REPORT ON EXTREME HEAT EXPOSURE AND ACTIONS FOR GUJARAT

GUJARAT INSTITUTE OF DISASTER MANAGEMENT
BUILDING RESILIENCE

CLIMATE CHANGE DEPARTMENT
Government of Gujarat

GEDA
GUJARAT ENERGY DEVELOPMENT AGENCY
(A GOVERNMENT OF GUJARAT ORGANIZATION)

INDIAN INSTITUTE OF PUBLIC HEALTH GANDHINAGAR

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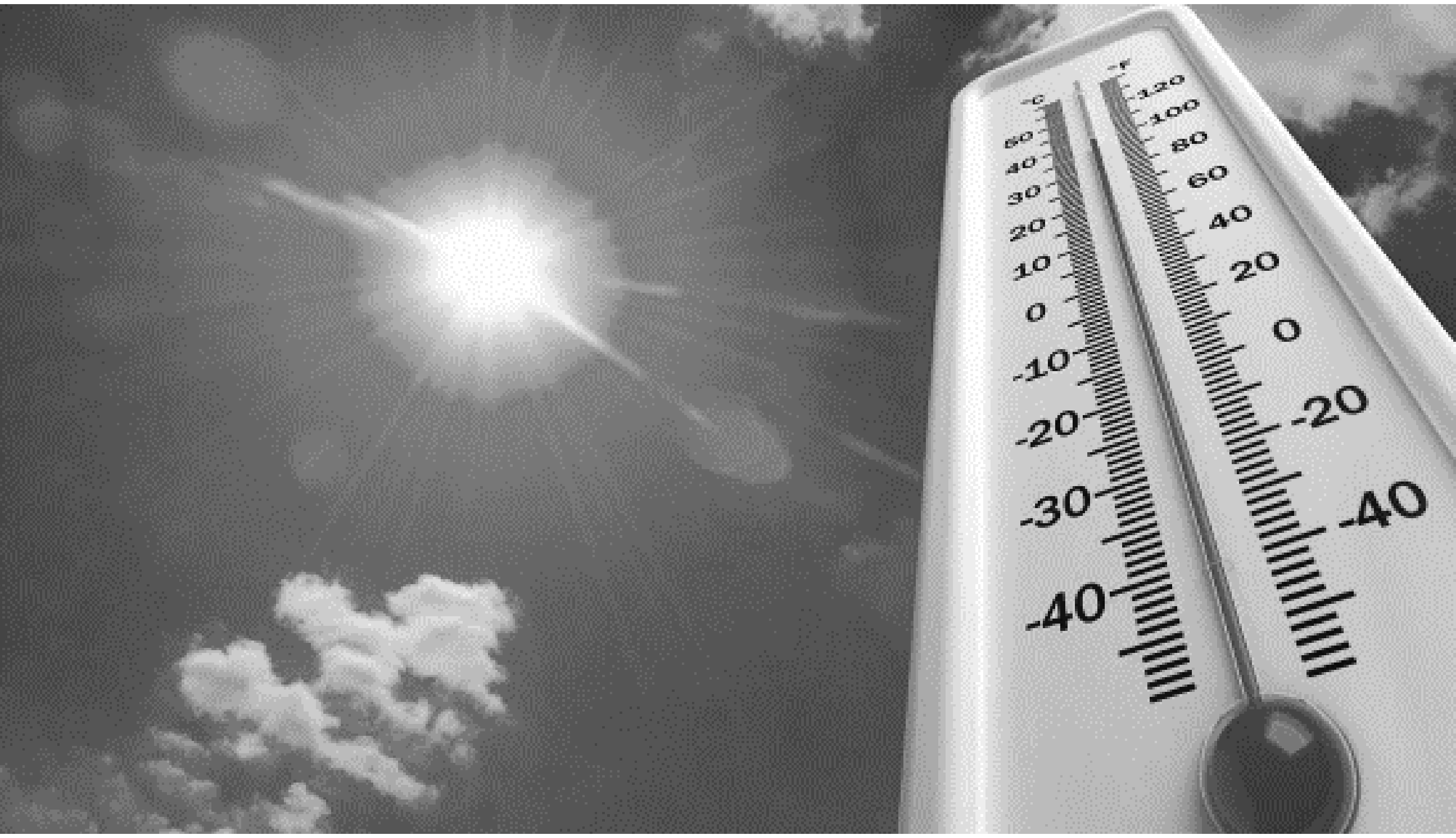

Gujarat Institute of Disaster Management

Report on Extreme Heat Exposure and Actions for Gujarat

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Message

Climate change has emerged as the biggest challenge to humanity in the 21st Century. It is imposing unprecedented damages on the environment, economies, and health of the people. And unfortunately, the impacts of climate change and global warming are further deepening the inequalities as the people at the bottom of the pyramid across the globe are facing higher consequences. On the other hand, the world seems to be failing on the 2015, CoP 21 Paris Agreement which aimed to limit the temperature increase to 1.5 °C above the pre-industrial era by end of the 21st Century as newer evidence coming in from the latest global climate studies are indicating that we may cross the threshold of 1.5 °C by mid of 21st century itself. This means, that the risk of occurrence of frequent, severe, and long-lasting extreme weather events like heatwaves will go further up!

The encouraging part here is that governments, institutions, and communities all around the world are putting together efforts to minimize the adverse impacts of heatwaves, especially on the health of the people. Learning from the disastrous extreme heat events in the past like the one in Europe in 2003 or South-Asia in 2015, many countries have developed their local Heat Action Plans to deal with any such devastating heatwave events in the future. I am happy to share that the city of Ahmedabad in Gujarat State has shown leadership by devising and implementing the first citywide comprehensive Heat Action Plan of the South-Asia region since the year 2013 learning from which, a numbers of cities and districts in several other states of India have developed their local Heat Action Plans.

The Report on Extreme Heat Exposure and Actions for Gujarat emphasizes on district-level vulnerabilities along with analyzing the temperature thresholds for each of the 33 districts of the State. It aims to complement the action plan to strategize alerting people and suggest inclusive Governmental strategies to prevent the major avoidable effects of extreme heat. I appreciate the efforts of GIDM team and extend my heartfelt gratitude to Climate Change Department for financial support. I am sure that this report will help in enhancing the Heatwave Action Plan of State in long term.

(P. K. Taneja)
Director General

April, 2023
Gandhinagar

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Introduction

1.1. Background

The health impact of heat-related vulnerability has been widely established in the Western countries (Revich, 2011), however, there is scarcity of such literature in the Indian context (G. Azhar et al., 2017). One of the most catastrophic heat-related climatic events is heat wave, which the the US National Oceanic & Atmospheric Administration (NOAA) defines as “a period of abnormally and uncomfortably hot and unusually humid weather lasting two or more days, and advisories are issued when these conditions are forecast. (G. S. Azhar et al., 2014)” With time, there is an increase in the frequency an exposure to heat waves in India (IPCC, 2007; “IPCC, 2012: Summary for Policymakers,” 2019), which places several regions in India at higher risk of the health impact of such events, for instance, Gujarat. The state lies in the arid and semi-arid climatic zones and has experienced several regular heat waves in recent history. A 2014 study on the 2010 heatwave in Ahmedabad predicted that the heatwave was associated with 41.3% increase in all-cause mortality (G. S. Azhar et al., 2014). Such regions are also more prone to droughts, given their rainfall deficiency and temperature extremes (Bhuiyan, 2008). The recent 2022 summers in the Western India gained a lot of attention due to its major heatwave exposure in an unusual way as early as 11 March. The 'major' and 'severe' heat waves came in six spells: 11-23 March, 27 March-12 April, 17 April-20 April, 23 April-2 May, 7-16 May and 19-21 May (Kumar Dash et al., 2022). In northwest India, the average maximum temperature in April 2022 was recorded the highest with 36.32ºC, creating a new record since 2010 (Kumar Dash et al., 2022).

