CENTRE FOR POLICY RESEARCH

HOW IS INDIA ADAPTING TO HEATWAVES?

AN ASSESSMENT OF HEAT ACTION PLANS WITH INSIGHTS FOR TRANSFORMATIVE CLIMATE ACTION

March 2023

CENTRE FOR POLICY RESEARCH

CPR is a non-profit, non-partisan, independent institution dedicated to conducting research that contributes to high quality scholarship, better policies, and a more robust public discourse about the issues that impact life in India. The Centre for Policy Research (CPR) has been one of India's leading public policy think tanks since 1973. For more, visit www.cprindia.org.

Acknowledgements: We thank Ankit Bhardwaj (New York University), Navroz K. Dubash (CPR), Kamal Kishore (NDMA), Bhargav Krishna (CPR), Rohit Magotra (IRADe), Sara Meerow (Arizona State University), Polash Mukherjee (Natural Resources Defense Council), Kirsten Vanderplanken (Antwerp Management School), and Sonali Verma (CPR) for their feedback on earlier versions of this document.

All the contents of this report are the responsibility of the authors alone. The reviewers bear no responsibility for any opinions or inaccuracies in this report.

Suggested citation: Aditya Valiathan Pillai and Tamanna Dalal. (2023). How is India adapting to heatwaves?: An assessment of heat action plans with insights for transformative climate action. CPR report. DOI: 10.5281/zenodo.7765430

EXECUTIVE SUMMARY

Extreme heat poses an unprecedented challenge to health and productivity in India. Heatwaves (prolonged periods of extreme heat) have increased in frequency in recent decades due to climate change. Landmark heatwaves (1998, 2002, 2010, 2015, 2022) have each led to large death tolls (according to government estimates) and extensive economic damage by reducing labour productivity and affecting water availability, agriculture, and energy systems.

Governments across India at the state, district, and municipal levels have responded by creating heat action plans (HAPs), which prescribe a variety of preparatory activities and post-heatwave response measures across government departments to decrease the impact of heatwaves (see Box 1 for more on what HAPs are). These documents are meant to be iterated upon and refined over time.

In this report, we aim to support this process of refinement by conducting what is, to our knowledge, the first critical review of heat action plans in India. We analysed 37 heat action plans at the city (9), district (13) and state (15) levels across 18 states. We identify several opportunities to strengthen Indian HAPs. We also document an encouragingly wide range of solutions (covering 62 distinct intervention types) prescribed across these HAPs, from promoting green roofs to state-wide school awareness programs (see Figure 3). This lays out a consolidated toolbox of options for the Indian HAP designer and policymaker.

In general, we find that these HAPs prescribe a balanced mix of short and long-term actions (those that have an impact over more than one heat season) though it is unclear to what extent these actions are being implemented. Long-term transformational actions, such as climate-sensitive urban planning and changing cropping patterns, will likely come with higher implementation costs than immediate responses but could significantly reduce heat exposure and ease HAP implementation in the long run.

Based on the analysis, we identify key areas for improvement:

1. **Most HAPs are not built for local context and have an oversimplified view of the hazard.** HAPs generally focus on dry extreme heat; only ten out of 37 HAPs reviewed seem to establish locally-defined temperature thresholds though it is unclear whether they take local risk multipliers (such as humidity, hot nights, duration of continuous heat among others) into account to declare a heatwave. Hot nights, heatwaves coming earlier, and cascading impacts are unevenly considered across HAPs. Climate projections, which could help identify future planning needs, are not integrated into current HAPs. We recommend nuancing and localizing the heat hazard definition, including by incorporating climate projections.
2. **Nearly all HAPs are poor at identifying and targeting vulnerable groups.** Only two of 37 HAPs explicitly carry out and present vulnerability assessments. This

leaves the implementer with little data on where to direct their scarce resources and could lead to poor targeting. While most HAPs identify broad categories of vulnerable groups, the list of solutions they propose do not necessarily focus on these groups. HAP designers must incorporate vulnerability assessments and shift to more holistic risk assessments where feasible.

3. **HAPs are underfunded.** Only 11 of 37 HAPs discuss funding sources. Of these, eight asked implementing departments to self-allocate resources, indicating a serious funding constraint. We propose systematically mapping HAP interventions against existing state and central schemes to unlock funding. We also call for more clarity on funding mechanisms either by linking HAPs to national climate funding mechanisms or by exploring adding heatwaves to the list of notified disasters to harness disaster preparedness funds.
4. **HAPs have weak legal foundations.** None of the HAPs indicate the legal sources of their authority. While this is not necessary for plans, it reduces bureaucratic incentives to comply with HAP instructions, which is significant in the context of understaffed and overburdened implementation agencies tasked with simultaneously implementing several other long-term plans. It also reduces the accountability of implementing agencies. We call for more explicit linkages with the legal structure for disaster management and environmental governance.
5. **HAPs are insufficiently transparent:** There is no national repository of HAPs and very few HAPs are listed online. Further, it is unclear whether these HAPs are being updated periodically and whether this is based on evaluation data. We recommend creating a national repository of HAPs housed in the National Disaster Management Authority (NDMA) and conducting independent, publicly accessible external evaluations of their performance.
6. **Capacity building is sectorally-targeted:** HAPs cover several forms of capacity building for key sectors such as health, construction, and schools. They place far less emphasis on the capacity of transformative, cross-cutting actors like government departments, civil society, and the local heat research ecosystem. We recommend greater capacity investment in these areas.

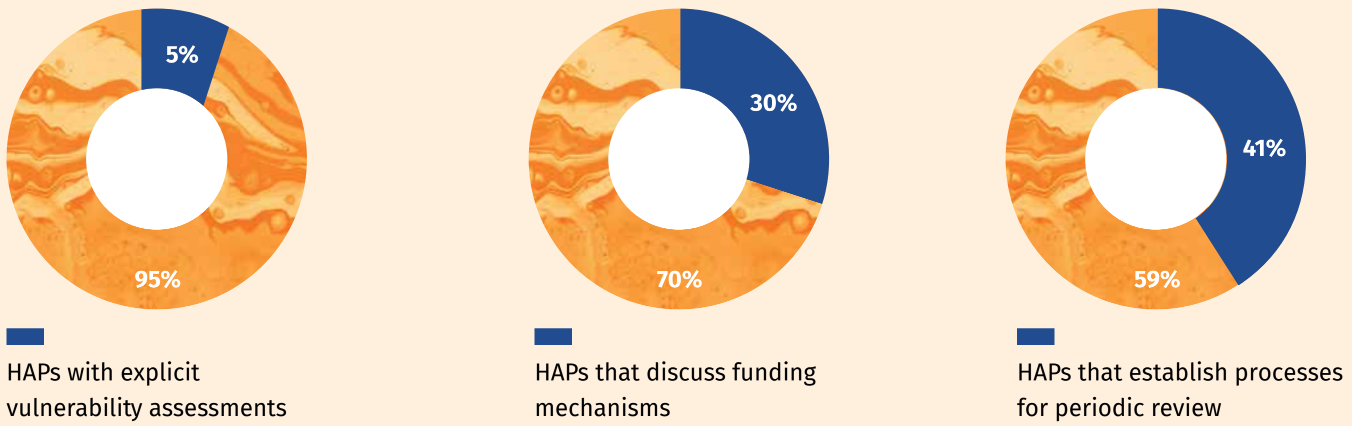


***Figure 1:** While offering a balanced range of solutions, Indian HAPs tend to lack location specificity and frameworks for effective implementation.*

INTRODUCTION

India is one of the countries most exposed and vulnerable to heat globally. Over 1951–2016, three-day concurrent hot days and hot night events have increased significantly, and are projected to increase between two and four-fold by 2050 under Representative Concentration Pathway (RCP) 4.5 and RCP 8.5 respectively.[1] Heatwaves are also projected to come earlier, stay longer, and become more frequent,[2] with urban heat island effects exacerbating heat impacts.

