PENN IUR **SERIES ON INFORMALITY**

Heat Vulnerability and the Built Environment in Ahmedabad, India

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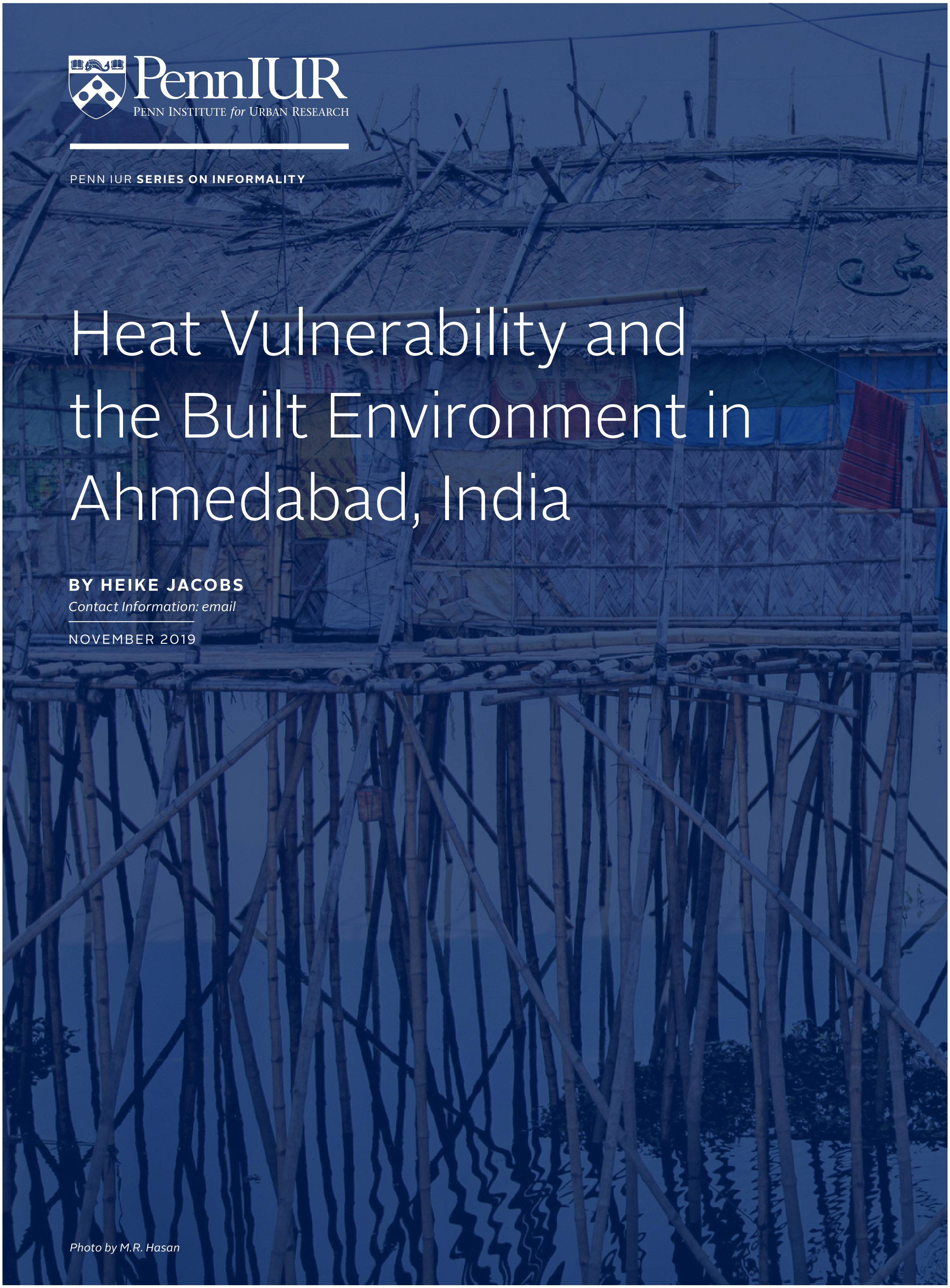