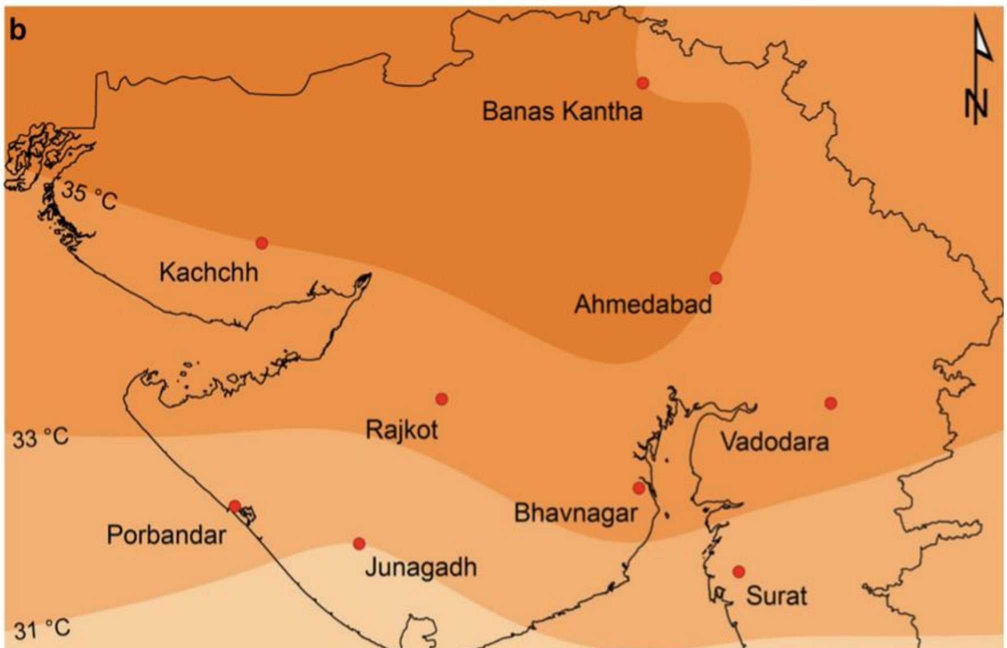

Figure 1: An annual isothermal map of Gujarat (imported from (Bandyopadhyay et al., 2016))

Drought in Gujarat

Northwest India (including Gujarat) experiences arid to semi-arid climatic conditions creating drought-proneness across the region. The droughts in Gujarat (every three to four years) are mostly associated with low monsoon touches and frequent heatwave exposure (Bandyopadhyay et al., 2016; Bhuiyan et al., 2017). Details about the drought vulnerability and years of drought has been extensively discussed in the paper by Bhuiyan et al. (Bhuiyan et al., 2017). The analyses performed by Bhuiyan et al. (Bhuiyan et al., 2017) revealed that "in Gujarat, the vegetative/agricultural droughts appeared entirely or partially only in 9 out of 15 meteorological drought years in the last three decades of 1981–2010. Out of these 9 years of vegetative drought, thermal stress was acute and widespread in 8 years.(Bhuiyan et al., 2017)" The authors further argued that "the stress in vegetation develops due to aboveground air-temperature, and the latter has an association with the number of Heat-Wave-Days during or prior to the monsoon season. Since agricultural production has a direct correspondence with the VH, and since the latter is strongly influenced by the thermal state in vegetation, low crop productivity is directly or indirectly associated with the thermal stress developed in the crops. (Bhuiyan et al., 2017)"

While analyzing the trend in droughts in Gujarat (Bandyopadhyay & Saha, 2014), Bandyopadhyay et al. have found in a trend assessment for the last 35 years that drought in the state occurred almost every year and led to severe water-scarcity across the state. In the state, rainfall is uncertain (even during the monsoons), unprecedented, and unequal spatially and temporally. The authors further discussed that the regions of Saurashtra, Kutch, and northern parts of Gujarat have witnessed famine every third year (Bandyopadhyay & Saha, 2014). It was also cited that Gujarat experienced nine major droughts occurred during 1977–2012, with coverage ranging from 23% to almost 90% of the total area. One of the grave concerns pertaining to heat, drought and water scarcity in the state is that in the non-drought years, about 10% to 15% of administrative Talukas were declared drought affected that demanded diverse relief works. Furthermore, the individuals and households belonging to the lower socioeconomic strata were found to be highly vulnerable to a variety of risks during droughts, especially because of the lack of resources, access to proper infrastructure.

Notwithstanding, while the entire region (the state) is exposed to the temperature extremes, there are within-state variations (district-level) in the vulnerability to the effects of such events (G. Azhar et al., 2017). These variations could be due to the difference in the population dynamics and governance dynamics of the localized regions within the larger boundary of the state that is exposed to any climatic event. For instance, people residing in different districts might react differently to the effects of extreme heat events due to their varied sensitivity such as existing comorbidities and adaptive capacities such as greater economic resources. Further, the different district-level governance could result in a varied quality (and quantity) of public health system in a particular district, thereby further leading to a difference in the adaptive capacity of the people residing in such districts.

Understanding the geographical heat-related vulnerability could help the government and other implementers design effective policies to mitigate the adverse local effects of extreme climatic events. The proneness to extreme temperature events in Gujarat and the scarcity of research in comprehensively assessing the vulnerability at the local (district) level demand a thorough district-level heat-related vulnerability assessment in the state of Gujarat. With this information, the state and the district can take necessary measures to mitigate the ill-effects of extreme heat occurrences.

1.2 A brief literature on other heat-action plans in India

Heat Action Plans are effective ways to streamline the governance to address issues related to the growing climate-change concerns. Following Heat Wave Action measures by the NDMA in 2016 and the subsequent drafting of Heat Wave Action Plans by many states, the mortality of individuals in the aftermath of heat-stress/heatwaves in the country have considerably reduced. Several cities and states (Ahmedabad, Rajasthan, Odisha, Telangana, etc.) have developed detailed action plans based on the NDMA's integrated guidelines. Among the key ones[1], Odisha stands out for its climate Adaptive HAP which has used heat impact intelligence (such as vulnerability assessment, heat hotspots, socio- economic factors, etc.) to effectively tackle heatwave impact among the most vulnerable to it. Most of the crucial elements of these heat action plans are focused on creating public awareness and developing a strategic community outreach initiatives through media engagement, the use of an early warning weather forecasts systems for a streamlined inter-agency collaboration, capacity building mong the healthcare professionals to be able to diagnose and respond to heat-related illnesses, identification of key-hotspots, collaborating with non-governmental organizations to expand outreach and communication, and the development of a heat emergency response plan.

The Telangana HAP focuses mostly on preparedness measures utilizing an integrative approach that include a Mandal-wise maximum temperature recorded from the year 2010-2018, identification of the severe heatwave days, and a heatwave vulnerability assessment. A few of the innovative strategies were the establishment of 924 Automated Weather Stations (AWS) provide weather data on an hourly basis and the development of a mobile App ("T-Weather") to understand the village level weather conditions from the nearest AWS for the use of department officials, expert agencies and common public. Similar approach was also taken by Orissa where heat stress vulnerability was assessed across the identified wards in hot spot areas of Bhubaneswar and used a comprehensive index to prioritize HAP in different wards of the city. The plan also emphasized on the prevention, preparedness, and mitigation measures for select cities. The Collaboration with non-governmental organizations (NGOs) in expanding the already existing outreach and communication approach with the most vulnerable communities have been a part of the Andhra Pradesh HAP along with the regular updating and monitoring of the evaluation of the Heat Action Plan. The Karnataka HAP has been well-known for its three core-elements: Dissemination heat wave alert to community using Early

[1] The review of literature is borrowed from https://climateandcities.org/wp content/uploads/2022/01/Review-of-Heat-Action-Plans.pdf

Warning System and its capacity building approach among healthcare professionals and the community. On the other hand, the Rajasthan HAP stands out to be one of the first kind to provide appropriate measures for heat-wave effect mitigation in the rural settings. Ahmedabad Heat Action plan has been a crucial (and we heavily draw from this plan given the same context) in the implementation of the major elements of HAP recommended by the NDMA: The HAP gives out a detailed Ahmedabad Heat Action Plan (HAP) departmental wise suggested activities during heatwave days for yellow, orange, and red alert days. The plan particularly emphasized on the strategies of 1) public awareness, 2) early warning systems, 3) capacity building, and 4) reducing heat exposure and promoting adaptive measures.

1.3 The Report on Extreme Heat Exposure and Actions for Gujarat

Given the vulnerability of Gujarat in terms of the exposure to extreme heat during the summers, the Gujarat State Heat Action Plan can be designed to protect the state's population from heat-related adversities to health and livelihood. Taking an interdisciplinary approach, a district-level vulnerability assessment was conducted along with analyzing the temperature thresholds for each of the 33 administrative districts of the state. The major aims of the plan are to strategize alerting people (especially those residing in the vulnerable districts) and suggest inclusive governmental strategies to prevent the major avoidable effects on health and livelihood during periods of summer.

The plan recommends a series of steps to reduce the risks to health from immediate and prolonged exposure to extreme heat for:

- The different governmental agencies at all administrative levels of the state, authorities and non-profit groups of social care, and other public agencies focused on mitigating the effects of heatwaves in the state

- Professionals working with people at risk (the elderly, children, the socioeconomically underprivileged, individuals with cardiovascular diseases and other comorbidities and so on)

- Individuals, local communities, and voluntary groups

- High-risk (vulnerable) groups

1.4. Core elements in the report for Gujarat State Heat Action Plan (GSHAP)

GSHAP emphasizes having inter-departmental state-level and district-level coordinated plans addressing preparedness, strategies, and monitoring of adverse hot weather before it strikes.

The plan builds on a rigorous district level ecosocial vulnerability assessment of heat in Gujarat, India (see details in Chapters 2 and 3). The core elements of the plan are:

1.4.1. The heat alert system

A heat-health watch alert system will operate in Gujarat from April to July each year. During this period, the IMD will forecast the weekly temperatures, as defined by forecasts of day and night-time temperatures and their duration.

Alert 1: Preparedness (yellow)

This is an alert throughout the summer season (April-July) where the social and healthcare service sectors will focus on ensuring that awareness among the public, communication between the departments and different levels have been established and the preparedness are maintained by implementing the measures set out in the heatwave plan (for instance, checking the stock of all relevant medical equipment's by the district and Taluka level health personnel; community awareness programs; delivering heat related messages through social media; awareness among school goers through school curricula based knowledge dissemination and so on).

