

# How India Copes with Heat

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August 2024



## About Artha Global

Artha Global is a global policy organisation that supports governments, multilateral agencies, philanthropies and private sector organisations to ideate, innovate, implement and institutionalise systems-level solutions that promote prosperity and resilience for all. We work globally, but have a primary focus on India and the developing world. We provide actionable research, support policy implementation, and build capacity to institutionalise change.

Over the next few decades, the developing world will negotiate important transitions, as societies and the economy move from rural to urban, farm to factory, informal to formal, brown to green, and analogue to digital. We help leaders manage these transitions and the inevitable dislocations they cause, in order to secure long-term prosperity and social stability for each individual. Key to our vision is the national pursuit of sustained economic growth.

Artha Global was founded by the leadership team of IDFC Institute, a Mumbai-based think/do tank with over a decade's experience working with the Union, state and local government in India.

## About Centre for Rapid Insights

The Centre for Rapid Insights (CRI) was established in 2022 to provide swift, actionable insights. Using Interactive Voice Response (IVR) technology, we rapidly collect survey data on a large scale. We employ statistical techniques to weight the data to improve the representativeness of claims about the studied population. Additionally, we utilise spatial methods to integrate administrative and public data, providing nuanced insights.

### Team<sup>1</sup>

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## 1 Introduction

There were at least 46 deaths reported just in May 2024 and 56 from March 2024 due to heat strokes in India.<sup>2</sup> While these extreme outcomes often catch our attention, the reality is that prolonged periods of extreme heat – what we witnessed in many parts of India – pose more generalised health risks.

The period from May 16 to June 18 recorded the highest minimum temperature since at least 1951, and about a third of India saw a summer in which the average maximum temperature was more than 2 degrees (Celsius) warmer than normal.<sup>3</sup> At such high temperatures, many Indians simply do not have the means to adequately cool their homes, and workplaces – especially those that require people to be outside – are rarely any more comfortable. Those who cannot adequately shelter themselves in cool places and drink enough water are prone to insomnia, fatigue, headache, fever, not to mention more severe illness. Unlike the discussion in the developed world, which is focused on the exponential growth in energy usage as temperatures rise, the first order problem for most Indians is simply coping with the heat.

This report focuses on the first order question for most Indians. How many people cannot adequately cool their homes, and who are they? To what extent can people protect themselves from the heat when at work? And what is the incidence of heat-induced illnesses in India? To answer these questions, one must combine and cross-reference across satellite data, meteorological data, and survey data. Because health outcomes and cooling in the home cannot be easily ascertained from official or administrative data, the data presented in this report rely on series of rapid surveys conducted in the months of May and June of 2024, during peak heat across much of India, using the technical machinery built by Artha Global's Centre for Rapid Insights (CRI).

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<sup>2</sup>Perappadan, B. S. (2024). 80 deaths due to confirmed and suspected heat strokes, 605 deaths due to cardiovascular diseases in May: Health Ministry data. *The Hindu*. <https://www.thehindu.com/news/national/80-deaths-due-to-confirmed-and-suspected-heat-strokes-605-deaths-due-to-cardiovascular-diseases-in-may-health-ministry-data/article68243688.ece>

<sup>3</sup>Jha, A. (2024). Number Theory: What led to the historic heatwave this summer? *Hindustan Times*. <https://www.hindustantimes.com/editors-pick/number-theory-what-led-to-the-historic-heatwave-this-summer-101718937198181.html>

## 1.1 International Concern for Heatwaves

Unsustainable industrial growth and consumption patterns increased greenhouse gas emissions, leading to a rise in global temperatures by 1.1°C since pre-industrial times. Efforts to limit the rise of global temperatures to 1.5°C above pre-industrial temperatures have been declared by leaders across the globe, with numerous climate action groups insisting on more efficacious and immediate measures. However, the damage already borne by communities is tremendous at existing global temperatures.

The Intergovernmental Panel on Climate Change (IPCC) revealed unsettling details on the impact of climate change in its sixth assessment report,<sup>4</sup> highlighting the frequency and impact of heat waves, droughts, floods, fires and other extreme weather events.<sup>5</sup> Around 950 million people spread across drylands are exposed to heat stress and desertification, alongside water scarcity. At 1.5°C, the frequency of heatwaves is predicted to increase by more than 4 times when compared to pre-industrial times.<sup>6</sup> If temperatures are pushed to 2°C, heatwaves would be experienced at least 5 times more often, exacerbating consequences for populations across the globe.

## 1.2 The Situation in India

South Asia, home to a quarter of the world's population, is a region highly vulnerable to the impacts of urban heat. Although the region is accustomed to heat, rapid urbanisation and climate change are pushing the region's limits of adaptation with lethal consequences. The impacts of heat in South Asia are already being seen. In India, as temperatures exceeded 50°C in parts during the summer, over 50

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<sup>4</sup> Lee, H. et al. (2023). Synthesis report of the IPCC Sixth Assessment Report (AR6). [https://report.ipcc.ch/ar6syrr/pdf/IPCC\\_AR6\\_SYR\\_LongerReport.pdf](https://report.ipcc.ch/ar6syrr/pdf/IPCC_AR6_SYR_LongerReport.pdf)

<sup>5</sup> Lee, H. et al. (2023). Synthesis report of the IPCC Sixth Assessment Report (AR6). [https://report.ipcc.ch/ar6syrr/pdf/IPCC\\_AR6\\_SYR\\_LongerReport.pdf](https://report.ipcc.ch/ar6syrr/pdf/IPCC_AR6_SYR_LongerReport.pdf)

<sup>6</sup> Boehm, S., & Schumer, C. (2023). 10 Big Findings from the 2023 IPCC Report on Climate Change. *World Resources Institute*. <https://www.wri.org/insights/2023-ipcc-ar6-synthesis-report-climate-change-findings%23::~:te xt=Even%2520if%2520countries%2520achieved%2520their>

heat-related deaths were reported between March and May of 2024 alone.<sup>7</sup> This is a glaring concern for a country where nearly 50% of Indians work outdoors.<sup>8</sup> Specific regions in India, including relatively underdeveloped states like Chhattisgarh and Madhya Pradesh, are particularly vulnerable to heat.<sup>9</sup> Apart from these regions, major Indian cities are expected to struggle with the urban heat island effect.<sup>10</sup> Cities will be much warmer than surrounding rural areas, due to the heat generated by the vehicles, dense built area and all the activities taking place in these densely populated areas.

