EXPANDING HEAT RESILIENCE ACROSS INDIA: HIGHLIGHTS FROM HEAT ACTION PLANS

Record-breaking brutally hot weather is a major health threat in India and other parts of the world. Climate change is fueling more frequent, intense, and longer heat waves.[1] The Indian Meteorological Department (IMD) in its annual seasonal outlook for the summer expects the 2021 heat season to be warmer than usual over most regions of India.[2] To counter the deadly heat, cities and regions across India are taking strong actions to build resilience and better prepare and protect communities. With the ongoing health threats from COVID-19, over 22.6 million confirmed cases and 246,116 deaths by May 10, 2021 in India, protecting public health is even more urgent, particularly as more infectious variants of the virus emerge.[3]

Drawing lessons from the ground-breaking 2013 Ahmedabad Heat Action Plan (HAP), city, state, and national level authorities are ramping up efforts to strengthen extreme heat warning systems and preparedness plans.[4] In 2016 three regions spanning 10 cities launched Heat Action Plans and the National Disaster Management Authority (NDMA) issued its first heatwave guidelines to provide a framework for implementation, coordination, and evaluation of extreme heatwave related activities. In 2021, the national government is working with 23 heatwave-prone states and over 100 cities and districts to develop and implement heat action plans across India.

IMD and NDMA lead national-level efforts to prepare and respond to heatwaves. NDMA is also the agency overseeing India's COVID-19 response and it has issued specific advisories for managing heatwaves during COVID-19 to ministries and department, states, districts, and municipal corporations.

Highlighted states and cities have developed and implemented Heat Action Plans

Heat Action Plans are comprehensive early warning systems and preparedness plans with the objectives of supporting public awareness and community outreach on heat and health; facilitating interagency coordination within government; building capacity among health care professionals; and reducing heat exposures and promoting adaptive measures at the population level. The Natural Resources Defense Council (NRDC) and Public Health Foundation of India - Indian Institute of Public Health-Gandhinagar (PHFI-IIPH-G), along with key local stakeholders, work with government leaders and key experts across India and internationally to develop, launch, and implement heat action plans. This annual issue brief highlights the progress at the city, state, and national levels in 2021 to improve India's resilience to the health risks of extreme heat.

THE DANGEROUS COMBINATION OF COVID-19 AND EXTREME HEAT IN INDIA

The coronavirus pandemic has caused rapid and widespread damage to human health around the world. With increased health threats from COVID-19, protecting public health is a priority. It is also important to avoid increasing the burden on health-care systems due to heat-related illness at a time when they are already severely stressed treating COVID-19 patients.

India's first wave of COVID-19 infections started climbing last summer and peaked in September-October, with numbers slowly declining until picking up again in March 2021.[5] The country is battling a devastating second wave of infections as the number of new cases a day shot up to approximately 400,000 on April 30, 2021 and 412,431 on May 5, 2021, from fewer than 20,000 in March.[6] Authorities are working to control the spike by stepping up the country's vaccine program; approximately 168,304,868 doses have been administered and 34,450,192 people (2.52% of India's population) are fully vaccinated as of May 10, 2021.[7]

Certain vulnerable groups may be susceptible to both heat stress and COVID-19.[8] For example, people living in slums are more likely to be exposed to heat outside or in unventilated areas and reside in homes made of heat-trapping materials with tin or tarp roofs. These residents are also more likely to face crowding, encounter challenges in accessing sanitation and lack reliable access to clean water. Other complications of simultaneous extreme heat and COVID-19 include increased Covid-19 transmission risks at sites where people usually gather to seek cooling relief and when extreme heat makes personal protective equipment (PPE) too hot to wear.

