NRDC

M.M.C.

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Partner Acknowledgements

Mahesana Municipal Corporation (MMC)

The Mahesana Municipal Corporation (MMC) is the governing body responsible for the administration and development of Mahesana city in Gujarat. Established on January 1, 2025, MMC was formed by merging the former Mahesana Nagarpalika with nine adjoining village panchayats Fatepura, Ramosana, Dediyasan, Palavasna, Heduva Rajgar, Heduva Hanumant, Taleti, Lakhwad, and parts of five others including Palodar and Panchot thereby expanding its jurisdiction and urban governance capabilities. Operating under the Gujarat Municipality Act of 1963, MMC is tasked with implementing state urban development schemes, overseeing infrastructure projects, and providing essential civic services such as waste management, water supply, and urban planning

Natural Resources Defense Council (NRDC)

The Natural Resources Defense Council (NRDC) is an independent organization dedicated to advancing both national and global climate goals through community-based solutions that emphasize public health, equity, job creation, and resilience. With a membership exceeding three million and a team of over 700 experts worldwide, NRDC works to protect the Earth its people, wildlife, and natural ecosystems on which all life depends.

Centre for Environment Education (CEE)

Centre for Environment Education (CEE) was established as a Centre of Excellence under the Ministry of Environment, Forest and Climate Change, Govt. of India, working in the field of Environmental Education and Education for Sustainable Development. It is registered as a Society under Societies Registration Act 1860 having its registered Office at Thaltej Tekra Ahmedabad. As a national institution, CEE's mandate is to promote environmental awareness nationwide. It is committed to ensure that Environmental Education (EE) leads to action for sustainable development.

MAHESANA CITY

HEAT ACTION PLAN

Heat Resilient Mahesana, 2025

MAHESANA MUNICIPAL CORPORATION, MAHESANA

ABBREVIATION / ACRONYMS

LIST OF ABBREVIATION

Abbreviation	Full Form
CEE	Centre for Environment Education
CHC	Community Health Centre
CV	Cardiovascular
DDMA	District Disaster Management Authority
DEO	District Education Officer
DH	District Hospital
GIDM	Gujarat Institute of Disaster Management
GIS	Geographic Information System
GPCB	Gujarat Pollution Control Board
HAP	Heat Action Plan
HAC	Heat Action Committee
HI	Heat Index
IEC	Information, Education and Communication
IIPHG	Indian Institute of Public Health Gandhinagar
IMD	India Meteorological Department
IPCC	Intergovernmental Panel on Climate Change
LST	Land Surface Temperature
MMC	Mahesana Municipal Corporation
NDMA	National Disaster Management Authority
NDVI	Normalized Difference Vegetation Index
NGO	Non-Governmental Organization
NHM	National Health Mission
NRDC	Natural Resources Defense Council
ORS	Oral Rehydration Solution
PHC	Primary Health Centre
SAPCC	State Action Plan on Climate Change
SSP5-8.5	Shared Socioeconomic Pathway 5-8.5 Scenario
UGVCL	Uttar Gujarat Vij Company Limited
UHI	Urban Heat Island
ULB	Urban Local Body
USGS	United States Geological Survey

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1. Introduction

1.1 Context and Rationale

Climate change has led to a significant increase in the frequency, intensity, and duration of heatwaves across India,[1] As a rapidly developing nation, India must balance the pursuit of economic growth with the need to ensure energy security, generate employment, and strengthen climate resilience. The economic implications of heat stress are substantial by 2030, India is projected to lose approximately 5.8% of daily working hours due to rising temperatures, leading to erosion in productivity and lower fiscal revenue.[2] The impacts of climate change, including extreme heat, disproportionately affect marginalized communities. A study indicates that almost 90% of Indians are more vulnerable to public health issues, food shortages, and increased risks of death due to heatwaves fueled by climate change.[3] Extreme heat events are now recognized as a major public health risk, often causing heat exhaustion, heatstroke, and fatalities, especially among vulnerable populations such as the elderly, children, and outdoor workers.[4] In response, HAPs have been developed as critical instruments to build resilience, reduce heat-related illnesses, and safeguard communities through a combination of early warning systems, public awareness campaigns, and institutional coordination.[5]

The Mahesana Heat Action Plan is a city-specific, evidence-based strategy designed to address the local impacts of extreme heat through short-term emergency response measures and long-term adaptation strategies. It aligns with national and state-level climate policies and builds on successful models implemented in Ahmedabad and other cities in Gujarat.[6]The plan has been developed in consultation with local authorities, health departments, and technical partners, with support from the Natural Resources Defense Council (NRDC) Centre for Environment Education and other stakeholders.

1.2 Climate Change and Rising Heat

Global climate change is unequivocally driving a rise in extreme weather events, with heatwaves becoming more frequent, prolonged, and intense worldwide. The Intergovernmental Panel on Climate Change (IPCC) confirms that with every additional 0.5°C of global warming, the frequency and severity of hot extremes including heatwaves will increase significantly, affecting both human health and ecosystems.[7] These rising temperatures are not isolated anomalies but part of a broader shift that places additional stress on health systems, water resources, agriculture, and infrastructure. Vulnerable populations including outdoor workers, the elderly, and low-income communities are particularly at risk. In tropical and subtropical regions, prolonged heat exposure is linked to elevated mortality and morbidity rates, especially from cardiovascular and respiratory illnesses.[8]

The economic consequences of extreme heat are also becoming more apparent. According to the International Labor Organization (ILO), heat stress is projected to reduce total working hours worldwide by 2.2% equivalent to 80 million full-time jobs by 2030, disproportionately affecting low- and middle-income countries.[9] In such contexts, high outdoor temperatures limit physical work capacity, reduce productivity, and increase occupational health risks, especially in sectors such as construction, agriculture, and transport. Addressing extreme heat requires a multi-pronged approach rooted in scientific data, early warning systems, and localized planning. Proactive adaptation strategies and policy interventions can significantly mitigate the risks of extreme heat and build long-term resilience in both urban and rural settings.

1.3 Strengthening Heat Preparedness through Heat Action Plans in India

In response to the rising threat of extreme heat, governments across India have progressively adopted Heat Action Plans (HAPs) as structured frameworks for climate risk mitigation. The launch of India's first HAP in Ahmedabad in 2013, after the deadly 2010 heatwave, marked a significant transition from reactive to preventive strategies.[10] These plans serve as cross-sectoral tools, delegating responsibilities across departments to ensure timely planning, early warning dissemination, emergency response, and recovery operations.

Currently, HAPs have been implemented in 23 states that are frequently exposed to high temperatures and heatwave events.[11] However, many of these plans are generic and lack the granular assessments needed to address the unique vulnerabilities of specific regions. Despite this, HAPs remain vital in integrating heat resilience into broader climate and development planning frameworks. They particularly focus on safeguarding vulnerable groups such as outdoor workers, slum dwellers, and the elderly by embedding heat preparedness into governance systems. Notably, Ahmedabad's HAP demonstrated its effectiveness by reducing excess mortality. A study found a decline of approximately 1,190 deaths during the 2014–2015 period compared to the 2007–2010 baseline, underscoring the life-saving potential of a well-executed heat response system.[10] These outcomes emphasize the need to expand, localize, and continuously refine HAPs nationwide to protect communities from intensifying heat stress.

1.4 Understanding the Local Context: State and City Overview

Gujarat: A Climate-Vulnerable State

Gujarat, one of India's most urbanized and industrially developed states, faces heightened vulnerability to climate extremes due to its diverse terrain comprising coastal belts, semi-arid inland districts, and dense urban cores.[12] The state routinely experiences summer temperatures exceeding 45°C, particularly in its northern and central districts.[13] According to the India Meteorological Department (IMD), heatwave alerts were issued in several districts during May 2024 as temperatures surged across the state.[14]

Gujarat has been a pioneer in climate resilience. It was one of the first states to draft a State Action Plan on Climate Change (SAPCC), focusing on vulnerable sectors such as health, urban infrastructure, and water resources.[15] The city of Ahmedabad launched India's first Heat Action Plan (HAP) in 2013, which has since become a model for other cities in the country. The plan integrates early warning systems, inter-agency coordination, and public outreach to reduce heat-related mortality, showing a decline in all-cause summer deaths in the years following its implementation.[10]

Mahesana: Urban Growth and Heat Stress

Mahesana, located in north Gujarat, serves as a regional centre for commerce, administration, and agriculture. With a population exceeding 1.8 lakh as per the 2011 Census (and substantially higher now), the city is expanding rapidly.[16] Its semi-arid climate, coupled with intensifying urban development, renders it highly vulnerable to extreme heat events. In 2024, the district recorded peak temperatures nearing 46.8°C during a prolonged heatwave.[14] Vulnerable populations such as informal sector workers, the elderly, slum residents, and outdoor labourers suffer disproportionately during heat extremes due to inadequate access to cooling and healthcare infrastructure.[17] In response, Mahesana is in the process of preparing a city-level HAP, aligned with the broader framework set by Gujarat's SAPCC. This plan aims to integrate temperature forecasts, local vulnerability assessments, and institutional coordination mechanisms to ensure targeted response strategies for at-risk populations.

1.5 Climate Trends and Heat Vulnerabilities in Mahesana

Mahesana is seeing rising average temperatures and more frequent heatwaves. During the summer months, especially from March to June, the city experiences prolonged dry spells, intensifying heat-related stress on both urban and peri-urban communities.[14] In 2024, the district reached 46.8°C, prompting emergency warnings by the IMD.[14] Climate models project that if global greenhouse gas emissions continue unabated, the annual mean temperature for india overall could rise by 1.5–2.5°C by mid-century.[18]

Water scarcity further exacerbates Mahesana's vulnerability to heat. Recognizing this, the Gujarat government launched the Sujalam Sufalam Jal Abhiyan (SSJA) 2.0 in April 2025, aiming to enhance water conservation efforts across the state. Mahesana led the initiative with 416 projects, including pond deepening, canal cleaning, and rainwater harvesting, highlighting the district's proactive approach to addressing water shortages.[19]

A well-structured HAP can provide a roadmap to mitigate heat-related mortality through early warning systems, training for frontline workers, public awareness campaigns, and infrastructure interventions like shaded areas, drinking water stations, and cool roof technologies.

1.6 Mahesana's Roadmap to Heat Resilience

Mahesana's growing heat vulnerability, combined with socio-economic and infrastructure challenges, requires a focused Heat Action Plan (HAP) built on three pillars:

1. Protection for Climate-Vulnerable Livelihoods:
   Many people in Mahesana work outdoors in agriculture, dairy, construction, and transport, facing high heat exposure and little protection.[20] Measures such as hydration points, shaded rest areas, flexible work hours, and awareness programs can help reduce heat-related health risks.[21]
2. Enhancing Public Infrastructure and Health System Readiness:
   Cooling infrastructure is limited, especially in peri-urban and rural areas, with unreliable electricity increasing heat vulnerability.[22] Health centers lack specific heat emergency protocols and training for frontline workers[4]. Strengthening early warning systems, staff training, and introducing low-cost cooling solutions can improve preparedness.[23]
3. Addressing Water Stress and Climate-Responsive Planning:
   Groundwater depletion and irregular rainfall worsen drought and heat risks.[24] Urban expansion with more paved surfaces and less greenery increases the urban heat island effect.[25] Planning efforts should focus on restoring green cover, adopting water-sensitive designs, and using reflective building materials to reduce heat impacts.

1.6.1 Rationale for developing Urban Local Body (ULB) level heat action plan

Recognizing the urgent need for urban heat resilience, the *Heat Resilient Mahesana* workshop held on 16th April 2025 under NRDC's Cool Roofs initiative served as a catalyst for coordinated climate action at the municipal level. Convened at the Mahesana Municipal Corporation (Figure 1) and organized by CEE, the workshop brought together key stakeholders—including experts from NRDC, IIPHG, and Panache Greentech to collectively explore cool roofs as a viable, scalable heat mitigation solution. Through insightful presentations and shared experiences, the session highlighted the potential for implementation across municipal schools, government infrastructure, and low-income housing.

The Hon'ble Commissioner, Shri Ravindra D. Khatale (IAS), reinforced the city's dedication to climate preparedness and called for the formulation of a comprehensive HAP tailored to Mahesana's local context. This call to action was met with strong support from NRDC and CEE, both of whom committed to working in partnership with the municipality. The workshop not only underlined the necessity of localized heat resilience strategies but also laid the groundwork for a collaborative roadmap to protect vulnerable populations and ensure sustainable urban living.

Figure 1: Multi - Stakeholder meeting for the Mahesana HAP in April 2025 along with CEE, NRDC, IIPHG and Panache Greentech

Source 1 : CEE

The key takeaways from the consultative discussion were:

1. Cool roofs offer a practical and inclusive heat mitigation solution: As a passive, low-cost strategy, cool roofs can effectively reduce indoor temperatures and enhance thermal comfort, especially in government buildings, municipal schools, and low-income housing. Their scalability and adaptability make them suitable for city-wide implementation.

2. Vulnerable populations face heightened risks from extreme heat: Children, the elderly, and informal sector workers are particularly susceptible to heat-related illnesses. Addressing heat vulnerability requires early interventions such as awareness drives, school-based programs, and sensitization at workplaces.

3. Data-driven planning and health integration are essential: Heat resilience strategies must be grounded in localized climate and health data. Incorporating heat morbidity and vulnerability mapping into the city's planning framework will help identify high-risk areas and prioritize interventions.

4. Demonstration and public engagement are crucial for scale: Practical demonstrations, visual outreach materials, and community-friendly innovations such as aesthetic reflective coatings and mobile awareness kits can improve adoption and ensure public participation in heat mitigation efforts.

5. Laying the foundation for an integrated Heat Action Plan: Effective heat action planning requires the active leadership of the municipal administration and coordination across departments like health, education, infrastructure, and housing. Local governance structures play a pivotal role in translating climate commitments into on-ground resilience measures.

