



# Heat Action Plan for Navsari City 2025

April 2025

Submitted to: Navsari Municipal Corporation and Gujarat State Disaster Management Authority (GSDMA)

Submitted by: Council on Energy, Environment and Water (CEEW)



## About the Navsari Heat Action Plan 2025

The Heat Action Plan (HAP) for Navsari City has been developed using a comprehensive approach that integrates on-ground socio-economic data, historical climate datasets, and future climate projections. Key climate data sources include the Indian Monsoon Data Assimilation and Analysis (IMDAA) and Regional Climate Models (RCMs) from the Ministry of Earth Sciences (MoES), covering the period from 1982 to 2050. This climatic data has been combined with satellite-derived indices and granular socio-economic information to map heat risk across Navsari at ward level and outline preparedness, response and long-term heat risk mitigation strategies.

The plan has been formulated in accordance with the guidelines issued by the National Disaster Management Authority (NDMA), 2019, and follows the formats prescribed by the National Programme on Climate Change and Human Health (NPCCHH), MoHFW and the National Disaster Management Plan (NDMP), 2019. The Gujarat State Disaster Management Authority (GSDMA) has led the development of this plan in collaboration with the Municipal Corporation of Navsari.

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## 1 Introduction

In January, 2025 India Meteorological Department announced 2024 to be the hottest year on record since 1901. With 2024 recorded as the hottest year globally and the 1.5°C global warming threshold approaching faster than anticipated, the impacts of climate change are becoming increasingly severe. These effects, evident through regional climate variability and extreme weather events, disproportionately affect vulnerable populations, particularly in developing and tropical countries like India (World Meteorological Organization, 2024).

One of the most immediate consequences of climate change is the intensification of heat extremes and the resulting heat stress. Globally, heatwaves have been linked to approximately 166,000 deaths between 1998 and 2017 (World Health Organization, 2018). In India, where nearly 80% of the population resides in climate-vulnerable districts, around 25,000 heat-related deaths were recorded between 1990 and 2015, despite challenges in directly attributing mortality to extreme heat events (CEEW, 2021; NDMA, 2020).

The summer of 2024 highlighted the growing risks of extreme heat in India. The country faced one of its longest heatwaves, exposing over one billion people across 23 heatwave-prone states (IMD, 2023). The intensity of recent years has been alarming: 2022 saw one of the most prolonged heatwaves, while 2023 had heatwaves declared in 10 states. By April 2024, the IMD had forecasted nearly 20 heatwave days—far above the usual 4–8 days—demonstrating the clear impacts of climate change, exacerbated by phenomena like El Niño (IMD, 2024). By the summer of 2024, India had recorded 536 heatwave days across meteorological subdivisions, the highest since 2010. June alone accounted for 181 heatwave days, surpassing the previous record of 177 days in 2010. In May, temperatures in over 37 cities across northern and central India exceeded 45°C, intensifying health risks and air pollution impacts, particularly in cities like Delhi.

Climate projections indicate that heatwaves in India will become more frequent, intense, longer-lasting, and geographically widespread (Im, Pal, and Eltahir, 2017). The health impacts of heat stress are projected to emerge as the most critical climate risk for India and South Asia (IPCC, 2019). Cities, which are warming at twice the rate of rural areas due to urbanization and the urban heat island effect, face compounding risks (Sethi and Vinoj, 2024). Coastal cities, in particular, will grapple with additional challenges from high humidity, which can increase the perceived temperature by 3–4°C (TMC and CEEW, 2024).

Without decisive mitigation and adaptation measures, heatwaves could escalate into catastrophic events, resulting in significant loss of life and severe damage to infrastructure. Addressing these escalating risks requires mapping climate variability, tracking extreme heat events, and designing robust, localized action plans.

This Heat Action Plan for Navsari City focuses on identifying trends in extreme heat, mapping heat risk hotspots, and developing tailored strategies for mitigation, preparedness, and response.

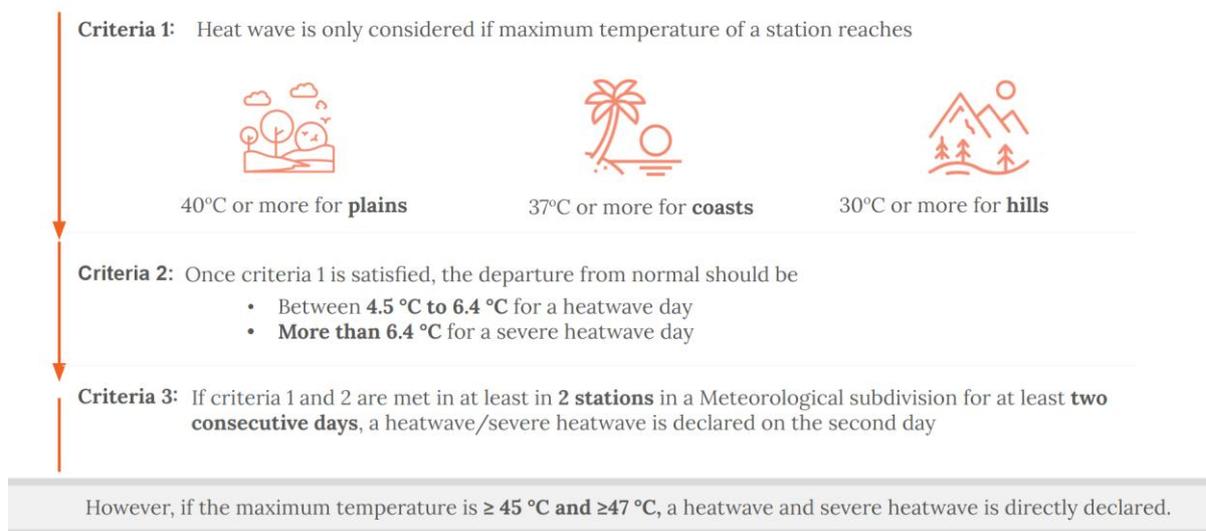
### 1.1 Understanding heat waves — global definitions and terminologies

Heatwaves lack a universally agreed-upon definition. The World Meteorological Organization (WMO) defines a heatwave as "*five or more consecutive days of prolonged heat, during which the daily maximum temperature exceeds the average maximum temperature by 5°C (9°F).*" However, definitions and criteria for assessing temperature extremes vary significantly across the world, tailored to local climatological and impact-specific conditions in each region (WMO 2011; Alexander et al. 2006; Vose et al. 2005).

For instance, the USA uses a complex "felt temperature" criterion that incorporates both humidity and temperature, while Denmark employs a simpler threshold, defining heat waves based on a daytime maximum temperature of 28°C. Similarly, countries like China and Brazil use a percentile-based approach to measure heat waves.

In India, the India Meteorological Department (IMD) employs a layered criterion to define heatwaves.

Figure 1: Criteria for mapping heatwaves in India



Source: India Meteorological Department 2019

Since 2024, the IMD has also begun issuing forecasts based on percentile exceedances, such as the 90th, 95th, and 99th percentiles, corresponding to yellow, orange, and red alerts, respectively. This approach helps capture district-level long-term normal and climatology, providing more regionally specific assessments of heatwave risks.

## 1.2 Climate change and escalating heat extremes in India

Between 1951 and 2016, India experienced a significant warming trend, with mean annual temperatures rising by 0.15°C per year (Krishnan et al. 2020). This increase in average temperatures has resulted in non-linear risks posed by extreme heat, contributing to nearly 25,000 deaths between 1992 and 2015, despite challenges in attributing mortality directly to heat (National Disaster Management Authority 2020).

Climatic projections indicate that heat extremes in India will intensify, becoming more frequent, lasting longer, and affecting broader geographical areas (Im, Pal, and Eltahir 2017). Both daytime and nighttime heat extremes are expected to increase two- to four-fold by 2050 under Representative Concentration Pathway (RCP) 4.5 and RCP 8.5, respectively (Krishnan et al. 2020). These impacts will be exacerbated by factors such as humidity and the urban heat island effect, leading to more heat-related deaths, challenging working conditions, and a wider spread of vector-borne diseases (Vaghela and Mangal 2017; Bordoloi and Saharia 2021), particularly in coastal cities like Thane, Mumbai, and Chennai, where the compounded effects will be most severe.

By 2050, as many as 23 cities in India are projected to experience average summertime maximum temperatures exceeding 35°C. This will have significant impacts on vulnerable populations, such as those living in slums, and place additional stress on resource allocation in the context of rapid

urbanization. The International Labour Organization (ILO) predicts a 5.8 percent rise in working hours lost due to heat stress by 2030, equivalent to 34 million lost hours (ILO 2019). While cities are generally considered most at risk, recent heatwaves in India have also affected other critical sectors, including agriculture and livestock. For example, the prolonged 2022 heatwave led to wheat yield reductions of 15-25 percent in states across the Indo-Gangetic plains. Milch animals also experienced a reduction in milk yield of up to 15 percent due to loss of appetite and elevated body temperature (Indian Council on Agriculture Research 2022). Moreover, the 2024 heatwave, one of the longest in India's history, resulted in over 44,000 suspected heat stroke cases, 350 plus heat stroke related mortalities, record-breaking power demand, declining reservoir water levels, and widespread crop damage (National Centre for Disease Control 2024).

The increasing risks from extreme heat and heat stress will disproportionately affect multiple sectors and populations, threatening progress toward the Sustainable Development Goals (SDGs) and alignment with the Sendai Framework for Disaster Risk Reduction.

### 1.3 Heat Action Plans (HAPs) in India

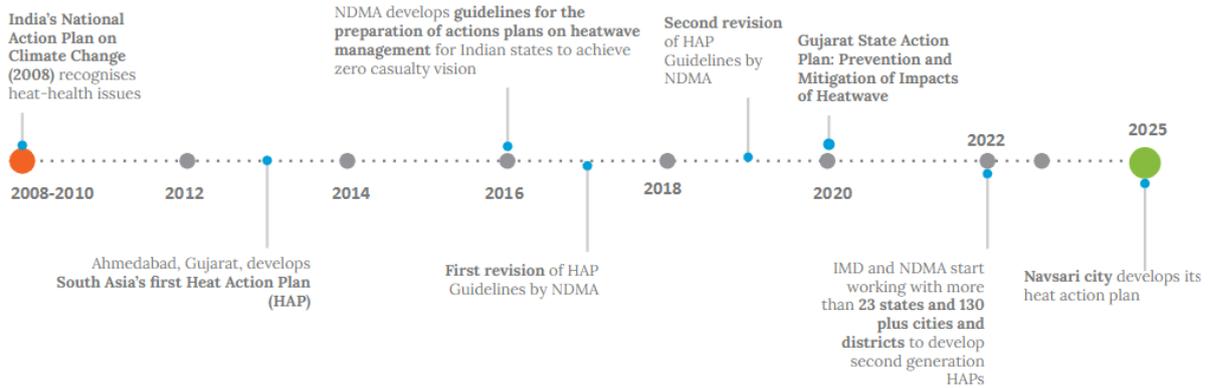
Despite the increasing risk of more frequent and intense heat extremes, this particular hazard has proven preventable from escalating into a disaster. The key to this prevention lies in the effective implementation of Heat Action Plans (HAPs) across India. HAPs are policy documents developed by state, district, and city governments that provide a comprehensive framework to prepare for, respond to, recover from, and learn from extreme heat events.

In 2016, the National Disaster Management Authority (NDMA) issued guidelines for developing HAPs, with a primary focus on enhancing the preparedness and response capacities of health systems and disaster management authorities. The overarching goal was to direct limited healthcare, financial, informational, and infrastructural resources toward protecting those most vulnerable to extreme heat within a specific jurisdiction.

The guidelines were further revised in 2017 and in 2019, these guidelines were revised to incorporate short-, medium-, and long-term strategies for heat risk reduction. The updated guidelines feature an eight-point checklist, highlighting the importance of effective coordination between agencies and stakeholders, mapping vulnerable and at-risk populations, establishing localized heat thresholds for early warning systems, creating a stakeholder responsibility matrix, and outlining strategies for monitoring, evaluation, and regular updates of the plans (NDMA 2019). The NDMA has also been conducting annual workshops with the nodal agencies, states, districts, municipalities, academia, civil society organizations and think tanks to enhance the preparedness before the heatwave season.

HAPs in India have demonstrated significant success in managing extreme heat, with studies showing a substantial reduction in heat-related mortalities and helping administrations better respond to heatwaves. Notable examples include the cities of Ahmedabad in Gujarat State, Thane in Maharashtra State, and Jodhpur in Rajasthan State, which have used scientific evidence-based assessments to identify heat thresholds and map heat risks down to the administrative ward level. Some studies indicate that Ahmedabad avoided an estimated 1,000 deaths annually (across all causes) in 2014–2015 compared to a baseline of 2007–2010, highlighting the tangible positive impact of HAP implementation (Hess et al. 2018).

Figure 2: Timelines of heat action plans in India and Navsari



Source: Authors' compilation

### 1.4 Nodal agencies

The Nodal Agencies for Heat Action Plans (HAPs), as outlined in the Ministry of Home Affairs' guidelines on combating extreme weather events—specifically heatwaves—are as follows:

1. National Disaster Management Authority (NDMA): At the national level, the NDMA issued the "National Guidelines for the Preparation of Action Plans – Prevention and Management of Heat Waves" in 2016. These guidelines serve as a framework for implementing, coordinating, and evaluating activities related to extreme heatwaves in India. The NDMA revised these guidelines in 2017 and again in 2019 to enhance their effectiveness in managing heatwave risks.
2. India Meteorological Department (IMD): Working in close coordination with the NDMA, the IMD plays a critical role by focusing on early warnings and impact-based forecasts/alerts for heatwave events. These alerts help states implement timely and appropriate mitigation measures. As of 2024, IMD is also developing an India-specific Heat Hazard Index, which combines factors such as temperature, humidity, wind, and the persistence of these variables to provide a more comprehensive heat risk assessment.
3. National Centre for Disease Control (NCDC) National Programme on Climate Change and Human Health (NPCCHH): The NCDC monitors and compiles data on epidemic-prone diseases on a weekly basis, enhances the capacity of medical personnel, and provides certification for illness and casualties related to heatwaves. Recently, the NCDC NPCCHH released a template for the development of District Action Plans on Climate Change and Human Health (DAPCCHH) and formats for recording heat-related illnesses and mortalities.
4. State Governments: Several state governments have undertaken essential preparedness and mitigation measures to address heatwaves. In recent years, many states, districts, and cities have developed and are actively implementing Heat Action Plans. These plans provide a comprehensive guide for state governments, district authorities, and city administrations to implement measures aimed at preventing heat wave-related mortalities.
5. Municipalities: The implementation of HAPs is primarily led by municipal authorities, with support from district and state governments. Effective coordination is essential between various municipal departments and state and district nodal officers to ensure the timely dissemination of early warnings and the successful execution of HAPs. This coordination framework is outlined in the national guidelines and is crucial for minimizing the impacts of extreme heat.

## 2. Profile of Gujarat state and Navsari city

### 2.1 Geographical and climatological profile of Gujarat State and Navsari city

The State of Gujarat is located on the western coast of India and has the longest coastline in the country. It comprises five types of terrain- River plain, hilly regions, uplands, deserts and coastal areas. Situated in the sub-tropical climate zone, the conditions vary from dry, arid in the central regions to hot and humid in the coastal region. Due to the varying terrain across the state, the average temperatures also differ. Summertime temperatures range between 25°C to 45°C, whereas in the winter it varies between 15°C to 35°C. Yearly average rainfall varies from 300mm to 2,100mm with the most rainfall during July to August (Climate Change Department, Gujarat). Consisting of 33 districts, 252 Talukas, 8 Municipal Corporations, 159 Municipalities, approximately 18000 villages and 6.04 crore inhabitants, it accounts for 5 per cent of India's population (Gujarat State Action Plan: Prevention and Mitigation of Impacts of Heat Wave, 2020).

The Navsari name of the town amongst many legends is said to be coined by the Parsi community who first stepped foot into this city in 1142 AD. The city at that time was called "Nag Mandal" but the aura of the city was such that it reminded the Parsis of their hometown "Sari" in Persia and hence called it "Nav" translating to "New Sari". It is the operational headquarters of the Navsari district and is the ninth biggest city in the state. Navsari is located in the southern part of Gujarat between Surat and Mumbai, the city is placed at an elevation of 9 metres. Geographically it is situated at 20.95°N 72.93°E in coastal lowland along the Purna River. Known for its trade and industries, Navsari is famous for "Zardosi" weaves. It is also the birthplace for many historic figures such as Dadabhai Naoroji and JRD Tata.

The southwest monsoon, occurring from June to September, brings moderate to heavy rainfall to Navsari, driven by moisture-laden winds from the Arabian Sea. The city's proximity to the Western Ghats and the Gulf of Khambhat significantly influences its rainfall patterns, contributing to high humidity levels and occasional intense downpours. Navsari experiences a tropical climate with relatively stable temperatures throughout the year, though seasonal variations are evident. The winter months, from December to February, bring mild and pleasant temperatures, while the pre-monsoon period from March to May is characterized by rising temperatures and increasing humidity. The dry season, lasting from October to May, is marked by warm to hot temperatures, with occasional heat waves during peak summer months, especially in April and May. The city's geographical location and coastal influence play a crucial role in moderating extreme temperature fluctuations, making the climate more humid but less arid compared to interior regions of Gujarat.

According to IMD records, Navsari recorded a maximum temperature of 38°C in 2024. The city experiences a typical tropical wet and dry climate characterized by an annual mean temperature of 27.1°C. Temperatures begin to climb in February, reaching their highest point in June, the warmest month. Following this peak, temperatures decrease during the monsoon season, which lasts from July to September. Navsari receives an average yearly rainfall of 1864 mm. The coolest month of the year is January, with temperatures falling as low as 10°C. The summertime conditions range between 29°C to 41°C and often crosses 45°C. During the winters, from November to February the weather is mild and pleasant with temperature ranges of 16°C to 30°C, January being the coldest month.

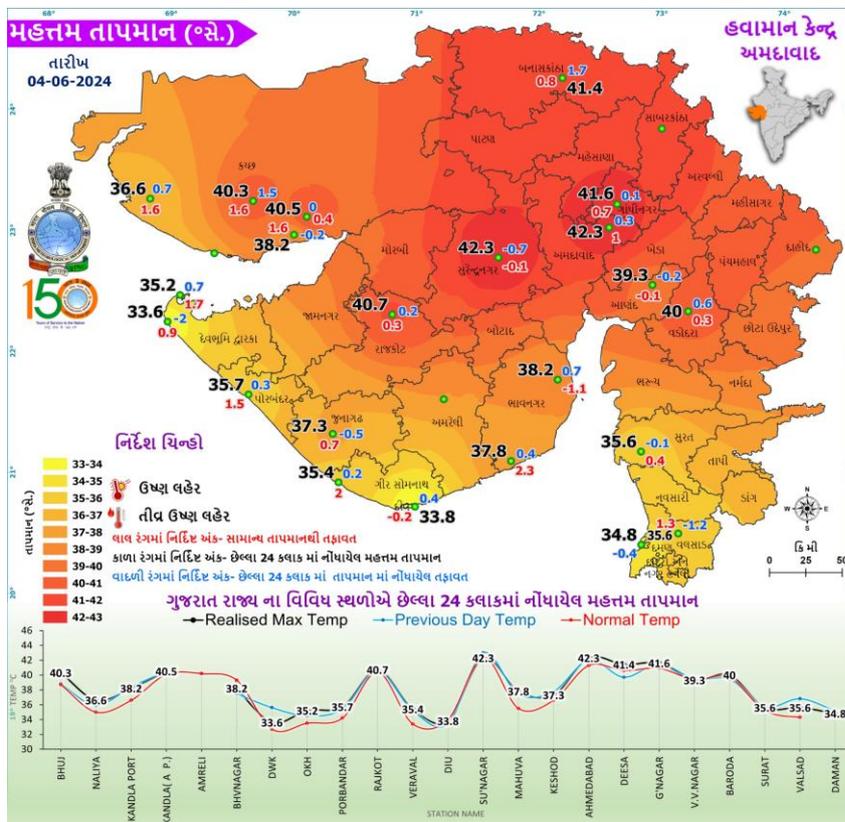
## 2.2 Gujarat state heat action plan

The first Heat Action Plan from Gujarat was developed in 2013 for Ahmedabad in response to severe heat-related morbidities and mortalities in 2010. The formulation of Gujarat’s State Action Plan: Prevention and Mitigation of Impacts of Heat Wave took fruition in 2020 offering a framework for the execution, integration and analysis of heat response activities directed towards reducing adverse heat-health related impacts primarily focusing on the vulnerable population.

The eight major aims of the HAP include- integration of prevention and mitigation strategies towards heat related illnesses, identification of heat vulnerable regions and communities, interagency coordination from developing early warning systems to implementation of the plan, capacity building of relevant entities and specialists, increased utilization of adaptive and risk reducing resources, making Gujarat heat resilient, provide evidence based care to individuals with heat related health outcomes and provision of safe drinking water in key regions.

In this plan, the Gujarat State Disaster Management Authority (GSDMA) also provides Standard Operating Procedures to be followed by officials during heat wave events. It facilitates multi sectoral involvement by allocating roles and responsibilities to various departments from the state to the village level in heatwave prevention and mitigation activities during pre-heat, during heat, and post heat season.

Figure 3: Maximum temperature for the state of Gujarat



Source: IMD, Ahmedabad, Gujarat

## 3 Rationale, objectives and approach for Navsari City HAP development

### 3.1 Rationale for developing city level heat action plans

The National Disaster Management Act of 2005 mandates the preparation of disaster management plans at the national, state, and district levels. While it does not explicitly require sub-divisional or city-level plans, it implies that the effectiveness of district-level plans relies on more localized analyses and adaptation strategies.

Additionally, the Constitution (Seventy-fourth) Amendment Act, 1992 (CAA), which came into effect on 1 June 1993, introduced Part IXA of the Constitution, granting constitutional status to Urban Local Bodies (ULBs). Article 243W of the CAA empowers state legislatures to enact laws that provide ULBs with the authority and responsibilities necessary to function as institutions of self-government. It also emphasizes the devolution of powers and responsibilities to these local bodies.

The XII Schedule of the Constitution outlines 18 key functions to be devolved to ULBs, including:

1. Urban planning, including town planning.
2. Regulation of land use and construction of buildings.
3. Planning for economic and social development.
4. Roads and bridges.
5. Water supply for domestic, industrial, and commercial purposes.
6. Public health, sanitation, conservancy, and solid waste management.
7. Fire services.
8. Urban forestry, environmental protection, and ecological promotion.
9. Safeguarding the interests of weaker sections of society, including individuals with disabilities.
10. Slum improvement and upgradation.
11. Urban poverty alleviation.
12. Provision of urban amenities such as parks, gardens, and playgrounds.
13. Promotion of cultural, educational, and aesthetic aspects.
14. Burial and cremation grounds, including electric crematoriums.
15. Cattle pounds and prevention of cruelty to animals.
16. Vital statistics, including the registration of births and deaths.
17. Public amenities such as street lighting, parking lots, bus stops, and public conveniences.
18. Regulation of slaughterhouses and tanneries.

This framework empowers urban local bodies (ULBs), including Navsari, to take significant steps in reducing disaster risks and vulnerabilities. By focusing on mitigation, preparedness, and response measures, ULBs can play a crucial role in addressing the rising frequency and intensity of extreme heatwaves, safeguarding their communities and fostering resilience.

### 3.2 Objectives of Navsari HAP

Recognizing the dynamic and intensifying nature of heat extremes—compounded by humid conditions and urban heat island effects—the Navsari Heat Action Plan 2025 has been developed as one of India’s most comprehensive heat mitigation strategies. Guided by the authority provided under the Constitution (Seventy-fourth) Amendment Act, 1992 (CAA), the plan adopts a holistic framework that integrates these factors to formulate effective, localized heat action strategies.

The Navsari HAP is uniquely designed to map heat risks at the administrative ward level, providing targeted mitigation, preparedness, and response strategies tailored for specific stakeholders and departments.

The mission of the Navsari HAP is to achieve:

- **Zero heat-related mortalities**
- **Reduced heat-induced illnesses and stress**
- **Minimized economic losses across key sectors**

## Objectives

To achieve this mission, the Navsari HAP focuses on the following objectives:

1. **Granular Mapping of extreme heat indices**
  - Map heat hazards under various climate change scenarios.
  - Establish localized heat-health thresholds for early warning systems.
  - Identify vulnerable populations for targeted interventions.
2. **Effective Preparedness and Response**
  - Design and implement preparedness and response strategies, focusing on health and disaster management.
  - Ensure zero heat-related fatalities through coordinated efforts.
3. **Reducing Heat-Health Risks**
  - Mitigate heat stress and heat-related illnesses through robust tracking and surveillance systems.
  - Deploy innovative cooling solutions to protect vulnerable populations.
4. **Minimizing Economic Losses**
  - Implement region-specific heat risk mitigation strategies to reduce long-term economic impacts across sectors.
5. **Capacity Building for Stakeholders**
  - Build the capacity of stakeholders to effectively prepare for and respond to heat events.
  - Periodically review and refine the Heat Action Plan to ensure its relevance and effectiveness.

The Navsari HAP further aims to identify the integration of heat resilience solutions into long term urban planning for the city. It aims to protect lives, improve health outcomes, and mitigate economic impacts by addressing the growing risks of extreme heat. With its localized and data-driven approach, the plan aims to set a replicable model for cities across Gujarat and coastal regions, which grapples with the combined impacts of heat and humidity.

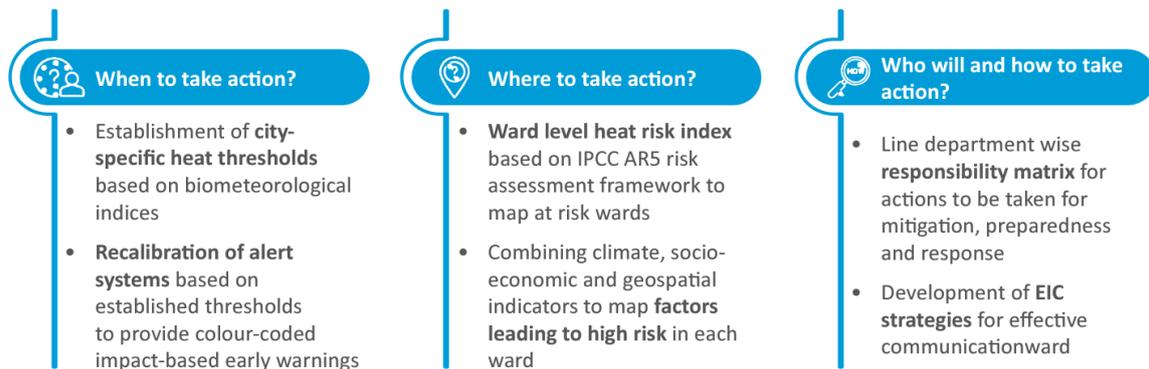
### 3.3 Approach for development of Heat Action Plan of Navsari City

To develop this Heat Action Plan, a multidisciplinary approach was adopted, integrating technical tools, scientific analysis, policy evaluation, and stakeholder engagement. The plan builds upon the guidelines established by the NDMA in 2019 for Heat Action Plans and the National Disaster Management Plan 2019, providing a comprehensive framework for effective heat action. This framework focuses on three key components:

- i) When to take action**
- ii) Where to take action**
- iii) Who will take action and what actions will be taken**

This framework has already been successfully piloted in Thane, where the Thane Municipal Corporation developed its HAP in 2024. Further details of this framework are provided in Figure 4. By following this structured approach, the plan ensures targeted, timely, and coordinated responses to heat risks.

Figure 4: Framework for development of the Navsari HAP



Source: Authors' compilation

Recent studies analysing existing HAPs in India have identified several design gaps in them. These gaps encompassed the absence of localised heat hazard and threshold mapping, insufficient vulnerability and heat risk assessments, and a lack of identification of financing mechanisms (Pillai and Dalal 2023). Consequently, to establish the Navsari HAP as a second-generation plan and as a template plan for other cities with similar climatic conditions to replicate, the approach was tailored to address these gaps comprehensively.

The approach to developing the Navsari HAP underwent rigorous validation through extensive stakeholder consultations. Various stakeholders, including line departments, scientific experts, and policymakers crucial to the plan's implementation, actively participated. The consultations centred around presenting climatological analysis, the heat risk index with its indicators, and the locally developed heat thresholds. Further details on these aspects, along with the stakeholder responsibility matrix, are elaborated in subsequent chapters of this heat action plan.

Furthermore, since the primary focus of the HAP is the long-term mitigation of risks from extreme heat, significant emphasis has been placed on urban greening solutions. A detailed financial breakdown and cost estimation for these solutions are also provided in the respective chapters.

Figure 5: Snapshots from various consultation-cum-validation workshops and meetings for HAP development

- a) One-day workshop on validation and discussion of HAP co-organised with GSDMA and various officials from various line departments in April 2025



- b) CEEW team in discussion with relevant line departments validating the heat risk assessments during the workshop



## 4 Heat Hazard, Vulnerability and Risk assessment

Heat impacts are not uniform and vary significantly depending on exposure and vulnerability, even within the same city. While climate science agrees that climate change has increased the frequency, intensity, and duration of extreme heat events, their risks are shaped by local population dynamics and socio-economic factors.

Many city-level Heat Action Plans (HAPs) in India have introduced response mechanisms, such as heat-health warning systems, to address heat as a hazard. These systems provide essential information about the health implications of extreme heat conditions, helping decision-makers determine ‘when to take action.’ However, these warnings are often issued at broad regional scales, lacking the detailed insights required to identify variations in vulnerabilities and risks within a city. Without this localized understanding, prioritizing effective actions becomes a challenge. A truly comprehensive HAP requires a clear understanding of sub-city-level at-risk populations, a critical component missing in nearly 95 percent of Indian HAPs (Pillai and Dalal, 2023).

To bridge this gap, the Navsari Heat Action Plan incorporates ward-level analysis of heat risks. This analysis is conducted following the Intergovernmental Panel on Climate Change’s (IPCC) climate risk framework, which evaluates heat risks through a granular assessment of:

- observed heat extremes (1982–2022) and projected trends (2022–2050) using historical climate data and future projections.
- exposure mapping, including urban heat islands identified through satellite imagery.
- socio-economic vulnerability mapping, using official data collated by the Navsari Municipal Corporation.

This localized approach enables decision-makers to not only identify ‘when to take action’ but also ‘where to take action,’ ensuring that resources are directed toward the most vulnerable populations and areas. The Navsari HAP sets a benchmark for incorporating localised heat risk analysis into urban planning and resilience strategies.

### 4.1 Mapping of heat and humidity hazards over Navsari City

In the context of rapid climate change, understanding local-level shifts in climatic variables is essential for effective action plan formulation. This section presents an analysis of climatological changes in Navsari City, focusing on heat extremes over observed (1982–2022) and projected (up to 2050) time periods. The analysis employs indices recommended by the World Health Organization (WHO), World Meteorological Organization (WMO), and India Meteorological Department (IMD). It is based on high-resolution climate data obtained from the Ministry of Earth Sciences (MoES) and climatological models developed by the Indian Institute of Tropical Meteorology (IITM).

To analyse observed and projected trends in both day-time and night-time heat extremes, this study uses a combination of data from:

- Indian Monsoon Data Assimilation and Analysis (IMDAA)
- India Meteorological Department (IMD) gridded data
- CORDEX-SA regionally downscaled models (RegCM4) developed by the Indian Institute of Tropical Meteorology (IITM)

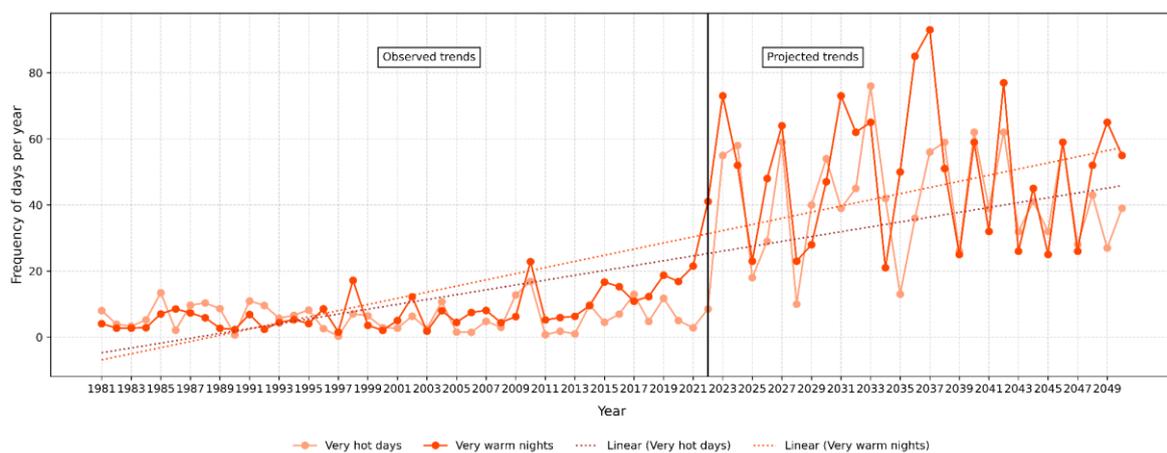
Details regarding the models, downscaling methodology, bias correction, and data processing are available in Annexure of this report.