RESOURCES

– World Health Organization: Preparing for a long, hot summer with COVID-19[9]

– Global Heat Health Information Network: COVID-19 and Heat[10]

NATIONAL AGENCIES HELP GUIDE HAPS

NDMA supports the development of local heat action plans and first issued guidelines in 2016. These guidelines were revised in 2017 and in 2019. NDMA updated its National Heatwave Guidelines to provide a roadmap to states and cities to develop heat action plans.[11] Based on IMD's Seasonal Outlook, NDMA has identified 23 heat-prone states and reviewed their preparedness plans with them. NDMA classifies a heatwave as a natural hazard along with cyclones, tsunamis, landslides, earthquakes, urban floods, and floods. India has included heat waves in its National Disaster Management Plan in the past, but much more remains to be done to provide financial support under the government's disaster response fund.[12] Often, it is left to state governments to include heatwaves as a disaster under the state disaster management plan, so far only six states have done so.[13]

To prepare for the summer heat season, NDMA held a national virtual workshop on "Early Planning for Heat Wave Risk Reduction" in January 2021, several months before the heat season.[14] This annual workshop brought together academicians, policy makers, national-level ministries, non-governmental organizations, intergovernmental organizations, state governments, and other stakeholders to discuss policies to address heat-related issues. The workshop achieved several objectives: to help vulnerable states and districts in preparation of their Heat Action Plans for 2021; to discuss the integration of various sustainable

Picture: Women cover themselves to protect against exposure to extreme heat

Source: beontheroad.com/creative commons

Picture: A cobbler in Ahmedabad, Gujarat works under a makeshift shelter. "
Source: NRDC

development plans including long-term heat mitigation measures; to specify short, medium, and long-term heat mitigation measures most suited for different regions; and to provide an opportunity for community capacity building and awareness generation. An IMD senior scientist discussed effective early warning dissemination and communication strategies on heat. The current challenge is to convey warnings, forecasts, and other information effectively to intermediaries and end users.

In 2021, NDMA launched public awareness campaigns, developed new television commercials, and updated its list of heatwave Do's and Don'ts.[15] NDMA also issued specific advisories for managing heat wave during COVID-19 to the central ministries, states, districts, and municipal corporations for taking actions. In early 2021, NDMA introduced the *Heat Wave Season 2021: Cool Roof Challenge* for cities to minimize heatwave impacts, accelerate access to affordable sustainable cooling through rapid cool roof deployment, and scale and institutionalize implementation of cool roofs as part of their HAPs.

NDMA tracked 24,223 heat-related deaths across India from 1992 to 2015.[16] Intense and sustained efforts by all stakeholders have significantly reduced heat-related mortality from 2,040 deaths in 2015 to 1,111 deaths in 2016.[17] Further reductions occurred in 2017 and 2018 with, 384 and 25 deaths respectively.[18] In 2019, many cities recorded all-time high temperatures and with effective mitigation measures, heatwave deaths were restricted to 226.[19] Most of the deaths were in Bihar.[20] While the impact of last year's heat season was complicated by COVID-19 and national lockdown, only four heat wave-related deaths were reported.[21]

IMD develops heat forecasts and alerts of heatwave events over specific areas, which helps Indian states to take appropriate, tailored measures to reduce the adverse impacts of extreme heat exposures. To disseminate local temperatures, IMD and the regional meteorological offices provide 5-day forecasts of daily maximum temperatures to over 350 cities, an increase from 100 in 2016. In addition, IMD Seasonal Outlook Forecasts are vital as they give communities lead-time to prepare for extreme heat.[22] The IMD Seasonal Outlook projected the 2021 March to May heat season to be warmer than usual (maximum and minimum temperatures) over most regions of India, except in some southern states.[23] Chandigarh, Punjab, Delhi, Haryana, Uttar Pradesh, and Bihar are likely to experience maximum temperatures that will be above normal. Odisha, Chhattisgarh, and Konkan in Maharashtra have been categorically warned of a hotter summer season this year.

