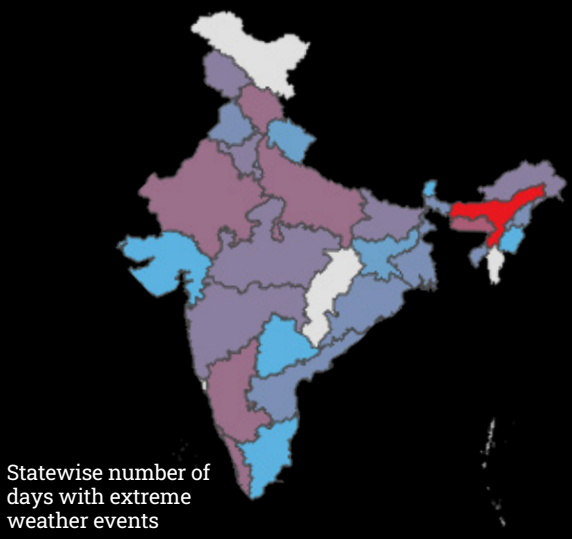


Source: India Meteorological Department, Pune

INDIA 2022
APRIL

EXTREME WEATHER EVENTS

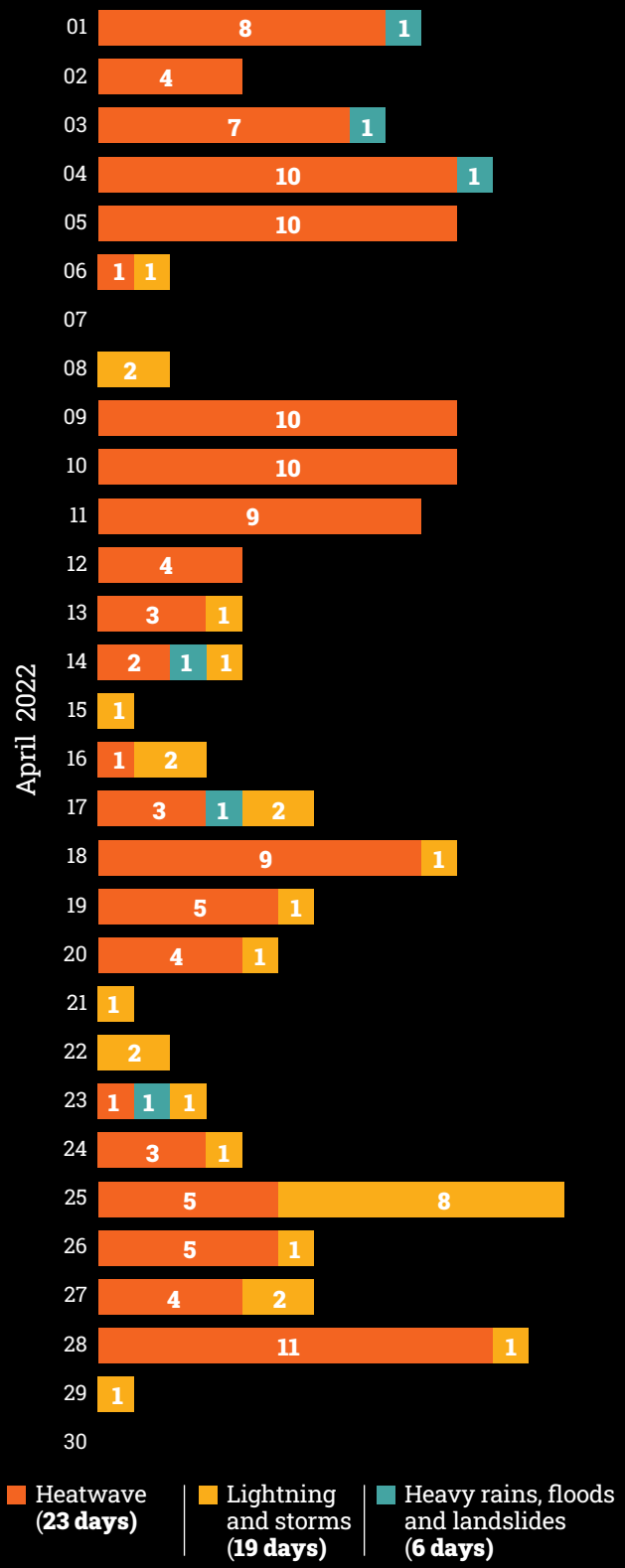
India experienced extreme weather events on 28 out of 30 days in April. This was spread across 22 states/UTs. Jharkhand experienced heatwaves on 17 days in the month, followed by Assam (16 days), and Rajasthan and Himachal Pradesh (14 days each).



Statewise number of days with extreme weather events

0 2 4 6 8 10 12 14 16 18 20

BARS INDICATE THE NUMBER OF STATES/ UTS THAT EXPERIENCED EXTREME WEATHER EVENTS EACH DAY



LOSS AND DAMAGE

61
people died due to extreme events across 10 states/UTs in April

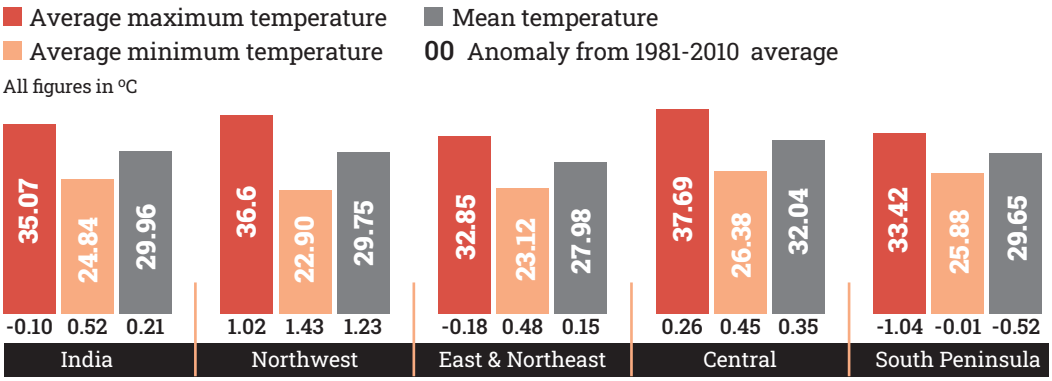
N/A
No crop area was affected across India

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

TEMPERATURE

Temperature wise, May was largely normal. The average maximum temperature was 0.1°C below normal, average minimum temperature was 0.52°C above normal and mean temperature was 0.21°C above normal for the country as a whole.

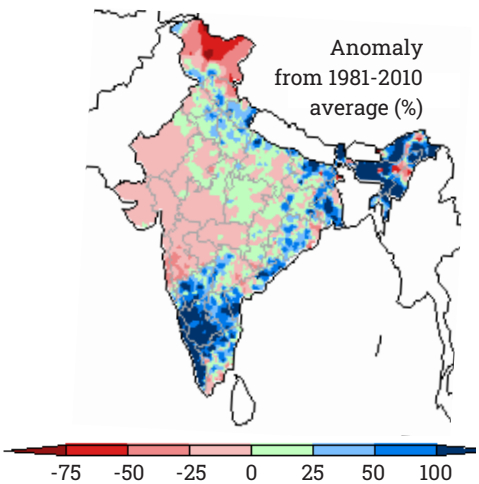
Northwest India saw 1.43°C warmer night-time temperature this May

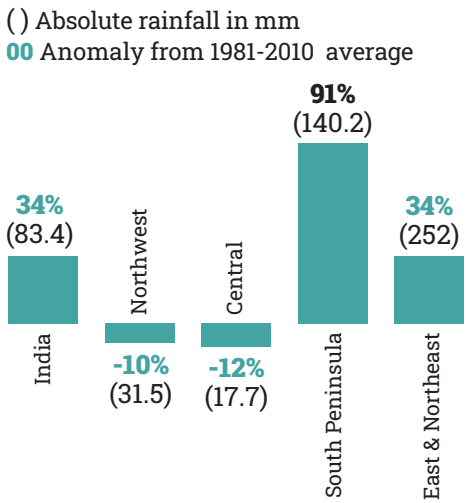


RAINFALL

India experienced a wet May (83.4 mm) this year, with rainfall levels over 34 per cent the long period average (1981-2010). While surplus rainfall was recorded in the South Peninsula and East and Northeast states, deficit rainfall was recorded in Northwest and Central India.

This year, South Karnataka saw its wettest May in 121 years





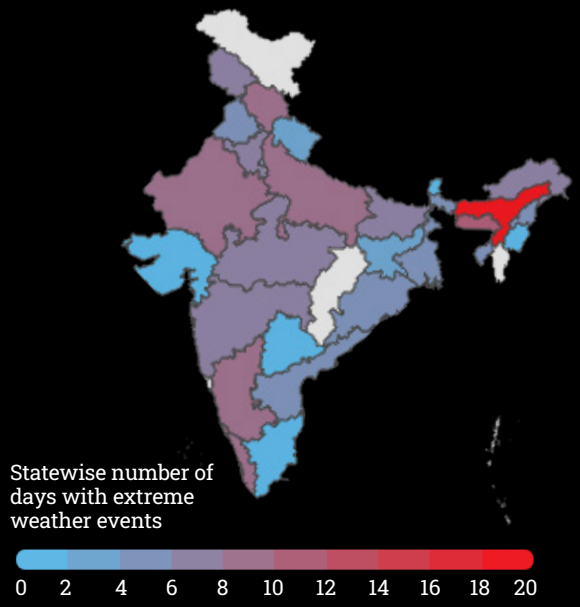
Source: India Meteorological Department, Pune