The analysis focuses on the frequency of extreme hot days and warm nights, projecting changes in Navsari City’s heat extremes under the representative concentration pathway (RCP) 4.5 scenario. RCP 4.5 represents a mid-emission pathway aligned with India’s and Gujarat’s net-zero targets.

The indices for extreme hot days and extreme warm nights are derived using the 95th percentile threshold of the baseline (1982–2011) for individual months from March to June. The number of days exceeding this threshold has been calculated for each year from 1982 up to 2050.

This granular analysis provides critical insights into how heat extremes in Navsari are expected to evolve, enabling the formulation of targeted strategies to mitigate heat risks and build resilience at the local level.

Figure 6: The increase in frequency of extreme warm nights is projected to be of greater magnitude than extreme hot days up to 2050 over Navsari city.



Source: Authors’ analysis

The trends indicate a steady increase in the frequency of extreme hot days from 2024 to 2050, compared to the period between 1982 and 2024. Notably, the frequency of warm nights is projected to rise to nearly 30-35 days annually during the summer (March to June). The heightened occurrence of warm nights is linked to the urban heat island effect, where building structures and other built-up areas like concrete roads trap the heat and impede the upward movement of ground heat during the day-time, resulting in warmer night-time temperatures (Parker 2010; Nichol 2005).

This surge in both extreme hot days and warm nights presents substantial challenges for Navsari's population. Warmer nights hinder the cooling of human bodies from daytime temperatures, compounded by the augmented heat stress due to increased relative humidity. Addressing these challenges, the heat action plan outlines long-term strategies for heat risk mitigation in the subsequent sections.

To understand the aggravated heat impacts by humidity with temperature and establish the thresholds for felt or felt temperature—a crucial factor in comprehending heat stress in regions experiencing both high heat and humidity—the heat index developed by Steadman in 1979, widely utilised by the National Oceanic and Atmospheric Administration (NOAA) has been used.

The human body typically regulates its temperature through the evaporation of sweat. Elevated relative humidity diminishes evaporation and the cooling effect, amplifying discomfort and the potential for heat stress. Individuals may perceive heat differently due to factors such as body shape, metabolism, hydration level, pregnancy, or other physical conditions. The heat index (HI) serves as

an indicator that combines air temperature and relative humidity in shaded areas, presenting an equivalent temperature perceived by humans – essentially, how hot it would feel if the humidity were at a different value in the shade. For instance, when the temperature reads 32 °C with 70 percent relative humidity, the heat index is 41 °C.

Figure 7: The heat index matrix

		Temperature															
		80 °F (27 °C)	82 °F (28 °C)	84 °F (29 °C)	86 °F (30 °C)	88 °F (31 °C)	90 °F (32 °C)	92 °F (33 °C)	94 °F (34 °C)	96 °F (36 °C)	98 °F (37 °C)	100 °F (38 °C)	102 °F (39 °C)	104 °F (40 °C)	106 °F (41 °C)	108 °F (42 °C)	110 °F (43 °C)
Relative humidity	40%	80 °F (27 °C)	81 °F (27 °C)	83 °F (28 °C)	85 °F (29 °C)	88 °F (31 °C)	91 °F (33 °C)	94 °F (34 °C)	97 °F (36 °C)	101 °F (38 °C)	105 °F (41 °C)	109 °F (43 °C)	114 °F (46 °C)	119 °F (48 °C)	124 °F (51 °C)	130 °F (54 °C)	136 °F (58 °C)
	45%	80 °F (27 °C)	82 °F (28 °C)	84 °F (29 °C)	87 °F (31 °C)	89 °F (32 °C)	93 °F (34 °C)	96 °F (36 °C)	100 °F (38 °C)	104 °F (40 °C)	109 °F (43 °C)	114 °F (46 °C)	119 °F (48 °C)	124 °F (51 °C)	130 °F (54 °C)	137 °F (58 °C)	
	50%	81 °F (27 °C)	83 °F (28 °C)	85 °F (29 °C)	88 °F (31 °C)	91 °F (33 °C)	95 °F (35 °C)	99 °F (37 °C)	103 °F (39 °C)	108 °F (42 °C)	113 °F (45 °C)	118 °F (48 °C)	124 °F (51 °C)	131 °F (55 °C)	137 °F (58 °C)		
	55%	81 °F (27 °C)	84 °F (29 °C)	86 °F (30 °C)	89 °F (32 °C)	93 °F (34 °C)	97 °F (36 °C)	101 °F (38 °C)	106 °F (41 °C)	112 °F (44 °C)	117 °F (47 °C)	124 °F (51 °C)	130 °F (54 °C)	137 °F (58 °C)			
	60%	82 °F (28 °C)	84 °F (29 °C)	88 °F (31 °C)	91 °F (33 °C)	95 °F (35 °C)	100 °F (38 °C)	105 °F (41 °C)	110 °F (43 °C)	116 °F (47 °C)	123 °F (51 °C)	129 °F (54 °C)	137 °F (58 °C)				
	65%	82 °F (28 °C)	85 °F (29 °C)	89 °F (32 °C)	93 °F (34 °C)	98 °F (37 °C)	103 °F (39 °C)	108 °F (42 °C)	114 °F (46 °C)	121 °F (49 °C)	128 °F (53 °C)	136 °F (58 °C)					
	70%	83 °F (28 °C)	86 °F (30 °C)	90 °F (32 °C)	95 °F (35 °C)	100 °F (38 °C)	105 °F (41 °C)	112 °F (44 °C)	119 °F (48 °C)	126 °F (52 °C)	134 °F (57 °C)						
	75%	84 °F (29 °C)	88 °F (31 °C)	92 °F (33 °C)	97 °F (36 °C)	103 °F (39 °C)	109 °F (43 °C)	116 °F (47 °C)	124 °F (51 °C)	132 °F (56 °C)							
	80%	84 °F (29 °C)	89 °F (32 °C)	94 °F (34 °C)	100 °F (38 °C)	106 °F (41 °C)	113 °F (45 °C)	121 °F (49 °C)	129 °F (54 °C)								
	85%	85 °F (29 °C)	90 °F (32 °C)	96 °F (36 °C)	102 °F (39 °C)	110 °F (43 °C)	117 °F (47 °C)	126 °F (52 °C)	135 °F (57 °C)								
	90%	86 °F (30 °C)	91 °F (33 °C)	98 °F (37 °C)	105 °F (41 °C)	113 °F (45 °C)	122 °F (50 °C)	131 °F (55 °C)									
	95%	86 °F (30 °C)	93 °F (34 °C)	100 °F (38 °C)	108 °F (42 °C)	117 °F (47 °C)	127 °F (53 °C)										
100%	87 °F (31 °C)	95 °F (35 °C)	103 °F (39 °C)	112 °F (44 °C)	121 °F (49 °C)	132 °F (56 °C)											

Source: NOAA 2022

To compute the heat index, the biometeorological formula illustrated in Figure 7, comprising 9 constants and 3 variables was applied. The inputs for calculating the heat index variable included the relative humidity in percentage and the 2m dry temperature in °F, derived from the IMDAA hourly reanalysis data over Navsari city from 1982 to 2022 for the months of March to June. The resulting heat index variable was then converted from °F to °C. The outputs of the heat index are referred to as 'felt temperature' or 'felt heat' for the sake of consistency and ease of interpretation.

Figure 8: Bio-meteorological formula used for developing heat index

$$HI = c_1 + c_2T + c_3R + c_4TR + c_5T^2 + c_6R^2 + c_7T^2R + c_8TR^2 + c_9T^2R^2$$

where

HI = heat index (in degrees Fahrenheit)

T = ambient dry-bulb temperature (in degrees Fahrenheit)

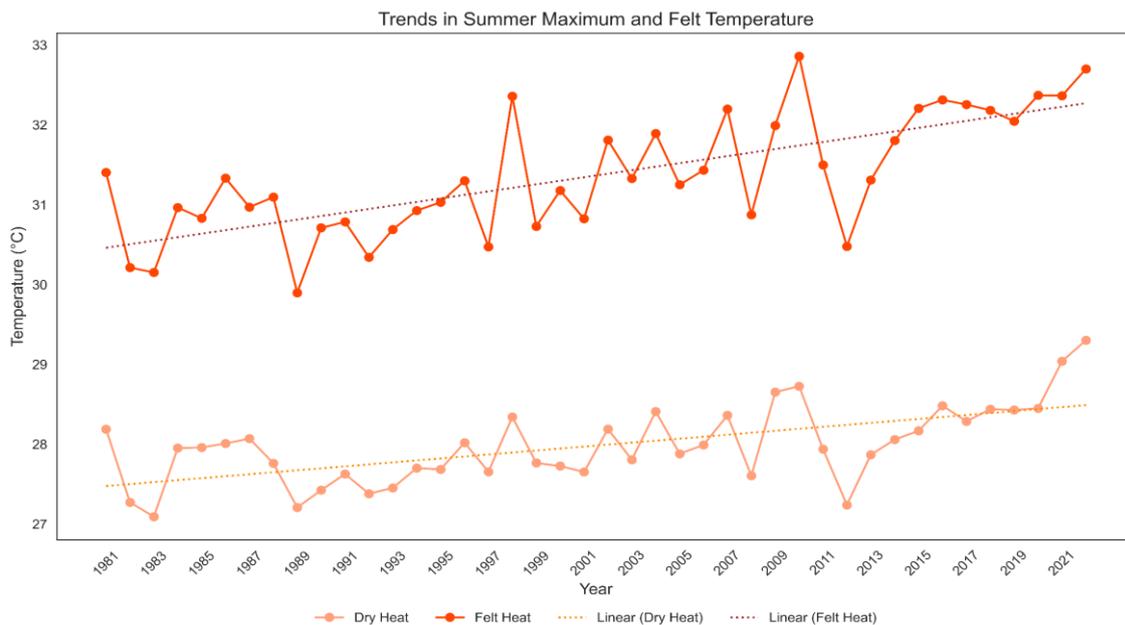
R = relative humidity (percentage value between 0 and 100)

$$\begin{aligned} c_1 &= -42.379, & c_2 &= 2.049\ 015\ 23, & c_3 &= 10.143\ 331\ 27, \\ c_4 &= -0.224\ 755\ 41, & c_5 &= -6.837\ 83 \times 10^{-3}, & c_6 &= -5.481\ 717 \times 10^{-2}, \\ c_7 &= 1.228\ 74 \times 10^{-3}, & c_8 &= 8.5282 \times 10^{-4}, & c_9 &= -1.99 \times 10^{-6}. \end{aligned}$$

Source: Steadman 1979

Analysis of the heat index indicates that the Navsari city reported a significant increase in both felt and dry maximum temperatures during the summer months in the last forty years (1982-2022). However, the difference between the felt and dry temperatures was also found to be slightly increasing in the recent few years, with 2022 for example having the felt heat being higher by almost 5°C than dry heat due to the added impacts of humidity as can be seen in figure 8.

Figure 9: Trends in average maximum summer dry heat and felt heat (HI) over Navsari city from 1982-2022



Source: Authors' analysis

## 4.2 Mapping of surface land temperatures to quantify the urban heat island impacts

While air temperature provides critical insights into its effects on human health, land surface temperature (LST) is equally important in understanding city-level heat extremes, particularly its role in the formation of urban heat islands (UHI).

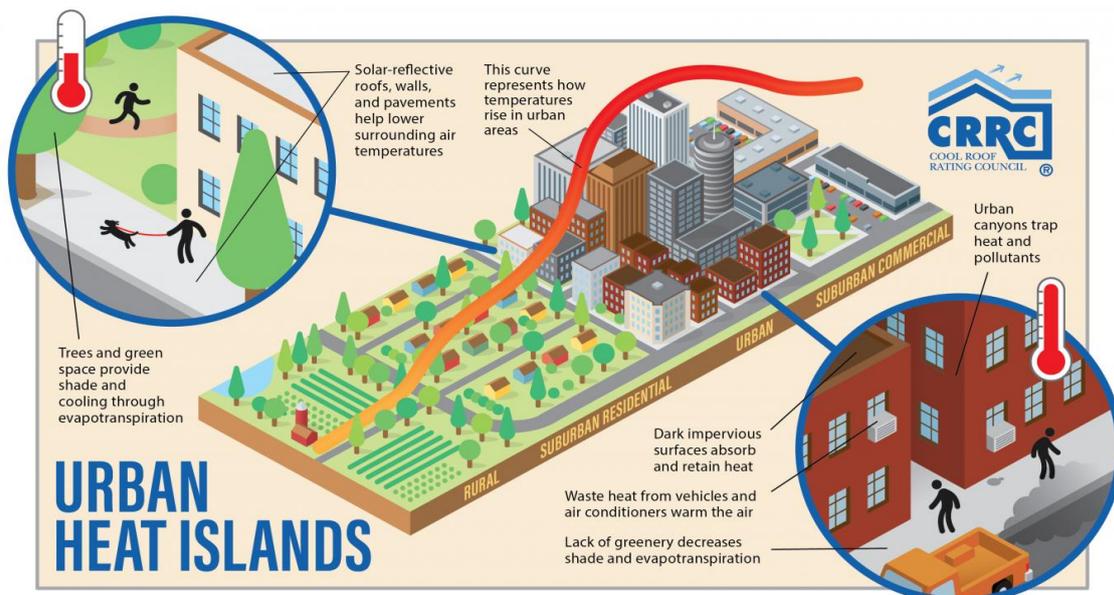
LST measures the Earth's surface temperature and is detected using remote sensing instruments. It provides key insights into the thermal properties of different land cover types. Urban Heat Islands (UHI) occur when urban areas are significantly warmer than surrounding rural regions due to human activities and changes to the natural environment. Urban areas, dominated by buildings, roads, and other infrastructure often made of materials like cement, steel, and bricks, absorb and retain large amounts of heat. The lack of green spaces exacerbates this effect, as solar radiation heats these surfaces, trapping warmth and raising temperatures, especially during the night.

Elevated surface temperatures not only contribute to higher air temperatures but also exacerbate the impacts of extreme heat. UHIs amplify discomfort, increase heat-related illnesses and mortality, and drive up energy costs as residents rely more heavily on air conditioning. This also leads to higher air pollution due to increased energy consumption.

The adverse effects of urban heat are not evenly distributed and disproportionately affect marginalized communities, who often lack access to resources like cooling systems or green spaces, compounding their vulnerability (Hsu et al., 2021; Hoffman et al., 2020; Wilson, 2020).

Understanding and addressing LST and UHIs is essential for developing effective urban heat mitigation strategies, reducing health risks, and promoting equitable urban resilience.

Figure 10: How urban heat islands develop and create heat risk

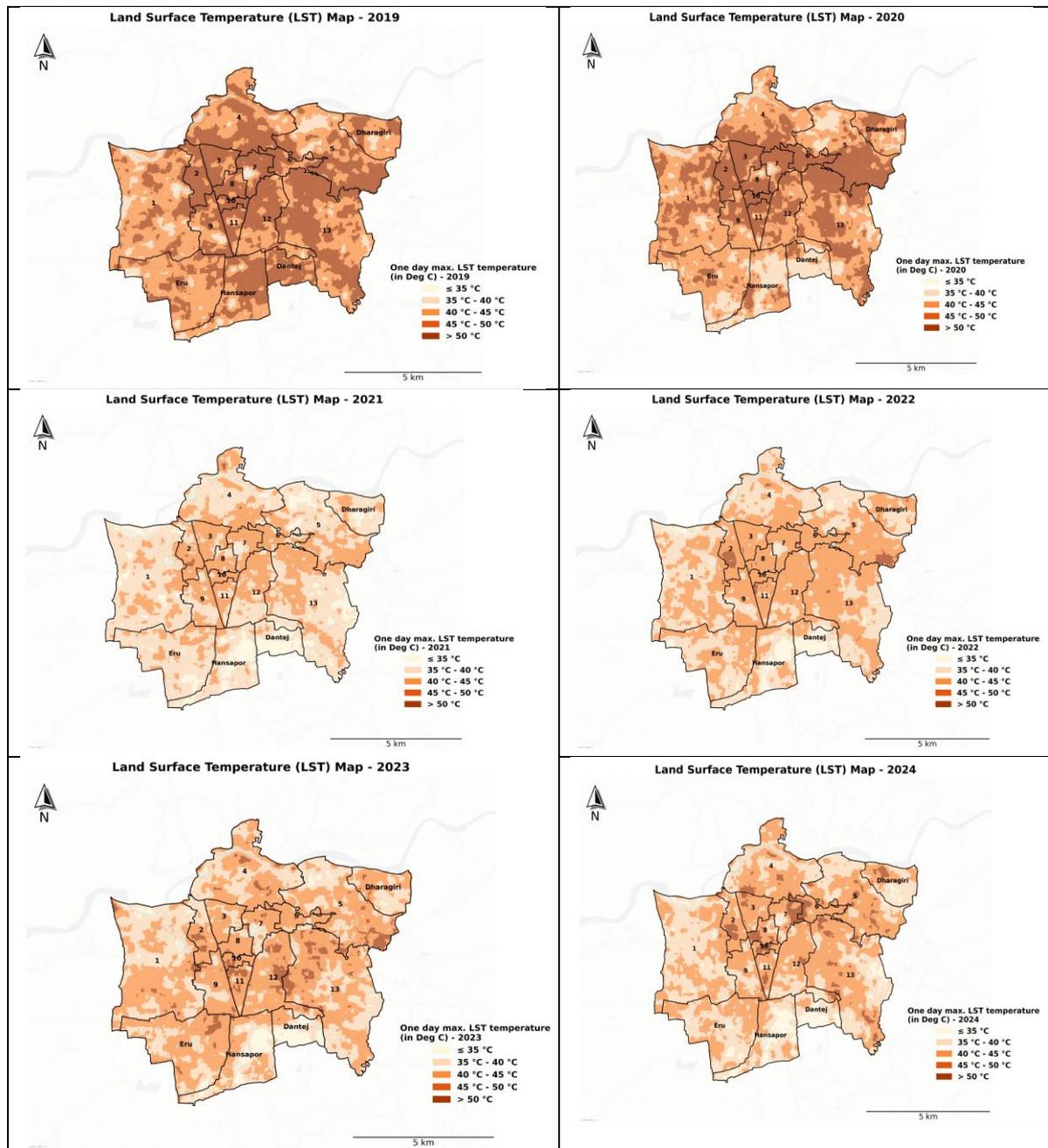


Source: Cool Roof Rating Council 2023

Land surface temperature data identifies cool and hot spots within the city. Cool spots, with lower temperatures, may indicate green spaces or bodies of water mitigating UHI effects, while hot spots signal more intense UHI, often linked to high-density development or insufficient green infrastructure. By understanding LST patterns, city planners can formulate targeted strategies, like green roofs or increased tree canopy cover, to mitigate UHI effects in specific areas.

For Navsari HAP, LST mapping over the last six years (2019-2024) used Landsat 8 satellite imagery at a 30-metre spatial resolution. This data aids in identifying UHI hotspots, guiding strategies like cooling shelters and greening interventions based on spatial and thermal information. Temporal variations in LST highlight areas consistently experiencing elevated temperatures, indicating potential UHI hotspots. The complete detailed methodology of the LST quantification can be found in the Annexure 1 of this plan.

Figure 11: Yearly one-day maximum land surface temperature (LST) from 2019-2024 during the months of March-June exceeds 50°C



Source: Authors' analysis

### 4.3 Mapping of ward level heat risks over Navsari city

To strengthen the ‘where to take action’ aspect of Navsari’s Heat Action Plan (HAP), this study introduces a ward-level heat risk index. The index evaluates extreme heat exposure and vulnerability across Navsari’s wards, assigning risk scores to enable targeted interventions.

Heatwave risks arise from the interplay of socio-economic, physiological, climatological, and behavioral factors. Changes in any of these variables can significantly alter the state of risk, either amplifying or mitigating it. This analysis systematically identifies the factors contributing to heat risk in each ward, paving the way for tailored adaptation and mitigation strategies.

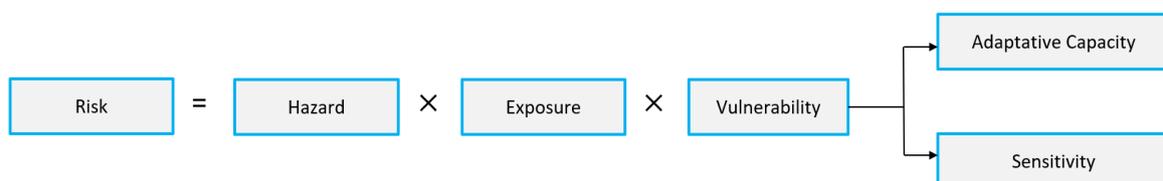
The ward-level heat risk index was developed following the IPCC Fifth Assessment Report (AR5) framework, a globally recognized methodology for climate risk assessment, also endorsed by the Department of Science and Technology (DST) for national-level evaluations. This framework, supported by the Ministry of Environment, Forests, and Climate Change (MoEFCC) in India, conceptualizes risk as the outcome of interactions between vulnerability, exposure, and hazard.

Risk here is defined as: *“Risk refers to the potential for adverse consequences for human or ecological systems, recognizing the diversity of values and objectives associated with such systems. In the context of climate change, risks emerge from potential impacts of climate change and human responses to it. Relevant adverse consequences include impacts on lives, livelihoods, health, infrastructure, ecosystems, and species.”*

The risk assessment framework comprises three key components:

1. Hazards: Climatic events that pose threats, such as extreme heat.
2. Exposure: Populations, infrastructure, or systems at risk of being affected by hazards.
3. Vulnerability: A function of two sub-components:
  - Sensitivity: The degree to which a system or population is affected by climate variability or change.
  - Adaptive Capacity: The ability of systems, institutions, and individuals to adjust to potential damage, seize opportunities, or respond to impacts.

Figure 12: Risk assessment equation



Source: Authors’ compilation

A robust risk assessment requires a systematic, multistep process guided by clear goals and objectives. These goals shape the type, scale, tier, indicators, and methods of the assessment. Risk can be assessed through two primary approaches: Starting Point/ Contextual Approach: Views risk as a pre-existing condition within a system in anticipation of a hazard. The second is an endpoint/

Outcome Approach: Focuses on assessing risk before and after exposure to a hazard (DST, 2019; Kelly, 2000).

For this action plan, the starting point/ contextual approach was adopted to identify risks based on pre-existing conditions in Navsari. This assessment, centered on current climate hazards, provides insights into existing vulnerabilities within natural and socio-economic systems. It identifies the factors contributing to these vulnerabilities, forming the basis for strategies to address weaknesses and enhance resilience.

The first step involved selecting indicators for each risk component—hazard, exposure, and vulnerability. Indicators are variables that represent complex phenomena in measurable terms. They allow for the relative assessment of a system's risk profile and are valuable tools for planning, monitoring, and evaluating development interventions over time (Crane et al., 2017).

In this analysis, indicators were chosen based on:

- Review of relevant literature to align with established risk determinants.
- Data availability at the sub-city level for granular insights.
- Stakeholder consultations to ensure relevance and applicability.

The selected indicators reflect the multidimensional nature of risk and provide a framework for targeted action. Detailed lists of these indicators, including their data sources and rationale, are provided in Tables 1 to 3.

This structured approach ensures a comprehensive understanding of heat risks in Navsari, enabling the design of effective mitigation and adaptation strategies.

Table 1: Indicators selected for computing heat hazard at ward level

Indicator	Description	Relation to heat risk	Data source
Increase in frequency of very hot days	An increase in frequency of day-time, night-time extremes and felt temperatures will directly lead to higher risk. The indicators have been calculated as increase in the indicator in the last decade (2012-2022) compared to climatic baseline (1982-2011)	Direct	CEEW analysis based on IMDAA reanalysis data at 12 km resolution from 1982-2022
Increase in frequency of very warm nights		Direct	
Increase in heat index		Direct	
Decrease in rainy days	A decrease in number of rainy days will lead to compounding impacts on increasing heat extremes	Direct	
Land Surface temperatures (LST)	LST aids in pinpointing hotspots in specific areas prone to elevated heat	Direct	CEEW analysis based on Landsat8

	conditions, primarily attributed to the urban heat island phenomenon.		data at 30m resolution
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Source: Authors' compilation

Table 2: Indicators for exposure component

Indicator	Description	Relation to heat risk	Data source
Population density	Dense urban areas with high population density often face heightened vulnerability due to inadequate infrastructure, limited access to cooling resources, and elevated socio-economic disparities, worsening the impact of extreme heat events on health.	Direct	Navsari Municipal Corporation
Percentage of built-up area to total geographical area	Areas with high levels of impervious surfaces such as roads and buildings may experience higher temperatures due to the urban heat island effect and the trapping of heat.	Direct	CEEW analysis based on Land Use Land Cover Analysis from Sentinel 2A at 10 m resolution, 2022
Building density	High building density exacerbates heat exposure by intensifying the urban heat island effect, trapping and radiating heat, elevating temperatures.	Direct	CEEW analysis based on Google building footprint data, 2023

Source: Authors' compilation

Table 3: Indicators for vulnerability

Indicator	Description	Relation to heat risk	Data source
Sex ratio	Women often face greater vulnerability to disasters, particularly in developing nations. Social and economic factors can magnify the impact of extreme heat on females, including gender-based inequalities in healthcare, education, and economic opportunities.	Direct	Navsari Municipal Corporation
Number of slum households	Slum populations face higher exposure to extreme heat due to poor housing, overcrowding, and lack of green spaces, intensifying the urban heat island effect.	Direct	

	Limited access to electricity, cooling appliances, clean water, and healthcare increases their susceptibility to heat-related illnesses.		
Illiteracy rate	Individuals with lower literacy rates may be more vulnerable to extreme heat events due to reduced awareness of potential dangers and limited access to heat alerts.	Direct	
Green spaces	Normalised Difference Vegetation Index (NDVI) is a remote sensing index employed to evaluate the health of vegetation. Higher NDVI values represent dense and healthy vegetation, which can be used as an indicator to depict green spaces that bring the cooling effect	Inverse	CEEW analysis based on Landsat8 imagery, 2023
Proportion of young population to total population (below 5 years)	It is widely acknowledged by the World Health Organisation and NDMA guidelines that the young and old population is more vulnerable towards extreme heat due to physiological factors and pre-existing health conditions. Limited adaptive capacity, behavioural considerations, and the urban heat island effect further exacerbate this vulnerability.	Direct	Navsari Municipal Corporation
Proportion of old population to total population (above 65 years)			
Proportion of population with chronic health conditions	Heat can lead to severe dehydration, acute cerebrovascular accidents, and contribute to thrombogenesis (blood clots). Those with chronic diseases on daily medications face an elevated risk of complications and death during heatwaves, along with older individuals and children (WHO 2018, WHO 2004)	Direct	Health department, Navsari city 2025
Proportion of population with disabilities (Both physical and mental)	It is crucial because individuals with disabilities often face heightened risks during extreme heat events due to physical, social, and economic barriers. These barriers can limit access to emergency services, exacerbate health risks, and disrupt essential caregiving and support systems.	Direct	Navsari Municipal Corporation
Access to water sources	Access to water sources is crucial in dealing with extreme heat. Water sources additionally reduce heat risk by moderating temperatures through evaporation and creating localised cooling.	Inverse	CEEW analysis based on Modified Normalised Difference Water Index (MNDWI), 2023 from Landsat8 satellite imagery

Access to road networks	It ensures quick mobility to healthcare, cooling centers, and emergency services during extreme heat events. A well-connected road system allows faster response times and better access to essential resources, reducing heat-related risks.	Inverse	Navsari Municipal Corporation
Number of parks per square kilometre	It plays a crucial role in reducing heat stress by mitigating the urban heat island (UHI) effect. Green spaces provide shade, lower local temperatures through evapotranspiration, and improve air quality, benefiting public health.	Inverse	Navsari Municipal Corporation
Number of health centers per thousand population	It is a key indicator of a city's ability to respond to climate-induced health risks, especially during heatwaves. A higher density of health facilities ensures quicker access to medical care for heat-related illnesses like dehydration, heat strokes, and cardiovascular issues.	Inverse	Navsari Municipal Corporation
Number of Automatic Weather Stations (AWS) per sq. km	A higher number of Automatic Weather Stations (AWS) facilitates the recording of localised meteorological data, enabling timely alerts for extreme heat. Moreover, it contributes to the enhancement of long-term forecasting systems.	Inverse	Navsari Municipal Corporation, 2025

*Source: Authors' compilation*

The development of the heat risk index at the ward level was heavily influenced by data availability, ensuring that the indicators selected provided a robust and granular understanding of heat risk. The selection process was guided by a comprehensive review of national and global literature, as well as recent heat action plans from Indian cities such as Jodhpur (2023) and Ahmedabad (2019) (Qureshi and Rachid, 2022; Wu et al., 2022a; Liu et al., 2020; Adnan et al., 2022; Xiang et al., 2022; Sidiqi et al., 2022; Estoque et al., 2020; Zhang, McManus, and Duncan, 2018; Abrar et al., 2022; Cai et al., 2019; Inostroza, Palme, and De La Barrera, 2016; Conlon et al., 2020; Rathi et al., 2022; Leal Filho et al., 2018; Nanda et al., 2022; Johnson et al., 2012). Additionally, stakeholder consultations with key line departments involved in the heat action plan played a crucial role in shaping the final set of indicators.

The selected indicators reflect both direct and inverse relationships with heat risk. For example:

- Direct relationship: An increase in the proportion of the population with chronic health conditions indicates greater vulnerability, thereby increasing heat risk.
- Inverse relationship: Improved access to water resources reduces vulnerability, consequently lowering heat risk.

This dual perspective ensured a comprehensive representation of factors contributing to heat risk across wards.

The indicators were normalised to bring all the indicators to a common scale and to make them unit-free by the min-max normalisation technique in case of indicators related to exposure, vulnerability and hazard. Due to certain gaps where data was not available at ward level, the city wide data was disaggregated based on population proportionment method. Normalisation is based on the indicators' functional relationship with vulnerability. For positively related indicators, i.e., where risk increases with an increase in the value of the indicator, the following formula is used.