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INTRODUCTION

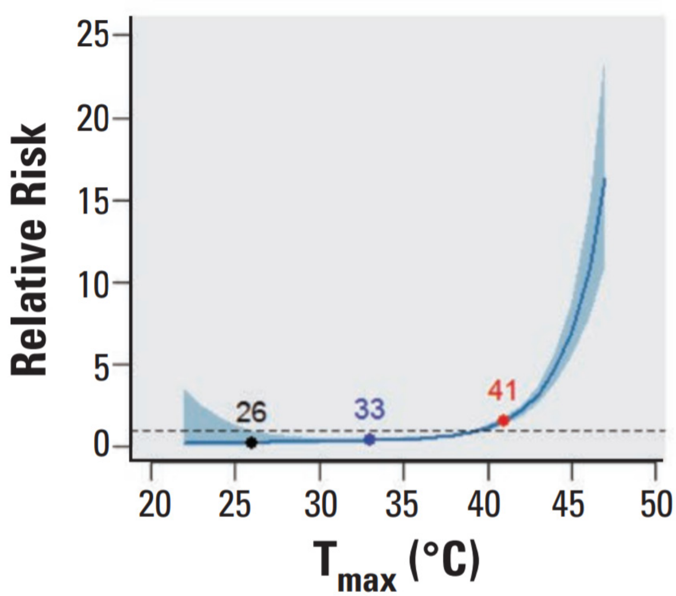
Heat waves, or extreme heat events, which are defined as any period of time in which the daily maximum temperature exceeds 45°C or 113°F, are extremely common across India and cause approximately 20 percent of all deaths in India resulting from extreme weather events (Mahapatra, Walia, and Saggurti 2018, 111). To make matters worse, extreme heat events are predicted to become more frequent and more severe in the future due to global warming. Even in a scenario in which global warming is limited to less than 2°C of warming above pre-industrial levels, which was the goal agreed upon in the Paris Agreement, severe heat waves in India will become eight times more frequent by the mid-21st century, and will last approximately three times longer (Mishra et al. 2017, 5-6). The daily maximum temperature in India is also expected to increase by 1 to 4°C by 2050 (Krishna Kumar et al. 2011, 321). Currently, temperatures during the months of April and May (India's heat wave season) reach highs of 40 to 42°C on average, which means that in just three decades, it would not be unusual for temperatures during the heat wave season to reach 46°C and for extreme heat events to occur on a yearly basis (Sharma 2018).

Although an increase of 1 to 4°C may seem small, the difference between 40 and 45°C can have a significant impact on human health. While an individual's heat tolerance can vary based on age and other factors (children, the elderly, and those with chronic illnesses are more likely to be adversely affected by extreme heat), research has shown that the risk of dying from exposure to extreme heat rises exponentially after the daily maximum temperature exceeds approximately 37°C, which is considered to be normal body temperature (Hanna and Tait 2015, 8042-8043; Petitti et al. 2015, 180; see Figure 1 below). After the daily maximum temperature exceeds 37°C, the body has to work harder to maintain normal body temperature and the usual mechanisms of thermoregulation, such as sweating, are no longer as effective. As a result, the risk of dying when the daily maximum temperature reaches 45°C is approximately five times higher than at 40°C (Petitti et al. 2015, 180; see Figure 1 below).

FIGURE 1:

Relative Risk of Mortality by Daily Maximum Temperature (°C)

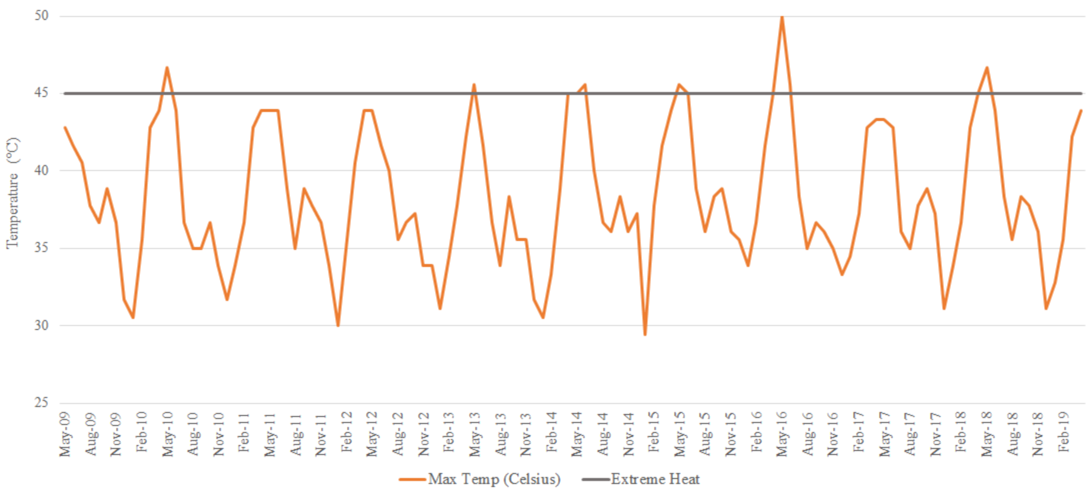
Source: Petitti et al. 2015, 180



In May 2010, the city of Ahmedabad in northwestern India experienced a particular deadly heat wave, with the daily maximum temperature reaching 47°C (Azhar et al. 2014, 2; see Figure 2 on the next page). The official estimate from the Indian Institute of Health was that 310 people died from exposure to this extreme heat, but this is likely an underestimate (Langa 2017). Some experts place the death toll as high as 1,344 (Azhar et al. 2014, 3).