INDIA 2022

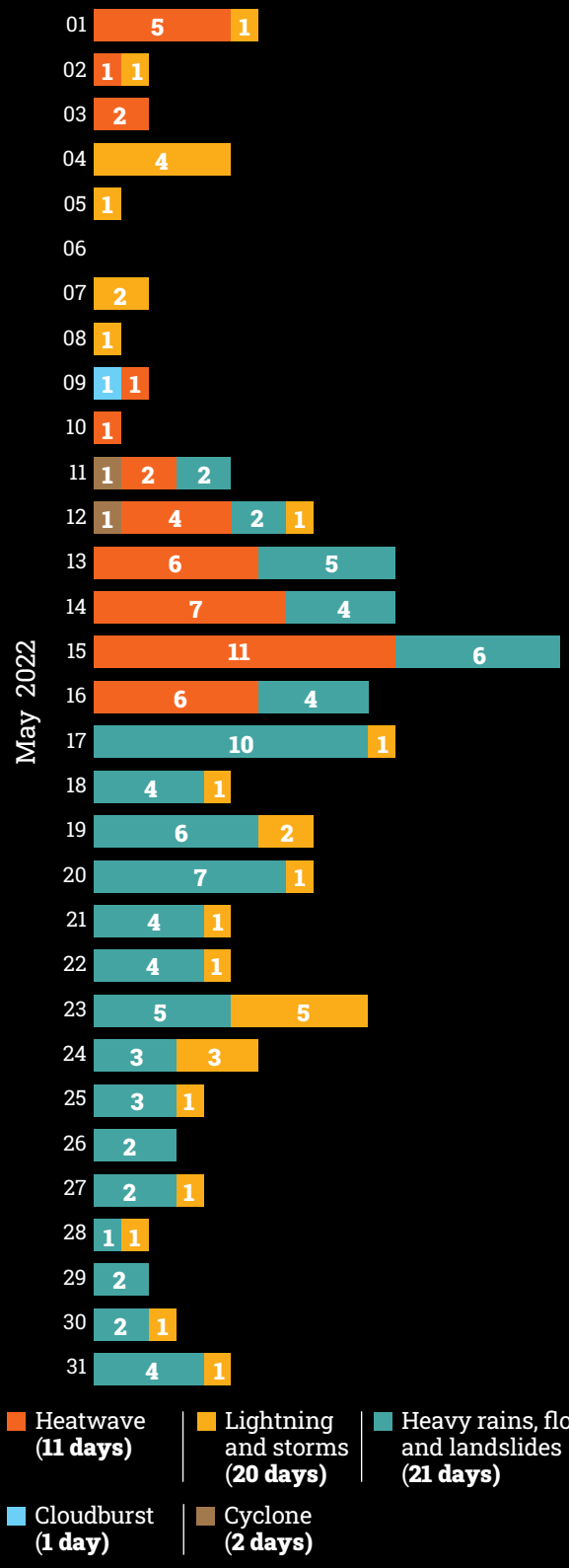
MAY

EXTREME WEATHER EVENTS

India experienced extreme weather events on 30 out of 31 days in May. This was spread across 30 states/UTs. Assam experienced heavy rainfall, floods and landslides on 20 days. Karnataka recorded extreme weather events on 9 days, followed by Himachal Pradesh (8 days).



BARS INDICATE THE NUMBER OF STATES/ UTS THAT EXPERIENCED EXTREME WEATHER EVENTS EACH DAY



LOSS AND DAMAGE

230
people died due to extreme events across 15 states/UTs in May

13,169 hectares
of crop area was affected in Andhra Pradesh

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

MONSOON

June-September 2022

122 Days

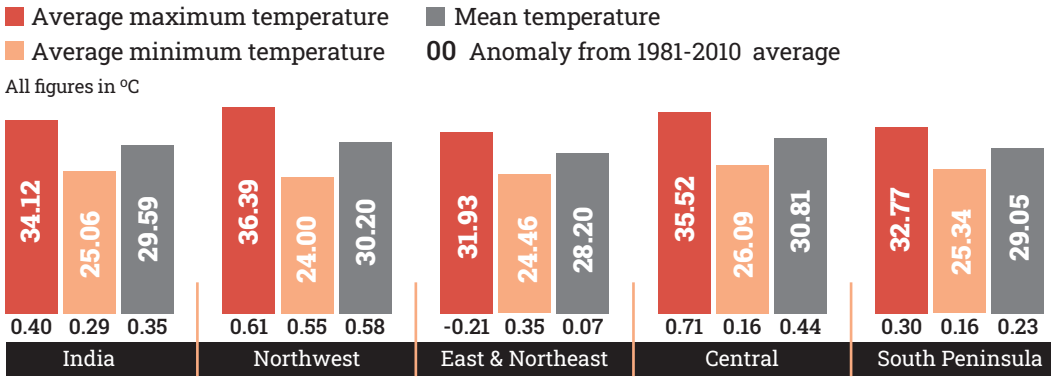
While India experienced an overall normal monsoon, the season oscillated between dry and wet spells. It began in June with catastrophic floods in Northeast India, especially in Assam and Meghalaya. The region then went through a dry phase in July and August. In July, Gujarat, Rajasthan and Maharashtra suffered from floods. August brought flood-like conditions in Kerala, Karnataka and central Indian states of Odisha and Madhya Pradesh.

Extreme weather events were reported on all 122 days between June and September 2022, and they claimed over 2,400 human lives and damaged 1.8 million hectares of cropped area and 0.4 million houses.

TEMPERATURE

June was marginally warmer than usual. The average daytime temperature was 0.4°C above the long period average (1981-2010), average night-time temperature was 0.29°C above normal and mean temperature was 0.35°C above normal for the country as a whole.

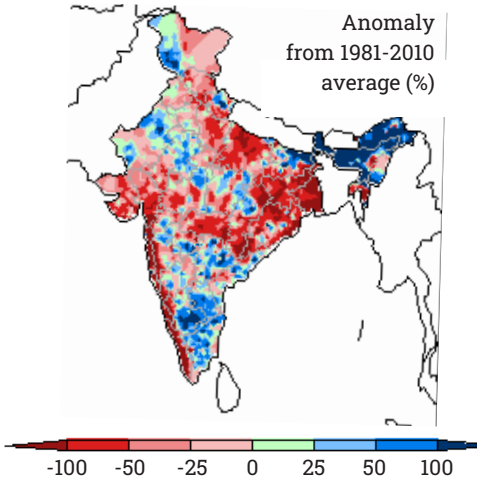
Central India was a 0.71°C warmer this June

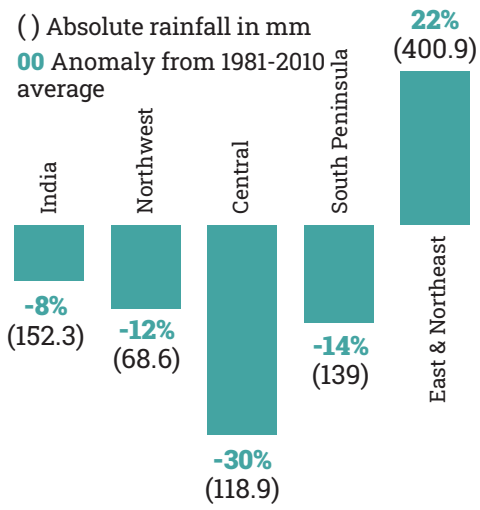


RAINFALL

India experienced a near-normal rain this June (152.3 mm). With 858.1 mm rainfall, Assam and Meghalaya experienced their wettest June since 1901. In contrast, Kerala and Mahe in Puducherry recorded their fourth lowest June rainfall (308.7 mm) since 1901.

Assam & Meghalaya saw wettest June in 121 years





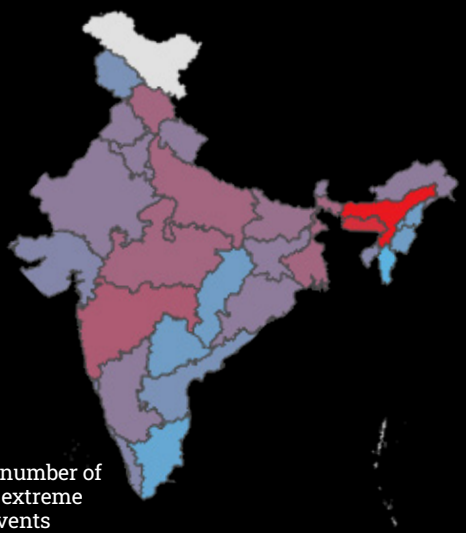
Source: India Meteorological Department, Pune

INDIA 2022

JUNE

EXTREME WEATHER EVENTS

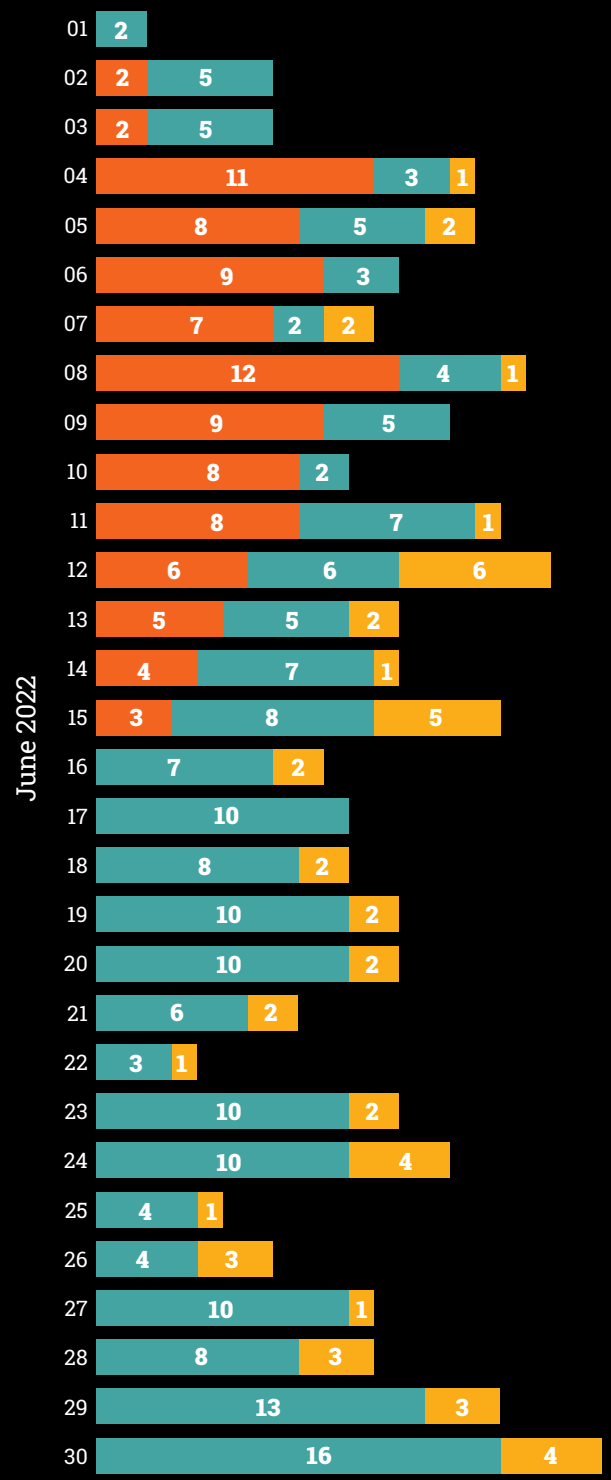
India experienced heavy rains, floods and landslides on all the 30 days of the month. This was spread across 32 states/UTs. The country also experienced lightning and storms (23 days) and heatwaves (14 days).



