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# Heat Waves in India:
## Assessing Socio-Economic and Environmental Consequences

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### Abstract

*Recent years have seen an alarming increase in natural disasters throughout the world, which scientists attribute to growing global pollution. The overuse of different environmentally damaging technologies has worsened the world's ecological situation. Pollution, climate change, and other natural calamities are only some of the results of this environmental deterioration. "India, a tropical country, experiences severe heat wave situations owing to its unique climate and geographical setup," says Omvir Singh, professor of geography at the Kurukshetra University in India and a lead researcher in the study. According to a recent study, "India is recognised as the most seriously afflicted country when worldwide extreme temperature-related deaths are analysed." Excessive heat waves are a major cause of death in India. An increase in lethal heatwaves in India has been connected to amplified warming in the Arctic, according to a study published in the Quarterly Journal of the Royal Meteorological Society earlier this year. Except for the western coast and north-eastern India, most of the nation experiences heat waves in the months of April, May, and June. Over the northwest and southeast of India, there are two major zones where heat waves are common. One heat wave occurrence lasting around 5 days happens each season over northwest India. A heat wave may continue longer than 7 days in some cases. No major heat wave has been observed for several years. On the other hand, heat waves are becoming more frequent and lasting longer on average. Because of the increasing frequency and severity of heat waves in India, the government is being forced to take strict measures for management and public education.*

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**Keywords**

heat waves, environment, natural disasters, Indian territory

## INTRODUCTION

India, due to its unique geo-climatic and socio-economic conditions, is vulnerable, in varying degrees, to floods, droughts, cyclones, tsunamis, earthquakes, urban flooding, landslides, heat waves and forest fires. The issue of India's heat wave has become a hot topic of conversation. University of California, Los Angeles climate scientist Daniel Swain said, "Climate change is making extreme and unusual heat events both more intense and more common, pretty much uniformly around the planet." A heat wave is often known as a "silent disaster" because it grows gradually and kills and injures people and animals across the nation.[3] As a result of climate change, higher daily maximum temperatures of prolonged timeframe and more heat waves are occurring more frequently over the world. When the temperature in the North-Western areas of India rises over its average high for the summer, we have a heat wave. Temperature extremes are most common between March and June, however they might last into July on rare occasions. People in these areas are put under a great deal of stress due to the abnormally high temperatures, and this can have fatal consequences. Multiple immediate and long-term social, ecological, and economic effects radiate out from heatwaves.

In India, the Meteorological Department (IMD) has defined a Heat Wave as meeting the following criteria:

- Maximum temperatures at a given station do not have to surpass 40 degrees Celsius (for Plains) or 30 degrees Celsius (for Hilly Regions) before the possibility of a heat wave is considered.
- When a station's average high temperature falls below 40 degrees Celsius, 5°C to 6°C above or below

[3]https://www.ndma.gov.in/Natural-Hazards/Heat-Waves

average indicates a heat wave. Temperatures 7 degrees or more above average during a heat wave

- When the average high temperature for a given station is higher than 40 degrees Celsius Temperatures in the heat wave are 4–5 degrees above average. Extreme Heat Wave Temperature Deviation of 6 degrees Celsius or More

If the actual highest temperature is 45 degrees Celsius or above, regardless of the typical maximum temperature, a heat wave should be proclaimed. As a result of global warming, we are seeing more regular occurrences of both longer and more severe heat waves and higher average daily highs. Heat waves are becoming more frequent and severe in India as a result of climate change, which is having a disastrous effect on human health and increasing the number of heat wave deaths.

Heat waves can cause serious health risks. The National Disaster Management Authority (NDMA) advises to stay safe, drink water regularly, wear light cotton clothes, and avoid strenuous activity. It also advises to rehydrate with ORS or homemade drinks, steer clear of dehydrating beverages, and eat fresh food; eep homes cool and ensure animals have shade and water to prevent heat-related illness.