For 2021 summer IMD introduced new services, in which the IMD website will share maximum temperatures and heatwaves observed in real-time through an online map. IMD is now issuing expanded impact-based heatwave warning bulletins that forecast minimum temperatures, humidity, and wind speeds twice per day. Humidity is an important factor because high humidity limits the loss of heat from the human body via perspiration, making hot days even more dangerous. In 2021, the IMD has also started issues forecasts for "warm or very warm nights" - considered when night time minimum temperature departure is 4.5C or higher and the maximum temperature is more than 40C. Warm nights are indicative of high heat retention and may be correlated to urban heat island effect.[24] The information generated will be available on a dedicated page on IMD's website.[25] Last year, IMD launched its Mausam Mobile App to communicate forecasts more easily to the public. Warnings in the app include IMD alerts and the severe weather forecasts.[26]

COOL ROOFS HELP REDUCE HEAT STRESS

Cool roofs, roofs painted with solar reflective paint, covered in tiles, or with white membranes, are better at reflecting sunlight and absorb less heat. Cool roofs are one of the simplest and most cost-effective ways to fight the heat; they keep indoor temperatures lower than traditional roofs, reduce dependence on air conditioners, and mitigate the urban heat island effects.[27] Depending on the setting, they can help lower indoor temperatures by as much as 1.5 - 5°C (3.5 - 9°F) as compared to traditional roofs.[28] At the national level, the Indian Cooling Action Plan (ICAP) released in 2019 focuses on reducing the demand for air conditioning with cool roofs as a major solution.[29]

Cool roofs programs are target-based programs that aim to expand the installation of cool roofs in the city or the state. In 2017 and 2018, the cities of Ahmedabad and Hyderabad initiated pilot cool roof programs. Building on their pilot cool roof programs, Ahmedabad and Hyderabad have painted over 3,000 roofs in slum communities.[30] Both cities are launching larger cool roofs programs. Telangana incorporated cool roofs as part of the Telangana Municipalities Act 2019 and the draft Telangana Cool Roof Policy is included in the 2021 Telangana Heatwave Action Plan.[31] In addition, local groups, such as the Mahila Housing SEWA Trust (MHT) have implemented programs to install cool roofs in Ahmedabad, Jodhpur, Bhopal, and Surat.

People living in slums and low-income communities are particularly heat vulnerable – most of their homes are far from optimal, with few options for cooling.[32] In January 2021, NRDC and partners MHT painted the roofs of selected slum households with solar reflective paint in four major cities - Jodhpur, Bhopal, Surat, and Ahmedabad.

Participating Cool Roofs Challenge cities are being asked to declare their cool roof targets in square footage of roof area and/or the total number of cool roofs to be installed before May 15, 2021. All cities that come forward and implement cool roofs will be awarded a certificate of appreciation from NDMA and the city with the largest cool roofed area will be declared as the lead city of the challenge in 2021. Cool roofs are to be implemented on slum dwellings, government, institutional, educational, medical buildings, and other buildings selected by the city.

FIVE KEY ELEMENTS OF AN EFFECTIVE HEAT ACTION PLAN

An effective heat action plan requires a combination of strong local leadership, interagency coordination, scientific expertise, broad communication strategies, and community engagement. Locally developed plans are the most effective. Yet, the heat action plans in India have common features that are important to protect communities from extreme heat. The five core elements are:

1. COMMUNITY OUTREACH TO BUILD PUBLIC AWARENESS

- Locally developed and scientifically supported information, education & communication (IEC) materials such as pamphlets, hoardings/billboards, and videos to inform people on how to protect themselves from extreme heat.
- Social media channels, bulk text messages, emails, radio, and mobile apps to reach the public.
- Special efforts to reach vulnerable populations through focused sessions and direct communication by health care professionals in local clinics, ambulance service, and urban health centers.

2. EARLY WARNING SYSTEMS AND INTERDEPARTMENTAL COORDINATION

- Early warning systems (at yellow, orange, and red levels corresponding to increasing heat levels) trigger joint response by relevant city and state authorities to alert residents.

