Heat-Resilient Infrastructure: Lessons from Emerging Global Experience



Urban trees and shaded street areas show how green cover and inclusive street design can reduce heat exposure. Photo: AIDMI.

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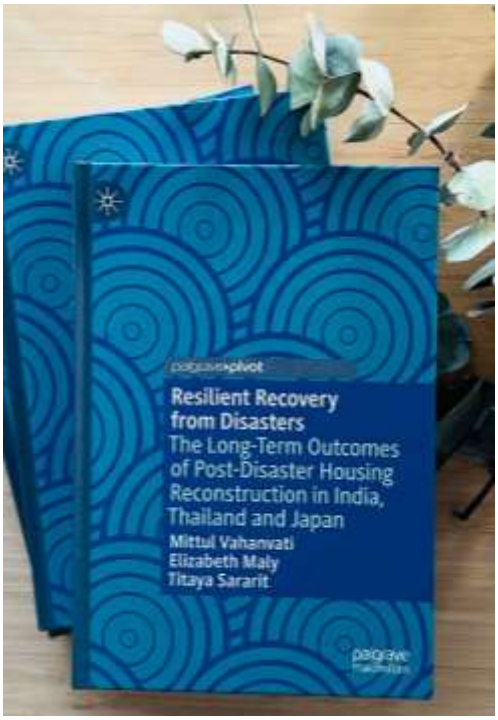
What Lessons from Past Long-term Recovery after Earthquakes and Floods Help Plan for Extreme Heat in India?

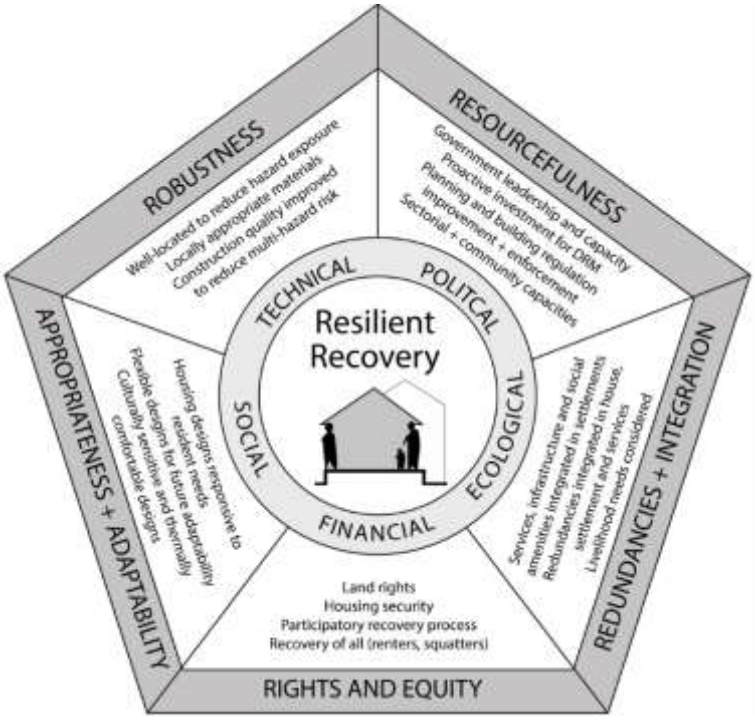
*By **Dr. Mittul Vahanvati,** Program Manager and Senior Lecturer, School of Global Urban and Social Studies, RMIT University, Melbourne, Australia*

People everywhere are experiencing heat, as well as increasing intensity, frequency and complexity of floods, storms and earthquakes due to a changing climate. We are living in a 'new abnormal', which demands innovative ways of planning, housing design, construction, maintenance, and governance. However, that requires us to learn from the past, about actions that have worked at reducing disaster risk, averting future disasters and building resilience.

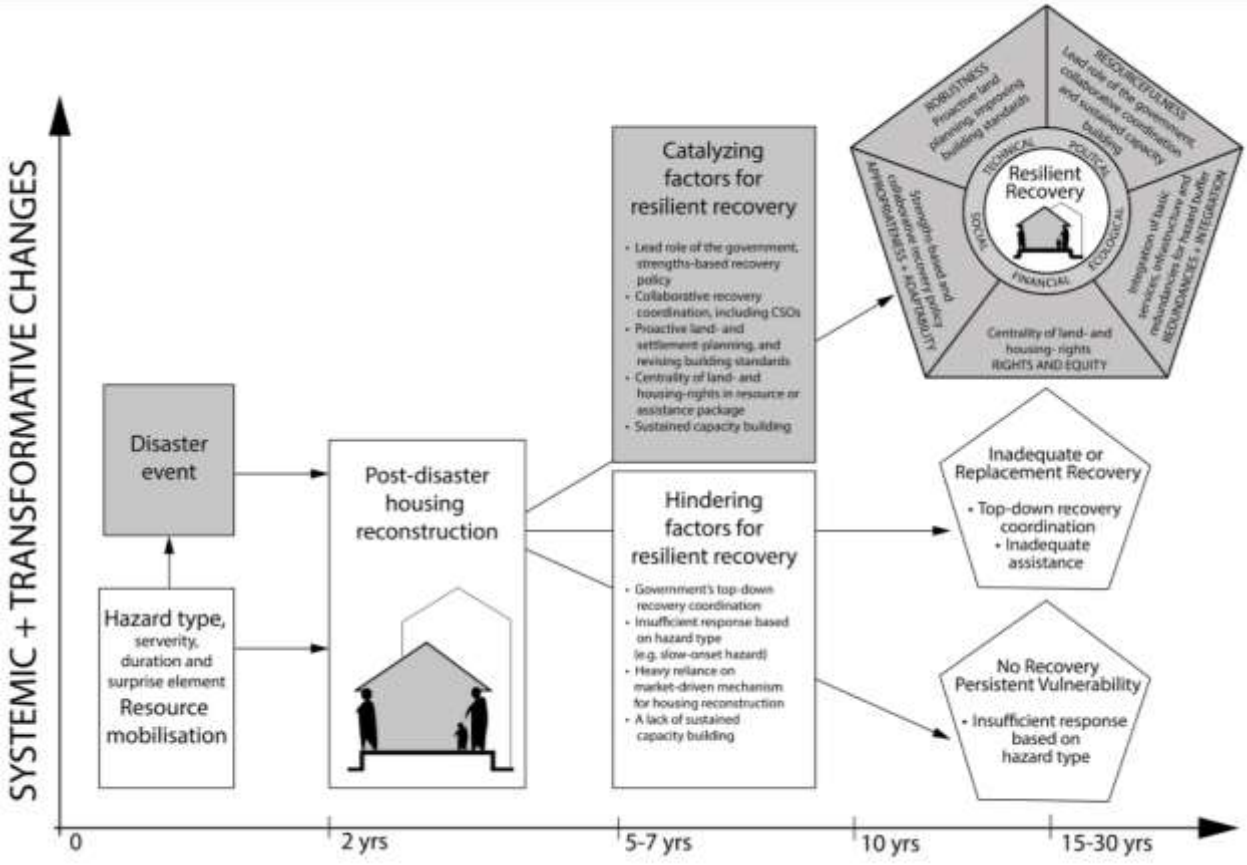
Post-disaster housing reconstruction and recovery is a long-term process that determines whether communities become safer or remain vulnerable to future hazards or stresses. However, there is limited research on long-term outcomes of post-disaster housing reconstruction. Following are some of the long-term outcomes following the 2001 Gujarat earthquake and the 2008 Kosi floods in Bihar, housing reconstruction and recovery efforts, and their implications for informing more practical and inclusive actions on extreme heat.

Improvised building standards and skills trainings for resilient housing and households. Housing is not only a structure; it is linked to health, work, culture, infrastructure, human rights and climate-resilience. Housing should be framed as a system (material, energy flows) within a system (cultural, legal/building standards). Buildings can provide the first layer of buffer and safety from floods, earthquakes and heat. Designing resilient buildings is one of the best ways of adapting to a changing climate. However, are we still building as per





Source: Vahanvati, M., Maly, E., & Sararit, T. (2025). Resilient Recovery from Disasters: The Long-Term Outcomes of Post-Disaster Housing Reconstruction in India, Thailand and Japan (1st 2025. ed.). Springer Nature Singapore. https://doi.org/10.1007/978-981-97-8047-1



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the building standards that are outdated for the changing climate, only to face costly retrofitting, stress and anxiety later?

