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Who are the refugees in Kamjong in east Manipur?

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Chhattisgarh's naxalite crackdown marred by arrests of activists and Adivasis

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The future looks hot

India has just emerged from the longest heatwave in its history. Will the government now take climate change seriously?

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On a hot summer day along the banks of the Sangam, the confluence of the Ganga and the Yamuna, in Uttar Pradesh.
GETTY IMAGES

Cover Story

INDIA SCORCHING

The country has just emerged from the longest-ever heatwave in its recorded history, and the forecasts for the future are alarming, especially for urban areas that are facing rapid green cover decline.

Divya Gandhi

In June this year, northern India turned into a dystopian nightmare: first, hundreds of fruit bats dropped dead from trees as the mercury touched 45°C in Kanpur, Uttar Pradesh, giving rise to fears that the animals could spread disease. Then, in Jharkhand, a troop of over 30 thirsty monkeys jumped into a well and drowned. A similar fate struck a pack of jackals in the State. The heatwave that seared through parts of the country had ratcheted up temperatures, with Delhi recording nearly 50°C on May 29.

The human cost of the heatwave this summer has been devastating: as many as 143 people died across the country and 41,789 people suffered from suspected heatstroke between March 1 and June 20, according to the Union Ministry of Health. The worst hit were the poor, who live in ill-ventilated homes with no cooling appliances. Street vendors, who work outdoors for an average of nearly 12 hours a day, were particularly vulnerable to dehydration, heat exhaustion, and fatal heatstrokes, according to a Greenpeace India-National Hawkers Federation survey of 721 street vendors in Delhi between April and May this year.

▼ **A patient being treated** for heatstroke and exhaustion at New Delhi's LNJP Hospital on June 19. The heatwave led to a huge influx of such patients in hospitals in the Delhi-NCR region. PTI

Dr Ajay Chauhan, professor of internal medicine at Delhi's Ram Manohar Lohia Hospital, said that he had never seen so many patients of heatstroke in such a short period of time. In June, no fewer than 75 patients came in with symptoms of heatstroke, out of whom 27 died.

Deconstructing the heatstroke, Dr Chauhan said: "There are two kinds: classical, that involves comorbidities and affects pregnant wo-

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men, people on certain medication, and the elderly, and exertional, which involves heat generated from within the body. This year there has been an overwhelming number of people with exertional heatstrokes: fruit vendors, factory workers, labourers... those who had to continue working despite the weather."