Increased heat is already leading to increased heat-related deaths, heat stress, unbearable working conditions, and the wider spread of vector-borne diseases.[3] By 2050, as many as 24 urban centres are projected to breach average summertime highs of at least 35°C, impacting economically weaker sections of the population disproportionately.[4] Heat-related risks have direct implications on health, mortality, and labour productivity. Government estimates indicate the loss of 25,983 lives between 1990 and 2020[5] due to heatwaves despite widely acknowledged limitations in gathering mortality data.[6] The International Labour Organisation estimates that working hours lost due to heat stress will increase to 5.8 per cent of working hours by 2030, or an equivalent of 34 million jobs.[7]

The risks of extreme heat are experienced disproportionately: some workers are disproportionately affected by the impacts of extreme heat due to personal risk factors (e.g. age, living in poorly ventilated or cooled housing), occupational risk factors (e.g. working outdoors) and societal risk factors (e.g. urban planning). Well-designed and effectively implemented heat action plans (HAPs) could reduce negative impacts on productivity and health.

Given continued projections of extreme heat and high levels of policy activity across levels of government (driven in part by NDMA guidelines on heat management in 2016), this is an opportune moment to reflect on the landscape of HAPs in India. We examine how cities, districts, and states are defining heat risk; the solutions they are proposing/implementing; and how they structure their institutions and finances for implementation.

We assess 37 HAPs published between 2016 and 2022 (this is likely a subset of all existing HAPs). They were collected through a web search, by contacting State Disaster Management Authorities and health departments, and by contacting technical consultants involved in plan design. Annex 1 details our methodology and the limitations of this study. Elements of heat governance are occasionally present in other planning documents such as district disaster plans, scheme documents (eg. urban greening programmes), and state climate plans, which are not part of this analysis.

Box 1. What is a heat action plan?

Heat Action Plans (HAPs) are guidance documents prepared by state, district, and city governments to help prepare for, respond to, and recover and learn from heatwaves. One of their most important functions is to direct scarce healthcare, financial, information, and infrastructural resources to those most vulnerable to extreme heat in that jurisdiction. This requires regular assessment of who is vulnerable and whether HAP interventions are reaching them.

HAPs regularly include a heatwave warning system (sharing alerts with vulnerable populations); means of coordination between several government departments; an awareness, training, and behaviour change component to reduce heat exposure; a list of short-term actions (focused on healthcare or changing work hours); and longer-term solutions such as investing in infrastructure (e.g., cool roofs, water harvesting bodies), changes in agricultural practice, or adjusting urban planning (e.g., green corridors).

Though the exact number of HAPs in India is unknown, some estimates claim the existence of well over 100 HAPs nation-wide (Natural Resources Defense Council April 2022).[8] If so, this is a striking case of policy diffusion since the first HAP (Ahmedabad) was developed in 2013. The 37 HAPs analysed here generally follow a template of actions before, during, and after heatwaves, assigned to specific government departments, but exhibit significant variation in scope, detail, and creativity (see Annex 2).

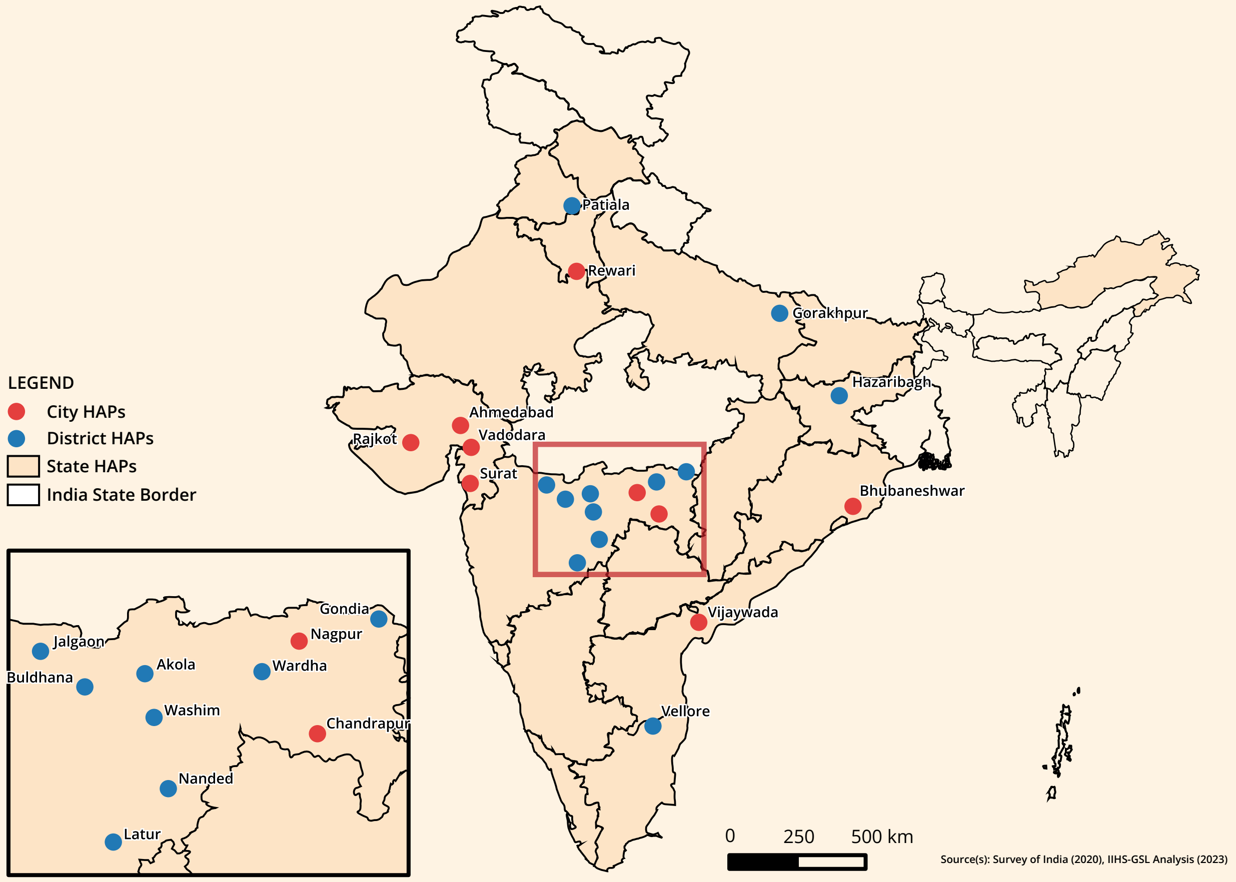


Figure 2: *We reviewed 37 Heat Action Plans across India at the city (9), district (13) and state (15) levels across 18 states.*

HOW IS THE HEAT HAZARD DEFINED?

HAPs carry the important task of defining the conditions under which heat becomes a hazard. The simplest way is to define a maximum threshold temperature at which there are significant mortality increases in a given biogeography.[9] Apart from daily maximum temperature, concurrent hot days and hot nights,[10] relative humidity[11] and indoor temperature[12] have significant implications for the experience of heatwave and heat-related stress, morbidity, and mortality.

We find that thresholds to declare heat waves do not adequately consider local conditions such as built-up area ratio, density of vegetation, and type of land surface, nor do they incorporate indicators like humidity and hot nights. Though 24 out of 37 HAPs indicate the need to use localised temperature and mortality thresholds, only ten out of 37 (unclear in a further eight)[13] listed thresholds different than the national threshold set by the Indian Meteorological Department (IMD)[14] though it is unclear which variables were used in determining these thresholds. The definition of a heatwave established by the IMD is used in most other HAPs. This is typically done through a colour-coded alert system to indicate the severity of the heatwave and response measures for each severity level.

Apart from temperature intensity, some HAPs also acknowledge parameters such as heat index value,[15] Urban Heat Island effect,[16] and UV index.[17] Some (12 out of 37) HAPs consider daily variations in temperature but most focus on seasonal variability, depicted through pre-heat, heat and post-heat periods. While diurnal temperature is the primary parameter considered in the HAPs, 17 of the 37 (unclear in a further 9) reviewed HAPs recognise a more nuanced approach. For example, the state HAPs of Gujarat and Odisha, and city HAPs of Rajkot and Bhubaneswar recognise the importance of all parameters in preparing a response plan, while some other HAPs only consider relative humidity or hot nights.

Localised medium to long-term heat projections can strengthen the immediate case for investing in long-term HAP interventions. All the reviewed HAPs acknowledge that anthropogenic climate change is driving increasing temperatures and intensity of heat waves, and rely on secondary sources to understand the nature of change. However, HAPs typically report past temperature trends based on observed data to inform their planning. Only state HAPs for Himachal Pradesh and Arunachal Pradesh use Providing Regional Climate for Impact Studies (PRECIS)[18] model-based projections of temperature and rainfall change in their plans.