In context of heat, it is worth inquiring whether our building standards are relevant for the changing climate. Is there a need for improvising building standards for thermal comfort and inclusion of traditional materials?

Building standards should be accompanied with guidance notes showing best-practice examples of house orientation, wind flows at settlement scale, passive design principles and nature-based solutions for cooling.

Without adequate enforcement of building standards and skills training of construction labour, mere building standards won't change the building culture.

Proactive land and settlement planning based on risk mapping and integration of nature-based solutions. E.g. in case of Kutch, Gujarat, land readjustment was done in the central Bhuj's old town to make it safer, allow for fire trucks to access roads and allow people to evacuate. However, people from the central Bhuj area were relocated to another earthquake-prone zone, due to lack of land. Relocation and rebuilding ought to reduce future disaster risk, not rebuild vulnerability.

> Long-term recovery shows that heat resilience must be built before crisis arrives, through better housing standards, local skills, risk-informed planning, nature-based solutions, and sustained institutional capacity.

In context of heat, proactive heat risk mapping must be done. Such a map should also include identification of socio-economically vulnerable groups.

Our cities are much hotter than regional or rural areas due to urban heat island effect, and due to lack of integration of green-blue

infrastructure. Green-blue infrastructure can not only help with cooling hotter areas, but it would also support disaster risk reduction and provide additional societal benefits such as biodiversity, cleaner air, and human well-being.

Policies and programs, when tailored to context-specific needs and strengths, have the greatest potential to bring about large-scale changes. E.g. both Gujarat State Disaster Management Authority (GSDMA) and Bihar SDMA adopted an owner-driven housing reconstruction policy and recovery program. That allowed households to make decisions about their housing recovery based on their values, aspirations and needs. Government provides households with social support and technical support apart from financial support to rebuild or adapt existing buildings to better standards for safety and sustainability.

For extreme heat action planning, government has to play a proactive role. They can tailor programs such as subsidised retrofitting of existing housing for cooling. They could offer technical support to each household to provide tailored advice about the sort of retrofitting required for heat resistance/ cooling.

However, policies and programs would not have the foreseen effect without adequate enforcement and monitoring to keep corruption at bay.

Additionally, the other challenge is to do with funding. Who would pay for such retrofitting and how will government be able to subsidise such a program?

To ensure equity and inclusiveness of the program, government must consider providing more financial assistance to lower-income groups.

Lastly, a **long-term view of post-disaster housing recovery** is a valuable source of learning for extreme heat action planning. For example, due to a dedicated agency for emergency management and recovery, for each state, i.e. SDMA, government has experienced, and developed institutional capacity for continual learning and proactive planning. Such continuation of a dedicated authority moves from a seasonal mindset to continual disaster management mindset.

In case of heat action planning, government authorities must move beyond seasonal response towards long-term risk reduction.

Sustained capacity building of the construction sector equally important as sustained capacities of the government organisation's officials.

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Strengthening Heat Governance and Heat Action Plan Implementation in India

*By **Jorge Gastelumendi**, Senior Director, Climate Resilience Center, Atlantic Council, United States*

Indian cities are warming almost twice as fast as rural areas, largely driven by the urban heat island effect. As temperatures continue to rise, there is an urgent need to strengthen coordinated heat adaptation efforts, particularly in dense, urban areas where vulnerable groups including women, children, and informal workers face heightened risk of heat-related illness. Local and state governments are at the forefront of this challenge. They play an important role in coordinating adaptation efforts and translating Heat Action Plans into tangible solutions. Building on our work supporting the global network of Chief Heat Officers who lead heat resilience efforts in their jurisdictions, the Atlantic Council's Climate Resilience Center is expanding this initiative through a new capacity-building program that will equip local and state officials across India with the practical knowledge and peer networks needed to accelerate Heat Action Plan implementation. ■

Humanitarian Leadership for Slow-Onset Urban Heat Crises

*By **Dr. Jamie Munn,** Executive Director, International Council of Voluntary Agencies (ICVA), Switzerland*

At ICVA, our mandate is to make humanitarian action more principled, more effective, and more accountable to people affected by crisis. As a global network of NGOs, we work to ensure that the voices, experiences, and expertise of local, national, and international NGOs shape humanitarian policy and practice. In that spirit, we are grateful for the leadership of our members working on the frontline of climate adaptation and disaster risk reduction, including the important work of the All India Disaster Mitigation Institute (AIDMI), whose long-standing commitment to community-centred resilience continues to shape global thinking.

Heat is no longer a seasonal inconvenience. It is a humanitarian risk multiplier.

Across South Asia and beyond, prolonged and intensifying heatwaves are exposing a profound gap in how we understand and respond to slow-onset crises, particularly in urban environments. Unlike floods, earthquakes or cyclones, extreme heat often unfolds quietly. There is no dramatic moment of impact, yet the consequences are severe: rising mortality, collapsing livelihoods, strained health systems, and deepening inequalities.

For humanitarian leaders, this presents a challenge. Our systems are largely designed for visible, acute shocks. Heat demands something different: anticipation, adaptation, and sustained local action.

Urban centres are increasingly on the frontline. Dense populations, poor ventilation, inadequate housing, vanishing green spaces, and unreliable access to water combine to create dangerous urban heat traps. The burden falls disproportionately on those least protected: women workers in informal economies, displaced populations, elderly people, people with disabilities, and communities living in informal settlements.

From ICVA's perspective, three leadership shifts are urgently needed.

First, **preparedness must become more localised**. Local and national actors are often the first to identify heat stress and the last to leave when crises deepen. Their knowledge of infrastructure gaps, social coping mechanisms, and community vulnerabilities is indispensable. Yet they remain too often underfunded and under-recognised.

Second, **infrastructure must be understood as protection**. Heat-resilient shelters, shaded public spaces, cooling centres, reliable water systems, and climate-sensitive urban planning are not simply development investments; they are humanitarian safeguards. Heat is increasingly blurring the line between humanitarian response and development action.

Third, **anticipatory action must evolve**. Forecast-based financing and early warning systems have advanced for floods and storms. We now need the same ambition for heat: financing earlier, acting sooner, and investing in prevention before temperatures become deadly.

The humanitarian sector must also confront an uncomfortable truth: funding cuts and hyper-prioritisation risk sidelining preparedness precisely when it is most needed. If we reduce investments in local capacity, urban resilience, and community protection systems, we are not saving resources; we are storing up greater human and financial costs.

Heat is shaping the future of humanitarian need. Leadership today means listening to local actors, investing in resilience, and recognising that dignity in crisis depends as much on preparedness as it does on response. ■

Extreme heat is becoming a quiet humanitarian crisis in many cities. It may not create sudden visible damage like a flood or cyclone, but it can still take lives, reduce incomes, strain health services, and make daily life unsafe for workers, children, older people, people with disabilities, displaced families, and communities in informal settlements. Humanitarian leadership must therefore focus on acting early, supporting local organisations, improving shaded spaces, water access and cooling centres, and making preparedness a core part of protecting people's dignity and resilience.

Risks to Critical Infrastructure due to Extreme Heat

*By **Ramraj Narasimhan,** Senior Director, Programme Management and Technical Support, Coalition for Disaster Resilient Infrastructure (CDRI), India*

Extreme heat is no longer just a health issue. It's also putting a strain on the infrastructure that people use every day. Systems designed for past climate conditions are being pushed to the limit as heatwaves become more frequent, more intense and longer lasting. Buildings, roads, railways, power networks, water supply systems, schools, hospitals, public transport, and cooling centres are all increasingly exposed to heat-related risks.

The economic costs are also substantial. The global average annual losses from heatwaves are USD 23.9 billion, with the buildings sector accounting for USD 11.8 billion and the power sector for losses estimated at USD 5.8-8.7 billion. Roads and railways together face losses of around USD 4-6 billion. These figures demonstrate that extreme heat needs to be addressed not only as a seasonal hazard, but also as a core issue in infrastructure planning, public investment and climate resilience.