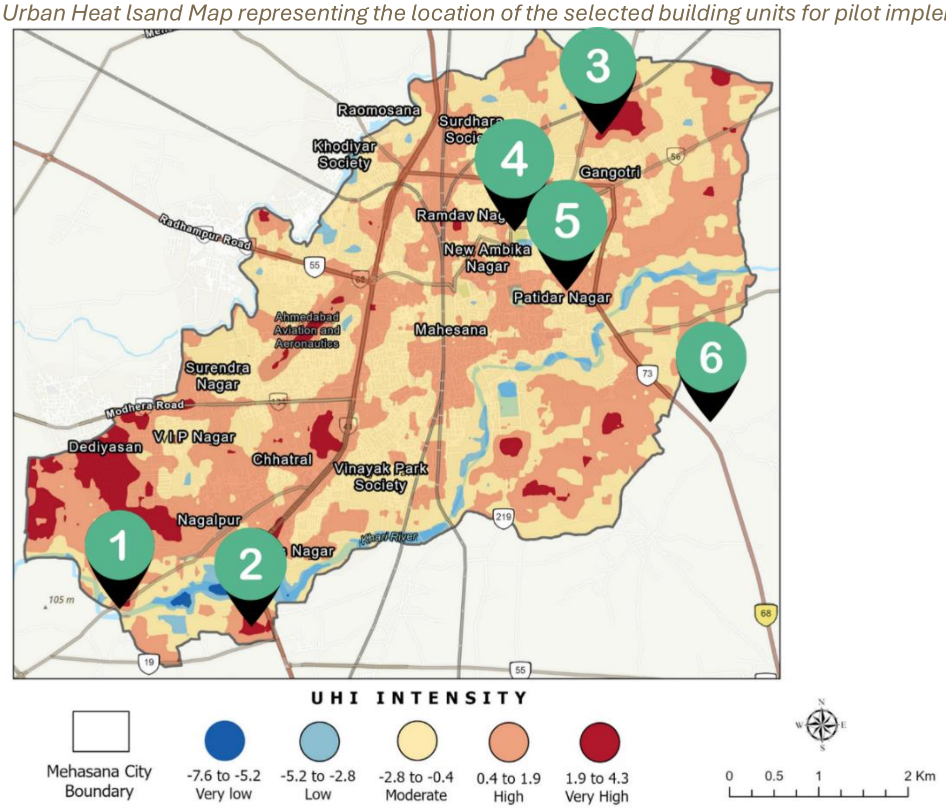
Urban Local Bodies (ULBs) are pivotal in implementing Heat Action Plans (HAPs), serving as the central link between departments such as health, infrastructure, water, and urban planning. Their role in coordinating multi-sectoral efforts allows for localized, data-informed strategies that not only mitigate heat-related risks but also strengthen overall urban resilience.

1.6.2 Cool Roof Pilot Implementation in Mahesana

1.6.2.1 Site Profiling for Pilot Implementation

To validate the effectiveness and feasibility of cool roof technology in Mahesana, a pilot project was implemented across multiple sites identified as heat-prone zones using UHI mapping and temperature analysis. The pilot aimed to evaluate the reduction in surface and indoor temperatures post-application of solar-reflective cool roof coatings, thereby demonstrating its potential as a key intervention in Mahesana's Heat Action Plan. The locations and typologies of the selected building units are illustrated in Figure 2 below.

Figure 2 : Urban Heat Island Map representing the location of the selected building units for pilot implementation



Source 2 : Plotted by CEE

Table 1: Pilot Sites and Building Typologies

No.	Area	Unit	Unit Typology
1	Dediyasan	House	Slum
2	Dediyasan Road	House	Residential
3	Vishnagar Road	House	Residential
4	Para Talav	Ward Office	Government
5	Patidar Nagar	Ward Office	Government
6	Lakhavad	Gram Panchayat Office	Government

1.6.2.2 Pre-Pilot Temperature Recordings

Table 2 : Pre-Pilot Temperature Recordings

No.	Area	Typology	Time	Indoor Temperature (°C)	Roof Temperature (°C)
1	Dediyasan	Slum	04:40 PM	52.00	47.90
2	Dediyasan Road	Residential	05:02 PM	49.10	52.10
3	Vishnagar Road	Residential	03:40 PM	43.60	56.40
4	Para Talav	Government	03:55 PM	40.20	60.00
5	Patidar Nagar	Government	03:16 PM	51.10	69.50
6	Lakhavad	Government	03:25 PM	48.90	61.60

1.6.2.3 Pilot Intervention

Based on the above data and spatial heat mapping, cool roof paints were applied to the rooftops of the identified structures across diverse typologies ranging from residential slum dwellings to government ward and panchayat offices. The objective was to analyze the comparative thermal performance post-intervention and derive inferences to scale the solution across other heat-stressed areas in Mahesana.

Figure 3 : Pilot implementation of cool roof paint

Source 3 : CEE

Figure 4 : Pilot implementation of cool roof paint

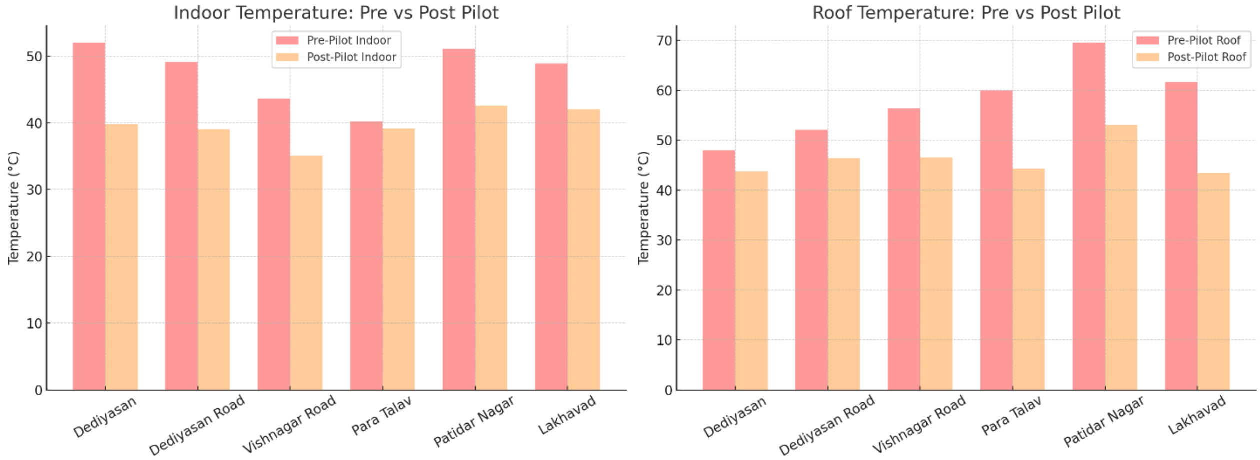
Source 4 : CEE

1.6.2.4 Post-Pilot Temperature Recordings

Table 3 : Post pilot temperature readings

No.	Area	Typology	Time	Indoor Temperature (°C)	Roof Temperature (°C)
1	Dediyasan	Slum	02:10 PM	39.80	43.80
2	Dediyasan Road	Residential	02:22 PM	39.00	46.30
3	Vishnagar Road	Residential	01:18 PM	35.06	46.50
4	Para Talav	Government	12:55 PM	39.20	44.30
5	Patidar Nagar	Government	01:04 PM	42.60	53.00
6	Lakhavad	Government	01:15 PM	42.00	43.40

Figure 5 : Surface Temperature analysis Pre vs Post cool roof application



Source 5 : Plotted by CEE

Temperature Reduction Analysis: Cool Roof Pilot – Mahesana

The bar charts above illustrate the temperature variations across six locations Pre and Post the implementation of cool roofs. Measurements were taken for both indoor and roof (outdoor) conditions.

Average Temperature Reductions

- Indoor Temperature
  - Pre-Pilot Avg: 47.98°C
  - Post-Pilot Avg: 40.11°C
  - 🔻 Reduction: 7.87°C
- Roof Temperature
  - Pre-Pilot Avg: 57.92°C
  - Post-Pilot Avg: 46.22°C
  - 🔻 Reduction: 11.70°C

Conclusion and Insights

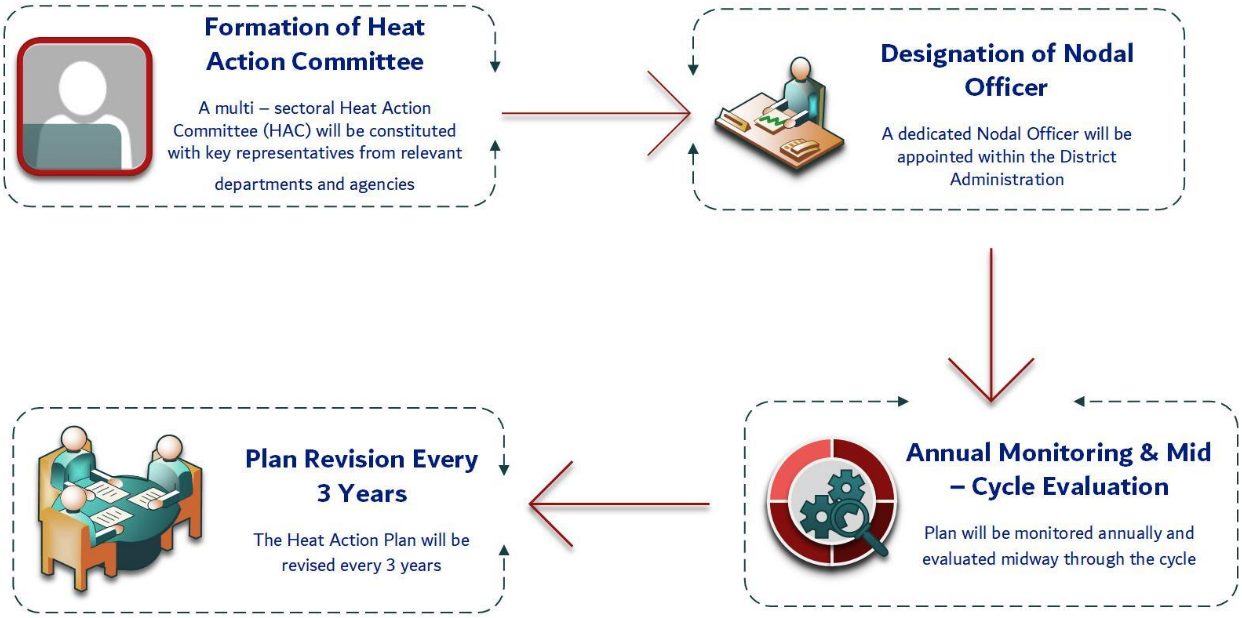
The implementation of cool roof solutions in Mahesana has resulted in significant temperature reductions, particularly over rooftops and indoor spaces:

- Indoor comfort improved considerably, with reductions up to 8°C, helping reduce heat stress for vulnerable populations.
- Roof surface temperatures experienced a drop of nearly 12°C, demonstrating the effectiveness of reflective coatings in reducing heat absorption.
- These results confirm that cool roofs are a low-cost, scalable adaptation strategy for urban heat mitigation.

1.6.3 Approach for Mahesana Heat Action Plan

In Gujarat, heatwaves are recognized as a climate risk under the State Action Plan on Climate Change (SAPCC), prompting urgent urban-level interventions. Building on this, the Mahesana HAP will adopt a multi-stakeholder, institutionalized approach grounded in scientific evidence and participatory planning. The plan will be locally led, context-specific, and progressively strengthened through the following implementation framework. *(*Figure 6 : Framework for Mahesana HAP*)*

Figure 6 : Framework for Mahesana HAP



Source 6 : Varanasi HAP of NRDC India

1. Formation of a Heat Action Committee:

A multi-sectoral **Heat Action Committee (HAC)** will be established for Mahesana, comprising key representatives from relevant city and district-level departments and agencies (Table 4). This committee will be responsible for coordination, implementation, and monitoring of the HAP.

Table 4 : Heat Action Committee Task Force – Mahesana

Designation	Role
District Collector, Mahesana	Chairperson
Municipal Commissioner, Mahesana Municipal Corporation	Co-Chair
Elected MLAs from Mahesana City	Member
Mayor, Mahesana Municipal Corporation	Member
District Development Officer (DDO), Mahesana	Member
Chief District Health Officer (CDHO)	Member
Executive Engineer, Mahesana Municipal Corporation	Member
District Education Officer (DEO)	Member
District Disaster Management Officer (DDMO)	Member
Nodal Officer, HAP – Mahesana Municipal Corporation	Member
GSRTC Depot Manager, Mahesana	Member
District Officer, Forest Department	Member
Chief Fire Officer, Mahesana Municipal Corporation	Member
District Social Welfare Officer	Member
District Agriculture Officer	Member
Traffic Police Inspector, Mahesana	Member
Representatives from Civil Society Organizations (CSOs)/NGOs	Member
Technical Experts from Partner Institutions (NRDC, IIPHG, CEE)	Invitee

2. Designation of a Nodal Officer:

A dedicated Nodal Officer will be appointed from Mahesana Municipal Corporation or District Administration to oversee the coordination, integration, and real-time management of the HAP.

3. Annual Monitoring & Mid-Cycle Evaluation:

The Heat Action Committee will:

- Convene before the heat season (Feb/March) for preparedness review.
- Meet fortnightly during the heat season (April–June) for monitoring.
- Hold emergency meetings in response to IMD alerts.
- Conduct a comprehensive evaluation post-heat season (July/August).