Heat levels are expected to rise continuously unless drastic changes are made, with severe implications on health, well-being and productivity. There is a need for more research on the consequences of heat in India and the ways in which different communities cope. This will help develop more coherent strategies to mitigate and adapt to the impacts of climate change. In this report, we aim to aggregate insights from publicly available data, spatial data and citizen surveys to understand the varied impacts of heat and the distinct ways of coping in India.

### 1.3 The Recent Heatwave in India

In order to make sense of the recent heatwave in India, data was obtained from Copernicus ERA5-Land hourly data set,<sup>11</sup> which provides temporal global coverage from 1950 to the present at an hourly resolution. This data set contains information on air surface temperature 2m above the land surface. Data was collected for the period 1 May 2024 - 31 July 2024 and the hourly measurements aggregated by day

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<sup>7</sup>Mint. (2024, June 3). Heatwave: 56 heat-related deaths, 25,000 heatstroke cases reported in India from March to May. *Mint*.

<https://www.livemint.com/news/india/heatwave-56-related-deaths-reported-in-india-from-march-to-may-25-000-heat-stroke-cases-odisha-20-deaths-in-may-11717401959354.html>

<sup>8</sup>Jha, A., & Kishore, R. (2022, May 2). 49% of Indian workers are employed outdoors in scorching heat. *Hindustan Times*.

<https://www.hindustantimes.com/india-news/49-of-indian-workers-are-employed-outdoors-in-scorching-heat-101651514183004.html>

<sup>9</sup>Patil, M. (2017). Facing fire: India's poorest regions are the most vulnerable to heat waves. *Scroll.in*.

<https://scroll.in/article/838261/facing-fire-indias-poorest-regions-are-the-most-vulnerable-to-heat-waves>

<sup>10</sup> National Geographic Society. (n.d.). Urban heat island. *National Geographic*.

<https://education.nationalgeographic.org/resource/urban-heat-island/>

<sup>11</sup>Copernicus Climate Change Service. (n.d.). ERA5 land reanalysis data. *European Centre for Medium-Range Weather Forecasts*.

<https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-land?tab=overview>

into mean, median, minimum, and maximum values in Celsius. This produced a collection of images, one for each day in the period of interest. Once this collection was obtained, each day's values were summarised at the Assembly Constituency (AC) level using a geospatial data file of ACs. These values were then combined to produce a single data set with values for each day, for each AC.

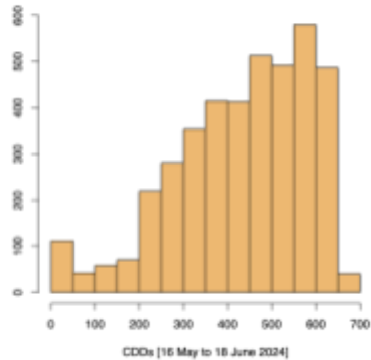
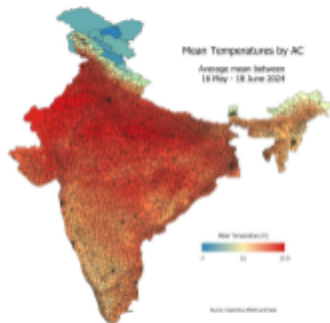
The resulting dataset provides the minimum, maximum, median, and mean temperatures for each AC in India for the period 1 May 2024 to 31 July 2024. The distribution of average temperatures is shown in figure 1a.

In order to use a generalised measure of heat, we use *cooling degree days* (CDDs) – which captures the extent of cooling required for a person to be comfortable. We follow Bhatnagar et al. (2018) in defining the baseline temperature at which one would be comfortable at 18 degrees Celsius.<sup>12</sup> To calculate CDDs, for each day we subtract 18 from the average hourly temperature, while giving a value of 0 if the average temperature is below 18 for the day. Then, we add up the daily CDD values over the specified period (16 May 2024 to 18 June 2024).

We are able to resolve almost all ACs in the entire country, with 4,094 ACs across the country in our data. The distribution of aggregate CDDs from 16 May 2024 to 18 June 2024 is shown in figure 1b. The median CDD over this period is 455, with about 12% of ACs having a value over 600. Each of the ACs that recorded a value over 600 was in one of 7 states or union territories: Bihar, Delhi, Haryana, Madhya Pradesh, Punjab, Rajasthan, Uttar Pradesh. Intuitively, this implies that the data largely coincides with a severe heatwave across the northwestern part of India (with Bihar and parts of Uttar Pradesh being notable exceptions).

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<sup>12</sup> Bhatnagar, M., Mathur, J., & Garg, V. (2018). Determining base temperature for heating and cooling degree-days for India. *Journal of Building Engineering*, 18, 270–280. <https://doi.org/10.1016/j.jobee.2018.03.020>



The CDD measure is useful in that it captures key information about prolonged periods of heat, where we are most concerned about the most detrimental impacts of heat. Traditionally, CDDs are used as a correlate to estimate energy demand.<sup>13</sup> In this report, we alter the standard literature in estimating the “health costs” of CDDs.<sup>14</sup> This allows us to put a spotlight on the difficult tradeoffs faced by India as temperatures rise – between protecting the health of its citizens and addressing growth in energy demand.

#### 1.4 Heat and Public Health

Extended exposure to high temperatures has been shown to exacerbate chronic illnesses such as diabetes, cardiovascular disease, and respiratory conditions, which are among the leading causes of death globally.<sup>15</sup> Women’s reproductive health also tends to deteriorate under extreme heat.<sup>16</sup> Additionally, communities living in densely populated, low-income neighbourhoods with inadequate green spaces are

<sup>13</sup> Khosla, R., Renaldi, R., Mazzone, A., McElroy, C., & Palafox-Alcantar, G. (2022). Sustainable Cooling in a Warming World: Technologies, Cultures, and Circularity. *Annual Review of Environment and Resources*, 47, 449–478.  
<https://doi.org/10.1146/annurev-environ-120420-085027>

<sup>14</sup> Khosla, R., Jani, A., & Perera, R. (2021). Health risks of extreme heat. *BMJ*, 375, n2438.  
<https://doi.org/10.1136/bmj.n2438>

<sup>15</sup> World Health Organisation. (2024). Heat Waves. *World Health Organisation*.  
<https://www.who.int/india/heat-waves>

<sup>16</sup> Woods, Z., & Agoncillo, M. P. (2019). Safeguarding Women’s Health in the Face of Rising Temperatures. *Asian Development Blog*.

disproportionately affected during heatwaves.<sup>17</sup> Factors such as heat-absorbing infrastructure and the inability to afford air conditioning make these communities particularly vulnerable.