The goal of the *Heat-Wave Action plan* is to offer a framework for the execution, coordination, and assessment of efforts in Indian cities and towns to mitigate the effects of excessive heat. Heat stress disorders, including heat stroke, can be brought on by prolonged exposure to extremely high temperatures. In extreme cases, heat can cause heat stroke, the most dangerous condition. The inability of the organism to regulate its internal temperature is the underlying cause. When the system responsible for sweating fails, the body's temperature increases fast and it becomes unable to cool itself.

The National Disaster Management Authority's (NDMA) heat wave action plan 2022-23 seeks to aid in the preparation of a heat wave management plan by giving stakeholders insight into heat-related illness and the necessary mitigative and response action to be taken, as well as aiding in the mobilisation and coordination of various departments.[4]

## LITERATURE REVIEW

- (Kumar, Priyankar, et al., 2022)[5] Heat is trapped at the earth's surface, making cities hotter and hotter. The cities of Kolkata, Chennai, Delhi, and Mumbai have been hit hard by heat waves and heat stress this summer. Delhi's relative humidity is lower than that of other major cities, therefore even if the temperature is higher there, the risk of severe heat exhaustion is reduced.
- (Dubey, Aditya Kumar, et al., 2021)[6] The heat wave is a hazardous risk that has far-reaching effects on health and society. Using socioeconomic vulnerability and temperature records, this study examines the dangers and risk of heatwaves in present-day and future India. The analysis revealed that the current scenario poses the greatest danger to the south-eastern coast and the Indo-Gangetic plains
- (Golechha, Mahaveer, Dileep Mavalankar, and Subhash Chander Bhan, 2021)[7] Heat waves have become increasingly deadly, making India one of the countries most at risk from the effects of climate

[4] https://vmc.gov.in/pdf/Annoucement/2022/Heat%20wave%20action%20plan%202022-23.pdf

[5] P. Kumar, et al., Analysis of Heat Stress and Heat Wave in the Four Metropolitan Cities of India in Recent Period, 818 SCI. OF THE TOTAL ENV'T 151788 (2022)

[6] A.K. Dubey, et al., Present and Future Projections of Heatwave Hazard-Risk over India: A Regional Earth System Model Assessment, 201 ENV'T RSCH. 111573 (2021)

[7] M. Golechha, D. Mavalankar, & S.C. Bhan, India: Heat Wave and Action Plan Implementation in Indian Cities, in URBAN CLIMATE SCIENCE FOR PLANNING HEALTHY CITIES 285 (2021)

change. From 1992 to 2016, 25,716 fatalities were reported across the country. To mitigate the hazardous effects of high temperatures on human health, heat action plans are being developed to serve as a guide for early warning and the implementation of appropriate intervention.

- (Naveena, N., et al , 2021)[8] The location, frequency, and trend of recent heat waves in India are the focus of a research project. The average, standard deviation, coefficient of variation, and trends of the highest monthly temperature were calculated using gridded daily temperature data sets for the period 1951-2019. Heat waves are more common in May, with Andhra Pradesh and south Telangana in southeast India seeing the highest incidence.
- (Singh, Saumya, R. K. Mall, and Nidhi Singh , 2021)[9] A pattern of worsening heat wave characteristics has been recorded throughout India from the middle of the 20th century. If this tendency continues to rise dramatically, it might have devastating effects on people's health, especially the most defenceless among us. Recognizing heat waves as a possible health danger necessitates more research, stronger preparation, and legislative intervention.
- (Mahadevia, Darshini, et al, 2020)[10] Internal temperature has been the subject of very few research in India, despite its obvious influence on the condition of homes and the diversity of their architectural styles. To

[8] N. Naveena, et al., Spatial and Statistical Characteristics of Heat Waves Impacting India, 8 AIMS ENV'T SCI. 117 (2021)

[9] S. Singh, R.K. Mall, & N. Singh, Changing Spatio-Temporal Trends of Heat Wave and Severe Heat Wave Events over India: An Emerging Health Hazard, 41 INT'L J. CLIMATOLOGY E1831 (2021)

[10] D. Mahadevia, et al., Climate Change, Heat Waves and Thermal Comfort—Reflections on Housing Policy in India, 11 ENV'T & URBANIZATION ASIA 29 (2020)

reduce the risk of heat illness, neither the state nor local governments mandate heatproofing for new or existing homes. Moving people from unofficial to official housing is one of the possibilities being explored right now. Renewing existing squatter settlements is another option that has to be considered right now.

