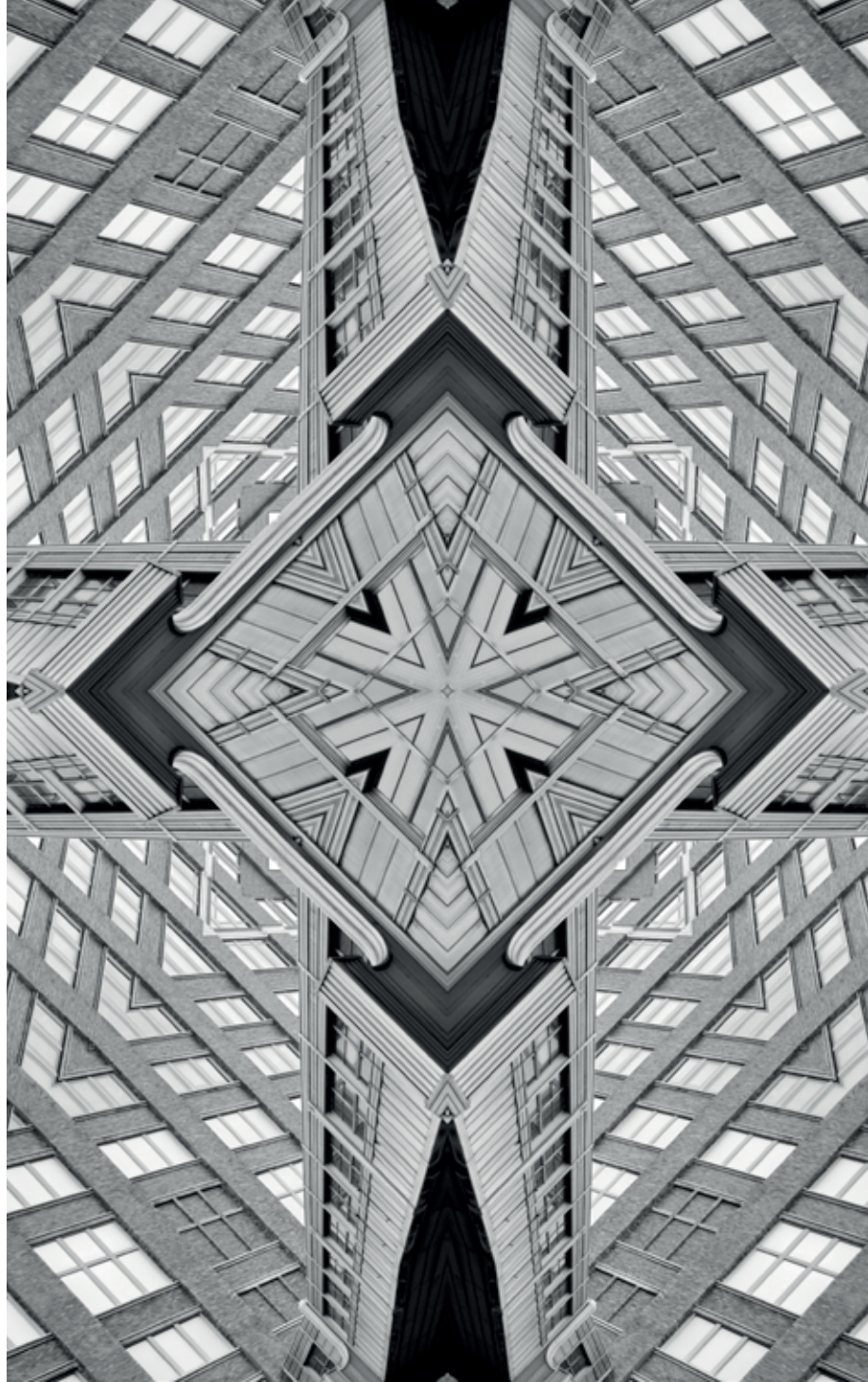


Issue

Brief

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Extreme Heat Events in India's Cities: A Framework for Adaptive Action Plans

Ramanath Jha

Abstract

Among the most severe consequences of climate change is the global rise in average temperatures, and the resultant increase in the frequency and intensity of heatwaves. Cities are particularly vulnerable to heatwaves as their high built density absorbs and retains heat, leading to higher temperatures than the surrounding areas and causing the 'heat island' effect. India's northwest region routinely experiences abnormally hot days during the summer months, but cities elsewhere in the country are also now seeing such extreme hot weather conditions. To protect citizens from heatwaves, city administrations must prepare and implement heat action plans and modify cities' overall planning.