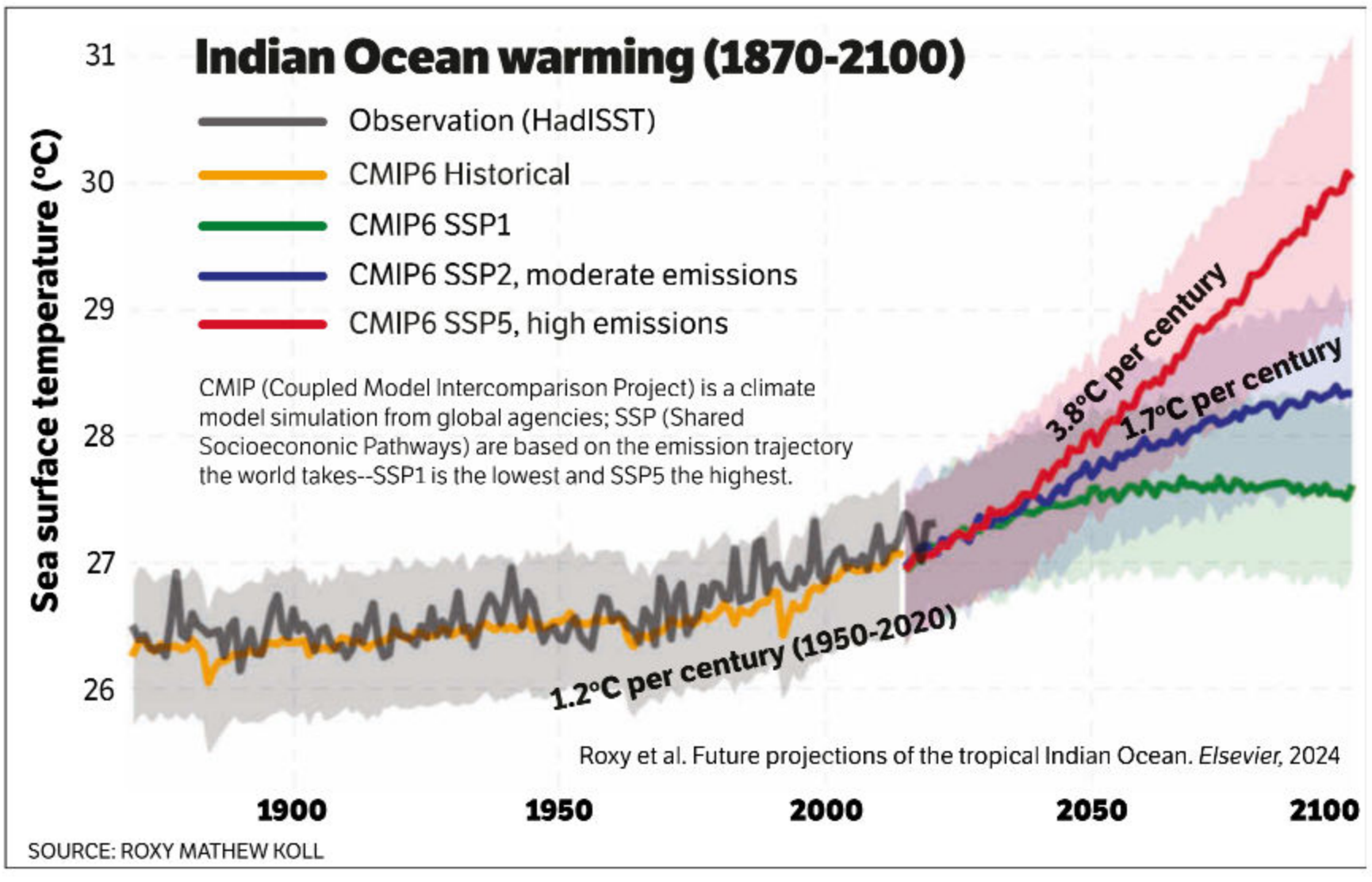
A doctor needs a combination of three factors in order to diagnose a patient with heatstroke, he told *Frontline*. One is an alteration in consciousness; two, a body temperature higher than 105°Fahrenheit (40.5°C); and three, a history of exposure to heat stress.

WHEN THE CORE BODY temperature rises, the heart races and produces other symptoms such as headaches and nausea, delirium, and seizures. Heatwaves impact every human organ, from the brain to the heart, intestines, kidneys, liver, lungs, and the pancreas, according to a paper published this year in *Environment International*, which studied data from several cities, including Ahmedabad, Bengaluru, Chennai, Delhi, and Varanasi. (*Environment International* is a peer-reviewed scientific journal covering environmental science and health.) This year's heatwave has been the longest ever since meteorological records were maintained in the country. It was experienced for about 24 days in different parts of the country, according to Mrutyunjay Mohapatra, head of the India Meteorological Department. The IMD declares a heatwave when the maximum temperature reaches 40°C in the plains and 30°C in hilly terrain.

The warming of the Indian Ocean and more frequent El Niño events may lead to more frequent and longer heatwave episodes over India in the future.

This is not the first time the country has been hit by heatwaves. But they have been increasing in frequency, according to the *Environment International* paper. There was a severe two-week heatwave in May 1998, the worst in 50 years; in April 1999, temperatures rose to 40°C; in 2003, there were more than 3,000 heat-related deaths in Andhra Pradesh; in May 2010, as many as 1,300 died in Ahmedabad; then, heatwaves occurred in rapid succession in 2016, 2018, 2019, 2022, and 2023.

What is the anatomy of a heatwave? What are the meteorological phenomena that make it form? Can we authoritatively link it to climate change? Are fatal extreme weather events (EWEs) projected to increase in the future in India?