- Formal communication channels to alert state and city government agencies, including health officials and hospitals, emergency responders, local community groups, media outlets and other key stakeholders – with an identified "nodal" officer.
- Standard Operating Procedures (SOPs) for activities before, during, and after heat season for each department to successfully implement a HAP that identified and defines its responsibilities.

3. CAPACITY BUILDING AMONG HEALTHCARE PROFESSIONALS

- Special training modules for health staff in urban health centers.
- Training programs for private general medical practitioners to equip first responders with knowledge of effective diagnosis and first-aid treatment for heat-related illnesses.
- List of "Do's and Don'ts" created with help of local health professionals and disseminated to the public.

4. ADDRESSING VULNERABLE GROUPS

- Focused efforts, such as awareness and drinking water for children, elderly people, and people exposed to prolonged periods of extreme heat due to their profession.
- Affordable space cooling solutions and health care for vulnerable groups.
- Adaptive measures, such as cool roofs, for vulnerable communities.

5. IMPLEMENTING ADAPTIVE MEASURES

- Communication on response methods, including drinking water, cooling centers, gardens, and shade spaces during extreme heat days.
- Land use strategies to reduce the urban heat island effect, including green infrastructure, cool roofs, trees and vegetation, and increasing green spaces.
- Streamlining traffic and congestion reduction policies and strategies.

SUCCESS STORY: THE BENEFITS OF AHMEDABAD'S HAP

A recent study estimated that Ahmedabad, one of India's largest cities, avoided an estimated 1,190 deaths a year after implementing the country's first Heat Action Plan (HAP) in 2013.[33] This plan included a heatwave early warning system, public outreach to explain heat-health risks, and trainings aimed at health professionals who diagnose and treat heat-related illnesses. The study, "Building Resilience to Climate Change: Pilot Evaluation of the Impact of India's First Heat Action Plan on All-Cause Mortality" jointly authored by public health and municipal authorities in India, academic environmental health researchers in the U.S., and NRDC, was published in the peer-reviewed scientific Journal of Environmental and Public Health.

By comparing citywide summertime death rates before and after the HAP was launched, researchers found that:

- The biggest decrease in death rates was on the hottest days. Mortality rates on the hottest days (at or above 45°C (113°F) daily maximum temperature) dropped by 27% after the HAP was implemented, relative to pre-HAP years.
- While very hot days were still dangerous, the risks were much lower post-HAP. Before the HAP, death rates more than doubled on days when the maximum temperature reached 47°C (116°F), compared to rates at 40°C (104°F). After the HAP was implemented, death rates were only 25% higher on days when maximum temperatures reached 47°C (116°F) compared to death rates at 40°C (104°F).
- Extreme heat warnings, a key part of Ahmedabad's HAP, were associated with decreased summertime all-cause mortality rates, with the largest declines at the highest temperatures.

Picture: Water stations set-up under the Ahmedabad HAP

Source: NRDC

LOCAL HEALTH BENEFITS FROM SUSTAINABLE COOLING

As temperatures rise, so does the demand for air conditioning. Meeting the demand for electricity to keep people cool and safe from extreme heat is critical. Depending on the source of power for electricity (e.g., fossil fuels or renewable energy sources like solar and wind), the skyrocketing cooling demand in India may also worsen the country's health risks from dangerous air pollution and extreme heat.

Cooling demand in India is growing at the rate of 15-20% annually.[34] Space cooling for buildings currently dominates the total cooling energy demand in India and buildings are expected to drive major demand for cooling in the country in the future. Urbanization and the rise of incomes of the middle class in India imply many more people will soon purchase their first air conditioner.

NRDC and local partners are working to quantify air quality and health benefits in the city of Ahmedabad from climate change mitigation and adaptation policies.[35] Local experts at Gujarat Energy Research and Management Institute (GERMI), Indian Institute of Tropical Meteorology (IITM) and Indian Institute of Public Health-Gandhinagar (IIPH-G) are exploring future air quality scenarios for two climate change response strategies: (1) shifting fossil fuel use away from polluting coal to clean solar energy, and (2) expanding cool roof interventions in Ahmedabad. NRDC and partners are using these local air quality forecasts to estimate the health impacts in 2030 of these different climate change response strategies, and the health benefits of actions addressing climate change.