4. Plan Revision Every Three Years:

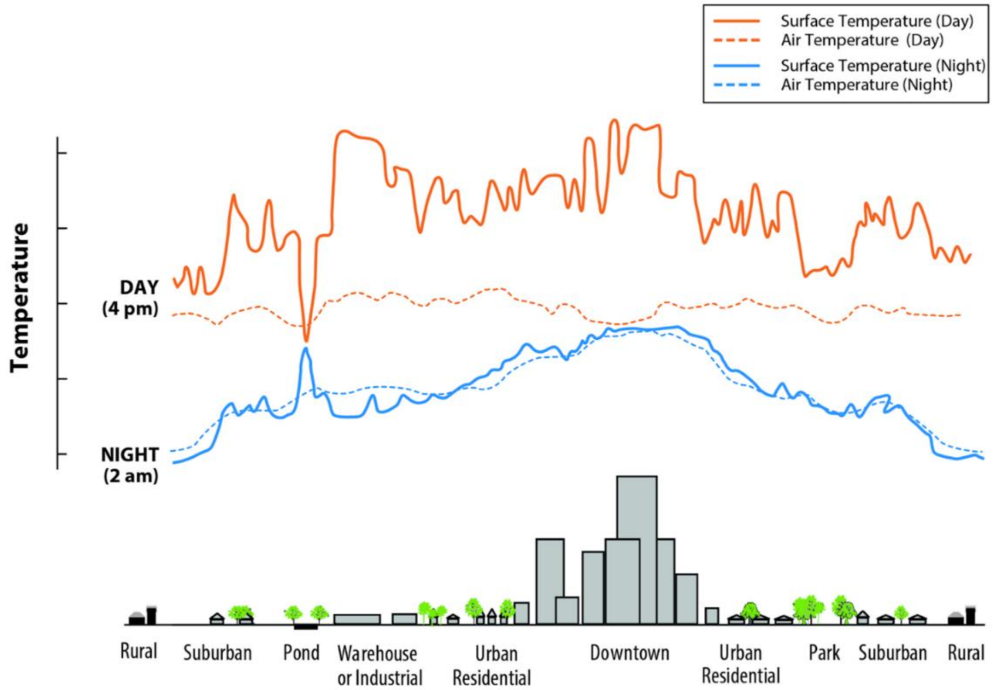
The Mahesana HAP will be revised every three years to incorporate:

- New temperature trends and climate risk data.
- Revised local vulnerability indicators.
- Feedback from stakeholders and implementing departments.

2. Heat and Human health

Pro longed exposure to elevated temperatures poses significant risks to human well-being, particularly in urban environments where densely built-up areas exacerbate heat retention[26]. Figure 7 is a conceptual illustration of spatial variation in surface and air temperatures across diverse landscapes, with urban cores such as downtowns and industrial zones exhibiting notably higher temperatures, especially during the day[27]. In contrast, vegetated and water-rich areas like parks and ponds demonstrate a marked cooling effect. This urban heat island phenomenon which refers to the increased temperature in urban areas compared to surrounding rural regions or natural landscapes, due to human activities and built-up surfaces absorbing and retaining heat[28], intensifies thermal stress in cities, underscoring the need for systematic heat vulnerability assessments. Such evaluations are essential for identifying critical hotspots, informing evidence-based public health responses, and guiding climate-resilient urban planning strategies that prioritize green infrastructure and equitable access to cooling resources.

Figure 7: Urban Heat Island effect illustration



Source 7 :U.S. Environmental Protection Agency. (n.d.). What are heat islands? U.S. Environmental Protection Agency. https://www.epa.gov/heatislands/what-are-heat-islands

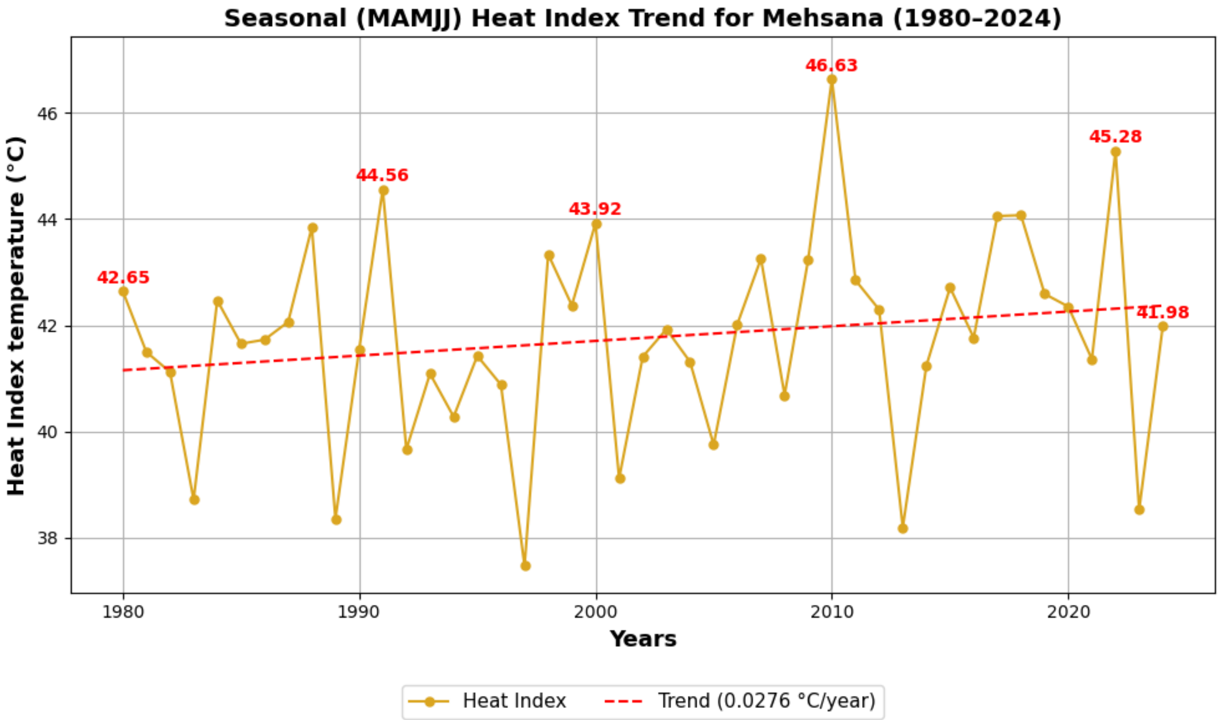
2.1 Heat Vulnerability Risk Assessment

Most HAPs in India fall short in delivering detailed insights at the intra-city level, especially regarding vulnerable populations a critical factor in targeting effective heat mitigation strategies. The Centre for Policy Research's 2023 review of 37 HAPs across India highlighted a major shortfall: most lacked detailed, data-backed vulnerability mapping[29]. To bridge this gap, Mahesana City's HAP has embraced a data-driven approach to improve heat risk preparedness at the grassroots level. Central to this approach is the analysis of long-term temperature trends from 1980 to 2024, using ERA5 reanalysis data. The assessment concentrates on the high-heat period from March to July (MAMJJ), enabling a more informed understanding of evolving heatwave patterns and supporting targeted interventions. This timeframe also captures peak humidity levels in June and July, which exacerbate heat stress and health risks across urban and peri-urban communities.

2.2 Daytime and Night-time Temperature and Heat Index trend

To assess long-term patterns of both daytime and nighttime heat extremes in Mahesana, ERA5 air temperature reanalysis data has been used to study historical temperature trends. Mahesana has a semi-arid climate[30], a type of climate characterized by hot summers, minimal rainfall and warm to cool winters [31].Hence, It is essential to analyze temperature in conjunction with humidity in semi-arid climate, as even with low humidity levels, high temperature can significantly influence heat stress and human thermal comfort during peak summer months in such regions. To better understand periods of heightened humid heat and temperature, the NOAA Heat Index (HI) formula was applied. This widely recognized method combines air temperature and relative humidity to estimate how hot it feels to the human body, providing a more accurate representation of heat stress relevant to both climatological and public health contexts.[32]

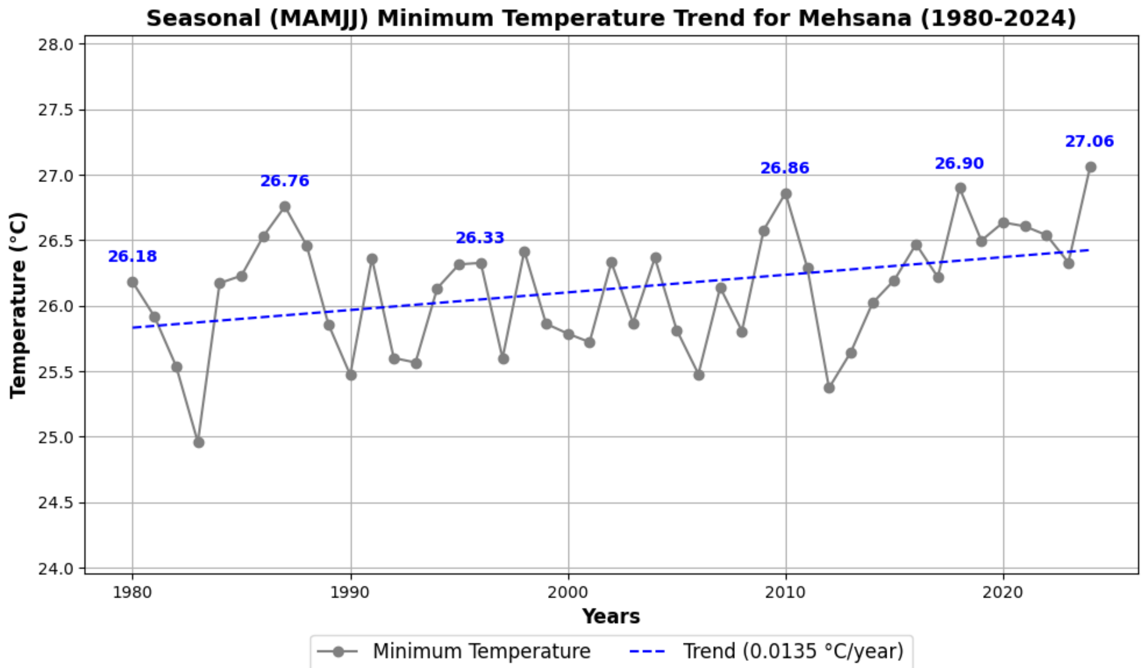
Figure 8: Seasonal (MAMJJ) Heat Index (1980-2024) For Mahesana



Source 8 : Plotted by CEE

Figure 8 presents the seasonal (MAMJJ) trends of heat index for Mahesana from 1980 to 2024. The heat index, which incorporates both temperature and relative humidity exhibits a steady rise at 0.027°C per year. Between 1980 and 2024, Mahesana experienced an approximate increase in the heat index of 1.18°C during MAMJJ. Although the actual air temperature has remained relatively stable, the potential heat stress experienced by individuals has increased significantly over the 44-year period. The growing heat index can be attributed to rising humidity levels, which reduce the effectiveness of the body's natural cooling mechanism—sweating. When humidity is high, sweat does not evaporate as easily, preventing heat from being released efficiently. This results in a higher perceived heat index, making conditions feel hotter than the actual air temperature. Prolonged exposure to such conditions can lead to significant thermal discomfort, fatigue, and a higher risk of heat-related illnesses particularly during peak summer months when both temperature and humidity are elevated.[33]

Figure 9 : Seasonal (MAMJJ) Night-time temperature (1980-2024) For Mahesana



Source 9 : Plotted by CEE

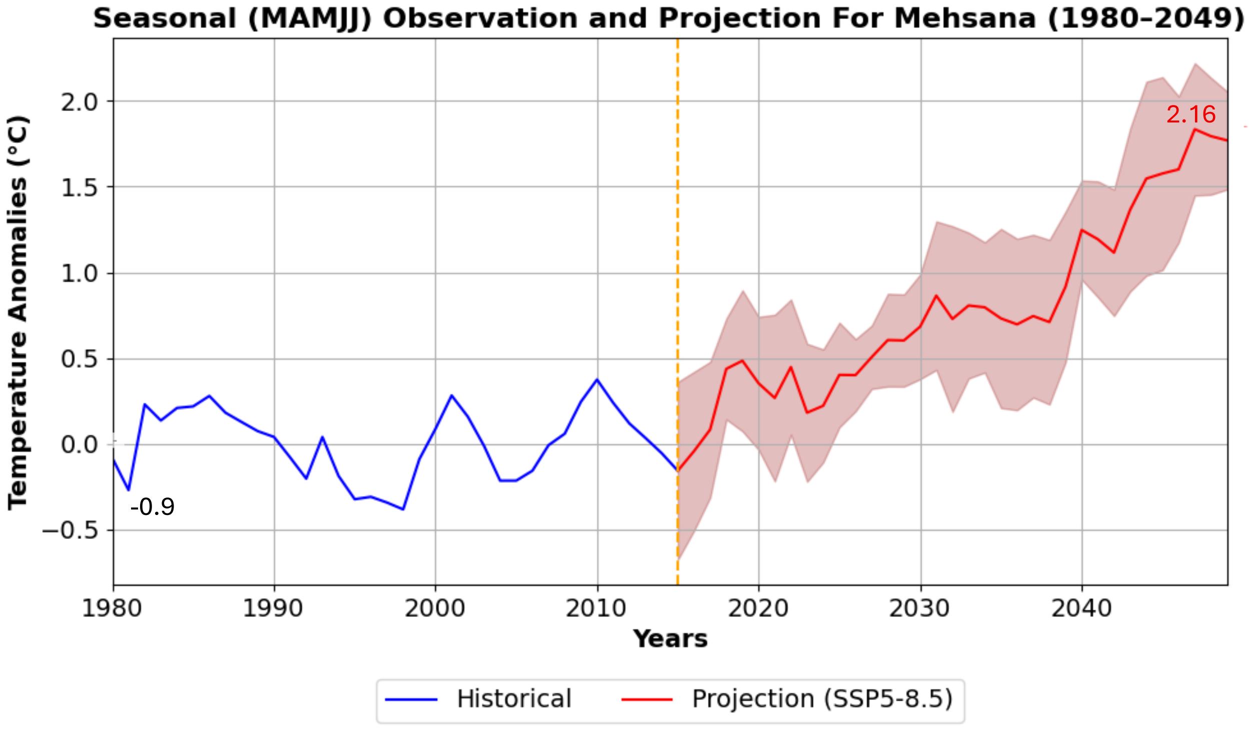
Figure 9 illustrates the trend of minimum temperature which refers to lowest temperature recorded during the night, typically just before sunrise, for Mahesana from 1980 to 2024. The trend is showing a consistent upward trajectory with an increase of 0.57°C over the observed period. Starting around 26.18°C in the early 1980s, minimum temperatures have steadily increased, reaching approximately 27.06°C in recent years. Notable peaks are observed in the years 1987 (26.76°C), 2010 (26.86C), 2018 (26.90°C), and 2024 (27.06°C), indicating a pattern of more frequent warm nights in the later decades. This rise in minimum temperature is particularly concerning since it limits night-time cooling, can disrupt sleep and reduce the body's ability to recover from daytime heat thereby increasing the risk of heat-related illnesses especially in vulnerable populations [34]. Nighttime heat places added strain on the cardiovascular system, with effects that can intensify over consecutive hot nights.