FIGURE 2:

Monthly Maximum Temperature (°C) in Ahmedabad, India, May 2009 to April 2019 (Source: Weather Underground)



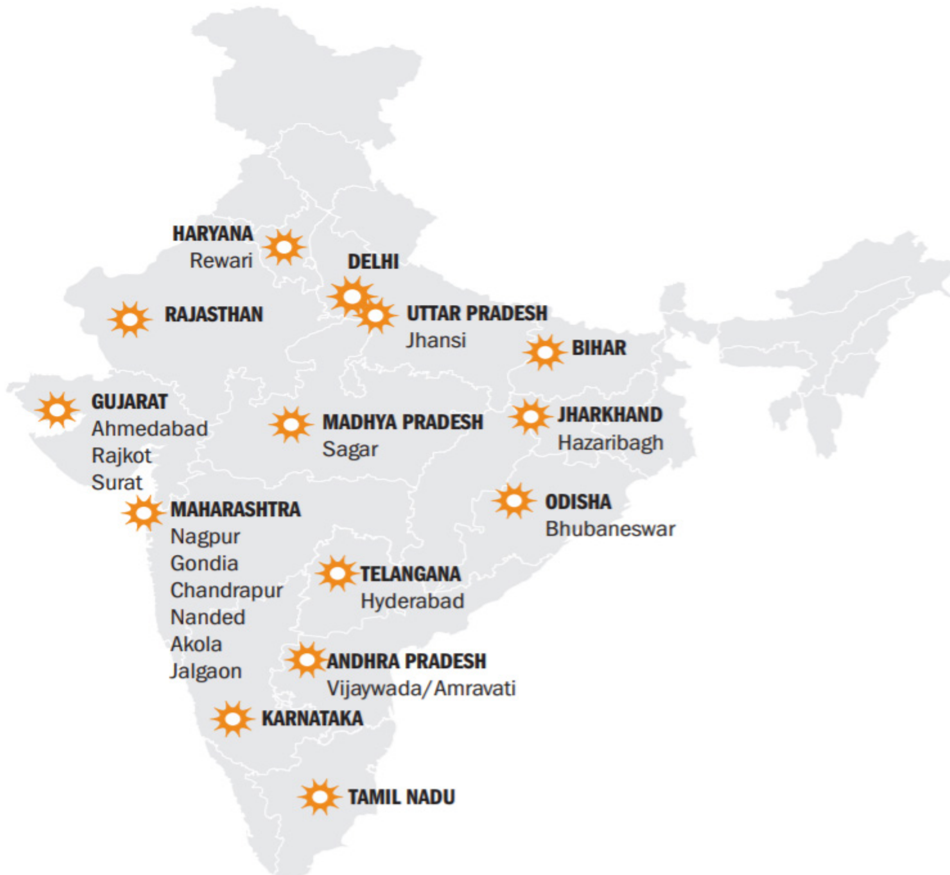
The loss of life that resulted from the 2010 heat wave prompted city officials to begin planning for extreme heat events, with the hopes of preventing heat deaths in the future (Langa 2017). In 2013, the first edition of Ahmedabad's Heat Action Plan made its debut, with updates published every year since, and it was put to the test for the first time just three years later (Langa, 2017). 2016 was the hottest year on record in India, and in May, the daily maximum temperature reached a high of 50°C in Ahmedabad (Thomas 2019; see Figure 2 above). Despite this record-high temperature, however, the Indian Institute of Public Health estimated that only 250 people died in the 2016 heat wave, which is a 20 percent reduction from their estimate for the 2010 heat wave (Langa, 2017).

Ahmedabad is by no means the first or the only city to have developed a heat action plan. Both New York City and Philadelphia in the United States developed plans to prepare for extreme heat as early as the late 1990s (Adler et al. 2010, 33). Ahmedabad was, however, the first city in India to develop a heat action plan, as well as one of only a handful of cities in a developing country to have done so at that point in time (Chakraborty 2013). It has also served as a model for other Indian cities; as of September 2018, 30 cities across India as well as 13 out of India's 29 states have adopted or are in the process of developing their own heat action plans (NRDC 2018, 1; see Figure 3 below).