The energy demand analyses conducted by GERMI are designed, within the context of the India Cooling Action Plan (ICAP) and India's national climate goals, to better understand seasonal patterns in cooling demand at the local level, and the downstream impacts on air quality and public health.

IMPLICATIONS OF A WARMING WORLD

Continuing the planet's long-term warming trend, 2020 tied with 2016 as the hottest year on record.[36] India was the seventh most affected country due to extreme weather events in 2019, according to the Global Climate Risk Index, which ranks countries according to their vulnerability both in terms of fatalities and economic losses.[37]

An analysis of climate trends in several of South Asia's biggest cities found that if current warming trends continued, by the end of the century, heat and humidity levels would be so high that people directly exposed for six hours or more may not survive.[38] Soaring temperatures and heatwaves are increasingly limiting the labor capacity of various populations. In 2018, 133.6 billion potential work hours were lost globally, 45 billion more than the 2000 baseline.[39] Extreme heat will significantly lower the outdoor working capacity of India's labor workforce in the next three decades, putting the country's economic growth at risk. The impact of global heating on outdoor work and the resultant loss in productivity is estimated to put 2.5% to 4.5% of India's Gross Domestic Product (GDP) at risk annually.[40]

Launched in 2019 by the Indian government, the Coalition for Disaster Resilient Infrastructure (CDRI) is a partnership of national governments, United Nations (UN) agencies and programs, multilateral development banks and financing mechanisms, the private sector, and knowledge institutions. CDRI aims to promote the resilience of new and existing infrastructure systems to climate and disaster risks in support of sustainable development. CDRI works to assess infrastructure gaps in early warning systems.[41] CDRI will support enhancing information on an infrastructure system's exposure and modeling climate related hazards, such as heatwaves, thus enabling near real-time response. In March 2021, CDRI held a virtual conference on significant international commitments for building disaster and climate resilient infrastructure and COVID-19's impact on infrastructure. The U.S. Agency for International Development (USAID) announced it will award up to $9.2 million to support CDRI.[42]

The Integrated Research and Action for Development (IRADe) and International Development Research Centre (IDRC), in collaboration with Global Heat Health Information Network (GHHIN), held a Session on "Climate Adaptive Heat Stress Management in South Asia" in January 2021.[43] In 2020, IRADe collaborated with the local and state governments of the cities of Delhi, Rajkot, and Bhubaneswar to raise awareness and inform stakeholders on the impact of heat stress. Awareness activities in all three cities included highlighting the need for cool roofs to improve thermal comfort and the covering or shading of rooftops.

ACROSS INDIA, STATES ARE STEPPING UP ACTION ON EXTREME HEAT

As extreme temperatures become more frequent, states are instituting heat action plans, including in geographies that do not have a history of heatwaves, such as Himachal Pradesh and Kerala. In 2015, nine states were affected by heat waves; by 2018 and 2019, the number of heat-prone states increased to 19 and 23, respectively (listed below).[44]

- Andhra Pradesh
- Arunachal Pradesh
- Bihar
- Chhattisgarh
- Delhi
- Gujarat
- Goa
- Haryana
- Himachal Pradesh
- Jharkhand
- Jammu and Kashmir
- Karnataka
- Kerala
- Maharashtra
- Madhya Pradesh
- Odisha
- Punjab
- Rajasthan
- Tamil Nadu
- Telangana
- Uttarakhand
- Uttar Pradesh
- West Bengal

➔ BIHAR

As a result of extreme temperatures in 2019, more than 107 people died in Bihar due to heat-related illnesses.[45] As heatwaves and hot days are increasing, the state government is acting to manage heat wave impacts and protect lives. The state is also focusing on long-term measures to address climate change, and with the support of the UN Environment Program (UNEP), will pursue a climate resilient and low-carbon development pathway.[46] This increases the capacity of Bihar's government departments to deal with climate-related issues.