- (Nageswararao, M. M., et al., 2020)[11] When it comes to deaths caused by heat waves before the monsoon, the central east coast of India (CECI) is among the most impacted regions. Over the CECI, it's important to examine the features of weekly maximum temperatures and the heat waves they cause. According to the data, during all 10 weeks, the climatological weekly Tmax near the shore is lower than in the interior areas.
- (Neethu, C., K. V. Ramesh, and K. B. Shafeer, 2020)[12] In the peak months of May and June, India experiences severe heat waves. To effectively counteract it, we need to comprehend the processes behind its development and spread. Central India, the North West, and states like Odisha, Andhra Pradesh, and Telangana are experiencing the worst of the heat wave.
- (Satyanarayana, G. Ch, and DV Bhaskar Rao, 2020)[13] In the light of the current global warming situation, heat waves across the Indian subcontinent are examined to better understand their geographical sensitivity and their underlying causes. The warmest month of the year, May, is analysed using high-resolution gridded

[11] M.M. Nageswararao, et al., Occurrence of More Heat Waves over the Central East Coast of India in the Recent Warming Era, 177 PURE & APPLIED GEOPHYSICS 1143 (2020)

[12] C. Neethu, K.V. Ramesh, & K.B. Shafeer, Understanding the Spatio-Temporal Structure of Recent Heat Waves over India, 102 NAT. HAZARDS 673 (2020)

[13] G. Ch. Satyanarayana & D.V.B. Rao, Phenology of Heat Waves over India, 245 ATMOSPHERIC RSCH. 105078 (2020)

surface air temperature data from the India Meteorological Department (IMD) over the most recent 65 years (1951–2015). The advection of heat by anomalous southwest, west, and northwest wind flow from the 3 maximum temperature zones was shown to be the root cause of heat waves.

- (Rohini, P., M. Rajeevan, and P. Mukhopadhay , 2019)[14] Nine CMIP5 models were used to analyse the characteristics of heat waves across India under a future warming scenario. There may be an additional two heat waves and a 12- to 18-day extension in heat wave length between 2020 and 2064, according to the models. The research also indicates that the strengthening of the mid-tropospheric high and related subsidence over central and northwest India are to blame for the anticipated rise in the frequency of heat waves in the future.
- (Azhar, Gulrez, et al., 2017)[15] Recent devastating heatwaves in India have brought attention to heat as a public health concern. India's susceptibility to heat has not been evaluated on a national scale. According to the heat exposure maps, the most at risk areas are in the middle of the country. These areas are less developed and suffer from illiteracy and poor infrastructure such as lack of running water and clean restrooms.
- (Mishra, Vimal, et al., 2017)[16] Conditions predicted if the RCP8.5 'business as usual' emissions scenario are adopted are associated with around 2.5 times more frequent severe heatwaves in India (than the low-warming scenario of 2 °C).

[14] P. Rohini, M. Rajeevan, & P. Mukhopadhay, Future Projections of Heat Waves over India from CMIP5 Models, 53 CLIMATE DYNAMICS 975 (2019)

[15] G. Azhar, et al., Heat Wave Vulnerability Mapping for India, 14 INT'L J. ENV'T RSCH. & PUB. HEALTH 357 (2017)

[16] V. Mishra, et al., Heat Wave Exposure in India in Current, 1.5 C, and 2.0 C Worlds, 12 ENV'T RSCH. LETTERS 124012 (2017)

Strategies to slow India's population development in the 21st century may do nothing to protect the country's residents from heat waves.