Statewise number of days with extreme weather events

0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30

BARS INDICATE THE NUMBER OF STATES/ UTS THAT EXPERIENCED EXTREME WEATHER EVENTS EACH DAY



LOSS AND DAMAGE

757
people died due to extreme events across 24 states/UTs in June

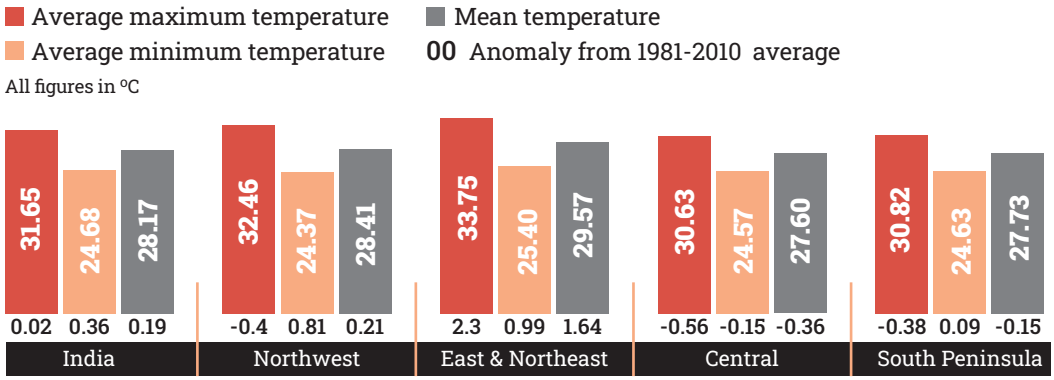
236,868 hectares
of crop area was affected across six states

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

TEMPERATURE

July was marginally warmer than usual. The average daytime was 0.02°C above the long period average (1981-2010), average night-time temperature and mean temperature were 0.36°C and 0.19°C above the long period average for the country as a whole.

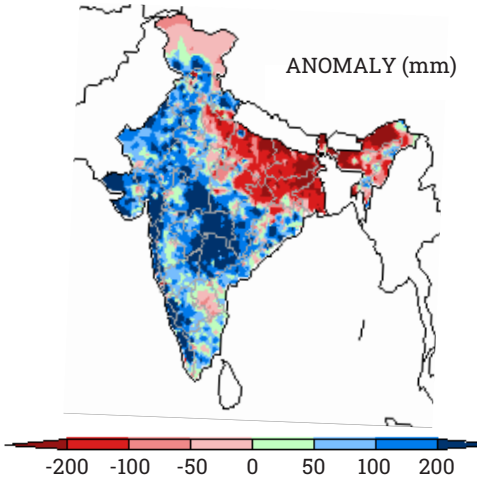
East & Northeast India saw its warmest July in 121 years

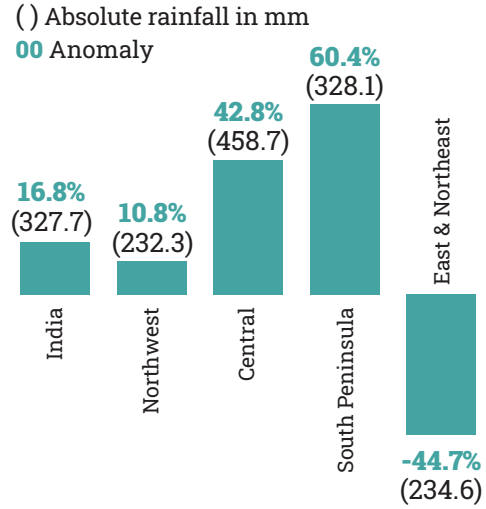


RAINFALL

India experienced a wetter July (327.7 mm) this year, with rainfall 17 per cent more than the long period average (1981-2010). While surplus rainfall was recorded in the South Peninsula, Central India and Northwest, deficit rainfall was recorded in East and Northeast India.

East & Northeast India also recorded its driest July in 121 years





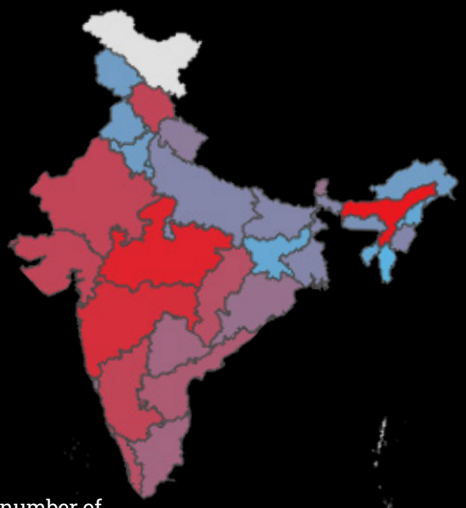
Source: India Meteorological Department, Pune

INDIA 2022

JULY

EXTREME WEATHER EVENTS

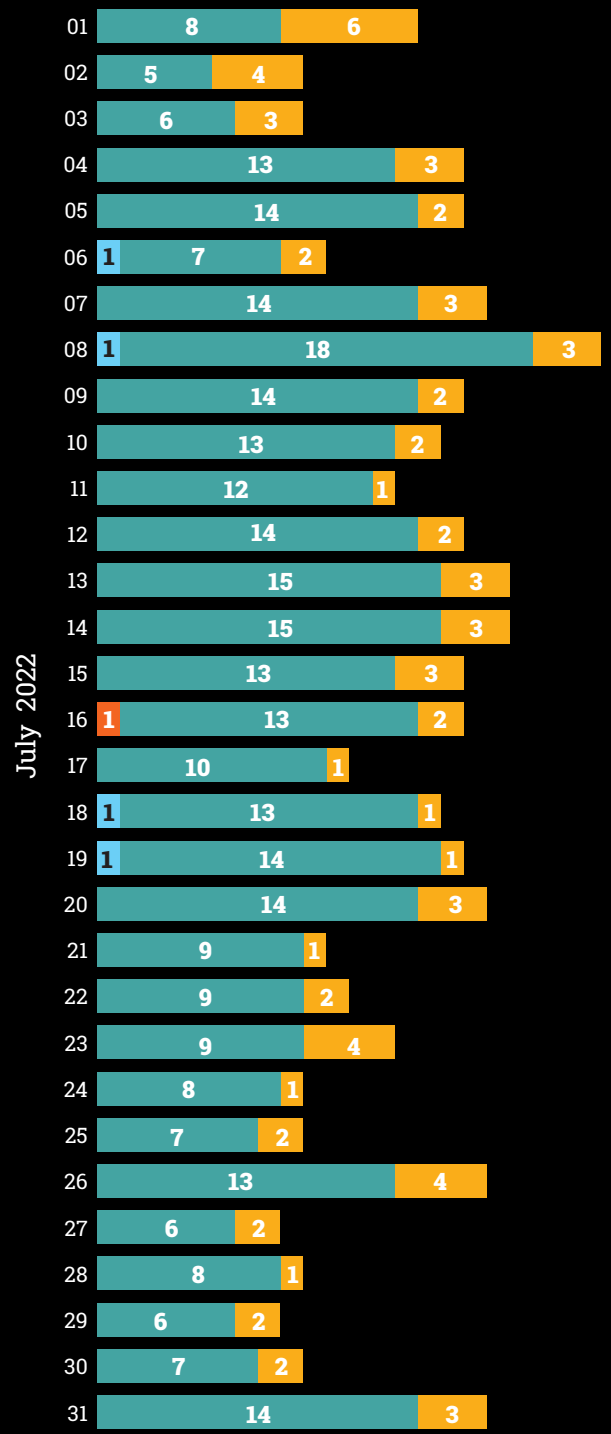
India experienced heavy rains, floods and landslides and lightning and storms on all the 31 days of the month. The extreme weather events were spread across 32 states/UTs.



Statewise number of days with extreme weather events

0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30

BARS INDICATE THE NUMBER OF STATES/ UTS THAT EXPERIENCED EXTREME WEATHER EVENTS EACH DAY



Heatwave **(1 days)**

Cloudburst **(4 days)**

Lightning and storms **(31 days)**

Heavy rains, floods and landslides **(31 days)**

LOSS AND DAMAGE

813
people died due to extreme events across 24 states/UTs in June

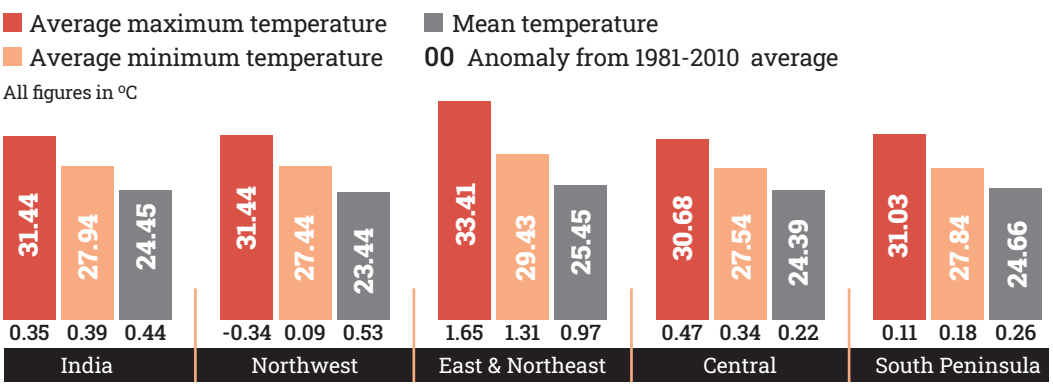
121,651 hectares
of crop area was affected across eight states

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

TEMPERATURE

August was warmer than usual. India's average minimum temperature for the month was fourth highest with 24.45°C after 2020 (24.73°C), 1931 (24.52°C), 2009 (24.46°C).