The rapid increase in heat-induced health issues and deaths places immense pressure on medical systems, which are also susceptible to power outages during heat spells. Medical facilities need to be prepared to serve large segments of the population, especially those at high risk. Women, socio-economically disadvantaged groups, and individuals who must work outdoors are particularly vulnerable, necessitating targeted healthcare measures.

## 1.5 Heat and the Economy

Beyond quality of life issues, the inability to cope with extreme heat negatively impacts economic productivity and livelihoods. Over 50% of the Indian workforce is susceptible to health issues and decreased productivity due to their exposure to heat at work.<sup>18</sup>

A large number of Indians rely on the manufacturing and agricultural sectors, where many workers spend long hours in hot environments such as factories or outdoors. Increasing cases of heat exhaustion, heat stroke, and worsening pre-existing medical conditions affect working hours, productivity, and operational costs.<sup>19</sup> Informal workers and women are particularly vulnerable to reduced income and early retirement, impacting their livelihoods and access to critical services like healthcare.<sup>20</sup>

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<sup>17</sup> Ghosh, S., & Aggarwal, M. (2019). Low-Income Neighbourhoods Are More Vulnerable to Heatwave Spells. *The Wire*.

<https://thewire.in/environment/heatwave-india-urban-cities-neighbourhoods>

<sup>18</sup> Jha, A., & Kishore, R. (2022, May 2). 49% of Indian workers are employed outdoors in scorching heat. *Hindustan Times*.

<https://www.hindustantimes.com/india-news/49-of-indian-workers-are-employed-outdoors-in-scorching-heat-101651514183004.html>

<sup>19</sup> Singh, D. (2024). Five things to know about the impact of extreme heat on MSMEs and their workers in India. *MicroSave Consulting*.

<https://www.microsave.net/2024/06/05/five-things-to-know-about-the-impact-of-extreme-heat-on-msmes-and-their-workers-in-india/>

<sup>20</sup> Chandrashekar, N. (2024). Rising temperature, falling income: Heat stress in the informal sector. *India Development Review*.

<https://idronline.org/article/climate-emergency/rising-temperature-falling-income-heat-stress-in-the-informal-sector/>

In May 2024 alone, the manufacturing sector was predicted to suffer a 15% productivity loss in heat-intensive industries such as steel and plastics production.<sup>21</sup> Another recent study highlighted the impact of heat on Micro, Small, and Medium Enterprises (MSMEs), which are crucial for growth, innovation, and employment. Estimated losses exceed 100 billion hours annually, equivalent to the work performed by 35 million people working 8-hour days. Many MSMEs lack adequate cooling systems and experience frequent power outages, exacerbating the heat problem.

Similarly, the agricultural sector's workers and productivity are also adversely affected by rising temperatures. The Indian Council for Agricultural Research noted that a 1°C increase above the average temperature of 30°C during the grain-filling period significantly limits wheat growth.<sup>22</sup> Each 1°C increase is expected to result in a 3-4% decline in wheat yield. Rising temperatures also lead to more pest infestations and reduced nutritional value of crops, raising concerns about food security and public health.<sup>23</sup>

## 1.6 Heat and Energy Demand

Between 2019 and 2030, about 4.8 billion units of cooling equipment are expected to be sold globally. Further, India's demand for cooling is expected to be the highest when compared to other lower-middle income countries, foreshadowing the country's overwhelming presence in this market. Therefore, it is crucial to understand the steep surge in energy consumption for space cooling.<sup>24</sup>

Although fans continue to be used most extensively, the purchase and utilisation of air conditioners is growing steeply, especially in urban India. The India Cooling Action

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<sup>21</sup>Kumar, D. (2024, May 4). Severe heatwave to result in production loss in heat-intensive industries. *Mint*.

<https://www.livemint.com/economy/severe-heatwave-to-result-in-production-loss-in-heat-intensive-industries-11714719011055.html>

<sup>22</sup>Das, S. (2024). Explainer: Impact of heat waves on food production. *Financial Express*.

<https://www.financialexpress.com/policy/economy-explainer-impact-of-heat-waves-on-food-production-3525512/>

<sup>23</sup> Rajput, P., Singh, S., Singh, T. B., & Mall, R. K. (2022). The nexus between climate change and public health: A global overview with perspectives for Indian cities. *Arabian Journal of Geosciences*, 16(1), 15. <https://doi.org/10.1007/s12517-022-11099-x>

<sup>24</sup>Chilling Prospects: Providing Sustainable Cooling for All. (2018). *Sustainable Energy for All | SEforALL*. <https://www.seforall.org/our-work/research-analysis/chilling-prospects-series/publications/chilling-prospects-cooling-for-all-repo>

Plan of 2019 states that the share of room air conditioners will grow 6 times in the next 20 years. As this trend unfolds, energy efficient cooling appliances need to be more accessible.

According to a study examining urban areas in Delhi, over 99% of households owned fans and over 40% owned air conditioners. Despite fans being ubiquitous, merely 7% of these appliances were energy efficient.<sup>25</sup> Further, the more energy efficient air conditioners tended to be inaccessible to sizable sections due to their high prices. A 20% price difference was found between air conditioners with mid-rated efficiency, and high efficiency air conditioners.