2.3 Climate Change Projections: Analysis of SSP5 8.5 Scenario

The temperature projections shown in Figure 10 CMCC and CNRM climate model [35]from the Coupled Model Intercomparison Project Phase 6 (CMIP6)[36]. The projections' data came from the Copernicus Climate Data store, specifically from the cohort of CMIP6 dataset.[37] The baseline period of 1980–2000 was used to compute temperature anomalies. This baseline is the reference period against which future temperature changes are measured. The anomaly method allows for a clearer picture of the warming trend independent of seasonal variations.

In addition to the historical climate analysis (1980–2014), future projections for the period 2015–2050 are assessed using the SSP5-8.5 scenario to better anticipate the trajectory of heat-related risks in Mahesana. The Shared Socioeconomic Pathways (SSPs), developed by the Intergovernmental Panel on Climate Change (IPCC), are tools to explore how global socioeconomic developments may impact greenhouse gas (GHG) emissions and associated climate outcomes. SSP5-8.5 represents a high-end baseline scenario characterized by rapid economic growth driven by fossil fuel use, particularly a global reversion to coal as the dominant energy source.[38] This pathway leads to GHG emissions in 2100 that are more than three times current levels. Notably, SSP5-8.5 results in approximately 20% higher CO_2 emissions than the earlier RCP8.5 scenario by the late 21st century, although it reflects slightly lower emissions of other non-CO_2 greenhouse gases[39]. This makes SSP5-8.5 a useful benchmark for understanding the upper bounds of future heat stress and planning adaptive strategies accordingly.

Figure 10 : CMIP6 Mean Temperature anomalies projections (MAMJJ) for period 1980-2049 For Mahesana



Source 10 : Plotted by CEE

Seasonal temperature anomalies for Mahesana from 1980 to 2049 (Figure 10), shows both historical observations (1980–2014) and future projections under the high-emission SSP5 8.5 scenario (2015–2049). The historical data indicates considerable inter-annual variability, with anomalies fluctuating around the baseline and generally remaining below 1.0°C. From 2015 onward, the projected anomalies show a clear warming trend, with values increasingly exceeding historical levels. By the 2040s, anomalies consistently approach and reach 2.0°C, indicating a significant rise in seasonal temperatures under continued high-emission conditions. The shaded area indicates inter-model spread (10th–90th percentiles), a measure of uncertainty in projected anomalies arising from differences among climate models under the SSP5 8.5 scenario. This trend highlights the likelihood of intensified warming in Mahesana if current emission pathways remain unchecked.

2.4 Heat Vulnerability Index

To assess heat vulnerability in Mahesana, three key dimensions are evaluated: exposure, sensitivity, and adaptive capacity. These components are chosen based on theoretical relevance, literature, and available data, aligning with the IPCC Sixth Assessment Report's definition of vulnerability as the predisposition to be adversely affected, combining both sensitivity and limited coping capacity[40]. A composite vulnerability index is developed by integrating socio-economic, environmental, and infrastructural indicators, allowing spatial identification of areas most at risk and guiding targeted climate adaptation efforts.

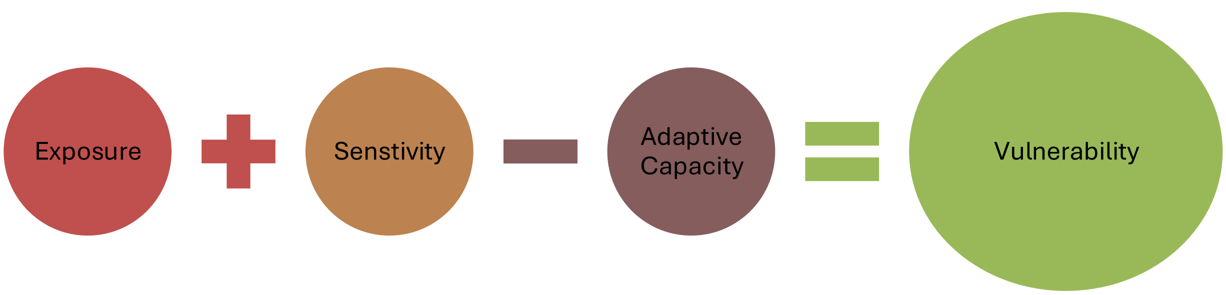


Table 5 : Factors, Parameters and sources utilized in Vulnerability index

Sr No.	Factors	Parameters	Units/ Measurement approach	Resolution	Source
1	**Exposure**	Land Surface Temperature	°C,	Ward-level	USGS

2		Population Density	No. of persons per square km	Ward-level	Kontur population data
3	**Sensitivity**	Normalized Difference Built-up Index (NDBI)	Built –up area/total ward area	Ward-level	USGS
4		Land Use	Major Land Use Classification in the ward	Ward-level	USGS
5	**Adaptive Capacity**	Access to Urban Health Centers	Percentage area within 300m of a Health Center	Ward-level	Open street Map + GIS
6		Access to Parks	Percentage area within 300m of a Park	Ward-level	Open street Map + GIS
7		Normalized Difference Vegetation Index	Vegetated area/total ward area	Ward-level	USGS
8		Access to Water Bodies	Percentage area within 300m of a Water Body	Ward-level	Open street Map + GIS
9		Access to Roads	Km length of the roads/ Area of the ward	Ward-level	Open street Map + GIS

2.4.1 Exposure Index

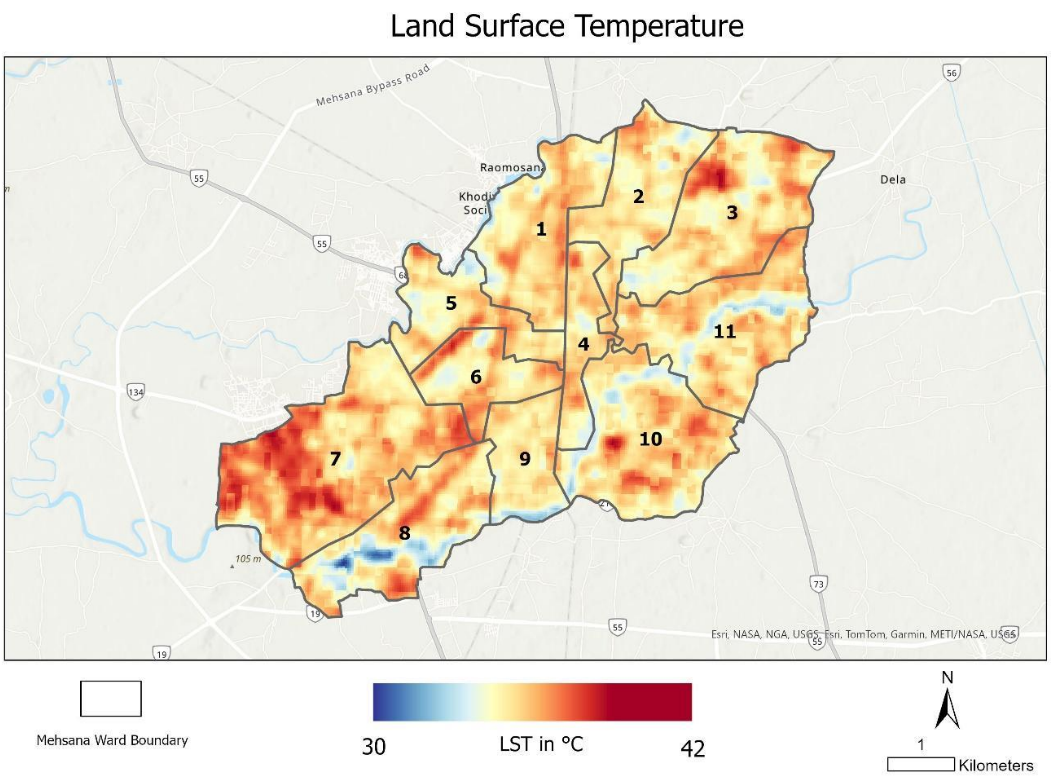
The Exposure Index quantifies the degree to which a population or area is subject to heat stress based on spatial and environmental parameters. It captures the intensity and frequency of elevated temperatures experienced across the landscape, which is a critical determinant in assessing heat-related vulnerability. Key indicators commonly used in constructing the Exposure Index include Land Surface Temperature (LST) and Population Density.

- Land Surface Temperature (LST) reflects the radiant heat emitted from the Earth's surface and is a direct proxy for surface heating due to urbanization, impervious surfaces, and lack of vegetation. Areas with high LST are more prone to intense heat exposure.

- Population Density represents the concentration of individuals within a specific area. Densely populated zones tend to have more built-up infrastructure, reduced green cover, and limited air flow, which collectively exacerbate heat stress. Moreover, more people are at risk in high-density areas, amplifying the public health and environmental impacts of elevated temperatures.

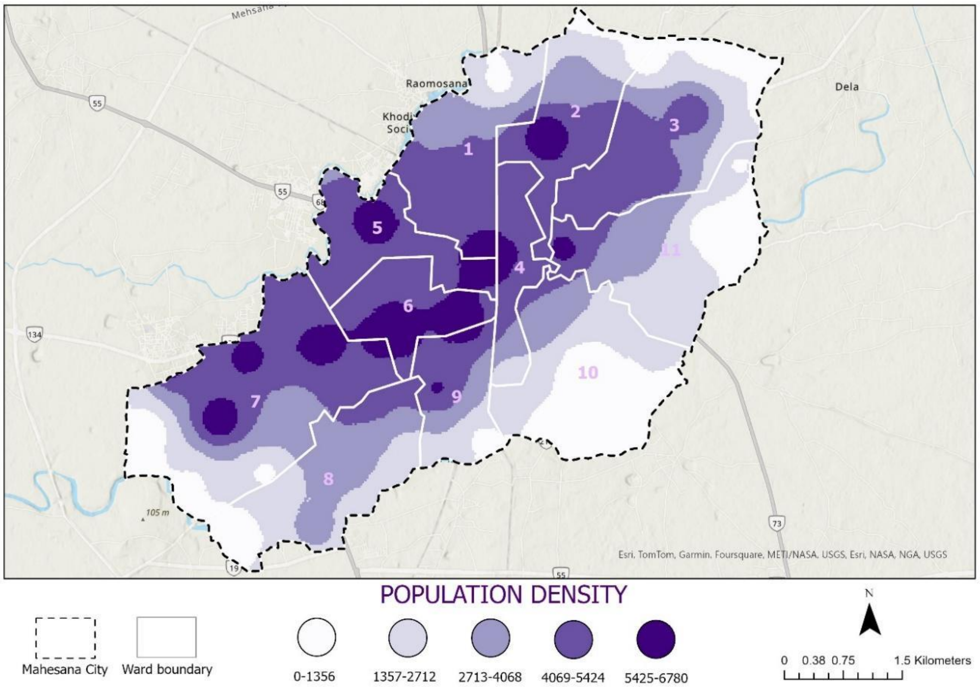
By integrating these parameters, the Exposure Index helps identify spatial hotspots where human populations are most exposed to extreme heat conditions. This spatial insight is essential for prioritizing interventions and resource allocation in urban planning and climate resilience strategies.