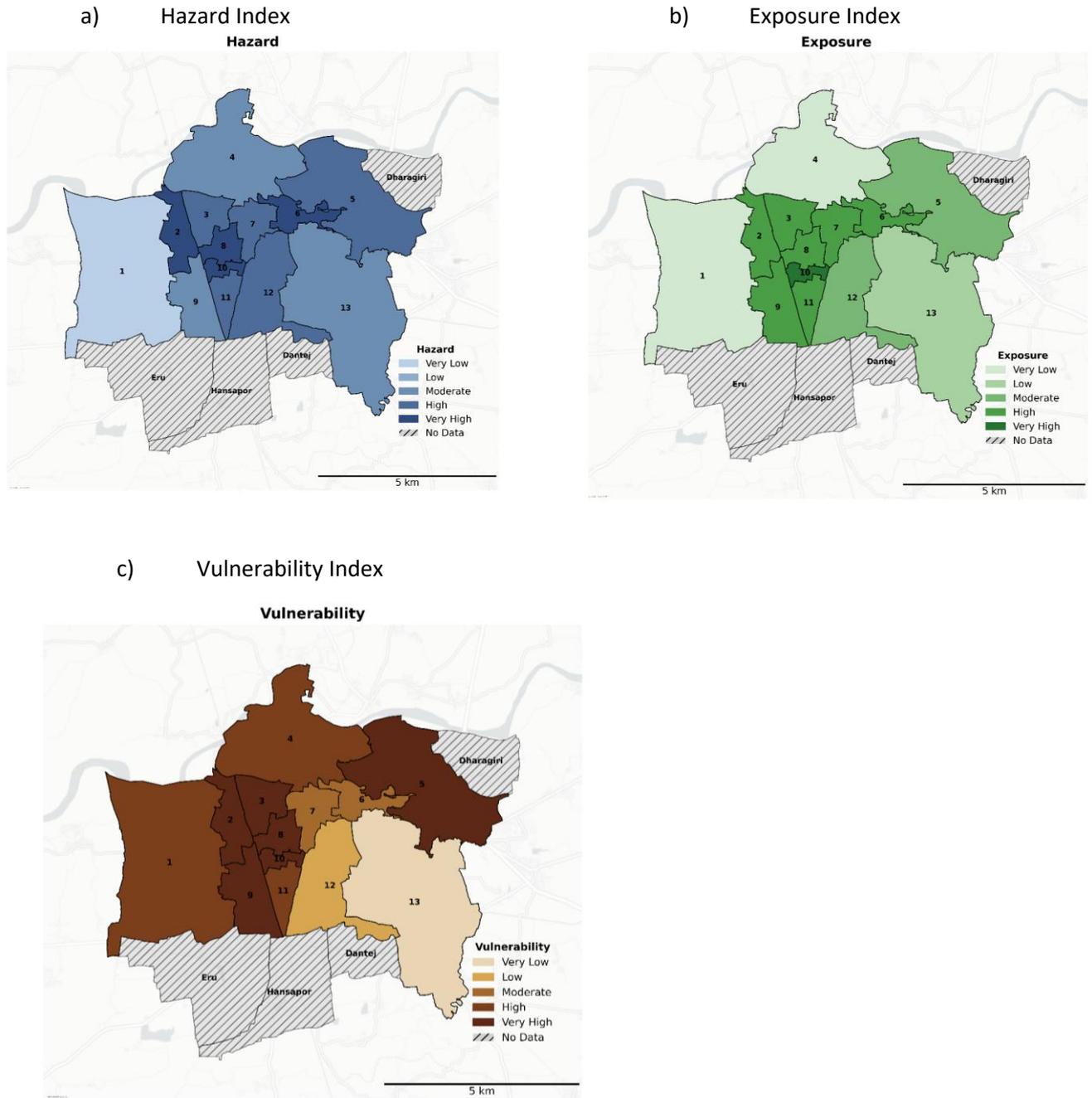
$$x_{ij}^P = \frac{X_{ij} - \text{Min}_i \{X_{ij}\}}{\text{Max}_i \{X_{ij}\} - \text{Min}_i \{X_{ij}\}}$$

For negatively related indicators, i.e., where vulnerability decreases with an increase in the value of the indicator, the following formula was used:

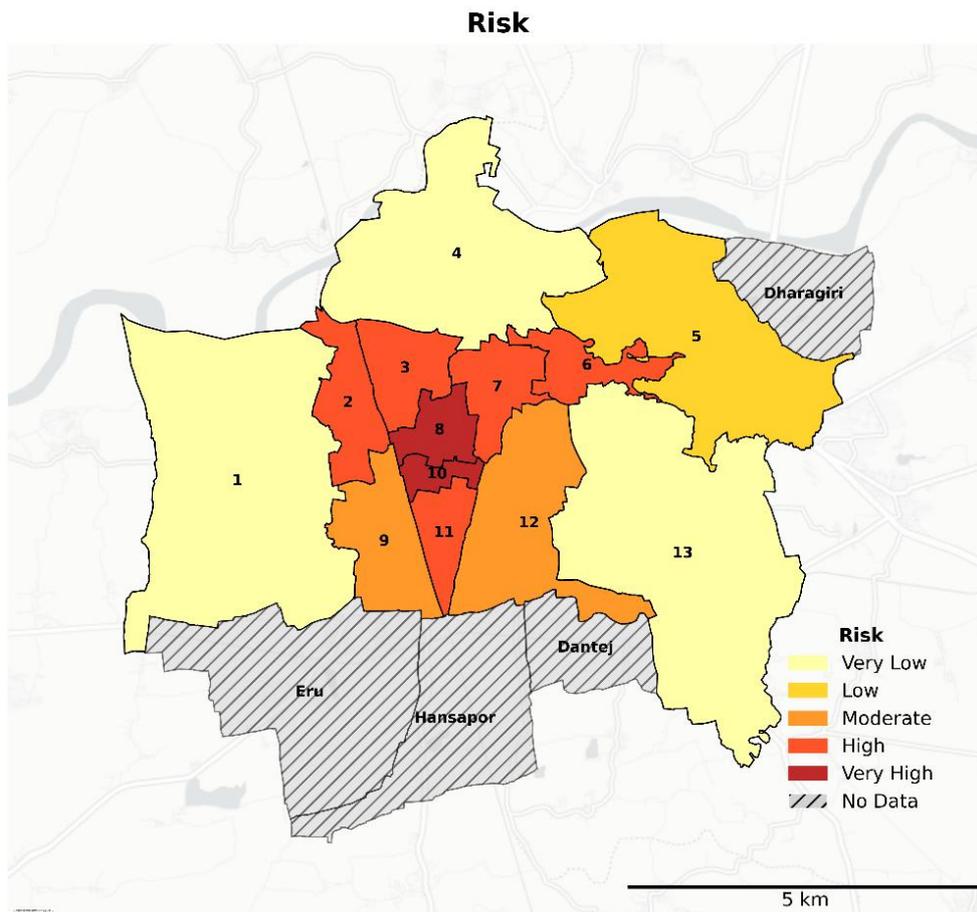
$$x_{ij}^N = \frac{\text{Max}_i \{X_{ij}\} - X_{ij}}{\text{Max}_i \{X_{ij}\} - \text{Min}_i \{X_{ij}\}}$$

Normalised values of an indicator will lie between 0 and 1. The value 1 will correspond to a ward with maximum risk and 0 will correspond to a ward with minimum vulnerability with respect to a particular indicator. This meticulous approach to indicator selection and normalization ensures that the heat risk index accurately reflects the varying levels of risk across Navsari's wards, supporting informed decision-making for targeted interventions.

Figure 13: Findings from the heat risk index for Navsari city



d) Heat risk index



Source: Authors' analysis

Table 4: Ward numbers of wards falling in very high, high and moderate risk categories

Wards falling in very high risk category	8, 10	15.38% of total wards
Wards falling in high risk category	2, 3, 6, 7, 11	38.46% of total wards
Wards falling in moderate risk category	9, 12	15.38% of total wards

Source: Authors' analysis

The indicator of each component of hazard, exposure and vulnerability that showed a very high score (equal to or more than 8 out of 10) have been identified in this section. Table 5 illustrates this information, offering government stakeholders a tool to address potential causes of heat risks in specific wards. This enables targeted actions for enhancing heat resilience.

Table 5: Factors contributing to heat risk in the very high risk category wards.

Component	Indicator leading to risk	WARD 8	WARD 10	Correlation to risk
Hazard	Land surface temperature			Direct
Exposure	Building density			Direct
	Population density			Direct
	Percentage of built-up area			Direct
Vulnerability	Green cover			Inverse
	Illiteracy rate			Direct
	Water cover			
	Sex ratio			Direct
	Population below 5 years			Direct
	Population above 65 years of age			Direct
	Number of parks per sq kms			Inverse
	Number of health centres per thousand population			Inverse
	Proportion of population with chronic health illnesses			Direct

Source: Authors' analysis

## 5 Establishing local level heat thresholds for early warning systems

In addition to identifying ‘where to take action’ through the heat-risk index, it is equally important to determine ‘when to take action.’ Unlike sudden-impact hazards like floods or cyclones, heatwaves have gradual and cumulative effects on human health. Therefore, understanding the thresholds at which temperatures become hazardous and necessitate a response is critical. This section focuses on developing and implementing localized heat-health thresholds tailored to Navsari, enabling precise early warnings and alerts for heatwaves.

### 5.1 Approach for establishing local heat-health Thresholds

Heat-health thresholds differ from general heatwave criteria by focusing on the specific impacts of extreme heat on the human body. In 2015, the World Meteorological Organization (WMO) and the World Health Organization (WHO) introduced guidelines for Heat Health Warning Systems (HHWS), emphasizing the importance of early warning systems in Heat Action Plans (HAPs). These guidelines outline two primary methods for establishing heat thresholds:

#### 1. Biostatistical Analysis

This method identifies the relationship between extreme temperature variables and health outcomes. It often uses health indicators such as:

- All-cause daily mortality (standardized to account for seasonal variability).
- Cause-specific daily mortality (e.g., non-accidental deaths or mortality in people aged 65 and older).
- Daily hospital admissions or emergency service calls (e.g., ambulance service data).

For meteorological variables, thresholds are determined using either:

- A single parameter, such as maximum temperature (T.Max).
- A composite parameter, like the Heat Index, considering geographical and historical data availability.

Widely referenced studies (e.g., Sheridan and Kalkstein, 2004; Pascal et al., 2006) have utilized these approaches. The Ahmedabad Heat Action Plan (2019), for example, used a dose-response relationship between daily maximum temperature and all-cause mortality to establish thresholds.

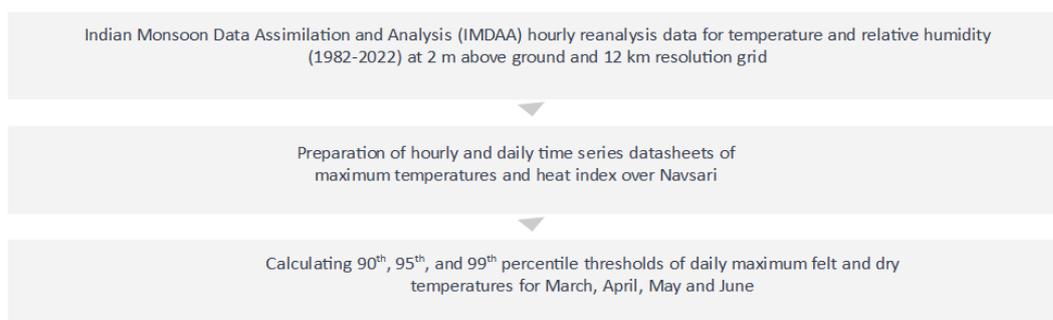
#### 2. Biometeorological Indices

In cases where health data is unavailable, percentile-based thresholds (e.g., 90th or 95th percentile) derived from long-term temperature data can serve as warning triggers. This percentile approach, endorsed by WHO-WMO, has been applied globally to identify critical thresholds for heat events.

In India, a hybrid approach combining both methodologies has been employed. For instance, the Ahmedabad Heat Action Plan (HAP) established thresholds by developing a dose-response relationship between the daily maximum temperature during summer and the corresponding daily all-cause mortality. Expanding on this initiative, in 2019, the National Disaster Management Authority (NDMA) conducted a comprehensive study to establish these thresholds for 103 cities in India. This involved a time-series analysis of temperature and mortality for five cities, determining thresholds based on published research for two cities, and establishing seasonal and monthly maximum temperature thresholds using the 75<sup>th</sup>, 85<sup>th</sup>, and 95<sup>th</sup> percentile values for 96 cities (Srivastava et al. 2019).

The local heat thresholds for Navsari city are developed by leveraging the latest fine-resolution IMDAA reanalysis data, available at a 12-km spatial grid. The approach goes beyond daytime extreme dry temperatures to incorporate felt temperatures, utilising the heat index - a composite of relative humidity and temperature outlined in the previous sections. Figure 13 provides a detailed methodology for the computation of heat thresholds for Navsari city. For this plan, the 90<sup>th</sup>, 95<sup>th</sup> and 99<sup>th</sup> percentiles have been analysed to compute yellow, orange, and red colour-coded alert thresholds, respectively, aligning with the IMD thresholds. It is important to note that the heat index used in this plan to develop thresholds is intended solely for estimating heat stress during the summer season. An India-specific heat index is currently under development by the India Meteorological Department (IMD) and is being provided on an experimental basis.

Figure 14: Schematic representation of approach for calculating percentile heat thresholds over Navsari city



Source: Authors' compilation

A percentile is a way to rank temperatures by comparing them to historical data. For example, if the 95<sup>th</sup> percentile is 38°C in a region, it means that 95 percent of the time, temperatures are below 38°C, and anything above it is unusually hot for that area. This approach, recommended by organizations like WHO, WMO, and IMD, considers local climate and how people in different areas are acclimatised to heat.

Table 6: Heat thresholds based on dry temperature for March-June (summer season)

Month	Yellow alert	Orange alert	Red alert
March	38	39	41
April	39	40	42
May	40	41	43
June	38	39	41

Source: Authors' analysis based on IMDAA data

Table 7: Heat thresholds based on felt heat – which includes temperature plus humidity for March-June (summer season)

Month	Yellow alert	Orange alert	Red alert
March	39	40	42
April	41	42	44
May	42	44	47
June	41	43	45

Source: Authors' analysis based on IMDAA data

The heat thresholds for both dry temperature and felt heat (which combines temperature and humidity) show important trends during the summer months (March–June). The thresholds steadily rise from March to May, with May emerging as the hottest and most critical month for extreme heat in Navsari. They then drop slightly in June, signaling the transition towards the onset of monsoon season.

The clear progression from yellow to orange to red alerts highlights the increasing risk levels and the importance of early warnings to prepare for heat impacts. The higher thresholds for felt heat compared to dry temperature underscore the need to factor in humidity when designing heat warning systems for Navsari city. Doing so provides a more accurate picture of heat risks, enabling better protection for vulnerable communities.

## 6 Heatwave Preparedness and Response Plan

This section outlines a stakeholder responsibility matrix for preparedness and response to address extreme heat events in Navsari city. Its purpose is to provide stakeholders and departments within the Navsari Municipal Corporation and GSDMA with clear actions and strategies. These measures are designed for implementation in the short and medium term, particularly during the pre-summer months (January and February) and throughout the summer season (March to June).

Table 8: heatwave preparedness and response plan

Sr No.	Key strategy	Planned action	Responsible authority
<b>Preparation and updation of plans and policies</b>			
1	Preparation and implementation of annual heat action plan	Coordinate with relevant stakeholders and experts to develop and implement the Heat Action Plan effectively, ensuring a collaborative and comprehensive approach.	Heatwave Task Force Committee
2	Standard Operation Procedures (SOPs)	Develop a comprehensive Standard Operating Procedure (SOP) for heatwave response, clearly defining the roles and responsibilities of various departments within the Municipal Corporation (MC), along with specific timelines for implementation. Issue necessary orders and notices to ensure clarity and accountability, while coordinating effectively among all stakeholders for seamless execution.	Heatwave Task Force Committee
<b>Early warning and alert mechanisms</b>			
3	Early warning and Coordination	Establish coordination with weather forecasting and warning institutions prior to the summer season to ensure timely access to critical weather updates and forecasts for proactive planning and response.	Heatwave Task Force Committee
		Analyze weather updates received from the India Meteorological Department (IMD), district and state authorities, and other research institutions, and disseminate the information promptly to all ward members to ensure informed decision-making and proactive heatwave management.	Deputy Municipal Commissioner
		Modify and customize heatwave warnings and alerts at the local level, tailoring them to ward-specific thresholds and target groups to ensure effective communication and targeted response measures.	Deputy Municipal Commissioner

4	Impact based early warning dissemination	Disseminate color-coded, impact-based early warnings to all ward members, clearly communicating the severity of heatwave risks to enable timely preparedness and response. Prioritize targeted outreach to the most vulnerable populations identified in the Heat Action Plan (HAP), ensuring they receive actionable information to mitigate risks effectively. Collaborate with city-level institutions and experts to enhance local capacity for information dissemination	Deputy Municipal Commissioner
<b>Interagency coordination mechanisms for preparedness and response to extreme heat events</b>			
5	Formation of a heatwave task force committee	Establish a dedicated Heatwave Management Cell at the Municipal Corporation level to oversee and coordinate heatwave preparedness and response efforts. Appoint a Heat Officer to lead the cell and ensure effective management. Develop a clearly defined, area-specific response plan tailored to local needs and vulnerabilities. Coordinate closely with district and state agencies to facilitate response and mitigation activities. Monitor the implementation of the Heat Action Plan on a daily basis during the heatwave season to ensure timely actions. Regularly organize meetings to assess ongoing conditions, ensure immediate response measures, and recommend necessary actions.	Municipal Commissioner
6	Appointment of a nodal officer	Appoint a Heat Officer as the nodal officer to oversee heatwave management, along with ward-level heatwave in-charge officers to ensure localized implementation. The Heat Officer should coordinate preparedness, response, and mitigation measures with all relevant stakeholders, including municipal divisions, district and state agencies, non-governmental organizations (NGOs), and other key partners to ensure an integrated and efficient approach.	Fire and Emergency Department
		The nodal officer, with permission of chairman of the heatwave task force committee, can implement regulatory and advisory orders related to heatwaves, ensuring compliance within the municipal area. These measures should include flexible timings for schools, markets, and offices during heatwave alerts to	Deputy Municipal Commissioner

		minimize exposure to extreme heat and safeguard public health.	
7	Formation of expert groups	Establish city-level technical advisory groups or committees comprising experts, NGOs, academicians, and other key stakeholders to provide guidance and support for the effective implementation of the Heat Action Plan (HAP). These groups will ensure evidence-based decision-making, foster collaboration, and enhance the plan's overall impact.	Deputy Municipal Commissioner
		Form ward-level working groups or committees comprising representatives from local NGOs, Civil Society Organizations (CSOs), and Resident Welfare Associations (RWAs) to coordinate activities within their respective wards. These committees will facilitate the implementation of heatwave response measures, ensure effective communication, and share vital information to enhance community resilience.	Town Planning Department
8	Restrict public gatherings and limit permissions for large events during heatwave alerts to minimize exposure	Avoid granting permissions for public gatherings during heatwaves. If such gatherings are unavoidable, seek approval from the district authority and develop a comprehensive checklist to ensure the availability of essential facilities, such as drinking water, shaded areas, and other necessary resources at the site. Additionally, discourage outdoor games, sports, and activities during daytime hours, and regulate the use of swimming pools to minimize heat exposure and ensure public safety.	Traffic, Transport and Parking Department
9	Protecting the traffic and outdoor police workers	Ensure the provision of adequate shade at traffic points for traffic police personnel, as they are highly exposed to heatwave conditions. Facilitate the distribution of cool jackets to traffic personnel to help mitigate heat stress and enhance their safety and comfort during duty hours.	Traffic, Transport and Parking Department
10	Protection from exposure due to summer elections	Ensure polling booth-specific precautionary measures during election periods, including the provision of shaded areas, adequate drinking water, and accessible medical facilities, to safeguard voters and election personnel from heatwave-related risks.	Urban Community Development Department
11	Hospital and health	Develop a comprehensive city wide hospital plan	Health and

	center preparedness	<p>to address heatwave-related illnesses and treatment, ensuring preparedness across all healthcare facilities. The plan should include the following measures:</p> <ol style="list-style-type: none"> <li>1. <b>Heat Related Illness Management:</b> Establish protocols for the diagnosis and treatment of heatwave-related illnesses in all healthcare centers.</li> <li>2. <b>Mental Health Preparedness:</b> Develop and implement a specific mental health plan to address the psychological impacts of heatwaves.</li> <li>3. <b>Procurement of Essential Supplies:</b> Ensure the timely procurement and stockpiling of life-saving medicines, IV fluids, oral rehydration salts (ORS), and other critical supplies across all healthcare centers.</li> <li>4. <b>First Aid Facilities:</b> Set up First Aid and Medical Aid stations at key high-risk areas identified in the Heat Action Plan (HAP) to provide immediate relief.</li> <li>5. <b>Specialized Health Facilities:</b> Ensure that specific healthcare services are available for individuals with pulmonary illnesses, renal conditions, psychiatric issues, and other heatwave-aggravated health conditions.</li> <li>6. <b>Daily Reporting:</b> Implement a system for daily reporting of heatwave-related cases and activities from all relevant departments and units within health facilities.</li> <li>7. <b>Data Collection and Analysis:</b> Collect ward-wise data on heatwave impacts based on formats provided in chapter 11.</li> </ol>	Hospital Department
12	Water supply	Ensure the continuous supply of safe drinking water at all identified vulnerable points and worksites on a priority basis. This measure will help mitigate heatwave-related risks, particularly for individuals working outdoors or residing in high-risk areas.	Sanitation Department
13	Livestock	Ensure the well-being of livestock during heatwaves by providing sufficient shade and access to water in vulnerable wards. Additionally, establish First Aid and Medical Aid facilities for livestock and ensure the procurement of adequate quantities of necessary medicines to address heat-related health issues in animals.	Livestock Department

14	Outdoor workers	Coordinate with relevant authorities to reschedule working hours for workers and laborers across various sectors within municipal areas to minimize exposure to peak heatwave conditions. Ensure the provision of safe drinking water at worksites and promote the use of temperature control measures, such as fans and coolers, to enhance workplace safety and comfort during extreme heat.	Urban Community Development Department
15	Tourism	Ensure that all tourist guides adhere to the issued heatwave advisories and guidelines. Provide comprehensive training to tourist guides to raise awareness about the effects of heatwaves and educate them on preventive measures to safeguard both themselves and tourists during extreme heat conditions.	Information and Communication Department
<b>Capacity Building – Training, public awareness, community outreach</b>			
16	Training and capacity building	Organize targeted training programs for various stakeholders, including health professionals, ASHA workers, ANMs, municipal school teachers, and representatives from NGOs/CSOs. These programs should focus on activities to be undertaken before, during, and after the heatwave season, ensuring they are well-equipped to respond effectively and contribute to mitigation and preparedness efforts.	Health and Hospital Department
		Organize training sessions for Civil Defense (CD) personnel, Resident Welfare Associations (RWAs), community members, volunteers, health workers, and rapid response teams to build their capacity for effective heatwave preparedness and response. Additionally, conduct specialized training programs tailored to the needs of specific vulnerable groups, ensuring they are informed about heatwave risks and equipped with the knowledge to protect themselves during extreme heat conditions.	Health and Hospital Department
17	Mock-drill exercises	Collaborate with local administration and staff to conduct joint emergency mock drills in areas prone to heatwave impacts. These drills should simulate heatwave emergencies to assess preparedness, identify gaps, and strengthen coordination among stakeholders for effective response and mitigation measures.	Deputy Municipal Commissioner

18	Inclusive response heat	Integrate gender-sensitive and equitable approaches into capacity-building programs to address heatwave-related illnesses, symptoms, and protective measures, ensuring inclusivity and addressing the unique vulnerabilities of different population groups.	Health and Hospital Department
		Identify and engage youth groups and college student associations to actively support vulnerable communities by disseminating heat-related information and raising awareness about preventive measures. Their involvement will strengthen outreach efforts and foster a community-driven approach to heatwave resilience.	Municipal Secretary
19	Public awareness campaigns	Raise public awareness about heatwave preparedness through targeted sensitization campaigns. Utilize print and electronic advertisements in local newspapers to educate the general public about heatwave risks and preventive measures. Highlight safety guidelines regarding the use of swimming pools during heatwaves to minimize heat-related risks. Additionally, disseminate forecasts and alerts via bulk mobile messages to ensure timely communication, including distribution to media outlets for wider outreach and broadcast.	Information and Communication Department
20	Information, Education and Communication (IEC) campaign	<p>Develop and implement an Information, Education, and Communication (IEC) campaign to raise awareness about heatwave preparedness and response. Target individuals, communities, Resident Welfare Associations (RWAs), and the general public through various modes such as posters, pamphlets, and public advertisements.</p> <p>During red alert warnings, prominently display information about heat-related illnesses, symptoms, and protective measures in high-visibility areas. Ensure Do's and Don'ts are displayed at public places, hospitals, parks, schools, and RWA premises in local languages to maximize reach and comprehension. This approach will foster widespread awareness and empower communities to mitigate heatwave impacts effectively.</p>	Information and Communication Department

		Broadcast short TV commercials (TVCs) in public places at regular intervals to raise awareness among the general public about the precautions necessary to safeguard against heatwaves. These ads should provide clear, actionable guidance on heatwave preparedness, including hydration, avoiding outdoor activities during peak hours, and recognizing the symptoms of heat-related illnesses, ensuring maximum reach and impact.	Information and Communication Department
		Install electronic screens at busy traffic intersections and market areas to display real-time heatwave information. These screens should provide critical updates, including heatwave alerts, temperature forecasts, safety tips, and hydration reminders, to ensure public awareness and prompt action in high-risk areas.	Information and Communication Department

Source: Authors' compilation

While the primary responsibility for implementing this plan will rest with the **Navsari Municipal Corporation**, successful execution will depend on close collaboration and support from the **Gujarat State Disaster Management Authority**. The key areas of responsibility will include:

Table 9: Key strategies for heatwave preparedness and response – district and state

Key Action Points	District-Level Responsibilities	Responsible Authority (District)	State-Level Responsibilities	Responsible Authority (State)
Heat Action Plan (HAP) Development	Develop or update district-specific HAP aligned with state and NDMA guidelines, incorporating local vulnerabilities.	Epidemic Medical Officer under Chief District Health Officer	Formulate or update State HAP integrating district-level plans for a unified heatwave response strategy.	State Epidemiologist under Deputy Director Epidemic
Early Warning Systems	Collaborate with IMD, RMCs, and local institutions to establish robust systems and disseminate timely alerts to local authorities and vulnerable groups.	Epidemic Medical Officer under Chief District Health Officer	Coordinate with IMD, RMCs, and research institutions to disseminate short, medium, and long-range	State Epidemiologist under Deputy Director Epidemic

			forecasts to districts, municipalities, and PRIs.	
Healthcare Preparedness	Equip district hospitals and health centers with resources such as life-saving medicines, IV fluids, ORS, and mental health support plans.	Chief District Health Officer	Direct hospitals to establish heatwave response units, ensure procurement of medical supplies, and address the needs of vulnerable groups.	State Epidemiologist under Deputy Director Epidemic
Capacity Building and Public Awareness	Train ASHA workers, ANMs, teachers, and NGOs on heatwave response activities, and conduct community outreach and IEC campaigns to build awareness.	Chief District Health Officer	Organize statewide public awareness campaigns and prepare IEC materials. Provide resources to districts for outreach to communities and vulnerable groups.	State Epidemiologist under Deputy Director Epidemic
Monitoring and Evaluation	Monitor HAP implementation daily during heatwave season through the Heatwave Management Cell using IT tools like GIS for data-driven decisions.	Epidemic Medical Officer under Chief District Health Officer	Establish a state-level monitoring cell to review HAP execution weekly across districts, collecting and analyzing data to scale up best practices.	State Epidemiologist under Deputy Director Epidemic
Policy Directives and Regulatory Orders	Ensure compliance with state directives for regulatory measures, such as adjusting public gatherings, school timings, and industrial	District Health Officer and District Collector	Issue regulatory orders and advisories on public gatherings, working hours,	Revenue Department

	safety protocols.		school timings, and industrial safety during heatwaves.	
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*Source: Authors' compilation*

## 7 Long term heat risk mitigation plan for Navsari city

This section presents a stakeholder responsibility matrix for heat risk mitigation, focusing on both structural and non-structural measures. The Navsari Municipal Corporation will take the lead in implementing these measures, with a particular focus on identifying synergies and necessary support from GSDMA whenever required. These measures are aimed at long-term implementation and sustainability.

Table 10: Heat risk mitigation plan

Sr No.	Key strategy	Planned action	Responsible authority
<b>Understanding and mapping of heat risks and vulnerabilities</b>			
1	Hazard, vulnerability and risk assessment	Conduct a comprehensive heatwave vulnerability and risk assessment to evaluate ward-level exposure, sensitivity, and adaptive capacity, with a particular focus on slums, individual households, and communities. Additionally, identify infrastructure at risk and assess occupational hazards affecting vulnerable groups such as outdoor workers. Utilize this information to map heatwave risk hotspot areas, which will serve as a basis for designing targeted and effective response and mitigation measures.	Town Planning Department
		Develop a detailed mapping of physical and socio-economic vulnerabilities based on primary survey data, considering factors such as age, pregnancy, chronic illnesses, morbidities, and the specific challenges faced by outdoor vendors, workers, and indoor laborers. Incorporate housing types, occupational risks, and other socio-economic parameters into the assessment. Leverage available resources and apply robust scientific methods to ensure the accuracy and reliability of the vulnerability analysis, which will form a critical foundation for targeted heatwave response and resilience strategies.	Town Planning Department
		Develop a heatwave risk index through a comprehensive assessment that integrates exposure, sensitivity, and adaptive capacity parameters. Use the findings to create a ward-wise atlas that identifies areas of varying risk levels. This atlas will serve as a critical tool for planning and implementing targeted mitigation and adaptation measures, ensuring that resources and interventions are prioritized for the most vulnerable communities.	Town Planning Department
2	Estimation of local temperature	Estimate ward-wise thresholds by analyzing key variables such as temperature, humidity, and health indicators like all-cause mortality. Collaborate with state and district research	Deputy Municipal Commission

	threshold	<p>organizations to ensure a robust and data-driven approach, enabling the identification of critical heatwave thresholds for effective risk mitigation and response planning.</p>	er and Fire and Emergency Department
		<p>Enhance the availability of weather observation networks across the city to achieve a density of at least one weather observation station for every 4 square kilometers, in alignment with World Meteorological Organization (WMO) guidelines. This expansion will improve the accuracy and granularity of weather data, enabling more precise monitoring, forecasting, and early warning systems to support heatwave preparedness and response efforts.</p>	
3	Mainstreaming and up-scaling	<p>Facilitate the integration of developmental schemes into heatwave risk reduction activities across all relevant departments, ensuring alignment with heat resilience objectives. Engage local NGOs, CSOs, and ward leaders to collaborate in implementing these measures, leveraging their community reach and expertise to create inclusive and sustainable solutions. This approach will ensure that developmental initiatives contribute directly to reducing vulnerabilities and enhancing adaptive capacities to heatwave impacts.</p>	Gardening Department, Urban Community Development Department
		<p>Identify opportunities for the convergence of various programs and schemes implemented by different departments that align with heatwave risk reduction activities. Conduct a comprehensive review to identify overlapping objectives, resources, and potential synergies. Issue clear instructions to relevant departments to facilitate coordination and integration, ensuring a unified and efficient approach to addressing heatwave vulnerabilities while maximizing the impact of existing resources and efforts.</p>	Urban Community Development Department
<b>Non-structural heat risk mitigation measures</b>			
4	Community cooling systems	<p>Coordinate the establishment and management of public cooling centers, as well as the development and maintenance of green spaces and parks, to provide residents with safe locations to cool off and prevent heat-related illnesses. Incorporate urban planning strategies to address future heatwave risks, ensuring that city designs are resilient and adaptable to evolving climate scenarios. Implement measures such as sprinkling water on roads to mitigate surface temperatures and improve air quality, particularly during peak heatwave conditions. These efforts will create a more sustainable and heat-resilient urban environment.</p>	Town Planning Department, Gardening Department