Systematically identifying cascading secondary impacts can help governments prepare for unexpected heatwave consequences. Several HAPs (21 out of 37 reviewed, unclear in a further eight) recognize that heat waves either occur in conjunction with or result in other hazards such as high levels of water stress, drought, high winds, forest fires etc. that compound the impacts of heatwaves. Many (18 out of 37) also note their cascading impacts on sectors such as energy and power supply, water supply, public transport, education, and animal husbandry, among others.

Recommendations

Nuance and localize the heat hazard definition: Heat planning can be strengthened by using available scientific data to understand the changing nature of the hazard (e.g., heat and humidity interactions), the compounding of heat with other hazards (e.g., heat and drought and forest fires), and the cascading impacts across sectors beyond human health. The HAPs inconsistently take this expanded view of the hazard.

Thresholds to declare heat waves are not adequately tailored for local conditions in cities or habitations, and do not adequately incorporate indicators like humidity, hot nights etc. There are examples of how this can be done for specific Indian cities[19] which need to be incorporated in future HAPs.

Future-facing understanding of heat hazard: The science is clear. India is projected to see increased frequency and intensity of heat waves, along with hotter days and nights, and seasonal shifts with heat coming earlier and staying longer. High resolution, downscaled climate projections are available for India[20] and must be used in HAP revisions in addition to past temperature trends. This will make HAPs anticipatory tools for heat *planning* rather than reactive tools of heat *management* alone.

HOW IS VULNERABILITY UNDERSTOOD AND ASSESSED IN HAPs?

Ideally, HAPs assess vulnerability at a localised level (i.e. neighbourhoods and sub-districts with a high concentration of hazardous built infrastructure and low coping capacity) and then direct resources to these areas. In our review, we find that very few HAPs base their actions on vulnerability assessments, and instead draw on a fairly homogenised characterisation of vulnerable groups (as outlined in the NDMA guidelines) which results in a high risk of misdirected efforts.

In all 37 HAPs reviewed, vulnerability is primarily understood through the health implications of heat. All but four HAPs (unclear in a further 5) explicitly identify the elderly, children, pregnant and lactating women, those with cardiovascular and respiratory illnesses, and people with physical disabilities as being vulnerable to heat-related illness owing to impairments in their thermoregulatory capacities. For more on gendered vulnerability to heat, see Box 2. Some HAPs also categorise slum residents (15 HAPs) and those below the poverty line (seven HAPs) as being vulnerable to heat, clearly linking asset poverty and vulnerability to heat.

Twenty-five out of 37 HAPs (unclear in a further five) reviewed recognise specific occupations and livelihoods groups as being particularly vulnerable to excessive heat exposure. Of these, five HAPs identify those engaged in outdoor, casual, or informal work as being particularly vulnerable but do not specify the livelihood groups. The remaining 20 HAPs list down vulnerable livelihood groups, including construction workers, industrial workers, street vendors, waste pickers, farmers, rickshaw drivers, door-to-door salespeople, and traffic police officers. Only Kerala recognised more recent forms of urban livelihoods such as online delivery agents as a group vulnerable to heat and only Kerala, Rajkot, and Bhubaneshwar explicitly acknowledged the vulnerability of indoor workers to heat.

While most HAPs characterise heat vulnerability in terms of exposure and sensitivity, only three HAPs (Rajkot, Surat, and Bhubaneshwar) recognise that the capacities to adapt to heat also shape vulnerability. Identification of vulnerable populations and livelihoods is rarely based on localised vulnerability assessments (exceptions being Rajkot and Bhubaneshwar). Instead, they drew on vulnerable groups identified in the NDMA guidelines.

Notably, the recognition of vulnerable groups does not necessarily translate into implementation measures that systematically address these vulnerabilities. We argue for a two-pronged approach that (a) conducts localised vulnerability assessments to improve implementation targeting and (b) attempts to address the structural causes of differential vulnerability. While the former is within the mandate of HAPs, the latter requires systemic interventions that address socio-economic inequalities and build the adaptive capacities of particularly exposed groups.

Recommendations

Shift from vulnerability assessments to holistic risk assessments: While the HAPs acknowledge differential vulnerability for different demographic and livelihood groups, there is a need to move beyond homogenised categories to measure intersectional vulnerability (e.g., all women or all outdoor workers are not similarly vulnerable) as well as how risks accrue and amplify (e.g., elderly individuals working outdoors vs. those working indoors). They also need to expand vulnerable groups to include informal livelihoods within the home. Some HAPs have undertaken vulnerability assessments but this is not uniform. Ideally, implementing agencies should conduct risk assessments which bring hazards, vulnerability, and exposure together to comprehensively examine who is at risk. This will also enable more evidence-based, targeted approaches rather than homogenous solutions that reproduce existing vulnerabilities. We do not advocate for large surveys or data-intensive approaches that are onerous on already stretched governments but recommend using existing census and geospatial data to examine overall heat risk.

Box 2: How do the HAPs discuss gendered vulnerability?

The National Action Plan on Climate Change explicitly recognises that vulnerability to climate change and people's capacities to adapt are deeply mediated by gender. It notes, "in each of the adaptation programmes, special attention should be paid to the aspects of gender" (NAPCC, 2008:14). The HAPs present an opportunity to meet this call by identifying and addressing gendered vulnerability. Across the HAPs, a few key themes emerge:

- **Need for more focus on differential vulnerability:** About half of the HAPs reviewed *recognise* gendered vulnerabilities, identifying pregnant and lactating mothers, old people, and young children as most vulnerable. These assessments of vulnerability rarely cite primary data (except Bhubaneshwar and Rajkot) but are in line with emerging evidence on how household headship affects vulnerability to heat (e.g., in Angul and Kolkata[21]). HAPs tend to discuss all women as vulnerable, labelling women as a homogenous group, instead of examining how gender intersects with income, caste, livelihoods etc. to shape overall vulnerability to heat. There is no acknowledgement of higher vulnerability of home-based work or extra care work burdens, both of which tend to be borne by women, exacerbating their vulnerability.
- **Solutions to heat can be gender-transformational:** Many HAP interventions note the need for gender-targeted interventions such as "special care for vulnerable groups children, disabled, women and old aged" (Himachal Pradesh HAP, p. 20) or "special focus on children, pregnant women and lactating mothers in order to protect them from dehydration" (Bihar HAP). In most cases, these activities are designated to the Women and Child Development Department, which is made responsible for "creating awareness and educating young girls and mothers regarding the dangers of Heat Waves" (e.g., Gujarat and Odisha HAPs). A common intervention is civil society-led training workshops and outreach sessions with community groups and mobilizers such as ASHA workers, ANM nurses (e.g., in Surat). While these solutions tend to target women, they can go beyond mere targeting to gender-transformational solutions such as undertaking gender budgeting exercises and ensuring solutions have synergies with SDG 5 (gender equality) targets.

The HAPs do recognise differential and gendered vulnerability but there is insufficient evidence on how this feeds into solutions to reduce vulnerability. Heat management solutions tend to focus on individuals (e.g., women, elderly) but not address or acknowledge the unequal structures which generate differential vulnerability (e.g., conditions of indoor or outdoor work, care work burdens etc.).

MAPPING ACTIONS TO MANAGE HEAT

HAPs across India contain a diversity of preparedness and response actions, stretching across several sectors and government departments. This indicates that heat is correctly being thought of as a multi-faceted, multi-sectoral problem in India's policy response to heatwaves.

The solutions covered by these HAPs are typically divided into pre-, during-, and post-season interventions that span short-term coping measures, i.e. heat management interventions such as advisories to drink water, avoid going outdoors, and longer-term heat hazard mitigation measures that cool the local environment[22] (investing in water infrastructure and green spaces, installing cool roofs). In Figure 3 below, we calculate the frequency of different response measures across all reviewed HAPs to show a fairly even spread between different categories of interventions, and the presence of several varieties of actions within each category. It gives HAP designers an expansive palette to choose from in managing heat in their jurisdiction.

__Figure 3: (Right)__ Heat Action Plans reviewed contain a large variety of interventions and were balanced across intervention types.[23] The exact design or wording of these solutions might vary marginally across HAPs. Lighter shades within a category are short-term actions (with effects lasting one heat season) and darker shades are long-term solutions (more than one heat season).