- (Mora, Camilo, et al , 2017)[17] Heat waves are dangerous because they are isolated instances of extremely high temperatures. Humans, even the young and healthy, can be negatively affected by heat waves in ways other than cardiovascular illness, as science has demonstrated. We argue that the only way to avoid the health hazards of heat waves is a quick reduction in greenhouse emissions combined with considerable economic investment in adaptation.
- (Panda, Dileep Kumar, Amir AghaKouchak, and Sunil Kumar Ambast., 2017)[18] Due to concerns over agriculture, food security, and social advancement, India's recent heat waves have been a source of severe worry. Nighttime heat wave measures revealed the most dramatic amplifications in the northern portion of India, which is both highly inhabited and agriculturally dominant. The results highlight the significance of strategy planning in light of the increasing frequency with which dry and hot occurrences occur together.
- (Pattanaik, D. R., et al , 2017)[19] A severe heat wave hit areas of India in the summer of 2015, particularly the central and north western regions. This year's heat wave peaked the week of May 22–28 and continued into the week of May 29–June 4. Early warning from a coupled model of such lethal heat waves can be

[17] C. Mora, et al., Twenty-Seven Ways a Heat Wave Can Kill You: Deadly Heat in the Era of Climate Change, 10 CIRCULATION: CARDIOVASCULAR QUALITY & OUTCOMES e004233 (2017)

[18] D.K. Panda, A. AghaKouchak, & S.K. Ambast, Increasing Heat Waves and Warm Spells in India, Observed from a Multi-Aspect Framework, 122 J. GEOPHYSICAL RSCH.: ATMOSPHERES 3837 (2017)

[19] D.R. Pattanaik, et al., Heat Wave over India During Summer 2015: An Assessment of Real Time Extended Range Forecast, 129 METEOROLOGY & ATMOSPHERIC PHYSICS 375 (2017)

invaluable to emergency response teams.

- (Mahdi, S. Sheraz, and B. S. Dhekale , 2016)[20] There were an average of 337 hot days and 182 cold days in the South Bihar Alluvial Zone. It has been discovered that the frequency of heat waves is growing at a pace of 0.11 per year, whereas the frequency of cold waves is declining at a rate of 0.04 per year, however this difference is not statistically significant. According to the study's findings, May has heat waves that are more intense and last longer than those occurring in any of the other months analysed.
- (Murari, Kamal Kumar, et al., 2015)[21] India is already very vulnerable to heat waves, and the country's poor ability to adapt means that future heat wave consequences might be particularly devastating. According to forecasts, a significant portion of India will be affected by heat stress in the near future. During the pre-monsoon hot season in northern India, the average number of days with high heat stress condition would rise to 30
- (Azhar, Gulrez Shah, et al., 2014)[22] Extreme heat in May of 2010 caused an apparent rise in mortality in the Indian city of Ahmedabad, when temperatures peaked at 46.8 degrees Celsius. There was an increase in deaths from all causes during the heat wave in May of 2010. In the seasonally "summer" months of April and June, we discovered strong associations between mortality and daily max
- (Perkins, Sarah E., and Lisa V. Alexander.,2013)[23] There is a lack of

[20] S.S. Mahdi & B.S. Dhekale, Long Term Climatology and Trends of Heat and Cold Waves over Southern Bihar, India, 125 J. EARTH SYS. SCI. 1557 (2016)
[21] K.K. Murari, et al., Intensification of Future Severe Heat Waves in India and Their Effect on Heat Stress and Mortality, 15 REG'L ENV'T CHANGE 569 (2015)
[22] G.S. Azhar, et al., Heat-Related Mortality in India: Excess All-Cause Mortality Associated with the 2010 Ahmedabad Heat Wave, 9 PLOS ONE e91831 (2014)
[23] S.E. Perkins & L.V. Alexander, On the Measurement of Heat Waves, 26 J. CLIMATE 4500 (2013)

clarity in the definition and measurement of heat waves despite the harm they do. The current research solves this problem by using three different ways of defining heat waves. The number of heat waves, their duration, the number of days in which they occurred, and their peak and average magnitudes are all analysed within a multidimensional framework. Heat wave intensity appears to be growing at a quicker rate than the average magnitude, as shown by larger-scale trends in the hottest phase of a heat wave.