SOURCE: ROXY MATHEW KOLL

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A group of Muslim worshippers take shelter from the heat before the start of prayers, at a mosque in Ahmedabad on June 17.
AMIT DAVE/REUTERS

Speaking to *Frontline*, Madhavan Nair Rajeevan, former Secretary of the Ministry of Earth Sciences, said: "Heatwaves are associated with high pressure [anti-cyclonic flow] in the middle atmosphere [about 3 to 7 km] which causes a downward motion of air [subsidence]. This downward motion causes the air below to get compressed and heat up."

He added: "However, many local factors, such as lack of rain, depleted soil moisture, and urban landscapes, also add to the genesis of heatwaves. El Niño also has an important role to play in the genesis of heatwaves over India; we see that heatwave frequency is greater in a year following an El Niño year. Last year was an El Niño year."

The intricate interplay between EWEs in the marine, atmospheric, and terrestrial environments has been the subject of study for Roxy Mathew Koll of the Indian Institute of Tropical Meteorology, Ministry of Earth Sciences, Pune. "Marine heatwaves [extreme ocean temperatures] can indeed alter weather systems," he told *Frontline*.

At the National Symposium on Understanding the Science of Heatwaves under the Warming Scenario and Challenges Ahead, held in March 2024, Koll said that he observed that "an increasing number of marine heatwaves in the Bay of Bengal, riding on a rapid ocean warming, are energising tropical cyclones and driving intense heat over the Indo-Pak region".

When the core body temperature rises, the heart races, and other symptoms include headaches and nausea, delirium, and seizures. Heatwaves impact every human organ, from the brain to the heart, kidneys, liver, and lungs.

AS FOR THE FUTURE, owing to mid-to-high greenhouse gas emissions, the Indian Ocean will very likely experience surface warming of 1.4-3°C between 2020 and 2100, according to Koll and co-authors in a chapter of *The Indian Ocean and its Role in the Global Climate System,* published in 2024. Their forecast is based on climate model simulations from global agencies.

"Marine heatwaves are projected to increase from 20 days per year (during 1970-2000) to 220-250 days per year, pushing the tropical Indian Ocean into a basin-wide near-permanent heatwave state by the end of the 21st century," they added (*see graph on heating Indian Ocean and future projections*).

He also alluded to a dire future prognosis: "Terrestrial heatwaves are projected to increase sixfold in this region if emissions are to continue. This raises concerns for the vulnerable population that is projected to reach one billion by 2050."

In fact, by the end of the 21st century, the frequency of summer (April-June) heatwaves over India is projected to be three to four times higher compared with the 1976-2005 baseline period, according to the Ministry of Earth Sciences' *Assessment of Climate Change over the Indian Region* (2020).