Climate change, the long-term alteration of temperature and typical weather patterns,¹ has emerged as a defining challenge of the 21st century. Although it is both naturally induced and anthropogenic in character, climate change's rapid rate is mostly human-made.² Over 150 years of industrialisation, deforestation, fossil fuel use and large-scale agriculture have resulted in record levels of greenhouse gases (GHGs) being emitted into the atmosphere.³ Burgeoning populations, growing economies, and improved living standards have also meant a considerable rise in the cumulative level of GHG emissions.⁴ There is a direct link between the concentration of GHGs in the Earth's atmosphere and the average global temperature—rising GHG concentration has translated into increasing mean global temperature.⁵ In its Fifth Assessment Report (2013), the United Nations Intergovernmental Panel on Climate Change (IPCC) revealed that between 1880 and 2012, the average global temperature rose by 0.85 percent.⁶ The report also stated that a great deal of irreversible damage had already been triggered and most aspects of climate change will persist for centuries, even if emissions are controlled.⁷ A 2018 IPCC report concluded that many of the adverse impacts of climate change would come at the 1.5°C mark,⁸ including extreme temperatures in most inhabited regions, a rise in mean sea level, heavy precipitation in many areas, and the probability of drought and precipitation deficits in some areas. Consequently, there will also be impacts on biodiversity and the ecosystem, including species loss and extinction. This is likely to lead to climate-related risks to health, livelihoods, food security, water supply, human security and economic growth.⁹

“The adverse outcomes of climate change will persist for centuries, even if carbon emissions are controlled.”

Understanding Heatwaves

Heatwaves are among the many consequences of global warming. A heatwave refers to surface temperatures being significantly higher than normal for several days at a time.¹⁰ The World Meteorological Organization defines heatwaves as “five or more consecutive days during which the daily maximum temperature surpasses the average maximum temperature by 5°C (9°F) or more”.¹¹ However, there is no universally accepted definition for heatwaves. Heatwaves are measured relative to the usual weather in an area and the normal temperatures for the season, and so definitional differences are reflective of global climatic variations and the geographically variable nature of heatwaves and their impact. Several countries have adopted their own standards on heatwaves. The India Meteorological Department requires that temperatures should reach at least 40°C in the plains and at least 30°C in the hilly regions, and should reflect an increase of at least 5°C-6°C (or 9°F-10.8°F) above the normal temperature to be classified as a heatwave.¹² The US National Weather Service defines a heatwave as a spell of “abnormally and uncomfortably hot and unusually humid weather” over two days or more.¹³ In Denmark, a heatwave occurs when the mean of the highest recorded temperature measured over three consecutive days exceeds 28°C (82.4°F).¹⁴ In Adelaide, Australia, a heatwave is defined as five straight days with temperatures at or above 35°C (95°F), or three consecutive days at or over 40°C (104°F).¹⁵

Heatwaves “may be characterized by low humidity, which may exacerbate drought, or high humidity, which may exacerbate the health effects of heat-related stress, which include heat exhaustion, dehydration and heatstroke”.¹⁶ Experts identify two facets to a heatwave—the physiological (centred on the general thermoregulation of the human body) and the sociological (focused on local adaptations to the climate).¹⁷ “The human thermoregulatory mechanism endeavors to maintain a constant core temperature for the body, which commonly requires that the internal heat generated by metabolism be transferred through the skin and, to a much lesser extent, the lungs to the surrounding atmosphere”.¹⁸ If the atmospheric conditions are such that the removal of body heat is hampered (as it may be during extreme heat events), the body’s core temperature will likely rise and cause health problems, and may culminate in death.

Heatwaves are a global phenomenon; around the world, days are getting hotter more frequently. The proportion of the Earth’s surface area that was subjected to scorching summers (significantly higher than the average temperatures) increased from 1 percent between 1951-80 to over 10 percent between 1981-2010.¹⁹ Record-breaking heat events were experienced in Australia, Argentina, China, Central Asia, large parts of Europe, Mexico, Japan, South Korea and

Understanding Heatwaves

the US in 2016,²⁰ and there will almost certainly be an increase in frequency, severity, duration and the spatial extent of heatwaves in the future.²¹