Fire incidents occur in summers due to high temperatures and hot, dry, westerly wind. In 2016, Bihar had devastating rural fires that killed 156 people.[47] The fires impacted large tracts of standing crop causing economic loss to farmers and burned slums. The state government announced a Fire Safety and Mitigation Plan, which includes empowerment of local government and an implementation schedule.[48] The local government is responsible for identification of extremely vulnerable areas, procuring water from private sources, incident reporting, running information and education campaigns, and mock drills for slum areas and farmers.

Ahead of the 2021 heat season, the state planned the following actions:[49]

- District collector will disseminate information on heatwaves using various forms of media.
- Coordinate closely with IMD officials in affected regions.
- Hold orientation and training programs, with the health department, for stakeholders such as hospital staff and district disaster management authority officials.
- Implement timed closings by changing working hours for laborers under government schemes, and closing markets in the afternoon. Also, construct permanent roof structures in markets.
- Add sprinklers for cool mist on railway platforms, have ice bags available at health centers, and consider making rainwater harvesting compulsory.
- Use light colors in government buildings, schools, offices, and housing societies.
- Increase drinking water and public shelter spots.

➔ GUJARAT

Ahmedabad, in the western state of Gujarat has been the leading city in India for its work on building resilience against extreme heat. The Gujarat State Disaster Management Authority (GSDMA) prepared a *Gujarat State Action Plan for Prevention and Mitigation of Heat Wave 2020*, as per the NDMA guidelines 2019.[50] GSDMA has a list of Do's and Don'ts during COVID-19 on its website, with specific guidance for workers, outdoor workers, and the elderly.[51] The Gujarat Institute of Disaster Management (GIDM) developed a training module "Extreme Heat Prevention and Management," which can be used by participants to protect the health of people from extreme heat during summers.[52]

At the 2021 NDMA workshop, experts from IIPHG, discussed the importance of understanding the heat island effect (higher temperatures in the central parts of cities) and the characterization of heatwaves based on humidity and minimum temperature at night.[53]

Picture: School and college students are especially vulnerable to extreme heat
Source: NRDC

To continue to reduce heat-related illness, long term state plans include adopting cool roof technology and carbon neutrality for all buildings. Additionally, the state, under the guidance of the Gujarat Ecological Education and Research Foundation, set up an initiative to enhance the adaptive capacity of natural resource-dependent communities of agricultural, coastal fishing, and pastoral sectors in the Kachchh region.[54]

➔ ODISHA

Odisha continues as a pioneer in disaster preparedness in India from cyclones to heatwaves. Building on its 2015 Heat Action Plan, the Odisha State Disaster Management Authority (OSDMA) tackles heatwaves through an early warning system that considers both temperature and humidity levels to issue heat alerts. A state-level preparatory meeting on heatwave management is held annually by the chief secretary and involves key departments and stakeholders.

The government developed a contingency measure to tackle the heat following IMD's prediction that Odisha, among other states, would be the worst affected this summer. The state held a district level training program on heatwave preparedness for OSDMA personnel and the Indian Institute of Public Health - Bhubaneswar (IIPHB). The capacity building workshops included sessions on vulnerability assessment, clinical management, developing a resilient health system, and monitoring of heat stress cases. IIPHB is currently conducting vulnerability assessment studies and a threshold analysis in five smaller towns of Odisha.[55] IRADe collaborated with the Bhubaneswar government to raise awareness and inform stakeholders on the impact of heat stress and developed a medical stakeholders training program in collaboration with IIPHB, to train medical staff in the state.