Figure 11 : Land surface temperature



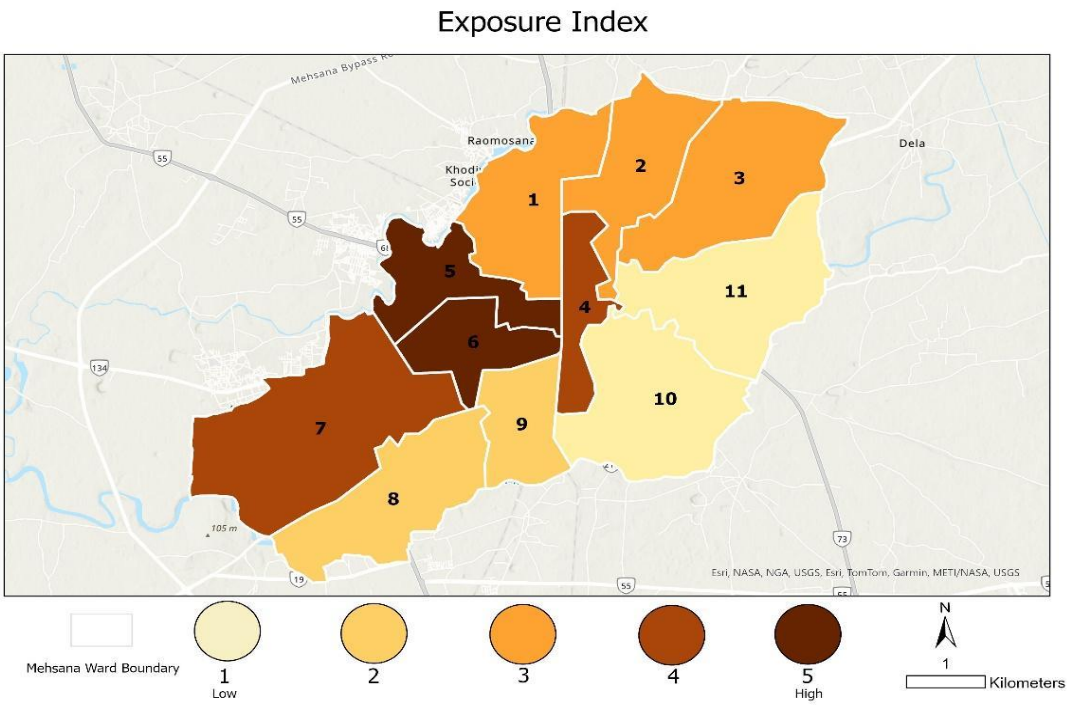
Source 11 : Plotted by CEE

Figure 12 : Population Density



Source 12 : Plotted by CEE

Figure 13 : Exposure Index



Source 13 : Plotted by CEE

2.4.2 Sensitivity Index

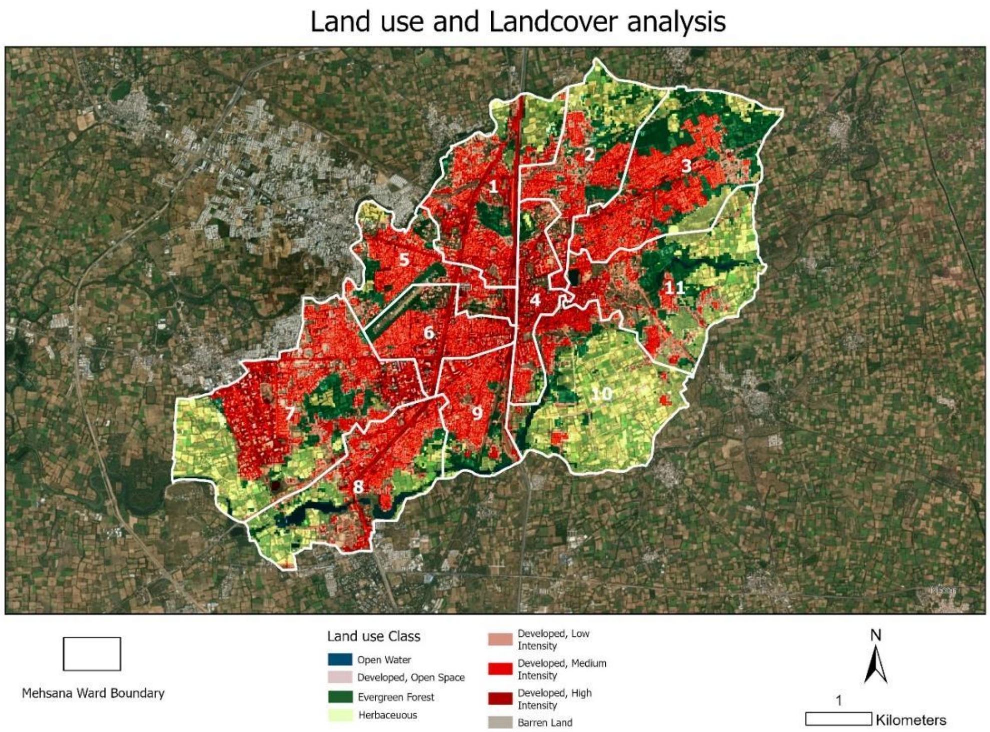
The Sensitivity Index reflects how severely a population may be impacted by heat stress once exposed, based on socio-economic and environmental factors. It highlights the underlying vulnerabilities that amplify the effects of high temperatures on different communities.

Key indicators include:

- Land Use and Land Cover (LULC): Built-up areas, with their impervious surfaces, trap heat more than vegetated or agricultural lands, increasing local temperatures and sensitivity.
- Built-up Density: Densely constructed urban zones experience higher heat retention, especially where green cover is minimal.

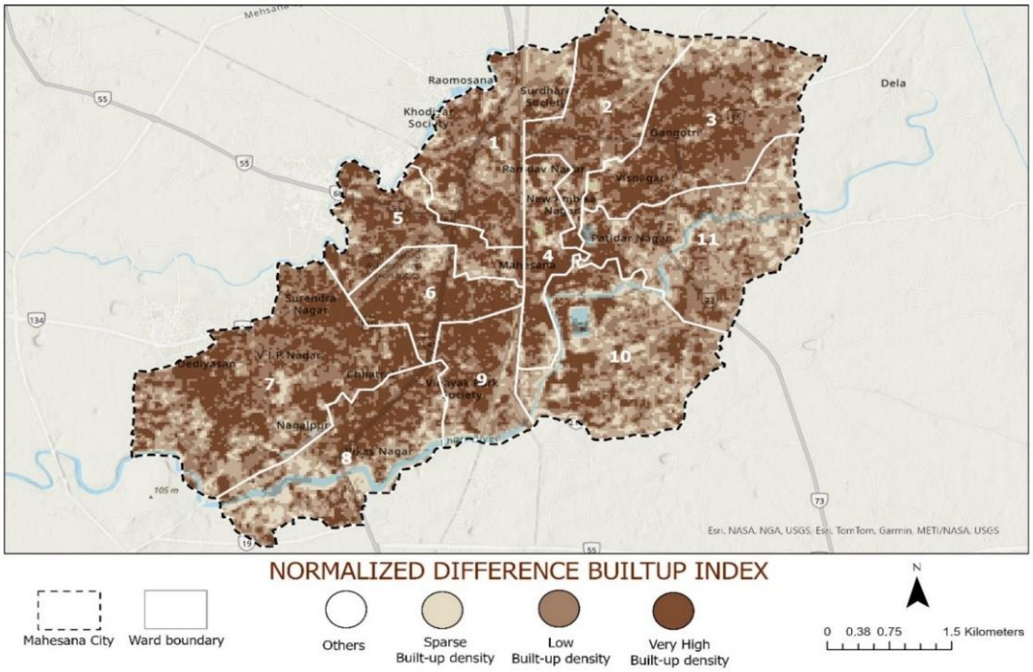
Together, these factors help identify which areas are more susceptible to heat impacts, guiding equitable interventions and infrastructure planning to reduce health risks and enhance resilience.

Figure 14 : Landuse and Landcover



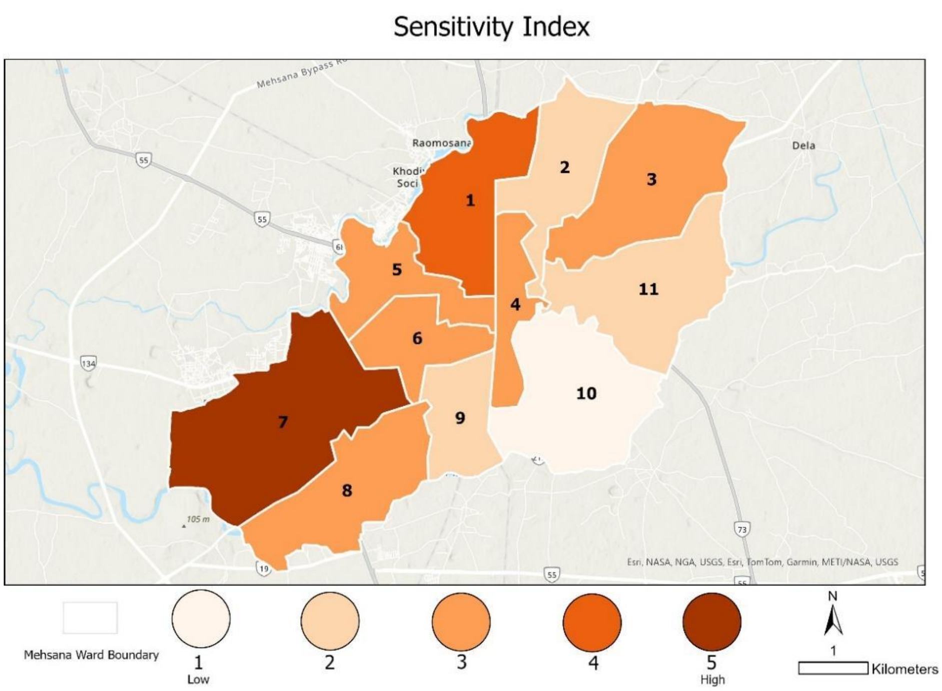
Source 14 : Plotted by CEE

Figure 15 : Built-up index



Source 15 : Plotted by CEE

Figure 16 : Sensitivity Index



Source 16 : Plotted by CEE

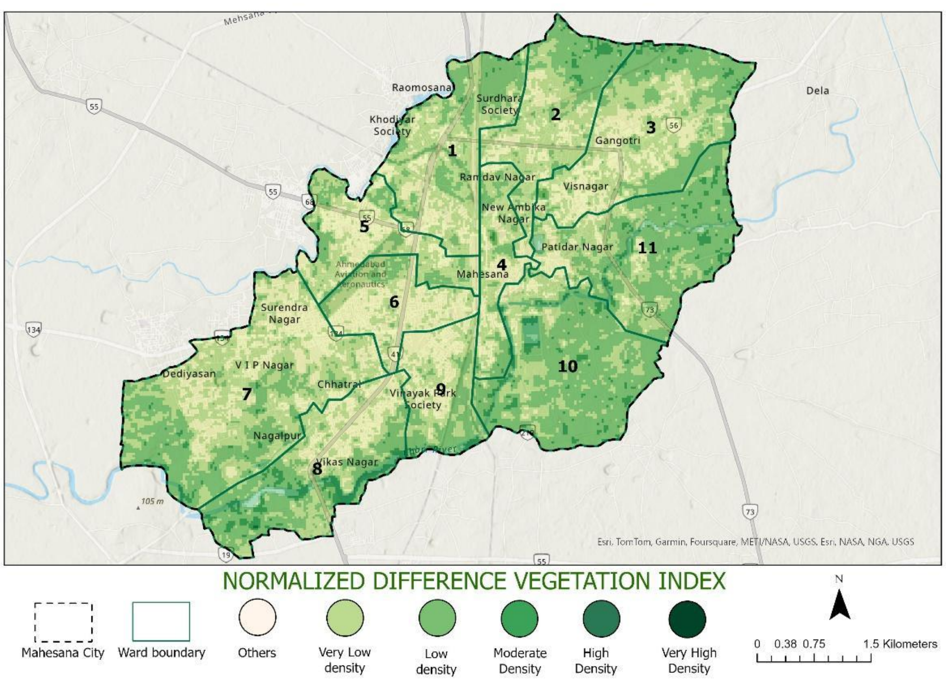
2.4.3 Adaptive capacity Index

Adaptive capacity refers to the ability of individuals and communities to cope with, respond to, and recover from the impacts of extreme heat. It is a critical component of heat vulnerability assessments, as it reflects the resources and infrastructure available to mitigate heat stress. Data for Parks, gardens waterbodies, health infrastructure and road network access was taken from Open Street Map services[41] and NDVI was calculated using Landsat-8 and Landsat 9 Data from USGS earth explorer.[42]

Key indicators used to evaluate adaptive capacity include:

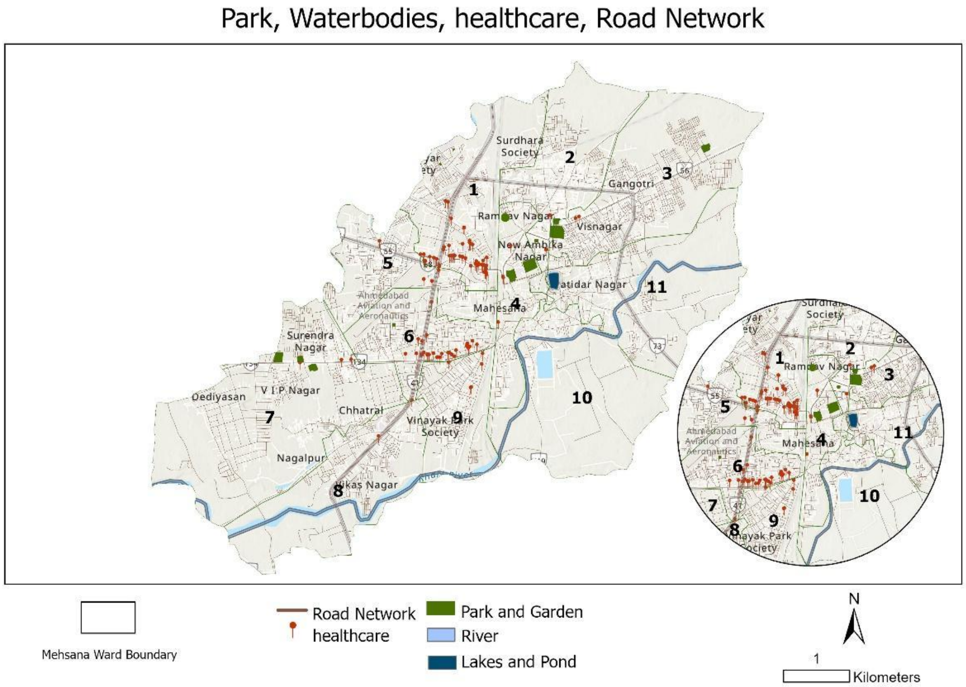
- Access to Parks and Green Spaces: Vegetation provides natural cooling, reducing surface temperatures and offering refuge during heatwaves.
- Proximity to Water Bodies: Lakes, rivers, and ponds contribute to microclimatic cooling and help regulate local temperature extremes.
- Urban Health Infrastructure: Availability of health centers ensures timely medical attention during heat-related emergencies, enhancing community resilience.
- Vegetation Index (NDVI): Areas with higher vegetative cover are more capable of regulating temperature and providing climate buffers.
- Road Network Access: Well-connected areas can ensure faster mobility and emergency response, while also supporting heat-responsive urban services.