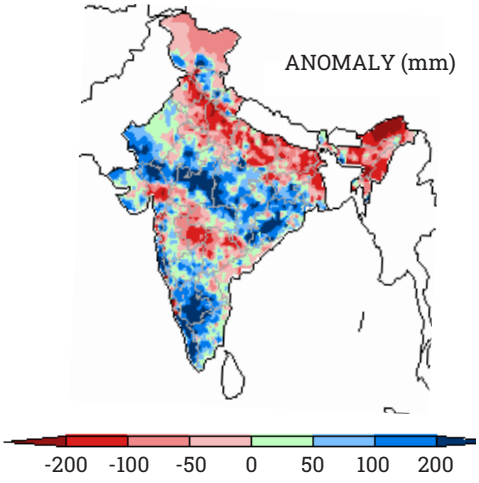
East & Northeast India saw its warmest August in 121 years

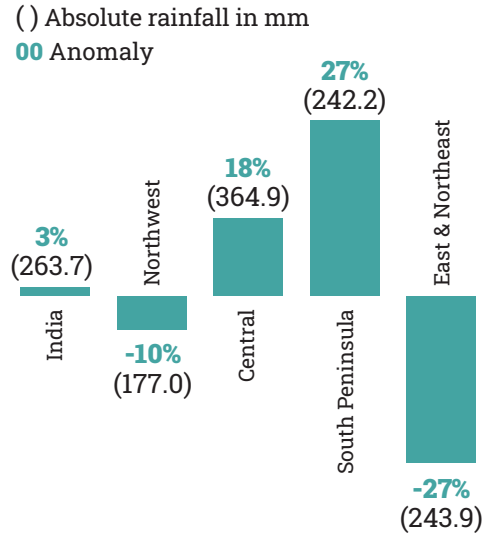


RAINFALL

India experienced a near-normal rain this August (263.7 mm). With 243.9 mm rainfall, East and Northeast India experienced their third lowest rainfall since 1901. In contrast, South Peninsula and Central regions recorded their fourth highest rainfall for August in 20 years

East & Northeast India recorded its third driest August in 121 years



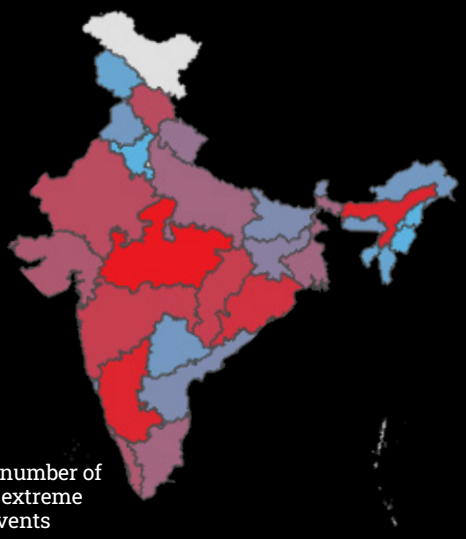


Source: India Meteorological Department, Pune

INDIA 2022
AUGUST

EXTREME WEATHER EVENTS

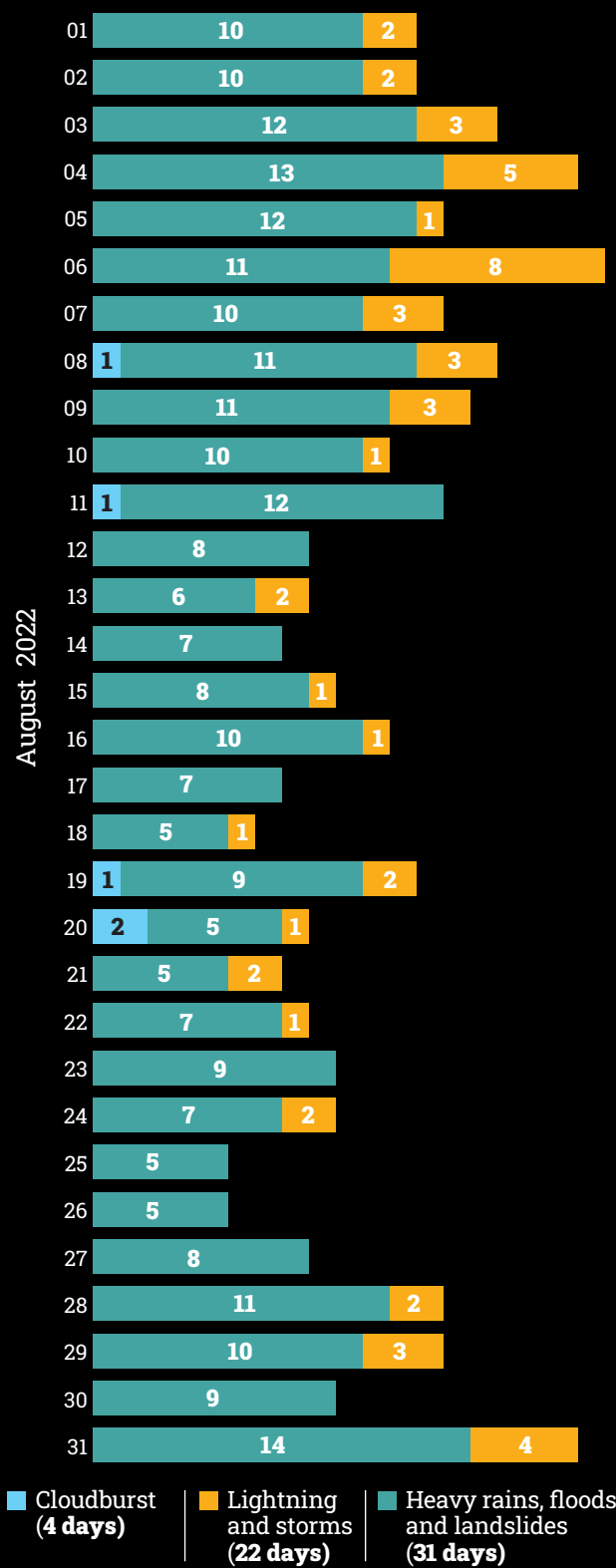
India experienced heavy rains, floods and landslides on all the 31 days of the month. They were spread across 31 states/UTs. Madhya Pradesh was the worst hit with extreme weather events on 27 days. It was followed by Assam and Karnataka with 22 days each.



Statewise number of days with extreme weather events

0 2 4 6 8 10 12 14 16 18 20 22 24 26

BARS INDICATE THE NUMBER OF STATES/ UTS THAT EXPERIENCED EXTREME WEATHER EVENTS EACH DAY



LOSS AND DAMAGE

466
people died due to extreme events across 22 states/UTs in August

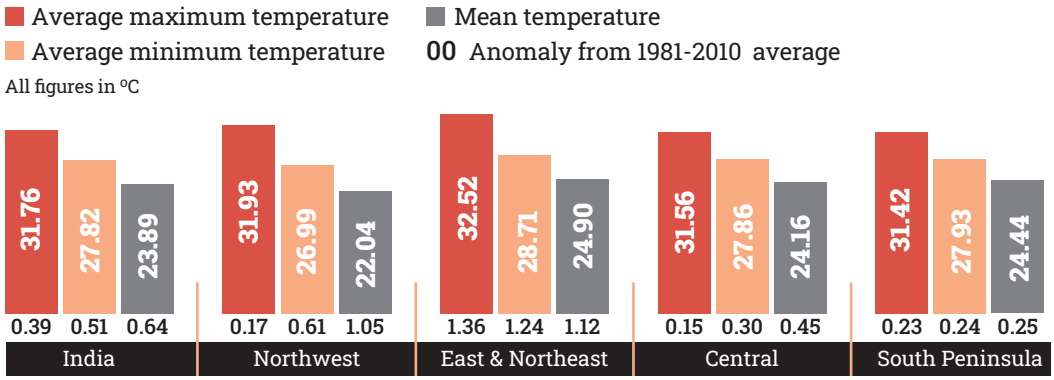
756,538 hectares
of crop area was affected across seven states

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

TEMPERATURE

September was warmer than usual. India's average minimum temperature was third highest with 23.89°C after 2020 (24.08°C) and 2021 (24.06°C).

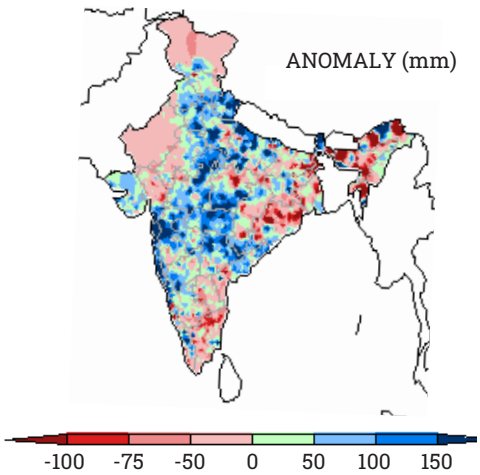
East & Northeast India saw its fourth warmest September in 121 years

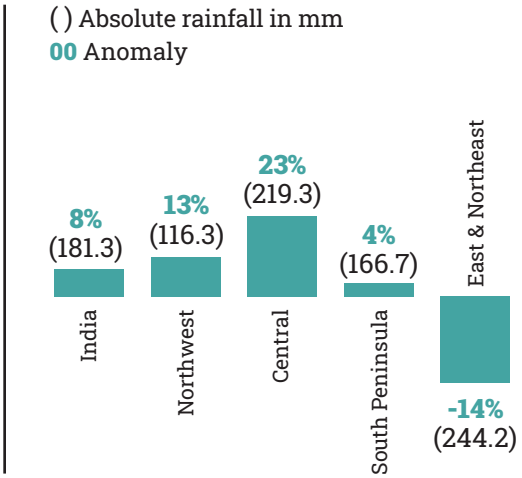


RAINFALL

India experienced a near-normal rain this September (181.3 mm). Central and Northwest India experienced 23 and 13 per cent surplus rainfall respectively. In contrast, East & Northeast India recorded a 14 per cent deficit rainfall.