5	Restoration of natural buffers	Enforce laws and regulations aimed at increasing heat resistance and resilience across communities and infrastructure. Enhance urban green cover by implementing large-scale plantation drives and restoring natural water bodies such as ponds, fountains, and lakes, while expanding the number of green parks to mitigate heat impacts. Promote the adoption of heat-resilient building codes to encourage the development of infrastructure designed to withstand extreme heat. Advocate for the use of heat-resistant building materials and urban planning strategies that reduce the urban heat island effect, fostering a cooler and more sustainable urban environment.	Law Department, Gardening Department
6	Public health interventions	Implement targeted health advisories tailored to the needs of vulnerable populations in all wards and ensure these advisories are prominently displayed on ambulances to raise public awareness during the summer season. Organize regular health check-up camps focused on mental health, providing necessary treatments to address heatwave-induced psychological impacts. Conduct health check-up camps in slums and other vulnerable areas to reach at-risk populations effectively. Ensure the timely procurement of adequate quantities of life-saving medicines, IV fluids, ORS, and other essential supplies in all health centers under the jurisdiction of the Municipal Corporations to address heat-related illnesses promptly and efficiently.	Health and Hospital Department
7	Water supply	Ensure the portability and quality of water to safeguard public health during the summer season. Guarantee the availability of drinking water supply across all wards, with a special focus on vulnerable areas. Establish clean drinking water facilities at common public locations such as bus stands, labor hubs, markets, and parks to cater to the needs of the community. Provide sufficient water supply at all cooling centers to support their functionality and effectiveness. Set up water kiosks at identified heat hotspot areas to ensure easy access to drinking water for at-risk populations. Conduct frequent repair and maintenance of mechanical and electrical components of water supply systems before the onset of the summer season to prevent service disruptions and ensure uninterrupted water availability.	Sanitation Department
8	Road transport	Promote the use of public transport, electric vehicles, and bicycles to reduce vehicle emissions and traffic congestion, contributing to a safer and more sustainable environment. Ensure roadside assistance during traffic congestion and implement effective diversions to facilitate smooth vehicular movement. Provide essential amenities such as shelters and shaded areas at bus stops, along with drinking water facilities,	Road Transport Department

		to enhance commuter comfort and safety during extreme heat. Prioritize roadside tree plantations and the creation of green dividers to mitigate the urban heat island effect and improve air quality, fostering a cooler and greener urban landscape.	
9	Railway transport	Collaborate with local railway station authorities to ensure timely repair and maintenance of mechanical and electrical systems, prioritizing their functionality during the heatwave season. Facilitate the provision of adequate sheds, shelters, temperature cooling equipment, and a reliable water supply in public waiting areas to enhance passenger safety and comfort, reducing the risk of heat-related illnesses.	Road Transport and Deputy Municipal Commissioner
10	Power and electricity	Coordinate with the electricity department to ensure uninterrupted power supply, especially in high-risk areas and wards, and facilitate the prompt restoration of electricity during outages. Strengthen power infrastructure to enhance resilience against heatwave impacts. Encourage energy-saving practices and promote the use of renewable energy sources, such as solar energy, to meet cooling and electricity demands. Prioritize the integration of solar energy in cooling centers and other critical facilities to ensure sustainable and reliable power during extreme heat conditions.	Electric Engineering Department
11	Education	Adjust the timings of municipal schools and institutions to align with prevailing heatwave conditions, prioritizing the safety and comfort of students. Ensure that all schools and institutions are equipped with functional cooling equipment and sufficient water facilities to mitigate heat stress. Restrict outdoor games and physical activities during the heatwave season to prevent heat-related illnesses among students. Integrate heatwave awareness and preparedness into school curricula to educate students about heat-related risks and preventive measures, fostering a culture of resilience from an early age.	Municipal Secretary
12	Labour	Conduct heat illness orientation programs for factory officers, staff, and general practitioners, using IEC materials to raise awareness about the symptoms, risks, and preventive measures for heat-related illnesses. Organize regular awareness campaigns, with heightened efforts during high-risk heatwave days, to ensure all workers are informed and prepared. Ensure that drinking water is readily available at work sites, and promote the use of temperature control measures such as fans and coolers to maintain a safer working environment during extreme heat conditions.	Sanitation, Health, and Hospital
13	Livestock	Ensure the provision of adequate sheds and shelters for livestock in high-risk wards to protect animals from extreme heat. Launch public awareness campaigns to educate farmers and communities on protective measures for livestock and	Livestock Department

		poultry during prolonged heatwaves. Guarantee that all veterinary hospitals are stocked with sufficient medicines and fluids to address heat-related health issues in animals. Additionally, ensure that mobile veterinary hospitals are well-equipped and ready to be deployed to vulnerable areas at short notice, providing timely care to livestock and poultry in need.	
14	Parks and gardens	Ensure that all parks provide open spaces with sitting and resting areas to offer the public a comfortable environment during heatwaves. Conduct promotional campaigns to encourage the adoption of green roofs and cool roof buildings, which help in reducing indoor temperatures, enhancing ventilation, and promoting the development of green spaces. Advocate for the construction of green buildings that incorporate sustainable practices to mitigate heat effects. Work to increase green cover by engaging individuals, households, communities, RWAs, and institutions in tree planting and landscaping efforts, fostering a cooler and more resilient environment.	Gardening Department, Town Planning Department
15	Fire	Coordinate with the fire department to ensure readiness for potential fire emergencies during heatwaves. Ensure that an adequate supply of water and foam is available at critical locations to effectively combat fires. Maintain a list of designated points of contact for each ward and zone, ensuring that emergency responders can be swiftly reached in the event of a fire emergency. Communicate the locations of emergency facilities, including cooling shelters and shaded areas, to the public to provide safe refuge during heatwave conditions and fire emergencies.	Fire and Emergency Department
16	Tourism	Ensure the availability of cooling-off sheds, drinking water, and immediate first aid facilities at key tourist junctions to provide relief during heatwaves. Additionally, ensure that all tourist guides are well-trained and fully informed about the effects of heatwaves and the necessary prevention measures, so they can effectively assist tourists in managing heat-related risks.	Information and Communication Department
<b>Structural heat risk mitigation measures</b>			
17	Heat resilient infrastructure	Establish public cooling centers and green spaces, including parks, where people can find refuge during heatwaves, reducing the risk of heat-related illnesses and fatalities. Promote adherence to building codes that mandate the use of heat-resilient infrastructure and building materials in all new construction projects to minimize the urban heat island effect. Ensure that these constructions incorporate cool roofs, thermal insulation, and other heat-resistant materials as part of the design to enhance energy efficiency and protect residents from	Town Planning Department, Gardening Department

		extreme temperatures.	
18	Urban planning for climate change	Ensure that all building infrastructure incorporates heat-resistant materials, including cool roofs and thermal insulation, to reduce indoor temperatures and improve comfort during heatwaves. Encourage the greater use of permeable materials in civic infrastructure and residential construction, as these can help mitigate the urban heat island effect by promoting better water absorption and reducing heat retention. Additionally, implement strategies for managing transport and parked vehicles, ensuring that adequate shading and cooling measures are in place to prevent heat buildup and reduce the impact of heat on public spaces.	Town Planning Department
19	Social housing schemes	Increase urban greenery through the extensive plantation of trees in public spaces, streets, and residential areas to provide shade, reduce heat retention, and improve overall air quality. Ensure that social housing schemes incorporate incentives for using reflective materials on buildings to reduce heat absorption. Additionally, include the integration of ventilated cooling spaces into building bylaws, encouraging the design of homes that promote natural cooling, reduce energy consumption, and enhance the resilience of communities to heatwaves.	Civil Engineering Department
20	Rooftop solar energy	Incentivize and promote dual climate change adaptation and mitigation activities by encouraging the installation of rooftop solar panels, which not only generate renewable energy but also contribute to cooling the interiors of buildings. This dual benefit helps reduce energy consumption, lower indoor temperatures, and increase the overall sustainability of buildings, thereby enhancing resilience to heatwaves and reducing the urban heat island effect.	Electrical Engineering Department
21	Renewable energy	Encourage the widespread use of renewable energy sources, such as solar and wind energy, to meet cooling and electricity needs, reducing dependency on conventional power sources and promoting sustainability. Promote the installation of solar-powered appliances, including fans and air conditioners, to help individuals and businesses stay cool and comfortable while minimizing energy consumption and supporting environmental goals.	Electrical Engineering Department, Town Planning Department
22	Solid waste management	Implement and closely monitor solid waste management at the source to reduce methane emissions and prevent the occurrence of fires, both of which exacerbate urban heat. Effective waste management strategies, including segregation and proper disposal, can significantly mitigate these risks. Additionally, enforce the state policy aimed at minimizing the impact of solid waste on human health and the environment,	Sanitation Department

		ensuring that practices such as recycling, composting, and safe waste disposal are followed to reduce heat-related and environmental hazards.	
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*Source: Authors' compilation*

## 8 Case study-based details of potential solutions for Navsari's city-level heat action plans (HAPs)

This chapter provides details of the proposed solutions in the previous chapter based on selected case studies of their implementation across multiple countries. The following solutions have been proposed, catering to multiple thematic areas: EWS, infrastructure, public health resilience, and urban greening.

Table 11: Contents of the proposed solutions

Name of the solution	Theme and scale of the solution		
	Infrastructure	Public health	Sustainable urban planning
Green Roof			
Cool Roof			
Green Facade			
Cooling Shelter			
Shade Structure on Footpaths			
Urban Greenery			
Cool Pavements			
Development of Urban Acupuncture			
Thatch / Palm leaves roofing.			
Hollow Concrete / Terracotta Tiles			
Heat Wave Wards			

### 1. Name of Solution - Green Roofing Systems

**Location** - Open Roofs with direct exposure

A green roof is a layer of vegetation planted over a waterproofing system installed on top of a building. It helps mitigate urban heat by cooling the environment, reducing building temperatures, and improving overall thermal comfort.

#### Types of Green Roof System

Green roofs come in three main types: **extensive, intensive, and semi-intensive**, each varying in design, vegetation, maintenance, and structural requirements.

### Intensive Green Roof

Intensive green roofs are **heavier and more complex** due to their deeper soil layer, often exceeding **6 inches**. This allows them to support a variety of plant species, including shrubs, perennials, and even small trees, creating a park-like setting. Due to their weight, these roofs require regular irrigation, maintenance, and structural reinforcement. They significantly contribute to urban cooling by absorbing and retaining heat, preventing temperature spikes in buildings, and improving air quality through excellent plant coverage.

### Semi-Intensive Green Roof

Semi-intensive green roofs combine elements of both extensive and intensive systems. They can support a mix of grasses, ground covers, and small shrubs with a moderate soil depth. They require **intermediate levels of maintenance and irrigation** compared to intensive green roofs. These roofs are commonly used in commercial and institutional buildings where a balance between ecological benefits and functional aesthetics is needed.

### Extensive Green Roof

Extensive green roofs are the lightest and most low-maintenance type. They have a shallow soil depth, typically between **2 to 6 inches**, and support hardy, drought-resistant plants such as sedums, grasses, and mosses. These roofs are designed primarily for environmental benefits rather than aesthetic or recreational purposes. Because they require minimal irrigation and upkeep, they are ideal for retrofitting buildings with limited structural capacity.

Figure 15: Cross Section of Green Roof



Source: Calheiros, Cristina, Stefanakis, Alexandros. 2021. *Green Roofs Towards Circular and Resilient Cities. Circular Economy and Sustainability*. 1. 10.1007/s43615-021-00033-0.

### How green roofs help in reducing heat

Green roofs play a vital role in **reducing urban heat** through various natural cooling mechanisms:

1. **Evapotranspiration & Cooling:** Plants absorb and release water as vapor, naturally lowering surrounding air temperatures.
2. **Thermal Insulation:** The soil and vegetation act as a barrier, reducing heat transfer into buildings, leading to **lower indoor temperatures in summer** and **heat retention in winter**.
3. **Reduction of Urban Heat Island (UHI) Effect:** Several studies demonstrate that green roof temperatures can be 16–22°C (60.8–71.6°F) lower than that of conventional roofs. When transforming 80–90% of the roofs in a city to green roofs, they may reduce the average ambient temperature between 0.3°C and 3°C (32.5°F and 37.4° F) (Santamouris 2014). Research conducted in Lagos , Nigeria, showed that a green facade reduces internal air temperatures by an average of 2.3°C (36.14°F) (Akinwolemiswa et al. 2018), and reduces the temperature of the facade itself between 2°C and 10°C (35.6°F and 50°F) compared to the natural stone (Eisenberg and Polcher 2020).
4. **Heat Absorption & Delayed Heat Release:** Green roofs absorb solar radiation and release it slowly, preventing temperature spikes during the day and stabilizing nighttime temperatures.

Figure 16: Heat Dissipation in Green Roof in contrast with Conventional Roof



Source: Heidarinejad, Ghassem and Arash Esmaili.2016. "Assessment of Green Roof Energy Savings compared to Conventional Roof.", *Environmental Science, Engineering*.199603023

#### Potential Location of Implementation of Green Roof Systems



**Government Buildings**



**Schools**



**Hospitals**



**Libraries**

1. World Bank, 2021. *A Catalogue of Nature-based Solutions for Urban Resilience*. Washington, D.C. World Bank Group

2. Akinwolemiwa, O., Bleil de Souza, C., De Luca, L. M., Gwilliam, J. 2018. *Building community-driven vertical greening systems for people living on less than £1 a day: a case study in Nigeria. Building and Environment* 131, 227-287. (10.1016/j.buildenv.2018.01.022).
3. Eisenberg, B. and Polcher, V. 2020. *Nature-Based Solutions Technical Handbook. UNaLab Horizon*. <https://unalab.eu/system/files/2020-02/unalab-technical-handbook-nature-based-solutions2020-02-17.pdf>
4. Santamouris, M. 2014. *Cooling the cities—a review of reflective and green roof mitigation technologies to fight heat island and improve comfort in urban environments. Solar energy*, 103: 682–703.

## 2. Name of Solution - Cool Roof Systems

**Location** - Open Roofs with direct exposure

A **cool roof system** is a heat-mitigating solution designed to reduce urban temperatures by reflecting more sunlight and absorbing less heat compared to conventional roofs. It plays a crucial role in **mitigating the urban heat island (UHI) effect**, lowering indoor temperatures, and improving energy efficiency. Ahmedabad, a city in India known for its extreme summer heat, has successfully implemented **cool roof strategies** to combat rising temperatures and enhance thermal comfort for its residents.

### How Cool Roof Systems Work

Cool roofs utilize **high-albedo (reflective) materials** or **coatings** that reduce heat absorption and improve energy efficiency. These roofs can be categorized into:

1. **Reflective Coatings & Paints** – These are applied to existing roofs with high solar reflectance, reducing surface temperatures.
2. **Cool Roofing Sheets & Membranes** – Prefabricated sheets with reflective properties that minimize heat absorption.
3. **High-Albedo Tiles & Roofing Materials** – Light-colored, heat-reflective tiles that help keep rooftops cooler.

Conventional roofs can reach temperatures of 150°F or more on a sunny summer afternoon, sun. Under the same conditions a reflective roof could stay more than 50°F (28 °C) cooler.

### Implementation of Cool Roofs in Ahmedabad

Ahmedabad, one of India's hottest cities, experiences summer temperatures exceeding **45°C (113°F)**. The city adopted **cool roof solutions** to address extreme heat conditions under its **Heat Action Plan (HAP)**. The initiative focused on:

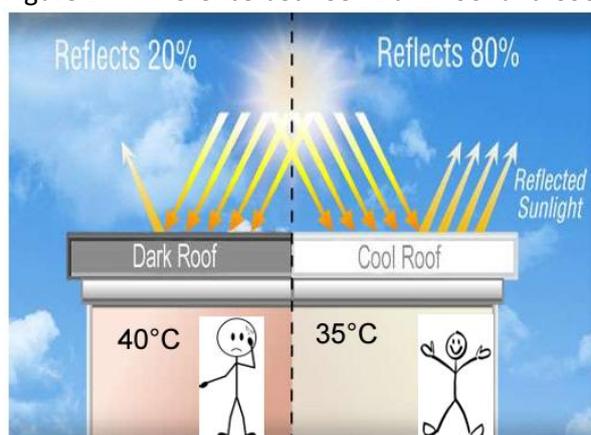
1. **Pilot Cool Roof Program (2017)**
  - Ahmedabad Municipal Corporation (AMC) launched a **pilot project** covering **3,000 low-income houses** with white reflective coatings, reducing indoor temperatures by **2–5°C** (NRDC 2017)
  - The project focused on **slum areas, informal settlements, and public buildings**, where people were most vulnerable to extreme heat.
2. **Scaling Up in 2019**

- The **cool roof program expanded** to include more households, commercial buildings, and public infrastructure based on successful pilot results.
  - The initiative encouraged **private developers** and homeowners to adopt cool roofing materials.
3. **Integration into Urban Planning (2020–Present)**
- AMC made cool roofs part of **building by-laws and urban heat resilience strategies**.
  - Government and private agencies partnered to **subsidize** cool roofing solutions for low-income communities.
  - Roof cooling materials such as **white lime coatings, solar-reflective paints, and cool tiles** were promoted citywide.

### Benefits of Cool Roof Implementation in Ahmedabad

1. **Reduction in Indoor Temperatures**
  - Cool roofs **lower indoor temperatures by 2–5°C**, improving thermal comfort, especially for vulnerable populations (NRDC 2017)
2. **Energy Savings & Reduced Cooling Costs**
  - A cool roof can reduce the amount of energy needed for air conditioning by up to 15 per cent on a single-story building, leading to substantial savings on energy bills (EESI 2012).
3. **Mitigation of the Urban Heat Island (UHI) Effect**
  - Large-scale implementation of cool roofs helps **reduce citywide temperatures**, making Ahmedabad more **resilient to heat waves**.
4. **Improved Public Health & Heat Resilience**
  - Reduced indoor heat exposure minimises **heat-related illnesses and deaths**, particularly for low-income communities and elderly populations.
5. **Scalability & Affordability**
  - The Cool Roof program is **cost-effective**, requires minimal investment, and can be **easily implemented on new and existing buildings**.

Figure 17: Difference between Dark Roof and Cool Roofs



Source: S. Himmelstein. 2017. “California Study: Cool Roof Technology impacts Air Quality

Source:

1. United States Department of Energy. n.d. “Cool Roofs”. accessed at <https://www.energy.gov/energysaver/cool->

[roofs#:~:text=A%20cool%20roof%20is%20designed,a%20sunny%20summer%20afternoon%2C%20sun.](#)

2. NRDC. 2017. “Cool Roofs: Protecting Local Communities from Extreme Heat”

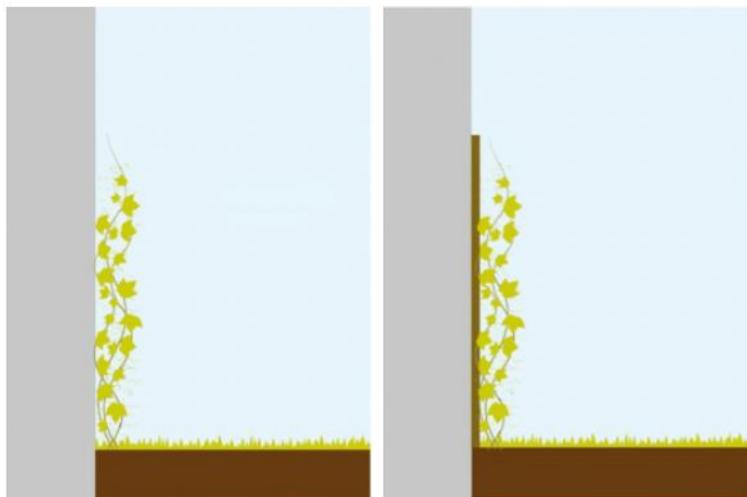
3. EESI. 2012. “Fact Sheets: Cool Roofs” accessed at <https://www.eesi.org/papers/view/fact-sheet-cool-roofs#:~:text=A%20cool%20roof%20can%20reduce%20the%20amount,leading%20to%20substantial%20savings%20on%20energy%20bills.>

### 3. Name of Solution - Ground-Based Green Facade and Facade Bound Greening

**Location** - Building Facade, Periphery of Building

**Ground Based** - Ground-based green facades are green walls with climbing plants rooted in ground planters. With adhesive pads as part of their anatomy, the climbing or self-clinging plants can grow directly on the wall or in a unique frame connected to the wall. The plants extract water and nutrients from the soil at ground level, grow very tall, and adjust to climate fluctuations and lighting conditions. Many flowering and evergreen species can add aesthetic experience to exterior walls, calm, and freshen the air

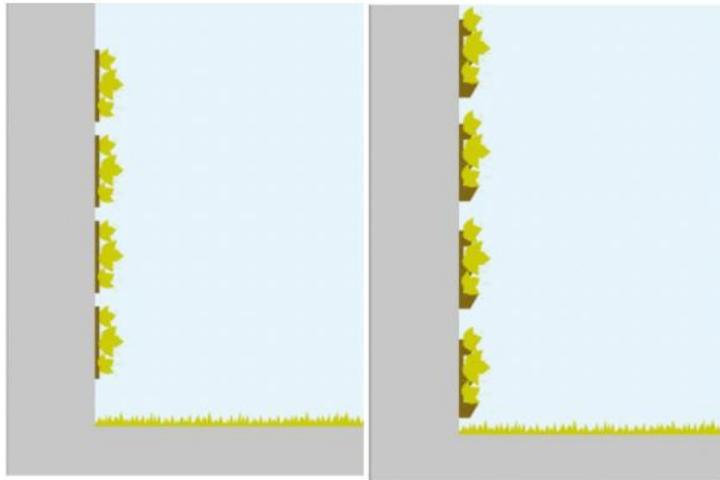
Figure 18: Ground-based green facades, either self-climbing or with support structure



Source: *Closing Water Cycles in the Built Environment through Nature-Based Solutions: The Contribution of Vertical Greening Systems and Green Roofs Water, 2021.*

**Facade Bound Greening** - Facade-bounded greening is a type of green wall using irrigation technology and unique substrates to reduce the weight of green facades. They are more expensive than ground-based greening and require higher use of resources in construction and maintenance. Facade-bounded greening allows for a combination of 10–15 plant species, most often mosses and perennials, and grows fast and uniform. The thin layer of soil inhibits their suitability in cold, temperate regions.

Figure 19: Wall-based green facades, either with panels attached to the wall or as stand-alone systems



Source: *Closing Water Cycles in the Built Environment through Nature-Based Solutions: The Contribution of Vertical Greening Systems and Green Roofs*. Water. 2021.

#### Heat Regulation

- The vegetation layer of the green facade absorbs solar radiation through photosynthesis, protects the heat transmission into the building, and provides shade if trees are planted. It reduces building temperature and cools the surrounding air.
- Research conducted in Lagos, Nigeria, showed that a green facade reduces internal air temperatures by an average of 2.3°C (36.14°F), and reduces the temperature of the facade itself between 2°C and 10°C (35.6°F and 50°F) compared to the natural stone (World Bank 2021)

#### Potential Location of Implementation of Green Facade Treatment



Retail Buildings



Hotels



Bus Stops



Residential Buildings

Source - World Bank, 2021. *A Catalogue of Nature-based Solutions for Urban Resilience*. Washington, D.C. World Bank Group

#### 4. Name of Solution - Cooling Shelter

**Location** - Places of high footfall and pedestrian-intensive location

Cooling shelters in cities serve as **climate-resilient spaces** designed to provide relief from extreme heat, particularly during heatwaves. These shelters are strategically located in **high-footfall areas such as bus stops, markets, parks, and transport hubs**, offering shaded and ventilated spaces for public use.

They incorporate **passive cooling techniques**, including **green roofs, bamboo or perforated structures, solar-reflective materials, and evaporative cooling systems**. Some shelters also integrate **water dispensers, misting systems, and vegetation** to enhance cooling further.

Cooling shelters help protect vulnerable populations, improve urban thermal comfort, and contribute to a city’s **heat action plan by reducing** heat exposure and offering a comfortable resting place.

Figure 20: Cooling Shelter



Source: Freepik

Figure 21: Components of Cooling Shelter

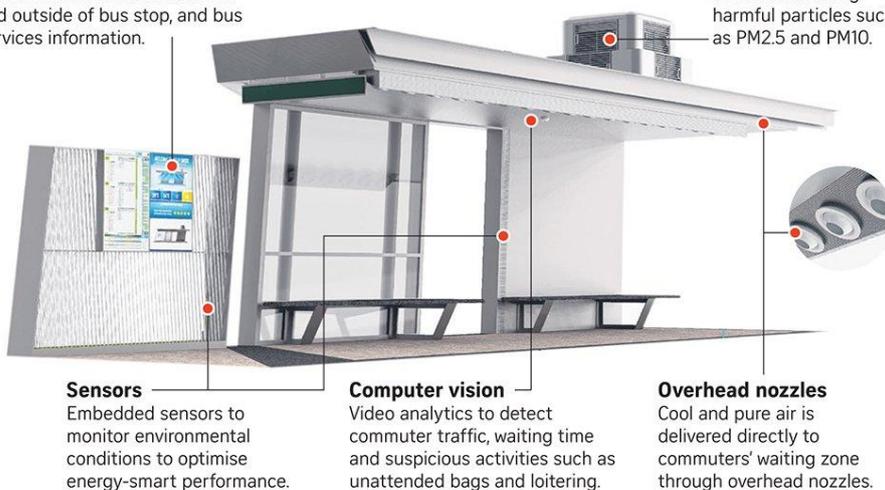
### Cool comfort for commuters

**Interactive panels**

Displays real-time information on environmental conditions within and outside of bus stop, and bus services information.

**Airbitat Oasis**

Creates cool and pure air while removing harmful particles such as PM2.5 and PM10.



**Sensors**

Embedded sensors to monitor environmental conditions to optimise energy-smart performance.

**Computer vision**

Video analytics to detect commuter traffic, waiting time and suspicious activities such as unattended bags and loitering.

**Overhead nozzles**

Cool and pure air is delivered directly to commuters’ waiting zone through overhead nozzles.

Source: Ilyas Sholihyn. 2018. “Singapore trials ‘smart’ bus stop that tracks commuters, detects shady activities, and blows cool air”.

With more than 900 plus multi-purpose cyclone shelters, already established in the state, it provides a good opportunity to also leverage the existing infrastructure for a combination of passive cooling (green roofs, cool roofs) and active cooling solutions (misting, AC, fans).

Figure 22: Ahmedabad Cool Bus stop



Source: Ahmedabad Cool Bus Stop, AMC, AMTS, and MHT

Source:

1. Hess, Jeremy.J. 2023. "Cooling Centres", Risk Reduction Guidance
2. Open Gov. 2018. "Smart Bus Stop being trialled in Singapore to improve the commuter experience", Singapore. accessed at <https://opengovasia.com/2018/03/12/smart-bus-stop-being-trialled-in-singapore-to-improve-commuter-experience/>

## 5. Name of Solution - Shading Structures on Footpaths

**Location** - Pedestrian Pathways

Shading infrastructure is crucial in **enhancing pedestrian comfort, reducing heat exposure, and improving walkability** in urban areas. Shading is an effective method of improving microclimate conditions in cities, and shading structures such as canopies and covered walkways can improve pedestrians' thermal comfort in open urban spaces (Hsing-Yu Ou et.al 2023). By integrating shading solutions, cities can create **cooler, more comfortable, and safer pedestrian environments** while mitigating the **urban heat island (UHI) effect**.

**Fabric Canopies & Tensile Structures** (Latifa Sultana et.al 2019)

- Lightweight, **fabric-based shading systems** (e.g., tensile fabric canopies) offer **flexibility and easy installation**.
- Reflective or light-colored fabrics help **reduce heat absorption**.
- Ideal for **temporary events, public plazas, or narrow streets where trees cannot be planted**.

**Bamboo & Wooden Shade Structures** (Renwu Wu et al. 2023)

- **Sustainable materials** like bamboo and wood create **eco-friendly and visually appealing shading elements**.
- These can be used as **arched walkways, pergolas, or modular canopy designs**.
- Suitable for **urban promenades, cultural districts, and heritage sites**.

### Benefits of Shading Infrastructure in Urban Areas

- **Enhances Pedestrian Comfort & Walkability:** Encourages people to **walk and use public spaces**, reducing car dependency.
- **Mitigates Urban Heat Island (UHI) Effect:** Reduces heat absorption from roads, buildings, and sidewalks.
- **Improves Public Health:** Lowers risks of **heat exhaustion, dehydration, and heat-related illnesses**.
- **Supports Sustainable Urban Design:** Integrating greenery and shading promotes **climate-adaptive city planning**.

Figure 23: Pedestrian Shelter



Source: Adele, Peters. 2021. "What US Cities can learn from Abu Dhabi about surviving record heat"

#### Source

1. Ou, Hsing-Yu, Tzu-Ping-Lin. 2023. "Effects of Orientation and Dimension of Shading Structure on Thermal Comfort". vol(243). <https://doi.org/10.1016/j.buildenv.2023.110715>
2. Sultana, Latifa, Bari, Nafisa. 2019. "A Study on the Impact of Tensile Fabric Structure in Semi-Outdoor Spaces of Tropical Cities". International Journal of New Innovations in Engineering and Technology. vol(10)
3. Wu, Renwu, Na Wu, Xinge Nan, Hai Yan, Ke Wang, Tingting Ma, Juan She, and Zhiyi Bao. 2023. "Effects of the Bamboo Communities on Microclimate and Thermal Comfort in Subtropical Climates" *Forests* 14, no. 6: 1231. <https://doi.org/10.3390/f14061231>

### 6. Name of Solution - Urban Greenery

**Location** - Locations in cities with exposed pavements, exposed roads, and locations with less green covers

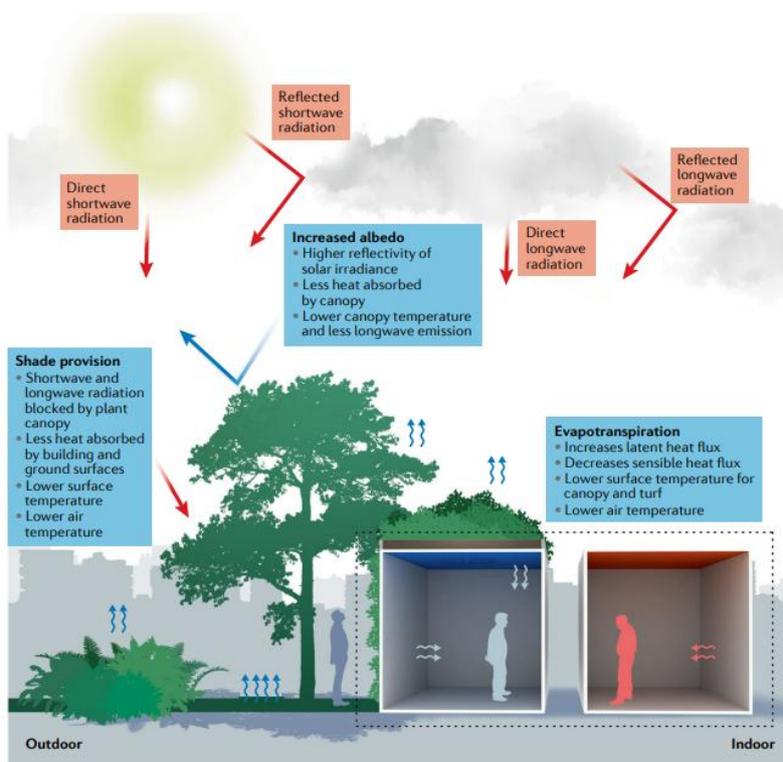
Urban greenery modifies shade provision, evapotranspiration, and albedo. Combining these three

mechanisms reduces sensible heat gain, lowering heat gain and surface temperatures. Red boxes indicate warming mechanisms and blue boxes indicate cooling mechanisms.

### How Urban Greenery Reduces Heat (Nyuk Hien Wong et al. 2021)

1. **Shade Provision**
  - Trees and vegetation block direct solar radiation, reducing the heat absorbed by buildings, roads, and ground surfaces.
  - This leads to lower surface temperatures and cooler surrounding air, creating shaded microclimates that enhance pedestrian comfort.
2. **Increased Albedo Effect**
  - Green canopies reflect more sunlight than dark urban surfaces, reducing heat absorption.
  - Lower canopy temperatures result in less longwave radiation emission, which helps cool the environment.
3. **Evapotranspiration Cooling**
  - Plants absorb water through their roots and release moisture through evapotranspiration, increasing humidity and reducing surrounding air temperature.
  - This process also lowers surface temperatures of green spaces, rooftops, and walls, preventing excessive heating of urban structures.

Figure 24: Factors contributing to UHI in cities



Source: Nyuk Hien Wong, Chun, Liang Tan, Dionysia, Denia Kolokotsa and Hideki Takebayash. N.d. "Greenery as a mitigation and adaptation strategy to urban heat".

### Case Studies - Singapore Green Plan (2030)



GSDMA

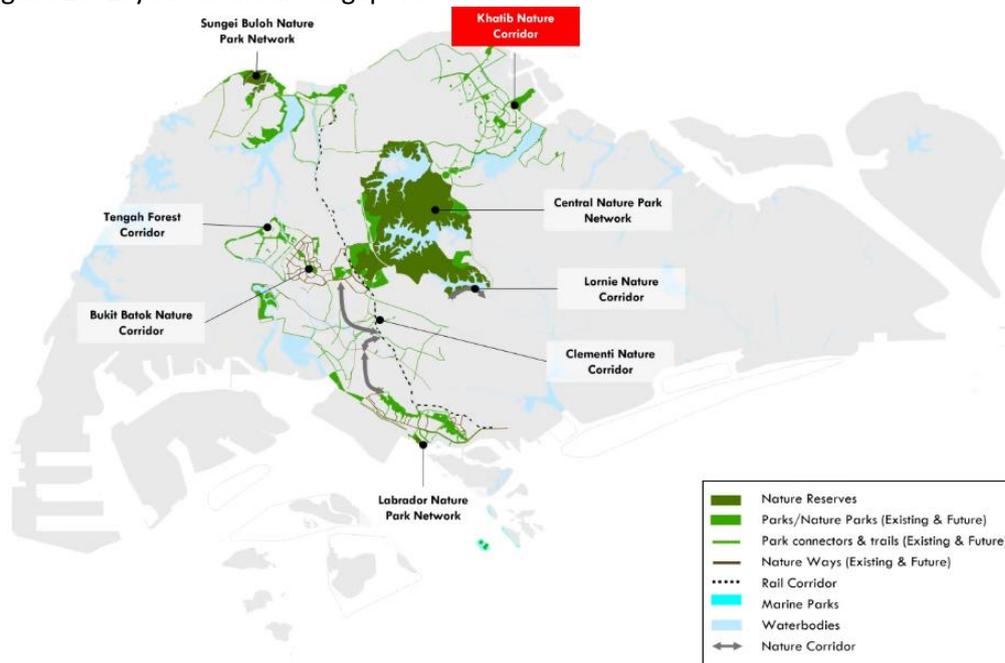


The **City in Nature** program, launched in 2020, was a key initiative under **Singapore's Green Plan 2030**. It aimed to transform the country into a green, livable, and sustainable home for its citizens by 2030 ([Green Plan Singapore 2023](#)).