Earlier this year, the Special Relief Commissioner directed district authorities to identify water scarcity pockets and prepare plans to ensure the supply of water for drinking and other uses through tankers.[56] Following IMD's Seasonal Outlook, the Special Relief Commissioner asked district authorities to remain prepared for the heatwave conditions in certain places.[57]

➔ TELANGANA

Telangana is a state vulnerable to droughts, floods, hailstorms, fire, lightening, and heatwaves, and northern districts occasionally experience cold waves.[58] Telangana experienced unprecedented heatwaves in previous summers and developed a comprehensive heatwave management action plan for extreme heat events. The Heat Wave Action Plan is based on regular inputs from NDMA and was updated in 2017, 2018, and 2019. Telangana incorporated cool roofs as part of the 2019 Telangana Municipalities Act. The draft Telangana Cool Roof Policy is included in the *2021 Telangana Heatwave Action Plan* and the plan is awaiting formal release by

Government of Telangana.[59] The Telangana Cool Roofs Policy aims to: (1) drive rapid state-wide adoption of cool roofs to save energy, strengthen heat resilience, and increase thermal comfort; (2) support inter-agency coordination to implement the city-wide cool roof policy; (3) identify financing frameworks to implement cool roofs; and (4) support workforce development and training programs for cool roof installation.

TABLE 1: Draft annual targets of cool roofs for Hyderabad and Telangana (source: Telangana State Heatwave Action Plan 2021).[60]

Year	Hyderabad Cool roof area (square kms) targets	Telangana Cool roof area (square kms) targets
2021-22	0.1	0.1
2022-23	0.2	0.2
2023-24	0.3	1
2024-25	0.7	2
2025-26	1.7	5
2026-27	3.3	10
2027-28	6.7	20
2028-29	12.3	37
2029-30	25	75
2030-31	50	150
2031-32	100.3	300.3

Picture: A drinking water station in Ahmedabad, part of local efforts to respond to extreme heat through the city's Heat Action Plan, NRDC

Telangana's 2021 heat plan also includes the construction of green building and Energy Conservation Building Codes (ECBC) related to heatwave risk mitigation. The Revenue (Disaster Management) Department Government of Telangana initiated heatwave preparedness programs for 2021 with key departments in coordination with Telangana State Development Planning Society (TSDPS) and UNICEF's Hyderabad field office.[61] The plan acknowledges the ongoing threat of COVID-19 and that the risks of hot weather are amplified for those already most vulnerable to the negative effects of extreme heat.

COMBATING HEAT IN CITIES AND DISTRICTS

In addition to state and national efforts, heat action plans led by city officials are vital to protect local communities. City leaders have a clear mandate to protect residents and are effective in communicating with citizens. Municipal corporations can design programs better tailored to their communities as well as provide early planning, coordination, capacity building, surveillance, and longer-term measures to combat the heat island effect and climate change. City leaders are often charged with issuing "heat alerts" in association with a color- coded early warning system developed specifically for the city, while the IMD issues "heat wave warnings" that are more climatology-based than health-based. The IMD looks to city and regional governments to issue more health communication-based "heat alerts" and to use the forecasts to strengthen heat resilience. Select cities with robust plans are highlighted below.

AHMEDABAD, GUJARAT

Ahmedabad's groundbreaking Heat Action Plan serves as a template for many cities and states across India, and internationally. Ahmedabad started painting its cool roofs for the 2020 heat season, a target of painting roofs of 15,000 slum households and 1,000 municipal buildings. However, the program was suspended due to COVID-19 was suspended due to COVID-19. Additionally, the Ahmedabad Municipal Corporation (AMC) will plant 500,000 trees annually between 2020 and 2025 to reduce the urban heat island effect; and solar panels will be installed on AMC buildings to reduce direct exposure to heat.[62]

HYDERABAD, TELANGANA

The UNICEF Hyderabad field office in association with the Revenue Department, and Telangana State Development Planning Society (TSDPS) reviewed last year's state heatwave action plan, and initiated District Disaster Management Plans for districts in the state. UNICEF's

partnership helped the state prepare a Child Risk and Impact Analysis to understand the risk to children due to different kind of hazards, such as heatwaves and floods.[63] The analysis also identified risks and critical services for lactating and pregnant women. Emphasis is given to heatwaves, which will help to develop special heat-related strategies.