Overall, the inaccessibility of more efficient cooling appliances has augmented electricity usage significantly, taking us farther away from sustainable energy consumption. As per a report by the World Bank, the total electricity consumption by air conditioning will increase to 50,000 GWh per year in 2031. Increasing energy consumption underscores the need to foster green and sustainable cooling strategies.<sup>26</sup>

## 1.7 Heat and Urban Built Area

Heat has uneven spatial distributions, with wide variations in temperatures and adaptive capacities across buildings, communities, and cities around the world. Urban areas often experience higher temperatures by absorbing more solar radiation than surrounding rural areas, a phenomenon called the urban heat island (UHI) effect. Contributing factors may include reduced coverage of naturally cooling vegetation and water bodies, higher usage of heat-absorbing and heat-retaining building materials, reduced air circulation from densely built infrastructure, and higher output of anthropogenic heat sources, such as waste heat from vehicles and cooling devices.<sup>27</sup>

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<sup>25</sup> Khosla, R., Agarwal, A., Sircar, N., & Chatterjee, D. (2021). The what, why, and how of changing cooling energy consumption in India's urban households. *Environmental Research Letters*, 16(4), 044035. <https://doi.org/10.1088/1748-9326/abebc>

<sup>26</sup> Carbon Brief Staff. (2021). Guest post: How energy demand for cooling in India's cities is changing. *Carbon Brief*. <https://www.carbonbrief.org/guest-post-how-energy-demand-for-cooling-in-indias-cities-is-changing/>

<sup>27</sup> United States Environmental Protection Agency. (2014). Heat Island Effect. *US EPA*. <https://www.epa.gov/heatislands>

Heat also has uneven socioeconomic variations. Within urban areas, vulnerability to the effects of extreme heat is not uniform. Those belonging to lower socioeconomic groups, particularly those residing in informal settlements, are more vulnerable to extreme heat and shifting climatic conditions.<sup>28</sup> A combination of several dimensions of poverty result in this higher propensity to be damaged by heat: lower income, fewer assets, social exclusion, along with a number of contextual factors. Those residing in densely populated informal settlements find themselves significantly more susceptible to extreme heat. An examination of temporal and spatial patterns of heat exposure in Delhi revealed that informal neighbourhoods consistently remain more affected by high temperatures.<sup>29</sup> A series of satellite maps published by World Resources Institute (WRI) India revealed variations in microclimatic conditions within Mumbai in the month of October. A stark difference in temperature was observed between slums and surrounding neighbourhoods. In the Dharavi region, temperatures were found to be 5 degrees higher, illustrating the extent to which the nature of the settlement can impact vulnerability to heat.<sup>30</sup>

Inhabitants of these areas are severely constrained in their ability to cope with heat as they simultaneously face water shortages and power outages. Lower income neighbourhoods often resort to a host of makeshift measures, such as covering their roofs with jute bags or thermal insulation sheets, in order to cope with excruciating heat.<sup>31</sup> In Jodhpur, community organisations are encouraging slum residents to paint the roof of their houses with white solar reflective paint, as a way to increase heat resilience.<sup>32</sup>

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<sup>28</sup>Ramsay, E. E., Fleming, G. M., Faber, P. A., Barker, S. F., Sweeney, R., Taruc, R. R., Chown, S. L., & Duffy, G. A. (2021). Chronic heat stress in tropical urban informal settlements. *IScience*, 24(11), 103248. <https://doi.org/10.1016/j.isci.2021.103248>

<sup>29</sup> Jacobs, C., Singh, T., Gorti, G., Iftikhar, U., Saeed, S., Syed, A., Abbas, F., Ahmad, B., Bhadwal, S., & Siderius, C. (2019). Patterns of outdoor exposure to heat in three South Asian cities. *Science of The Total Environment*, 674, 264–278. <https://doi.org/10.1016/j.scitotenv.2019.04.087>

<sup>30</sup>Chatterjee, B. (2020). Mumbai slums are six degrees warmer than neighbouring hsg societies in Oct. *Hindustan Times*.

<https://www.hindustantimes.com/mumbai-news/mumbai-slums-are-6-degrees-celsius-warmer-than-neighbouring-housing-societies-in-october-study/story-wo22fMA4bIUzvV5OldamN.html>

<sup>31</sup>Pandey, K. (2024). Extreme heat compounds vulnerabilities in low income neighbourhoods.

*Mongabay-India*.

<https://india.mongabay.com/2024/06/extreme-heat-compounds-vulnerabilities-in-low-income-neighbourhoods-delhi-ncr/>

<sup>32</sup>K, V. (2023). The white roofs cooling women's homes in Indian slums. *BBC*.

<https://www.bbc.com/future/article/20230628-the-white-roofs-cooling-womens-homes-in-indian-slums>

There is limited structured analysis on coping mechanisms for extreme heat and a paucity of data on the prevalence of illness during such periods. In this policy brief, we address gaps in existing knowledge by integrating insights from publicly available data, spatial analysis, and citizen surveys to understand the varied impacts of heat and the distinct coping strategies.

## **2 The Rapid Survey Framework**

CRI's framework uses Interactive Voice Response (IVR) technology to gather large scale survey data rapidly, allowing access to thousands of responses in a matter of hours. The rapid polling is conducted via mobile phones. In order to carry out these surveys, CRI has partnered with Prashnam.ai, a survey company that enlists a large opt-in population across 21 States in India.

The rapid insights framework ensures that there are no day-level or surveyor-level effects on survey response, and that we can gather recent, topical data at scale. Similar to in-person surveys, each person has a different propensity to answer a survey, so accounting for non-response bias is important.

New statistical tools in the analysis of public opinion data can significantly mitigate these biases. In other words, the relatively large sample size with appropriate statistical adjustment, allows us to make robust empirical claims from the survey data at a fraction of the cost and time that it would take to roll out a brick-and-mortar in-person survey. Most importantly, the rapid insights framework allowed us to conduct and complete a survey at the precise moment when the impacts of the heatwave were most noticeable and generate insights that are representative of India's population.

## **3 Methodology**

CRI conducted three rapid polls to investigate the impact of excess heat on health (May 28-30) and to understand how people are coping with it at home and at the workplace (June 6-8). The surveys sampled over 27,500 people across India in a matter of a few days and were conducted across 20 states and Union territories, encompassing 421 assembly constituencies within 421 of India's 543 parliamentary constituencies. The survey questions were written and recorded in 10 languages,

including Hindi, Marathi, Gujarati, Malayalam, Kannada, Tamil, Telugu, Punjabi, Bengali and Assamese.

The rapid polling was conducted on mobile phones followed by a rigorous process of estimation and weighting using the National Family Health Survey (NFHS) as an anchor to provide representative claims of those households that own a mobile phone.

Since respondents on a telephone typically have a short attention span, we limited each survey to three questions to maximise the number of responses with complete data. For each key substantive question, we formed a “bundle” where the first question would be substantive question of interest (e.g illness due to excess heat or people coping with high temperatures), followed by a question on asset ownership (ownership of vehicle) to understand economic well being and a question on social identity (caste), to understand the social stratum of society. Each respondent would, thus, respond to this bundle of three questions consisting of a single substantive question and two demographic questions (asset ownership and caste).