By 2030, Singapore intends to introduce **200 hectares of skyscraper greenery and plant over 170,000 more trees in industrial areas**, bringing nature into the city's dense urban fabric.

To improve accessibility to green spaces, Singapore committed to strengthening connections between green spaces by constructing **300 kilometers of Nature Ways and 500 kilometers of park connectors**. This would ensure that every household was within a 10-minute walk of a park.

Figure 25: Layout of Green Singapore



### Singapore Therapeutic Garden

- These gardens are designed based on scientific research to **encourage interaction with nature, enhancing the overall well-being** of visitors and residents ([Green Plan Singapore 2023](#)).
- These gardens are carefully planned spaces that provide a **calm and natural environment to promote relaxation, reduce stress, and improve mental and emotional health**. They aim to offer a restorative experience for individuals of all ages.

Figure 26: Therapeutic Garden



Source

1. Wong, N.H., Tan, C.L., Kolokotsa, D.D. *et al.* Greenery as a mitigation and adaptation strategy to urban heat. *Nat Rev Earth Environ* 2, 166–181 (2021). <https://doi.org/10.1038/s43017-020-00129-5>
2. Singapore Green Plan. 2023. “A City of Green Possibilities”. accessed at <https://www.greenplan.gov.sg/>

## 7. Name of Solution - Cool Pavements

**Location** - Pedestrian Pathways and locations with high footfalls

### Cool Pavements and Their Implementation in Urban Areas

Cool pavements are specially designed surfaces that reduce heat absorption and **lower urban temperatures** than conventional asphalt and concrete pavements. These pavements are essential in mitigating the **urban heat island (UHI) effect**, as traditional dark-colored roads and sidewalks absorb and retain heat, increasing surface and air temperatures.

Cool pavements use materials and technologies that **reflect more sunlight, absorb less heat, and enhance cooling**. They are categorized into:

1. **High-Albedo Pavements** – These pavements have **light-colored or reflective surfaces** that reduce heat absorption and increase solar reflectance (albedo), keeping temperatures lower.
2. **Permeable Pavements**—Made of materials like porous asphalt, permeable concrete, or interlocking pavers, permeable pavers allow water to seep through, reducing surface temperatures through evaporative cooling.
3. **Evaporative Pavements** contain water-retaining materials that **absorb and release moisture through evaporation**, cooling the pavement surface.

### Benefits of Cool Pavements and Evaporative Pavements Work

#### Cool Pavements

1. **High reflectivity (Albedo Effect):** They reflect more sunlight rather than absorbing it as heat (Taha H et al. 2002).
2. **Lower surface temperatures:** Studies show they can be **10-20°C cooler** than traditional asphalt (Sophia Kappou et al. 2022).
3. **Durability & Sustainability:** Many superb pavement materials are designed to be **longer-lasting** and reduce energy costs.

#### Evaporative Pavements

1. **Moisture retention:** These pavements contain hydrophilic materials that **store water and gradually release it** through evaporation.
2. **Heat dissipation:** The evaporative cooling effect lowers surface temperatures, making surrounding areas more comfortable.
3. **Permeability:** They allow rainwater infiltration, reducing runoff and improving groundwater recharge.

### Actionable Implementation of Cool Pavements in Urban Areas

1. **Public Spaces & Sidewalks** – Applying cool pavement coatings to pedestrian pathways and public squares reduces surface heat and improves walkability.
2. **Roadways & Parking Lots** – Using high-reflectivity materials in parking areas prevents excessive heat accumulation.
3. **Playgrounds & Sports Courts** – Implementing cool pavement surfaces in schools and parks enhances thermal comfort for children and athletes.
4. **Bus Stops & Transit Hubs** – Applying permeable and evaporative pavements in transportation areas lowers heat stress for commuters.
5. **Residential & Commercial Driveways** – Using permeable concrete or reflective coatings in driveways improves local cooling and stormwater management.

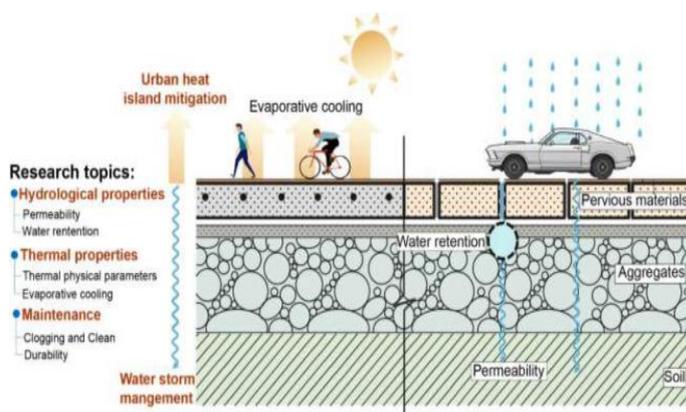
Cool pavements are **cost-effective, environmentally friendly, and improve urban resilience** against extreme heat. Their integration with **green infrastructure**, such as **tree-lined streets and shaded pedestrian pathways**, further enhances city cooling benefits.

Figure 27: Dark Pavements v/s Cool Pavements



Source: Lui, Hui, John, Harvey, Arash, Saboori, Ali, A Butt. 2017. “Development and Application of LCA Tool for Cool Pavement”. University of California

Figure 28: Evaporative Cooling



Source: Performance synergism of pervious pavement on stormwater management and urban heat island mitigation: A review of its benefits, key parameters, and co-benefits approach. Water Research. 2022

Source

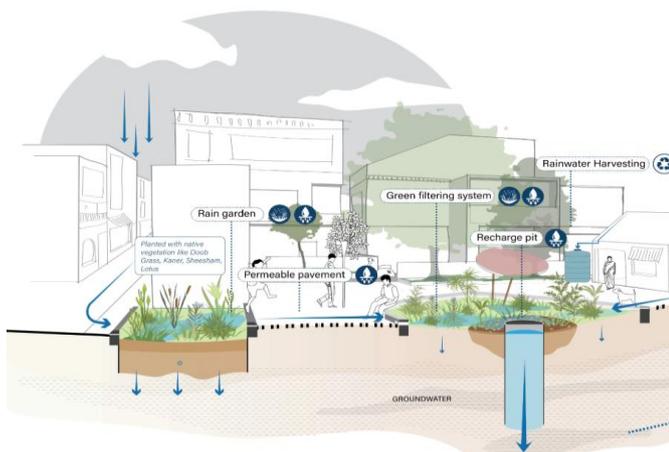
1. USEPA. 2024. "Using Cool Pavements to Reduce Heat Islands". accessed at <https://www.epa.gov/heatislands/using-cool-pavements-reduce-heat-islands>
2. Kappou, Sophia, Manolis Souliotis, Spiros Papaefthimiou, Giorgos Panaras, John A. Paravantis, Evanthie Michalena, Jeremy Maxwell Hills, Andreas P. Vouros, Aikaterini Ntymenou, and Giouli Mihalakakou. 2022. "Cool Pavements: State of the Art and New Technologies" Sustainability 14, no. 9: 5159. <https://doi.org/10.3390/su14095159>
3. H, Taha, Hammer H, Akbari H. 2002. Meteorological and air quality impacts of increased urban surface albedo and vegetative cover in the greater Toronto area, Canada. Lawrence Berkeley National Laboratory report No. LBNL-49210. Berkeley, CA.

**8. Name of Solution - Development of Urban Acupuncture**

**Location** - Urban Voids, Pocket Parks, Kitchen Gardens in Hospitals

Areas with high public activity levels can be used to incorporate the Disaster Risk Reduction (DRR) concept. These public spaces can also leverage the **small niches, corner greens/buffers, and neighborhood parks to be holistically developed into blue-green acupunctures of varying scales.** Multiple acupuncture can also be designed in conjunction. For example, recharge wells can be part of a stormwater park that can help improve the overall livability of the area. If the groundwater level is shallow, water collected into these wells can be treated using native plants. In cases where it's deep, the water can retain and recharge naturally.

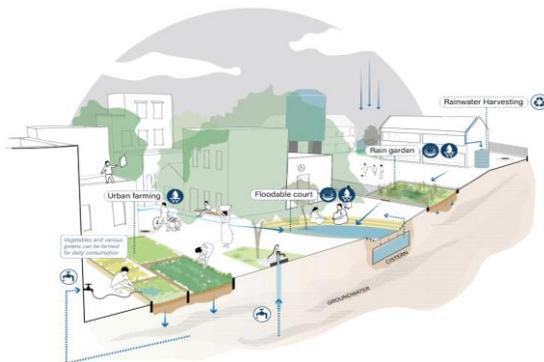
Figure 29: Development of Urban Blue-Green Acupuncture



Source: WRI India. 2021, "Creating a flood resilient Indian "Sheher" through Water Sensitive Urban Design"

In cities, the marginalised neighborhoods are adversely affected by flooding and are further crippled with challenges such as inadequate access to WASH and the right to healthy spaces. These urban settlements are highly dense, organic, and lack open spaces; the blue-green acupunctures will have multi-functional and circular values. Small pockets of open spaces (community kitchen gardens, wetlands) will be carved up, which can be synergistically designed to provide clean water, livelihood, and public green spaces. Efficient rainwater harvesting and recharge wells can ensure access to safe, clean water for the community.

Figure 30: Leveraging small open spaces to act as temporary ground for water



Source - WRI India. 2021, "Creating a flood resilient Indian "Sheher" through Water Sensitive Urban Design"

### 9. Name of Solution - Thatch / Palm Leaves for roofing

**Location** - Rural and Peri-Urban Areas

Bamboo, Thatch, and palm leaves are locally available across India and can be installed as a secondary roof screen, reducing the heating effect.

Traditional materials like bamboo, thatch, and palm leaves offer excellent heat mitigation and solar reflectance benefits, making them ideal for sustainable architecture.

With natural light tones, thatch and palm leaves reflect some solar radiation while providing effective insulation due to the trapped air within their fibers, keeping interiors cooler.

When used in slatted or woven forms, bamboo creates a semi-permeable barrier that allows light and air to pass through, reducing heat buildup.



Medium to High



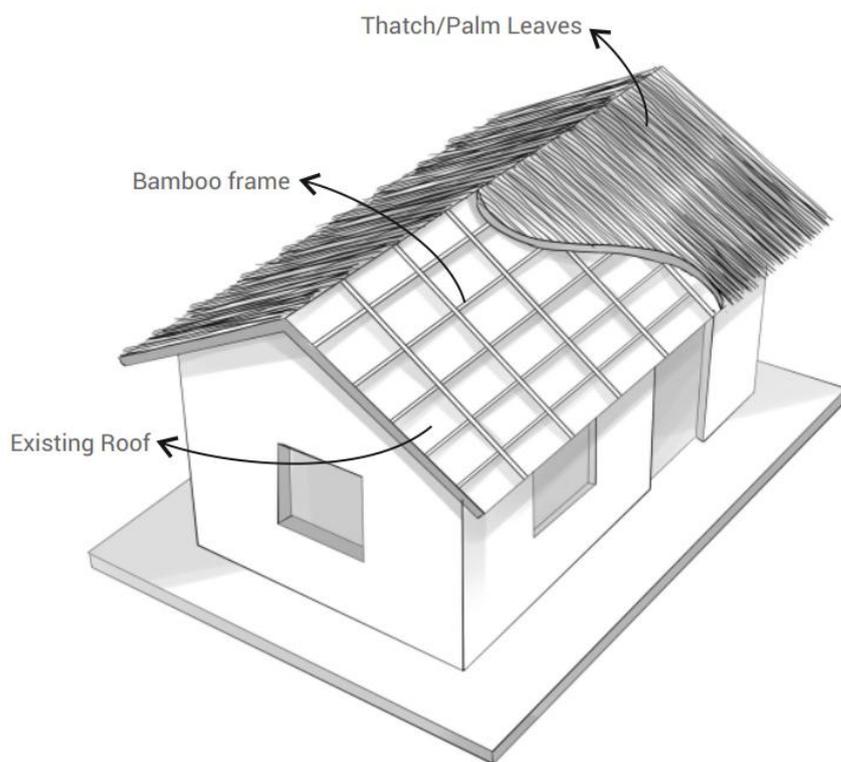
6 - 8 Months



< Rs 100/sqft

### Method for Installation

Figure 31: Deployment of Thatch / Palm leaver over roofs



Clean the roof surface to remove dust and particles



Fix the bamboo frame on to the roof



Lay the thatch/leaves on the frame and tie with rope

Source: NDMA 2021 "House Owners' Guide to Alternate Roof Cooling Solutions," New Delhi

Source -

1. NDMA (2021) "House Owners' Guide to Alternate Roof Cooling Solutions," New Delhi

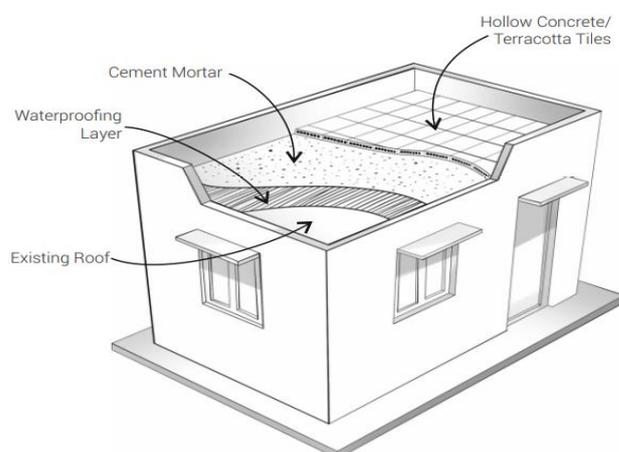
## 10. Name of Solution - Hollow Terracota/ Concrete Tiles

Location - Exposed Rooftops

- Hollow concrete/terracotta tiles have high thermal and sound insulation properties, limiting heat flow. The air inside the cavities provides the insulation to heat.
- Hollow concrete tiles contribute to heat mitigation by enhancing thermal insulation and reducing heat absorption. Their **hollow cores trap air as a natural insulator, slowing heat transfer and cooling surfaces.**
- Unlike solid concrete, which retains heat and radiates it back into the surroundings, hollow tiles minimize thermal mass, reducing the urban heat island effect.
- Additionally, their design allows for **better airflow, further aiding in cooling by dissipating trapped heat.**

- Hollow concrete tiles can significantly lower surface temperatures, creating a more comfortable microclimate, especially in hot and humid regions when used in pavements, roofs, or facades.
- Their ability to accommodate **water-permeable designs also supports cooling through evaporative effects**, enhancing their role in sustainable urban development.

Figure 32: Deployment of Hollow Concrete / Terracotta Tiles on existing roofs



Source: NDMA. 2021 "House Owners' Guide to Alternate Roof Cooling Solutions," New Delhi

Source -

1. NDMA (2021) "House Owners' Guide to Alternate Roof Cooling Solutions," New Delhi

## 9 Health sector preparedness and response plans

Health sector has to play one of the most crucial roles in advancing heat resilience. Effective health sector preparedness, timely response, and long-term planning for risk reduction are crucial for minimizing the adverse impacts of extreme heat, particularly on vulnerable populations. This includes understanding the clinical manifestations of heat-related illnesses (HRIs), establishing protocols for their timely management, and ensuring that health facilities are equipped with dedicated heatwave wards and robust response mechanisms. Integrating Heat Health Early Warning Systems is also a key component, allowing for timely alerts and coordinated interventions when extreme heat conditions are anticipated.

As part of a comprehensive Heat Action Plan (HAP), these measures form the foundation for a resilient public health response—one that can anticipate, manage, and mitigate the health impacts of extreme heat through both preventive and reactive strategies. This chapter, based on the guiding documents provided by India's National Programme on Climate Change and Human Health, NCDC, MoHFW, outlines measures for health sector resilience.

### 1. Understanding and managing heat-related illnesses

One of the most direct outcomes of extreme heat is Heat-related illnesses (HRI), which have now emerged as a significant public health concern, notably contributing to fatalities associated with extreme heat events ([Savioli et al., 2022](#)). In India alone, reports presented in the Lok Sabha in 2024 revealed that there were more than 67,637 suspected cases of heatstroke between March and July

due to severe heat waves in the same year ([Vasudha Mukherjee, 2024](#)). A global systematic review indicates that for every degree rise in temperature from the baseline, there is an associated increase of 18 per cent in morbidity and a staggering 35 per cent in mortality related to heat illnesses ([Faurie et al., 2022](#)).

### 1.1 Pathophysiology

Human beings maintain a core body temperature of 37°C through four primary heat dissipation mechanisms :

- Conduction: transfer of heat through direct contact with a cooler object or air.
- Convection: heat transfer through direct contact with cooler air.
- Evaporation: loss of heat through sweat or water on the skin.
- Radiation: Heat is transferred from the skin tissue to the surrounding air.

It's important to note that, except for evaporation, the effectiveness of the other three pathways diminishes at temperatures above 35°C. Additionally, when relative humidity exceeds 75 per cent, evaporation becomes inefficient too ([NPCCHH, 2024](#)). As the thermoregulatory system becomes overwhelmed due to the inability to dissipate body heat, individuals may experience a range of heat-related illnesses (HRI). These can range from non-fatal conditions such as heat cramps, exhaustion, rashes, and edema to the more severe and potentially fatal heat stroke. If non-threatening conditions are not addressed on time, they can progress into heat strokes.

Table 12: The range of heat-related illness

Heat-Related Illnesses	ion	nt
<b>Severe illness</b>		
Heat stroke	A multisystem, life-threatening illness characterised by elevation of the core body temperature (>40°C) and CNS dysfunction	Move the patient to a cool environment; manage airway, breathing, and circulation; administer rapid cooling with cold-water or ice water immersion or other means; administer intravenous rehydration; and evacuate to the emergency department after on-site cooling is performed. ICU admission is warranted for the management of end-organ sequelae.
<b>Moderate illness</b>		
Heat exhaustion	Profound fatigue, weakness, nausea, headache or dizziness or a combination of these symptoms resulting from a decrease in body water content or blood volume due to water or salt depletion from heat exposure; mild elevation (<40°C) in body temperature may be present, but not altered mental status	Remove patient from the hot environment; treat with rest in supine position, evaporative cooling, and intravenous or oral rehydration; monitor mental status. A delayed response to treatment warrants further evaluation
<b>Mild illness</b>		
Heat syncope	Brief loss of consciousness due to vasodilation and pooling of blood in the limbs as a result of physiological compensation to heat exposure	Remove patient from the hot environment; treat with rest in supine position, passive cooling, and intravenous or oral rehydration. Prolonged recovery or a medical history or physical examination arousing concern for a cardiac cause, if the patient has cardiac risk factors, should prompt further evaluation
Heat edema	Swelling of limbs caused by peripheral vasodilation and interstitial pooling resulting from physiological compensation in response to	Remove the patient from the hot environment and elevate the legs. Diuretic agents are not indicated

	heat exposure	
Heat cramps	Painful muscle spasms in the abdomen, arms, or legs during or after activity in the heat, which often occur when excessive amounts of salt are lost during sweating from physical exertion	Remove patient from the hot environment, treat with rest, oral electrolytes, and fluid repletion
Heat rash	An inflammatory disorder of the epidermis that results from blockage of sweat glands; may be followed by superimposed bacterial soft-tissue infection	Remove patient's clothing; treat with evaporative cooling and glucocorticoid and antibacterial cream as needed, but avoid topical emollients; monitor for cellulitis. Advise the patient to avoid hot environments and to wear loose clothing.

Source: [Sorensen et al., 2022](#)

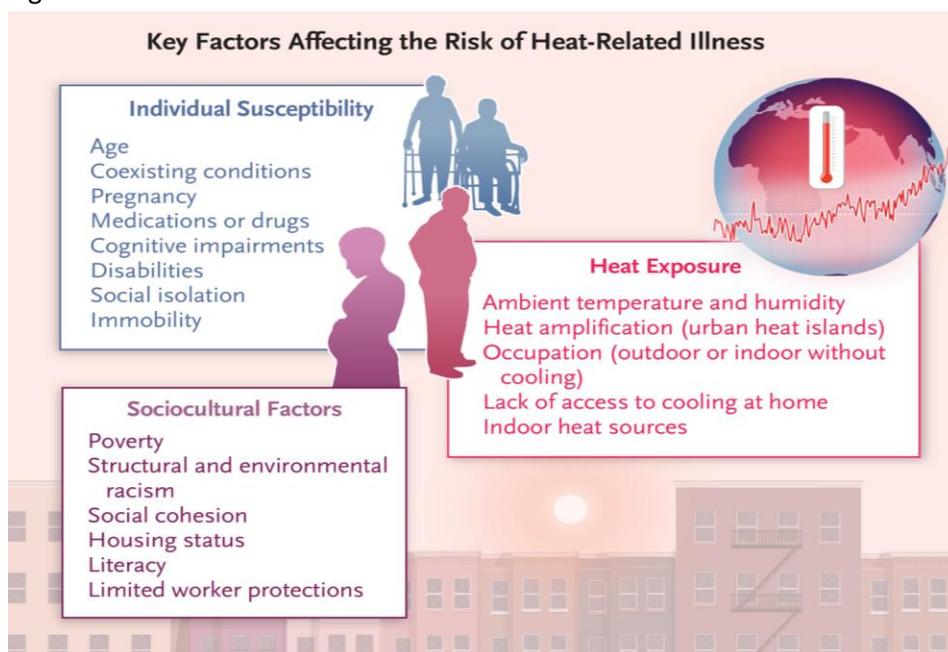
### 1.2 Risk factors for HRI

Increasing frequency and intensity of extreme heat events predispose certain groups to HRI. This risk is an amalgamation of 3 factors ([Sorensen et al., 2022](#)):-

- Heat exposure: a combination of ambient temperature, humidity, and bodily metabolic heat generated
- Individual vulnerability: age, sex, gestational status, and preexisting illnesses
- Socio-cultural factors: income status, healthcare access, working and living conditions

The risk factors have been quantified in chapter four of this heat action plan, where a ward-level heat risk map has been developed.

Figure 33: Risk Factors of Heat-Related Illness



Source: [Sorensen et al., 2022](#)

### 1.3 Heat stroke

On the spectrum of HRI, Heat strokes are considered a catastrophic emergency requiring immediate medical assistance. It is characterised by an increased core body temperature of 40°C and above associated with neurological dysfunction such as convulsions, delirium, and, in severe cases, coma. There are two types of heat strokes:

- Classical Heat Stroke (CHS): Occurs periodically in vulnerable groups at increased risk to HRI in extreme heat and humid environments
- Exertional Heat Stroke (EHS): Individuals engaged in high physical activity levels in extreme heat and humid conditions are predominantly at risk. Occupations such as athletes, outdoor manual workers, and military personnel are particularly vulnerable to these environmental stresses.

The primary distinction between EHS and CHS is the inability to dissipate excess internal heat stored from increased skeletal muscle activity. However, the clinical manifestations of both conditions remain the same, irrespective of the cause.

Table 13: Features of EHS and CHS

Feature	Exertional Heat Stroke	Classic Heat Stroke
Occurrence	Sporadic (any time of year)	Epidemic (heat waves)
Exposure	A. Athletic event B. Working in high heat stress conditions	A. High environmental heat with/without high humidity

Acute risk factors	<ul style="list-style-type: none"> <li>● Dehydration</li> <li>● Concurrent illness</li> <li>● Obesity</li> <li>● Wearing too much clothing</li> <li>● Poor cardiovascular fitness</li> </ul>	<ul style="list-style-type: none"> <li>● Lack of adequate ventilation/cooling</li> <li>● Confined places</li> <li>● Physical exertion not a prerequisite</li> </ul>
Heat equilibrium	<p>Overwhelmed: heat gain &gt; heat loss</p> <ul style="list-style-type: none"> <li>● Heat gain from environment with/without an increase in internal heat production</li> </ul>	<p>Impaired: reduced heat loss capacity</p> <ul style="list-style-type: none"> <li>● Internal heat loss mechanism impaired</li> <li>● Restricted/ inadequate ventilation</li> </ul>
Heat injury development	Quick rise in core body temperature (over minutes/hours)	Slow rise in core body temperature (over hours or days)
Sweating	Usually present (wet skin)	May be absent (dry skin)
CNS dysfunction	Common	Common
Pathophysiological changes	<ul style="list-style-type: none"> <li>● Metabolic acidosis</li> <li>● Hypoglycaemia</li> <li>● Rhabdomyolysis: Frequent</li> <li>● Liver dysfunction: Severe</li> <li>● Renal failure: Common</li> <li>● DIC: Severe</li> <li>● Hypocalcaemia, Hyperkalemia</li> </ul>	<ul style="list-style-type: none"> <li>● Respiratory alkalosis</li> <li>● Liver dysfunction: mild</li> <li>● DIC: Mild</li> <li>● Volume and electrolyte abnormality is common</li> </ul>
<b>Risk factors</b>		
Physiological	<ul style="list-style-type: none"> <li>● Healthy, active adult</li> </ul>	<ul style="list-style-type: none"> <li>● Elderly</li> <li>● Children</li> <li>● Pregnancy</li> <li>● Obesity</li> <li>● Chronic illness</li> <li>● Poor physical or psychological health</li> </ul>
Medication/ drug use	Amphetamines and amphetamine like agents, MDMA, cocaine, PCP and LSD, synthetic stimulants of the cathinone class, alcohol	Antihypertensives, laxatives, anticholinergic drugs, salicylates, thyroid agonists, benzotropine, trifluoperazine, butyrophenones, tricyclic antidepressants, SSRIs
Socio-economic (individual/ institutional)	Occupation/ physical exertion linked: work time, duration, adequate time to rest, lack of cooling and hydration facilities	<ul style="list-style-type: none"> <li>● Social isolation</li> <li>● Living on higher floors</li> <li>● Unventilated and non-air conditioned living space</li> <li>● Inability to care for oneself</li> </ul>

Source: [NPCCHH, 2024](#)

#### 1.4 Clinical manifestation

The signs and symptoms of heat stroke are:

- Warm skin with or without sweating
- Hypotension
- Tachycardia
- Tachypnea
- Anhidrosis is the last presentation

The liver and brain are particularly vulnerable to the effects of hyperthermia, and the prognosis is influenced by both the severity and duration of the hyperthermic episode. However, if cooling measures are implemented promptly and completed within 30 minutes of the onset of symptoms, the chances of death can be reduced to zero. This emphasises the critical importance of rapid intervention in preventing severe health outcomes in hyperthermic patients ([Savioli et al., 2022](#)).

#### 1.5 Severe Heat-related Illness Management

Heat-related illnesses are largely preventable, but if not promptly identified and managed, they can lead to severe health complications and, in critical cases, even death. The clinical manifestations of heat stroke can closely resemble those of various other conditions, including sepsis, metabolic disorders, cerebrovascular events, neuropathic emergencies, and potential toxicological exposures. Therefore, it is always essential to record the core body temperature and rule out other causes of hyperthermia. Simultaneously, prompt initiation of heat stroke treatment is critical to avoid adverse health outcomes. A comprehensive set of routine investigations should be conducted for patients suspected of heat stroke. These include:

- Complete blood count (CBC)
- Arterial blood gas (ABG) analysis
- Liver function tests (LFTs)
- Kidney function tests (KFTs)
- Blood glucose levels
- Electrolyte panel
- Toxicological screening
- Urinalysis
- Additionally, a chest X-ray should be performed if the patient exhibits respiratory symptoms. This thorough assessment helps guide appropriate treatment and management of heat stroke.

The foundation for effectively treating HRI lies in quickly recognising heat as a causative factor, implementing rapid cooling techniques, and relocating the patient to a cooler environment. Rapid cooling is the most effective treatment for suspected HRI cases, reducing the risk of mortality from more than 50 per cent to as low as 5 per cent ([U.S. Customs and Border Protection](#)). The technique adopted should be completed within 30 minutes of the onset of symptoms, ultimately maintaining a core body temperature between 38 to 39°C.

## 2. Rapid cooling

Heat-related illnesses, particularly heatstroke, require immediate cooling to prevent severe organ damage or fatal outcomes. Rapid cooling treatments help lower the body temperature as quickly as possible to prevent complications like brain swelling, kidney failure, and cardiovascular stress.

## 2.1 Managing principles when considering Rapid Cooling in heat stroke suspected cases

- Assess competency of airway, breathing, circulation, disability, and exposure before treatment initiation and monitor them throughout the procedure, particularly in CHS patients.
- A temperature gradient must be created between the skin and the surroundings, leveraging the body's thermoregulatory mechanisms.
- Cooling rates between 0.784 to 0.154 Deg C/min are efficient in preventing further organ dysfunction complications.
- The primary aim of managing heat stroke patients in emergencies is to *“Cool first, Transport second”* (NPCCHH, 2024)
- Depending on the scene of the collapse, appropriate cooling techniques should be undertaken to complete cooling within 30 minutes of clinical presentation.
- It is not required to differentiate a case between EHS and CHS, as the treatment line remains the same.
- Cooling is not advised when the body temperature is normal or low.
- Avoid prescribing antipyretics such as Paracetamol, Aspirin, Ibuprofen, etc.
- The use of Dantrolene, a skeletal muscle relaxant, is also not recommended in EHS.

## 2.2 Challenges

- Shivering may be triggered by rapid cooling even after persistent hyperthermia and is more commonly seen in the elderly and children. In such cases, wet bedsheets, water spray, and fans are used to cool the patient down. If shivering persists, seek pharmacological support.
- Monitoring of vital signs is crucial through electrodes, especially for severely ill patients presenting with CHS, as they are at an increased risk of cardiovascular decompensation. In cases of rapid cooling methods such as cold water immersion, it is not possible.

## 2.3 Appropriate rapid cooling techniques for heat strokes

### 2.3.1 For Exertional Heat Stroke

#### i. Ice/ Cold water immersion

The use of cold water immersion is widely recognized as the gold standard for cooling patients with exertional heat stress (EHS) who are otherwise physically healthy. Due to its high thermal conductivity, cold water facilitates efficient and rapid cooling compared to alternative methods.

Resources required: Tub/ Portable pool/ Tarp, cold water, ice buckets with ice, rectal thermometer, lubricating gel, 3-4 towels, tarp for shade, if outdoors, 3 to 4 trained personnel for stirring the water, recording vitals, managing patient vitals, and monitoring rectal temperature.

Mechanism: In this technique, a vessel filled with ice slurry or cold water is maintained at a temperature between 2 to 10°C. The patient should be exposed as much as possible to the cool medium and immersed up to the torso with hands outside the vessel. A cold cloth should also be placed on the head for additional cooling. The patient should be securely positioned with a cloth under the axilla and stabilised by personnel to prevent any risk of drowning. The immersion should

last between 15 to 20 minutes, with the water being vigorously stirred to enhance heat transfer. This process should continue until shivering occurs or the patient reaches a target temperature of 38°C to 39°C. Following successful cooling, the patient should be transported to the nearest emergency department for further monitoring and evaluation. Continue cooling in the best possible way if temperatures are not met during transportation.

Cooling time: 15 minutes

Challenges: Effective pre-planning is essential for managing heat stroke incidents in the field, necessitating the allocation of appropriate resources, both material and personnel. This requires thorough preparation and coordination to ensure a timely and effective response.

Figure 34: Cold Water Immersion in the field



Source: NPCCHH, 2024

## ii. Tarpaulin-Assisted Cooling with Oscillation (TACO)

This method is designed for use in resource-limited settings.

Resources required: Instead of a traditional tub or pool for cold water immersion, a tarpaulin is utilized.

Mechanism: First, the tarpaulin is filled with ice, and the patient lies on their back in the centre of the tarp. The corners of the tarp are then lifted, allowing cold water to be added until the patient's chest is fully submerged. To enhance the cooling effect, the tarp is gently moved back and forth to mix the ice and water, facilitating effective cooling.

Challenges: It requires dedicated staff just for lifting patients. For obese patients, more people may be needed.

Cooling time: 10 to 15 minutes

Figure 35: TACO in the field



Source: NPCCHH, 2024

### iii. Cold water dousing with ice massage

Also known as Water Ice Therapy.

Resources required: Utilizes same resources as cold water immersion; additionally, a porous stretcher is used.

Mechanism: The patient is placed on the porous stretcher inside the tub/ portable pool, and multiple personnel drench the patient entirely except the head in the ice-cold water from the tub. Simultaneously massage muscles of the chest, abdomen, thighs, and legs with icepacks.

Cooling time: 12 to 24 minutes

## 2.3.2 For Classical Heat Stroke

### i. Body bag immersion

The technique has similar cooling rates as that of cold water immersion but allows for continuous monitoring of the patient as the chest is exposed. Hence, it is the ideal treatment mode in CHS patients. This technique can be used in the field, in an ambulance, or the emergency room of a hospital.