Alert 2: Action and readiness (orange)

This is an important stage to ensure readiness for the swift assessment of infrastructure in place by all the relevant departments (especially health) and swift action to reduce harm from a potential heatwave. This alert will give emphasis on alerting the public about how to mitigate the ill-effects of the wave, how to adapt (economic strategies for personal safety), alerting the vulnerable groups (socioeconomically underprivileged, children and older adults, women, outdoor workers such as the individuals associated with MNREGA work, and so on).

Alert 3: Emergency response (red)

At this alert, the likelihood of chronic and adverse illness and death will be higher even among the fit and healthy. While a special focus will be given to the high-risk groups and that will demand a multi-sector response at state and local levels, hospitals, and other health centers (permeant and temporarily created) will self-monitor their stocks and be sufficiently equipped with staff. Mobile health centers will be functional at the remote (hard to reach) locations, especially in the moderate to highly vulnerable districts. Daily (or hourly) forecast and alert of heatwaves will be disseminated to the public of the districts through internet and SMS services.

1.4.2. Long term strategies (mitigation)

- A coordinated long-term planning between different stakeholders (at state, district, and Taluka levels as part of a convergence scheme) to protect the people and infrastructure from the effects of heat adversities and thereby reduce the additional number of summer illness and deaths attributable to heat in the state.

- Making long term infrastructural improvements, for instance, creating special summer emergency units in hospitals and PHCs, designing greener built environments (e.g. cool roofing), improving the building design (e.g. increasing shading around and insulation of buildings), increasing energy efficiency (e.g. reducing carbon emissions), emphasizing on the implementation of water distribution programs such as the Jal Jeevan Mission, and navigating the transport policies (ways to minimize traffic during the summers)

- Including heat and its impacts related knowledge in the school curricula

- Emphasizing and prioritizing ways to mitigate existing population level issues such as poverty, gender-gap, education and so on that contribute to the (mal)adaptation to heat adversities.

- Capacity building of all stakeholders at the supply side of programs

- Community awareness and participation

1.4.3. Preparedness (short term strategies and adaptation)

The following points are suggestively essential for preparedness:

- Annual convergence meetings (at the district-level) in around September-January where all the concerned departments discuss their plans to address heat related issues in the upcoming summer season. This meeting will enable the key authorities to be aware of the agenda of all the departments and take appropriate actions accordingly in crucial times.

- Developing a state level portal (with district level connectedness) with relevant data and information on status of activities carried out by different departments

- Frequent (once in two weeks during the summer season) visits by the authorities (collaborative of all key departments) to the vulnerable regions of the districts (in terms of exposure or population) to conduct an on-field first-hand assessment. This will be additional to the annual Taluka level assessments (Taluka level officials such as the BDO will conduct annual assessment to identify the location of the most vulnerable groups, their proximity to PHCs/UHCs, and the status on awareness campaigns).

- A thorough monitoring of the vulnerable groups for indicators identified to be suggestive of heat vulnerability (through NGOs, and Taluka/field level functionaries)

- Discussion of the governmental departments with local NGOs and taking their inputs in addressing local-level concerns of the people regarding adaptation

- Training of existing staff (district, Taluka, and GP levels), assess the appropriate healthcare and the physical environments before summer.

- Involving the community in discussions at the Taluka/village level (annually) to understand their concerns during the summer season, their current adaptation strategies, take their suggestions and so on.

- Action by the district administration to ensure reduced indoor heat exposure (such as the implementation of programs that offers safe cooling practices (for instance, a subsidy to purchase solar electric fan/cooler and so on) and drinking water facilities, especially among the disadvantaged groups)

- Introduce an exclusive summer hotline (state level) managed by the health department.

1.4.4. Communication to the public

- Creating LED banners that display real time temperature and humidity in all traffic points and government offices/hospitals/schools/buildings

- Informing the public about the forecast of temperature at least thrice everyday (during orange and red alerts) using radio, television social media, and if possible, through SMS

- Development of an app to check for weather updates and what to do and not do during yellow, orange and red alerts.

- Communication with the public through young human messengers (for instance, select school students and youth volunteers) about how to use the app and steps to use for different alerts

- Attention should be especially given to the reach of these important messages and information to the vulnerable groups

1.4.5. Awareness of and engagement with the public

- Mass awareness campaigns with the help of district administration (District Collector office) with the coordination of the health department and Women and Child Development Department about adaptation and ways to mitigate the extreme heat-effects at the individual and community level

- Special Gram Panchayat (GP) sessions ahead of the peak summer months especially focused on the adaptation strategies

- School camps, AWC camps (could be integrated with VHSND/immunization days, and SHG camps related to awareness of heat related health and livelihood effects, especially reach out the children and women

- At least one district level awareness meeting with the presence of a strong administrative official such as the District Collector themselves or other personnel such as the Resident Addl. Collector (RAC).

- Efforts by NGOs in awareness through their collectives, especially reach out to the vulnerable population such as children, aging population, and pregnant women

- Development of an app to understand the heat-related health and livelihood effects, and what to do (or not), and whom to approach through what channel

1.4.6. Monitoring the progress of the plan every year

We recommend a framework (public health) to set desired outcomes to monitor and evaluate the plan annually:

- Online publishing of local level data so that different agencies and different level agencies can keep a track of the data. This demands the development of an online portal to feed and access data across the state, across departments, and across administrative levels.

- Feed in daily and weekly heat-related casualty during the summers

- The district/Taluka administration will keep monitoring the statistics and map out the vulnerable regions and population and pay special emphasis on awareness and adopt localized mitigation strategies

- The state will monitor the weekly district level updates and map out the vulnerable districts based on the real time health indicators

- Conduct annual convergence meetings (all relevant departments) pre-summer, share updates on the past year, share experiences, present statistics, and plan for smoother coordination for the upcoming summer.

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Heat Hazard & Vulnerability Profile of Gujarat

2.1. District-level eco-social vulnerability assessment

The primary objective was to identify and rank the districts in the state of Gujarat based on their socioeconomic (including health) vulnerability to exposure to heatwaves. This ranking would inform prioritization of policy-related efforts in the most vulnerable districts, especially for development/implementation of adaptation planning and creating awareness about the heat-related stress and vulnerability among the policymakers and the common public of such regions. We utilize the concept of "vulnerability" as discussed in The Fifth Assessment Report of the Intergovernmental Panel on Climate Change, i.e., IPCC-AR5 (IPCC, 2014) defines "*the risk of climate change at the intersection of 'Hazard', 'Exposure' and 'Vulnerability'*". Aligned with this, we conceptualized vulnerability as the 'internal property of a system' that suggests the propensity of the system to be adversely affected, independent of any hazard and exposure to heatwaves.

Hazard	The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. In this report, the term *hazard* usually refers to climate-related physical events or trends or their physical impacts.
Exposure	The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.
Vulnerability	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

Table 2: Definitions from The Fifth Assessment of IPCC (2014) (IPCC, 2014)

Vulnerability if often understood as the function of exposure, sensitivity, and adaptive capacity of the system (Climate Change 2022: Impacts, Adaptation and Vulnerability | Climate Change 2022: Impacts, Adaptation and Vulnerability) (in our case, each district of Gujarat is a system).

- Sensitivity: Sensitivity refers to the degree to which 'a system or species is affected, either adversely or beneficially by climate variability or change' (IPCC, 2014). There are direct effects such as any change in crop yield in response to a change in temperature) or effects those are indirect in nature such as the physical affect increase in the frequency of flooding due to sea/river water level rise.
- Adaptive capacity: Adaptive capacity is defined as 'the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences' (IPCC, 2014). For example, a higher adaptive capacity would mean that a person would have potential resources such as an Air Conditioning at home which will help the person to adapt to the heat effects during a heatwave in the summer.

When exposure and sensitivity increases, vulnerability increases. Conversely, when adaptive capacity increases, vulnerability of a system decreases.