For our second survey on how people cope with heat in their homes, we wanted to study the rise of ‘heat islands’; dense urban areas where the population is more vulnerable to heat and is disproportionately affected. We narrowed down on a list of urban/semi urban ACs across India for our sampling frame as well as incorporated open-source satellite imagery data into its analysis to provide additional context for the citizen surveys, situating their findings within larger local, regional, and national geographic patterns. Satellite data paired with their survey included the European Space Agency’s (ESA) Global Human Settlement Layer (GHSL) program on the built up area inside the assembly constituency, annual rainfall data from NASA/ GSFC from the India Meteorological Department via a study by Srivastava et al.

Given a significant proportion of our population is engaged in heat-exposed work, the productivity of our manufacturing and production sector is at stake. Our third survey assessed individuals coping with heat in the workplace and how excess heat is impacting productivity and causing economic losses.

#### **4 Significant Evidence of Heat-Induced Illnesses**

Many parts of the country averaged temperatures three degrees Celsius higher than the average in the month of May, 2024. Beyond severe consequences such as

fatalities, those who are unable to adequately shelter themselves in cool places and drink enough water are prone to insomnia, fatigue, headache, fever, and more severe illnesses.<sup>33</sup>

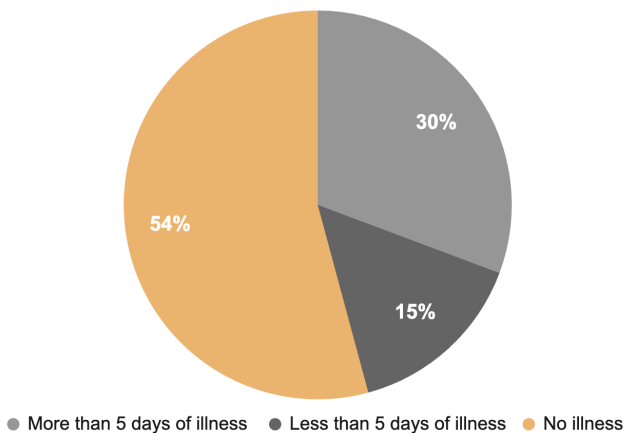
We asked the following question to study the impact of heat on health:

*'In the past month, have you or anyone in your household experienced illness, such as fever, vomiting, headache, or dizziness, due to the heat outside?'*

1. Yes, more than 5 days in the last month
2. Yes, but fewer than 5 days in the last month
3. No, not at all

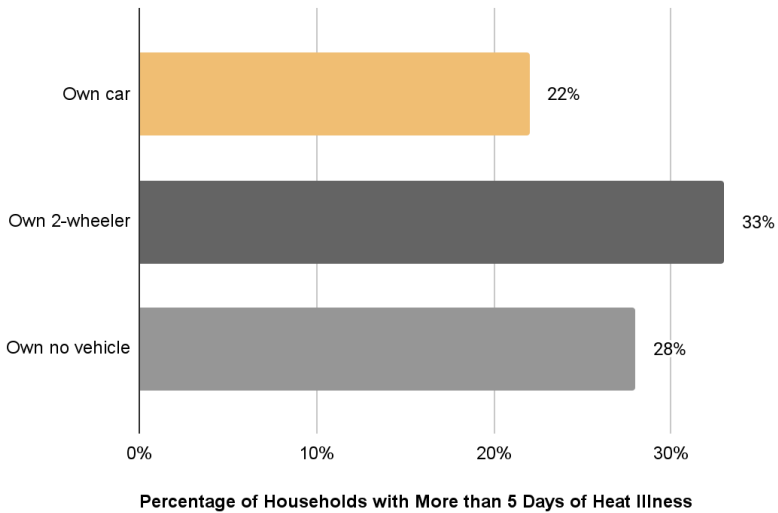
Figures 1 and 2 below display the estimated responses to the question using our modelled approach.

**Figure 1:** Overall Rates of Heat-Induced Illness in the Past Month



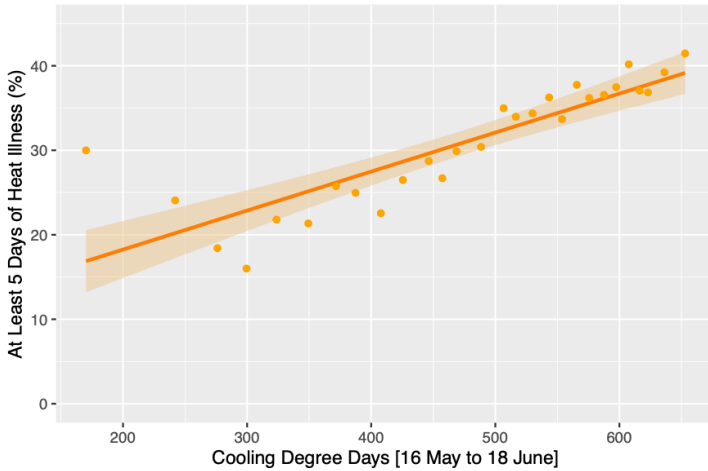
<sup>33</sup> Sircar, N. (2024). Hope soaring mercury affects quality of life. *Hindustan Times*. <https://www.hindustantimes.com/india-news/how-soaring-mercury-affects-quality-of-life-101718599246286.html>

**Figure 2: Health Impact of Heat by Economic Group**



The rapid insights infrastructure allows us to quickly assess the health impacts of heatwaves. Using the CDD measure we derived from satellite data and meteorological data, we can correlate CDDs to heat-induced illness. Indeed, figure 3 below shows a strong positive relationship between the number of CDDs and the percentage of households with at least 5 days of heat-induced illness. Moving from the 25th percentile of CDDs (378) to the 75th percentile (579) predicts that the percentage of households with at least 5 days of heat-induced illness grows from 26% to 36% – a 10 percentage point increase and a 39% increase in the incidence of high levels of heat-induced illness. Taken together, this points to the fact that at extreme levels of heat a significant proportion of the population cannot sufficiently cool their environment irrespective of energy demand and, thus, experience heat-induced illness. Furthermore, the incidence of such heat-induced illnesses is highest among the poorest populations.