Resources required: Utilizes same resources as cold water immersion, except for a tub, a waterproof, leakproof body bag is used, and other medical equipment such as monitor, chest and limb leads.

Mechanism: Place the patient into the body bag filled with ice and cold water, baring the chest. Attach the monitor to assess ABCDE. Once the initial assessment is completed, close the body bag until the rectal temperature reaches 38 to 39°C.

Cooling time: 15 mins

Figure 36: Cold water immersion using a body bag in the emergency department



Source: NPCCHH 2024

### ii. Water spray and Directed Fan

This technique effectively utilizes the body's evaporative and convective thermoregulatory pathways, making it particularly beneficial in cases of CHS, especially for children and older adults.

Resources required: Spray bottle, fan

Mechanism: Once the initial assessment is complete, carefully expose the patient and lightly spray them with cold water while turning on the fan to enhance the cooling effect. If the patient begins to shiver, switch to using room temperature water to ensure their comfort.

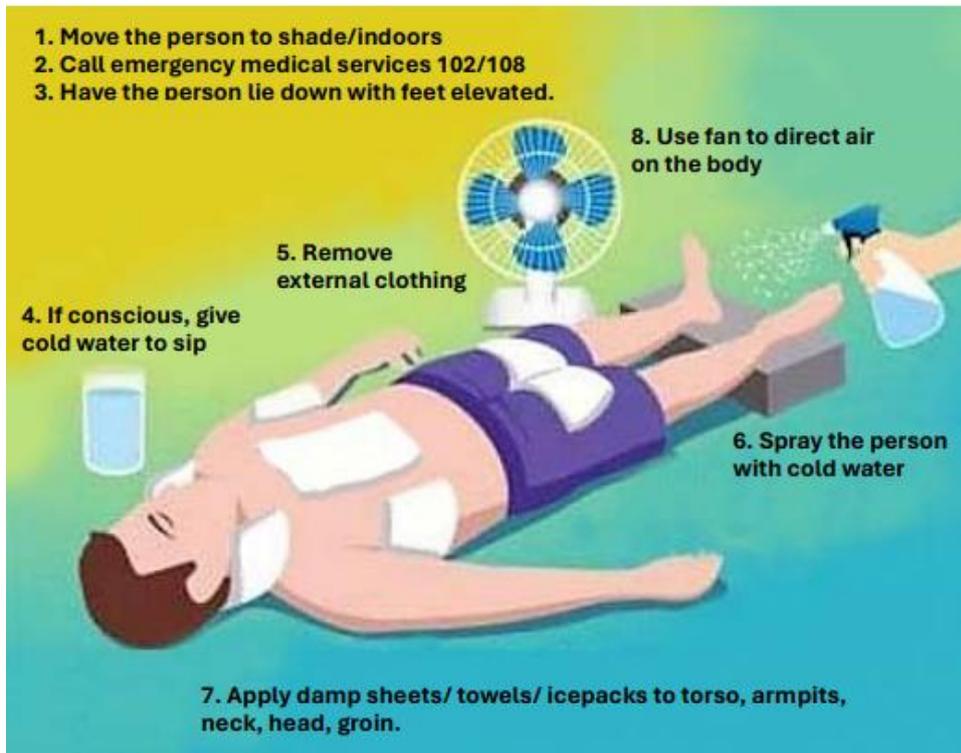
Challenges: It requires access to ample amounts of water and takes longer to cool down when utilizing water at room temperature.

### iii. Water-soaked bedsheets and Directed Fan

Soak bed sheets in cool water and apply them over the patient's exposed skin while positioning a fan to blow air at a high speed. This method is particularly effective for children and elderly patients, as it helps to lower body temperature quickly and safely.

**iv. Ice pack/ Crushed Ice, Water spray, and directed fan**

Figure 37: Multiple methods implemented at a time for rapid cooling



Source: [NPCCHH, 2024](#)

**3. Hospital initiatives towards heat wave preparedness**

Heatwave Ward: Specialised Hospital Care for Heat-Related Illnesses (Anumeha Yadav, 2024)

A heatwave ward is a dedicated hospital space designated for the treatment of patients suffering from mild and severe heat-related illnesses. These wards are especially crucial in regions experiencing extreme heat conditions due to climate change and rising global temperatures, leading to an increased frequency of hot days and nights.

Owing to the sudden rise in heat-related mortality in 2024, hospitals like Safdarjung, AIIMS (All India Institute of Medical Sciences), and RML (Dr. Ram Manohar Lohia Hospital) in Delhi have established specialised heatwave units to provide dedicated care for patients affected by extreme heat. These wards feature well-ventilated, air-conditioned rooms equipped with life-saving drugs, expert HRI-skilled medical staff, ORS, IV fluids, ice and cold water, along with advanced cooling technologies to stabilize patients and prevent life-threatening complications. (Ankita Upadhyay, 2024)

### Benefits of Heatwave Wards

- ❖ Prevents Fatal Heatstroke Cases: Rapid cooling interventions reduce mortality rates drastically, using evidence-based rapid cooling techniques to lower core body temperature.
- ❖ Reduces Heatwave-Related Hospital Admissions: Early intervention prevents complications and shortens hospital stays.
- ❖ Enhances Climate Resilience in Healthcare: These wards facilitate hospital preparedness for the rise in climate change-associated heat waves.
- ❖ Protects Vulnerable Populations: This is critical for elderly patients, outdoor workers, pregnant women, and those with chronic illnesses.

Figure 38: Inflated pools and Ceramic Tubs for Heat Wards



Source: Upadhyay, Ankita. 2024. "Battling 107°F fever with ice and water: Inside RML Hospital's heat stroke unit".

#### 4. Hospital Preparedness Measures for Managing Heat-related Illness

The hospital preparedness plan developed under the NPCCHH serves as a foundational guide for states to design, implement, coordinate, and assess heatwave response measures within health facilities.

It outlines planned activities across three seasonal phases: pre-heat season, heat season, and post-heat season. These activities are categorized into three main areas: infrastructure and logistics, capacity building and information, and education and communication (IEC)/awareness. The plan is tailored for three tiers of healthcare institutions: Primary Health Centres (PHCs), Community Health Centres (CHCs), and District Hospitals (DHs)//medical colleges (MCs).

Table 14: Hospital Preparedness Chart- Pre-heat, during, and post-heat Season

PHC	CHC	DH/MC
<b>A. Pre-heat Season</b>		
<b>INFRASTRUCTURE AND LOGISTICS</b>		
<ol style="list-style-type: none"> <li>1. Check inventories for basic equipment and medicines required.</li> <li>2. Ensure adequate arrangement of staff</li> <li>3. Explore the creation of ice pack dispensaries to increase access to vulnerable communities</li> <li>4. Adopt long-term measures such as cool roofs and improving the green coverage of health facility</li> <li>5. Identify a Rapid Response Team (RRT) to respond to any exigency call outside the hospitals</li> <li>6. Try to establish outreach clinics at various locations easily accessible to the vulnerable population</li> </ol>		
<b>CAPACITY BUILDING</b>		
<ol style="list-style-type: none"> <li>1. Prepare a detailed action plan to tackle HRI (updated annually).</li> <li>2. Organize fresher/refresher targeted training course—maintaining hospital records, improve expedience of recording of cause of death, heat illness examination procedures</li> <li>3. Community involvement of trained staff to create awareness.</li> </ol>		
<ul style="list-style-type: none"> <li>• Map susceptible villages (identify areas/populations that are vulnerable)</li> </ul>	<ul style="list-style-type: none"> <li>• Map susceptible PHCs (identify areas/populations that are vulnerable)</li> </ul>	<ul style="list-style-type: none"> <li>• Map susceptible blocks (identify areas/ populations that are vulnerable)</li> </ul>
<b>IEC/AWARENESS</b>		
<ol style="list-style-type: none"> <li>1. Prepare targeted IEchoardings, banners, posters, leaflets, factsheets, information cards, media, mic announcements, rallies, song/drama activities, and street plays.</li> <li>2. Plan for dissemination as per assessment of vulnerable area/ communities.</li> <li>3. Conduct sensitisation meetings.</li> <li>4. Prepare handouts for health staff about heat illness</li> <li>5. Ensure the availability of funds for the above activities</li> </ol>		
<b>B. Heat Season</b>		
<b>INFRASTRUCTURE AND LOGISTICS</b>		



<ol style="list-style-type: none"> <li>1. Ensure adequate medical supplies are available</li> <li>2. Identify surge capacities and mark the beds dedicated to treating heatstroke victims and enhance emergency department preparedness to handle more patients</li> </ol>		
<ul style="list-style-type: none"> <li>• Increase ASHA/ANM/ MPHW outreach in at-risk villages during a heat alert, if feasible.</li> </ul>	<ul style="list-style-type: none"> <li>• Increase ASHA/ ANM/MPHW outreach in at-risk PHC during a heat alert, if feasible.</li> <li>• Ensure dedicated bed availability</li> <li>• Ensure ambulance availability</li> </ul>	<ul style="list-style-type: none"> <li>• Increase MPHW outreach in at-risk blocks during a heat alert, if feasible.</li> <li>• Ensure dedicated bed availability</li> <li>• Ensure ambulance availability</li> <li>• Dedicated heat corners</li> <li>• Increase staffing at DH/MCs to attend to the influx of patients during a heat alert, if feasible.</li> <li>• Organize DNO-CC/ SNO-CC visits to CHCs to confirm proper preparation has been made for HRI and conduct case audits during the heat season.</li> </ul>
<p><b>CAPACITY BUILDING</b></p>		
<ol style="list-style-type: none"> <li>1. Ensure reporting of HRI cases daily</li> <li>2. Adopt HRI treatment and prevention protocols</li> <li>3. Expedite recording of cause of death due to HRI</li> </ol>		
<ul style="list-style-type: none"> <li>• Referral of patients to the higher facility only after ensuring adequate stabilization and basic definitive care (cooling and hydration)</li> </ul>	<ul style="list-style-type: none"> <li>• Prepare weekly reports of health impact for nodal officer</li> <li>• Conduct case review during heat season</li> </ul>	<ul style="list-style-type: none"> <li>• Prepare weekly reports of health impact for nodal officer</li> <li>• Conduct case review during heat season</li> </ul>
<p><b>IEC/AWARENESS</b></p>		
<ol style="list-style-type: none"> <li>1. Ensure IEC dissemination</li> <li>2. Target the vulnerable area/communities followed by other areas.</li> <li>3. Plan activities as per the Heatwave alert issued by IMD</li> </ol>		

<b>C. Post-heat Season</b>
<b>A. INFRASTRUCTURE AND LOGISTICS</b>
<ul style="list-style-type: none"> <li>• Review to assess/identify gaps, if any, e.g.,             <ul style="list-style-type: none"> <li>▶ Any shortage of equipment, medicine, staff.</li> <li>▶ Any long-term measures adopted and maintained</li> </ul> </li> <li>• Enlist/document the lessons learnt for the next season</li> </ul>
<b>CAPACITY BUILDING</b>
<ul style="list-style-type: none"> <li>• Review to assess/identify gaps, if any, e.g.,             <ul style="list-style-type: none"> <li>▶ Any flaw/fault in reporting channel/format/ efficiency</li> <li>▶ Number of deaths reviewed</li> </ul> </li> <li>• Enlist/document the lessons learnt for the next season</li> </ul>
<b>IEC/AWARENESS</b>
<ul style="list-style-type: none"> <li>• Review to assess/identify gaps, if any, e.g.,             <ul style="list-style-type: none"> <li>▶ IEC messages</li> <li>▶ Dissemination area/community</li> <li>▶ Efficient use of resources</li> </ul> </li> <li>• Enlist/document the lessons learnt for the next season</li> </ul>

Source: National action plan on heat-related illnesses (HRIs) by NPCCHH, 2024

#### 4.1. Basic equipment and medicines required as a part of Hospital preparedness for heat season

Primary Health Centre (PHC), Community Health Centre (CHC), District Hospital (DH) and Medical Colleges should ensure the following requirements before the start of heat season:

- Dedicated bed for HRI patients in cooler area of hospital
- Thermometer, ORS packets, ice packs, BP apparatus
- Silver sulphadiazine cream, Calamine lotion, Chlorhexidine in a light cream or lotion base
- Cold IV normal saline (0.9%), dextrose 50% in water solution (D50W)
- Glucometer and testing strips
- ECG equipment: ECG machine, Gel, electrodes, ECG paper
- Cooling equipment: AC, cooler, fan as per requirement
- Water cooler
- Medicines: Lorazepam, diazepam
- Ambulance with ice packs and cold water.

**The director/In-charge of Hospitals CHCS and PHCS in all States/Districts should ensure that the following measures are in place:**

- A detailed action plan to tackle heat-related illnesses well in advance of hotter months.
- Operational framework - preparing specific health adaptation plan, development of guidelines and response plan for climate sensitive diseases (CSD).
- Need to update heat health action plan and issue advisories for hospital preparedness, surveillance, and weekly monitoring, including capacity building.
- Promoting strategic media coverage of climate and health linkages at the State level in regional languages to increase support for climate mitigation and adaptation responses.
- Long-term measures such as adopting cool roofs, improving green/forest coverage and analysing health impacts in urban planning.
- Standard Operating procedures should be established to tackle all levels of heat-related illnesses. Capacity-building measures for doctors, nurses, and other staff should also be undertaken.
- Cases with suspected heat stroke should be rapidly assessed using standard Treatment Protocols.
- Identify surge capacities and mark the beds dedicated to treat heat stroke victims and enhance emergency department preparedness to handle more patients.
- Identify RRTs (Rapid Response Teams) to respond to any exigency call outside the hospitals.
- Ensure adequate arrangements of Staff, Beds, IV fluids, ORS, essential medicines, and equipment to cater to the management of volume depletion and electrolyte imbalance.
- May try to establish outreach clinics at various locations easily accessible to the vulnerable population to reduce the number of cases affected. Health Centers must undertake awareness campaigns for neighborhood communities using different means of information dissemination.
- Primary health centres must refer the patients to the higher facility only after ensuring adequate stabilization and basic definitive care (cooling and hydration).
- Hospitals must ensure proper networking with nearby facilities and medical centres to share the patient load that exceeds their surge capacities.

All cases of heat-related illnesses (suspected or confirmed) should be reported to the IDSP (Integrated Disease Surveillance Programme) unit of the district.

### **5. Heat Health Early Warning Systems (EWS)**

Heat Health Early Warning Systems (EWS) utilize climate and weather forecasts, along with predefined heat stress thresholds, to issue public advisories and activate health interventions aimed at minimizing heat-related health risks before, during, and after extreme heat events. These systems are essential decision-support tools, typically developed and maintained through collaboration between public health experts and meteorological agencies. As a core element of broader Heat Action Plans (HAPs), Heat Health EWS plays a vital role in informing health and social service protocols, ensuring timely and appropriate preparedness, prevention, and response measures during heatwaves.

Local heat thresholds for early warning systems can be developed using the following methods:

- A. Biostatistical methods: The thresholds for temperature are prepared by IMD in India and can be coupled with impact indicators of health. These two can be used in combination to send out alerts and can be used to plan for preparedness as well.

To establish a correlation between temperature and health impact (outcome) variable, which may include-

- All cause daily mortality count data
- Cause-specific daily mortality count data
- Hospital daily admissions count data
- Emergency ambulance (108) services daily call count data

- B. Meteorological (Bio-meteorological) method: The 2015 WMO WHO Heatwaves and Health: Guidance on Warning-System Development suggests that “In situations where there is basic meteorological information but no health data, a percentile-based threshold (90th, 95th) could be contemplated as a warning trigger value.”

Establishing of percentile thresholds based on thermal and bio-meteorological variables-

- Tmax, Tmin, and Tmean
- Humidex
- Wet bulb globe temperature
- Universal thermal climate index
- Heat index

NDMA recommends using the 75th, 85th and 95th percentile for Indian context

Extreme heat goes beyond just high daytime temperatures—it also involves factors like humidity and how well people are acclimatised. For early warning systems to be effective, they must account for these variables. This means combining weather forecasts with historical health and climate data to better anticipate the actual health impacts. Without this integrated approach, the true danger of extreme heat events can be missed. For example, many heat-related illnesses are triggered by persistently high nighttime temperatures, even when daytime highs don't seem extreme.

## 10 Financing the implementation of Navsari HAP

Financing the Heat Action Plan (HAP) is a critical component of its implementation strategy through the convergence of existing government schemes and programs at the district/local level. Securing adequate financial resources is critical for the successful implementation of Heat Action Plans (HAPs) in Gujarat. Effective climate finance strategies enable the state to strengthen heat resilience, protect vulnerable communities, and sustain long-term adaptation efforts. By mobilizing funds through government budgets, international climate finance, and public-private partnerships, Gujarat can ensure the efficient execution of HAPs. A well-structured financing framework, combined with transparent allocation and monitoring, will be key to building climate resilience and mitigating the impacts of extreme heat in the state.

### The outline of the financial resources:

- A. Government Funds:
  - 1) National Disaster Response Fund (NDRF)/State Disaster Response Fund (SDRF)
  - 2) National Disaster Mitigation Fund (NDMF)/State Disaster Mitigation Fund (SDMF)
  - 3) Grant in Aid recommendation by Central Finance Commission (CFC)
  - 4) Grant in Aid recommendation by Fifth State Finance Commission (SFC)
  - 5) Central Sector Program/Schemes (CSS)
  - 6) State Program and Schemes (SPS)
  - 7) Local resources – own taxes and duties
  - 8) Loan and Advances
  
- B. Private Sector Funds
  - 1) Corporate Social Responsibilities (CSR) Fund
  - 2) Non-Government Organisation (NGOs) projects/programs
  - 3) Public and private sector donation

### Financial resources – Government Fund

#### 1. National Disaster Response Fund (NDRF)/State Disaster Response Fund (SDRF):

The coverage of the funds recommended by 15th Finance Commission goes beyond the disaster response funds that already exist at the national (NDRF) and state (SDRF) levels. The State Disaster Response Fund (SDRF), constituted under Section 48 (1) (a) of the Disaster Management Act, 2005, is the primary fund available with State Governments for responses to notified disasters. The Central Government contributes 75% of SDRF allocation for general category States/UTs and 90% for special category States/UTs. The annual Central contribution is released in two equal installments as per the recommendation of the Finance Commission. SDRF shall be used only for meeting the expenditure for providing immediate relief to the victims.

- **Disaster (s) covered under SDRF:** Cyclone, drought, earthquake, fire, flood, tsunami, hailstorm, landslide, avalanche, cloudburst, pest attack, frost and cold waves.
  
- **Local Disaster including Heat wave as notify:** A State Government may use up to **10 percent of the funds available under the SDRF** for providing immediate relief to the victims of natural disasters that they consider to be ‘disasters’ within the local context in the State and which are not included in the notified list of disasters of the Ministry of Home Affairs

subject to the condition that the State Government has listed the State specific natural disasters and notified clear and transparent norms and guidelines for such disasters with the approval of the State Authority, i.e., the State Executive Authority (SEC).

### **1.2 National Disaster Risk Management Fund (NDRMF) and State Disaster Risk Management Funds (SDRMF)**

The 15th Finance Commission has recommended the creation of funds for disaster mitigation along with disaster response, which will now together be called National Disaster Risk Management Fund (NDRMF) and State Disaster Risk Management Funds (SDRMF).

### **1.3 National Disaster Mitigation Fund (NDMF)/State Disaster Mitigation Fund (SDMF)**

On the recommendations of the 15th Finance Commission, Government of India has set-up National Disaster Mitigation Fund (NDMF) and respective State Governments, except Telangana has set-up State Disaster Mitigation Fund (SDMF) for the purpose of mitigation measures.

These funds are exclusively for the purpose of mitigation projects in respect of notified disasters covered under SDRF/ NDRF guidelines and the State specific local disasters notified by the State Governments. The State Governments can undertake mitigation activities for various disasters, as per the guidelines issued by the Ministry of Home Affairs for SDMF and NDMF on 14.01.2022 and 28.02.2022, respectively, and revised on 25th September, 2024.

### **1.4 State Disaster Risk Management Funds (SDRMF) and State Disaster Mitigation Fund (SDMF) [including Central (75%) as well as Gujarat State share (25%)]**

**State Disaster Risk Management Funds** is the primary fund available with Gujarat State Governments for responses to notified disasters. SDRMF shall be used only for meeting the expenditure for providing immediate relief to the victims of Gujarat. However, the State Government may use up to 10 percent of the funds available under the SDRF for providing immediate relief to the victims of natural disasters that they consider as State specific natural disasters and notify clear and transparent norms and guidelines for such local disasters with the approval of the State Authority.

**State Disaster Mitigation Funds** are exclusively for the purpose of mitigation projects in respect of notified disasters covered under SDRF/ NDRF guidelines and the State specific local disasters notified by the State Governments. The State Governments can undertake mitigation activities for various disasters, as per the guidelines issued by the Ministry of Home Affairs for SDMF and NDMF.

### **1.5 Grant in Aid recommendation by Central Finance Commission (CFC) for Gujarat**

To cater to the growing urbanisation needs, a total of Rs. 1,21,055 crore is recommended for urban local bodies for the period 2021-26. Inter state distribution among States is with a weightage of 90 percent on population and 10 percent on area. The Commission has recommended grants in two parts - a Basic grant and a Performance grant for duly constituted Gram Panchayats (Rural Local Bodies) and Municipalities (Urban Local Bodies). The ratio of basic to performance grant is 90:10 with respect to Gram Panchayats and 80:20 with respect to Municipalities. The Commission has recommended grants to local bodies (Rural and Urban); Sector Specific grant; State Specific grant and Disaster management grant to Gujarat.

## 1.6 State Finance Commission (SFC) Gujarat

The Fourth State Finance Commission was constituted on 5th November 2024 by Gujarat and terms of reference are yet to be finalised. Gujarat has encouraged local governments to adopt innovative models for revenue generation, such as charging nominal fees for public services.

However, the Third State Finance Commission Recommended as per Performance based grant is essentially to incentivise performance and therefore, must be sizable or meaningful relative to the size of revenue of ULBs. It should be different for different sizes or Classes of ULBs. Learning from this experience, GoI increased the size of funds available to ULBs enormously under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM). In the light of this design parameter, the Table given below provides a preliminary recommendation for size of performance based grant per annum for different classes of ULBs. This would amount to about 30 percent of the total divisible pool of non-tied transfers made in 2012-13.

## 1.7 Major Central and State Sectors Schemes

The funds are available on the different programs and schemes at the district level in Gujarat, varying from the specific scheme, the objectives of the program, and the district's development priorities. The funds are allocated to districts by the state and central governments and are disbursed based on the needs and priorities of each district. Gujarat, being a large state with both rural and urban districts, receives funding from the central government, state government, and various schemes targeting specific sectors like infrastructure, rural development, health, education, and climate resilience. Therefore, the need for financial resources and convergence with different government schemes / programs running at district / local level is a critical aspect of ensuring that adequate resources are allocated for heat wave resilience. This will create a holistic, multi-dimensional response system that maximizes resources and ensures that vulnerable populations are better prepared for heat waves resilience. While several schemes exist to address different aspects of climate resilience and community welfare, the specific issue of heat waves is often addressed in isolation. The converging efforts at district level authority through coordination by District Nodal officers to easily available resources for implementation of Heat Action Plan.

The table below presents the overview of some key indicative funding sources of program and schemes available at the district level in Gujarat, including their typical allocations and uses for heat wave resilience activities:

Table 15: Key indicative funding sources of program and schemes available at the district level in Gujarat (including their typical allocations and uses for heat wave resilience activities)

Source: CEEW Authors' Compilation

SN	Program/Schemes	Purpose	Support to heat wave resilience activities
1	<b>National Health Mission (NHM)</b>	To improve healthcare services, with a special focus on rural and underserved areas	The funds can be used for healthcare interventions related to heatwaves, such as setting up health camps, providing treatment for heat-related illnesses, and launching awareness programs in vulnerable districts
2	<b>Swachh Bharat Mission (SBM)</b>	To promote sanitation and cleanliness	Funds are used for sanitation facilities, water supply systems, and public awareness campaigns that are crucial during heatwave conditions
3	<b>Smart Cities Mission</b>	To promote sustainable urban development and smart city initiatives.	Funds can be used for heatwave mitigation in urban areas, such as creating smart cooling systems, improving water distribution, and increasing green cover.
4	<b>Pradhan Mantri Awas Yojana (PMAY)</b>	To provide affordable housing for the urban and rural poor.	Funds are used for constructing affordable housing units with provisions like cool roofs and efficient ventilation, which can indirectly help mitigate heatwave effects in urban and rural areas.
5	<b>Mission Manglam (Urban) Scheme</b>	To help Urban poor	The Scheme helps the poor urban Self help Groups and "Sakhi Mandals" by linking them with the banks for easy and speedy financial assistance
6	<b>Atal Mission for Rejuvenation and Urban Transformation (AMRUT)</b>	To provide basic infrastructure in urban areas, such as water supply, sewage, and green spaces.	Funds are used for heat mitigation measures in urban areas, including the creation of green spaces, water fountains, and other cooling infrastructure.
7	<b>National Urban Livelihood Mission (NRLM)</b>	To promote sustainable livelihoods through community-based interventions.	A mission to empower women in the community, including capacity building and training, self-employment programs, and support to urban street vendors
8	<b>Gujarat Urban Development Mission (GUDM)</b>	To improve urban infrastructure in smaller towns and cities.	Funds can be used for heatwave mitigation efforts in urban areas, such as creating cool roofs, establishing shade-giving public spaces, and improving water infrastructure
9	<b>District Mineral Foundation (DMF) Fund</b>	To support welfare programs in mining-affected areas	DMF funds can be used for building infrastructure that addresses heat wave mitigation such as providing water supply systems, afforestation, improving community infrastructure, public health

			infrastructure and enhancing health services in mining-affected districts.
10	<b>Urban and Rural Infrastructure Development Fund</b>	To improve urban /rural infrastructure in cities and towns	This fund supports both urban and rural infrastructure projects that contribute to disaster resilience and overall development. Funding can be used for heatwave mitigation by improving water supply, public cooling centers, and public green spaces.
11	<b>Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA)</b>	To provide employment to rural households through the creation of public assets such as water bodies, plantation, greeneries, etc	The funds can be used for creating community infrastructure that mitigates heatwaves, such as water harvesting systems, shade-providing trees, and other heat-resilient projects.
12	<b>Rashtriya Krishi Vikas Yojana (RKVY)</b>	To promote agricultural development in states and districts by providing grants for agricultural infrastructure and growth	The funds can be used for agricultural climate resilience projects, such as promoting drought/heat-resistant crops, enhancing water efficiency in agriculture, and other heat-related interventions in districts. Also provide shelter and water to reduce livestock heat stress and deaths
13	<b>Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)</b>	To improve irrigation infrastructure and water use efficiency in agriculture.	Funds can be used in rural districts to develop irrigation infrastructure, water conservation systems, and agriculture heat resilience measures
14	<b>National Rural Livelihood Mission (NRLM)</b>	To promote sustainable livelihoods through community-based interventions.	NRLM funds can be used for training programs, creating local heat resilience projects, and building community infrastructure to address heatwave challenges.
15	<b>State Action Plan on Climate Change (SAPCC)</b>	To address the impacts of climate change, including heatwaves	Funds are directed to districts for long-term climate adaptation measures, such as afforestation, water conservation, and the creation of green spaces to reduce heat.
16	<b>Forest Fire Prevention and Management Scheme</b>	To prevent fire incidents and public infrastructure	Prepare firefighting equipment to allow for rapid responses to forest fires
17	<b>Gujarat Rajya Institution for Transformation (GRIT)</b>	Formulating strategic scheme for infrastructure development	Under this scheme, various sectors considering long-term and short-term project objectives of Viksit Gujarat 2047

18	<b>Viksit Gujarat Fund</b>	To provide Urban infrastructure development	Execute projects and public welfare schemes as a key initiative. (High Speed Corridor, Development of Economic Region, Water Supply Projects, Tourism, Express Ways etc.)
19	<b>SJMMSVY (Swarnim Jayanti Mukhyantri Saheri Vikas Yojana)</b>	To provide Basic Infrastructural Facilities in urban areas.	The Scheme is to provide Basic Infrastructural Facilities in urban areas.
20	<b>Town Planning Scheme</b>	To provide provides basic amenities in urban areas	This program ensures well-planned development and provides basic amenities like roads, water, drainage, and street lights.

### 1.8 Corporate Social Responsibilities (CSR) Fund

The term "Corporate Social Responsibility (CSR)" refers to a company's commitment to assessing and taking responsibility for its impact on the environment and social welfare. Under the Corporate Social Responsibility Rules, as outlined in Section 135 of the Companies Act, 2013, the Board of Directors must ensure that the company spends at least 2% of the average net profit made during the three immediately preceding financial years in each financial year. The following activities may be undertaken under CSR-

- i. Eradicating hunger, poverty & malnutrition, promoting preventive health care & sanitation & making available safe drinking water;
- ii. Promoting education, including special education & employment enhancing vocation skills especially among children, women, elderly & the differently unable & livelihood enhancement projects;
- iii. Promoting gender equality, empowering women, setting up homes & hostels for women & orphans, setting up old age homes, day care centers & such other facilities for senior citizens & measures for reducing inequalities faced by socially & economically backward groups;
- iv. Reducing child mortality and improving maternal health by providing good hospital facilities and low cost medicines;
- v. Providing with hospital and dispensary facilities with more focus on clean and good sanitation so as to combat human immunodeficiency virus, acquired immune deficiency syndrome, malaria and other diseases;
- vi. Ensuring environmental sustainability, ecological balance, protection of flora & fauna, animal welfare, agro forestry, conservation of natural resources & maintaining quality of soil, air & water;
- vii. Employment enhancing vocational skills
- viii. Protection of national heritage, art & culture including restoration of buildings & sites of historical importance & works of art; setting up public libraries; promotion & development of traditional arts & handicrafts;
- ix. Measures for the benefit of armed forces veterans, war widows & their dependents;
- x. Training to promote rural sports, nationally recognized sports, sports & Olympic sports;

- xi. Contribution to the Prime Minister's National Relief Fund or any other fund set up by the Central Government for socio-economic development & relief & welfare of the Scheduled Castes, the Scheduled Tribes, other backward classes, minorities & women;
- xii. Contributions or funds provided to technology incubators located within academic institutions, which are approved by the Central Government;
- xiii. Rural development projects, etc
- xiv. Slum area development.

The Above list is illustrative not exhaustive. All activities under the CSR activities should be environment friendly and socially acceptable to the local people and Society. Contribution towards C.M relief fund shall be a part of CSR activities above 2% of Net profit other than the activities mentioned above.

## 11 Inter-agency and departmental coordination mechanisms

To ensure inter-departmental and inter-agency coordination for successfully implementing the strategies outlined in the previous chapters, a heatwave task force committee has been established in the Navsari city under the chairmanship of the Commissioner, Navsari Municipal Corporation.

Table 16: The heatwave task force committee

### Heat Wave Task force Committee at Municipal Corporation level

Designation	Role
Commissioner/ Dy. Municipal Commissioner	Chairman
Medical officer of health (MoH), Nodal officer	Member Secretary
Sr. Town Planner	Member
City engineer / Executive Engineer (Engineering & Building)	Member
Chief Fire Officer	Member
Sanitation Superintendent / Executive Engineer (Drainage)	Member
Executive Engineer – Water Works / Irrigation	Member
Transport Officer / Garage Division	Member
Food Safety Officer / Biologist	Member
Municipal Secretary	Member
Electric Engineer – Street Light	Member
Project Officer – UCD / NULM / Shelter homes	Member
Public relations officer	Member
Environmental Engineer / officer	Member
Urban Town Planner	Member
Shashnadhikari / DPEO/ BRC (Education)	Member
Program Officer – ICDS	Member
Veterinary Officer	Member
Officer - Garden Branch	Member
NGO / Consultant	Member

Source: As per the discussion held during State workshop in Gandhinagar, Gujarat on 4th April 2025

### 11.1 Early warnings and alert mechanisms

India Meteorological Department (IMD), Ministry of Earth Sciences, is the nodal agency for providing weather information, including forecast and current warnings for all weather-related hazards for optimum operation of weather-sensitive activities. It provides a warning against severe weather phenomena like tropical cyclones, squally winds, heavy rainfall/ snow, thunder-squall, hailstorms, dust storms, heat waves, warm nights, fog, cold waves, cold nights, ground frost, etc. It also provides real-time data and weather prediction of maximum temperature, heat wave warnings, extreme temperatures, and heat alerts for vulnerable cities/ rural areas.