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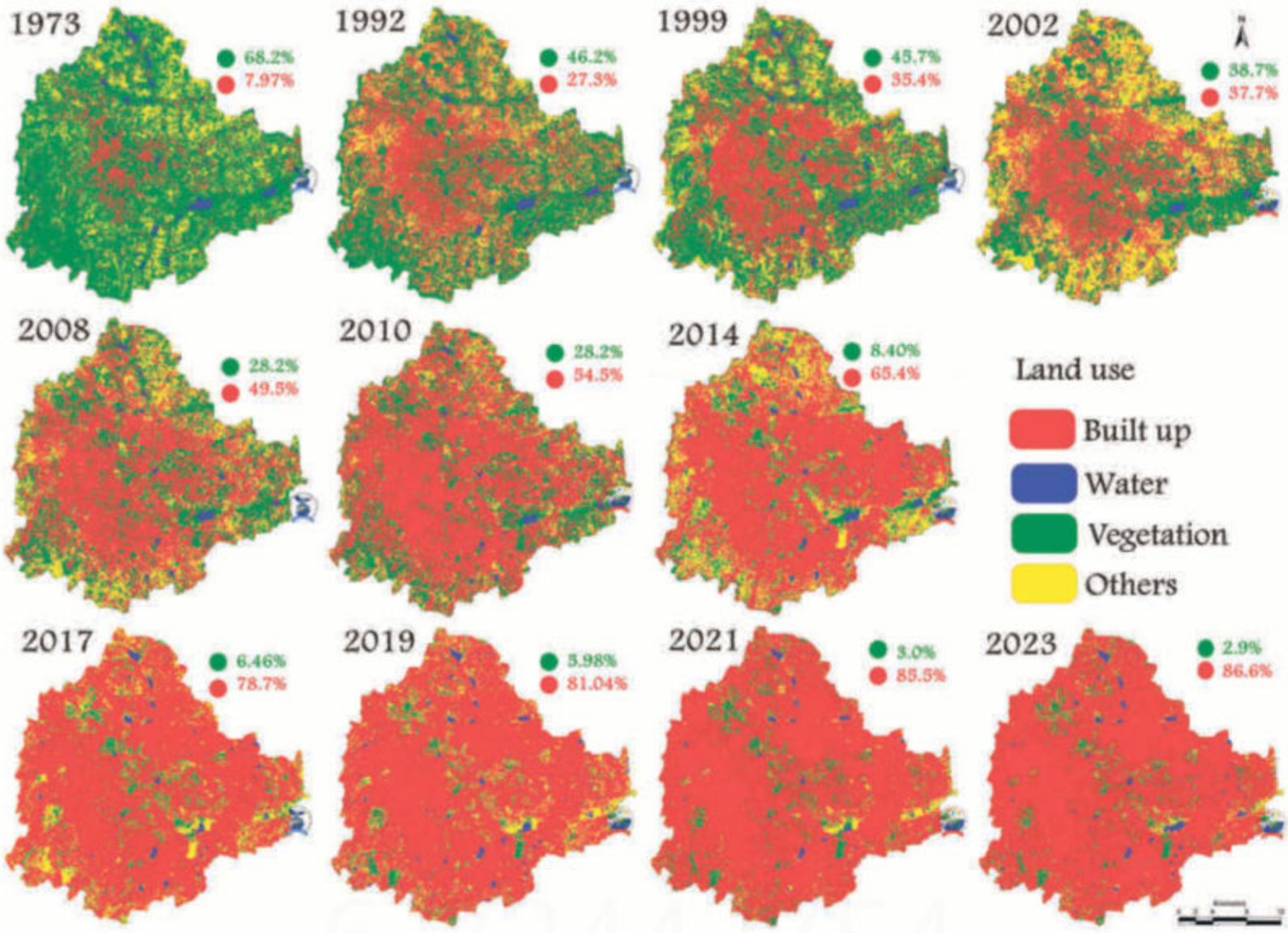
Urbanising Bengaluru



▶ **Charting the change** in built-up area in Bengaluru over the past 50 years. COURTESY: DR T.V. RAMACHANDRA, IISC

Weighing in on the association between heatwaves and global climate change, Rajeevan said: "Even though the heatwave is a natural process, human-induced climate change is making it more frequent, longer, and stronger. Past observations suggested that the frequency, duration, and intensity of heatwaves are increasing in India, and climate change or global warming could be contributing to this observed trend."

THERE IS AN INCREASING trend in the frequency and intensity of heatwaves across India, according to a 2024 paper published in *Climate Dynamics* by Rajib Chattopadhyay of IMD, Pune, and others. They said: "This is consistent with the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report (AR5), which stated some time back that an increase in frequency, duration, and intensity of heatwaves will be 'very likely over most land areas' well into the future."

The authors added: "The humidity-driven, moist heat stress conditions are showing an increasing trend over the Indian region, especially in the eastern coastal states, which cause discomfort."

Experts warn that between 2020 and 2100, the Indian Ocean will very likely experience surface warming of 1.4°C to 3°C.

In the country's urban areas, the effects of a heatwave on the human body can be heightened by the "heat island" effect, where the urban microclimate is made hostile by shrinking green cover and increasing heat-absorbing surfaces. A case in point is Bengaluru, India's "garden city", which saw record-breaking high temperatures and a severe water crisis this summer.

In a 2023 paper published in *Advances in Environmental and Engineering Research*, T.V. Ramachandra of the Centre for Ecological Sciences, Indian Institute of Science (IISc), Bengaluru, said: "The increase in paved surfaces and the reduction in green spaces have contributed to the urban heat island effect in Bangalore, with increased Land Surface Temperature (LST) from 33.07 degrees Celsius to 41.14 degrees Celsius (in urban areas) of March to May from 1992 to 2017."