Figure 17 : Normalized Vegetation Index



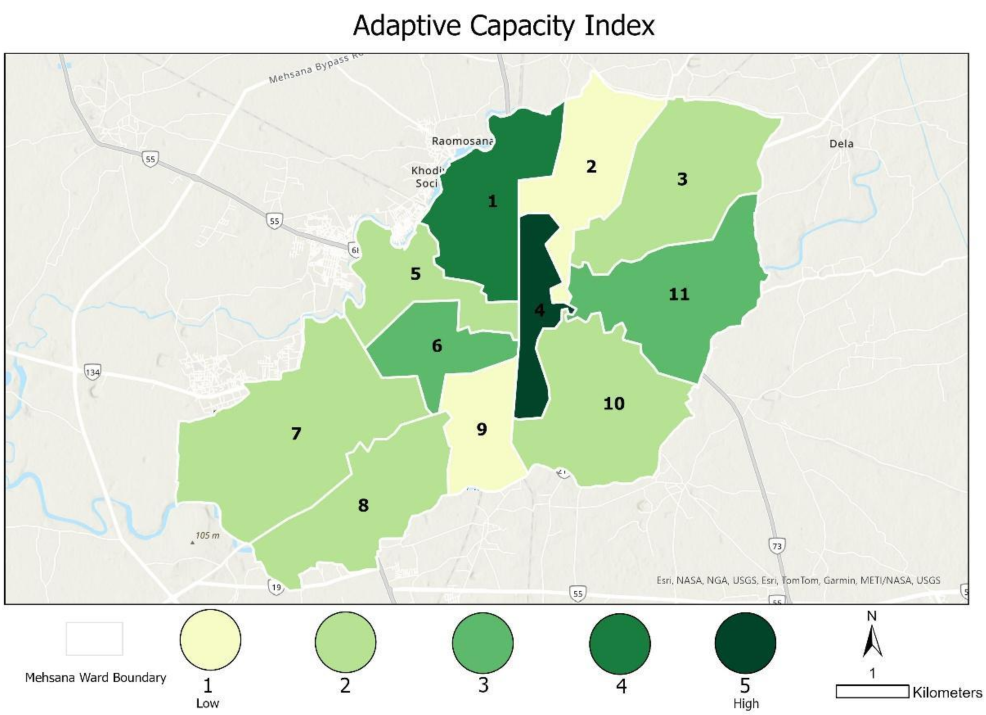
Source 17 : Plotted by CEE

Figure 18 : Map showing Parks, Healthcare, Road Network and waterbodies of Mahesana



Source 18 : Plotted by CEE

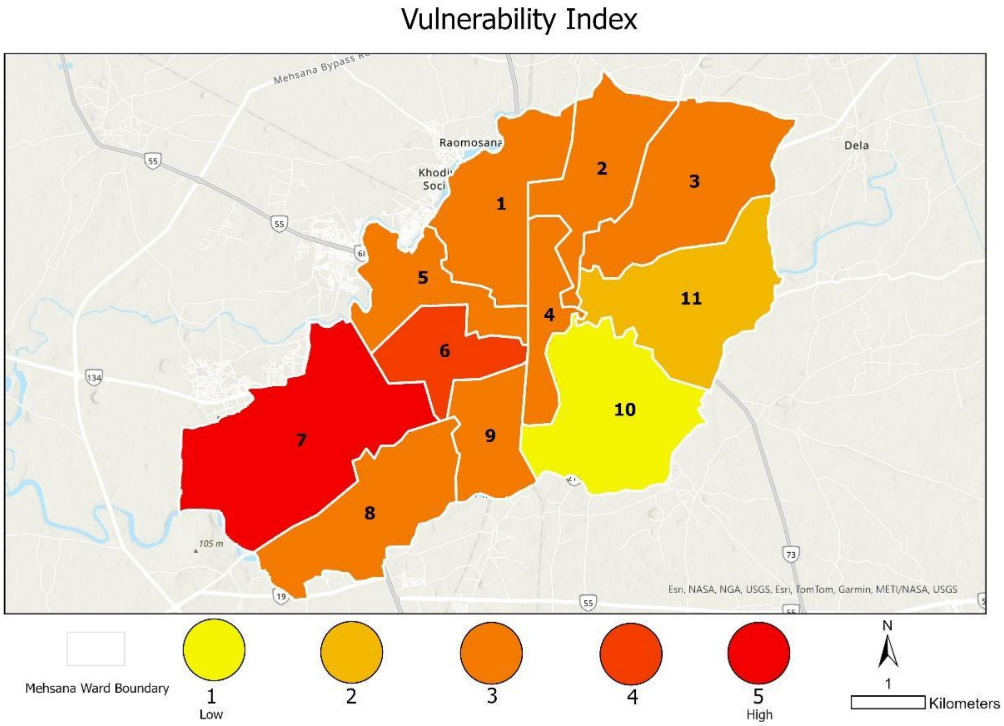
Figure 19 : Adaptive Capacity index



Source 19 : Plotted by CEE

2.4.4 Vulnerability Index

Figure 20 : Vulnerability Index



Source 20 : Plotted by CEE

Table 6 : Vulnerability index level across wards in Mahesana City

Sr No	Vulnerability Level	Ward No
1	1	Ward 10
2	2	Ward 11
3	3	Ward 1,2,3,4,5,8,9
4	4	Ward 6
5	5	Ward 7

In Mahesana city, an assessment across 11 wards reveals varying levels of vulnerability to heat exposure (Figure 20). Ward 7 emerges as the most vulnerable, exhibiting both high heat exposure and the lowest adaptive capacity, indicating a critical need for targeted intervention. Ward 6 also shows elevated vulnerability, ranked at level 4. In contrast, Wards

10 and 11 demonstrate the highest adaptive capacity and are relatively resilient to heat stress. This resilience can be attributed to the presence of natural features such as a river and surrounding agricultural fields, which contribute to local cooling. Meanwhile, Wards 1, 2, 3, 4, 5, 8, and 9 fall into a moderate vulnerability category. Their stronger adaptive capacity, supported by infrastructure such as parks, gardens, an extensive road network, and accessible healthcare facilities, helps buffer the impacts of rising temperatures.

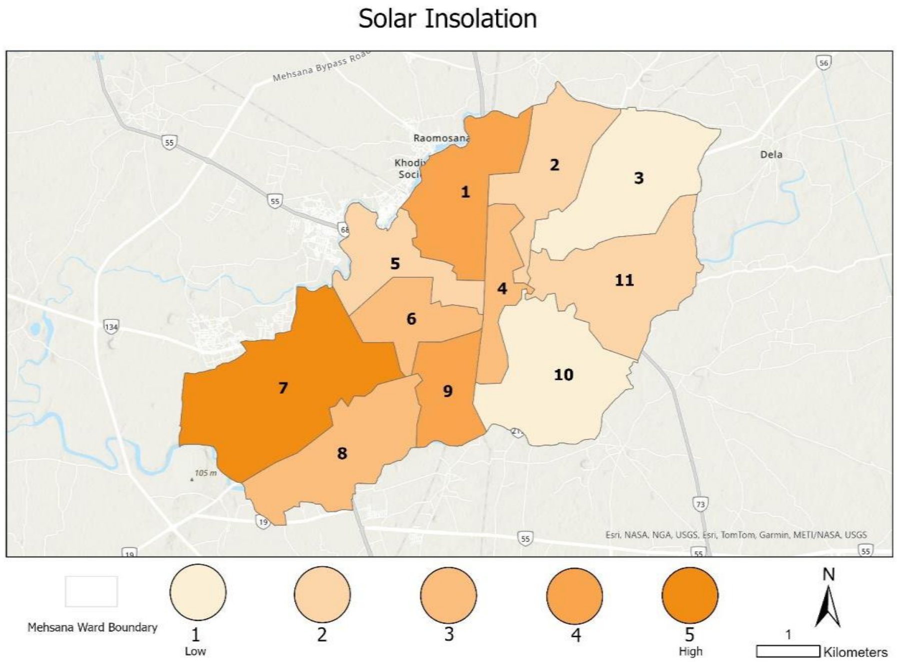
2.5 Solar Insolation

Solar insolation is calculated as the amount of solar insolation energy received during an amount of time for each feature or area.[43] Solar insolation calculations are essential for understanding how much solar energy different parts of a city receive, which directly influences surface and ambient temperatures[44]. Materials like asphalt and concrete absorb and retain more heat compared to greenspaces, which reflect more sunlight and provide cooling benefits[45]. This difference in surface properties leads temperature increase, contributing to the urban heat island effect. By identifying these zones, planners can implement targeted mitigation measures such as increasing vegetation cover, promoting the use of reflective or green roofing materials, and enhancing shade through urban design. These strategies help lower localized temperatures, improve thermal comfort, and reduce heat stress for urban populations, especially during extreme heat events.

To assess solar insolation in Mahesana city, the Solar Radiation Analysis tool in GIS software was employed using high-resolution Digital Surface Model (DSM) and building footprints as input layers. The analysis calculated global total solar insolation (in KWh) by simulating direct and diffuse radiation interactions with urban surfaces over a month of April over the area of each building roof surface.[46] Key parameters such as latitude, slope, aspect, shadowing effects, and surface orientation were factored in. The outputs were spatially aggregated at the ward level to reflect average solar radiance values per administrative unit, thus enabling spatial comparisons across the area (Figure 21). A detailed map for entire Mehsana city has also been provided showing roof to roof changes in solar insolation.

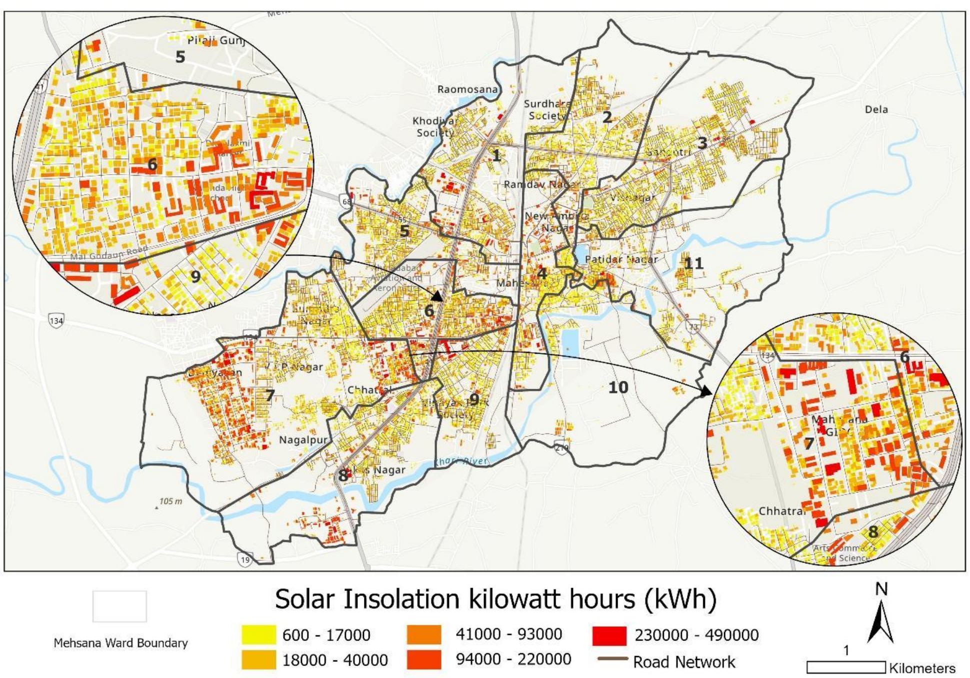
The solar insolation analysis at ward level reveals the building rooftop surfaces in ward 7 receives the most solar insolation for month of April, followed by Ward 1 and 9 (Figure 21). The lowest solar insolation is received by ward 3 and 10. Figure 22 illustrates the spatial distribution of solar insolation across Mahesana city's buildings, highlighting zones with comparatively higher solar potential, which can inform targeted interventions for rooftop solar energy deployment.