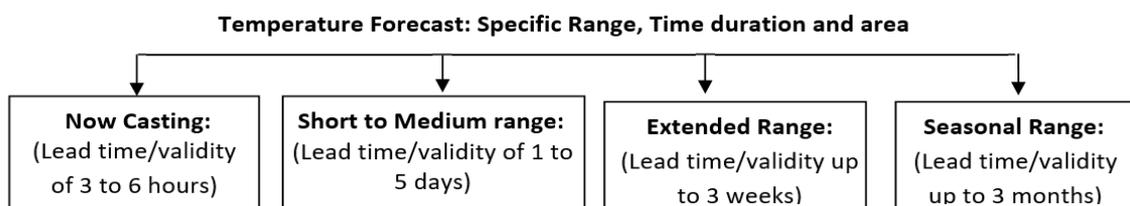
IMD issues forecasts and warnings for all weather-related hazards in short to medium range (valid for the next five days) every day as a part of its multi-hazard early warning system. These warnings, updated four times a day, are available on the link (<http://www.imd.gov.in/pages/allindiawxfbulletin.php>.)

A new system of exclusively heat-related warnings has been introduced with effect from 03 April, 2017. These warnings, valid for the next four days, are issued around 1600 hours IST daily and are provided to all concerned authorities (Departments of Health, Disaster Management, Indian Red Cross and Indian Medical Association, NDMA etc.) for taking suitable action at their end. A bulletin in extended range with an outlook for the next two weeks (for all hazards including heat waves) is issued every Thursday (<http://www.imd.gov.in/pages/extended.php>).

In addition to the above, Climate Forecast System-based forecast maps of daily maximum temperatures and their departures from normal for the next 21 days (issued every Thursday) are also available on the IMD website ([http://nwp.imd.gov.in/cfs\\_all.php?param=tmax](http://nwp.imd.gov.in/cfs_all.php?param=tmax)) and ([http://nwp.imd.gov.in/cfs\\_all.php?param=tmaxa](http://nwp.imd.gov.in/cfs_all.php?param=tmaxa)).

IMD has also issued seasonal temperature outlooks for the next three months, valid from March to May, and the second one for April to June every year. These seasonal outlooks are issued as press releases on the IMD website and through electronic and print media. They are also provided to all concerned Chief Secretaries, Disaster Managers, and the health sector through the India Medical Association (IMA).

Figure 39: The operational system of weather forecasts and warnings

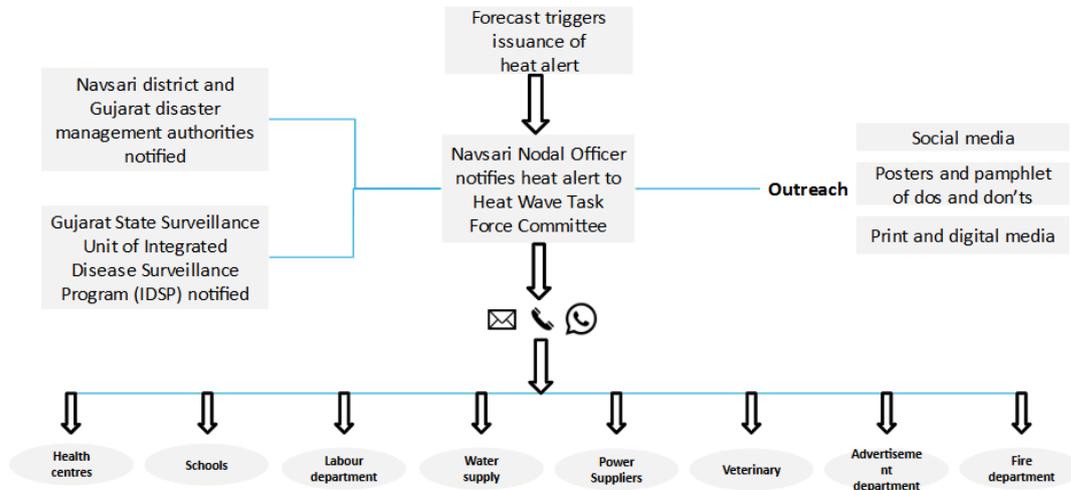


Source: IMD 2019

The District Disaster Management Authority (DDMA) will receive forecasts from the IMD Regional Meteorological Centre in Mumbai and forward them to the nodal officer of the Navsari Heatwave Taskforce Committee through the Navsari DDMA. Based on the heat thresholds established in this plan, the nodal officer will analyze meteorological variables such as temperature and relative humidity. Using this analysis, the nodal officer will issue color-coded heat alerts to the Heatwave Taskforce Committee. These alerts will then be disseminated to relevant line departments and

vulnerable populations. Figure 40 illustrates the communication flow for the dissemination of these alerts.

Figure 40: Communication flow for sending out heat alerts



Source: Authors' compilation

The outreach materials in the form of Information, Education, and Communication (IEC) presented in the next chapter will be utilised by the heatwave task force committee in collaboration with the AMC advertisement department and social media influencers to raise awareness among vulnerable populations. The focus will be on communicating essential do's and don'ts, with priority actions emphasised in identified at-risk and vulnerable wards.

## 12 Monitoring, evaluation and updating the Navsari heat action plan

While this action plan integrates all the necessary components for an effective Heat Action Plan (HAP), the successful implementation of the plan is equally crucial. Continuous monitoring, evaluation, and revision are vital to its success. Evaluation is essential to assess whether the activities are achieving their intended effects (effectiveness), determining if they are cost-efficient (efficiency), ensuring they are acceptable to the target population (social acceptability), and guaranteeing that evaluation occurs at all stages of planning, development, implementation, and review (WHO, 2008).

To ensure the effective and timely implementation of the HAP, both the process and outcomes must be monitored at designated intervals. Monitoring short-term strategies through quantitative, performance-based indicators will enhance the preparedness of officials and stakeholders, as well as raise awareness and build the capacity of vulnerable groups. After the heatwave season, analyzing the plan's outcomes and impacts will provide valuable insights into its effectiveness, highlight any remaining gaps, and identify future needs for improving the plan's impact.

### 12.1 Monitoring and evaluation framework for the Navsari HAP implementation

Key Performance Indicators (KPIs) aligned with each outlined strategy—both for preparedness and response (in the short term) and heat risk mitigation (in the long term)—will enable a quantitative evaluation of the plan's performance. The KPIs associated with each strategic theme, as outlined in Chapters 6 and 7, have been presented as part of an actionable framework. The authority responsible for implementing each sub-theme will also be tasked with data collection, mapping, and estimating the measurable KPIs against established minimum performance standards. This process will track progress and ensure alignment with the larger goal of effectively mitigating heat risks and improving resilience.

Table 17: Monitoring and evaluation framework for the Navsari HAP implementation

Process Evaluation					
Code	KPI type	Description of Measurable KPI	Short Term	Long Term	Assessment Period
6.1	Evaluation of Stakeholders' Understanding of Heat Risk	No. of expert consultations for understanding of heat risk			End of March
6.2		No. of questionnaire-based interviews with heat wave cell for understanding of SOP			
6.2		No. of stakeholders participating in training programmes			
6.3		No. of consultations with RDMC before summer season			

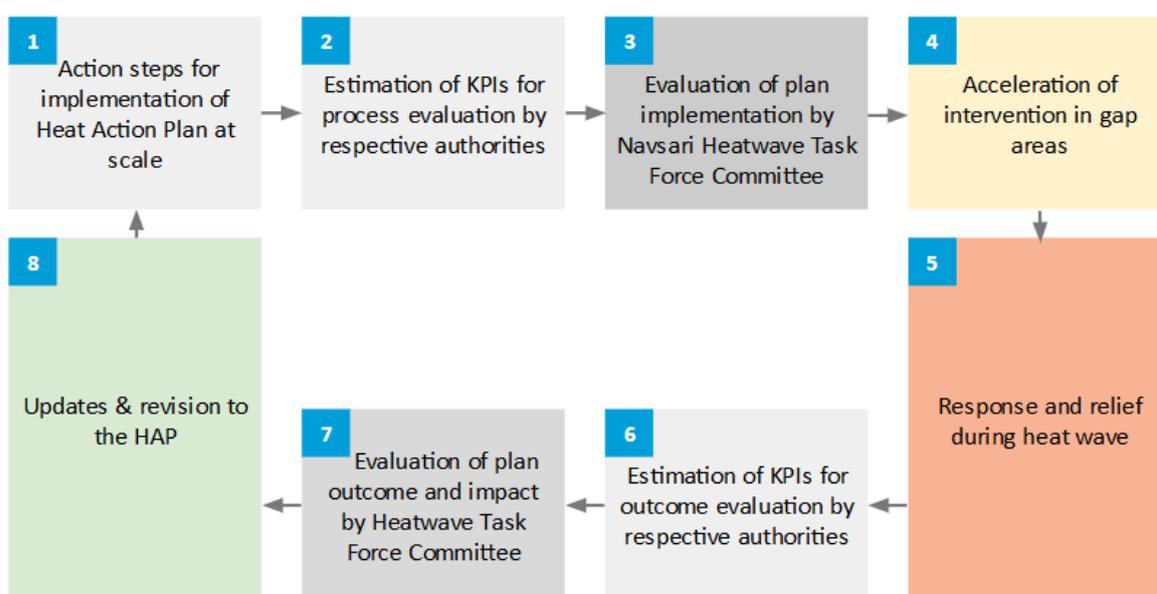
6.4	Evaluation of Vulnerable Communities' Awareness of Heat Risk & Preparedness	No. of wards that received colour coded impact based early warning				
6.4		No. of focus group discussions conducted with identified vulnerable communities in each at risk ward				
6.4		No. of questionnaire-based surveys with heat vulnerable households				
6.4		No. of emergency mock drills conducted with vulnerable communities				
6.4		No. of IEC Materials distributed				
6.5	Evaluation of Preparedness against heat-wave related illnesses	No. of wards with appointed heat wave in-charge officer			Mid-April	
6.5		No. of nodal officers for coordinating preparedness				
6.11		No. of wards with identified population identified at risk from heat related illnesses				
6.11		No. of workshops in hospitals to implement hospital preparedness plan				
6.15		No. of trainings conducted for health professionals				
6.11		No. of wards with data collection plan				
6.12		No. of wards with identified population identified at risk from heat related illnesses				
6.12		No. of water supply stations added in vulnerable wards				
6.7		Evaluation of preparedness & response of relevant authorities	No. of ward level committees to coordinate preparedness and response actions			
6.7			No. of meeting organised to prepare for emergency response			

Output Evaluation					
Code	KPI type	Description of Measurable KPI	Short Term	Long Term	Assessment Period
		and relief			
7.2	Monitoring of heat-related socio-economic parameters	No. of reported heat related illnesses (ward-wise)			July
7.2		No. of heat induced mortality cases (ward-wise)			
7.2		No. of wards with reported water shortage			
7.8	Monitoring of Mitigation & Adaptation measures	Ward-wise change in green space per person			December
7.10		No. of wards with improved water access			
7.10		No. of wards with improved water quality			
7.11		Change in modal share of electric vehicles			
7.11		Change in share of renewable energy use			
7.11		No. of roads with green divider introduced			
7.13		Change in share of renewable energy use			
7.21		No. of rooftop solar panels installed (ward-wise)			
7.17		No. of promotional campaigns for innovative cooling solutions			
7.19		No. of ward-wise cooling shelters installed			
7.9	No. of health check up camps organised in slum areas				
7.23	Monitoring of heat-related environmental parameters	Change in ward-wise land surface temperature			January

## 12.2 Revising the HAP

Given the evolving and projected heat extremes in Navsari city, and recognizing this as the inaugural version of the Heat Action Plan (HAP) for the city, it is essential to revisit and revise the plan after the 2025 heatwave season. The revision process should be guided by the successes and challenges observed during the 2025 heatwave season. The heatwave management cycle, as illustrated in Figure 24, integrates monitoring, evaluation, and plan updates into a continuous, year-round implementation framework. This cyclical approach ensures the plan remains adaptable and effective in addressing emerging heat-related challenges in Navsari city, fostering long-term resilience and preparedness.

Figure 41: Heatwave management cycle for Navsari city heat action plan



Source: Authors' compilation

In preparation for the next iteration of Navsari city's Heat Action Plan (HAP), several key considerations should guide its development:

**Establishment of Heat-Health Thresholds:** While the current plan establishes local-level thresholds using biometeorological indices, it is crucial to enhance this by correlating mortality and heat illness data (as outlined in Chapter 13) with observed felt and dry temperatures. The use of bio-statistical analysis techniques will allow for the establishment of more precise and accurate heat-health thresholds, improving the plan's ability to predict and mitigate heat-related impacts.

**Incorporation of Wind Speeds and Meteorological Persistence:** The current version of the plan relies on the heat index based on daytime and nighttime relative humidity and temperature variables. Moving forward, it would be beneficial to incorporate India-specific heat index data being developed by the India Meteorological Department (IMD). Integrating this data will provide a more comprehensive understanding of heat risks, accounting for variables such as wind speed and meteorological persistence, which play a significant role in heatwave intensity and duration.

**Development of Ward-Level Heat Risk Index:** The current plan includes a heat risk index at the sub-city level using secondary data, but it is essential to refine this approach to the ward level through on-ground surveys. By collecting socio-economic data via field surveys, authorities can assess heat risk more accurately at the local level. This localized analysis will allow for better prioritization of mitigation and response measures, ensuring that resources are allocated to areas with the highest heat vulnerability.

These key considerations aim to enhance the accuracy, relevance, and effectiveness of future heat action plans for Navsari city, enabling more informed decision-making and better preparedness in the face of rising heat risks.

## 12 Information, Education and Communication (IEC)

Figure 42: IECs Issued by NPCCHH for Heat wave warning and management



Source: National Programme on Climate Change & Human Health (NPCCHH), NCDC



GSDMA



Figure 43: IECs issued by Ahmedabad Municipal Corporation for Heat wave management

**ગરમીથી તમે કેવી રીતે બચશો**

- પાણી, છાશ અથવા અન્ય પ્રવાહી પીવો (ઠંડા પીણા નહિ)
- તડકામાં ન રહો
- હળવા રંગના કપડાં પહેરો
- ઠંડક વાલુ કોઈ સ્થળ શોધી કાઢો
- મિત્રો અને કુટુંબીજનોની સંભાળ રાખો

**પાણી વધુ પીવો**

**ઈમરજન્સીમાં ૧૦૮ પર ફોન કરો**

**ઉનાળાની ઋતુમાં ગરમી (હીટ સ્ટ્રોક) થી રક્ષણ માટેના અગત્યના ઉપાયો...**

- પુરતન પ્રમાણમાં ઠંડુ પાણી તથા લીનુ શરબત જેવા સ્વચ્છ પ્રવાહીનું સેવન કરવું.
- વધુ પડતો કામ તાગો શરબ થોડા થોડા સુગી તડકામાં કરવાનું ટાળવું.
- બરબરોડા કામ ઉપર જાવ ત્યારે સહવા કામના સમયે થોડો સમય છાંચડા નીચે સારવા કરો.
- ઠંડક માટે માથા પર ઠંડુ ભીનું કપડું રાખો, ઉઘાડા સારીદે કરવું નહીં, ઉપવાસ કરવા નહીં તેમજ સુતરાઈ ખુલા કપડાં પહેરવા.
- ઠંડકવાળા સ્થળો પર જાઓ, જેવા કે મંદિર, મસ્જિદ, સિવેટર, શોપીંગ મોલ.
- પંખા, ફુલર તથા બે.સી.નો ઉપયોગ કરો.
- સગર્મી માત્રાઓ, નાના બજારો અને વૃક્ષોનું ખાસ ધ્યાન રાખવું.

**"ચાલો સૌ સાથે મળીને ગરમી સામે લડીએ"**

**ગરમી (હીટ સ્ટ્રોક)ના લક્ષણો**

- વધુ તાપ હાજરવું, ગરમ અને સુગી લગવું.
- નાડીના ઘટાડાવા વાળવા, ગાડા-ઉભી જેવું ચાલુ મલકતી દુખાવો, ઘટ્ટર હાજરવું, ડોભાત થવું.

**108 પર ફોન કરો**

**વધુ (હીટ સ્ટ્રોક)ના લક્ષણો જણાય તો તાત્કાલિક બહુકાના ડોક્ટર, મુખ્ય ઓસ્પિટલ/ સર્કલ ટેલ સેન્ટરની સંપર્ક કરો.**

**સ્વચ્છતાથી સુરક્ષિત થાઓ અને તમારા પરીવારને પણ સુરક્ષિત કરો.**

**સરંદેદ થશે છત તો ગરમીથી મળશે રાહત**

**ગરમીમાં ઘરની છત પર સરંદેદ રંગ / સરંદેદ ચૂનો / સરંદેદ ટાપવલ ઘટાડશે**

**ઘરનું તાપમાન, વીજપાણી ડીલ અને બચાવશે સ્વાસ્થ્ય**

**તમારી જાતને ગરમી/લૂથી બચાવો**

**વસંત અને ગ્રીષ્મમાં અમદાવાદમાં ગરમી અતિસથ વધી શકે છે. કલામકેટ ચેન્જના વીધે લીટવેલ અને સમાનતા ધારણે પૂલોની, નવપરત વીધુ, હાથાલો,મજુરો અને મુખપટ્ટીમાં રહેતા લોકોના સ્વાસ્થ્યને ગરમીથી વધુ ભય છે.**

**મેડિકલ ઈમરજન્સી માટે ૧૦૮નો સંપર્ક કરો**

**આ રીતે તમે ગરમીથી બચી શકો:**

પૂર્વ તૈયારી	હોટવેલ દરમ્યાન	શરબ પીવો
<ul style="list-style-type: none"> <li>પૂર્ણ થઈ પાણી પીવું જાણવાનું હોવું.</li> <li>મરુદિ સ્થળે જે ગરમી અને કામ વધુ કરવામાં આવે તેવા સ્થળે કામગીરી નહીં કરવું.</li> <li>વ્યક્તિના કામ કરવાની સમયે કામગીરી નહીં કરવું.</li> <li>વ્યક્તિના કામ કરવાની સમયે કામગીરી નહીં કરવું.</li> </ul>	<ul style="list-style-type: none"> <li>ગરમીમાં કામ કરવાની સમયે કામગીરી નહીં કરવું.</li> <li>કામ કરવાની સમયે કામગીરી નહીં કરવું.</li> <li>કામ કરવાની સમયે કામગીરી નહીં કરવું.</li> <li>કામ કરવાની સમયે કામગીરી નહીં કરવું.</li> </ul>	<ul style="list-style-type: none"> <li>પૂર્વ તૈયારી કરીને પાણી પીવું.</li> <li>પાણી પીવું અને કામ કરવાની સમયે કામગીરી નહીં કરવું.</li> <li>પાણી પીવું અને કામ કરવાની સમયે કામગીરી નહીં કરવું.</li> <li>પાણી પીવું અને કામ કરવાની સમયે કામગીરી નહીં કરવું.</li> </ul>

**કોઈ નથી લાગતું?**

વધુ ગરમીમાં રહેવાથી જુ.લગી થઈ શકે છે. આ સ્થિતિમાં રહેવા છે, પણ તાત્કાલિક સારવાર સુધારવા છે.

વિભાગ	સંપર્ક	વધુ વિગત
કોઈ નથી	કોઈ નથી	કોઈ નથી
વધુ ગરમી	વધુ ગરમી	વધુ ગરમી
કોઈ નથી	કોઈ નથી	કોઈ નથી

Source: Ahmedabad Heat Action Plan, 2019

## 14 Documentation of the heat related mortality and morbidity data

To mitigate the risks associated with the projected heat extremes in Navsari, resilient health systems must serve as the primary responder to heat-related mortalities and illnesses. For this, the availability of detailed and granular health data related to heatwave-induced mortalities and illnesses is crucial. High-quality heat-tagged data will not only strengthen heat-health early warning systems but will also enhance localized heat risk assessments in future revisions of this action plan.

This chapter outlines the formats and guidelines for recording and documenting this data, based on national-level formats provided by the National Program on Climate Change and Human Health (NPCCHH), Ministry of Health and Family Welfare (MoHFW) and the National Disaster Management Authority (NDMA). In 2015, MoHFW issued the "Guidelines on Prevention and Management of Heat-Related Illnesses." Building on this, the "National Action Plan on Heat-Related Illness, July 2021" was developed. This plan includes chapters addressing pediatric age groups, hospital preparedness plans, updated surveillance formats, standard operating procedures, and guidelines for investigating suspected heat-related illness (HRI) deaths. Since 2015, the Integrated Disease Surveillance Programme (IDSP), under MoHFW, has collected and compiled data on HRI and related deaths annually from 17 heat-vulnerable states (now 23 as of 2019). These states include Andhra Pradesh, Bihar, Chhattisgarh, Delhi, Gujarat, Haryana, Jharkhand, Karnataka, Maharashtra, Madhya Pradesh, Gujarat, Punjab, Rajasthan, Tamil Nadu, Telangana, Uttar Pradesh, Kerala, Goa, Uttarakhand, Jammu & Kashmir, West Bengal, Arunachal Pradesh, and Himachal Pradesh. The surveillance formats were revised in 2021 to capture cases of heat stroke, deaths due to suspected/confirmed heatstroke, deaths due to cardiovascular diseases (CVD), and all-cause deaths.

These guidelines and formats were developed by an internal MoHFW committee at the National Centre for Disease Control (NCDC) and an expert group consisting of specialists from the departments of medicine and pediatrics in central government hospitals, NDMA, National Institute of Disaster Management (NIDM), India Meteorological Department (IMD), World Health Organization (WHO), Emergency Medical Relief (EMR), IDSP, Indian Institute of Public Health Gandhinagar, and the Public Health Foundation of India (PHFI).

This section integrates these formats into the Navsari Heat Action Plan to ensure effective data collection on heat-related illnesses and mortalities. These formats will also be incorporated into the Navsari District Action Plan on Climate Change Human Health (DAPCCHH), ensuring cohesive data collection at various administrative levels. The detailed formats and the report on the 'National Action Plan on Heat-Related Illnesses' can be accessed here: <https://ncdc.gov.in/WriteReadData/linkimages/NationActionplanonHeatRelatedIllnesses.pdf>.

### 14.1 Guidelines for Investigation of Suspected Heat Related Illness Death

Unique ID:

Respondent's Name: Relationship of respondent with deceased:

Residential address of respondent:

#### Section A: Deceased's identifier details

A.1. Name of deceased:	A.2. Age (in completed years & months):	Y	Y	M	M
A.3. Sex: Male / Female/Transgender:	A.4. Father's/Mother's/Spouse's name:				
A.5. Residential Address of deceased					
A.5.1 State:			A.5.2. District:		
A.5.3. Block/Taluka:			A.5.4. Ward/village:		
A.6. Does the deceased have the following socio-economic card	i. BPL ii. Antayodya iii. Annapurna iv. Other or equivalent (mention)..... v. None				
A.7. What was the last occupation of the deceased:					

#### Section B: Death detail

No.	Questions	Coding categories	If no, Skip to
B.1	Was the deceased found unconscious or dead?	Yes.....1 No.....2 I don't Know.....3	B.3
B.2	Place where deceased was found unconscious or dead?	Athome.....1 At workplace.....2 At social gathering...3 On-road.....4 Other (specify).....	
B.3	Location where deceased was found unconscious or dead		

B.3.1 State:		B.3.2. District:				
B.3.3. Block/Taluka:		B.3.4. Ward/village:				
B.4	Name of hospital and address where deceased was brought dead or died:					
B.5	Date and time of the death: (from medical record)	DD	MM	YYYY	HH	MM



GSDMA



**Section C: Clinical history in past 24 hr before death (from medical record followed by respondent)**

C.1. Symptoms at the time of onset of illness:					
C.1.1. Was the skin hot and dry? (a. From Medical Record b. From Respondent c. both)			Yes.....	1	
			No.....	2	
			I don't Know.....	3	
C.1.2 Was the deceased in altered mental sensorium? (a. From Medical Record b. From Respondent c. both)			Yes.....	1	
			No.....	2	
			I don't Know.....	3	
C.1.3. What was the core body temperature? (from medical record only):					
C.1.4. What was the deceased's vitals? (from medical record only):					
a. Pulse rate:		b. Respiratory rate:		c. Blood pressure:	
C.2. Date and time of onset of the first symptom of heat illness:		DD	MM	YYYY	HH MM
C.3. Place of onset of first symptom:			At home.....	1	
			At workplace.....	2	
			At social gathering.....	3	
			On-road.....	4	
			School/college.....	5	
			Other (specify).....		
C.4. Location of onset of symptoms					
C.4.1 State:			C.4.2. District:		
C.4.3. Block/Taluka:			C.4.4. Ward/village:		
C.5. Did the deceased have an alcoholic beverage within a day of onset of illness?			Yes.....	1	
			No.....	2	
			I don't Know.....	3	

**Section D: Outdoor activities just before the onset of illness**

No.	Questions	Coding categories	If no, Skip to
D.1	Just before the onset of illness, was the deceased present outdoors?	Yes.....1 No.....2 I don't Know.....3	E.1
D.2	Was the deceased engaged in outdoor occupational activities?	Yes.....1 No.....2 I don't Know.....3	D.3
D.3	Was the deceased working under direct sunlight?	Yes.....1 No.....2 I don't Know.....3	
D.4	Was the deceased working in peak hours of the day, i.e. 11 AM to 4 PM?	Yes.....1 No.....2 I don't Know.....3	
D.5	Was the deceased working near heat sources.e., hot furnace, stove, gas fire, wood fire, steam, hot engines/ machines?	Yes.....1 No.....2 I don't Know.....3	D.7
D.6	If yes to D.5, the type of heat source was:	Fire (hot furnace, stove, gas fire, hot engines).....1 Steam .....2	
D.7	Was the deceased doing any physical exertional activity?	Yes.....1 No.....2 I don't Know.....3	D.8
D.8	Was the deceased sitting in a vehicle?	Yes.....1 No.....2 I don't Know.....3	D.12
D.9	If yes to D.8, was the vehicle parked in a shaded area?	Yes.....1 No.....2 I don't Know.....3	
D.10	If yes to D.8, what was the approx. duration of sitting in vehicle?	0-1 hr.....1 >1 hr .....2	
D.11	If yes to D.8, was the air-conditioner working in vehicle?	Yes.....1 No.....2 I don't Know.....3	
D.12	Remarks on outdoor activity, if any:		

**Section E. Indoor conditions just before the onset of illness.**

E.1	Was the deceased INDOORS?	Yes.....1 No.....2 I don't Know.....3	F1
E.2.	If yes to E.1, were the following items, i.e., ceiling fan, desert cooler, air conditioner present?	Yes.....1 No.....2 I don't Know.....3	
E.3	If yes to E.2, describe the item, its working condition and whether it was switched on or not? Description:		
E.4	Type of house/Room where decease was found	Pucca house (house-made with high-quality materials throughout, including the floor, roof and exterior walls).....1 Katcha house (House made from mud, thatch, or other low-quality materials).....2	
E.5	Windows in rooms	Yes.....1 No.....2 I don't Know.....3	
E.6	If there were windows in the room, were they open at the time of onset of symptoms	Yes.....1 No.....2 I don't Know.....3	

**Section F: Medical conditions recorded at first medical contact (as per medical record)**

No.	Questions	Coding categories	If no, Skip to
F.1	Was the deceased suffering from any chronic medical condition?	Yes.....1 No.....2 I don't Know.....3	
F.2	Was the deceased suffering from any acute medical conditions before the onset of the current illness?	Yes.....1 No.....2 I don't Know.....3	F.4
F.3	If yes to F.2, list the illness and duration of suffering-		
F.4	Was the deceased taking any medications before the onset of current illness?	Yes.....1 No.....2 I don't Know.....3	Section -G
F.5	If yes to F.4, list the medication and duration since taking-		



GSDMA



**Section G: Weather data from the India Meteorological Department**

No.	Questions and Filters	Coding categories/Response	If no, Skip to
G.1	What was the maximum temperature (Tmax) of the day in the area at/ around the onset of illness/death (if onset unknown)?		
G.2	What was the maximum temperature (Tmax) for each day of the past 3 days from the date of patient death?:	a. One day back: b. Two days back: c. Three days back:	
G.3	Was there a heatwave affecting the area/region on the date of onset of illness?	Yes.....1 No.....2 I don't Know.....3	
G.4	Was there a heatwave in the previous 3 days in the area where the onset of illness occurred?	Yes.....1 No.....2 I don't Know.....3	
G.5	What was the relative humidity of the area at/around the onset of illness(or at time of death if onset unknown)?:		
G.6	What was the relative humidity for each day of the past 3 days from the patient's date of death?:	a. One day back: b. Two days back: c. Three days back:	

Form filled by:

Name: .....

Signature:

Designation:.....

Date:

## 14.2 Surveillance of Heat -Related Illnesses (Formats with Standard Operating Procedures)

### FORMAT 1 (A): HEALTH FACILITY FORMAT

#### Daily line List of Suspected Heatstroke CASES# at Health Facility

(From Medicine, Paediatrics and Casualty/Emergency department)

(To be kept at health facility for record)

Name of health facility: _____ Block: _____ District: _____						Date of reporting: _./_./_.					
Type of health facility (Circle the applicable): 1. PHC 2. CHC 3. Taluka/Rural Hospital/Block Hospital 4. Sub-district 5. District Hospital/Civil Hospital 6. Medical College & Hospital 7. Private hospitals with emergency facility 8. Other.....											
(A). Total no. of patients in department (Casualty/Emergency of Medicine + Paediatrics):											
Daily line List of Suspected Heatstroke CASES# at Health Facility											
S. No	Hospital Registration No.	Name	Age*	Sex (M/F)	Address		Outcome within date of reporting (tick the box)				Re-remarks
					Block	District	Admitted	Died	Referred	Recovered	
<b>Total</b>											

\*Age in completed years

Name of person filling the form:

Name of Facility In-Charge:

Designation:

Signature of Facility In-Charge:

Signature:

Date:

**#Suspected Heatstroke:** Altered mental status (including disorientation, delirium, seizure, obtundation) with elevated core body temperature  $\geq 40\text{ }^{\circ}\text{C}/\geq 104\text{ }^{\circ}\text{F}$ , without signs of stroke, history of infection, or signs of medication overdose **OR** Altered mental status (including disorientation, delirium, seizure, obtundation) with hot and dry skin and deranged vitals, i.e., tachycardia, tachypnoea and wide pulse pressure without signs of stroke, history of infection, or signs of medication overdose. (definition is applicable during heatwave season, i.e., March to July)

### Standard Operating Procedures: Format 1(A)

1. **Format 1 (A)** is a daily line list format of **suspected heatstroke cases** to be filled at health facility.
2. It will be kept at health facility for record purpose.
3. It will be **used to compile line list Format 1(B) and daily reporting Format 2.**
4. **Suspected heatstroke (Case definition):** Altered mental status (including disorientation, delirium, seizure, obtundation) **with elevated core body temperature  $\geq 40^{\circ}\text{C}/\geq 104^{\circ}\text{F}$** , without signs of stroke, history of infection, or signs of medication overdose **OR** Altered mental status (including disorientation, delirium, seizure, obtundation) with hot and dry skin and deranged vitals i.e., tachycardia, tachypnoea and wide pulse pressure without signs of stroke, history of infection, or signs of medication overdose. (*definition is applicable during Heatwave season i.e., March to July*)
5. **Institute and department who will compile suspected heatstroke cases:**
  - a. All public hospitals with casualty/emergency.
  - b. All private hospitals with casualty/emergency.
  - c. Reporting Departments will be casualty/emergency of medicine and paediatrics.
6. **Data collection period:** In standard it will be from **01st March to 31st July, every year**. Further direction will be communicated at the start of the year if required.
7. **Case identification:**
  - a. **Person who will diagnose:** A qualified medical doctor will diagnose HRI case as per case definition.
  - b. **Where will the data be recorded:** A qualified medical practitioner will write the provisional diagnosis in the casualty/emergency register as suspected heatstroke.
  - c. **Data collecting person:** Pharmacist, multipurpose health worker-male (MPHW-M), staff nurse -either of the employee will collect the data of suspected heatstroke cases that were diagnosed on previous day from emergency/casualty of medicine and paediatrics departments every day.
8. **Day of diagnosis and recording:** The date of diagnosis will be considered as day zero. Cases diagnosed on day Zero should be recorded on the following day, i.e., day One in **FORMAT 1 (A)**. Example: Cases diagnosed on Sunday (Day Zero) will be recorded on Monday (Day One).
9. **Data compilation:** A hard copy of each completed and signed **Format 1(A)** should be stored in a file **daily** in a proper order. A soft copy of the line list should be maintained as a single excel sheet which should be updated **weekly** to include all Heatstroke cases. It should be ready to be submitted to DSU or SSU as per request.
10. **Reporting after a holiday:** A report which should have been prepared on holiday (e.g. Sunday or gazetted holiday) must be compiled and filed on the next working day. For example, cases diagnosed on Saturday (Day Zero) must be recorded on **Format 1 (A)** on Monday (Day Two) along with a separate daily **Format 1 (A)** report of cases diagnosed on Sunday (Day One).
11. **Nil reporting is mandatory in the prescribed format.** No columns will be left blank; in case of nil reporting, “0” should be written.