East & Northeast India also saw a 14 per cent rainfall deficit



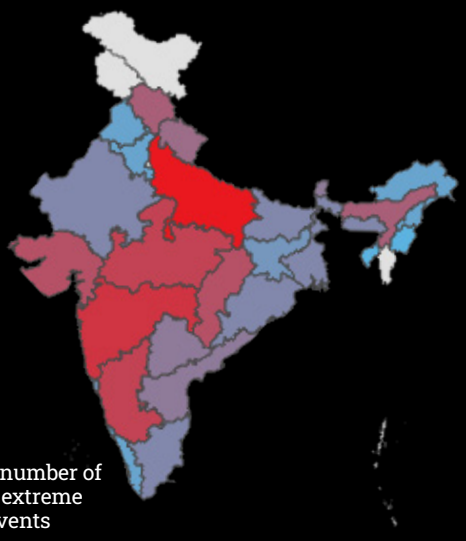


Source: India Meteorological Department, Pune

INDIA 2022
SEPTEMBER

EXTREME WEATHER EVENTS

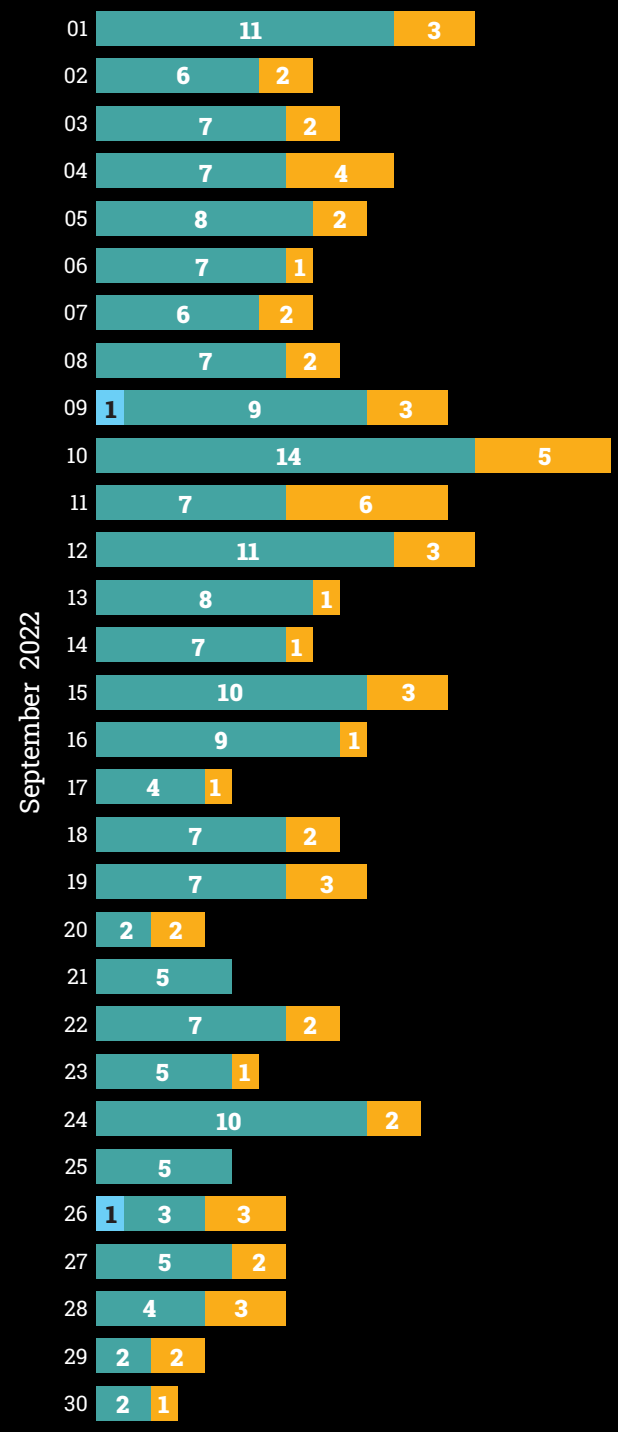
India experienced extreme weather events on all the 30 days of the month. This was spread across 31 states/UTs. Uttar Pradesh experienced extreme weather events on 24 days, followed by Maharashtra (19 days) and Madhya Pradesh (18 days).



Statewise number of days with extreme weather events

0 2 4 6 8 10 12 14 16 18 20 22 24

BARS INDICATE THE NUMBER OF STATES/ UTS THAT EXPERIENCED EXTREME WEATHER EVENTS EACH DAY



LOSS AND DAMAGE

395
people died due to extreme events across 22 states/UTs in September

682,134 hectares
of crop area was affected across seven states

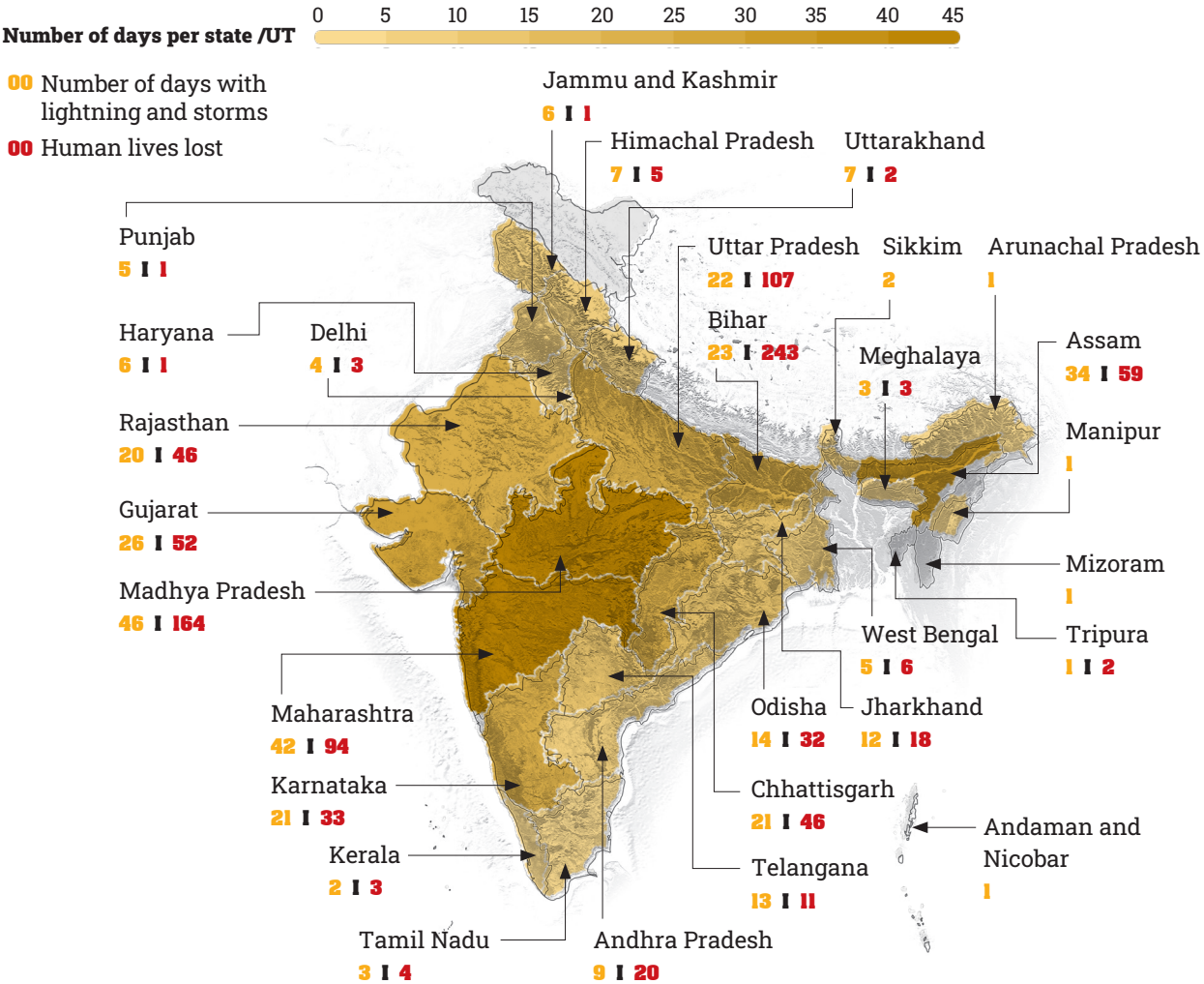
Sources: India Meteorological Department, Pune, Disaster Management Division under the Union Ministry of Home Affairs and media reports

EXTREME WEATHER EVENTS

DISASTER-WISE

LIGHTNING AND STORMS

On 159 of 273 days, India experienced lightning and storms. They claimed 954 lives.

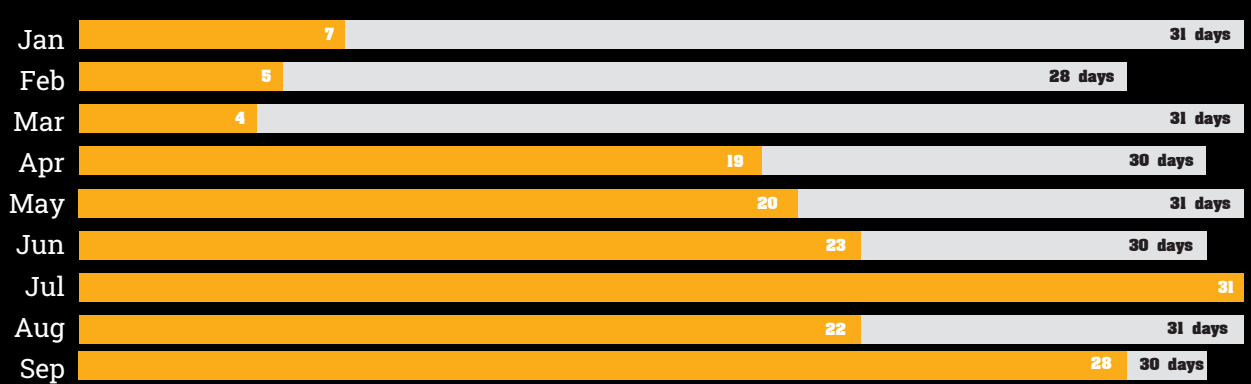


IMD definition/criteria

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

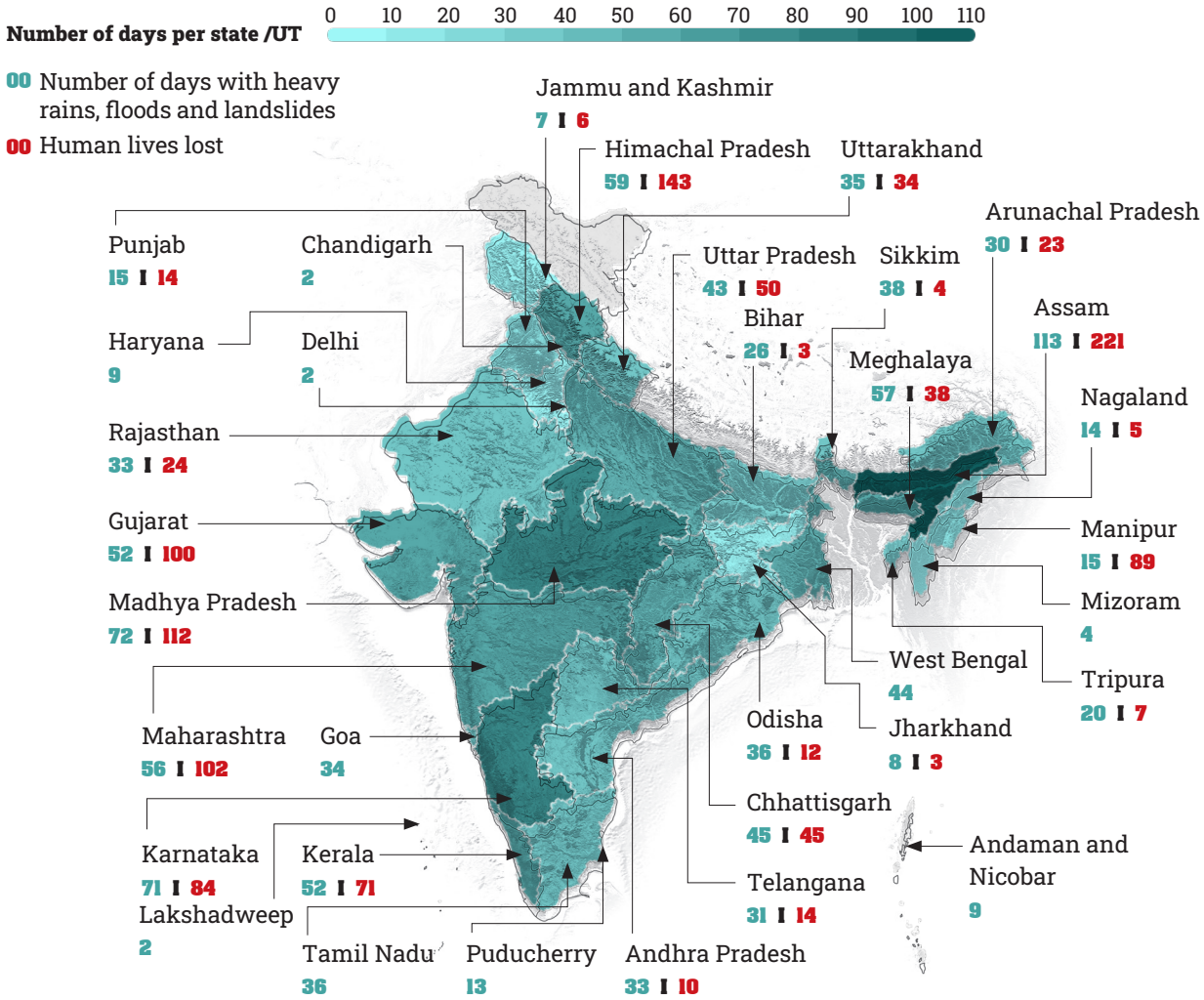
The number of days lightning and storms were recorded in India