Buildings are among the most affected systems. High indoor temperatures reduce comfort, health, productivity, and learning. Schools



Heat-Smart Schools: Guidance for Building Resilience to Extreme Heat. https://cdri.world/heat-smart-schools/

are especially vulnerable because children's learning ability declines when classrooms become too hot. Hospitals and health centres face rising cooling demand even as power systems are under stress. In dense urban areas, buildings also contribute to the urban heat island effect, worsening local heat exposure.

Transport infrastructure is also at risk. Extreme heat can soften, rut or melt roads. Extreme heat can crack or warp concrete surfaces. Extreme heat can warp railway tracks, creating safety hazards and service disruptions. Heat also puts stress on bridges, airports, runways and transportation hubs. Impacts extend beyond infrastructure assets to workers, commuters, patients, students, and small businesses that rely on reliable mobility.

Power is a critical link in heat resilience. Heatwaves spike cooling demand that can stretch grids beyond their design limits. Transformers overheat, transmission lines sag, distribution networks fail and blackouts or brownouts happen. When power goes out, cooling centres, schools, hospitals, homes and public transport systems are also at risk.

We need a holistic approach to address these risks. Infrastructure providers, utilities, urban local bodies, transport agencies, schools, health departments and communities should be involved in the Heat Action Plans. Cities need heat-risk mapping, early warning for utility providers, heat-aware load forecasting, backup power for cooling centres and priority restoration for vulnerable areas.

Extreme heat resilience is ultimately about keeping essential services running when people need them most. Infrastructure needs to be planned, designed, operated and maintained for a hotter future. Protecting critical infrastructure from extreme heat and enabling continued infrastructure services is central to protecting people, livelihoods, and local economies. ■

From a programme perspective, extreme heat is not only a climate or health concern; it is a growing risk to the everyday systems that communities depend on. When roads, railways, power networks, water systems, schools, hospitals, public transport, and cooling centres are affected by heat, the impact is felt directly by workers, children, patients, commuters, small businesses, and vulnerable households. Heat-resilient planning must therefore focus on keeping essential services functional during heatwaves through risk mapping, early warning, backup power, coordinated Heat Action Plans, and practical support for the communities most exposed.

WATER-SECURE HEAT PLANNING

Locating Water in the Heat Action Plan

*By **Shiny Saha**, Senior Programme Officer, International Water and Sanitation Centre (IRC WASH), South Asia Hub, India*

Heat level is increasing globally. As a strategy to address heat stress, in 2022, the National Disaster Management Authority (NDMA) collaborated with the India Meteorological Department (IMD) to work with select States to develop Heat Action Plans.

The Heat Action Plan is "a comprehensive early warning system and preparedness plan for extreme heat events. The Plan presents immediate as well as longer-term actions to increase preparedness, information-sharing, and response coordination to reduce the health impacts of extreme heat on vulnerable populations."[1]

Role of Water in Heat Management

Water has a critical role to play in heat management. Water is required for hydration and to cool off the body with baths. Thus, "household water security—affordable, reliable, safe, and acceptable water—is a prime avenue for heat adaptation…."[2] Further, waterbodies naturally manage heat by cooling and ventilating surrounding areas.

This paper attempts to understand how water is addressed in Heat Action Plans, with the help of an example.

Water in Heat Action Plan

Rajkot, the fourth largest city in the state of Gujarat, with a population of 1.28 million (Census 2011), developed a Heat Action Plan in 2024. The Heat Action Plan mentions the need for access to water and sanitation services to reduce heat exposure. Especially for women and children, the plan highlights the loss of productivity, risk of heat exposure, and threat of abuse and violence faced in spending extended time to fetch water or access toilet facilities, in the absence of a household connection. The plan further identifies the locations facing water shortage in the city as heat hotspots.

Thus, as a preparatory step for a heatwave, the plan suggests setting up intermittent drinking water points. As a short- and medium-term mitigation strategy, it lists the provision of drinking water in open/public areas and construction sites. For slums and squatter settlements, it recommends the provision of water tankers on call during orange/red alert days. As a long-term mitigation strategy, the plan encourages investing in waterbodies. Further, as steps to minimise the impact of heatwaves, the plan recommends drinking water and taking cold water baths.

In terms of stakeholders, the plan mentions that the Municipal Corporation – the author and the implementor of the plan – needs to coordinate with Department of Water and Sanitation to provide drinking water in public places, and to make water and sanitation services available in slums and squatter settlements.

The importance of water is well noted in Rajkot's Heat Action Plan. However, it appears to take household water security as a given. According to the Rajkot Municipal Corporation, the city is able to provide 90 MLD to 110 MLD of water compared to the 135 MLD demand. The demand is primarily met through the Narmada pipeline water from the Sardar Sarovar Project, while local reservoirs cater to only one-third of the city. The Narmada pipeline costs the Municipal Corporation (RMC) crores in electricity bills. As per a 2022 newspaper article, Rajkot Municipal Corporation (RMC) had an outstanding water bill of INR 90 Crores since 2017.[3]

Located in an arid region with irregular and erratic monsoons, the city experiences water supply problems annually, in terms of both quality and quantity. The water woes are particularly severe for those living in the slums and squatter settlements. At the same time, the city is known to witness water wastage due to leakages. Further, wastewater generated by the city is not efficiently treated to be reused. Total sewage generated in the city is 190MLD against a treatment capacity

[1] Press Information Bureau, Government of India, "Union Minister Dr. Jitendra Singh says, NDMA and IMD are working with 23 States to develop Heat Action Plans," 22 December 2022, available at https://www.pib.gov.in/Pressreleaseshare.aspx?PRID=1885718&reg=3&lang=2

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of 95MLD as of 2015-16.[4] Untreated sewage is discharged into the Aji River; the Aji River basin is a network of 19 natural drainage courses, which are being used for sewage disposal. Neither is there a systematic approach followed to capture rain water, which has resulted in the city flooding.

Given that water is scarce and costs the city a fortune, the plan appears to be incomplete without suggesting ways or connecting the dots on how to make the city water secure. Without mentioning ways to increase access to water, mitigation actions like staying hydrated or cooling the body hold little meaning.

One of the low hanging fruits for the plan would have been to revive the existing water bodies in the city –as a means to secure drinking water as well as to naturally cool the city. The waterbodies in the city have historically been suffering from dumping of untreated and partially treated domestic sewage. There are not only insufficient checks to prevent dumping, but the city also lacks (as discussed above) efficient wastewater treatment. Further, with rapid urbanisation, there have been encroachments on the natural water channels, reducing their storage capacity. Further, as discussed above, Rajkot has been receiving more than usual rain in the last few years. However, the city lacks rainwater storage capacity.

Thus, as mitigation strategies, the plan could have prescribed:

> Water is essential for heat protection. Rajkot's Heat Action Plan includes drinking water points, water tankers for slums, and investment in waterbodies. But heat action will remain incomplete unless cities ensure safe, reliable, and affordable water through better water storage, wastewater treatment, rainwater harvesting, and protection of local waterbodies.

- Prevention of water pollution
- Prevention of illegal encroachment on water bodies
- Investment in stormwater management
- Investment in wastewater treatment

The city of Bhubaneswar in its Integrated Heat and Cooling Action Plan[5] acknowledging the criticality of water in heat management, provides detailed steps on rejuvenation of water bodies and ensuring drinking water supply.

Other Plans

In 2018, the Climate Action Plan for the city of Rajkot was published. The Climate Action Plan, addressing all climate risks, including heat, floods, droughts, air pollution, and emissions, is broader and multi-sectoral in scope. Aimed at building climate resilience, it addresses ensuring water security and rejuvenating water bodies.