Figure 21 : Solar insolation at ward level



Source 21 : Plotted by CEE

Figure 22 : Solar insolation received by each building rooftop surfaces in Mahesana city



Source 22 : Plotted by CEE

3. Preparedness and Response Plan

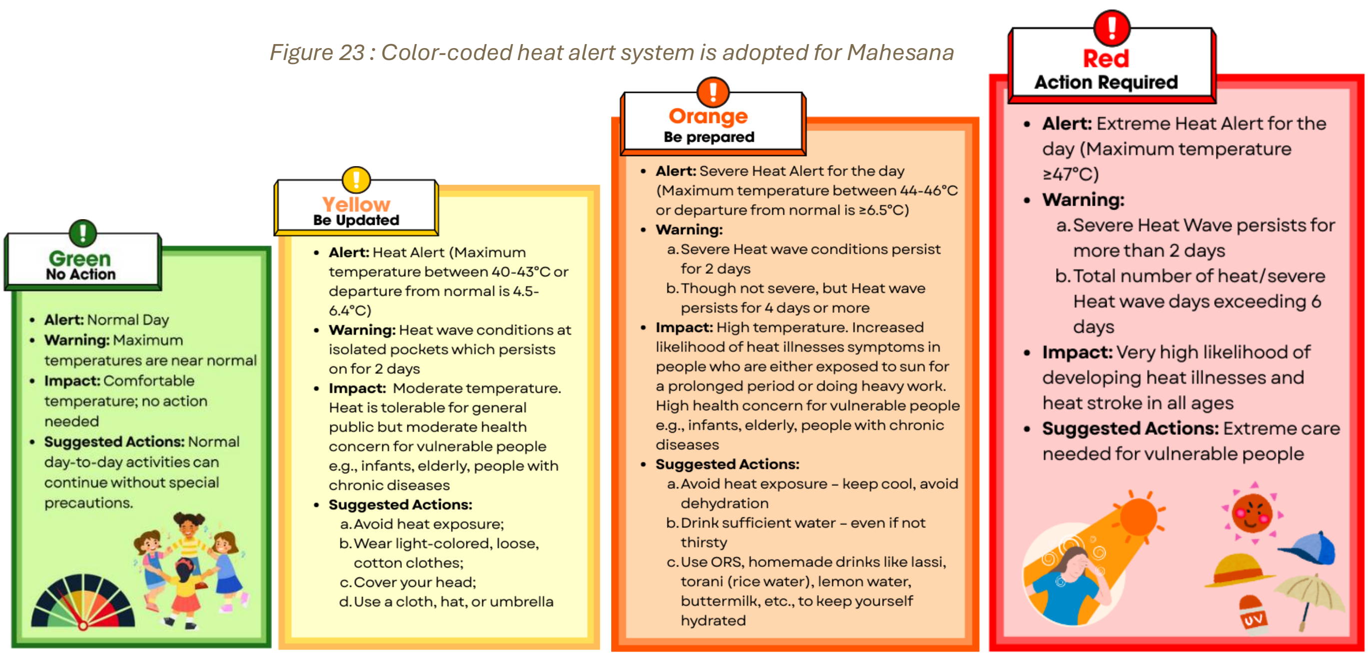
Mahesana has experienced a noticeable rise in extreme temperatures, especially during the summer months from March to July. With large populations engaged in outdoor work (agriculture, dairy, construction), and uneven access to cooling infrastructure, specific wards and localities show higher vulnerability to heat stress. It is therefore essential that the city adopts a targeted, ward-level, and community-based heat risk strategy. This chapter outlines the early warning system, inter-agency coordination framework, and public communication mechanisms to guide action during extreme heat events.

3.1 Early Warning System and Alert Mechanism

The India Meteorological Department (IMD), issues impact-based heat alerts[47] for Gujarat districts including Mahesana. For the Mahesana HAP, the city will follow these alerts, which incorporate temperature levels, humidity, and heatwave duration to better inform public health actions.

The following color-coded heat alert system is adopted for Mahesana:

Figure 23 : Color-coded heat alert system is adopted for Mahesana



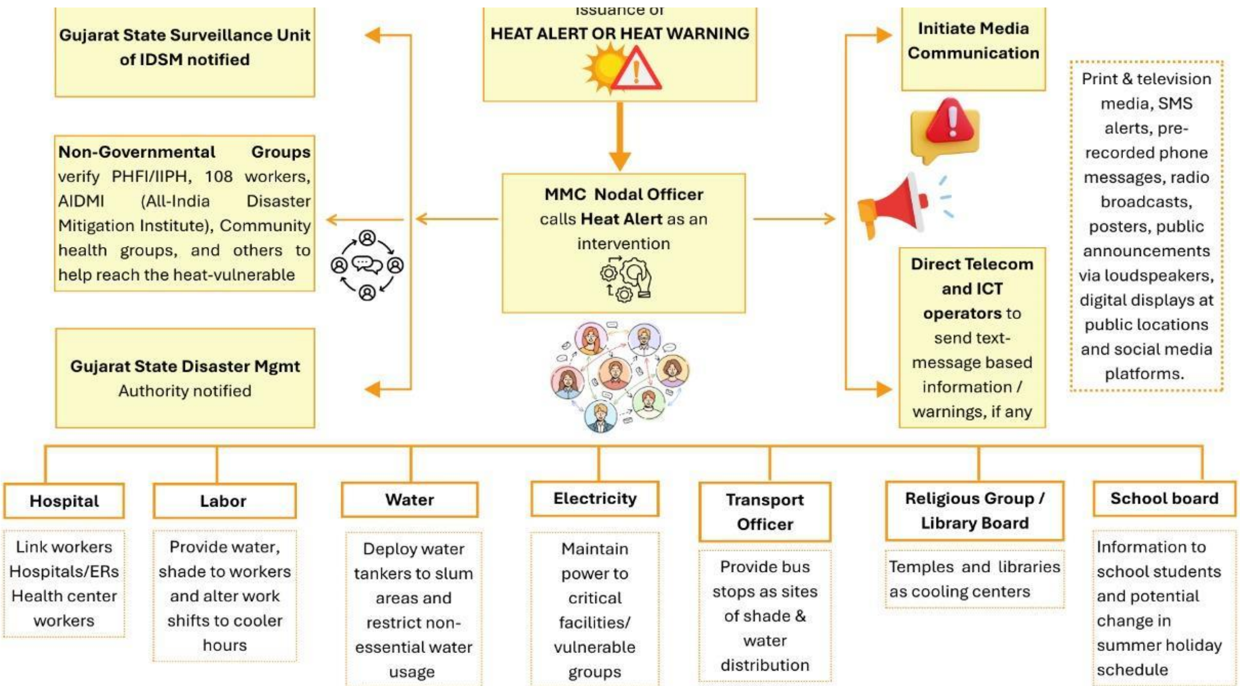
Source 23: IMD Color Code Heat Warning Framework

Note: Alerts for Mahesana will be locally interpreted using real-time IMD data issued through Ahmedabad or regional centers, coordinated by the District Disaster Management Authority (DDMA) and Mahesana Municipal Corporation (MMC).

3.2 Inter-agency coordination chart (for dissemination of alerts and warnings)

The Mahesana Municipal Corporation (MMC) shall designate a Nodal Officer to lead the overall coordination and effective implementation of the HAP. The Nodal Officer will be responsible for triggering heat alerts upon the issuance of warnings by the India Meteorological Department (IMD) and facilitating coordinated responses across departments.

Figure 24 :Inter-agency coordination chart



3.3 Information, education and communication strategies

In this section, we provide essential Information, Education, and Communication (IEC) materials designed to prepare alerts for vulnerable populations and support outreach efforts. These materials have been integrated from the National Centre for Disease Control (NCDC) [48], National Health Mission (NHM)[49], and the Gujarat State Disaster Management Authority (GSDMA)[50], ensuring that the resources are tailored to address heat impacts effectively in the context of Gujarat.

IEC Material in English

Figure 26 : Stay cool, stay safe

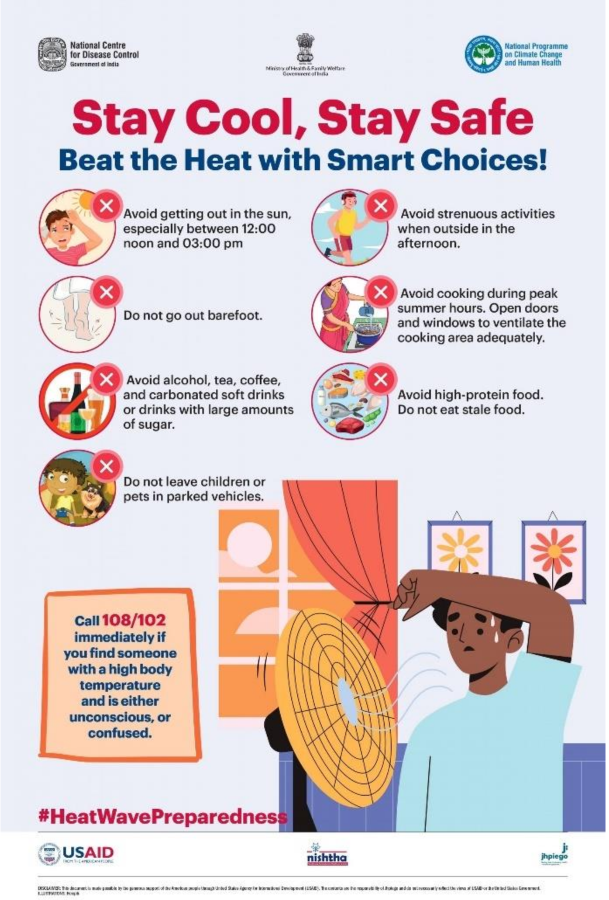
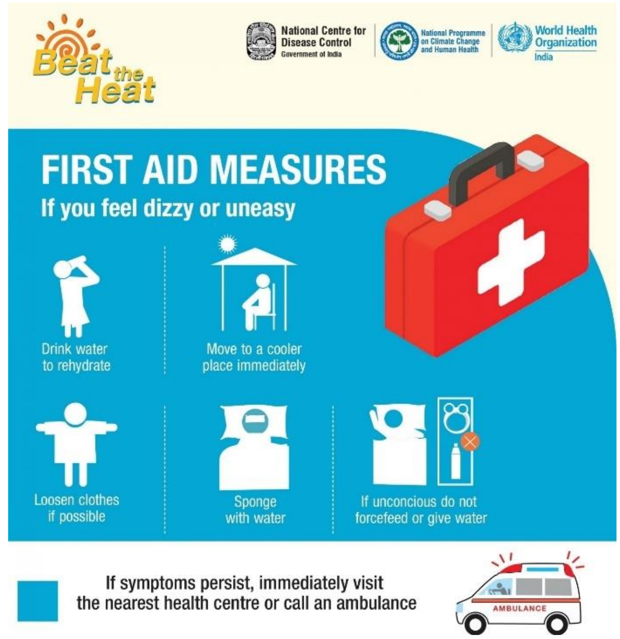


Figure 25 : Heatwave essentials

Source : National Centre for Disease Control. (n.d.). Heat IEC Materials. Ministry of Health and Family Welfare, Government of India. https://ncdc.mohfw.gov.in/centre-for-environmental-occupational-health-climate-change-health/

Figure 27: IEC-Safeguard workers from the heat

Figure 30: IEC- First aid measures



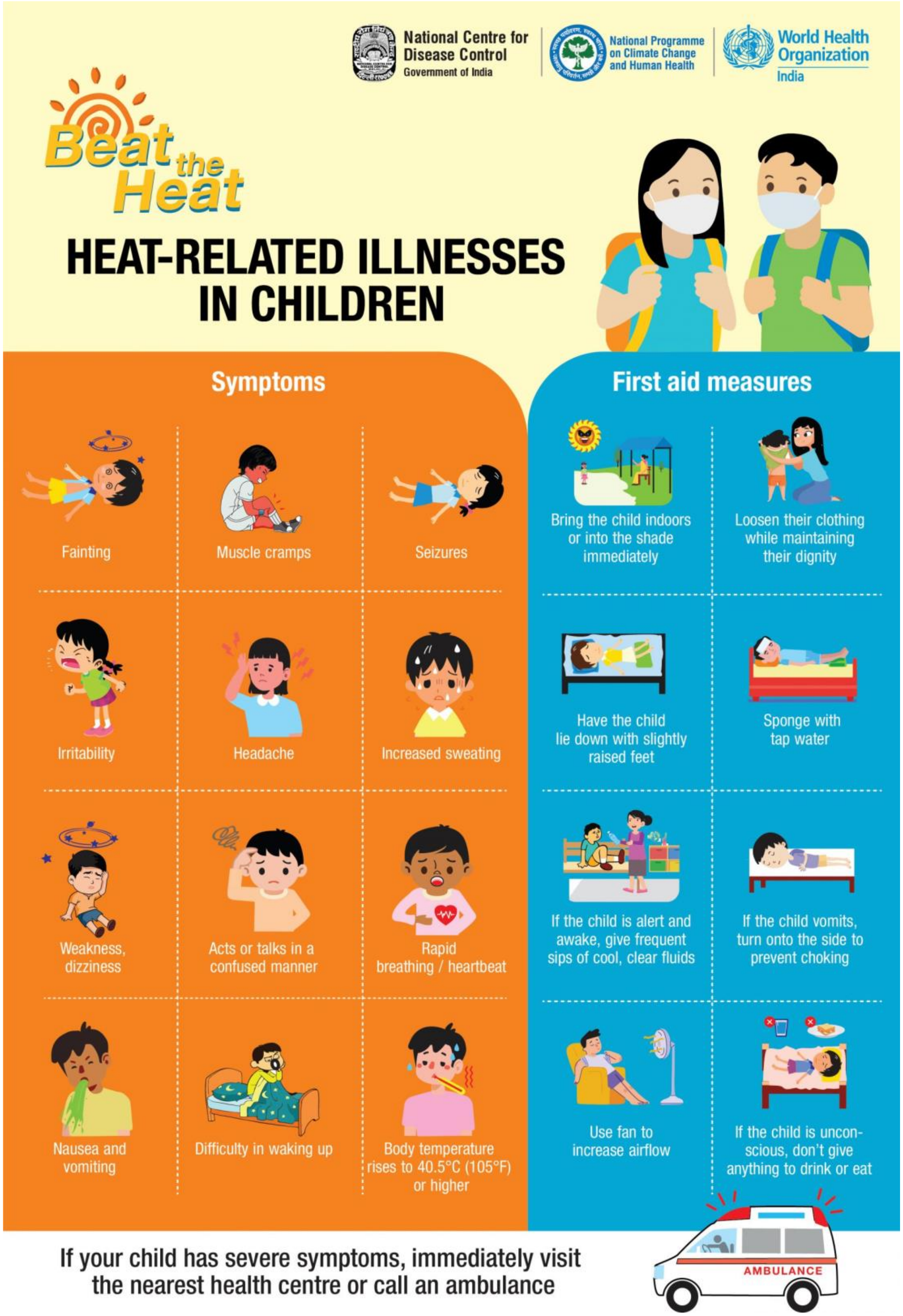
Source : National Centre for Disease Control. (n.d.). Heat IEC Materials. Ministry of Health and Family Welfare, Government of India. https://ncdc.mohfw.gov.in/centre-for-environmental-occupational-health-climate-change-health/

Figure 28: IEC-Avoid exposure to the sun at peak time

Figure 29:IEC-Safeguard yourself from the heat

Source : National Centre for Disease Control. (n.d.). Heat IEC Materials. Ministry of Health and Family Welfare, Government of India. https://ncdc.mohfw.gov.in/centre-for-environmental-occupational-health-climate-change-health/

Figure 31: IEC-Heat related illness in children



Source : National Centre for Disease Control. (n.d.). Heat IEC Materials. Ministry of Health and Family Welfare, Government of India. https://ncdc.mohfw.gov.in/centre-for-environmental-occupational-health-climate-change-health/

Figure 32: IEC-Stay safe from heat stroke – know the signs, stay cool, and drink plenty of water.