INDIA 2022

HEAVY RAINS, FLOODS AND LANDSLIDES

On 157 of 273 days, India experienced the extreme weather event. They claimed 1,214 lives.



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.

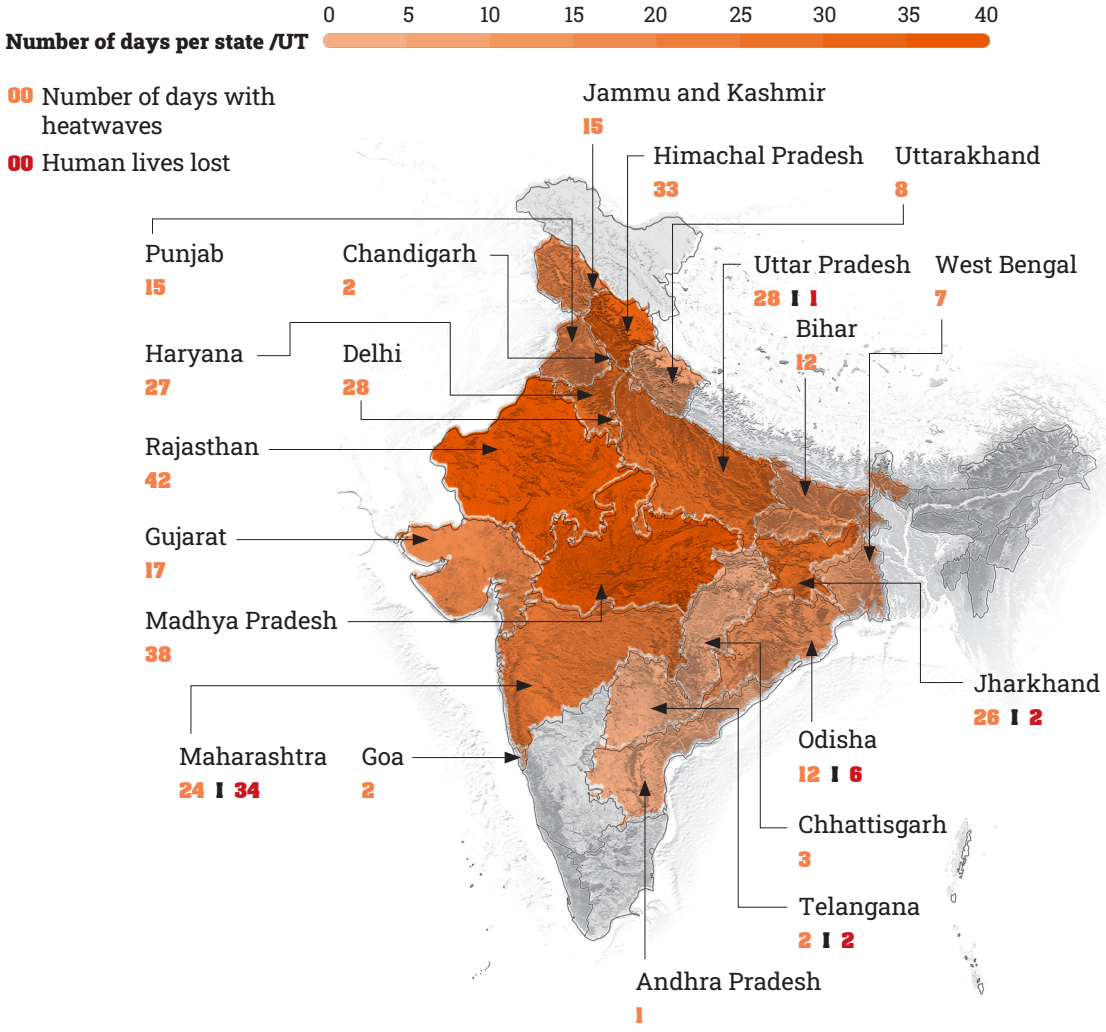
FREQUENCY TRACKER

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

INDIA 2022

HEATWAVES

On 66 of 273 days, India experienced heatwaves. They were spread across 20 states/UTs and claimed 45 lives.

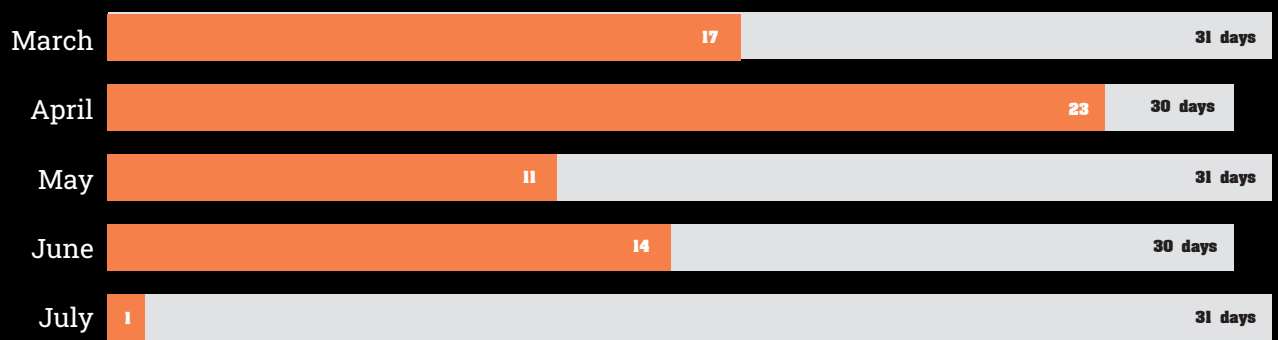


IMD definition/criteria

Heatwave conditions signify a certain amount of rise in temperature at a given place with respect to 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

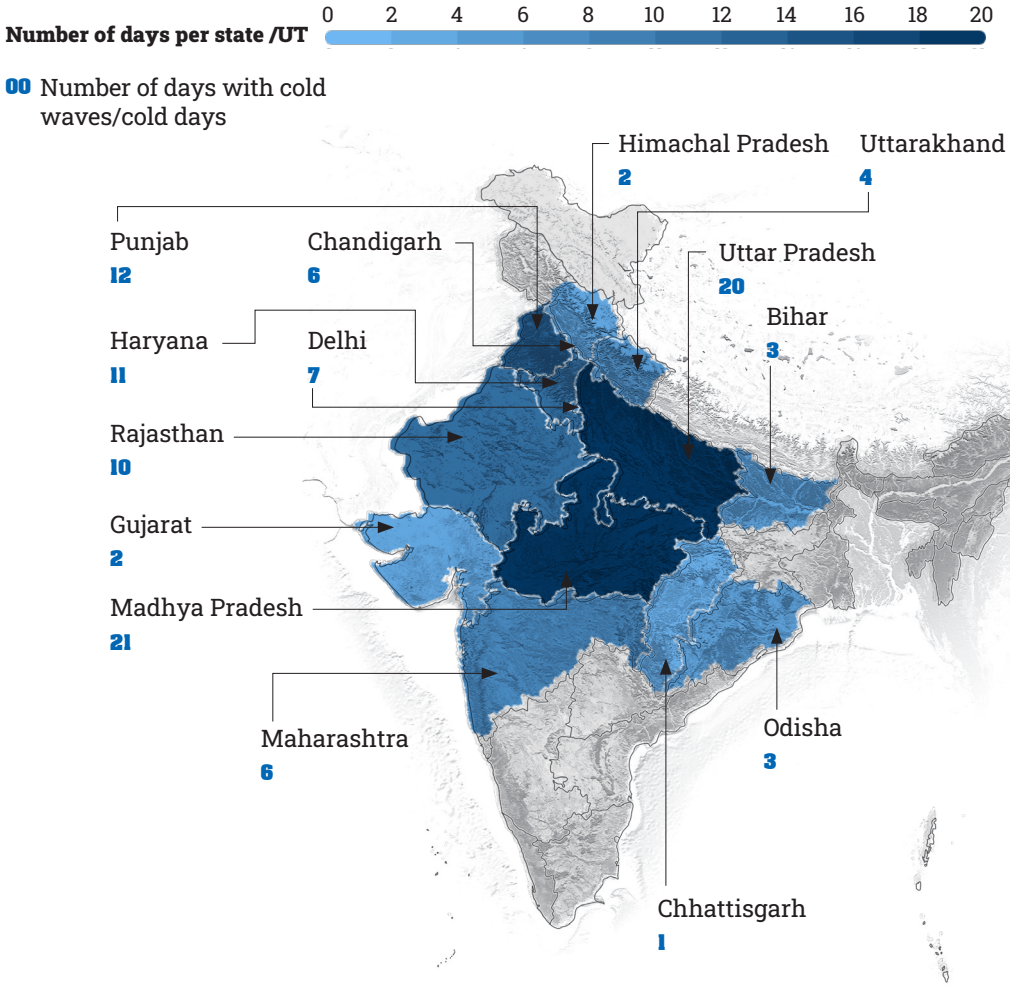
The number of days heatwaves were recorded in India



INDIA 2022

COLD WAVES/COLD DAYS

On 30 of 273 days, India experienced cold wave/cold day. They were spread across 14 states/UTs