The purpose of climate action plans is to address environmental change while meeting other long-term goals such as socio-economic development and environmental protection. "(The) ….plans aim to help cities to reduce greenhouse gas emissions and adopt low emission development trajectories, as well as adapt to the impacts of climate change and build local climate resilience, while aligning to the local development goals and plans."[6]

Further, as a part of AMRUT 2.0, to promote circular economy of water, development of City Water Balance Plan (CWBP) was recommended, focusing on recycle/reuse of treated sewage, rejuvenation of water bodies and water conservation. The aim of the CWBP is to "help cities to identify scope for projects focusing on universal coverage of functional water tap connections, water source conservation, rejuvenation of water bodies and wells, recycle/reuse of treated used water, and rainwater harvesting."[7]

Given the multiplicity of plans, like the Heat Action Plan, Climate Action Plans and City Water Balance Plan, with close overlaps, a few questions become important to be asked:

- Is the existence of multiple plans for a single city a boon or a bane?
- Is it better to have a holistic plan that addresses all aspects of climate – heat, flood, drought, etc – holistically, or to have focused single-issue plans?
- Are there mechanisms in place to monitor development activities in the cities and their adherence to the plans?
- How binding are the plans on the city governments?
- Once the plans have been prepared, what next? ■

[4] Rajkot Municipal Corporation, *Climate Resilient City Action Plan: Rajkot*, July 2018, available at https://www.capacitiesindia.org/wp-content/uploads/2020/10/CRCAP_Rajkot_July-2018.pdf
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Urban Heat Action Plans: Progress, Gaps, and Priorities for Protecting Vulnerable Groups of India

*By **Abhiyant Tiwari** and **Anshima Mishra**, NRDC India*

India's heat governance is at an inflection point. For nearly two decades, Heat Action Plans (HAPs) have been the country's primary instrument for managing extreme heat, growing from a single city-level plan in Ahmedabad in 2013 into a sprawling policy architecture spanning 23 heat-prone states. As of June 2026, India's heat governance encompasses over 250 HAPs across various cities. The question today is no longer whether a city has a plan, but whether that plan protects the people most exposed to heat.

India's heat governance has matured considerably in recent years. Following Odisha's pioneering 1999 plan, adopted after a heatwave that claimed over 2,000 lives the previous year, and Ahmedabad's globally studied 2013 plan, the National Disaster Management Authority has worked with the India Meteorological Department across 23 states to push HAPs toward becoming standing institutional mechanisms, anchored to colour-coded early-warning triggers rather than ad hoc emergency response. A newer generation of HAPs is also grounding response around heat vulnerability risk assessments and locally derived temperature thresholds for early warning, rather than a single national criterion applied uniformly across climatologically different cities. This is being matched by movement on the financing side: heatwave mitigation projects, such as cooling shelters and early warning systems, can be eligible for funding under the National and State Disaster Mitigation Funds (NDMF/SDMF), while the 16th Finance Commission has additionally recommended, that heatwave be added to India's nationally notified disasters list, which would open up the complete state and national disaster response funds (SDRF/NDRF) for relief and compensation as well.

Yet progress in the number of plans has outpaced progress in their design. There is a meaningful difference between a heat-intentional measure and a heat-incidental one, and most HAPs lean heavily on the latter. Tree plantation drives, water kiosks, and shaded infrastructure often exist for other civic reasons and simply get folded into the heat narrative, rather than being designed from the ground up around who actually bears the heat burden. That burden falls unevenly. Street vendors, construction labourers, domestic workers, and small business owners remain peripheral to most plans, named in vulnerability lists but rarely designed for. So do the elderly, the chronically ill, residents of poorly ventilated informal settlements, and migrant workers who fall outside a city's data systems entirely. Most HAPs also operate at the city level, missing intra-city heat variation that can span several degrees between wards, so resources get allocated blind to where exposure actually concentrates. Few plans explicitly factor in the compounding heat exposure and unpaid care burden faced by women informal workers, even though they are among the most consistently exposed.

The next phase of India's heat governance needs to be as forward-looking as the crisis itself, anticipating exposure rather than just responding to it. That starts with seeing risk more clearly: occupation and gender disaggregated heat-health data, paired with ward-level heat mapping powered by satellite and AI-based urban heat island analysis, would let cities direct resources to where risk is actually concentrated, not just where temperatures are highest on average. It also means reaching people faster. Heat alerts folded into the digital welfare and wage-payment systems millions of informal workers already use would travel further than posters and loudspeaker announcements ever could, and parametric heat insurance, paying out automatically once a temperature threshold is crossed, could offer workers and small businesses a financial cushion without the delays of conventional claims. And finally, it means building heat resilience into the city itself: treating nature-based cooling, tree cover, reflective and green roofs, revived water bodies, as core infrastructure rather than a beautification add-on.

Heat and cooling are often treated as separate policy tracks, one a disaster-response issue, the other an energy and infrastructure one, even though they affect the same people for the same underlying reason: those most exposed to extreme heat are usually those with the least access to cooling. The Centre of Excellence for Heat Resilience and Sustainable Cooling, launched in April 2026 through



An Emergency Cooling Centre in Barmer, Rajasthan, offering shade, water, and rest to heat-affected residents during peak summer. Source: https://www.licas.news/2022/08/16/church-offers-cooling-centers-to-help-poor-beat-heat-as-temperatures-soared-in-india/

NRDC's partnership with the Government of Maharashtra, brings the two together under one institutional mandate. Anchored eventually within Maharashtra's State Institute of Disaster Management, it offers a model for cross sectoral long-term HAP intervention at scale: research, capacity-building, and technical support that persist well beyond any single heatwave season.

Extreme heat, as this issue argues, encompasses both rapidly intensifying and prolonged events, with health, environmental, and socioeconomic impacts that are unevenly distributed across populations. The next generation of Heat Action Plans must treat informality, gender, and granularity not as addenda, but as design parameters from the outset, anchoring response not just to temperature, but to who is left exposed when temperatures rise.

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कच्छ की महिलाएँ और हीट रेजिलिएंस के सबक

By ***Lata Sachde***, *Kutch Mahila Vikas Sangathan (KMVS), Gujarat, India*

कच्छ ने आपदाओं से उबरने की प्रक्रिया में एक महत्वपूर्ण बात सिखाई है कि मजबूती केवल बाहर से मिली सहायता से नहीं आती, बल्कि समुदाय की अपनी क्षमता, स्थानीय ज्ञान और महिलाओं की भागीदारी से बनती है। कच्छ बार-बार सूखा, चक्रवात, भूकंप और अब बढ़ती गर्मी जैसी चुनौतियों का सामना करता रहा है। इन परिस्थितियों में महिलाओं ने केवल प्रभावित व्यक्ति की भूमिका नहीं निभाई, बल्कि वे परिवार संभालने, आय बढ़ाने, जरूरतों की पहचान करने और समुदाय को संगठित करने में आगे रहीं।

2001 के भूकंप के बाद यह स्पष्ट हुआ कि राहत और पुनर्वास तभी प्रभावी होते हैं जब वे स्थानीय जीवन, मौसम, संस्कृति और कौशल के अनुरूप हों। टीन की चादरों जैसे एक जैसे समाधान कच्छ की गर्म जलवायु के लिए उपयुक्त



नहीं थे। स्थानीय सामग्री, कारीगरों और महिलाओं की भागीदारी से बने घर अधिक उपयोगी, मरम्मत योग्य और सम्मानजनक साबित हुए।

ये अनुभव आज अत्यधिक गर्मी की तैयारी के लिए बहुत प्रासंगिक हैं। हीट एक्शन प्लान केवल सलाह या चेतावनी तक सीमित नहीं रह सकते। उनमें महिलाओं के समूहों, स्थानीय संस्थाओं और प्रभावित परिवारों की भागीदारी जरूरी है। महिलाएँ सुरक्षित कार्य समय, पानी, छाया, स्वास्थ्य जागरूकता और कमजोर परिवारों की पहचान में अहम भूमिका निभा सकती हैं। कच्छ का सबक साफ है: गर्मी से सुरक्षा तभी मजबूत होगी जब महिलाएँ योजना, क्रियान्वयन और निर्णय प्रक्रिया में शुरुआत से शामिल हों। ■

Women of Kutch and Lessons for Heat Resilience

Kutch's experience of disaster recovery shows that resilience is built not only through external support but also through local knowledge, community capacity, and women's leadership. The region has faced repeated droughts, cyclones, earthquakes, and now rising extreme heat. In each crisis, women have played a central role in protecting families, sustaining livelihoods, identifying needs, and organising community responses.

After the 2001 earthquake, Kutch learned that recovery solutions must suit local climate, culture, skills, and everyday realities. Uniform shelters, such as tin-sheet structures, were not appropriate for the hot climate. Houses built with local materials, by local artisans, and with women's involvement were more functional, repairable, and dignified.