In the US, for instance, the frequency of heatwaves has increased substantially, from an average of two per year during the 1960s to over six per year during the 2010s.²² The average heatwave season across 50 major US cities was reported to be 47 days longer than it was in the 1960s, and about 10,000 lives were lost to heat events between 1999 and 2016—more than to hurricanes, tornadoes or floods in those years.²³ In England, between 2015 and 2019, over 3,400 people lost their lives on account of extreme temperatures, with nearly 900 extra deaths (deaths above the normal numbers recorded each year) during the 2019 summer heatwaves.²⁴ In 2003, a devastating heatwave during Europe's hottest summer since the sixteenth century killed about 30,000 people across the region.²⁵ In 2018, Japan's weather agency warned of unprecedented levels of threat on account of extreme heat and declared the heatwave sweeping the country as a natural disaster.²⁶ While Sub-Saharan Africa has been identified as a heatwave 'hotspot', regional governments have not reported such events, but the African continent is as vulnerable to the impacts of heatwaves as elsewhere.²⁷

“Heatwaves are a global phenomenon; around the world, days are getting hotter, and more frequently.”

India routinely experiences hot summers but, in recent years, several parts of the country have seen abnormally high temperatures—4°C-5°C (39.2°F-41°F) above normal—over several days, being defined as heatwaves. India’s northwest region typically experiences heatwaves between March to June, and in rare cases until July.²⁸ Heatwaves have several health impacts—dehydration, heat cramps, heat exhaustion and/or heat stroke. Heat cramps result in edema (swelling) and syncope (fainting), often accompanied by fever below 39°C (102°F). Heat exhaustion can cause fatigue, weakness, dizziness, headaches, nausea, vomiting, muscle cramps and sweating. Meanwhile, heat strokes cause the body temperature to rise to 40°C (104°F) or more and can result in delirium, seizures, coma or possible fatality.²⁹ Heatwaves killed about 6,187 people in India between 2011 and 2018.³⁰ However, data on heatwave fatalities are not widely available since most cases go unreported and the ambiguity of symptoms may mean that mortality rates are not accurately captured.

Additionally, during the summer months, north and northwest India also experience the ‘loo’—strong, hot, dry winds that blow during the day and sometimes until late in the evening.³¹ On account of its extreme temperature, ranging between 45°C-50°C (115°F-120°F) and very low humidity, the ‘loo’ zaps the human body dry on exposure, leading to fatal heatstroke. However, the ‘loo’ is a normal weather phenomenon in northern India, and heatwaves are considered to occur above this condition not before it.

Urban habitats are more prone to disasters than rural areas—cities have frequently been hit by floods and other calamities and bore the brunt of the COVID-19 pandemic worldwide.^{a,32} Similarly, cities are more vulnerable to heatwaves due to the ‘heat island effect’. Urbanised areas experience higher temperatures due to their built density. Buildings, roads and other infrastructure absorb and re-emit the sun’s heat more than natural landscapes such as forests and water bodies.³³ Urban areas, where such structures are highly concentrated and greenery is limited, become ‘islands’ of higher temperatures in comparison to outlying areas. Consequently, temperatures in urban areas are about 1°F-7°F higher in the daytime and about 2°F-5°F higher in the nighttime than temperatures in outlying areas.³⁴

India is rapidly urbanising, with many of its cities adding large populations regularly. Indian cities have already experienced the fallout of rising

a Mumbai (2005), Chennai (2017), Patna (2019) and Hyderabad (2020) are some of the major cities to have been devastated by floods. Delhi, Pune and Mumbai had the highest number of COVID-19 positive cases for many months. Ahmedabad, Delhi, Churu, Prayagraj, Akola and Nagpur have had debilitating heatwaves. Each of these events has led to loss of lives and property and near total disruption of life over several days, and huge loss to the national economy.

temperatures. In 2015, Hyderabad recorded a temperature of 46°C (114.8°F) on 21 May, Delhi was 46.4°C (115.5°F) on 25 May, Prayagraj recorded a temperature of 47.8°C (118°F) on 9 June, and Bhubaneswar 44°C (111.2°F) on 10 June. It was the fifth deadliest heatwave ever recorded, with 2400 death reported across the country that year.³⁵ In 2016, Delhi set a new maximum temperature record of 48°C (118.4°F) and Phalodi and Churu in Rajasthan recorded the highest day temperatures in India, at 51°C (123.8°F) and 50°C (122°F) respectively.³⁶

According to the ‘Assessment of Climate Change Over The Indian Region’ report by the Union Ministry of Earth Sciences, India’s average temperature has risen by 0.7°C (33.2°F) between 1901 and 2018 and will rise by 4.4°C (39.9°F) by 2100, while heatwaves will multiply by a factor of two or three and their duration will double compared to the 1976-2005 period.³⁷ Similar conclusions were made by the McKinsey Global Institute, which predicted that by 2050 India would face many lethal heatwaves—three-day events during which the average daily maximum wet-bulb temperature^b exceeds the survivability threshold for a healthy human resting in the shade.³⁸ Scientific literature holds that at 35°C (95°F) wet bulb, a healthy human being can survive by resting in the shade for approximately five hours.³⁹