**Figure 3: Heat-induced illness and CDDs**



#### 4.1 Findings

**1) Overall impact of heat on health:** 45% of Indians reported at least one family member falling ill due to the heat in the past month: Of those who reported a household member falling ill due to the heat, more than 67% reported household members falling ill for more than 5 days in the past month. As a result, these households could face increased healthcare costs, compromised wellbeing (both physical and psychological), and invariably high economic losses. The rising illnesses as a result of heat could put a further strain on the country's healthcare systems and resources.

**2) Lower economic groups experience greater health impacts as a result of heat:** A total of 32.5% of households with a two-wheeler, and a total of 28.2% of households with no motorised vehicle reported having a household member who experienced illness for more than five days; this number dropped to 21.8% among households with cars to significantly more heat exposure in their daily movements.<sup>34</sup> The economically disadvantaged often have limited access to sufficient healthcare or face substantial medical bills that worsen their economic situation. Additionally, they may experience

<sup>34</sup> This is also likely an underestimate on the impact of heat on the poorest in society, as our survey results are representative of households that own a mobile phone

business losses due to absenteeism caused by health issues, contributing to the widening of inequalities.

## 5 Formation of heat islands and increased reliance on cooling measures

In urban areas, heat disproportionately affects the poor, with semi-urban regions being especially vulnerable due to unplanned development. A combination of multiple dimensions of poverty contributes to this increased vulnerability to heat: lower income, fewer assets, social exclusion, and various contextual factors.

We asked the following question to understand the variety of heat and coping measures in urban/ semi-urban areas:

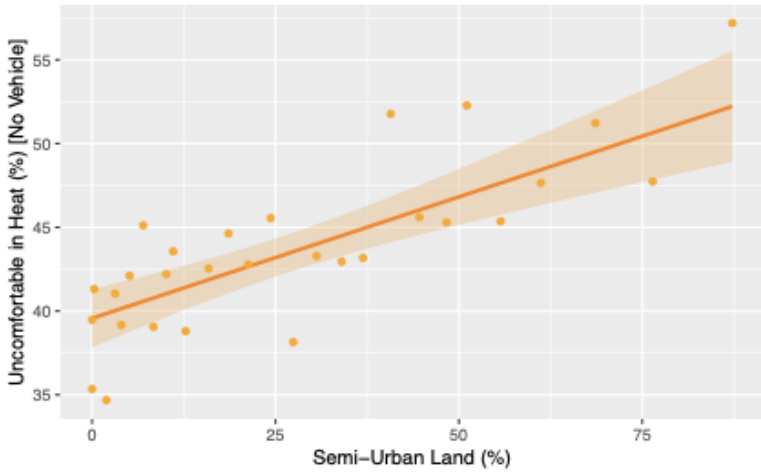
*In the afternoon, when it is hot outside, is the inside of your home comfortable?*

1. *Yes, but we turn on an air conditioner or cooler*
2. *Yes, but we turn on a fan*
3. *Yes, and we do not need fan, cooler, or air conditioner*
4. *No, it is hot and uncomfortable inside the home*

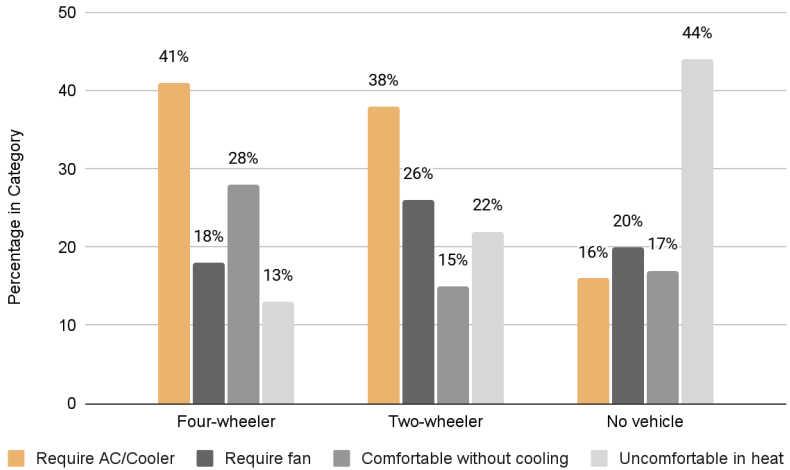
We looked at the built-up area data within assembly constituencies, focusing on semi-urban land (combination of semi-dense and suburban settlements) as they are less likely to be planned and particularly vulnerable to heat. The sample in this case was also restricted to our poorest respondents (those with no vehicle) and assess the relationship between the percentage of semi-urban land in an assembly constituency and the percentage of people who find their homes to be hot and uncomfortable in the assembly constituency.

Figure 4 displays the relationship between the percentage of semi-urban land in an assembly constituency and the percentage of those with no vehicle who are uncomfortable in the heat – indeed showing significant effects of built area on the inability to cope with the heat. Finally, Figure 5 shows the distribution of reported heat-coping mechanisms by asset class – demonstrating that the most well-off in our sample (those with a car or 2-wheeler) have much greater capacity to cope with heat using an air conditioner or cooler.

**Figure 4: Semi-Urban Land Area and Inhospitable Dwellings for the Poor**



**Figure 5: Heat Coping Measures by Economic Group**



## 5.1 Findings

**1) A strong relationship between those living in semi-urban areas and likelihood of living in an uncomfortable home:** Our model predicts that moving from 5% semi-urban land area (25th percentile) to 50% semi-urban land area (80th percentile) increases the likelihood of living in an uncomfortable home by 20% for the poorest in our sample. The use of building and roofing materials in these areas, such as poorly insulated construction and a lack of adequate green cover, results in higher temperatures. Apart from decreased productivity and poor health conditions due to excess heat, they can also face increased energy costs to implement required cooling measures.

**2) A large number of people owning a two or four wheeler depend on ACs and coolers:** With inadequate cooling at home, the costs of coping with heat are increasing in India, with a high proportion of the middle income category spending a significant amount on cooling measures. Findings indicate that only about one in eight four-wheeler owners feel their home is uncomfortable during extreme heat, compared to nearly half of those without a vehicle. Alternately, around 40% of people with either a two-wheeler or four-wheeler need an AC or cooler to maintain a comfortable home environment, while only about 16% of those without a vehicle use such devices. This data highlights the significant heat exposure faced by the poor, even when they are inside their homes away from direct sunlight. This leads to substantial spending and financial strain for middle income groups. Increased AC and cooler reliance also has environmental implications; higher energy consumption and greenhouse gas emissions. Additionally, the widespread use of cooling devices can strain power grids and exacerbate urban heat island effects.