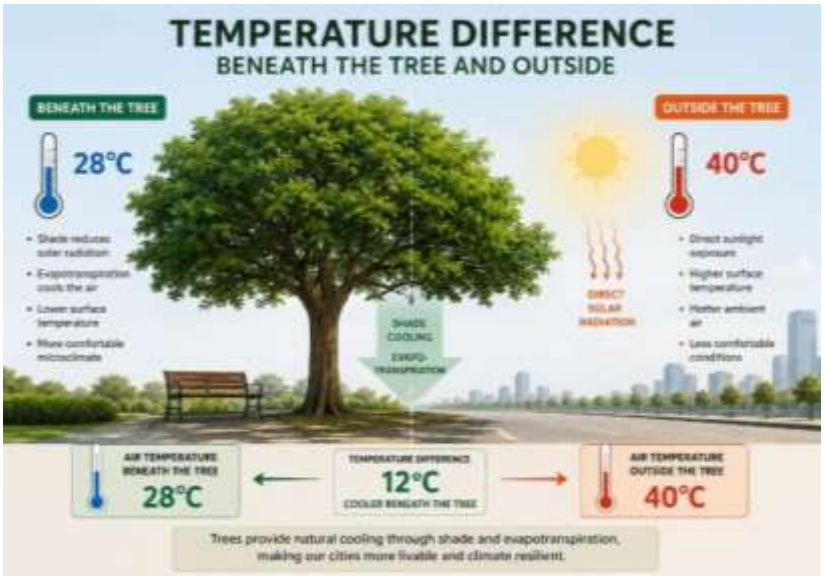
These lessons are so applicable today for heat resilience. Heat Action Plans must be more than advisories and technical warnings. Women's groups, local institutions and affected families must be involved from the beginning. Women can help to identify safe hours for work, water needs, shaded spaces, vulnerable households, health risks and trusted ways to share early warnings.

The lesson from Kutch is simple. To protect against extreme heat, women need to be involved in planning, implementation and decision-making. Heat resilience must be community-led, locally rooted and inclusive. ■

Old Trees, Green Cover, and Urban Cooling: Nature-Based Infrastructure for Heat Resilience

*By **Dr. Deepa Gavali**, Executive Secretary, Gujarat Ecology Society, and*
***Dr. Jitendra Gavali**, Botanist, Vadodara, Gujarat, India*

The year 2026 has been the hottest summers. The urban areas across India have seen temperatures hovering around 40^{O}C and heatwaves continues for a longer duration. The major reasons behind this are rapid urbanisation, loss of green cover and the expansion of impervious surfaces such as roads, buildings, and pavements. In this context, old trees and urban green cover have emerged as critical nature-based infrastructure that can help cities adapt to rising temperatures and improve overall climate resilience.



Old, luxuriant trees provide a range of ecosystem services that directly contribute to urban cooling. Their extensive canopies intercept solar radiation and create shade, reducing surface and ambient temperatures in streets, parks, residential neighbourhood, and public spaces. In addition to shading, trees cool the surrounding environment through evapotranspiration, a natural process in which water absorbed by roots is released into the atmosphere through leaves, thereby lowering air temperatures. Native tree like banyan, mahuva, neem, ashok, imli etc. have thick, luxuriant canopies and they remain evergreen during the summers, thereby are best for urban cooling.

Trees can lower pedestrian-level temperatures by up to 12°C through large radiation blockage and transpiration. In tropical, temperate, and continental climates, a mixed use of deciduous and evergreen trees in open urban morphology provides approximately 0.5°C more cooling than a single species approach.



Indira Avenue (Jail road), Vadodara, Gujarat, India.

There are a few examples in India where old trees are left intact within gardens and parks, e.g., Cubbon Park in Bangalore, Sayaji Garden in Vadodara, Lodhi Garden in New Delhi, and others. However, due to urban infrastructure projects like road widening, flyovers constructions, lake beautification and new urban area developmental works, the first ones to be removed are the old trees. The Indira Avenue or Jail Road of Vadodara was once dotted with huge banyan trees on both sides. Their canopy was so dense that the road was avoided after 5.00 pm. People used to feel cool temperatures and were enjoying cycling beneath, even during hot summers. Unfortunately, this green

જૂના વૃક્ષો: શહેરોની કુદરતી ઠંડક

2026નું વર્ષ સૌથી ગરમ ઉનાળો રહ્યું છે. મોટાભાગના ભારતના શહેરોમા તાપમાન 40 ડિગ્રી સેલ્સિયસની રહ્યું છે. ઝડપી શહેરીકરણ થતાં રસ્તા, ફૂટપાથ અને ઊંચી ઇમારતોનું નિર્માણ થયું ને શહેરોમાં વૃક્ષાચ્છાદિત હરિયાળા આવરણને બહુજ નુકસાન થયું છે. તેમ છતાં જ્યાં જુના વૃક્ષો અને હરિયાળી બચી છે તેવા વિસ્તારોમાં શહેરના વધતા તાપમાનને અનુકૂલિત કરી આબોહવા માં અમુક અંશે સુધારો કરવામાં મદદ કરી શકે છે.

જુના, ઘેઘુર વૃક્ષો ઇકો-સીસ્ટમમાં વિવિધ સેવાઓ પૂરી પાડે છે તેમજ શહેરને ઠંડુ રાખવામાં સીધો ફાળો આપે છે. તેમના વિશાળ છત્ર સૌર કિરણોત્સર્ગને અટકાવે છે અને શેરીઓ, ઉધાનો, રહેણાંક વિસ્તાર અને જાહેર સ્થળોએ છાયા આપી બાષ્પીભવન દ્વારા વાતાવરણને ઠંડુ રાખે છે. વડ, મહુડો, લીમડો, આસોપાલવ આંબલી અને અન્ય દેશી વૃક્ષો ગીચ છત્ર ધરાવે છે અને ઉનાળા દરમિયાન શહેર ને ઠંડક આપે છે. રસ્તાના વૃક્ષો છાયા થકી 12°C સુધી તાપમાન ઘટાડી શકે છે. શહેરોમાં રોડ પહોળો કરવા, ફ્લાયઓવર, તળાવ બ્યુટિફિકેશન અને શહેરી વિસ્તારના બાંધકામોમાં સૌથી પહેલા જૂના વૃક્ષોને દૂર કરવામાં આવે છે. અમુક શહેરોમાં જ્યાં ઘેઘુર વૃક્ષો સચવાયેલા છે ત્યાં ગરમીમાં રાહત મળે છે. ક્લાઈમેટ ચેન્જના આકરા સમયમાં આવા જુના, ઘેઘુર વૃક્ષોને આધુનિક શહેરોના ડિઝાઇનનો ભાગ બનાવી તેઓને જાળવવા જોઈએ. જુના વૃક્ષો જે ઈકોલોજીકલ સર્વિસ આપે છે, એ સેવાઓની સરખામણી એજ પ્રજાતિના છોડ જોડે કરવી અશક્ય છે. શહેરમાં ગ્રીન કોરિડોર જાળવવાથી તેનું પર્યાવરણ ઠંડુ રહેશે જ, સાથે સાથે ટ્રાફિકની અવરજવર પણ સુખદ બનશે. વૃક્ષોની છાયા રસ્તાઓને વધુ પડતી ગરમીથી બચાવશે. હાલના તબક્કે જૂના વૃક્ષોને જાળવી રાખવાની અત્યંત જરૂરી છે.

pathway was lost in the road expansion in the early 1980s.

Urban infrastructure developers need to integrate the old trees within their designs and pave the way for climate-resilient cities. In Hawaii, huge banyan trees are an integral design element at places like the International Marketplace and the City Mall. The places around these trees are used for children's activities.

Ecological services provided by an old tree cannot be compensated even with the plantation of saplings of same species. During the scorching summers, pedestrians, cyclists and two-wheeler riders have a tough time moving out during daytime. The citizens look desperately for tree shade and everyone tries to cramp in whatever small shade if available along the roadside. Maintaining green corridor within the city will not only keep the city microenvironment cool but it will make pleasant traffic movement. Tree shade will prevent wear and tear of roads from excessive heating. The need of the hour is to retain the existing old trees. ■





The International Marketplace, Vadodara, Gujarat, India.