In 2015, Indian meteorologists analysed summer high-temperature days in two timeframes—1969 to 1990 and 1991 to 2013.⁴⁰ The study separately considered data from 25 Indian megacities and metropolitans over the same period. It found that 17 cities had long-term summer high-temperature days for over 50 percent of the summer season’s total period (generally considered extending for 122 days per year; see Table 1). Furthermore, 16 cities showed long-term increasing trends of hotter days (see Table 2).

“By 2050, India could face many lethal heatwaves: 3-day events when the average maximum temperature exceeds a healthy human’s survival limit.”

^b The lowest temperature at which air can be cooled by the evaporation of water into the air at a constant pressure. The human body cools itself by shedding heat through sweating. However, the survivability threshold of the human body is reached at the wet bulb temperature of 35°C (95°F). Beyond this, the human system becomes ineffective and humans may develop hyperthermia or elevated body temperature beyond normal, leading to health complications.

**Table 1:
Mean High Temperature Days in
Select Towns**

City	Mean high temperature days 1969-2013
Ahmedabad	88.7
Nagpur	87.9
Solapur	84.1
Baroda	82.4
Rajkot	82.0

Source: A K Jaiswal, P C S Rao and Virendra Singh¹

**Table 2:
Mean High Temperature Decadal
Trends in Select Towns**

City	HT days trends in days/decade
Vishakhapatnam	+4.59
Madurai	+4.57
Chennai	+2.96
Jaipur	+2.91
Kolkata	+2.73

Source: A K Jaiswal, P C S Rao and Virendra Singh²

The report concluded that there has been a significant increase in the number of high-temperature days across India and that the pace has quickened in the second period of study (1991-2013). It found that the megacities experienced a sharp increase in summer high-temperature days during the second period of study: +2.16 days per decade in Mumbai, +6.3 days per decade in Delhi, +7.96 days per decade in Chennai, +7.73 days per decade in Jaipur, and +18.14 days per decade in Vishakhapatnam.⁴³

Despite the high incidences of deaths due to heatwaves and the rising number of extreme weather events, India does not recognise heatwaves as a disaster under its Disaster Management Act (2005). However, in the wake of the 2015 heatwaves, the National Disaster Management Authority (NDMA) published guidelines on preventing and managing heatwaves. The NDMA urged cities and states to prepare heat action plans (HAPs) that focus on early warning systems, training healthcare professionals, raising public awareness and encouraging collaboration with NGOs and civil society, as a means to tackle heatwaves.

In 2013, the Ahmedabad Municipal Corporation (AMC) implemented the country's first HAP, developed in the aftermath of the 2010 heatwave that hit the city, with temperatures exceeding 46.8°C (116.2°F) and 1344 people losing their lives. The AMC partnered with the Gandhinagar-based Institute of Public Health, the US-based Natural Resources Defence Council and several NGOs to design and implement the HAP,⁴⁴ with updates in 2016,⁴⁵ 2018⁴⁶ and 2019.⁴⁷ The HAP stipulated a series of actions to increase preparedness, information-sharing and response coordination to reduce the health impacts of extreme heat on vulnerable populations.

The HAP included four key strategies. First, public awareness and community outreach to share information on the risks of heatwaves and dos and don'ts to follow to prevent heat-related deaths and illnesses. Second, to put an early warning system in place to alert citizens about the onset of the heatwave and set inter-agency coordination in motion. Third, to build capacity among healthcare professionals, including paramedical staff and community health staff. Fourth, to launch measures to reduce heat exposure and promote adaptive techniques, such as access to potable drinking water, cooling spaces and night shelters, especially for high-risk populations.

Preliminary evaluation of the HAP and its implementation shows substantial positive outcomes. During the 2015 heatwave, where about 2400 people lost

their lives across the country, fewer than 20 heat-related deaths were reported in Ahmedabad.⁴⁸

Several other cities in India have also adopted such strategies. Currently, 30 cities across 11 states facing extreme hot weather conditions have adopted HAPs, including Delhi, Hyderabad, Bhubaneswar and Nagpur. However, assessments of these HAPs show implementational deficits,⁴⁹ including a lack of coordination, communication and outreach gaps, and inadequate response.