### FORMAT 1 (B): HEALTH FACILITY FORMAT

Daily line List of Suspected Heatstroke DEATHS# and Confirmed CVD DEATHS\*

(From Medicine, Paediatrics and Casualty/Emergency department)

(To be kept at health facility for record)

Name of health facility: _____ Block: _____ District: _____						Date of reporting: -./-./--		
Type of health facility (Circle the applicable): 1. PHC 2. CHC 3. Taluka/Rural Hospital/Block Hospital 4. Sub-district 5. District Hospital/Civil Hospital 6. Medical College & Hospital 7. Private hospitals with emergency facility 8. Other.....								
(A). Total no. of all-cause deaths in health facility (Casualty/emergency of Medicine and Paediatrics):								
Daily line List of Suspected Heatstroke DEATHS and Confirmed CVD DEATHS								
S.No	Registration number	Name	Age	Sex (M/F)	Address		Deaths (tick the box)	
					Block	District	Suspected Heatstroke death##	Confirmed CVD death
Total								

Name of person filling the form:

Name of Facility In-Charge:

Designation:

Signature of Facility In-Charge:

Signature:

Date:

**\*Suspected Heatstroke:** Altered mental status (including disorientation, delirium, seizure, obtundation) **with elevated core body temperature  $\geq 40^{\circ}\text{C}/\geq 104^{\circ}\text{F}$** , without signs of stroke, history of infection, or signs of medication overdose **OR** Altered mental status (including disorientation, delirium, seizure, obtundation) with hot and dry skin and deranged vitals, i.e., tachycardia, tachypnoea and wide pulse pressure without signs of stroke, history of infection, or signs of medication overdose. (definition is applicable during Heatwave season, i.e., March to July)

**##Suspected Heatstroke Death:** This is a death on account of suspected heatstroke patient.

**\*Cardiovascular death** includes death resulting from an acute myocardial infarction (MI) or sudden cardiac arrest or heart failure (HF) or cardiovascular (CV) procedures or CV haemorrhage or death due to other CV causes.

### Standard Operating Procedures: Format 1 (B)

1. **Format 1 (B)** is a daily line list of **suspected heatstroke deaths** and **confirmed cardiovascular disease (CVD) deaths**.
2. The total number of all-cause deaths in a health facility (casualty/emergency of medicine and paediatrics) should also be recorded.
3. **Institute and department who will report suspected heatstroke cases:**
  - a. All public hospitals with OPDs & casualty/emergency.
  - b. All private hospitals are having casualty/emergency.
  - c. Reporting departments will be casualty/emergency of medicine and paediatrics.
4. **Date of death and recording:** Date of death will be considered as day zero. Cases that died on day Zero should be recorded on the following day, i.e., day One in FORMAT 1 (B). Example: Cases diagnosed on Sunday (Day Zero) will be recorded on Monday (Day One).
5. **Data compilation:** A hard copy of each completed and signed **Format 1 (B)** should be stored in a file **daily** in a proper order. A soft copy of the line list should be maintained as a single excel sheet which should be updated **weekly** to include all suspected heatstroke deaths and confirmed CVD deaths. It should be ready to be submitted to the district or state nodal unit as per request.
6. **Nil reporting is mandatory in the prescribed format.** No columns will be left blank; in case of nil reporting, “0” should be written.

**FORMAT 2: HEALTH FACILITY FORMAT FOR SENDING TO DISTRICT**

Daily numbers of Suspected Heatstroke CASES# and All cause DEATHS\*

(Compilation of Format 1, A & B)

(To be sent to District Nodal Unit daily)

Name of health facility: _____ Block: _____ District: _____				Date of reporting: _./_./_.			
Type of health facility (Circle the applicable): 1. PHC 2. CHC 3. Taluka/Rural Hospital/Block Hospital 4. Sub-district 5. District Hospital/Civil Hospital 6. Medical College & Hospital 7. Private hospitals with emergency facility 8. Other.....							
Department (Circle the applicable): 1. Emergency Medicine 2. Emergency Paediatrics 3. Casualty							
Date	Total patients in the department	New Suspected Heatstroke Cases (A)	Total Suspected Heatstroke cases since 1st March 2020 (B)	All-cause deaths**			
				Suspected Heatstroke deaths## (a)	Confirmed CVD deaths (b)	Others including unknown (c)	Total deaths (a+b+c)
01-03-20							
02-03-20							

Form filled by (Name):

Name of Facility In-Charge:

Designation:

Signature of Facility In-Charge:

Signature:

Date:

**\*\*All-cause death:** All of the deaths in casualty/emergency medicine plus paediatrics, regardless of cause.

**\*Suspected Heatstroke:** Altered mental status (including disorientation, delirium, seizure, obtundation) **with elevated core body temperature  $\geq 40\text{ }^{\circ}\text{C}/\geq 104\text{ }^{\circ}\text{F}$** , without signs of stroke, history of infection, or signs of medication overdose **OR** Altered mental status (including disorientation, delirium, seizure, obtundation) with hot and dry skin and deranged vitals, i.e., tachycardia, tachypnoea and wide pulse pressure without signs of stroke, history of infection, or signs of medication overdose. (*definition is applicable during Heatwave season i.e., March to July*)

**\*\*Suspected Heatstroke Death:** This is a death on account of suspected heatstroke patient.

**\*Cardiovascular death** includes death resulting from an acute myocardial infarction (MI) or sudden cardiac arrest or heart failure (HF) or cardiovascular (CV) procedures or CV haemorrhage or death due to other CV causes.

### Standard Operating Procedures: Format 2

(Health facility format for sending to DISTRICT)

1. **Format 2** will be compiled from data of **Format 1 (A)** and **Format 1 (B)** by the nodal person at the health facility daily.
2. **Institute and department who will report HRI:**
  - b. All public hospitals with casualty/emergency.
  - c. All private hospitals are having casualty/emergency.
  - d. Reporting Departments will be medicine, paediatrics and casualty/emergency.
3. **Time of reporting to district nodal unit: Format 2 compiled from Format 1 (A) should be reported to District nodal unit on the following day (day one) by 12.00 hr ( i.e. noon).**
4. **Reporting person:** A nodal person identified for the health facility will prepare the report.
5. **Data compilation:** A soft copy in the form of an excel sheet shall be e-mailed **daily** to the district nodal unit through a proper channel. In places where the internet facility is not available, the report can be communicated by any possible means. A hard copy of each **Format 2** should be kept in a designated file daily at the institutions/health facility.
6. **Data collection period:** In standard, it will be from **01st March to 31st July every year**. Further direction will be communicated during the start of the year if required.
7. **Nil reporting is mandatory in the prescribed format.** No columns will be left blank; in case of nil reporting, “0” should be written.
8. **If not submitted on time:** Late report must be submitted within 48 hrs.

**FORMAT 3 (A): DISTRICT FORMAT FOR DAILY COMPILATION**

Daily numbers of Suspected Heatstroke CASES<sup>#</sup> and All cause DEATHS<sup>\*</sup>

(Compiled from Format 2)

(To be kept at District for record)

Cases and deaths due to HRI- District name 2020					Date of reporting: _././._				
S. No.	Name & type of Health Facility	Total patients of the day (Emergency Medicine + Emergency Paediatrics + Casualty)	New Suspected Heatstroke cases (A)	Total Suspected Heatstroke cases since 1st March, 2020 (B)	All-cause deaths**				Re-marks
					Suspected Heatstroke deaths## (a)	Con-confirmed CVD deaths (b)	Others including unknown (c)	Total deaths (a+b+c)	
	PHC1								
	PHC2								
	CHC								
	CH/DH								
	PVT1								
	PVT2								
	PVT3								
<b>Total for District 1</b>									

**Total number of New Confirmed Heatstroke Deaths\*\*\* in the District on \_././.\_:**

**Total number of Confirmed Heatstroke Deaths in the District since 1<sup>st</sup> March 2020:**

*[confirmed by death committee (heat death committee/three men committee)]*

Name of person filling the form:

Name of nodal officer:

Designation:

Signature of nodal officer:

Signature:

Date:

**\*\*All-cause death:** All of the deaths in casualty/emergency medicine plus paediatrics, regardless of cause.

**#Suspected Heatstroke:** Altered mental status (including disorientation, delirium, seizure, obtundation) **with elevated core body temperature  $\geq 40^{\circ}\text{C}/\geq 104^{\circ}\text{F}$** , without signs of stroke, history of infection, or signs of medication overdose **OR** Altered mental status (including disorientation, delirium, seizure, obtundation) with hot and dry skin and deranged vitals, i.e., tachycardia, tachypnoea and wide pulse pressure without signs of stroke, history of infection, or signs of medication overdose. *(definition is applicable during heatwave season, i.e., March to July)*

**##Suspected Heatstroke Death:** This is a death on account of a suspected heatstroke patient.

\***Cardiovascular death** includes death resulting from an acute myocardial infarction (MI) or sudden cardiac arrest or heart failure (HF) or cardiovascular (CV) procedures or CV haemorrhage or death due to other CV causes.

\*\*\***Confirmed Heatstroke Death:** A suspected heatstroke death confirmed by the death committee (heat death investigation committee/three-person committee) at the district level.

### **Standard Operating Procedures: Format 3 (A)** (District format for compilation from health facility)

1. **Format 3(A)** will be compiled by a nodal officer **daily** at District nodal unit.
2. **Format 3 (A)** will be compiled from **Format 2** from all health facility.
3. **Format 3 (A) adaptation:** Modify relevant fields (in grey italic fonts) in given Format 3 (A) to add the name of your district, to list **all** the government facilities and private reporting units in a proper order- from the primary health centre (PHC), Community Health Centre (CHC), District Hospital (DH), Civil Hospital (CH) to Private. This will be the **standard Format 3(A)** for your district for daily data compilation during the whole reporting period of a year.
4. **Total patient of the day:** Against each health facility, write the total patient of the day from emergency medicine, emergency paediatrics and casualty.
5. **Data compilation:** District nodal unit should receive Format 2 from health facilities by **12.00 hr (i.e. 12.00 noon) daily**. Format 3 (A) should be compiled daily from all submitted Format 2 reports. A date-wise soft copy of each daily Format 3 (A) report should be maintained digitally in a designated folder. A hard copy of the same should be printed and filed daily at the district level.
6. **Data collection period:** In standard, it will be from **01st March to 31st July every year**. Further direction will be communicated during the start of the year if required.
7. No reporting by health facility:
  - a. If a health facility report (**Format 2**) is not received on time, write "delayed" in the row for that facility.
  - b. If the facility reports to the district after the deadline of 12:00 noon, **Format 3 (A)** should be updated to reflect the change. Format 3 (A) for the given reporting period can be updated till 48 hrs and should show the updated date of reporting, if applicable.
  - c. If the health facility does not submit **Format 2 at all or** submits it after 48 hrs of reporting deadline, Format 3 of that reporting period should be updated; "delayed" should be changed to "not available".
8. **Reporting after a holiday: Format 3 (A)** which should have been prepared on holiday (e.g. Sunday) must be compiled and prepared on the next working day. For example, facility reports (Format 2) submitted to the district on Saturday must be compiled on **Format 3(A)** on Monday, along with a separate **Format 3(A)** for facility reports submitted to the district on Sunday.
9. **Nil reporting is mandatory in the prescribed format.** No columns will be left blank; in case of nil reporting, "0" should be written.
10. **Confirmed heatstroke death:** a suspected heatstroke death is to be reported as and when the death is confirmed by the death investigation committee (heat death committee/three men committee) at the district level.

**FORMAT 3 (B): DISTRICT FORMAT FOR SENDING TO STATE**

Daily numbers of Suspected Heatstroke CASES# and All-cause DEATHS\*

(Compiled from Format 3 A)

(To be sent to State Nodal Unit daily while keeping a copy for record)

Cases and deaths due to heatstroke- District name 20__					Date of reporting: __/__/__				
Date	Total patients of the day (Emergency Medicine + Emergency Paediatrics + Casualty)	New Suspected Heatstroke Cases (A)	Total Suspected Heatstroke cases since 1st March, 20__ (B)	All-cause deaths**				New Confirmed Heat-stroke Deaths***	Total Confirmed Heat Deaths since 1st March 20__
				Suspected Heatstroke deaths## (a)	Confirmed CVD deaths (b)	Others including unknown (c)	Total deaths (a+b+c)		
01-03-2020									
02-03-2020									

Name of person filling the form:

Name of nodal officer:

Designation:

Signature of nodal officer:

Signature:

Date:

**\*\*All-cause death:** All of the deaths in casualty/emergency medicine plus paediatrics, regardless of cause.

**#Suspected Heatstroke:** Altered mental status (including disorientation, delirium, seizure, obtundation) **with elevated core body temperature  $\geq 40\text{ }^{\circ}\text{C}/\geq 104\text{ }^{\circ}\text{F}$** , without signs of stroke, history of infection, or signs of medication overdose **OR** Altered mental status (including disorientation, delirium, seizure, obtundation) with hot and dry skin and deranged vitals i.e., tachycardia, tachypnoea and wide pulse pressure without signs of stroke, history of infection, or signs of medication overdose. *(definition is applicable during heatwave season, i.e., March to July)*

**\*\*All-cause death:** All of the deaths in casualty/emergency medicine plus paediatrics, regardless of cause.

**#Suspected Heatstroke:** Altered mental status (including disorientation, delirium, seizure, obtundation) **with elevated core body temperature  $\geq 40^{\circ}\text{C}/\geq 104^{\circ}\text{F}$** , without signs of stroke, history of infection, or signs of medication overdose **OR** Altered mental status (including disorientation, delirium, seizure, obtundation) with hot and dry skin and deranged vitals i.e., tachycardia, tachypnoea and wide pulse pressure without signs of stroke, history of infection, or signs of medication overdose. (*definition is applicable during heatwave season, i.e., March to July*)

**##Suspected Heatstroke Death:** This is a death on account of suspected heatstroke patient.

**\*Cardiovascular death** includes death resulting from an acute myocardial infarction (MI) or sudden cardiac arrest or heart failure (HF) or cardiovascular (CV) procedures or CV hemorrhage or death due to other CV causes.

**\*\*\*Confirmed Heatstroke Death:** A suspected heatstroke death confirmed by the death investigation committee (heat death committee/three men committee) at the district level.

### **Standard Operating Procedures: Format 3 (B)**

(District format for sending to State)

1. **Format 3 (B)** will be compiled by a nodal officer **daily** at District nodal unit.
2. **Format 3 (B)** will be compiled from the end row of **Format 3 (A)**.
3. **Time of reporting to state nodal unit:** Format 3 (B) compiled from Format 3 (A) should be reported to the state nodal unit on the following day (**day one**) **by 04.00 PM**.
4. **Reporting after a holiday: Format 3 (B)** which should have been prepared on holiday (e.g. Sunday) must be compiled and prepared on the next working day. For example, facility reports (Format 2) submitted to the district on Saturday must be compiled on **Format 3(B)** on Monday, along with a separate **Format 3(B)** for facility reports submitted to the district on Sunday.
5. **Nil reporting is mandatory in the prescribed format.** No columns shall be left blank; in case of nil reporting, "0" should be written.
6. **Confirmed heatstroke death:** a suspected heatstroke death is to be reported as and when the death is confirmed by the death committee (heat death committee/three-man committee) at the district level.

**FORMAT 4 (A): STATE FORMAT FOR DAILY COMPILATION (district wise)**

Daily numbers of Suspected Heatstroke **CASES<sup>#</sup>** and all-cause **DEATHS<sup>\*</sup>**

(To be sent to Central Nodal Unit daily while keeping a copy for record)

Cases and deaths due to Heatstroke- State name 2020						Date of reporting: _./_./_.				
S. No.	Name of District	Total patients of the day (Medicine + Paediatrics + Casualty/ Emergency)	New cases of Heat-stroke (A)	Cumulative total of Heatstroke cases since 1st March 2020 (B)	All-cause deaths**				New Con- firmed Heat- stroke Deaths***	Total Confirmed Heatstroke Deaths since 1st March 2020
					Suspected Heatstroke deaths## (a)	Con- firmed CVD deaths* (b)	Others including unknown (c)	Total deaths (a+b +c)		
1	District 1									
2	District 2									
3	District 3									
	<b>Total</b>									

Name of person filling the form:

Name of nodal officer:

Designation:

Signature of nodal officer:

Signature:

Date:

**\*\*All-cause death:** All of the deaths in casualty/emergency medicine plus paediatrics, regardless of cause.

**#Suspected Heatstroke:** Altered mental status (including disorientation, delirium, seizure, obtundation) **with elevated core body temperature  $\geq 40^{\circ}\text{C}/\geq 104^{\circ}\text{F}$** , without signs of stroke, history of infection, or signs of medication overdose **OR** Altered mental status (including disorientation, delirium, seizure, obtundation) with hot and dry skin and deranged vitals, i.e., tachycardia, tachypnoea and wide pulse pressure without signs of stroke, history of infection, or signs of medication overdose. (*definition is applicable during heatwave season, i.e., March to July*)

**##Suspected Heatstroke Death:** This is a death on account of a suspected heatstroke.

**\*Cardiovascular death** includes death resulting from an acute myocardial infarction (MI) or sudden cardiac arrest or heart failure (HF) or cardiovascular (CV) procedures or CV haemorrhage or death due to other CV causes.

**\*\*\*Confirmed Heatstroke Death:** A suspected heatstroke death confirmed by the death investigation committee (heat death committee/three-person committee) at the district level.

**Standard Operating Procedures: Format 4 (A)**  
(State format for sending to centre)

1. **Format 4** will be compiled from data reported by all districts by nodal officer at the state nodal unit daily.
2. **Districts** will report health facility-wise aggregate number of cases due to suspected heatstroke. Also, the aggregate number of all-cause deaths with segregation of suspected heatstroke deaths confirmed CVD deaths and others.
3. **Time of reporting:**
  - a. Health facility to district nodal unit: **Cases diagnosed on day zero** (from 00.01 hr to 24.00 hr of a day) at health facilities to be reported to district nodal unit on day 1 (i.e. next day) at 12:00 noon **in Format 2**. The daily compiled report from the district nodal unit (**Format 3**) should be submitted to Integrated Disease Surveillance Programme (IDSP) at the district Surveillance unit (DSU) through the proper channel by **01:00 PM** on day 1 (i.e. next day).
  - b. District to State: by **04:00 PM** the **day 1**.
  - c. State to centre: by **05:00 PM** the **day 1**.
4. **Data compilation:** A soft copy of **Format 4** in the form of an excel sheet shall be e-mailed **daily** to the Central unit through the proper channel. A date-wise soft copy of each daily **Format 4** report should be maintained digitally in a designated folder. A hard copy of **Format 4** should be kept daily in a designated file at the state level.
5. **Data collection period:** In standard, it will be from **01st March to 31st July every year**. Further direction will be communicated during the start of the year if required.

6. No report by a district:
  - a. If a **Format 3** from a district is not received on time, write "**delayed**" in the row for that district.
  - b. If the district reports to the state after the deadline of 4.00 PM, **Format 4** should be updated to reflect the change. **Format 4** for the given reporting period can be updated till 48 hrs and should show an updated date of reporting, if applicable.
  - c. If a district does not submit **Format 3 at all or** submit it after 48 hrs of reporting deadline, **Format 4** of that reporting period should be updated, i.e., "delayed" should be changed to "**not available**" for that district.
7. **Changing a filed report:** A submitted **Format 4** can be changed only if an update is generated by a health facility and communicated to the District within 48 hrs of reporting deadline. Updated **Format 4** for that reporting period should be submitted again to the Central unit with a new date of reporting if applicable.
8. **Reporting after a holiday:** A **Format 4**, which should have been prepared on holiday (e.g. Sunday), must be compiled and submitted on the next working day. For example, **Format 4** for Saturday must be compiled on Monday along with a separate **Format 4** for Sunday.
9. **Nil reporting is mandatory in the prescribed format.** No columns shall be left blank; in case of nil reporting, "0" should be written.
10. **If not submitted on time:** Late report must be filed within 48 hrs with the correct date of reporting.
11. **Analysis:** Analysis of the data should be done every week according to the guidelines provided here.

**FORMAT 4 (B): STATE FORMAT FOR DAILY COMPILATION (day wise)**

Daily numbers of Suspected Heatstroke CASES<sup>#</sup> and all-cause DEATHS<sup>\*</sup>

(To be kept at State for record)

Cases and deaths due to Heatstroke- State name 2020							Date of reporting: _././_		
Date	Total patients of the day (Medicine + Paediatrics + Casualty/ Emergency)	New cases of Heat-stroke (A)	Cumulative total of Heatstroke cases since 1st March, 2020 (B)	All-cause deaths**				New Confirmed Heatstroke Deaths***	Total Confirmed Heatstroke Deaths since 1st March 2020
				Suspected Heatstroke deaths## (a)	Confirmed CVD deaths* (b)	Others including unknown (c)	Total deaths (a+b+c)		
01-03-20									
02-03-20									
<b>Total</b>									

Name of person filling the form:

Name of nodal officer:

Designation:

Signature of nodal officer:

Signature:

Date:

**\*\*All-cause death:** All of the deaths in casualty/emergency medicine plus paediatrics, regardless of cause.

**#Suspected Heatstroke:** Altered mental status (including disorientation, delirium, seizure, obtundation) **with elevated core body temperature  $\geq 40^{\circ}\text{C}/\geq 104^{\circ}\text{F}$** , without signs of stroke, history of infection, or signs of medication overdose **OR** Altered mental status (including disorientation, delirium, seizure, obtundation) with hot and dry skin and deranged vitals, i.e., tachycardia, tachypnoea and wide pulse pressure without signs of stroke, history of infection, or signs of medication overdose. *(definition is applicable during heatwave season, i.e., March to July)*

**##Suspected Heatstroke Death:** This is a death on account of a suspected heatstroke.

**\*Cardiovascular death** includes death resulting from an acute myocardial infarction (MI) or sudden cardiac arrest or heart failure (HF) or cardiovascular (CV) procedures or CV haemorrhage or death due to other CV causes.

**\*\*\*Confirmed Heatstroke Death:** A suspected heatstroke death confirmed by the death investigation committee (heat death committee/three-man committee) at the district level.

## 15 Annexures

### 1. Methodology for undertaking climatological projections over Navsari city

To grasp future climatic patterns, the detailed downscaled projections from the Coordinated Regional Climate Downscaling Experiment (CORDEX) South Asia program, overseen by the Centre for Climate Change Research (CCCR) at the Indian Institute of Tropical Meteorology (IITM), Pune have been used in this plan. These projections stem from the CMIP5 (Coupled Model Intercomparison Projects, 5th generation) climate models, a collaborative platform showcased in the IPCC's fifth assessment report (AR5). Under CORDEX, regional models driven by CMIP5 data portray scenarios for Representative Concentration Pathways (RCPs) – specifically, RCP 4.5 (mid-range emissions) and RCP 8.5 (high-end emissions). These scenarios depict a time series of emissions, concentrations of greenhouse gases, aerosols, and land-use changes. While temperature projections are considered with high or moderate confidence, rainfall projections bear lower confidence, prompting the use of robust statistical methods for model selection and bias correction. Despite such corrections, the inherent variability in the Indian climate and coarse model resolution introduces some level of uncertainty.

Figure A1: Workflow for evaluating and selecting suitable Regional Climate Models (RCMs) for Gujarat

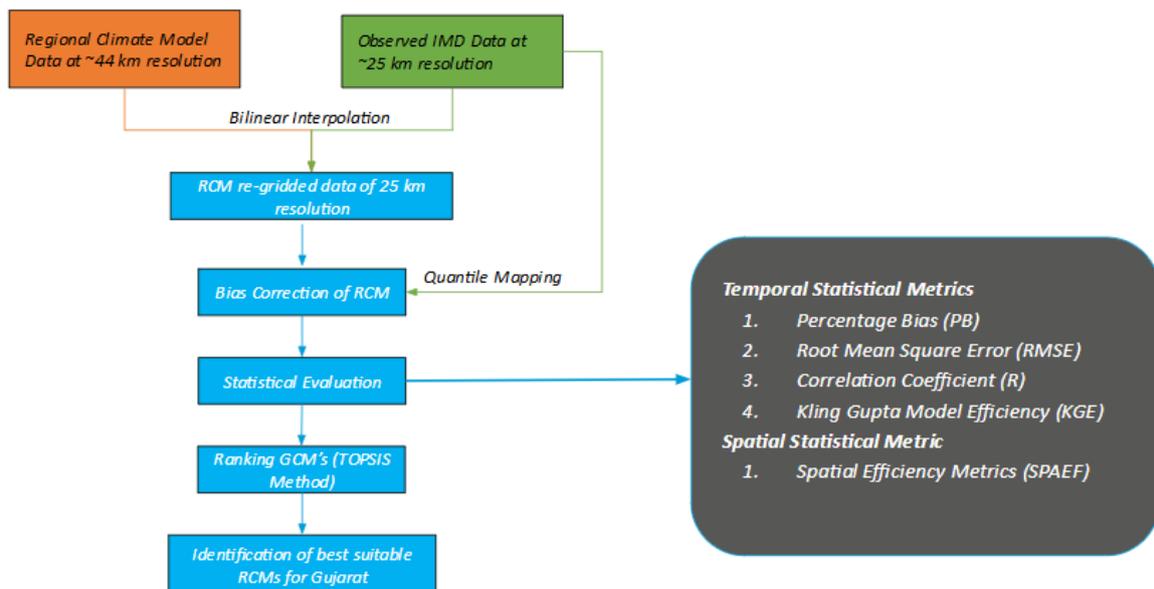


Table A1: List of models chosen for projection analysis

Driving CMIP5 GCM	Contributing CMIP5 Modelling Centre
CCCma-CanESM2	Canadian Centre for Climate Modelling and Analysis (CCCma), Canada
NOAA-GFDL-GFDL ESM2M	National Oceanic and Atmospheric Administration (NOAA), Geophysical Fluid Dynamics Laboratory (GFDL), USA
CNRM-CM5	Centre National de Recherches Me'te'orologiques (CNRM), France
MPI-ESM-MR	Max Planck Institute for Meteorology (MPI-M), Germany
IPSL-CM5A-LR	institut Pierre-Simon Laplace (IPSL), France
CSIRO-Mk3.6	Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia

Source: Authors' compilation

## 2. Detailed Methodology for calculating satellite based indices

**Calculating satellite derived Indices:** For mapping the urban heat islands and various other landscape indicators, a combination of satellite based data obtained from the Landsat-8 and Sentinel 2 has been used. Landsat-8 data is particularly useful for calculating various indices, such as the Normalised Difference Vegetation Index (NDVI), Modified Normalised Difference Water Index (MNDWI), etc. These indices utilise the spectral information captured by Landsat-8 to derive meaningful insights about land cover, vegetation health, and water bodies.

**Normalised Difference Vegetation Index (NDVI):** The NDVI is a widely used vegetation index calculated from remotely sensed data, in this case- Landsat-8 data. It quantifies the presence and health of vegetation by measuring the difference between near-infrared (NIR) and red (RED) bands of the electromagnetic spectrum (Sha Huang 2020). The formula for NDVI is:

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

NDVI values range from -1 to 1, where higher values indicate healthier vegetation and lower values indicate sparse or stressed vegetation. It provides insights into vegetation density, distribution, and health over large spatial scales.

**Modified Normalised Difference Water Index (MNDWI):** The MNDWI is designed to detect the presence of water bodies in remotely sensed imagery. It is particularly effective at distinguishing

between water and non-water features, such as built-up areas or vegetation. MNDWI calculated using the green (Green) and shortwave infrared (SWIR) bands of the electromagnetic spectrum (Liwei Chang 2022). The formula for MNDWI is:

$$MNDWI = \frac{Green - SWIR}{Green + SWIR}$$

MNDWI values typically range from -1 to 1, where higher values indicate the presence of water and lower values correspond to non-water features.

**Normalised Difference Built-up Index (NDBI):** The NDBI is used to detect built-up or urban areas in remotely sensed imagery. It helps differentiate between impervious surfaces, such as buildings and roads, and natural features, such as vegetation or soil. NDBI is calculated using the near-infrared (NIR) and shortwave infrared (SWIR) bands of the electromagnetic spectrum (Mohammad Subzar Malik 2019). The formula for NDBI is:

$$NDBI = \frac{SWIR - NIR}{SWIR + NIR}$$

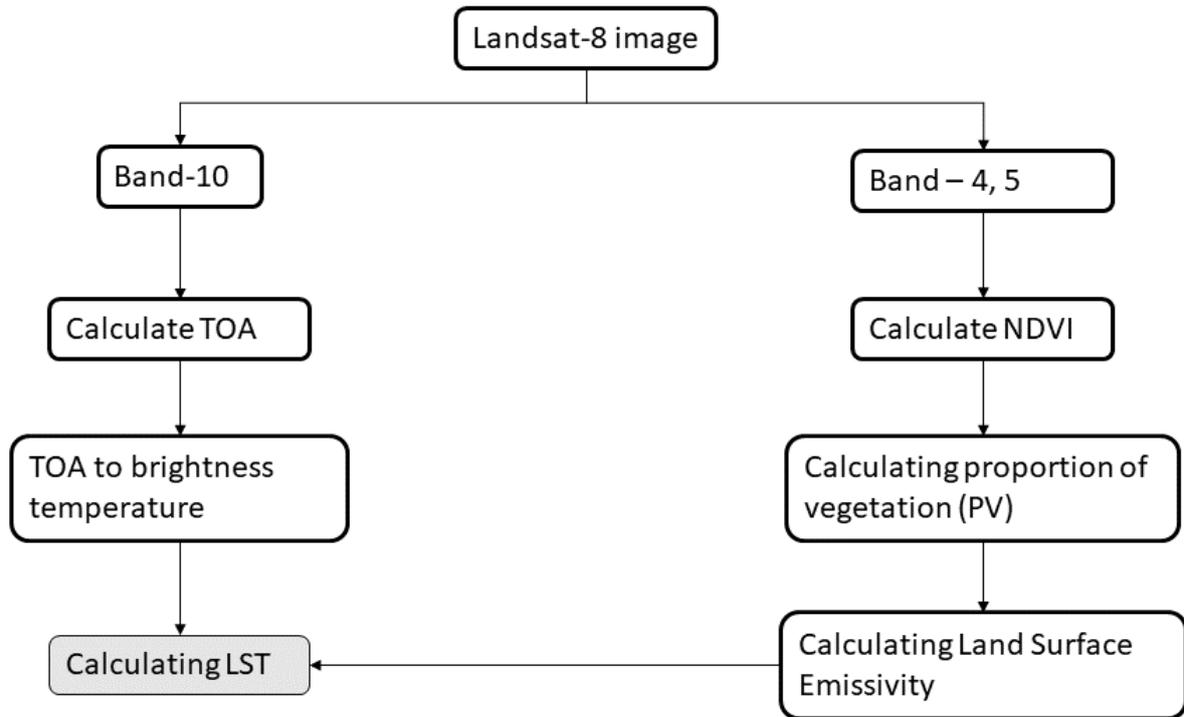
NDBI values typically range from -1 to 1, where higher values indicate the presence of built-up areas and lower values correspond to non-built-up areas.

**Land Use/Land Cover:** The land use/ land cover data was taken as the direct product of Sentinel 2A derived indices from the ESRI's Living Atlas as a raster data of the year 2022 (most recent available data at the time of analysis). This data underwent initial categorization into various classes, subsequently refined into six distinct categories tailored for our specific analysis. These categories include: Water, Vegetation, Crop, Build, Swampy region, and Bare.

**Building Density:** Utilising Google's Open Building dataset, an assessment of building density was conducted through the creation of 500-m square grids. These grids were generated using the fishnet tool within ArcGIS Pro, ensuring a systematic and comprehensive coverage of the study area. Following this, a spatial join operation was executed, integrating the building data with the generated grids. As a result, each grid acquired a count of total buildings within its boundaries, facilitating the calculation of building density across the analysed region. This methodological approach ensures a detailed understanding of the spatial distribution and concentration of buildings within the study area.

**Land Surface Temperature (LST):** Land Surface Temperature (LST) refers to the temperature of the Earth's surface as measured from a satellite or other remote sensing platform. It is a crucial parameter which provides insights into surface energy fluxes, urban heat island effects, and land-atmosphere interactions. Landsat-8 is equipped with the Thermal Infrared Sensor (TIRS), which enables the estimation of land surface temperature (Ridho 2023), (Anandababu D 2018), .

Figure A2: Methodology for computing Land Surface Temperatures from Landsat-8



Source: Authors' analysis

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