Cooling, Housing Design, and Thermal Comfort: Applying Recovery Lessons to Urban Heat Resilience

*By **AIDMI Team**, India*[8]

Extreme heat is no longer only an environmental concern. It is shaping how people live, work, sleep, care for family members, and recover in Indian cities. However, heat action planning still tends to focus mainly on outdoor temperatures. This misses an important part of the problem: for many people, the most sustained heat exposure takes place indoors, especially in affordable housing, informal settlements, and small workspaces. For low-income families, women workers, children, older persons, and people with health conditions, the home is not only a shelter. It is also a workplace, a care space, and a place where the body must recover.

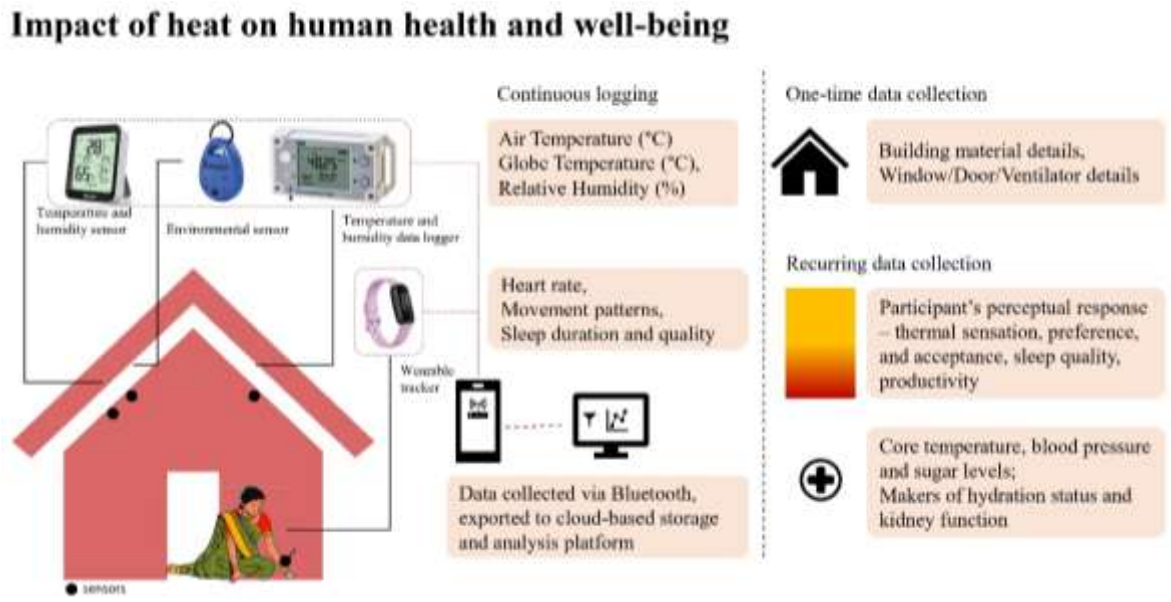
A key lesson from recent research is that temperature alone does not explain heat risk. Humidity is equally important. According to NASA Jet Propulsion Laboratory, for every 1°C of global warming, atmospheric humidity may rise by about 7 percent. When humidity is high, the body's natural cooling through sweating becomes less effective. Heat stress can therefore become dangerous even when temperatures appear moderate. This is particularly true in Indian cities during the pre-monsoon and monsoon months, when heat and humidity tend to combine.

Buildings can either protect people from heat or worsen their exposure to it. Poorly designed homes may absorb heat during the day and release it slowly at night. This affects sleep, recovery, health, learning, care work, and productivity. For women and home-based workers, indoor heat is also a livelihood issue, as it can reduce working hours, output, and income.

Urban heat resilience therefore requires a shift from simply "cooling buildings" to improving comfort and safety for people. Whole-room air-conditioning is often unaffordable, unreliable, and energy-intensive. More practical options are ventilation, shaded openings, reflective roofs, insulation, low energy cooling and personal comfort systems.

Better housing design and neighborhood planning are central to this shift. New housing should consider orientation, roof insulation, shaded windows, reflective surfaces, and materials that reduce indoor heat gain. Existing homes need practical retrofits such as cool roofs, roof shading, external window shading, and ventilation improvements. Beyond the house, shaded streets, trees, green corridors, permeable surfaces, rain gardens, and blue-green infrastructure can reduce heat while supporting water management.

The way forward is to connect housing, health, livelihoods, urban planning, and disaster risk reduction. Heat action planning must move closer to people's lived realities, especially in low-income settlements where exposure is high and adaptive choices are limited. ■



[8] AIDMI acknowledges Prof. Rajan Rawal, CEPT University, for his insights on cooling, housing design, thermal comfort, personal comfort systems, and blue-green infrastructure, shared during the virtual round table on May 27, 2026.

Can Assam's Cities Beat the Heat? The Role of Green and Blue Infrastructure

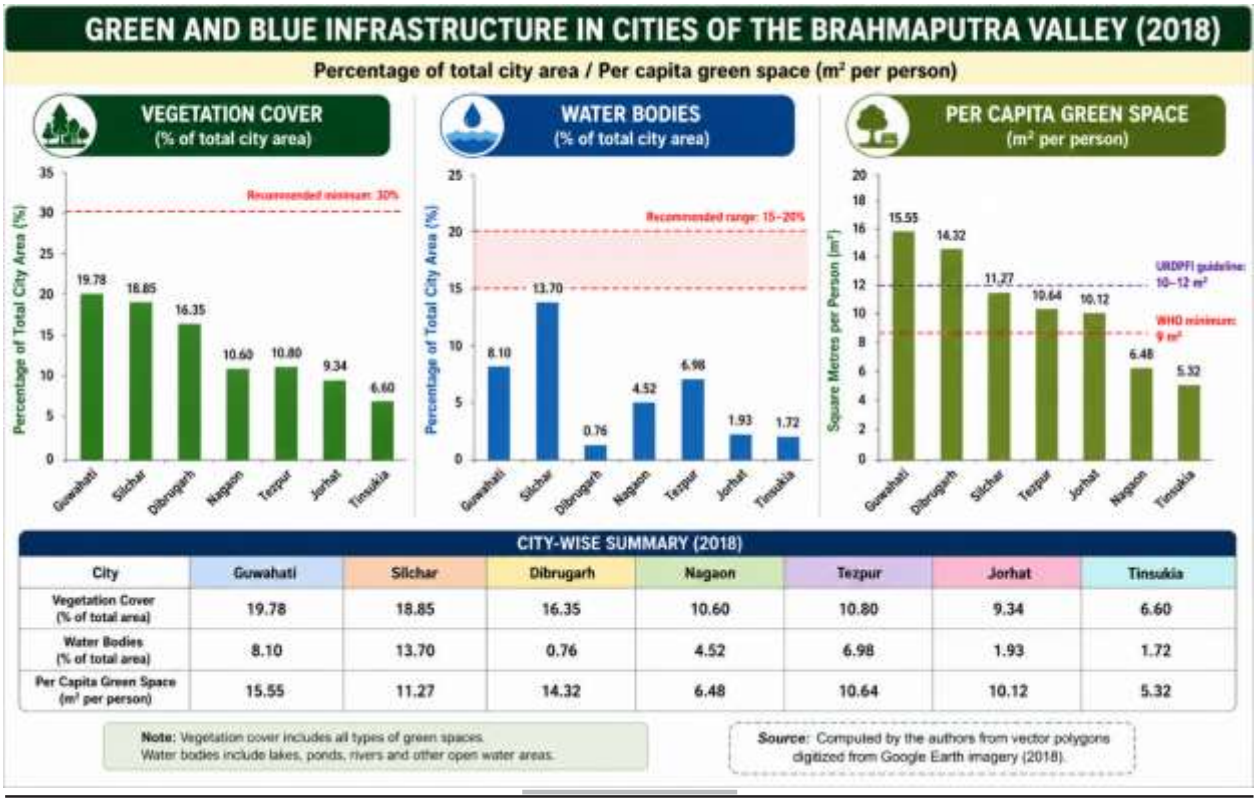
*By **Rituraj Neog**, Assistant Professor, Department of Geography, Gargaon College, Simaluguri, Assam, India; and **Shukla Acharjee**, Assistant Professor, Department of Geography & Centre for Atmospheric Studies, Dibrugarh University, Dibrugarh, Assam, India*

Heat stress is a major environmental challenge in urban areas worldwide driven mainly by climate change, rapid urbanisation and land-use/land-cover (LULC) transformations. Northeast India, a major tropical region of the country, is witnessing increasing urbanisation-induced LULC changes leading to the degradation of urban green and blue infrastructure (BGI). Cities located in the Brahmaputra Valley such as Guwahati, Silchar, Nagaon, Jorhat, Dibrugarh, Tinsukia and Tezpur are experiencing rapid urban expansion and substantial rural-to-urban migration, putting considerable pressure on the existing ecological resources and urban landscapes.