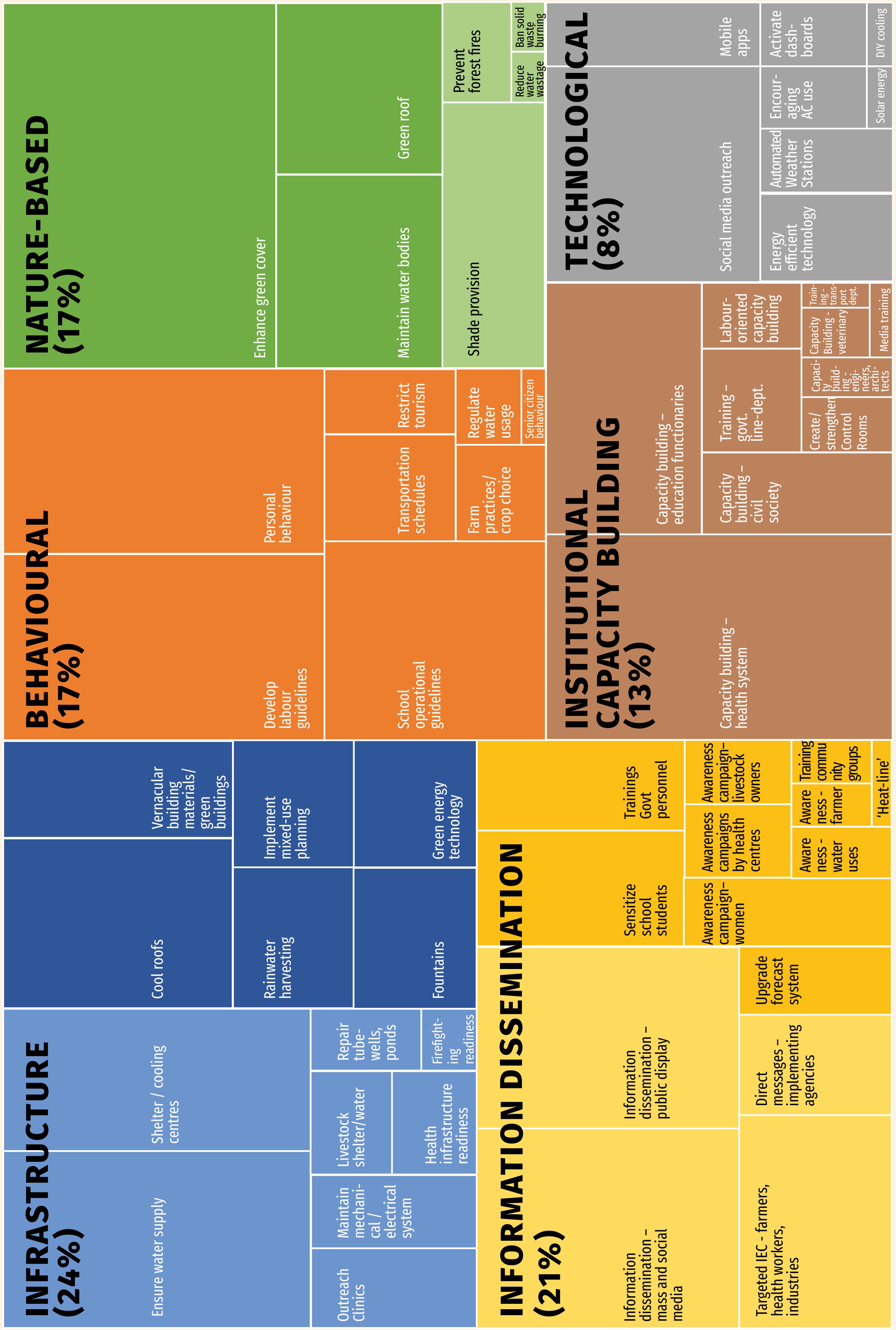


Figure 3 shows that the HAPs reviewed contain a somewhat balanced mix of six major solution types (excluding short-term health measures). This indicates that Indian HAPs are, in general, not heavily skewed towards a particular intervention type. We make observations about the utility of these interventions in the Indian context below.

As expected, around a third of all *infrastructure solutions* were focused on emergency measures to reduce heat stress by ensuring the availability of water, setting up shelters/cooling centres, and ensuring electricity supply. This set of solutions also contains interventions that promote long-term change in built environments (using vernacular building materials, cool roofs, rainwater harvesting) and healthcare infrastructure. These solutions will likely be challenged by growing space constraints in densifying cities, inadequate finance, and the challenge of public acceptability as they are scaled up; HAPs do not adequately engage with these implementation challenges at present.

All HAPs *harness nature* to adapt to heat, discussing a mix of blue infrastructure (wetlands and water storage structures) and green infrastructure (green roofs and trees for shade). But tensions and tradeoffs between short-term and long-term measures (e.g., one-off tree planting vs. urban planning that prioritises green spaces) as well as nature-based and built infrastructure measures remain (e.g., how do the benefits of green roofs interact with continued built infrastructure inefficiencies such as glass facade-based buildings). There is a very strong and welcome focus on planting new or restoring existing green cover through plantation drives or afforestation activities, which have clear policy convergences (e.g. Green India Mission), however what trees to grow and where is rarely clarified[24]. In the short-term, execution is entrusted to citizen action, engagement with environmental trusts, and school-led tree planting. It is unclear how these discrete activities fit with long-term urban planning for green spaces.

Further, most HAPs invoke the idea of green roofs but these are not adequately defined nor is it clear who will bear their costs and maintenance, especially in the absence of trainings and subsidies for green roofs. Clearer definitions of green roofs and pointed empirical research on their effectiveness under different conditions are needed before they are rolled out at scale. Most HAPs prioritise shade and water security for livestock and zoo animals, demonstrating how proactive heat planning can have co-benefits for livelihoods and non-human values.

All HAPs use *information-dissemination strategies* to alert the public and shape behaviour in a heatwave. However, in the absence of reliable vulnerability and risk assessments, it is unclear whether these efforts can reach those most likely to be impacted in a cogent and timely manner (particularly across large cities and states with tens of millions of people). Vulnerability targeting is evidenced in activities such as the training of ASHA and *anganwadi* workers and awareness building for school children but targeted awareness building for certain vulnerable groups (e.g., farm labourers and indoor industry workers) is mentioned in only a few plans. Notably, given that in urban areas, primary health care for the urban poor and community health worker capacities are poorly developed, alternative interlocutors must be considered in HAPs. Trainings for government officials plays a surprisingly small role within this solution set despite heat being a new and complex policy area.