The built-up area in Bengaluru went up from about 8 per cent in 1973 to 86.6 per cent in 2023, with a concurrent decrease in green cover and water bodies (*see map of an urbanising Bengaluru*).

Tirthankar Banerjee, an assistant professor at the Institute of Environment and Sustainable Development, Banaras Hindu University, said:

During a hot summer afternoon in Prayagraj on June 10, when the country was in the grip of a heatwave, the longest ever to hit the country.
ANIL SHAKYA/AFP

"The urban microclimate is regulated by green space, urban growth, albedo [fraction of light reflected], and other ancillary parameters. Warmer temperatures caused by urban heat islands exhort additional heat stress, and potentially interact with heatwaves to exacerbate mortality or morbidity risk."

In urban areas, the effects of a heatwave on the human body can be heightened by the "heat island" effect. A case in point is Bengaluru.

A STUDY OF THE DEADLY 2022 heatwave in India and Pakistan, published in *Environmental Research Climate* in 2023, categorically states that "human-caused climate change made this heatwave about 1°C hotter and 30 times more likely in the current, 2022 climate, as compared to the 1.2°C cooler, pre-industrial climate".

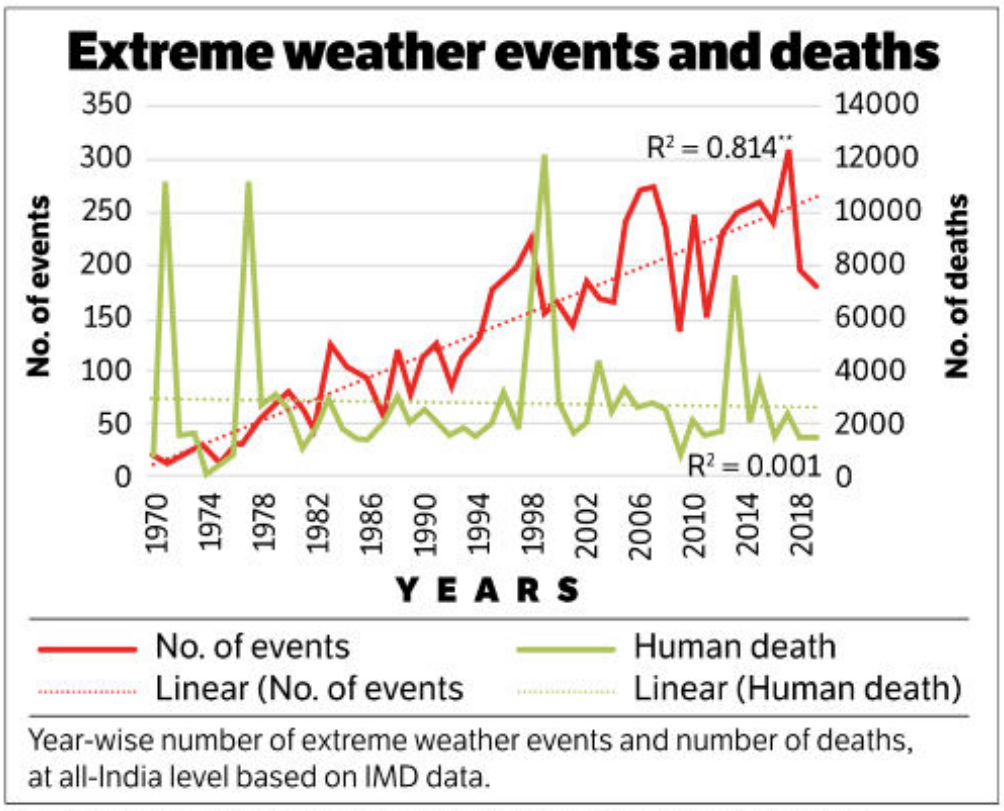
On the future, the paper states, rather ominously: "Under a future global warming of 2°C above pre-industrial levels, heatwaves like this are expected to become even more common (2-20 times more likely) and hotter [by up to 1.5°C] compared to now."