According to available estimates for 2018, vegetation cover accounts for only 19.78% of the total area in Guwahati, followed by Silchar (18.85%), Dibrugarh (16.35%), Nagaon (10.60%), Tezpur (10.80%), Jorhat (9.34%) and Tinsukia (6.60%).

These values are considerably lower than the recommendation of the International Union for Conservation of Nature (IUCN) Urban Alliance, which advocates at least 30% vegetation cover in urban areas to maintain favourable microclimatic conditions and ecological sustainability. Similarly, blue infrastructure, particularly urban water bodies, plays a crucial role in regulating urban thermal environments through evaporative cooling and heat dissipation. The proportion of water bodies also remains relatively low across most cities, accounting for only 8.10% of the area in Guwahati, 13.70% in Silchar, 6.98% in Tezpur, 4.52% in Nagaon, 1.93% in Jorhat, 1.72% in Tinsukia, and merely 0.76% in Dibrugarh. These values fall substantially short of the commonly recommended threshold of 15–20% water coverage required for effective thermo-regulation and the development of heat-resilient urban environments.

Per capita availability of urban green space provides another important indicator of ecological adequacy. The



World Health Organisation (WHO) recommends a minimum of 9 m² of green space per person, while the Urban and Regional Development Plans Formulation and Implementation (URDPFI) Guidelines prescribe 10–12 m² per capita for Indian cities. Although Guwahati, Dibrugarh, Silchar, Tezpur, and Jorhat currently exceed these thresholds, Nagaon and Tinsukia exhibit comparatively lower per capita availability of green space, reflecting increasing ecological stress. Furthermore, the rapid growth of urban populations, particularly in Guwahati, Tezpur, Dibrugarh and Silchar, is likely to intensify pressure on existing green and blue infrastructure, leading to a progressive decline in per capita ecological resources.

Consequently, continued urban expansion and associated LULC transformations are expected to compromise the ecological functions of urban landscapes, thereby reducing their capacity to mitigate heat stress and regulate local climatic conditions. In this context, the restoration of degraded green and blue infrastructure, the protection of existing ecological assets, and the strategic utilisation of vacant and open spaces to develop new BGI networks are essential for enhancing urban thermal resilience and promoting sustainable urban development in the rapidly urbanising cities of the Brahmaputra Valley. ■

MAPPING HEAT RISK

Making Heat Visible: From Preparedness to Resilience

Geospatial tools for mapping heat risk and prioritising resilient infrastructure investments

*By **Uttam Pudasaini**, Director, Climate and DRR Technology Department, and*
***Kundan Jung Thapa**, Programme Coordinator, Urban Informatics Department, NAXA, Kathmandu, Nepal*

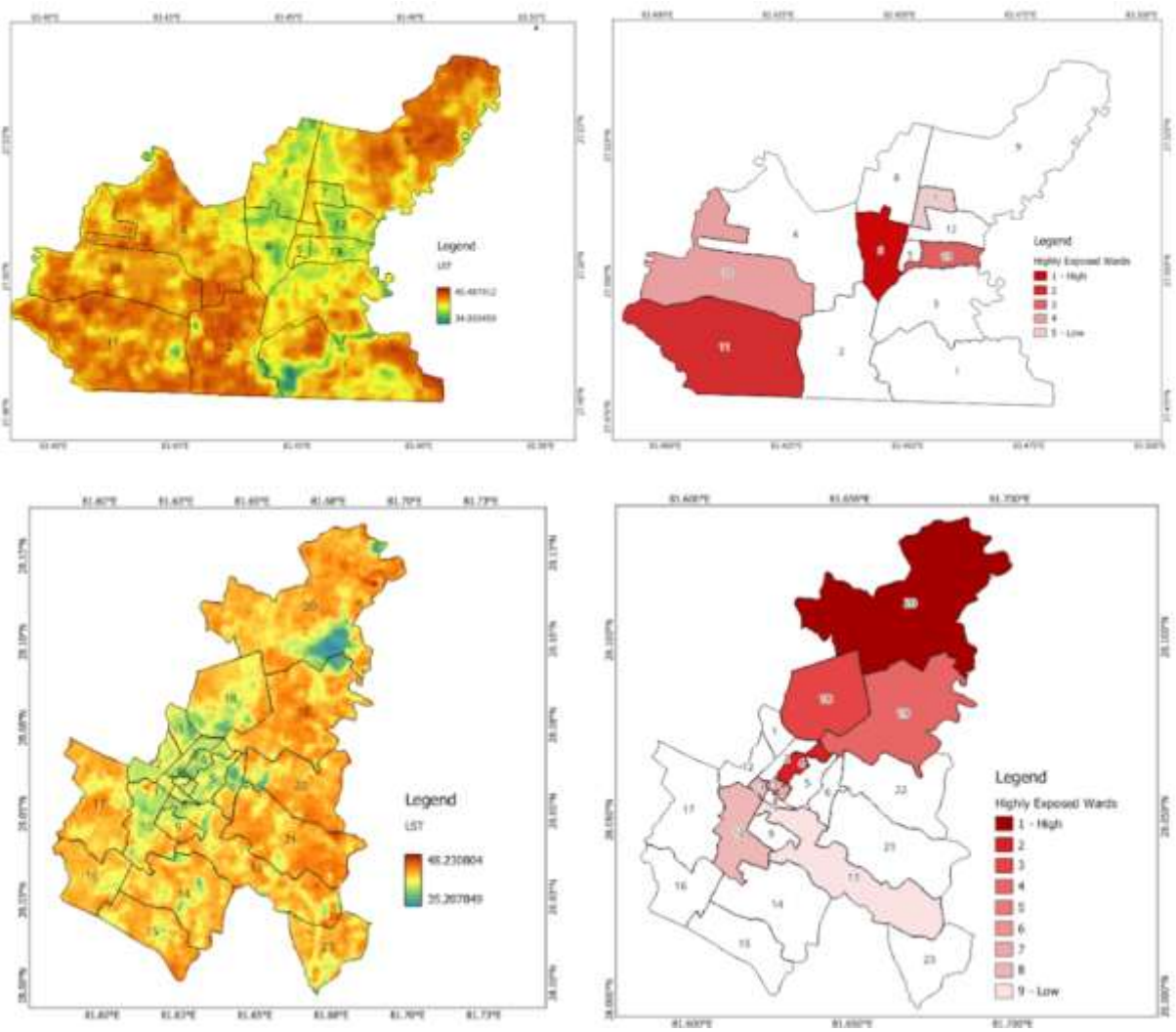
At NAXA, a youth-led GeoICT company based in Kathmandu, we have spent the past decade turning spatial data into decisions for disaster risk reduction, climate risk assessments and adaptation planning.

We understand that different data-driven, digital, and spatial tools and technologies add value across heat assessment and adaptation planning work.

- Satellite imagery from Landsat, Sentinel, and MODIS derives land surface temperature, vegetation, water, and built-up density to map urban heat islands at neighbourhood scale.
- Drones add centimetre-level detail on rooftops and settlements that satellites miss.
- Weather station data anchors the analysis to local heat thresholds.
- Web platforms turn results into interactive dashboards, ward-level risk maps, and automated alerts.
- AI classifies land cover, detects building footprints, and scales the analysis across cities and much more.