## 6 Workplace productivity

As India faces scorching temperatures, the impact on both productivity and the health of individuals is significant. In workplaces across the country, more than half of the workforce is vulnerable to health issues and reduced efficiency due to extreme heat. According to a World Bank report, about 75% of India's workforce is employed in heat-exposed jobs.<sup>35</sup> With key sectors like agriculture and manufacturing heavily

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<sup>35</sup> World Bank. (2022). Climate Investment Opportunities in India's Cooling Sector. *World Bank*. <https://doi.org/10.1596/38340>

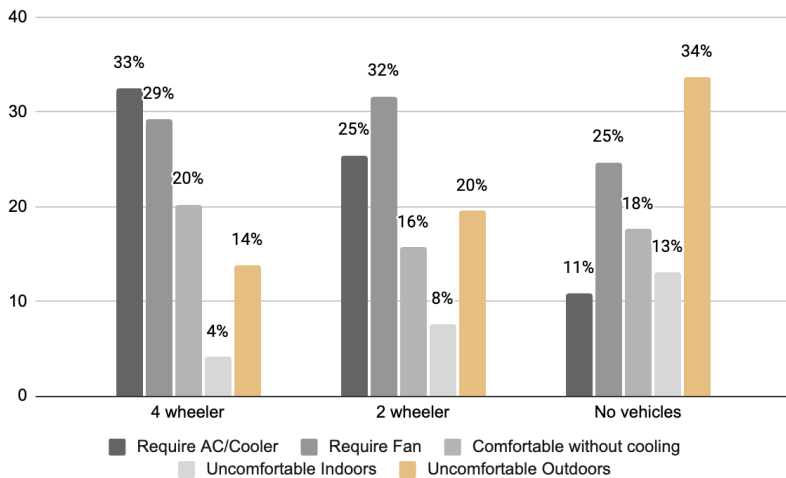
relying on outdoor and hot factory work, these industries could face significant impacts. We asked the following question to learn about the impact of heat on workplace productivity:

*In the afternoon, when it is hot outside, is your workplace comfortable?*

1. Yes, we work indoors and turn on an air conditioner or cooler
2. Yes, we work indoors and turn on a fan
3. Yes, we work indoors and are comfortable without air conditioner, cooler or fan
4. No, we work indoors and it is uncomfortable
5. No, we work outdoors and it is uncomfortable

We note that we do not re-weight the data for this sample, as a “population estimate” of those individuals who work is more difficult to estimate from existing administrative data. Even though we expect our population of those who answer the mobile phone to be somewhat more well-off than the average Indian, we find that one-third of our respondents do not have access to adequate cooling in the workplace – about 25% of the sample works outside, while about 9% of the sample works indoors but in a place that is not adequately cooled.

**Figure 6: Impact of Heat on Workplace Productivity**



There are noticeable class effects in the data, as can be seen in figure 6. Only about 18% of the wealthiest in our sample, those who own a 4-wheeler, are uncomfortable in their workplace (whether inside or outside) as compared to 47% of the poorest in our sample, those without a vehicle, being uncomfortable in their workplace. More than a third of the poor are working outside, whereas about a third of the wealthiest have access to an air conditioner or cooler in the workplace to adequately cool the inside. This shows that the class effects we identified in our second survey persist in the workplace – implying that there is a significant share of the population that cannot mitigate the impact of heat in home or in the workplace.

## 6.1 Findings

**Almost 50% of the respondents that belong to lower income groups (without a vehicle) are uncomfortable in their workplace:** With a high proportion of workers (perhaps belonging to the informal sector) engaged in outdoor work, half of them claim to be uncomfortable in their workplace, while less than 20% of the high income groups respondents (those with a car) state that they are uncomfortable at work due to the heat. Reduced worklife expectancy,<sup>36</sup> productivity, and income due to shorter business hours disproportionately affect poorer sections who cannot afford cooling measures, exacerbating inequalities. Additionally, this leads to significant losses for the manufacturing and agricultural sectors that employ the maximum number of informal workers

## 7 Policy recommendations

Due to its catastrophic impacts, extreme heat is gaining traction in the media and across government policy agendas. Heat is distinct from other climate risks due to its historic lack of governance and legal regulatory structure, spatial and temporal complexity, and invisibility. In India, the National Disaster Management Agency (NDMA) has developed a roadmap for states and cities to plan and prepare for heat risk as a precautionary short-term strategy.<sup>37</sup> The India Cooling Action Plan (ICAP), 2019, was implemented to provide sustainable cooling and thermal comfort. Many still wonder if policy efforts are coordinated at the State level and comprehensive

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<sup>36</sup> Worklife expectancy is a statistical average of the total time an individual is estimated to be active in the workforce before retiring.

<sup>37</sup>National Disaster Management Authority.(2019). Heat Wave Guidelines and Preparedness. National Disaster Management Authority.

<https://ndma.gov.in/sites/default/files/IEC/Booklets/HeatWave%20A5%20BOOK%20Final.pdf>

enough to face the existential threat ahead. Although the Center has provided an instructive framework for action, states are developing plans to manage and mitigate extreme heat largely independently, with few resources provided by the national seat of power.<sup>38</sup>

In this policy brief our attempt was to understand the health effects of urban heat in India, particularly focusing on how vulnerable groups, such as informal workers and residents of informal settlements are coping. This analysis underpins our recommendations, offering policy makers guidance on areas that require increased attention and resources to improve urban heat management. Our recommendations include the following:

### **1) Improve data collection and analysis on urban heat**

Further data is required to adequately identify, manage, and monitor urban heat risks. Satellite data are not sufficient in providing an accurate representation of the thermal conditions being experienced throughout urban areas. Systematic data collection and analysis are required to identify heat-vulnerable environments and populations within each city. This information can help develop more effective and targeted heat management plans. Therefore, improving the understanding of urban heat profiles through high-resolution data collection and mapping should be a major priority for the government.