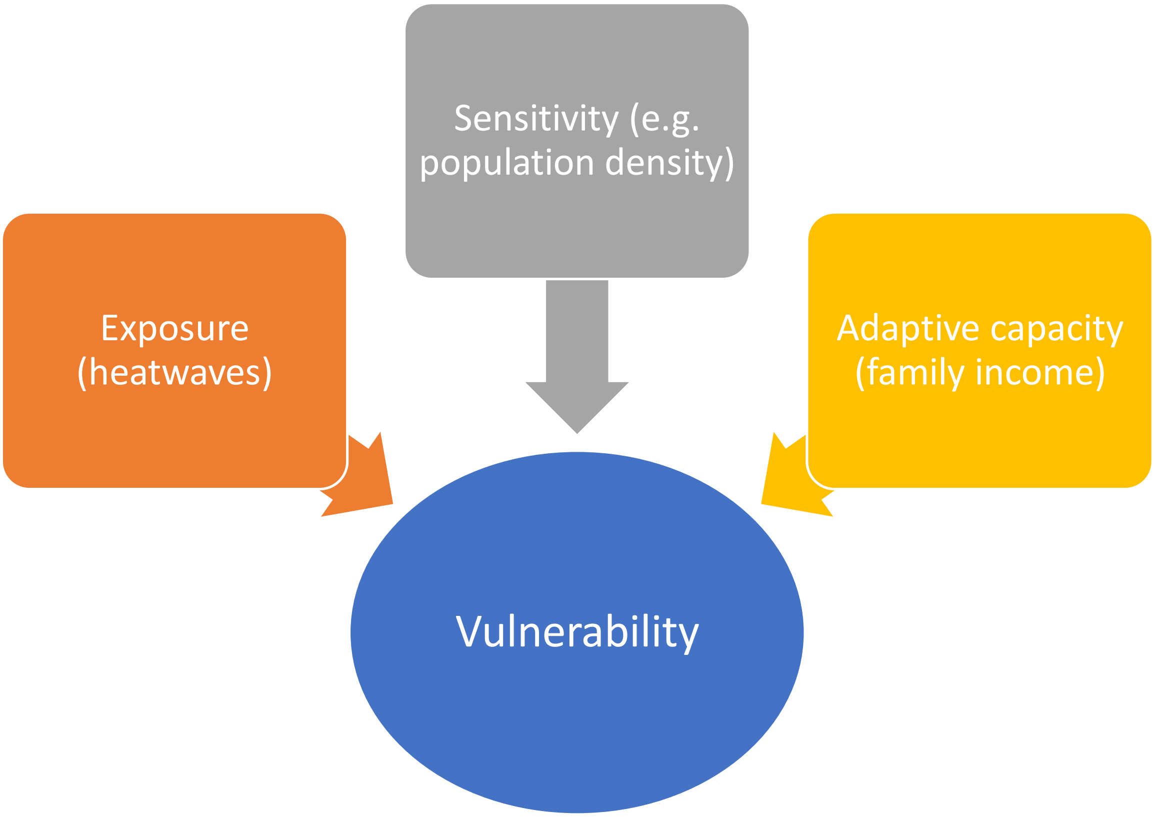

Figure 1: The demonstration of vulnerability as a function of exposure, sensitivity, and adaptive capacity

<u>Methods used in the Vulnerability Assessment</u>

Choice of indicators

For a comprehensive vulnerability assessment, we adopted the integrated vulnerability assessment method in which both biophysical and socio-economic vulnerabilities are considered. For instance, we have considered biophysical aspects such as vegetation cover in our analysis along with socioeconomic indicators such as poverty. Further, vulnerability assessment could be carried out at a different spatial scale, i.e., micro-scale (Taluka-level) or macro-scale (state-level or district-level). Our heat-vulnerability assessment is conducted at a macro-scale with districts as the unit of analysis, the reason being that the vulnerability amongst the districts can be compared across the state and different programs and policies could be implemented at the district level targeting the requirement. Following a thorough literature review on vulnerability assessment, we shortlisted 24 indicators (both bio-physical and socioeconomic) for our heat-related vulnerability assessment. The indicators and the rationale for their selection can be found in the table below.

Table 1: List of indicators included for the heat vulnerability assessment and the rationale for their inclusion.

Indicator	Rationale for their selection
1. Percentage of under-six children (census 2011) (+)	Age has been found to have an influence on vulnerability, especially the children with frequent health issues during extreme weather events.
2. Sex ratio (census 2011) (-)	A higher sex ratio (number of females per 1000 males) could indicate the gender-friendliness of the region, and perhaps to a great extent could be a proxy for women-empowerment that influences the vulnerability of the region to climate-related adversities.
3. Percentage of STs (census 2011) (+)	A higher percentage of marginalized population in a region suggests greater sensitivity of the region to the effects of adverse-climatic-events, due to their lack of voice and lesser access to economic and emotional capital.
4. Percentage of SCs (census 2011) (+)	A higher percentage of marginalized population in a region suggests greater sensitivity of the region to the effects of adverse-climatic-events, due to their lack of voice and lesser access to economic and emotional capital.
5. Percentage of men with secondary education or higher (NFHS-4) (-)	A greater education of men indicates greater adaptive capacity to climatic events. For instance, with access to higher education, men could be better aware of disaster risk reduction policies implemented in the aftermath of climate-related disasters.
6. Percentage of women with secondary education or higher (NFHS-4) (-)	A greater education of women indicates greater adaptive capacity to climatic events. For instance, with access to higher education, women could be better aware of disaster risk reduction policies implemented in the aftermath of climate-related disasters. Further, greater education among women could also suggest greater women empowerment in the region, giving them a greater voice during the aftermath of any disaster.
7. Percentage of households in the lowest wealth quintiles (NFHS-4) (+)	Income has been an indicator of adaptive capacities not just to vulnerabilities, but any major adversities in life. Therefore, a greater percentage of poorer households suggests greater vulnerability.
8. Percentage of households with drinking water inside household premises (NFHS-4) (-)	Access to drinking water facility within the household premise has been used as a key indicator of heat-related vulnerability assessment by previous studies likely due to its inherent importance in coping with dehydration during such climatic phases.
9. Percentage of households with either a fan or air cooler or both (NFHS-4) (-)	Possession of air-conditioners can be a strong protective factor against heat-related deaths. While possession of air-conditioners are not common among a majority of Indians; we propose to use possession of air-coolers or fans as proxy for this indicator.
10. Percentage of households owning television (NFHS-4) (-)	Previous research from South Asia has shown that access to media sources such as television, radio, and mobile phones could also be resourceful in the preparedness for disasters
11. Percentage of households owning a mobile phone (NFHS-4) (-)	Previous research from South Asia has shown that access to media sources such as television, radio, and mobile phones could also be resourceful in the preparedness for disasters

12. Percentage of women who received full antenatal care (NFHS-4) (-)	This is an indicator of the public health system of the region. Greater percentage of women who received full antenatal care indicates greater adaptive capacity of the region.
13. Percentage of children who are fully immunized (NFHS-4) (-)	This is an indicator of the public health system of the region. Greater percentage of immunization of children indicates greater adaptive capacity of the region.
14. Proportion of households where member(s) has been covered with health insurance (NFHS-4) (-)	Greater percentage of health-insurance holders of a region translates to greater adaptive capacity of the region, since availability of health-insurance could reduce financial burdens in the aftermath of any disaster related health issue.
15. Population density (persons per square kilometer) (census 2011) (+)	A higher population density indicates crowding over available resources in a region, thereby increasing the sensitivity of the region, further increasing the vulnerability.
16. Number of PHCs per 1000 persons (-)	This is an indicator of the public health system of the region. Greater number of PHCs per 1000 persons indicate greater adaptive capacity of the region.
17. Infant mortality rate (census 2011) (+)	This is an indicator of the public health system of the region. Higher infant mortality rate indicates greater vulnerability of the region.
18. Percentage of utilization of any ICDS services (-)	This is a proxy indicator for awareness about governmental programs and policies targeting the common public of a region. A greater percentage of utilization of ICDS services indicates greater adaptive capacity of the region.
19. Normalized Difference Vegetation Index (-)	This is an indicator of the green cover of a region, previously identified as a protective factor to heat island effects and heat deaths.
20. Milk production density (kg/day/sqkm) (-)	Gujarat is a state known for its high milk production. This sector has a high contribution to the economic growth of the state and its districts, thereby providing greater economic resources to the workers. Therefore, a greater milk production density reflects greater adaptive capacity.
21. Vegetable yield (-)	Agriculture sector has a high contribution to the economic growth of the state and districts including greater employability. Therefore, higher vegetable yield reflects greater adaptive capacity.
22. Percentage of stunted under-fives (NFHS) (+)	Higher proportion of malnourished (student) under-five children in a district increases the sensitivity of the district thereby increasing the vulnerability.
23. Milk consumption among under-fives (NFHS) (-)	With more nutritious food among children (under-fives), the district attains more adaptive capacity (ability to be nutritious during heat events) thereby decreasing the vulnerability.
24. Heat-friendly roofing (NFHS) (-)	Better cooling roofs increases the adaptive capacities of the district thereby decreasing the vulnerability.

Tool used in our analysis for the Vulnerability Assessment (VA): Principal component analysis (PCA)

The method we have used for our vulnerability assessment is the widely cited Principal Component Analysis (PCA). The PCA method is often used in exploring large datasets which might have several dimensions in it. For instance, the 24 indicators chosen in our analysis may carry humongous information on different domains such as socioeconomic conditions, environmental factors and so on, which makes the dataset complex in terms of visualization and analysis. The key logic behind performing a PCA is to reduce the dimensionality of the dataset. A PCA reduces the larger number of variables into smaller ones that still have most of the information as the larger dataset. It breaks down the dataset into fewer components that carries most of the information about the entire dataset. In general, a PCA transforms the original indicators into a new set of indicators that considers the following criteria (1) the new sets of indicators are a linear combination of the original ones, (2) are uncorrelated or feebly correlated with each other, and (3) are ordered according to the amount of variation in the original indicators, which can be accounted for by the new indicators. Different statistical applications are often used for the PCA analysis. For our analysis, we used STATA version 12.1 (SE).