Some of our recent key assignments illustrate this practice:

- **Heat Hotspot Analysis, Mapping and Web-based Visualisation with Alert System (Client/Partner: IFRC / American Red Cross).** We mapped heat hotspots across Siddharthanagar and Nepalgunj by processing land surface temperature and vegetation indices, then overlaying exposure and vulnerability to rank the most affected areas, feeding a dashboard that monitors thresholds and automatically alerts communities and authorities.
- **Web-based Platform for Heatwave and Coldwave (Client/Partner: Institute of Himalayan Risk Reduction).** A web-GIS anticipatory tool linking real-time and forecast data from the Department of Hydrology and Meteorology with 1991–2020 climate baselines. It flags hotspots using absolute and percentile-based thresholds, tracks anomalies, and triggers alerts, built on a modular architecture with training so local institutions can run it themselves.
- **Heat and Heat-Related Health Risk Assessment in Biratnagar and Sainamaina (Client/Partner: IFRC/Swiss Red Cross/Finnish Red Cross).** Our most comprehensive assignment moves from hazard to human impact, pairing hotspot and vulnerability mapping with a health-impact study covering heat-related illness, mortality, dehydration, cardiovascular, respiratory, maternal, child, and mental health. Findings fed local



A heat risk map overlays hazard, exposure and vulnerability to rank wards by priority in Siddharthanagar and Nepalgunj.

heat thresholds and a municipal Heat Action Plan centred on women workers, the elderly, children, and pregnant women.

- **DASTAA (Digital and Spatial Technologies for Anticipatory Action) - where people, data, and technology converge:** DASTAA is our in-house platform that brings this analysis down to a single facility or household, fusing field sensor readings, satellite analytics, and facility surveys into a tailored risk assessment, scorecard, and adaptation and disaster-response plan. We have generated such plans for roughly 35,000 flood-exposed households across Nepal and Bangladesh. Applied to heat, the same engine assesses each school, health post, or market on its own terms rather than an averaged ward statistic, so a clinic with no shade is treated differently from one beside a park. We are now integrating AI into DASTAA to close the gap between assessment and action. Today, producing an adaptation plan requires expert interpretation. With AI, the platform will read a facility's sensor, satellite, and survey data and draft a tailored adaptation plan automatically, recommending shading, ventilation, cool roofing, water access, green cover, and adjusted working hours, refining its recommendations with each new assessment. ■

> "Heat-resilient infrastructure can only protect the health, livelihoods, and dignity of those most at risk if planners can answer a deceptively simple question first: where does heat concentrate, and who does it harm first?"

EXTREME HEAT ADAPTATION

Continuing Business in Extreme Heat: Jashiben's Story of Heat Adaptation

*By **Pallavi Rathod,** All India Disaster Mitigation Institute (AIDMI), India*

For the past 25 years, Jashiben Motibhai Suthar has been selling cricket bats from a small roadside stall. The business is her family's only source of income. She waits for customers to come in every day, but that gets a lot harder in summer.

By the afternoon, as the temperature rises, the roads become empty. Not many customers come to buy cricket bats, and people prefer to stay indoors. It's exhausting sitting out in the heat for hours. "It was becoming difficult to sit during the day in the heat," Jashiben often told people. Even after sitting at her stall all day, her sales kept falling. Many customers have also started buying products online, making business even more difficult.

The heat affects not only her work but also her home. She lives in a *kachcha* house without electricity. There is no fan to provide relief from the heat, and sleeping at night is difficult. Without proper rest, she wakes up tired and has less energy to manage her business the next day.

She realised that while afternoons were too hot, more people came out in the evening when the weather became cooler. She wanted to keep her business open during those hours, but she had no lighting facility after sunset.

Through AIDMI's support, she received a battery and a cool box. This small support brought a big change to her life.

"Now that there is light in the evening, I can continue with my business."

The battery powers a light that makes her stall visible after sunset, allowing her to serve customers during the cooler evening hours. She also started selling cold drinking water from the cool box. This has become an additional source of income, especially during hot days when people need safe drinking water.

The battery has another important benefit. Since her house has no electricity, it provides light at night for her family as well.

"The battery helps both my house and my business."

At AIDMI workshops on Heat Action Planning for All, Jashiben shared her experience with other small business owners. She told them that it doesn't always have to cost a lot to adapt to extreme heat. Small, practical actions can help protect health and livelihoods in conjunction with the knowledge gained through Heat Action Planning for All. ■



Jashiben Motibhai Suthar uses simple heat adaptation measures, including shade, battery-powered lighting, and a cool box, to continue selling wooden items from her roadside stall during extreme heat. Photo: AIDMI.

WAY AHEAD

Making Heat-Resilient Infrastructure People and Nature Centred

*By **Mihir R. Bhatt,** All India Disaster Mitigation Institute (AIDMI), India*

"Why does any new infrastructure cut across land and water and clear air?", asked a member of a group of low-income citizens who had joined to discuss with us the future of resilience of Bhuj city after the earthquake in 2001.

The idea remained in our minds, since and after years, we received the book by Mittul Vahanvati titled "Resilient Recovery from Disasters: The Long-Term Outcomes of Post-Disaster Housing Reconstruction in India, Thailand and Japan", and again we started thinking about the above question by the Bhuj citizen before and during in the roundtable on "Lessons from Earthquake and Flood-Related Long-Term Recovery to Extreme Heat Action Planning".

Extreme heat is here as only now we all are realising. It is shaping how people live, work, travel, study, sleep, and recover in cities and around. This issue of Southasiadisasters.net shows that heat-resilient infrastructure is not only about stronger buildings, roads, railways, power systems, schools, hospitals, transport systems, or cooling centres. It is about keeping essential services functional when people need them most. It is about protecting health, livelihoods, dignity, and everyday continuity.

The way ahead must start with those who face heat first and longest. Women workers, home-based workers, outdoor workers, children, older persons, persons with disabilities, small businesses, low-income households, and residents of informal settlements must shape heat action planning. Their lived experience should inform infrastructure design, public investment, and local preparedness. A shaded bus stop, a cooler classroom, a ventilated home, a safe workplace, a reliable water point, and a functioning health centre are not small improvements. During extreme heat, they are life-saving infrastructure.

> "The real test of heat-resilient infrastructure is not how strong it looks on paper, but whether it keeps the most exposed people safe, healthy, and able to continue their lives with cool dignity."

India must now move from seasonal heat response to year-round heat risk reduction. We at AIDMI call it "All Season Infrastructure" and "All Weather Infrastructure" in our urban work. Heat Action Plans should guide decisions before summer begins. They must inform building standards, housing retrofits, school safety, hospital preparedness, transport operations, labour protection, water access, power reliability, and local government budgets. Lessons learnt from long-term recovery from earthquakes and floods show that risk reduction needs to be embedded in planning, construction, maintenance, skills, finance and governance.

Infrastructure planning must combine climate evidence with local knowledge and listening to nature in its many voices. Heat-risk maps, satellite data, ward-level vulnerability analysis, early warning systems, and digital tools can identify where heat concentrates. But data alone is not enough. Local women's groups, workers, health staff, school teachers, transport workers, small business owners, and community organisations know where heat creates the greatest hardship. Their knowledge must be part of planning and monitoring.

Nature must be treated as infrastructure for us and for itself. Both. Old trees, green corridors, water bodies, shaded streets, parks, and blue-green networks are cooling systems. They are also public health assets and social protection measures. Protecting existing trees is often more valuable than planting saplings after damage is done. Urban development should retain, restore, and expand natural cooling.

Heat resilience also needs finance that reaches local action. Many practical measures remain underfunded, although they can reduce exposure quickly. Governments, donors, CSR programmes, and development partners should support cool roofs, ponds to pool water, shaded public spaces, drinking water points, green cover, heat-safe schools, worker rest areas, trees to clean air, backup power for essential services, and community preparedness systems.

The next step is clear. Heat-resilient infrastructure needs to be inclusive, affordable, locally maintained and accountable to those impacted, both humans and nature. The extreme heat will test our cities, our services and our institutions. Our response must be practical, evidence-based, dignity-based and nature-based. The real test of success will be whether the most vulnerable are safer, healthier and better equipped to carry on their lives and livelihoods in a hotter but greener future, not how many plans are produced to build infrastructure that is people and planet centred.

Infrastructure itself should not lead to more heat but cool the area and nature around it. At the same time, we need to find thousands of new infrastructure structures that lead us to making our lives and cities and planet green and cool. ■

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