IMD definition/criteria

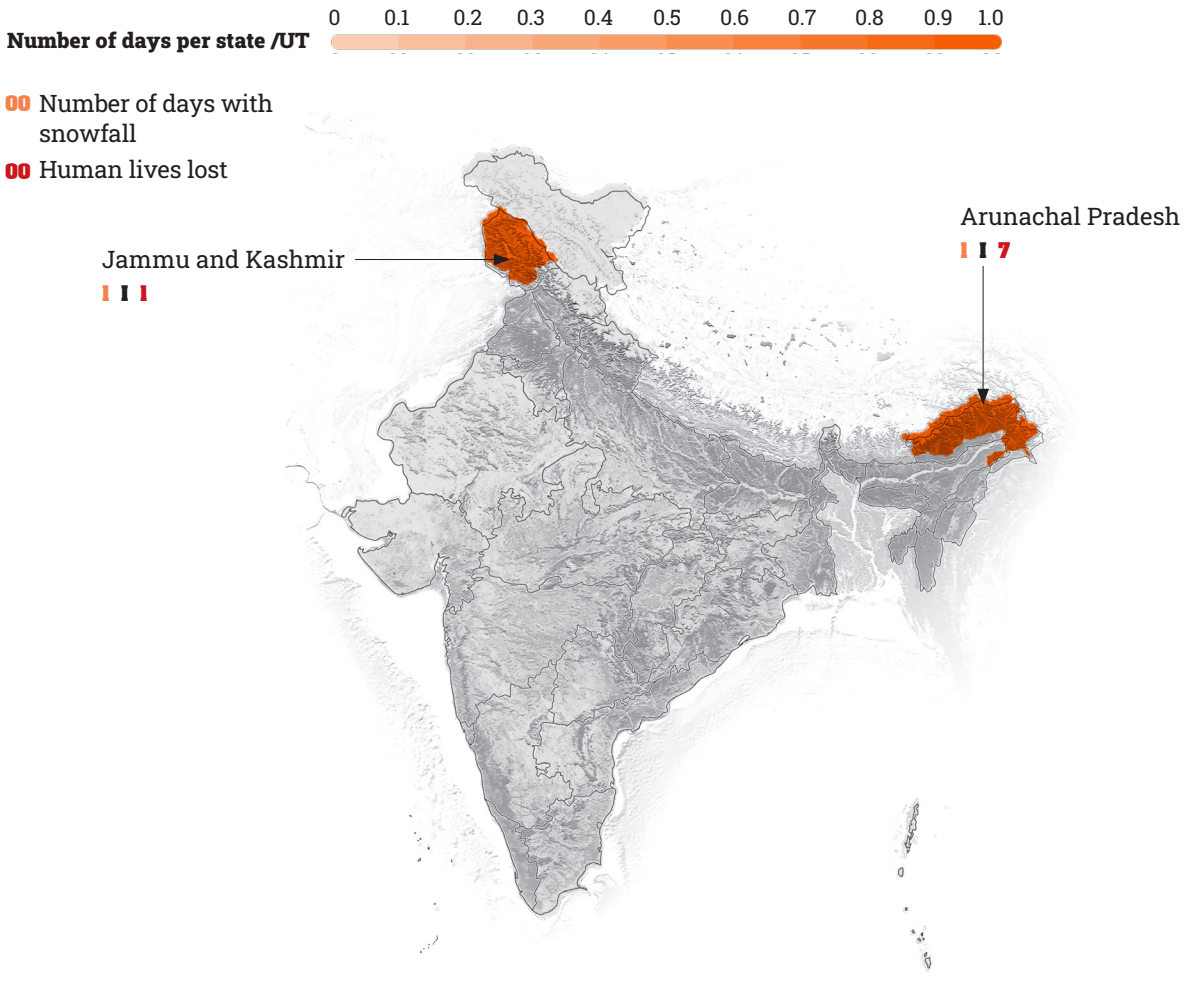
Cold day conditions occur when the maximum temperature drops by 4.5°C to 6.4°C than average. If the deviation is more than 6.4°C, then it is considered severe cold day. Cold wave conditions occur when the minimum temperature drops by 4.5°C to 6.4°C than normal. Similarly, severe coldwave occurs when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

FREQUENCY TRACKER

The number of days with cold waves/cold days

SNOWFALL

On 2 of 273 days, India experienced snowfall. They were spread across 2 states/UTs and claimed 8 lives.

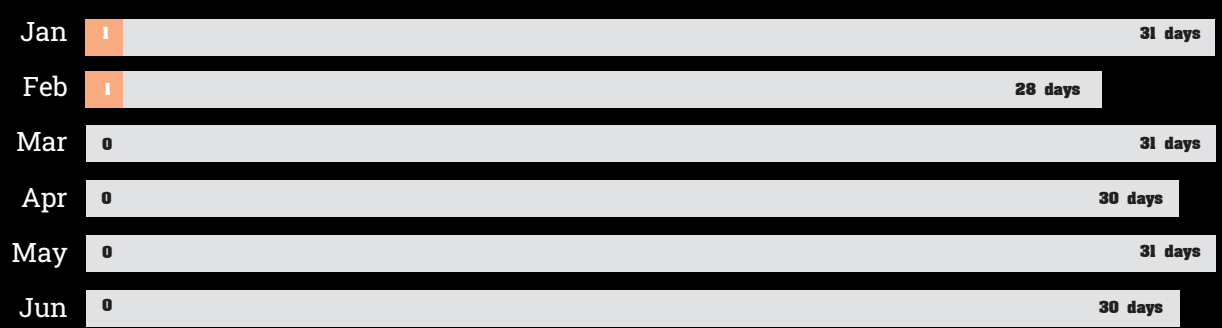


IMD definition/criteria

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. The report has also considered only those snowfall events that caused human deaths.

FREQUENCY TRACKER

The number of days with snowfall



INDIA 2022

CLOUDBURSTS

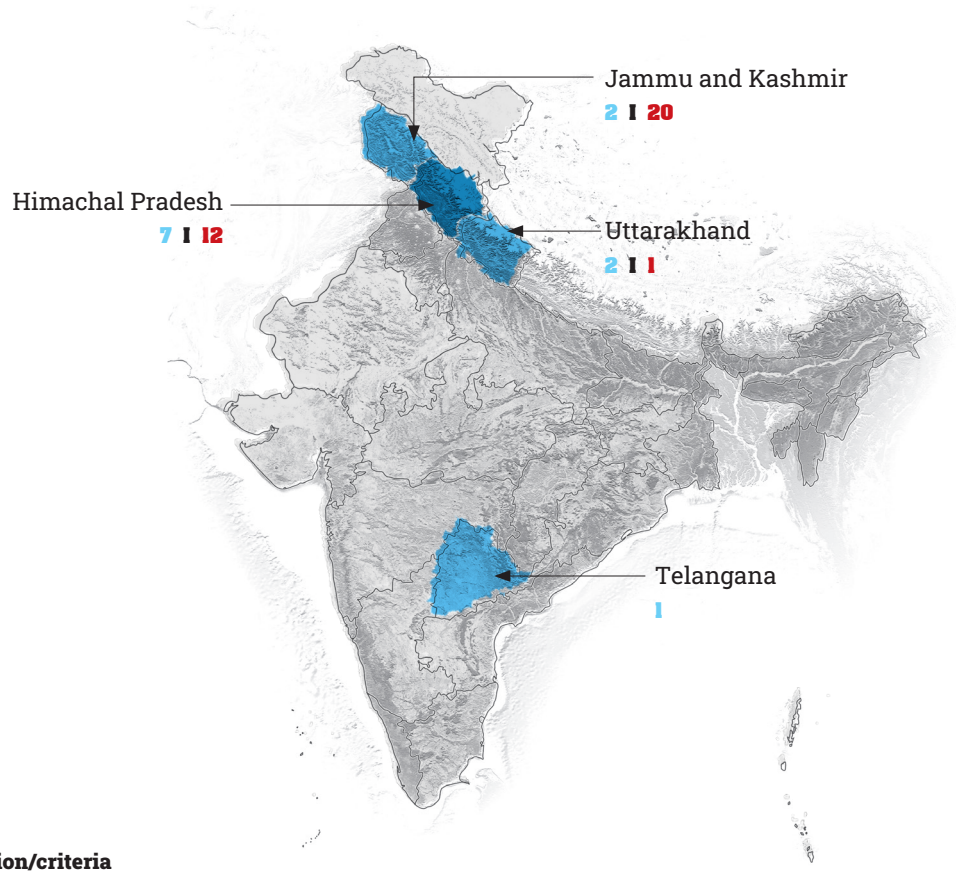
On 11 of 273 days, India experienced cloudbursts. They claimed 33 lives across four states/UTs