Source : Health and Family Welfare Department, Government of Gujarat. (n.d.). લુ લાગવા (હીટ સ્ટ્રોક) ના લક્ષણો [Symptoms of Heat Stroke]. National Health Mission, Gujarat.

Figure 33 : Heatwave Safety Tips for Children and Families – Stay Indoors, Stay Cool, and Respond Early to Symptoms.

Source : Health and Family Welfare Department, Government of Gujarat. (n.d.). ઉનાળાની અતિશય ગરમી (લૂ/હીટ સ્ટ્રોક) થી સુરક્ષા માટેના અગત્યના ઉપાયો.Gujarat State Disaster Management Authority (GSDMA).

Figure 34: Protect Yourself from Heatwave (Loo) with Simple Health Precautions – Stay Hydrated, Avoid Direct Sun, and Know the Symptoms.

Source : Health and Family Welfare Department, Government of Gujarat. (n.d.). ઉનાળાની અતિશય ગરમી (લૂ/હીટ સ્ટ્રોક) થી સુરક્ષા માટેના અગત્યના ઉપાયો. Gujarat State Disaster Management Authority (GSDMA).

4. Heat Risk Mitigation Measures

In Gujarat, heatwaves are recognized as climate-induced extreme events under the Gujarat State Action Plan on Climate Change (SAPCC)[51] and are treated as part of the broader disaster risk reduction (DRR) strategy. Provisions exist under the State Calamity Relief Fund (SCRF) and local municipal allocations for supporting preparedness and resilience-building activities.

Mahesana, being a rapidly urbanizing municipality in north-central Gujarat, faces increasing exposure to heat risks due to rising built-up areas, limited tree cover, high dependence on outdoor work (particularly in the dairy and construction sectors), and growing pressure on water and energy infrastructure. These vulnerabilities demand a dual focus on preparedness and long-term mitigation to ensure the city’s resilience to extreme heat events.

To address the intensifying impacts of heat, the city must implement a two-tier strategy.

Table 7 : Heat preparedness and Mitigation plan for Mahesana

Sl. No	Strategy	Description	Short/Long Term	Timeline	Implementing / Supporting Agency	Municipal Funds	State Govt Scheme	Central Govt Scheme	CSR / NGO Support
Preparedness & Response Plan – Mahesana									
1	**Cooling Centres**	Repurpose public schools, halls, and anganwadis as shelters with fans, water, ORS kits	Short	Pre-Heat & Heat Season	MMC, Health Dept	☑	–	–	☑
2	**Crowd Area Measures**	Provide water stations, mist fans, shaded rest areas, and emergency units in busy areas like bus stands & markets	Short	Heat Season	MMC, DDMA, Police Dept	☑	☑ (GIDM)	–	☑
3	**IEC Campaigns & Capacity Building**	Run awareness campaigns in Gujarati/Hindi, train frontline workers, and inform vulnerable populations	Short	Pre-Heat Season	MMC, Health Dept, NGOs	☑	☑	☑ (NHM, SSA)	☑
4	**Drinking Water Stations**	Install temporary and permanent drinking water points at high footfall locations	Short	Pre-Heat Season	Jal Shakti Dept, MMC	☑	☑	☑ (Jal Jeevan Mission)	☑
5	**Cool Roof Application**	Apply solar reflective coatings on rooftops of public and vulnerable housing clusters	Short	Pre-Heat Season	MMC, CEE	☑	☑	–	☑ (NRDC, CSR)
6	**Health Facilities**	Ensure heat illness preparedness at PHCs, CHCs, and district hospitals; ambulance and ORS stock readiness	Short	Pre-Heat & Heat Season	District Health Dept, MMC	☑	☑ (GIDM)	☑ (NHM)	☑
7	**Strengthening Anganwadis**	Provide fans, water, ORS, and shade structures in Anganwadis; train workers for heat response	Short	Pre-Heat Season	WCD Dept, MMC	☑	☑ (ICDS)	–	☑
8	**Adjusted Working Hours**	Modify working hours for municipal, construction, and outdoor workers to avoid peak heat	Short	Heat Season	MMC, Labour Dept	☑	☑ (Labour Welfare Board)	–	☑
9	**Cooling Gear for Outdoor Workers**	Provide cool jackets, hats, water containers to sanitation, police, and field staff	Short	Heat Season	MMC, Labour Dept, Police Dept	☑	☑	–	☑
10	**Cool Transit Areas**	Equip bus stands, auto stands with shade, drinking water, ORS, and loudspeaker alerts	Short	Pre-Heat Season	MMC, Transport Dept	☑	☑	–	☑
11	**School Timings**	Adjust school start and end times to avoid peak heat exposure	Short	Heat Season	Edu Dept, MMC	☑	–	☑ (SSA)	–

12	**School Readiness**	Ensure schools have ORS kits, water coolers, shaded assembly/play areas	Short	Pre-Heat Season	Edu Dept, MMC	☑	☑	☑ (SSA, MID DAY MEAL)	☑
13	**Livestock Protection**	Provide shaded shelters, water tanks, veterinary backup for livestock in peri-urban belts	Short	Pre-Heat Season	Animal Husbandry Dept	☑	☑	☑ (RKVY, Rashtriya Gokul)	–
14	**Power Grid Resilience**	Pre-summer maintenance of transformers and supply continuity to critical services	Short	Pre-Heat Season	UGVCL, MMC	☑	–	–	–
15	**Water Infrastructure Readiness**	Check and repair water pipelines, reservoirs to ensure uninterrupted supply	Short	Pre-Heat Season	Jal Nigam, MMC	☑	☑	–	–
16	**Monitoring & Review**	Track heat-related illnesses, collect ward-level data, review HAP effectiveness	Short	Post-Heat Season	MMC, Health Dept, GIDM	☑	☑	–	☑
17	**Inter-Agency Coordination**	Convene regular meetings with stakeholders like CSOs, RWAs, health, education, labour departments	Short	Pre-Heat & Heat Season	MMC, DDMA	☑	☑	–	☑
18	**Nodal Officer Preparedness**	Designate officer to coordinate alerts, supplies, mobile teams, and response evaluation	Short	Pre, During & Post Season	MMC (Nodal Officer)	☑	☑	–	☑
Mitigation Plan – Mahesana									
1	**Urban Greening**	Avenue plantations, parks, and shaded corridors to reduce UHI effect and improve microclimate	Long	3–5 Years	MMC, Forest Dept	☑	☑ (Nagar Van Yojana, AMRUT 2.0)	☑ (Green India Mission)	☑
2	**Passive Cooling in Buildings**	Integrate ventilated designs, shaded windows, and use of lattice and stone architecture in municipal DCR	Long	3 Years	MMC, Town Planning Dept	☑	☑	–	☑
3	**Thermal Comfort in Low-Income Housing**	Promote use of red oxide, mud plaster, tiled roofs in EWS housing to reduce internal heat load	Long	3–4 Years	MMC, Housing Board	☑	☑	☑ (PMAY-U)	☑
4	**Green Roofs**	Encourage rooftop gardens on govt offices, schools, health centres	Long	3–4 Years	MMC, Urban Planning Dept	☑	☑	–	☑
5	**Rainwater Harvesting Expansion**	Scale up mandatory rooftop rainwater harvesting in buildings and integrate into byelaws	Long	3 Years	Jal Shakti Dept, MMC	☑	☑	☑ (Jal Shakti Abhiyan)	☑
6	**Solar Cooling and Power Backup**	Install rooftop solar in PHCs, schools, shelters to power fans and lights during grid load	Long	3–5 Years	UGVCL, MMC	☑	☑ (Suryashakti Kisan Yojana)	☑ (MNRE)	☑

7	**Heat Resilient Infrastructure Standards**	Use heat-resilient materials (light-colored paving, shaded bus shelters, porous surfaces) in new infra	Long	3–4 Years	MMC, R&B Dept	☑	☑	–	☑
8	**Localized Cooling Corridors**	Develop green-lined pedestrian/cycling paths in heat-vulnerable zones	Long	4–5 Years	MMC, Urban Transport Dept	☑	☑ (Gati Shakti, AMRUT)	–	☑
9	**Cool Roof Policy Integration**	Institutionalize cool roofing via municipal guidelines and promote subsidies/coating campaigns	Long	2–3 Years	MMC, Town Planning, CEE	☑	☑	–	☑ (NRDC)
10	**Wastewater Reuse for Green Cooling**	Use treated greywater for watering parks and street-side trees	Long	3 Years	MMC, GPCB, Jal Dept	☑	☑ (SBM 2.0)	–	–
11	**Nature-Based Solutions for Agriculture**	Agroforestry and bund tree planting in peri-urban farms to reduce evapotranspiration stress	Long	4 Years	Forest Dept, Agri Dept	☑	☑ (GREEN INDIA MISSION, FARMER PRODUCER COMPANY programs)	–	☑
12	**Climate-Responsive Urban Planning**	Integrate heat risk in Master Plan, zoning codes, and revise building byelaws accordingly	Long	3 Years	Town Planning Dept, MMC	☑	☑ (GUDM, Urban Climate Cell)	–	☑
13	**Pocket Green Parks**	Convert under-utilized traffic islands, corners, and roundabouts into mini green lungs	Long	3 Years	MMC, Forest Dept	☑	☑	–	☑
14	**Localised Early Warning Dissemination Program**	Establish a ward-level alert system via WhatsApp, local FM, and community boards for heat warnings	Long	2–3 Years	MMC, DDMA, ICT Dept	☑	☑	–	☑

5. Annexures

This chapter presents the formats and guidelines for recording heat-related data, based on national templates from the Ministry of Health and Family Welfare (MoHFW) and the National Disaster Management Authority (NDMA). Building on MoHFW's 2015 *Guidelines on the Prevention and Management of Heat-Related Illnesses* and the 2021 *National Action Plan on Heat-Related Illness*, this section integrates updated formats—covering surveillance, hospital preparedness, and investigations of suspected heat-related deaths—into the Mahesana HAP.

5.1 Format 1 (a): health facility format

Daily line List of Suspected Heatstroke CASES# at Health Facility

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- marks**
					Block	**District**	**Admitted**	**Died**	**Referred**	**Recovered**	
Total											

**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 ≥ 40°C/ ≥104°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)*

<u>Standard Operating Procedures: Format 1(A)</u>

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 ≥ 40°C/ ≥ 104°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 pediatrics 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.

5.2 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)

<table>
<tr><td colspan="7">Name of health facility: _ Block: District:</td><td colspan="2">Date of reporting:
_._/_._/_._</td></tr>
<tr><td colspan="9">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...............</td></tr>
<tr><td colspan="9">(A). Total no. of all-cause deaths in health facility (Casualty/emergency of Medicine and Paediatrics):</td></tr>
<tr><td colspan="9">Daily line List of Suspected Heatstroke DEATHS and Confirmed CVD DEATHS</td></tr>
<tr><td rowspan="2">S.No</td><td rowspan="2">Registration number</td><td rowspan="2">Name</td><td rowspan="2">Age</td><td rowspan="2">Sex (M/F)</td><td colspan="2">Address</td><td colspan="2">Deaths (tick the box)</td></tr>
<tr><td>Block</td><td>District</td><td>Suspected Heatstroke death##</td><td>Confirmed CVD death</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Total</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Name of person filling the form:
Designation:
Signature:

Name of Facility In-Charge:
Signature of Facility In-Charge:
Date:

#Suspected Heatstroke: Altered mental status (including disorientation, delirium, seizure, obtundation) with elevated core body temperature ≥ 40°C/ ≥ 104°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.

<u>Standard Operating Procedures: Format 1 (B)</u>

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 pediatrics) 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 pediatrics.
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.

5.3 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): Pediatrics 3. Casualty 1. Emergency Medicine 2. Emergency	

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):

Designation:

Signature:

Name of Facility In-Charge:

Signature of Facility In-Charge:

Date:

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

#Suspected Heatstroke: Altered mental status (including disorientation, delirium, seizure, obtundation) with elevated core body temperature ≥ 40°C/ ≥ 104°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.

<u>Standard Operating Procedures: Format 2</u>

(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:
   a. All public hospitals with casualty/emergency.
   b. All private hospitals are having casualty/emergency.
   c. Reporting Departments will be medicine, pediatrics 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.

5.4 Format 3 (a): district format for daily compilation

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

(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**				Remarks
					Suspected Heatstroke deaths## (a)	Confirmed CVD deaths (b)	Others including unknown (c)	Total deaths (a+b+c)	
	PHC1								
	PHC2								
	CHC								
	CH/DH								
	PVT1								
	PVT2								
	PVT3								
Total for District 1									

Total number of New Confirmed Heatstroke Deaths*** in the District on _._/_._/_._: Total number of Confirmed Heatstroke Deaths in the District since 1st March 2020: *[confirmed by death committee (heat death committee/three men committee)]*

Name of person filling the form:
Designation:
Signature:

Name of nodal officer:
Signature of nodal officer:
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 ≥ 40 oC/≥104 oF, 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.

<u>Standard Operating Procedures: Format 3 (A)</u>
(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.

5.5 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 Con- firmed 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:
Designation:
Signature:

Name of nodal officer:
Signature of nodal officer:
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 ≥ 40 oC/≥104 oF, 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.

<u>Standard Operating Procedures: Format 3 (B)</u>
(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.

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Notes

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