The process of PCA in our VA

As the first step of PCA, the relationship among the indicators is assessed by creating a correlation (Spearman correlation) matrix. Highly correlated indicators are often taken out of the analysis which could otherwise lead to inaccurate results. The second crucial step in this analysis was the standardization of the indicators. Since different indicators were measured in different units, we converted them to one unit of analysis using their z-scores. In simple terms, a z-score gives the idea of how distant a data point is from the mean. This method of standardization has been widely used in public health studies. Further, seven variables, namely percentage of STs, percentage of SCs, percentage of children, infant mortality rate, percentage of poorest households, percentage of malnourished children, and population density were reversed scored (the z-scores multiplied by -1) so that the direction of all the variables is uniform. Thus, a greater value of the indicators would indicate lesser vulnerability in our models. Once this arrangement of z-scores was ready, we ran our PCA which revealed a 6-component acceptable structure of the data. After removing two factors (due to poor proportions), a composite score was then developed after aggregating the predicted PCA scores (of the four components).

<u>The district vulnerability-maps</u>

After the indexing was performed using the PCA, we categorized the 33 districts into 5 quintiles based on their index. Under Quintile-based categorization, 33 districts were divided into five categories: each category containing an equal number (6-7) of districts according to their order of ranking. Quintile I contains 20% of the most vulnerable states and Quintile 5 the 25% least vulnerable.

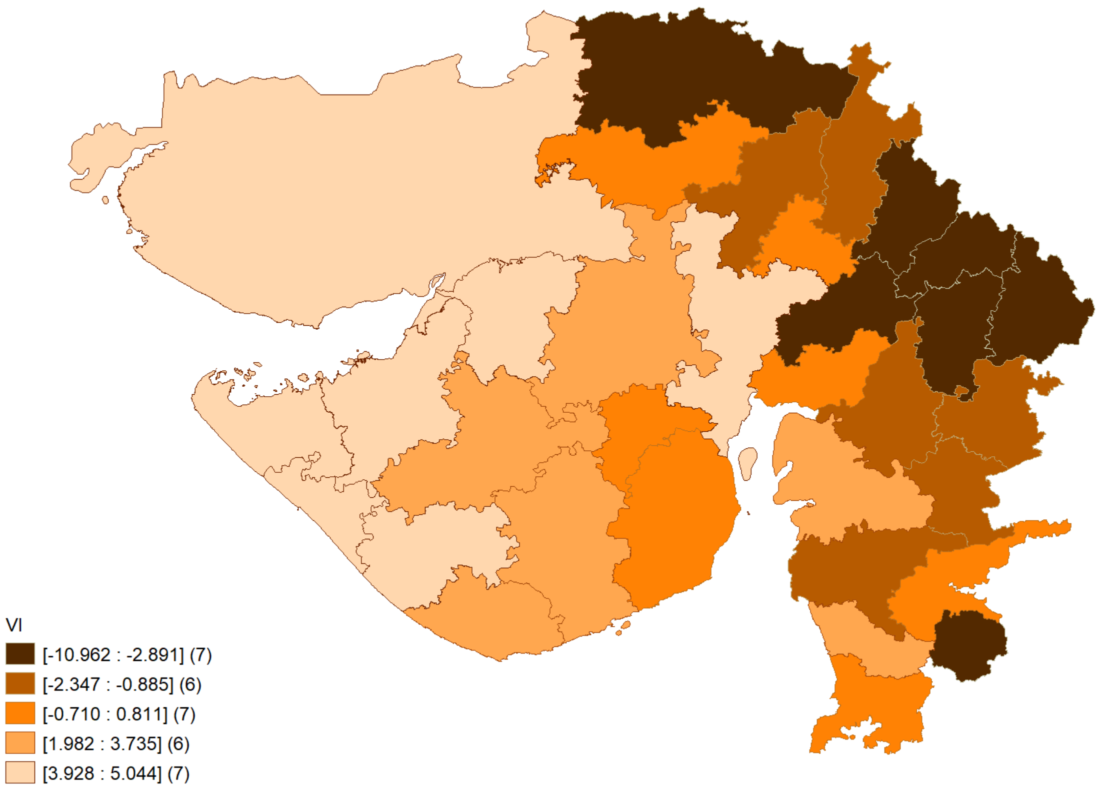

Figure 2: The district-level vulnerability map of Gujarat and their quintile-based categorization (darker shades suggest more vulnerable compared to the lighter shades)

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Capacity Building

Capacity building, according to the United Nations, refers to "the process of developing and strengthening the skills, instincts, abilities, processes, and resources that organizations and communities need to survive, adapt, and thrive in a fast-changing world. (Capacity-Building | United Nations)" It also means further developing performance which leads to greater capacity. Capacity building is an important component of adaptation to heatwave initiatives and refers to addressing specific target groups such as practitioners involved in contributing their capacities for the heatwave adaptation of the local communities.

The building Talukas of capacity building efforts for climate change adaptation are awareness raising and knowledge building. The end goal of capacity building however extends beyond this and seeks to empower people by developing skills and competencies. It is important to note that capacity building cannot be limited to a point in time and has to be consistent. Different modes of capacity building can be categorized as education, training, networking, specific coaching, technical assistance, and attention of groups at risk. Activities such as building targeted events, debates and sharing of information through internet platforms can support the discussed capacity building measures. Education and training initiatives are crucial capacity building efforts that can help even at the grassroots level, enabling communities to be more resilient to adverse effects of climate change and heat events.

The core elements of the capacity building approach suggested by the report:

1. There is a need for a *comprehensive approach* to capacity building that should be implemented in a *coherent* (where all relevant stakeholders get the same message/training), *structured* (with standard tools), *and progressive* (step-by-step) manner. The nodal agency for this approach will be the GSDMA (will coordinate with all relevant departments about training their officials and field level staff annually)

2. *Enhancing the awareness* about heatwaves and its impacts of decision-makers (at all levels and departments) and senior officials who will support the capacity building programme. This is also applicable for Non-Governmental Organizations. Awareness about heatwaves is key among the senior officials and volunteering organizations for a better capacity building approach.

3. Capacity building is a continuous process. While it is suggested to be done annually throughout all relevant departments and administrative levels, continuous efforts in training the facilitators (through integration with other capacity building initiatives, such as department specific approaches, is advised)

A strategy for capacity building in order to deal with heatwaves and other extreme heat events would include

- Establishing an early warning system as well as coordination among agencies.
    - This would include identifying key agency leaders and ensuring linkages between them.
    - Another aspect of this would be facilitating internal communication with community groups, local agencies, state and district officials, municipal bodies

- Training programmed for healthcare professionals to implement capacity building
    - This would entail organizing training for healthcare workers, other frontline workers, school-teachers, community members, and school children.
    - Conducting monitoring and supervision of the above-mentioned training (relevant departments, nodal agency GSDMA).

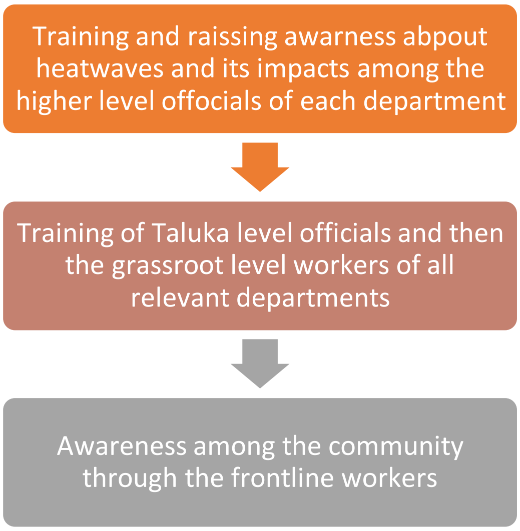

Figure 1: The step-by-step process of capacity building approach

3.1. Capacity building– Training programs

Once the senior administrative officials are trained with enhanced awareness about the issue, the next crucial step will be to ensure proper training among the grassroot level facilitators. The training component of the grassroot level frontline workers should include:

- Sharing of experiences and best practices by trainees themselves. This is the learn from experience approach.

- A detailed orientation to the heat wave action plan and other contingency measures

- Development of effective communication skills (for instance, how to conduct awareness campaigns with the public, especially among the most vulnerable districts and populations), advocacy, and planning of campaigns in order to help trainees mobilize community and increase its involvement

- Skill development in terms of resource management and organization

- Supervision of practice after training

3.2. Training of existing staff (district, Taluka, and GP levels)

- The Taluka Chief Medical Officer (BCMO) or Chief Medical and Health Officer (CMHO) of the Health Department are responsible for training staff in Primary Health Care Centers (PHCs) and Community Health Centers (CHCs) for heat focused examination procedures. Their training would include identification of heatwave related cases (Checklist attached in Annexure), stocking of relevant equipment and medicines, mobile interventions, and disseminating knowledge to the public.

- The District Program Officer (DPOs) will be responsible for training the Anganwadi workers (AWWs) and the Anganwadi Helpers (AWHs) for heat-related preparedness in the community. Their training would include identification of heatwave related cases among the vulnerable children, adolescents, pregnant and new mothers; stocking and efficient delivery of nutritious food during the summer season, especially those beneficiaries who missed coming to the AWCs, mobile interventions, and disseminating knowledge to the public.