- (Koppe, Christina, et al., 2004)[24] Even with the present weather patterns, high air temperatures can have negative effects on human health and cause more deaths. In Europe, heat health warning systems need to be improved. In order to modify urban bioclimates and lessen the impact of urban heat islands during the summer, long-term planning is essential.
- (D. D. Joseph and Luigi Preziosi, 1989)[25] The idea of heat transfer via waves is discussed and analysed. On the same lines as those previously employed to explain the elastic response of viscous liquids, we propose the concepts of an effective thermal conductivity, an effective heat capacity, and relaxation functions for heat and energy. An annotated bibliography covering the whole history of published material on the topic of heat waves is presented.

## OBJECTIVES OF RESEARCH

- To examine the average number of heat waves across India from 2010 to 2021.

[24] WORLD HEALTH ORG., HEAT-WAVES: RISKS AND RESPONSES (2004)

[25] D.D. Joseph & L. Preziosi, Heat Waves, 61 REV. MOD. PHYSICS 41 (1989)

- To assess the number of deaths due to heat waves across India from 2008 to 2021.
- To examine the number of heat wave days across India in 2021, by different states.
- To analyse overall impact on India due to heat waves.

## RESEARCH METHODOLOGY

Quality research is conducted to attain the objectives of this research paper, based on secondary data which is gathered from the variety of :

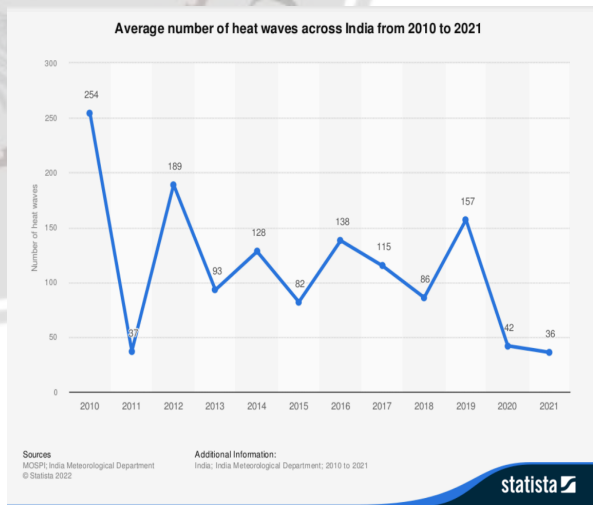
- ➢ Journals,
- ➢ Articles,
- ➢ Previously published Research papers,
- ➢ Reputable news websites

This study acknowledges the ideas and opinions of several well-known authors and reports published by the National Disaster Management Authority of India.

## DATA ANALYSIS & FINDINGS

### Average Number of Heat Waves Across India from 2010 to 2021

India saw one of the hottest seasons on record from April through May. The heat wave claimed to be the highest average no. with 254 across the country. This year's summer in India and across South Asia has been marked by a prolonged heatwave known as the 2010 Indian heatwave. On the other hand 2021 has the least no. of heat waves with average 36 heat waves.




**Source: Compiled from IMD Annual Climate Reports, NDMA (2010–2021)**

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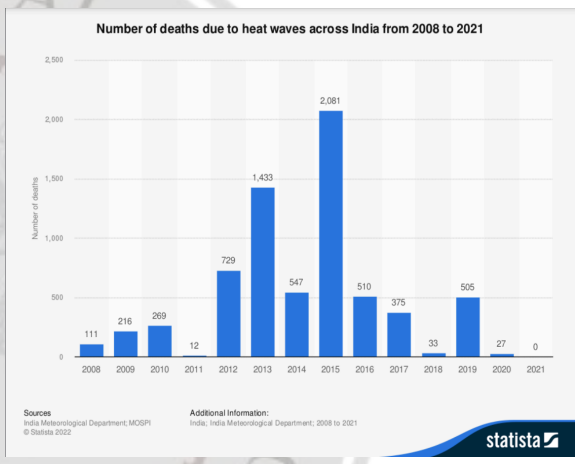
An evident result of the effects of heat waves in India was the occurrence of illnesses and fatalities. Year after year, record-breaking heat was reported, with highs in the 40s and low 50s Celsius. When a person's internal temperature reaches 40 degrees Celsius, it is considered to be febrile and should be treated by a doctor. Brain damage, or even death, is possible in the worst situations.