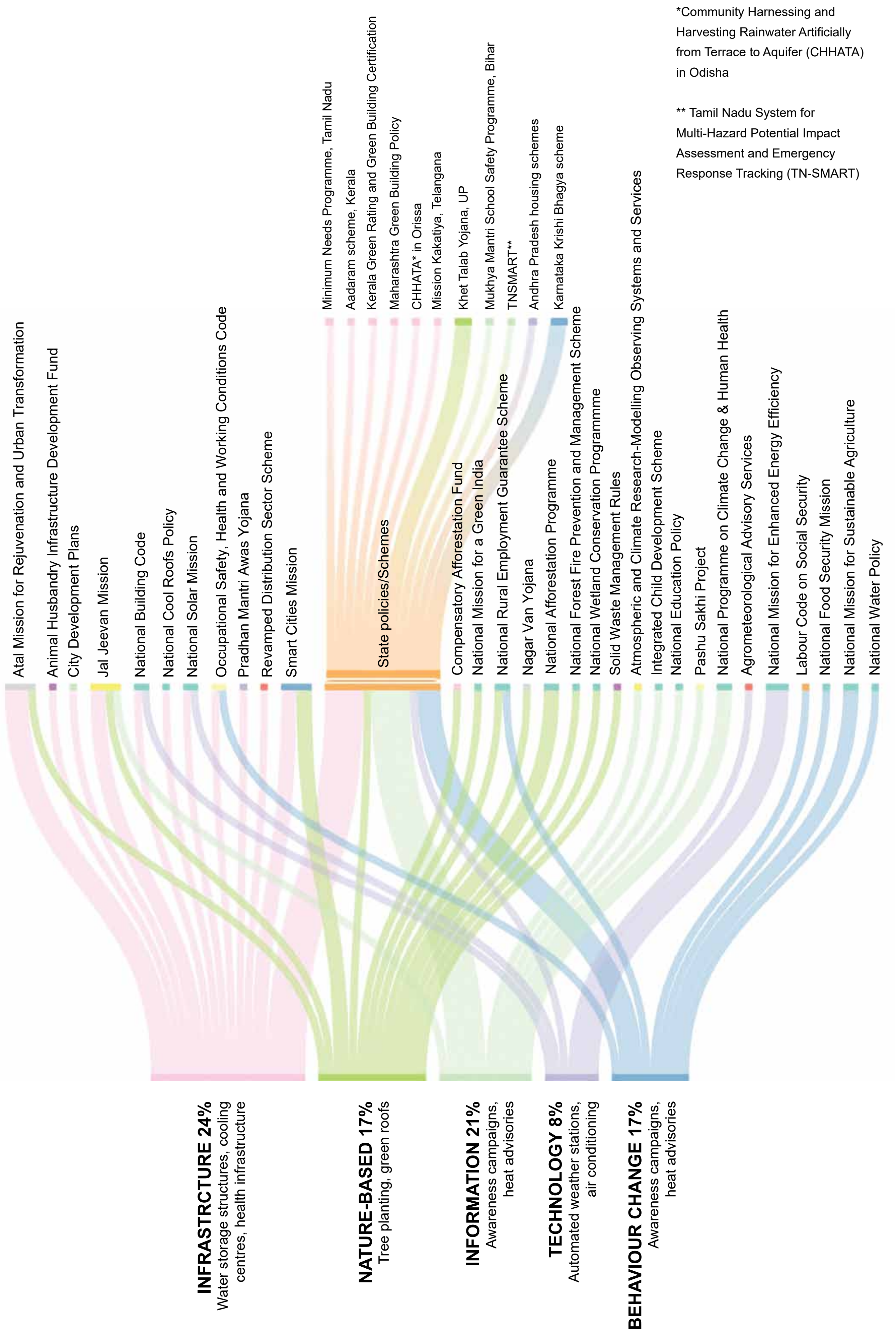
The HAPs include several *technological solutions* such as mobile-based heat advisories and promoting energy-efficient cooling technologies. Less attention is paid to overcoming unequal access. For example, HAPs may advocate the use of cooling equipment but do not make provisions for unaffordability and unequal access to reliable and cheap electricity. The reliance on mobile advisories overlook the possibility of inadequate reading comprehension in highly vulnerable areas or that mobile ownership is deeply gendered. Overall, technology-based interventions, with the exception of information dissemination, are not consistently included across HAPs.

Measures aimed at *behaviour change* are predominantly short-term and focused on reducing heat exposure. These include limiting time spent outdoors by temporarily changing school timings, rescheduling bus services, and shifting work timings away from peak heat exposure, particularly for those engaged in strenuous outdoor labour. Very few HAPs discuss long-term behavioural measures such as changing farmers' crop choices and practices to reduce summer yield losses, which require drivers of change beyond HAPs.

LINKING HAPs WITH EXISTING POLICIES

While HAPs put forward a wide variety of interlocking solutions, government departments often operate with little spare financial and human resources capacity. This makes alignment of HAP actions with existing schemes, already financed and staffed, an important objective.[25] Of the 37 plans reviewed, only ten tapped into this potential. For example, HAPs urged awareness building for students through the Mukhya Mantri School Safety Programme in Bihar; targeted interventions for vulnerable areas through the City Development Plan in Rajkot; and used crop insurance schemes and the Mahatma Gandhi National Rural Employement Guaranteee Act (MGNREGA) rural works programme to build rural resilience to heat in multiple instances.

None of the HAPs reviewed systematically explored policy integration across all listed interventions. Many actions in agriculture, water, housing, infrastructure, and urban design could usefully be linked to existing policies to unlock capacity and finances. In Figure 4 below, we lay out an indicative list of national and state-schemes that could be tapped into to improve implementation prospects. HAP designers should consider a systematic assessment of policy linkages as they build and revise HAPs.



HOW ARE HAPs BEING INSTITUTIONALISED?

The diversity of solutions proposed in India's HAPs, documented in the previous section, creates significant governance challenges: it suggests that implementation requires the clear allocation of responsibilities and capacities across departments, institutional structures for information dissemination and coordination, financing, and accountability and learning mechanisms. We structure our analysis of institutions around these parameters. Cross-country evidence suggests that deliberate and structured governance mechanisms are needed for effective implementation of these multi-departmental plans stretched across several layers of government.[26]

The 37 HAPs reviewed often lay out the basic institutional framework for implementation—by allocating responsibilities to departments and officers, for example—but fail to establish incentives (such as legal mandates or funding)[27] and accountability structures that might compel departments to act. In the absence of clear legal foundations, funding, and human resource allocations, it is unclear how much capacity state, district and municipal governments have to execute these wide-ranging and ambitious plans.

On the positive side, several HAPs performed the following basic institutional tasks:

- *Allocation of responsibility:* Most HAPs (25 of 37, unclear in a further two of the 37) establish nodal officers or agencies for implementation. Many (18 of 37) identify specific officers in line departments responsible for implementation, which is necessary for accountability. These nodal agencies are responsible for coordination, but it was unclear to us whether the agencies carried enough bureaucratic authority to direct line departments, particularly for long-term, transformative actions such as those related to urban re-development or changing crop patterns. For example, state HAPs frequently allocate responsibility to disaster management agencies and revenue departments that may have limited long-term influence on urban afforestation and primary healthcare capacity trends.
- *Standard Operating Procedures (SOPs):* More than half the HAPs (18 of 37, unclear in a further eight) lay out, often to a high-level of detail, what individual departments must do in heatwave conditions. These SOPs (often specified for actions to be taken before, during, and after a heatwave) are useful but need to be revisited as the nature and duration of heat waves change over time.
- *Information dissemination:* Nearly all HAPs establish structures to communicate heatwave alerts, but further work is needed to examine the uptake and utility of heat advisories.[28]

The reviewed HAPs fell short in the following areas:

- *Lack of financing:* Several HAPs (17 of 37, unclear in a further nine) failed to mention funding mechanisms altogether. Of the 11 that did, eight called for implementing

Figure 4: *(Left) HAP activities could draw financial and bureaucratic resources from existing state and central schemes (indicative list of policies prepared by the authors). Convergence of HAPs with existing schemes is a crucial next step. The figure shows types of solutions and how they map onto a sample list of existing policies and schemes, with thickness of flow denoting number of solutions from each category converging with a particular policy or scheme.*

departments to self-allocate resources from existing budgetary sources. Since HAPs contain expensive structural investments and expansions of human resource capacity, financing shortfalls could lead to non-implementation.[29] Some HAPs contain useful experiments to draw finances from existing policies (as in Figure 4). Arunachal Pradesh and Telangana leverage 15th Finance Commission provisions for preparedness and capacity building; the Telangana Cool Roofs Programme looks to the state's low-cost housing programme as an implementation vehicle.

- *Insufficient focus on periodic review mechanisms:* By definition, HAPs must be adaptive, constantly refining targeting based on monitoring data and incorporating new data about vulnerability. We find that less than half of the HAPs in our sample (15 of 37, unclear in a further nine) allocate responsibility and identify at least some process steps for a periodic review. Very few mandate consultations with vulnerable communities; most focus on consultations with implementing departments.
- *Weak accountability structures:* Twelve of 37 HAPs reviewed establish hierarchical accountability through coordination committees, nodal officer evaluations, or implementation reports (these structures were unclear in a further nine HAPs). However, none of these 12 HAPs make provisions for independent evaluation of HAP implementation, nor do they specify transparency mechanisms where evaluation data is made available to the public.
- *Unclear legal foundations:* None of the HAPs reviewed specify the source of their legal authority. This leaves the legal force[30] of several HAPs in question, which is particularly important in establishing judicial accountability and ensuring that possibly understaffed implementation agencies prioritise HAPs actions.

Recommendations

Allocate responsibility for implementation: Ensure that all HAPs make clear who is responsible in each implementing department, and for what.

Improve performance transparency: Conduct external evaluations and make implementation data available to the public.

OVERARCHING RECOMMENDATIONS

Here, we list cross-cutting recommendations (that go beyond those in the sections above) aimed at firming up systems and capacities for HAP creation and delivery across the country.