- Intensified targeted training programmed and capacity building efforts directed towards medical officers as well as ANMs and ASHAs in heat prone areas

- Imparting training to improvise documentation of the cause of death-on-death certificates

- Incorporating information, education, and communication (IEC) as a component in training modules utilized for training health officials

- Building capacity among school principals and schoolteachers regarding heat protection and equipping them with an awareness module which can be used for dissemination in classrooms

- Training workshops with Self Help Groups (SHGs) and other community mobilisers

- Project Implementation Unit (PIU) of the Health and Family Welfare Department Engineer are responsible for collaboration with non-governmental organizations (NGOs) in order to ensure construction of adequate shelters and cooling public places as well as provision of drinking water in vulnerable areas and work sites. This entails training in terms of interaction with civil society and resource management.

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Annual convergence meetings to discuss preparedness

The Government of Gujarat aims to resolve the concerns and casualties brought about by rising atmospheric temperatures in the state and broader India. The heat action plan aims to recognize the early warning signs of an incoming heat wave and send pre-heatwave warnings and prepare protocols for the during and post heatwave phase.

Gujarat is a vast state with many different regions with different climatic conditions and thus the heat action plan works with multiple different stakeholders to reach each and every different geographic and socioeconomic group of the state. While the planning will be top-down, the monitoring will follow a bottom-up format along the administrative structural chain and the state-district-Talukas-panchayat model.

The heat action plan is an inter-agency coordinated. The Gujarat State Disaster Management Authority (GSDMA) acts as the nodal agency in Heat Action Plan. Besides the GSDMA, the Revenue Department of Gujarat is the other important office in formulation and implementation of the policies. The various state-level departments that are involved are: The Health and Family Welfare Department, Urban Development and Urban Housing Department, Labor and Employment Department, The State Transport and Tourism Departments, the State Education Department, The Women and Child Development Department, Gujarat Water Supply and Sewerage Board, Ministry of Power, Ministry of Consumer Affairs, Food and Public Distribution, Forest and Environment Department, Fire Department, Gujarat Police Department, Information and Technology Department, the media and press are the key departments.

Beyond the key departments a successful management of the disaster needs coordination from all administrative departments. The Gujarat division of the Indian Meteorological Department (IMD) forms the lead in pre-signaling temperature changes. Following this the color-coded alerts are issued based on the temperature and specific preset protocols are to be followed.
There will be an annual meeting held at the state level each year in the post heat wave period which roughly falls anytime between August to December. The meeting will most likely be held in the month of December. The annual convergence meetings will try to bring under one roof the diverse experiences of the different institutions/organizations working in the different districts. It aims to review the process, identify the gaps, and introduce changes if any are needed. Although the meeting is of the central body it will review each district specially. Before the meeting a report has to be submitted by every stakeholder. The report has to be submitted to the administrative body that it reports to, like the panchayats will submit their reports to the Taluka level, the Talukas will submit to the district and the districts will report to the state committee in charge. The report needs to feature both qualitative and quantitative data and needs to be handed in at least 45 days advance to the annual committee meeting.

As the annual convergence meetings are held in the period falling in the post- heat wave season. This makes it essential to evaluate how much the plan has worked and what changes need to be implemented. As different districts from different geographic and climatic zone and thus have different temperatures, there will be special focus with more monitoring and evaluation on the vulnerable districts with more representation from these districts present in the convergence meetings.

The plan recognizes that the work to reduce the adverse effects of rising atmospheric temperature cannot be implemented by a single administrative body or committee and thus will require both government and private/NGO stakeholders to work together. Gujarat comprises 33 districts, 252 talukas, 8 municipal corporations (Ahmedabad, Surat, Vadodara, Rajkot, Bhavnagar, Jamnagar, Junagadh, and Gandhinagar), 159 municipalities and approx. 18,000 villages. The panchayats need to submit their data to the Talukas. The Talukas will compile the data for all the panchayats under it and submit to the district. The nodal officer of the district shall be present at the meeting. Single office contact point of the Corporations, Municipalities, NGOs, Rotary Clubs, Lions Clubs shall need to be present as members in the meeting.

Formation and conducting evaluation committee meetings

The Heat Action Plan is an inter-agency coordinated project with awareness and complete cooperation from all legislative, administrative bodies of the government, NGOs, and private organizations. As it involves the active participation of every department and individual, it is important to have a well-represented, active central committee that overlooks the entire project. The central committee will also be the central point of policy formulation and information dissemination.

The main objectives of the annual convergence meeting would be to:

1. Identify the problems and drawbacks of each organization involved and also problems specific to each district/Taluka/panchayat
2. Develop detailed plan and instruction on how to overcome the existing lags so as to reduce the morbidity next year
3. Communicate the plan for the following year and clear roles and responsibilities of the departments.

The committee will be formed with three types of members: the convenor, the executive committee, and the general body. Other than the permanent members additional members like area experts can be invited as and when needed.

Convenor: Usually a representative/chairperson from GSDMA

The general body committee will be formed with the nodal officers from each department:

- The nodal officers for each unit: CDM and EOS at the state level, District Collector at district level, the Municipal Commissioner, state Police Department, or the District Development Officer
- Social Justice and Empowerment Department: Director of Social Welfare Director of social Defense, Commissioner for Persons with Disability
- Transport Department: Commissioner of Transport
- Energy and Petrochemicals Department: Electricity Distribution Companies (UGVCL, PGVCL, DGVCL and MGVCL) and Private Companies
- Labor and Employment Department: DISH
- Health Department: Commissioner of Health, CDMO and CDHO
- Revenue Department: Commissioner of Relief
- Water Resource Department: Chief Engineer
- Commissioner of Rural Development

The executive committee members will include members nominated by the general body from their respective departments who will be in-charge of implementing the strand of the plan for their own department (in consultation with other departments).

An external expert should be invited to hold a chair in the committee.

<u>Data collection for monitoring and evaluation</u>

The grassroot level frontline workers like ASHA will collect/present already existed data that is essential for monitoring and evaluation. Alongside the government assigned workers, the NGOs will also be contacted for data collection. There needs to be a unified system for data collection so as the reports can be easily compared and contrasted in the meetings. This process can be discussed at the annual meeting.

The annual convergence meeting will also create a state level report and a database for future reference. It should focus on comparing the statistics for the year before and showing an overall trend in the changes in indicators of evaluation. It needs a clear action plan not just for cities, corporations, and municipal areas but also rural areas with regional specificity.

The evaluation committee should meet at least once a year at the end of the year to discuss and conclude the working of the action plan for that year and also plan ahead. They could also meet at other times of the year as and when need arises.

Heat Early Warning System (HEWS)

7.1. Introduction to the Heat Early Warning System

- The Indian Meteorological Department (IMD) uses a system of color codes in order to issue warnings for expected heat waves. The categorization of a heat wave depends on the severity of the heat hazard.[2]
- The color-coded warnings are impact-based.[3]
- It is important to note that IMD issues country-wide warnings using the color codes, and the threshold temperatures for each category may differ across regions. It is therefore recommended that districts carry out their own threshold assessments.
- Code green indicates a normal day needing no cautionary action. Maximum temperature is near the normal temperature.
- Code yellow or yellow alert indicates heat alert, with heat wave conditions in some pockets persisting for a period of two days. There is a need to be updated when a yellow alert is issued. The temperature is tolerable in general but can pose a moderate health concern for vulnerable populations - infants, elderly, and people with chronic medical illness. Suggested actions include:
    - Avoiding heat exposure
    - Wearing lightweight, light-colored, loose, cotton clothes
    - Covering your head
- Code orange or orange alert indicates severe heat alert for the day, with high temperatures that can cause heat illness in people exposed to the sun for long durations. There is a need to be prepared when an orange alert is issued. The health concern for vulnerable populations is high. Suggested actions include:
    - Avoiding heat exposure
    - Avoiding dehydration
    - Covering your head
    - Wearing lightweight, light-colored, loose, cotton clothes
    - Ensuring adequate liquid intake of water, ORS, and other homemade drinks (such as lassi, lemonade, buttermilk) even when not thirsty
    - Taking frequent cold-water baths
    - Laying down a person affected by a sunstroke in a cool place, washing their body and wiping it with wet cloth to bring down body temperature regularly. A doctor must be consulted immediately
- Code red or red alert indicates extreme heat alert for the day, with severe heat waves persisting for more than two days and total number of heat or severe heat wave days persisting for more than six days. There is a need to take action when a red alert is

[2] https://nidm.gov.in/PDF/pubs/NDMA/27.pdf

[3] https://internal.imd.gov.in/section/nhac/dynamic/FAQ_heat_wave.pdf

issued. All sections of the population are at a very high risk of developing heat illness and heat stroke. Suggested actions include all the actions as recommended for an orange alert, along with providing extra care to vulnerable populations.