## Number of Deaths due to Heat Waves Across India from 2008 to 2021

Deaths from heat waves in India will be zero in 2021. This was a drastic drop from the 27 recorded the year before. During the month of May in 2015, a severe heat wave devastated India, causing the largest number of deaths ever recorded there. Typically, the Indian dry season runs from March to July, with the hottest months being April and May, when the heat wave occurs. India regularly suffers from deadly heat waves throughout the summer, but the number of deaths was disproportionately high in 2015. The heat wave in India has killed almost 2,081 people.




**Source: NDMA Annual Reports; WHO Heatwave Mortality Database**

Less frequent pre-monsoon season rains contributed to the heat wave by leaving significant portions of India drier than usual. The unusually early conclusion to pre-monsoon rain showers in India is a contributing factor to the current heat wave. The 2022 heat wave in India and Pakistan is an extreme weather phenomenon that has led to the hottest

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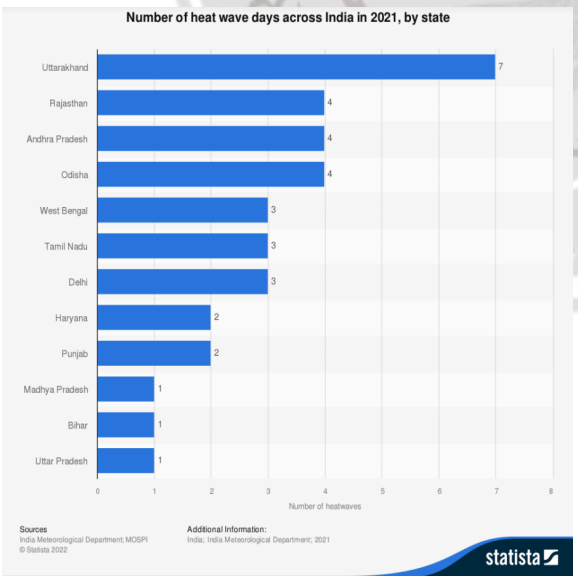
March in India since 1901. As of 9 May, at least 90 people have died as a result of the heat wave, including 25 in India and 65 in Pakistan.

### Number of heat wave days across India in 2021 (by State)

Heatwaves, which are caused by extreme fluctuations in temperature and weather, are mostly attributable to climate change. Coal, petroleum goods, and excessive gas use are to blame for this peril. They emit greenhouse gases, which degrade the atmosphere.




**Source: India Meteorological Department (IMD), 2021**

When it comes to days with extreme heat in 2021, the Indian state of Uttarakhand had the most, with around seven. All three of India's states of Rajasthan, Andhra Pradesh, and Odisha had heat waves lasting four days each in the year 2021. One of the hottest summers on record was observed in 2022, with 203 days of heatwaves in India. Uttarakhand led the nation with 28 such incidents reported this year, followed by Rajasthan with 26, Punjab and Haryana with 24, Jharkhand with 18, and Delhi with 2.

## FINDINGS

Heatwaves, or persistent periods of extreme temperature, can have serious consequences for civilization, including an increase in heat-related fatalities. Even though heatwaves produce some of the most deaths and property damage of any natural disaster, they are often overlooked because of the difficulty in gauging their true impact. Because of climate change, people will be subjected to higher temperatures. The frequency,

length, and intensity of worldwide heat waves are all on the rise.[26]

While the consequences of heat are likely to be felt more acutely in metropolitan areas, the livelihoods and well-being of populations in less urban areas can also be seriously impacted during and after periods of exceptionally hot weather. Heat waves put a strain on already overworked medical and emergency services, as well as the water, electricity, and transportation systems, perhaps leading to shortages or even blackouts. If crops or cattle are lost as a result of the heat, it might put a burden on people's ability to provide for themselves.

## IMPLICATIONS

Increases in average global temperature and the frequency and severity of heat waves are expected throughout the 21st century as a result of human-caused climate change. India experiences heat waves between the months of March and June, however they can sometimes last into July. About five or six heat waves a year are typically recorded in the northern half of the United States. A great number of people may be affected by a single incident that lasts for weeks and repeats itself repeatedly. The human lives lost from heatwaves can be mitigated through the rapid and efficient use of emergency planning, response, and recovery measures.