1. **Create a centralised national repository of HAPs and their updates (at the NDMA).**
2. **Set up an expert committee to assess notifying heatwaves as disasters.** Heat is not identified as a disaster in the 12 disasters eligible for mitigation and relief under the National and State Disaster Risk Management Funds (N/SDRMFs). It is important to review this decision through an expert committee which draws on the latest science and HAP implementation experience. Given the range of long-term preparatory actions documented here, this would allow states to execute the full range of HAP actions and, for immediate relief, go beyond the 10 per cent discretionary allocation of SDRF funds.
3. **Develop and institutionalise systems to monitor and evaluate effectiveness of HAP solutions, and to prepare for heat earlier.** Put regular monitoring at the heart of the periodic (usually annual) evaluation process. Specifically, check if interventions are reaching vulnerable groups and are reducing exposure. Existing evaluation processes tend to focus on preparedness in March, which is too late (as seen in the 2022 March heatwaves).
4. **Clarify funding mechanisms.** Create a central fund or harness the National Adaptation Fund on Climate Change (NAFCC), especially for long-run structural investments. Explore 15th Finance Commission funding mechanisms for preparedness and mitigation, as mentioned above.
5. **Clarify legal foundations of all HAPs by linking individual actions to existing (or new) sectoral laws, especially where coordination/implementation problems are known to exist.** Where possible, explore increasing the legal weight of the HAP itself through amendments or new laws. Explore whether HAPs can be aligned with the planning requirements of the Disaster Management Act, 2005.
6. **Institute targeted and recurring capacity building for actors engaged in revising and implementing HAPs.** Capacity building can target staff in various line departments and civil society actors expected to implement heat actions. Capacity building efforts can also be directed at the heat-health research ecosystem, 'Aapda Mitras' (community members trained as first responders), and key allied vocations through modules on heat-resilient buildings in architecture colleges or climate-resilient health systems in medical colleges.
7. **Create mechanisms for inter- and intra-state sharing of knowledge and best practices.** Several states and cities are simultaneously experimenting with different combinations of solutions with varying levels of effectiveness. It is important to create platforms to exchange which solutions and processes work.

ANNEX 1. A NOTE ON SOURCES AND METHODS

India does not have a unified repository of HAPs. A major challenge, therefore, was to collect HAPs from various jurisdictions - states, districts, and municipalities. Web-based searches helped identify 21 HAPs. We also reached out to State Disaster Management Authorities (SDMAs), health departments, and technical consultants to governments to source an additional 18, making our sample size 37. This is most likely a subset of all HAPs in existence but captures considerable variability in approach and substance across 18 states.

The absence of HAPs in the public domain poses significant limitations to empirical research and inter-state learning on heat planning in India. Given this, our assessment of 37 HAPs (out of the purported 100+ HAPs across India) is novel. The lack of transparency in the number of HAPs in the country and whether they are being revised or not leads to our first recommendation, which is to create a central repository of HAPs. This is also valuable because the large variations between HAPs showcase the potential for cross-learning between jurisdictions.

Our analytical framework aims to map risks, solutions, and implementation viability across Indian HAPs. To do this, the first part of the assessment (see Annex 2) draws on the Sixth Assessment Report of the IPCC (Working Group II) which understands risk as the interaction between hazard, vulnerability, and exposure.[31] We also draw on emerging research to nuance hazards as compounding and cascading,[32] vulnerability as highly differentiated and gendered, and exposure being indoor and outdoor.[33] The second part of the assessment examines the 'solution space' where we document the breadth of policies and interventions within these HAPs in order to provide a first-of-its kind overview of the existing solution set to HAP designers and reviewers. We categorise heat management solutions into infrastructural, nature-based, institutional capacity building, technological, informational, and behavioural strategies.[34] While the framework categories were developed deductively based on literature, new categories emerged during the coding process and were assimilated inductively. The third part captures implementation viability by assessing institutional mechanisms, finance, and monitoring and evaluation processes.

Taken together, the three part assessment maps how each HAP performs along the framework categories, with at least two researchers assessing each HAP. This allowed us to gauge how HAPs articulated the different elements of our framework (for example, how many HAPs consider heat projections; how many HAPs specify financial mechanisms for the proposed solutions; do HAP solutions target vulnerable populations/livelihoods they have identified). For each framework category, we used a binary response (Yes, No or Unclear) as well as a qualitative notes section detailing the response. For example, in the vulnerability categories, we queried, 'Does the HAP consider gendered vulnerability?' If the answer was 'Yes', we added direct quotes from the HAPs and detailed comments on how gendered vulnerability was looked at (only women, which women etc.).

This assessment is a desk-based review of HAPs and in future work will be 'ground-truthed' by interviewing key informants who develop and design HAPs, government department representatives who implement and revise HAPs, knowledge/practice brokering organisations who support the government (NGOs and think tanks), and heat-exposed communities and individuals in select locations.