Co-author Krishna AchutaRao, a professor at the IIT Delhi, told *Frontline*: "India is a hot country that has regions where every summer temperatures [for a few days] are high enough to be termed 'heatwaves'. However, due to global warming, increases in temperature into heatwave conditions are now more frequent in these regions [lasting for more days]; regions that did not previously experience heatwaves have the phenomenon occurring. Therefore, we can expect heatwave conditions more frequently."

He added: "Before the rise in human-caused warming, heatwaves would happen once in a few years. But now, with climate change, it appears to be occurring nearly every year."

Heatwaves are not the only fatal EWEs that have begun to ravage India with increasing frequency. In a 2021 paper in *Weather and Climate Extremes*, co-authored by Rajeevan, scientists analysed mortalities from floods, tropical cyclones, cold waves, lightning strikes, and heatwaves, in the country over a 50-year period. Using data from the IMD from 1970 to 2019, they found that the number of each of these EWEs, except cyclones, has increased significantly.

As for mortality, they said: "The maximum



Year-wise number of extreme weather events and number of deaths, at all-India level based on IMD data.

SOURCE: WEATHER AND CLIMATE EXTREMES, 2021, KAMALJIT RAY ET AL.

mortalities reported in the last decade were 49 per cent due to floods, followed by 24 per cent due to heatwaves."

THE WARMING OF THE Indian Ocean and more frequent El Niño events may lead to more frequent and longer heatwave episodes over India in the future, the paper warned.

The authors said: "In India, among the major States, Odisha, Andhra Pradesh, Assam, Bihar, Kerala, and Maharashtra were found to be having maximum mortality rates due to EWEs in the last two decades and thus, there is a need to consider these States with priority for developing disaster management action plans" *(see graph of number of extreme weather events and deaths)*.

There are murmurs of a heating nation in the behaviour of wildlife too. Birds that inhabit tropical montane forests in the Eastern Himalaya are shifting their ranges to higher elevations rapidly, "with strong evidence that such upslope shifts are a result of rising temperatures globally", according to a paper published in 2023 in *Global Ecology and Conservation*.

The paper was authored by scientists from the Centre for Ecological Sciences, IISc. The scientists used mist nets, made of nylon and strung between two poles, to capture and ring the birds and then studied them over a period of 10 years. This study of as many as 61 insectivorous bird species, including the long-tailed broadbill, lesser racket-tailed drongo, the grey-throated babbler, and yellow-throated fulvetta, revealed that the birds had moved to higher altitudes primarily because of logging and climate change.

Speaking to *Frontline*, Umesh Srinivasan, co-author of the paper, said: "Climate change will lead to species shifting their ranges upwards until they run out of space and ultimately go extinct. This has already happened in other mountain ranges and is commonly called the 'escalator to extinction'."

He added: "When species move up, they can either move into undisturbed or disturbed forest. Populations that move up into disturbed forest are much less likely to be viable than populations that move into undisturbed forest. Climate change and deforestation, therefore, can combine to have serious impacts on biodiversity."

IUCN says that climate change affects at least 10,967 species on the IUCN Red List, and if temperatures increase by 2°C by 2100, about 18 per cent of all species will be at a high risk of extinction.

The human cost of the heatwave has been devastating: across the country, as many as 143 people died and 41,789 people suffered from suspected heatstroke between March 1 and June 20.

MEANWHILE, THE FUTURE of our environment appears bleak to none other than scientists from the IPCC. A survey by *The Guardian* of nearly 400 IPCC scientists, published in May 2024, reflected deep pessimism about the future of the planet. Almost 80 per cent expected a temperature rise, in this century, of at least 2.5°C above pre-industrial levels, shooting past the international target of 1.5°C.

Many saw a "semi-dystopian" future, "with famines, conflicts and mass migration, driven by heatwaves, wildfires, floods and storms of an intensity and frequency far beyond those that have already struck".

The survey also prompted responses from several prominent climate figures. One solemn message came from the official spokesperson for UN Secretary-General António Guterres: "The battle to keep 1.5 degrees Celsius alive will be won or lost in the 2020s, under the watch of political and industry leaders today. They need to realise we are on the verge of the abyss. The science is clear and so are the world's scientists. The stakes for all humanity could not be higher." And India's humanity could not be more vulnerable. ■