Number of days per state /UT

0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0

00 Number of days with cloudbursts

00 Human lives lost

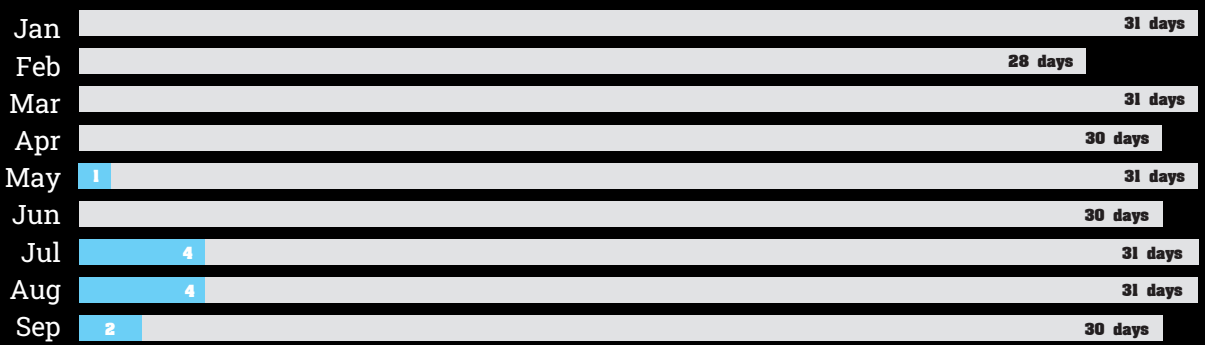


IMD definition/criteria

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 with cloudbursts



CYCLONES

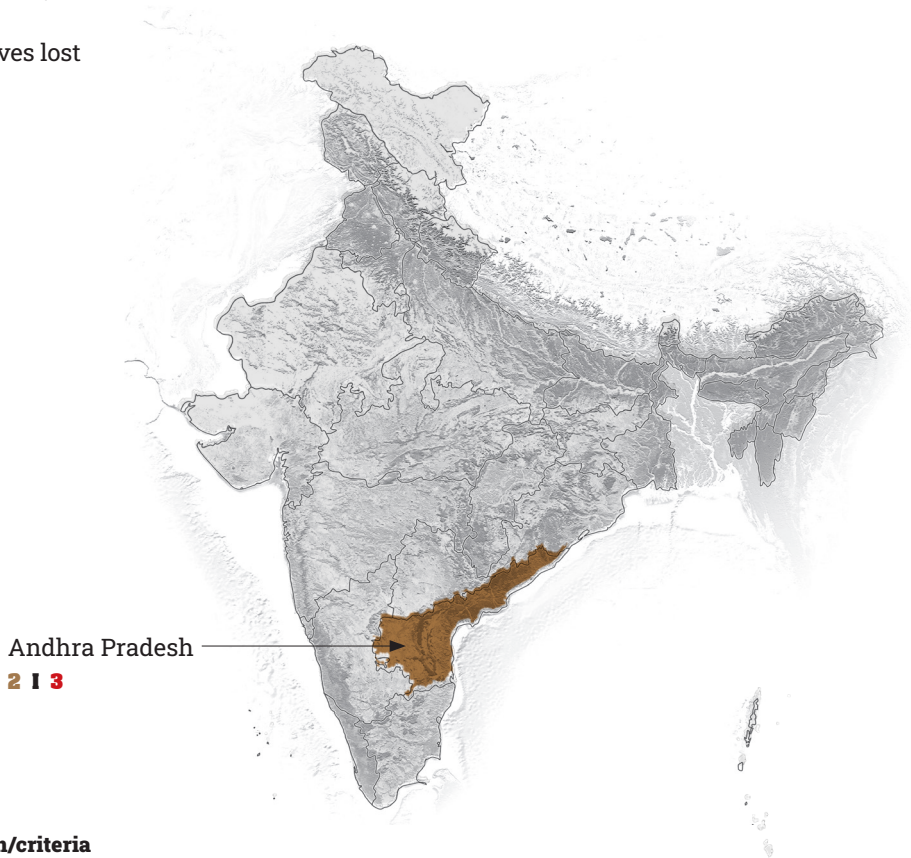
On 2 of 273 days, India experienced cyclones. They claimed three lives in Andhra Pradesh.

Number of days per state /UT

0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0

00 Number of days with cyclones

00 Human lives lost



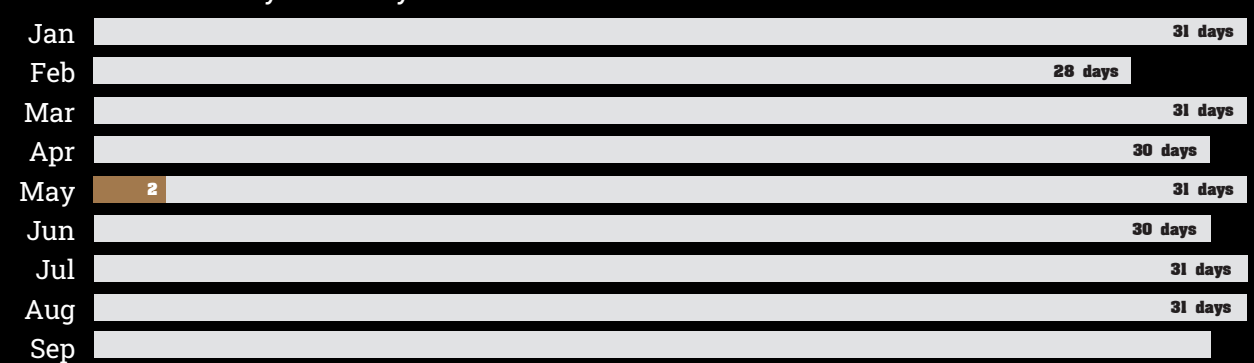
IMD definition/criteria

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 with cyclones



EXTREME WEATHER EVENTS

CLIMATE CHANGE COSTS

IN June 2020, the Ministry of Earth Sciences released India's first national climate assessment in a report titled "Assessment of Climate Change over the Indian Region". The report highlights several troubling yet unsurprising findings with respect to both climate trends over the past few decades, and projections for India's future.

The report finds that the surface air temperature over India has increased by 0.7°C between 1901 and 2018. Subsequently, the mean temperature rise over India by the end of the 21st century is projected to be in the range of 2.4 to 4.4°C relative to the average temperature between 1976 and 2005—a change that would be catastrophic for all life forms. The Indian Ocean has also warmed considerably in recent decades: by 1°C on average between 1951 and 2015.

TEMPERATURE RISE

Warming has occurred across most of South Asia over the 20th century and into the 2000s, with more temperature extremes, lesser numbers of cold days and nights, greater numbers of warm days and nights, and rising heat wave frequency, suggests the Climate Change and Land report by Intergovernmental Panel on Climate Change (IPCC) in 2019.

India Meteorological Department (IMD) data indicates that this regional trend is also visible in the country. All-India annual mean surface air temperature has increased by 0.6°C between 1901 and 2010, with most of this rise happening in the past 30 years. Since 1986, the country has warmed 0.15°C, 0.15°C and 0.13°C per decade (taking the annual mean, maximum and minimum temperatures averaged over India as a whole). The trend is most pronounced during the pre-monsoon and winter seasons in the years 1986-2015.

In 2022, the IMD had declared that 2021 was the fifth warmest year since 1901, when recording started. Eleven out of 15 warmest years in the country have been in the last 15 years (2007-2021); and the past decade (2012-2021) was the warmest on record.

MONSOON

The IPCC's Fifth Assessment Report (AR5) has found that most areas in Asia lack sufficient observational records to draw conclusions about trends in annual rainfall over the past century. One of its strongest findings was regarding India, noting extreme rainfall events and fewer weak rainfall events in the central Indian region.

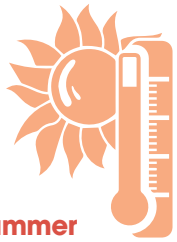
More recent India-focused assessments are more categorical than AR5. Summer monsoon rainfall (June-September, which is the bulk of the annual rainfall) has decreased over India since 1950, especially over the Indo-Gangetic Plains and the Western Ghats.

Pre-monsoon rainfall in India is driven by the western disturbances–weather systems that build eastward from the Mediterranean region towards South Asia. There is a significant rise in the observed western disturbances activity during the 1951-2015 period, increasing the unpredictability of pre-monsoon rains.

The frequency of localised heavy rain occurrences has significantly increased (by around 50 per cent) over central India (as the IPCC also noted). This is down to a combination of global warming as well as regional factors, such as land-use/land-cover changes, particularly due to urbanisation.

CLEAR LINK

At least seven attribution studies have been carried out in India since 2010, and five of them found that climate change made the event more severe or more likely to occur



2010
India's hottest regional summer

"Overall, the observed hottest summer in 2010 can be attributed to anthropogenic warming with high confidence."

A seven-fold rise in the probability of exceeding the observed hottest summer in India in a 2 °C warmer world| Nanditha, J. S. et al | 2020 Environmental Research Letters

2013
Severe rainfall in Northern India

"Cumulative precipitation in northern India in June 2013 was a century-scale event, and evidence for increased probability in the present climate compared to the preindustrial climate is equivocal."

Explaining Extreme Events of 2013 from a Climate Perspective | Singh, D. et al., 2014| Bulletin of the American Meteorological Society | Volume 95, Issue 9

2015
Record warmth in India

"In 2015, record warm surface temperatures were observed for the global mean, India, and the equatorial central Pacific. CMIP5 simulations suggest that for the globe and India, anthropogenic warming was largely to blame."

Multimodel assessment of anthropogenic influence on record global and regional warmth during 2015| Kam, J. et al| Bulletin of the American Meteorological Society | Volume 97,Issue 12

Deadly heat & humidity in India and Pakistan

"We find that the deadly heat waves in India and Pakistan in 2015 were exacerbated by anthropogenic climate change. Although the impacts of both events were severe, the events themselves were not connected to each other."

The deadly combination of heat and humidity in India and Pakistan in summer 2015| Wehner, M. et al.| Bulletin of the American Meteorological Society | Volume 97,Issue 12

2022
Deadly heatwave in India and Pakistan

"Because of climate change, the probability of an event such as that in 2022 has increased by a factor of about 30. The same event would have been about 1°C cooler in a preindustrial climate. With future global warming, heatwaves like this will become even more common and hotter."

Climate Change made devastating early heat in India and Pakistan 30 times more likely | World Weather Attribution Network | May 2022

Sources: Carbon Brief weather attribution map, accessed on October 28, 2022, and World Weather Attribution Network

Apart from the definite increase in extreme rainfall events, moderate rainfall events have decreased in the past 50 years, leading to an increase in both floods and droughts in India. This increase in the extremes at the expense of moderate events has resulted in a lack of clear trend in the seasonal mean all-India monsoon rainfall.

Monsoonal rainfall is projected to become more intense in future, and would affect larger areas. This is despite a weakening monsoon circulation. The increasing intensity will be driven largely by increases in atmospheric moisture content. This will make extreme precipitation events more frequent in India. Monsoon onset dates are somewhat likely to be early, and the monsoon retreat dates are likely to be delayed, resulting in the lengthening of the monsoon season.

The impact of the climate change is already visible. Since 2010, scientists have carried out attribution studies for seven extreme weather events in India and found that in five of them climate change made the event more severe or more likely to occur. Three of the attribution studies looked at heatwaves and two at rains and flooding events. The most recent one links climate change to this year's heatwaves in India and Pakistan. "Climate Change made devastating early heat in India and Pakistan 30 times more likely," says the study released by the World Weather Attribution Network in May 2022.

ECONOMIC IMPACTS

Rising temperatures and erratic rainfall patterns could cost India 2.8 per cent of its GDP. According to a World Bank estimate, climate change impacts are likely to lower the living standards of nearly half of India's population (approximately 600 million people).

These areas, called hotspots, were identified using spatial granular climate and household data analysis. The analysis was done for two scenarios – one indicating a pathway where climate change mitigating actions were taken, and the other where current trends of carbon emissions continued as before.

A Government of India estimate indicates that extreme temperature shocks reduce average farmer incomes by 4.3 per cent and 4.1 per cent during kharif and rabi seasons, respectively, while extreme rainfall shocks reduce average incomes by 13.7 per cent and 5.5 per cent. The main channels through which climate change would impact farm incomes would be an increase in average temperatures, a decline in average rainfall, and an increase in the number of dry days. All three are likely to be correlated, and therefore the total impact of climate change will not be the simple sum of these individual effects.

Whatever the global action on greenhouse gases mitigation, India needs enhanced adaptation efforts to keep the adverse impacts of climate change within acceptable limits for its vast vulnerable populations and ecosystems. The dividends from investing in adaptation is unlikely to be visible until 2040, but we cannot delay investments in adaptation that long.

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 Centre'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 obscures the bigger picture.

This report 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 2022.

Scan to access India's Atlas on Weather Disasters

Down To Earth

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