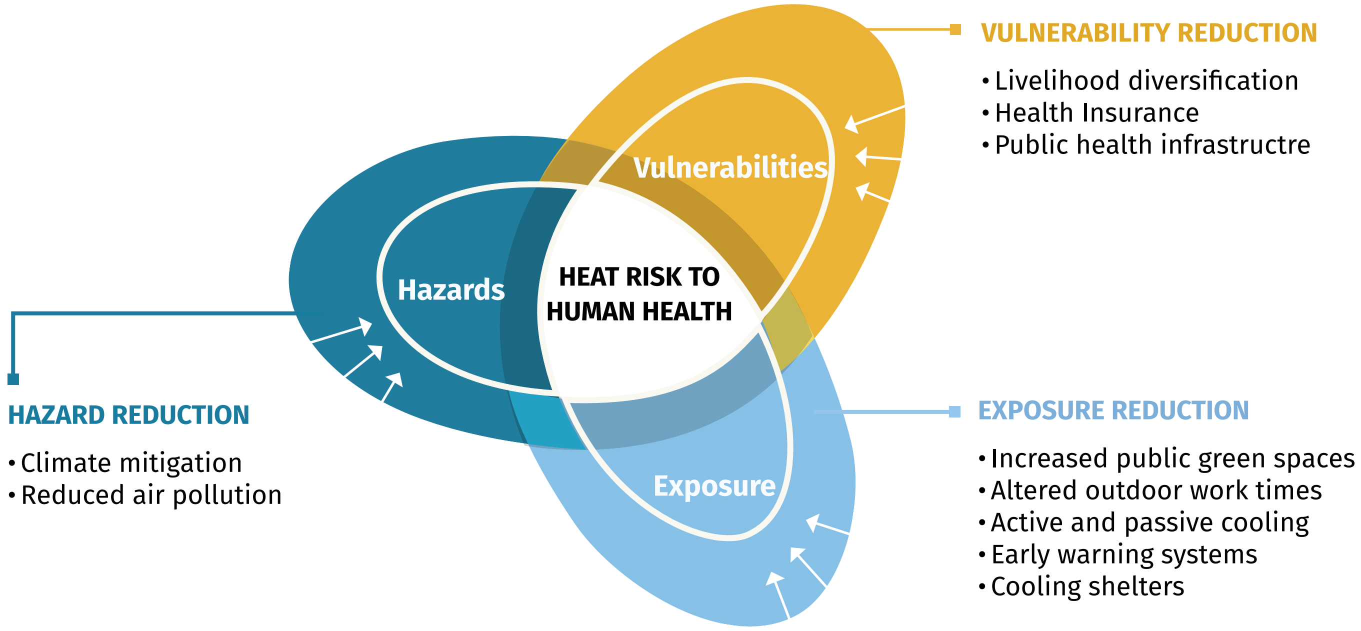
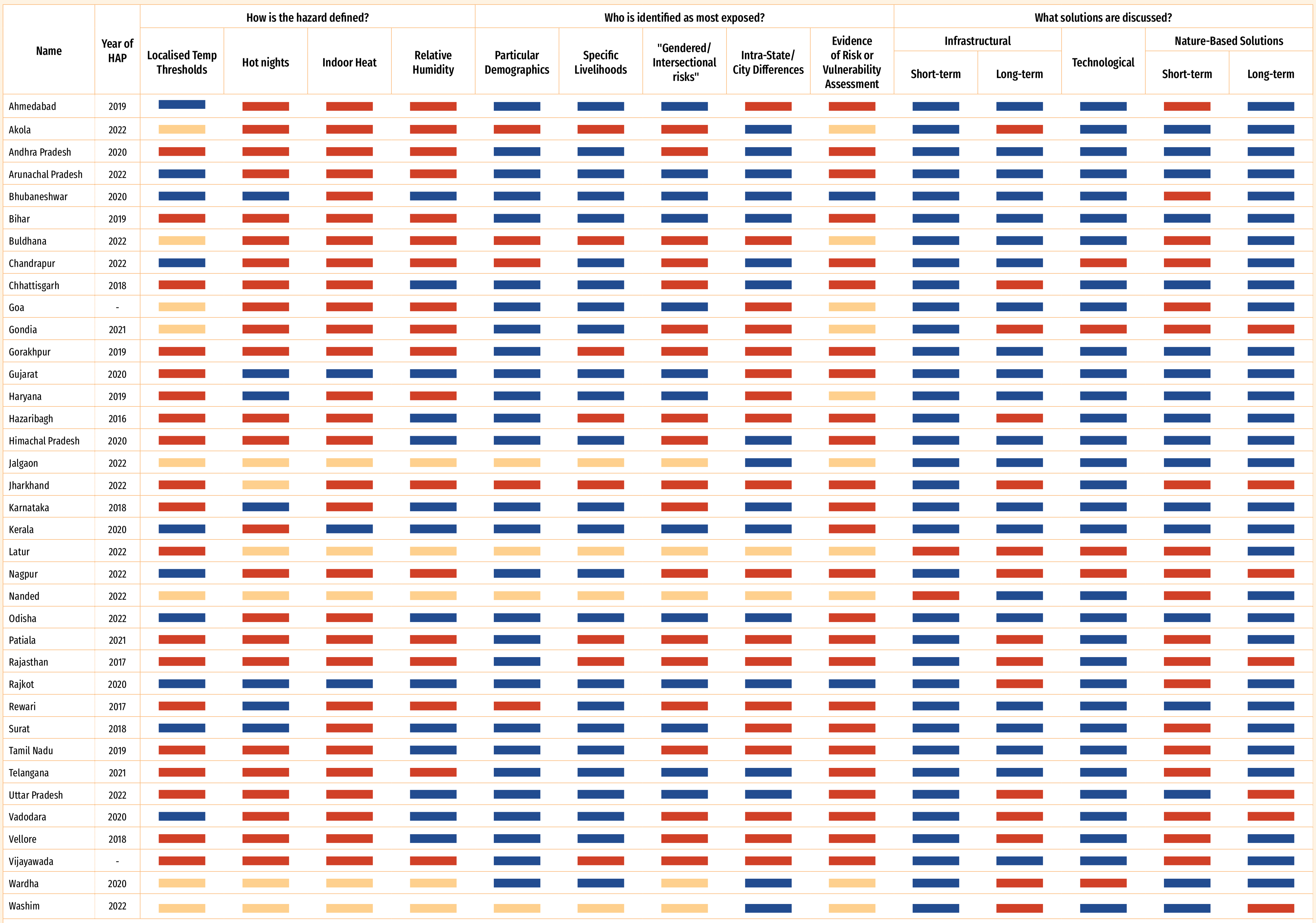
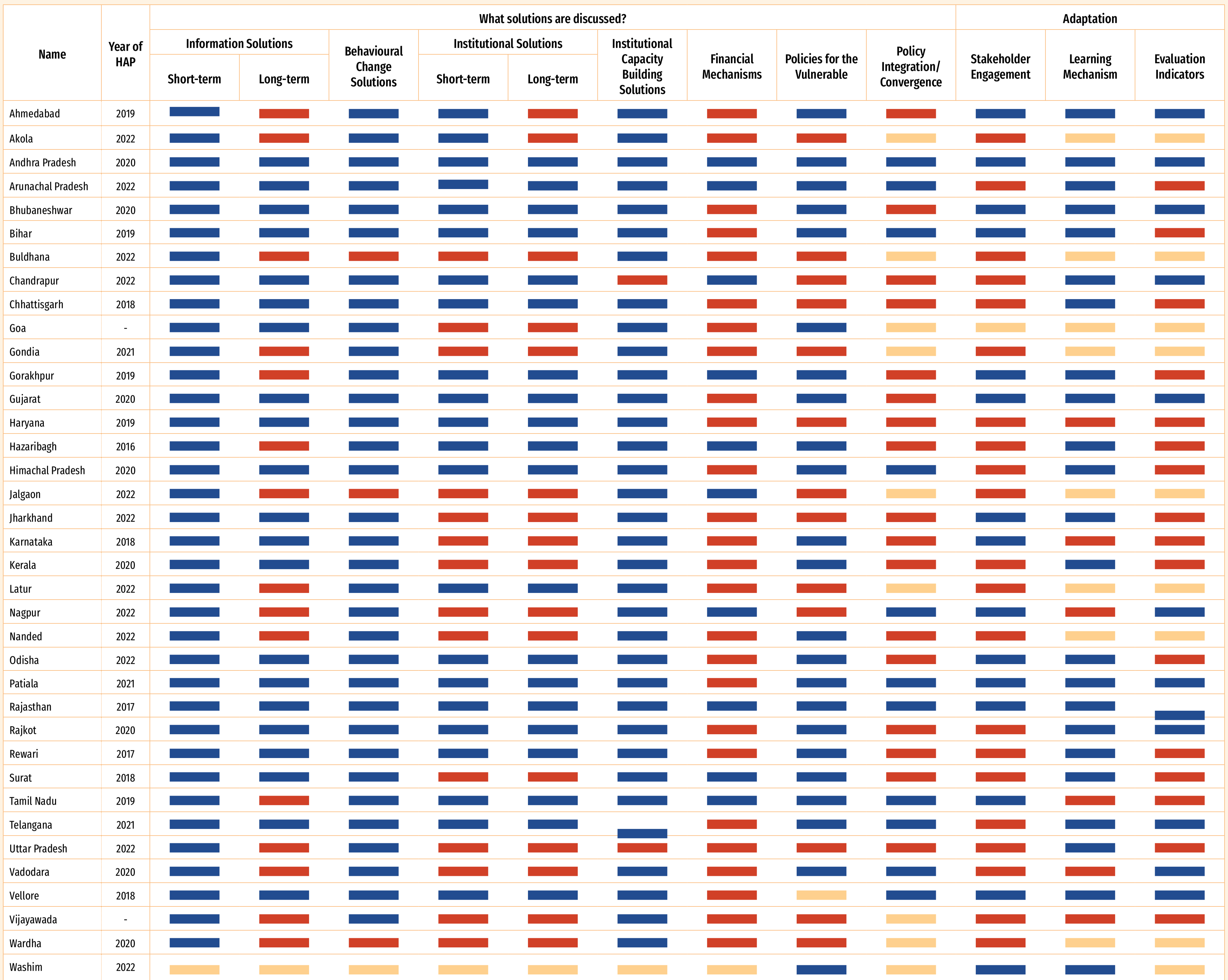


Figure A1: *Risk is produced by the interaction of hazards, exposure and vulnerability, and adaptive capacities; all of which are mediated by adaptation and mitigation responses. Source: Summary for Urban Policymakers Volume II*



Note : Blue lines represent 'yes', red lines represent 'no' and yellow lines represent 'unclear' in the table. For two HAPs year of publication was not mentioend (denoted by a dash). Nine HAPs received from various SDMAs were in unconventional forms (either as a slide deck or an excel sheet). It is unclear whether a full-fledged HAP document exists in these cases. We use the label 'unclear' to show that the information we were looking for was not present in these truncated formats but could well be present in an expanded document, if it exists.



Note: Blue lines represent 'yes', red lines represent 'no' and yellow lines represent 'unclear' in the table. For two HAPs year of publication was not mentioend (denoted by a dash). Nine HAPs received from various SDMAs were in unconventional forms (either as a slide deck or an excel sheet). It is unclear whether a full-fledged HAP document exists in these cases. We use the label 'unclear' to show that the information we were looking for was not present in these truncated formats but could well be present in an expanded document, if it exists.