NAGPUR, MAHARASHTRA

Nagpur developed its HAP in 2016. Through the leadership of the Maharashtra State Public Health Department and the Nagpur Municipal Corporation, the Nagpur Regional HAP was coordinated between Nagpur and four neighboring cities, creating the first regional approach to heatwave planning in India. The Nagpur Municipal Corporation, along with five neighboring districts, updated its Heat Action Plan in 2019 from the original 2016 plan. The Heat Action Plan consists of heat mitigation measures in accordance with the guidelines issued by NDMA. Prior to the 2020 heat season, two out of seven municipal corporations in Maharashtra, Chandrapur, and Nagpur implemented the mandatory Heat Action Plan. Nagpur and Chandrapur are in the eastern part of Maharashtra and experience extreme heat during summer. Here, summer months are extremely dry and arid, with day temperatures ranging between 45°C (113°F) and 48°C (118°F), making it one of the hottest regions in India.[64]

In 2019 the Nagpur Maha Metro launched a Heat Action Plan, under which metro workers can rest to help avoid illness and casualties due to heatstroke. The HAP also recommends that the Nagpur Metro Rail project contractors halt work between 12 noon and 4 pm through May.[65]

TEMPERATURE THRESHOLDS AND HEAT WARNING TRIGGERS

A key component to successfully activating and implementing heat-health early warning systems are locally developed temperature thresholds. Local temperature thresholds are the triggers for cities to initiate early warning systems. Cities and states using local thresholds have a better understanding of the temperature that corresponds to a level of heat beyond which people are likely to face adverse health effects, if they do not take adequate precautionary measures. This approach provides the authorities an opportunity to prepare and response better to extreme heat episodes.

Thresholds are developed based on local temperatures and calculated using either a mortality and temperature-based approach or a percentile-based approach.

Mortality and Temperature-Based Threshold Approach

This approach requires both heat and mortality data. It involves obtaining long term (10-15 years) daily mortality data, if possible, for the summer months from the city administration and analyzing correlation with daily maximum temperature observations. Historical temperature data is available from the can request data access from IMD regional centres.

Mortality data can often be obtained from city medical department or local medical colleges. To activate early warning systems, some cities in India have developed thresholds using the mortality and temperature approach, including Ahmedabad (see figure 1) and Nagpur. Mortality and temperature-based thresholds can be challenging to establish as few cities in India have publicly available long-term records of daily mortality data.

Alert Category	Alert Name	Temperature Threshold (°C)
Yellow Alert	Hot Day Advisory	41.1 °C – 43 °C
Orange Alert	Heat Alert Day	43.1 °C – 44.9 °C
Red Alert	Extreme Heat Alert Day	> 45 °C
White	No Alert	< 41 °C

FIGURE 1: Temperature thresholds developed by the Ahmedabad Municipal Corporation for issuing heat alerts (Source: Ahmedabad HAP 2016)

Percentile-Based Threshold Approach

The unavailability of daily mortality or other health outcome data can hinder the calculation of temperature-based mortality thresholds and thus impede development and implementation of early warning system. In these situations, where meteorological information is available but sufficient health data is not, a percentile-based threshold (90th, 95th and 99th) based on local temperature data can be used as a warning trigger value that captures the relative severity of observed temperatures.

NDMA, in its 2017 Heat Action Guidelines, recommends considering a percentile-based threshold (using 90th, 95th, and 99th percentile temperatures) as a warning trigger value where climate and weather data are available but reliable daily heath data is not. The percentile method is relevant for India and can help in a number of cities, smaller urban centres, and rural areas that lack adequate mortality data to determine local health-relevant temperature thresholds.

Endnotes

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