Therefore, Ahmedabad's Heat Action Plan serves as an important case study of how planners can respond to the unique challenges facing cities in the Global South, especially in terms of mitigating and adapting to climate change, of which extreme heat is but one manifestation. One such challenge is addressing the needs of informal settlers, who comprise a significant proportion of the city's overall population and who are disproportionately impacted by extreme heat events (Wang et al. 2018, 2, 11). This paper seeks to examine the extent to which Ahmedabad's Heat Action Plan has successfully risen to this challenge and addressed the increased vulnerability of Ahmedabad's informal settlements to extreme heat through adaptation of the built environment.

FIGURE 3:

Cities and States with Heat Action Plans, or Heat Action Plans in Development, as of September 2018 (Source: NRDC 2018, 1)



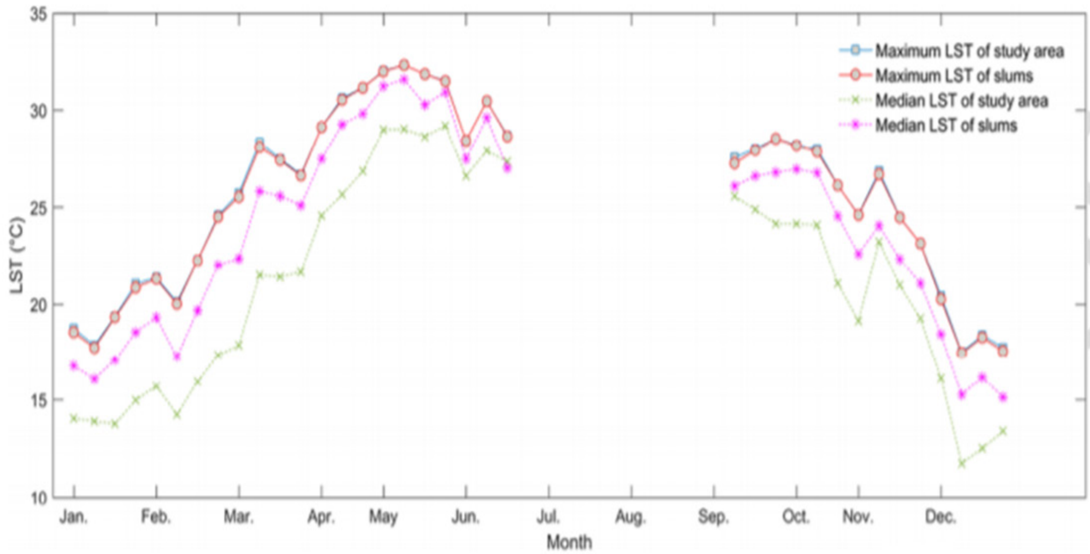
EXTREME HEAT, THE BUILT ENVIRONMENT, AND INFORMAL SETTLEMENTS

Planners should be particularly concerned about the impacts of extreme heat in informal settlements because those living in informal settlements are more exposed to heat and therefore more susceptible to developing heat-related illnesses. The hottest parts of Ahmedabad are nearly always in informal settlements, and the median land surface temperature of informal settlements is usually 2 to 3°C warmer than the city as a whole (Wang et al. 2018, 11; see Figure 4 on the next page). As discussed previously, when temperatures are already high, 2 to 3°C can dramatically increase an individual's likelihood of dying from exposure to extreme heat, as well as the likelihood of less severe outcomes, such as hospitalization (Petitti et al. 2015, 180).

Land surface temperature in informal settlements is likely higher than the city as a whole because informal settlements tend to be more densely settled than other urban areas, resulting in lower vegetative cover and an enhanced heat island effect (NRDC 2013, 5). In addition, informal settlers, due to a lack of secure tenure and a lack of resources, tend to construct their homes with materials, such as tin, asbestos, and brick, that absorb and trap heat instead of allowing air to flow through the structure (NRDC 2013, 5). Without proper ventilation, indoor temperatures can often exceed outdoor temperatures (Tran et al. 2013, 2521-2522). Informal settlers also lack access to air conditioning, even if they have access to electricity, and rely primarily on fans for indoor cooling (Tran et al. 2521-2522).

FIGURE 4:

Land Surface Temperature of Ahmedabad (Study Area) Compared to Informal Settlements in Ahmedabad (Source: Wang et al. 2018, 11)



Note that land surface temperature data is missing between June and September due to the monsoon season.