“Cities and states must prepare heat action plans that focus on early warning systems, training healthcare professionals, and raising public awareness.”

India must adopt several measures to prepare for and tackle the impacts of heatwaves. It must recognise heatwaves as a disaster and include it under the Disaster Management Act. This will equip the Centre, states and urban local bodies with statutory powers to enforce orders. It will also give authorities access to revenues that flow from the Act.⁵⁰ The current statutory weaknesses concerning heatwaves was evident when in June 2019 the district magistrate of Gaya, Bihar, had to prohibit the assembly of people (under Section 144 of the Criminal Procedure Code) to keep them indoors during a period of intense heat in the city.⁵¹

There are two broad types of responses to disasters—mitigation (the reduction of heatwave sources) and adaptation (adjustment mechanisms to cope with heatwaves). Mitigation measures can be more global while adaptation is primarily local. Within adaptation, annual preparatory and operational steps in a city and long-term but local policy-driven design changes should be included.

Annual preparatory and operational measures

Cities must develop sound early warning systems to inform citizens of a coming heatwave. Additionally, public health information and guidelines should be prepared and made available to all citizens. Special attention must be given to the urban poor and other vulnerable groups. During heatwaves, alternate accommodation in temporary, well-shielded shelters should be made available. Working hours and school hours may need to be curtailed or altered to avoid extreme heat conditions.

In periods of 'loo', residents in northern India are known to shield their houses with fibre-screens made of '*khas*',⁵² a variety of dry-grass that is kept damp by spraying it with water or through a simple water-pumping mechanism. Similar measures can be adopted elsewhere in the country to protect from heatwaves.

Potable drinking water should be provided at several places and along roads, and an adequate supply of ice packs, oral dehydration salts and intravenous fluids should be arranged. People should be advised to wear light-coloured, loose, cotton clothes and cover their heads when going out in the daytime. Capacity building of healthcare professionals should be undertaken, and a sizable public awareness campaign and community outreach programme should be included as part of the preparation. Cities should partner with NGOs, resident welfare associations and other civic organisations to encourage and implement such preparatory measures.

City planning and design

In addition to the short-term steps that need to be taken each year to manage heatwaves, cities must initiate several significant urban planning measures for long-term sustainability. Cities must be designed in climate-resilient and energy-efficient manner. Studies should be conducted on infrastructure and utilities that may be vulnerable in extreme heat. Elements of urban planning that will help reduce heat effects—green roofs or painting house roofs in a light colour to reflect heat, natural cooling, parks and water features—must be included in city regulations.

Cities should also consider promoting urban forestry. Building water bodies and fountains in dense areas, and improving green transport and energy systems is important. Unnecessary concretisation should be avoided and maximum permeability in construction should be encouraged.

Cities will have to introduce building plans that ensure inhabitants are protected from extreme temperatures. Building bylaws should include components on passive ventilation and cool-roof technologies to increase thermal comfort. Investments will need to be directed towards clean technologies and low carbon development.⁵³

“India should define heatwaves as a “disaster” and include it under the Disaster Management Act, which will equip the Centre, states and urban local bodies with statutory powers.”

Conclusion

Ramanath Jha is Distinguished Fellow at ORF, Mumbai.

Global and local measures must be initiated to protect cities and their inhabitants from the impacts of extreme heat events. Global forums dealing with climate change issues—such as the World Health Organization, World Economic Forum, First Global Forum on Heat and Health, and the Global Forum for Environment-OECD—also focus on heatwaves by investing in research on health risks of extreme heat, climate and weather information, advice on surviving heatwaves, partnerships and capacity building, and communications and outreach.⁵⁴ Similar efforts must be made in individual countries as well.

Given India's increasing vulnerability to heatwaves, it must first recognise such incidents as a disaster to make national and state disaster assistance available for mitigation efforts. Although the NDMA has issued guidelines on dealing with heatwaves, a national HAP will be extremely beneficial to cities and will “drive a national agenda to embed adaptation planning for rising temperature in our plans and design for space, utilities, infrastructure and industries.”⁵⁵

At the same time, cities must adopt a range of actions related to urban planning and governance, and governmental and community preparedness. These include establishing advance warning systems and good communication systems, and developing city HAPs in the absence of countrywide or state-specific plans. Local communities must also be educated on precautionary measures and steps to alleviate heatwave impacts. [ORF](#)

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20, Rouse Avenue Institutional Area,
New Delhi - 110 002, INDIA
Ph. : +91-11-35332000. Fax : +91-11-35332005
E-mail: contactus@orfonline.org
Website: www.orfonline.org