ENDNOTES

1 Mukherjee, S., & Mishra, V. (2018). A sixfold rise in concurrent day and night-time heatwaves in India under 2°C warming. *Scientific Reports*, 8(1), 1–9. https://doi.org/10.1038/s41598-018-35348-w

2 Im, E.-S. et al. (2017). Deadly heat waves projected in the densely populated agricultural regions of South Asia. *Science Advances*, 3(8), 1–8. https://doi.org/10.1126/sciadv.1603322; Nanditha, J. S., et al. (2020). A seven-fold rise in the probability of exceeding the observed hottest summer in India in a 2 C warmer world. *Environmental Research Letters*, 15(4). https://doi.org/10.1088/1748-9326/ab7555

3 Dholakia, H.H. et al. (2020). Extreme Events and Health in Mumbai, India. In: Akhtar, R. (eds) Extreme Weather Events and Human Health. Springer, Cham. https://doi.org/10.1007/978-3-030-23773-8_24; Banerjee, S., & Chattopadhyay, S. (2020). A meta-analytical review of outdoor thermal comfort research: Applications, gaps and a framework to assess low-income settlements in Indian megacities. *Urban Climate*, 33, 100641. https://doi.org/10.1016/j.uclim.2020.100641

4 Urban Climate Change Research Network. The future we don't want: How climate change could impact the world's greatest cities. Technical Report. C40 Cities, Global Covenant of Mayors for Climate & Energy, UCCRN and ACCLIMATISE. https://www.c40.org/wp-content/uploads/2021/08/1789_Future_We_Dont_Want_Report_1.4_hi-res_120618.original.pdf

5 NDMA (2020). Beating the heat. How India successfully reduced mortality due to heatwaves. https://ndma.gov.in/sites/default/files/IEC/Booklets/HeatWave%20A5%20BOOK%20Final.pdf

6 For more, see Bhasker Tripathi (2020). India underreports heatwave deaths. Here's why this must change. IndiaSpend https://www.indiaspend.com/india-underreports-heatwave-deaths-heres-why-this-must-change/

7 ILO. (2019). Working on a warmer planet: The impact of heat stress on labour productivity and decent work.

8 Natural Resources Defense Council. (2022). Expanding heat resilience across India: Heat Action Plan Highlights 2022. https://www.nrdc.org/sites/default/files/india-heat-resilience-20220406.pdf

9 For a detailed discussion on different approaches used to develop thresholds that trigger heat management, see Kotharkar, R., & Ghosh, A. (2022). Progress in extreme heat management and warning systems: A systematic review of heat-health action plans (1995-2020). *Sustainable Cities and Society*, 76, 103487. https://doi.org/10.1016/j.scs.2021.103487

10 Mukherjee, S., Mishra, V. (2018) A sixfold rise in concurrent day and night-time heatwaves in India under 2°C warming. *Scientific Reports* 8, 16922. https://doi.org/10.1038/s41598-018-35348-w

11 van Oldenborgh, G. J., et al. (2018) Extreme heat in India and anthropogenic climate change, *Natural Hazards and Earth System Sciences*, 18, 365–381, https://doi.org/10.5194/nhess-18-365-2018

12 Tasgaonkar, P., et al. (2022). Indoor heat measurement data from low-income households in rural and urban South Asia. *Scientific Data*, 9(285), 1–11. https://doi.org/10.1038/s41597-022-01314-5

13 Nine HAPs received from various SDMAs were in unconventional forms (either as a slide deck or an excel sheet). It is unclear whether a full-fledged HAP document exists in these cases. We use the label 'unclear' to show that the information we were looking for (on localised temperature thresholds, in this case) was not present in these truncated formats but could well be present in an expanded document, if it exists.

14 According to the IMD, a heat wave is declared if the maximum temperature of a station is +4.5°C or more above the normal (over 40°C) or above 45°C in absolute terms in the plains, and +4.5°C or more (over 30°C) for hilly regions over two consecutive days. In coastal areas, a maximum temperature departure of +4.5°C or more from the normal (over 37°C) is described as a heat wave. Also see https://internal.imd.gov.in/section/nhac/dynamic/FAQ_heat_wave.pdf

15 The Heat Index is a measure of how hot it really feels when relative humidity is factored in with the actual air temperature. As an example, if air temperature is 34°C and relative humidity is 75 per cent, the heat index—how hot it feels—is 49°C. The same effect is reached at 31°C if relative humidity is 100 per cent.

16 Urban heat island is a phenomenon where urban areas experience warmer temperatures than suburban or rural surroundings. Urban heat islands have higher daytime maximum temperatures and less night-time cooling compared with surrounding rural areas. Temperatures in urban areas can be 1–3°C warmer than their surroundings during the day. In the evening, this difference can be as high as 2–3°C because the built environment retains heat absorbed during the day.

17 UV index is a measure of the level of UV radiation of the sun at a given place and time. It is measured on a scale of 1–11.

18 Jones, R. et al. (2003). Workbook on generating high resolution climate change scenarios using PRECIS. *UNDP, GEF, and Met Office Hadley Centre Manual, 32*.

19 Kotharkar, R., & Bagade, A. (2018). Evaluating urban heat island in the critical local climate zones of an Indian city. *Landscape and Urban Planning*, 169, 92–104.

20 For example, the Coupled Model Intercomparison Project-6 (CMIP6) has daily data of precipitation, maximum and minimum temperatures at 0.25° spatial resolution for South Asia. For details see https://www.nature.com/articles/s41597-020-00681-1 and https://esgf-node.llnl.gov/projects/cmip6/

21 Nanda, L., et al. (2022). Characteristics of households' vulnerability to extreme heat: An analytical cross-sectional study from India. *International Journal of Environmental Research and Public Health*, 19(22), 15334.

22 For more on the distinction between heat management and mitigation, see Keith, L., & Meerow, S. (2022). Planning for urban heat resilience. American Planning Association. https://www.planning.org/publications/report/9245695/

23 Some solutions were listed under more than one category where relevant (for example, mobile-based information dissemination is counted under both information and technology). We distinguish between nature-based 'shade provision', which includes using trees and parks, and infrastructure-based 'shelter/cooling centres'. We also distinguish between infrastructure-based 'ensure water supply' (primarily by using water kiosks in public places) and nature-based 'maintain water bodies' (construction and/or maintenance of water bodies). We decided to place 'modifying farm practices/crop choice' under behavioural solutions and 'fountains' under infrastructure solutions.

24 Research shows that tree planting requires careful consideration of species type and planting along roads rather than in clusters may provide more cooling benefits. See Kotharkar, R., Bagade, A., & Singh, P. R. (2020). A systematic approach for urban heat island mitigation strategies in critical local climate zones of an Indian city. *Urban Climate*, 34, 100701. https://doi.org/10.1016/j.uclim.2020.100701

25 For more on how and why such mainstreaming actions take place, see Bhardwaj, A., & Khosla, R. (2021). Superimposition: How Indian city bureaucracies are responding to climate change. *Environment and Planning E: Nature and Space*, 4(3), 1139–1170. https://doi.org/10.1177/2514848620949096

26 Vanderplanken, K., van der Hazel, P., Marx, M., Shams, A. Z., Guha-Sapir, D., & van Loenhout, A., F. (2021). Governing heatwaves in Europe: Comparing health policy and practices to better understand roles, responsibilities and collaboration. *Health Research Policy & Systems*. 19(1). https://doi.org/10.1186/s12961-020-00645-2

27 This is consistent towards a globally seen inclination towards 'softer' adaptation measures. See Patterson, J. J. (2021). More than planning: Diversity and drivers of institutional adaptation under climate change in 96 major cities. *Global Environmental Change*, Volume 68, 102279. https://doi.org/10.1016/j.gloenvcha.2021.102279

28 Singh, C., et al. (2017). The utility of weather and climate information for adaptation decision-making: current uses and future prospects in Africa and India. *Climate and Development*, 10(5), 389–405. https://doi.org/10.1080/17565529.2017.1318744

29 Vanderplanken, K., et al. (2020). Critical analysis of heat plans and interviews. SCORCH project. https://ghhin.org/wp-content/uploads/D-2.4-Critical-Analysis-of-Heat-Plans-and-Interviews.pdf

30 Abeling, T. (2015). According to plan? Disaster risk knowledge and organizational responses to heat wave risk in London, UK. *Ecosystem Health and Sustainability*,1(3), 9. http://dx.doi.org/10.1890/EHS14-0022.1

31 Pörtner, H. O., Roberts, et al. (2022). Climate change 2022: Impacts, adaptation, and vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar6/wg2/

32 Simpson, N. P., et al. (2023). Adaptation to compound climate risks: a systematic global stocktake. *iScience*, 26(2). https://doi.org/10.1016/j.isci.2023.105926

33 Tasgaonkar, P., et al. (2022). Indoor heat measurement data from low-income households in rural and urban South Asia. *Scientific Data*, 9(285), 1–11. https://doi.org/10.1038/s41597-022-01314-5

34 Turek-Hankins, L. et al. (2021). Climate change adaptation to extreme heat: A global systematic review of implemented action. *Oxford Open Climate Change*, 1(1), kgab005. https://doi.org/10.1093/oxfclm/kgab005

CENTRE FOR POLICY RESEARCH

www.cprindia.org