While the built environment is the main factor increasing the exposure of informal settlers to extreme heat, other factors play a role. Informal settlers primarily work outdoors and travel mainly by foot (Tran et al. 2013, 2522). Both of these factors increase the likelihood of developing a heat-related illness. Lack of access to medical care is also a major issue, as informal settlers are less likely to seek medical care in the event that they develop a heat-related illness, and those medical providers that they do have access to may not be trained to recognize and treat heat-related illnesses (NRDC 2013, 5).

THE HEAT ACTION PLAN AND THE BUILT ENVIRONMENT

The first iterations of the Heat Action Plan did not include any strategies to increase resilience in the built environment. Instead, these plans focused on creating an early warning system, raising awareness of the issue of extreme heat through community outreach, improving inter-agency coordination, and training health care professionals to both better recognize and better treat heat-related illnesses (Knowlton et al. 2014, 3482; AMC 2014, 1). Later iterations include some strategies related to the built environment, such as "mapping . . . high-risk areas of the city," and increasing "access to . . . cooling spaces during extreme heat days" (AMC 2016, i). However, the 2017 edition of the Heat Action Plan was the first to propose permanent interventions in Ahmedabad's built environment (AMC 2017, 11).

One such intervention was a citywide "cool roof" pilot, which had the goal of converting 500 traditional roofs to cool roofs in informal settlements (Kaur 2017). Unlike traditional roofs, cool roofs reflect and emit heat instead of absorbing it, and in so doing lower indoor temperatures by 2 to 5°C (AMC 2018, 6). There are several different types of cool roofs, ranging from traditional roofs that are simply painted white to rooftop gardens (AMC 2018, 6-7). Modular roofs have shown particular promise for application in informal settlements, as they are not only low-cost, but can also be easily disassembled and reassembled should a household move or add additional floors to their home (AMC 2018, 8; see Figure 5 below). The 2018 Heat Action Plan touted the success of the 2017 cool roof pilot and promoted an expansion in the application of cool roofs, with a goal of converting the roofs of over 3,000 homes in informal settlements to cool roofs (Jaiswal 2018; AMC 2018, 5).

FIGURE 5:

Modular Roof in Comparison to a Traditional Tin Roof (Source: Dey 2017)

CONCLUSION

While it is too soon to tell whether the cool roof program will make an impact in terms of increasing the resilience of informal communities to extreme heat, and of what magnitude that impact will be, the cool roof program on its own will not be enough to substantially reduce the increased vulnerability of informal settlers to extreme heat. As extreme heat events become more frequent and severe due to global warming, the Heat Action Plan will need to continue to innovate and find inventive solutions to the problem of extreme heat. One such solution which would increase resilience in the built environment is an urban greening campaign. As discussed previously, low vegetative cover is one factor that leads to higher land surface temperatures in informal settlements in Ahmedabad (NRDC 2013, 5). Research has shown that planting trees can reduce the daily maximum temperature in urban areas by approximately 1.5°C (Nature Conservancy 2016, 29). According to the 2011 tree census conducted in the state of Gujarat, in which Ahmedabad is located, Ahmedabad has a tree cover of only 6.7 percent, which is below the recommended tree cover target for its biome (deserts and xeric shrublands) of 10 percent (Gujarat Forest Department 2011, 29; Nature Conservancy 2016, 117).

Besides continually innovating, there are a few other actions that city officials could take to ensure the success of the Heat Action Plan moving forward. For example, the Heat Action Plan has benefitted from strong mayoral leadership and support in the past (Knowlton et al. 2014, 3487; see Figure 6 on the next page). Future mayors, however, could deprioritize the Heat Action Plan and underfund its initiatives or discontinue it altogether. Therefore it is vital that city officials take steps to institutionalize the Heat Action Plan. Better data on the efficacy of the various strategies put forward by the Heat Action Plan could help city officials make a stronger argument for the need for the Heat Action Plan and also help planners to focus their efforts on those strategies that have the most impact on reducing heat deaths.

FIGURE 6:

Ahmedabad Mayor Gautam Shah Participating in the Cool Roof Program, April 2018 (Source: Jaiswal 2018)

April 2019 was the hottest April that Ahmedabad has experienced in the last eight years, which suggests that the city might have to brace itself for another brutal heat wave season (Ahmedabad Mirror 2019). Given the recent emphasis on increasing resilience in the built environment, perhaps the city will be even better equipped to beat the heat than it was during the last major heat wave in 2016. Or perhaps this coming heat wave season will be a sign that the city needs to redouble its efforts to protect the its most vulnerable citizens from the effects of extreme heat.

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