The World Health Organization (WHO) collaborates with the health sector to improve heatwave governance, readiness, and response by creating disaster recovery plans that identify and catalogue potential hazards, at-risk populations, and available resources. These strategies incorporate early warning systems and guarantee that institutions caring for the most vulnerable citizens, such as hospitals, nursing homes, and schools, have sufficient supplies of cooling equipment.

[26]https://mausam.imd.gov.in/Forecast/marquee_data/Press%20Release%2025.04.2022.pdf

WHO[27] coordinates with other organizations to provide food aid, restore primary health care services including vaccination, child and maternal health, and mental health, deploy mobile health teams and outreach, and monitor and respond to epidemics worldwide.

## THE WAY AHEAD

Environmental issues have been a key topic for more than 40 years, but recently they have become even more important as a consequence of the concerns we currently have about creating a sustainable and sterile environment. An increasingly dire climate problem calls for fair and reasonable solutions. We will need strategies tailored to boost population resilience during extreme events like heatwaves in India, in addition to government and corporate attention on adaptation and mitigation measures necessary to deal with climate change. Increased green space and protection of urban water supplies are only two examples of the kinds of measures that need to be taken in response to climate change.

India's temperatures often surpass 35°C, but the trend of more hot days is worrisome. India's hottest days have climbed from 40 to 100 every year since the 1950s. Because of climate change, India's already brutal summers are getting much hotter. Summer heat in India started early this year, around the end of March and the beginning of April. In most years, the hottest part of summer happens towards the end of April or beginning of May. Hottest weather in North, West, and Central India in 122 years, according IMD. Unfortunately, the maximum population is affected to its worst. The results show that unless drastic action is taken, the situation will only deteriorate in the following decades. There is an urgent need to take proper actions by governments such as :

[27] https://www.who.int/health-topics/heatwaves

- The devastating effects of heat waves highlight the need for improved disaster management policies and crisis adaptation plans.
- Improved early warning systems that disseminate information about heatwave hazards, suggest various precautionary measures, and limit catastrophe consequences can reduce fatalities caused by such events.
- Recognizing Heat Waves as a hazardous event is long overdue, we must now count heat waves among the world's most devastating natural disasters. There is much work to be done in India to raise public knowledge, especially on preventative health measures that may be taken at the personal and community levels.
- The heatwave is the second worst natural disaster in India, behind the flood. If heat waves were officially recognised as a natural disaster, state and district governments might work together to develop a strategy to mitigate the effects of heat waves across the region.
- Urban heat islands (UHIs) may be mitigated by the use of passive cooling technology, which is a common method for creating naturally ventilated buildings.
- Cities are hotter than rural places in part because they are covered with black surfaces like asphalt roads and parking lots.

## CONCLUSION

The world is seeing more frequent and severe heat waves with higher daily peak temperatures as a result of climate change. Heat waves, which are becoming more frequent and severe in India as a result of climate change, are having a disastrous effect on human health and contributing to a rise in heat wave deaths. A rise in hot days and other temperature extremes was projected in

the study for India. Thus, it is critical to quickly formulate a plan for early warning and mitigation of heat waves across the country. Between 2015 and 2019, 17 states with a high risk of heat waves drafted their *Heat Wave Action Plans*, and more than 120 districts or cities in 14 states have also drafted their own Heat Wave Action Plans.[28]

These plans facilitate multi-agency collaboration, allowing state governments to better analyze, anticipate, prepare for, and mitigate the effects of heat waves. The NDMA statement adds, "*In this approach, governments and local authorities may undertake long-term mitigation actions to mitigate the detrimental consequences of heat-wave conditions.*"

Since humanity's emergence as a civilization, climate change has posed the biggest danger to our continued survival. As the phrase goes, "*No one can purchase their way out of its consequences.*" There is an urgent need to find a solution to the issue of climate change. It should be given the highest importance.

[28] https://www.who.int/india/heat-waves