### **2) Implement strategies for heat mitigation and management**

An effective policy approach will require strategies for heat mitigation and management:

Heat mitigation strategies - These strategies are designed to cool cities by re-designing the built environment, incorporating vegetation, and reducing waste of heat. Effective strategies for heat mitigation include:

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<sup>38</sup>Sinha, A. (2022). Policy Lessons from the Front Lines: Tackling Extreme Heat in India. *South Asian Voices*. <https://southasianvoices.org/policy-lessons-from-the-front-lines-tackling-extreme-heat-in-india/>

- **Increasing green cover:** Trees and plants provide shade, evapotranspiration, and aesthetic benefits, reducing temperatures and improving urban residents' comfort and well-being. For instance, Singapore has successfully cooled parts of its city by planting over 7 million trees and creating more than 300 parks and gardens.<sup>39</sup>
- **Installing green or cool roofs:** Green roofs are covered with vegetation and cool roofs feature reflective coatings. Green rooftops reflect the heat instead of absorbing it, reducing the need for air-conditioning, enhancing urban biodiversity and cutting greenhouse gases. New York City, for example, has installed over 10 million square feet (929,000 square meters) of green and cool roofs since 2009, reducing annual greenhouse gas emissions by 16,000 metric tons.<sup>40</sup>
- **Replacing regular pavement with cool pavements:** Materials like concrete, asphalt, gravel, or pavers, or porous sealants are good materials for cool pavements. Such pavements have higher albedo (reflectivity) and permeability (water retention) than regular pavements, thereby reducing surface and air temperatures and stormwater runoff. In the United States, Los Angeles has tested cool pavement projects since 2017, showing surface temperature reductions of up to 11°C (51.8°F).<sup>41</sup>

**Heat Management** - These strategies are designed to protect people from heat that cannot be mitigated. Our research has shown that urban heat risks and vulnerabilities have important spatial and social variations and these need to be accounted for in heat management strategies:

Building heat action plans (HAPs) that target vulnerable populations: While States in India have recognised the importance of having HAPs, these are not always designed to protect vulnerable communities. States should have heat action plans that recognise the differential needs of vulnerable populations, such as slum-dwellers, children and develop targeted support strategies. To effectively support vulnerable

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<sup>39</sup> Kumar, P., Debele, S. E., Khalili, S., Halios, C. H., Sahani, J., Aghamohammadi, N., & Jones, L. (2024). Urban heat mitigation by green and blue infrastructure: Drivers, effectiveness, and future needs. *The Innovation*, 5(2). <https://doi.org/10.1016/j.xinn.2024.100588>

<sup>40</sup>Yang, J., Pyrgou, A., Chong, A., Santamouris, M., Kolokotsa, D., & Lee, S. E. (2018). Green and cool roofs' urban heat island mitigation potential in tropical climate. *Solar Energy*, 173, 597-609. <https://doi.org/10.1016/j.solener.2018.08.006>

<sup>41</sup>Kumar, P., Debele, S. E., Khalili, S., Halios, C. H., Sahani, J., Aghamohammadi, N., & Jones, L. (2024). Urban heat mitigation by green and blue infrastructure: Drivers, effectiveness, and future needs. *The Innovation*, 5(2). <https://doi.org/10.1016/j.xinn.2024.100588>

groups, HAPs need to:

- Incorporate vulnerability mapping: The majority of HAPs do not include hotspot-based interventions. A study by NDMA that examined over 50 HAPs from India, Bangladesh and Nepal concluded that the lack of focused hotspot-based priority interventions was one of the key barriers to implementing HAPs.<sup>42</sup> Vulnerability mapping can be done by using fine-resolution satellite data to map land use, population distribution, and other factors such as built-up, vegetation fraction, and land surface temperatures that influence the heat sensitivity of a region. Government authorities could collaborate with research institutions and NGOs to carry out such assessments.
- Effective and innovative messaging: it is crucial that vulnerable groups and communities are warned in advance. Heat alerts should be shared in a palatable format (e.g. 'Dos and Don'ts' lists) through social media channels and made available in local languages. For instance, the Gujarat Institute of Disaster Management (GIDM) developed a training module and a comic book in vernacular language and uses a simple, colour-coded, early warning system to alert locals of extreme temperatures.<sup>43</sup>
- Include region-specific thresholds in forecasts and early warning systems: Given India's heterogeneous climate, a one-size-fits-all approach can lead to underprediction.<sup>44</sup> Forecast systems need to be calibrated to regional thresholds. For example, the Odisha State Disaster Management Authority has collaborated with IMD to define region-specific thresholds that combine humidity and temperature, rather than just absolute air temperature.<sup>45</sup>
- **Ensuring access to reliable energy and indoor cooling:** Access to indoor cooling is a vital resource for coping with heat. However, as ours and findings

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<sup>42</sup> NDMA. (2019). *Heat Wave Guidelines and Preparedness*.

<https://ndma.gov.in/sites/default/files/IEC/Booklets/HeatWave%20A5%20BOOK%20Final.pdf>

<sup>43</sup> Gujarat Institute of Disaster Management. (2024). *Heat Wave Risk Mitigation & Management*. Gujarat Institute of Disaster Management.

<https://gidm.gujarat.gov.in/en/heat-wave-risk-mitigation-and-management>

<sup>44</sup> Council on Energy, Environment & Water (2023). 4 solutions for tackling heatwaves in India. Council on Energy, Environment & Water.

<https://www.ceew.in/blogs/strengthening-heat-action-plans-heatwaves-solutions-india>

<sup>45</sup> Odisha Institute of Disaster Management (2020). *Heat Action Plan*. Odisha Institute of Disaster Management.

<https://www.osdma.org/preparedness/one-stop-risk-management-system/heat-wave/#gsc.tab=0>

of similar studies show, low income households and communities lack it. Providing affordable, efficient, and clean energy and cooling solutions, such as solar panels, fans, evaporative coolers, or heat pumps, is going to be essential to protect people. In 2019, India launched the India Cooling Action Plan, aiming to provide sustainable cooling for all by 2038.<sup>46</sup> Ensuring successful implementation of this plan should be a priority for the government.

- **Encourage employers to implement protections for outdoor workers:** Outdoor workers, such as those in construction, agriculture, and transportation, are at high risk of contracting heat-related illnesses and injuries. Employers should be mindful of these risks and provide adequate protection, including regular breaks, shade, water, protective clothing, and training.

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<sup>46</sup> Ministry of Environment, Forest and Climate Change (2022). India Cooling Action Plan. *Ministry of Environment, Forest and Climate Change*. <https://www.carbonbrief.org/guest-post-how-energy-demand-for-cooling-in-indias-cities-is-changing/>



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