7.2. Alerts (temperature-based) for 33 districts of Gujarat

- Ahmedabad
  - The district has been vulnerable to frequent heat waves in the last decade, with one in 2010 causing 1300 fatalities.
  - Maximum temperature during summer months from 1951 to 2020 ranged between 29.39 and 47.41 degrees.
  - The district could be most vulnerable to heat waves during April and May.
  - Ahmedabad has infrastructural coping opportunities in terms of high access to drinking water in the household premises (58.62%) and ownership of fan/cooler/air conditioners (98.41%).
  - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95^{th} percentile	45
Orange alert	85^{th} percentile	43
Yellow alert	75^{th} percentile	41

  - Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	44	46	46	42
Orange	41	44	44	41
Yellow	40	42	42	40

- Amreli
  - The district has a local steppe climate with very little rain during the year. Maximum temperature during summer months from 1951 to 2020 ranged between 28.37 and 40.83 degrees.
  - Peak temperatures were observed in the months of April and May.
  - Amreli too has infrastructural coping opportunities in terms of high access to drinking water in the household premises (~54%) and ownership of fan/cooler/air conditioners (~98%).
  - The insurance coverage and ICDS utilization in the district was lower than the state average. There is thus a need for more efficient implementation of programs in order to mitigate the effects of heat waves.
  - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	39
Orange alert	85th percentile	37
Yellow alert	75th percentile	36

- Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	39	40	39	37
Orange	37	38	38	36
Yellow	36	37	37	36

- Anand
  - The district has a tropical climate with higher rainfall in the winters compared to the summer.
  - Maximum temperature during summer months from 1951 to 2020 ranged between 29.39 and 47.1 degrees.
  - The district could be most vulnerable to heat waves during April and May.
  - Despite high infrastructural coping opportunities, there is a need to reassess programs in order to improve infrastructural living quality in the district.
  - High ICDS coverage (about 76%), could be used to improve the low health insurance coverage among households in the district (15.65%) through increasing awareness. This can lead to better access to healthcare in times of heat events.
  - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	44
Orange alert	85th percentile	42
Yellow alert	75th percentile	41

- Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	43	45	45	42
Orange	41	43	43	40
Yellow	39	42	42	39

- Aravali
  - Maximum temperature during summer months from 1951 to 2020 ranged between 27.78 and 47.13 degrees.
  - Peak temperature events occur during the month of May.

- Infrastructural coping opportunities in terms of proportion of households with drinking water facilities (~31%) and access to fan/air coolers/air conditioners (~87%) was considerably lower compared to the state average.
- Health insurance cover among households in the district was higher than the state average.
- Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	44
Orange alert	85th percentile	41
Yellow alert	75th percentile	40

- Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	42	44	45	41
Orange	40	42	43	40
Yellow	38	41	42	39

- Banas Kantha
  - Maximum temperature during summer months from 1951 to 2020 ranged between 27.50 and 47.82 degrees.
  - The district temperatures peaked in April and May.
  - The proportions of households with access to drinking water in the household premise (53.56%) and ownership of fan/cooler/air-conditioners (77.99%), was only slightly greater compared to all districts' averages.
  - Given the low proportion of households with health insurance (about 20%), and a high proportion of poorer households (almost 16%), there is a pressing need for programs which raise awareness surrounding health insurance.
  - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	44
Orange alert	85th percentile	42
Yellow alert	75th percentile	40

- Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	42	45	45	43
Orange	40	42	43	40
Yellow	38	41	42	39

- Bharuch
  - The district has tropical savanna climate.
  - Maximum temperature during summer months from 1951 to 2020 ranged between 29.19 and 45.97 degrees.
  - The district could be most vulnerable during months of April and May
  - The district has lower proportions of households with access to drinking water in the household premise (~15%) and higher proportions of ownership of fan/cooler/air-conditioners compared to all districts' averages (~93%). The insurance coverage among the residents of the district was borderline (only about 24%) compared to the state average.
  - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	43
Orange alert	85th percentile	41
Yellow alert	75th percentile	40

  - Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	43	44	44	40
Orange	41	42	42	39
Yellow	39	41	40	38

- Bhavnagar
  - The district has semi-arid climate with a history of earthquakes.
  - Maximum temperature during summer months from 1951 to 2020 ranged between 28.99 and 43.14 degrees.
  - The district temperatures peaked in April and May.
  - The proportions of households with access to drinking water and ownership of fan/coolers was higher than the state's average. However, health insurance coverage and reception of governmental programs such as ICDS was quite low compared to the state's average.
  - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	41
Orange alert	85th percentile	39
Yellow alert	75th percentile	38

- Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	**Month**			
	March	**April**	**May**	**June**
Red	40	41	41	38
Orange	38	40	40	37
Yellow	37	39	38	37

- Botad
  - The district has tropical wet and dry climate, experiencing frequent thunderstorms in June and July.
  - Maximum temperature during summer months from 1951 to 2020 ranged between 29.38 and 45.05 degrees.
  - The district has a greater proportion of households with access to drinking water facilities within the household as opposed to the state average. However, the district had low coverage in terms of health insurance and a low proportion of households with ownership of fans/air coolers/air conditioners.
  - The district therefore needs efficient programmatic interventions.
  - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	**Cutoff criteria**	**Cutoff temperature**
Red alert	95^{th} percentile	42
Orange alert	85^{th} percentile	40
Yellow alert	75^{th} percentile	39

  - Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	**Month**			
	March	**April**	**May**	**June**
Red	41	43	43	40
Orange	39	41	41	39
Yellow	38	40	41	38

- Chotaudaipur
  - Summer months are characterised by a clear sky and hot temperature throughout.
  - Maximum temperature during summer months from 1951 to 2020 ranged between 29.22 and 47.31 degrees, with temperature peaking during the months of April and May.
  - The district has a lower proportion of households with access to drinking water facilities in the household (~28%), while the proportion of households with ownership of fan/cooler/air conditioner was borderline (~89%) and insurance coverage among households (~26%) was slightly higher compared to the state average.

- Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	44
Orange alert	85th percentile	42
Yellow alert	75th percentile	41

- Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	43	45	45	42
Orange	41	43	43	40
Yellow	40	42	42	39

- Dahod
  - The district has a sub-tropical climate with moderately low humidity.
  - Maximum temperature during summer months from 1951 to 2020 ranged between 28.35 and 47.07 degrees.
  - It has a lower proportion of households with access to drinking water facilities (~34%) and ownership of fan/coolers/air conditioners (~62%) compared to the state average. The insurance coverage among the households in the district was borderline (~23%) with the state average.
  - This calls for effective program interventions immediately.
  - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	44
Orange alert	85th percentile	42
Yellow alert	75th percentile	40

- Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	43	45	45	42
Orange	40	43	43	40
Yellow	39	41	42	39

- Dang
  - It is the least populated district in Gujarat.
  - Maximum temperature during summer months from 1951 to 2020 ranged between 27.60 and 43.77 degrees.
  - The district could be most vulnerable in the month of April followed by May.

- The district has a substantially lower proportion of households with access to drinking water in the household premise (~22%) as well as households with the ownership of fan/cooler/air-conditioners (~47%) compared to all districts' averages. However, the insurance coverage was higher than the state average.
- There is therefore a need for governmental interventions related to access to potable water and livelihood infrastructural programs in order to guard against the adverse effects of climate events.
- Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	41
Orange alert	85th percentile	39
Yellow alert	75th percentile	38

- Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	41	42	41	38
Orange	39	40	39	37
Yellow	38	39	38	36

- Devbhumi Dwarka
  - The district has a local steppe climate, with little rain being experienced throughout the year.
  - Maximum temperature during summer months from 1951 to 2020 ranged between 28.09 and 37.18 degrees, with temperatures peaking during April and May.
  - While the ownership of fan/air cooler/air-conditioner and access to drinking water facilities were high among the residents of the district, the district fell behind considerably when it comes to access to health insurance coverage.
  - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	35
Orange alert	85th percentile	34
Yellow alert	75th percentile	33

- Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	34	36	36	34
Orange	33	34	35	34
Yellow	32	34	34	33

- Gandhinagar
    - The district has a tropical wet and dry climate.
    - Maximum temperature during summer months from 1951 to 2020 ranged between 28.99 and 47.76 degrees, with temperatures peaking during April and May.
    - The temperature in the district saw major spikes in the maximum temperature during summer months of 1981, 2002 and 2019, with temperatures shooting over 50 degrees.
    - The proportions of households with access to drinking water in the household premise (~42%) and ownership of fan/cooler/air-conditioners (92%)was only slightly greater compared to the state average. Compared to the state average, the coverage of health insurance (~29%) was higher in Gandhinagar. I
    - Coverage of government programs was found to be higher in the district, indicating that effective heat-awareness programs could be effective in the district.
    - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	45
Orange alert	85th percentile	42
Yellow alert	75th percentile	41

    - Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	43	45	46	42
Orange	41	43	44	40
Yellow	39	42	42	39

- Gir Somnath
    - Maximum temperature during summer months from 1951 to 2020 ranged between 27.57 and 37.04 degrees, with temperatures peaking during March, April and May.
    - While the ownership of fan/air cooler/air-conditioner was high among the residents of the district compared to the average, the district fell behind when it comes to access to drinking water facilities within the household premises. On the contrary, the health insurance coverage was slightly higher compared to the state's average.
    - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	35
Orange alert	85th percentile	34
Yellow alert	75th percentile	33

- Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	35	36	35	34
Orange	34	35	34	33
Yellow	33	34	33	33

- Jamnagar
  - The district has a hot semi-arid climate, with the hottest season lasting from March to May.
  - Maximum temperature during summer months from 1951 to 2020 ranged between 28.31 and 47.26 degrees, with the district being most vulnerable during April and May.
  - The district has a higher proportion of households with access to drinking water in the household premise (~56%) and with ownership of fan/cooler/air-conditioners (~97%) compared to the state average, indicating high infrastructural coping opportunities. On the other hand, the proportion of households with health insurance coverage was comparatively lower than the state average.

  - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95^{th} percentile	44
Orange alert	85^{th} percentile	42
Yellow alert	75^{th} percentile	40

  - Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	42	45	45	42
Orange	40	42	43	40
Yellow	38	41	42	39

- Junagadh
  - The district has a tropical wet and dry climate bordering on a hot semi-arid climate.
  - Maximum temperature during summer months from 1951 to 2020 ranged between 28.27 and 37.99 degrees, with temperatures peaking during April and May.
  - While the ownership of fan/air cooler/air-conditioner was high among the residents of the district (~99% coverage), the district fell behind considerably when it comes to access to drinking water. This can affect coping during extreme summer heat.

- Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	36
Orange alert	85th percentile	35
Yellow alert	75th percentile	34

- Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	36	37	36	35
Orange	34	35	35	34
Yellow	33	35	34	34

- Kachchh
  - The district is the largest in India.
  - Maximum temperature during summer months from 1951 to 2020 ranged between 29.02 and 45.5 degrees, with temperatures peaking during April and May.
  - While the proportion of households with access to drinking water and ownership of fan/cooler/air conditioner to cope with the heat was higher than the state average, the insurance coverage was low in the district.
  - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	43
Orange alert	85th percentile	40
Yellow alert	75th percentile	39

- Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	41	43	44	41
Orange	39	41	42	39
Yellow	37	40	41	38

- Kheda
  - The climate of the district is classified as BSh (semiarid tropical steppe climate**)** according to Koppen and Geiger.
  - Maximum temperature during summer months from 1951 to 2020 ranged between 29.24 and 47.62 degrees, with the district being most vulnerable during April and May.

- The district has almost equal proportions of households with access to drinking water in the household premise(~40%) and ownership of fan/cooler/air-conditioners (~89%)compared to all districts' averages. This indicates towards greater infrastructural coping opportunities. The insurance coverage among the residents of the district is substantially low (16%) compared to the state average.
- Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	45
Orange alert	85th percentile	42
Yellow alert	75th percentile	41

- Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	43	45	45	42
Orange	41	43	43	40
Yellow	39	42	42	39

- Mehsana
  - Maximum temperature during summer months from 1951 to 2020 ranged between 28.48 and 47.78 degrees.
  - The district has a lower proportion of households with access to drinking water facilities within the households (~25%) compared to the state average. On the contrary, the insurance coverage among the households in the district (~32%) was considerably higher than the state average.
  - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	44
Orange alert	85th percentile	42
Yellow alert	75th percentile	41

- Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	43	45	46	42
Orange	40	43	44	40
Yellow	39	41	42	39

- Mahisagar
  - The district has a semi-arid climate.

- Maximum temperature during summer months from 1951 to 2020 ranged between 28.66 and 47.62 degrees, with the district being most vulnerable in the months of April and May.
- The district has a higher proportion of households with access to drinking water in the household premise (~45%) but a lower proportion of households with the ownership of fan/cooler/air-conditioners (~83%) compared to all districts' averages. The insurance coverage was also lower than the state average.
- Interventions related to awareness of health insurance are therefore warranted in this district.
- Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	44
Orange alert	85th percentile	42
Yellow alert	75th percentile	41

- Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	43	45	45	42
Orange	41	43	43	40
Yellow	39	42	42	39

- Morbi
  - The district has a local steppe climate, receiving very little rain throughout the year.
  - Maximum temperature during summer months from 1951 to 2020 ranged between 29.83 and 45.57 degrees, with the district being most vulnerable in the months of April and May.
  - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	43
Orange alert	85th percentile	41
Yellow alert	75th percentile	39

- Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	41	43	44	40
Orange	39	42	42	39
Yellow	38	40	41	38

- Narmada
    - Maximum temperature during summer months from 1951 to 2020 ranged between 28.57 and 46.10 degrees, with the district being most vulnerable in the months of April and May.
    - The month of March has historically been hotter than the month of June.
    - The district has a lower proportion of households with access to drinking water in the household premise (~34%) and ownership of fan/cooler/air-conditioners (~72%) compared to all districts' averages, suggesting greater infrastructural coping opportunities.The insurance coverage was substantially higher (~54%) compared to the state average.
    - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	43
Orange alert	85th percentile	41
Yellow alert	75th percentile	40

    - Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	43	44	44	40
Orange	40	42	42	39
Yellow	39	41	40	38

- Navsari
    - The district has an overall tropical climate observed as Aw (tropical wet and dry, called savanna climate) according to the Koppen-Geiger climate classification.
    - Maximum temperature during summer months from 1951 to 2020 ranged between 28.45 and 43.77 degrees, with temperatures peaking in the months of April and May.
    - Access to drinking water in the household premises, ownership of fan or air coolers or air conditioners, and health insurance coverage was comparatively higher than the state's average, likely suggesting better coping opportunities for the residents during extreme heat events.
    - The district also showcases a high utilization of the government programs such as the ICDS, suggesting a greater role of governmental intervention.
    - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	41
Orange alert	85th percentile	39
Yellow alert	75th percentile	38

- Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	**Month**			
	March	**April**	**May**	**June**
Red	41	42	41	38
Orange	39	40	39	37
Yellow	38	39	38	36

- Panchmahals
  - Maximum temperature during summer months from 1951 to 2020 ranged between 26.68 and 47.15 degrees, with temperatures peaking in the month of May, followed by April and March respectively.
  - While the proportion of households with drinking water facilities (~51%) was reportedly higher than the state average, the proportion of households with access to fan/air coolers/ air conditioners was considerably lower (~76%) compared to the state average. Health insurance coverage among the households from the district was also found to be lower than the state average.
  - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	**Cutoff criteria**	**Cutoff temperature**
Red alert	95th percentile	44
Orange alert	85th percentile	42
Yellow alert	75th percentile	40

  - Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	**Month**			
	March	**April**	**May**	**June**
Red	43	45	45	42
Orange	41	43	43	40
Yellow	39	41	42	39

- Patan
  - The district has a sub-tropical monsoon type climate (arid and semi-arid).
  - Maximum temperature during summer months from 1951 to 2020 ranged between 28.84 and 48.23 degrees, with the district benign most vulnerable in months of April and May.
  - The district has greater proportions of households with access to drinking water in the household premise (~48%) and ownership of fan/cooler/air-conditioners (~92%), compared to all districts' averages, suggesting greater infrastructural coping opportunities. Further, the insurance coverage and governmental program utilization was also higher than the state average.
  - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	45
Orange alert	85th percentile	43
Yellow alert	75th percentile	41

- Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	43	45	46	43
Orange	41	43	44	41
Yellow	39	42	43	40

- Porbandar
  - The district has a hot and windy climate across the year.
  - Maximum temperature during summer months from 1951 to 2020 ranged between 28.55 and 37.59 degrees.
  - It has a higher proportion of households with access to drinking water facilities in the household premises (~44%) and ownership of fan/cooler/ air conditioner (~97%) compared to the state average. On the contrary, the insurance coverage among the households in the district was considerably lower (~10%) than the state average.
  - Therefore coping mechanisms can be improved through greater awareness and coverage of health care facilities and health insurance.
  - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	36
Orange alert	85th percentile	35
Yellow alert	75th percentile	34

- Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	35	36	36	35
Orange	34	35	35	34
Yellow	33	34	34	34

- Rajkot
  - Rajkot has a hot semi-arid climate (Köppen BSh), with summers from mid-March to mid-June which are extremely hot and dry.
  - The district is prone to frequent cyclones.
  - Maximum temperature during summer months from 1951 to 2020 ranged between 29.13 and 42.15 degrees, with the district being most vulnerable during the month of May followed by April and March.

- The district has a lower proportion of households with access to drinking water in the household premise (~35%) but a greater proportion of households with the ownership of fan/cooler/air-conditioners (~97%) compared to all districts' averages. The insurance coverage was also lower than the state average.
- Therefore, interventions related to awareness of health insurance and programs related to access to drinking water facilities are required.
- Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	40
Orange alert	85th percentile	38
Yellow alert	75th percentile	37

- Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	39	40	40	38
Orange	37	39	39	37
Yellow	36	38	38	36

- Sabarkantha
  - The district has a sub-tropical climate with moderately low humidity.
  - Maximum temperature during summer months from 1951 to 2020 ranged between 27.47 and 47.08 degrees, with temperatures peaking during April and May.
  - Access to drinking water in the household premises, ownership of fan/air coolers/air conditioners were comparatively lower than the state's average. However, a higher utilization of government programs and health insurance coverage suggests the efficiency of programmatic interventions.
  - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	44
Orange alert	85th percentile	41
Yellow alert	75th percentile	40

  - Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	42	44	45	42
Orange	40	42	43	40
Yellow	38	41	42	39

- Surat
  - The district has a tropical savanna climate.
  - Maximum temperature during summer months from 1951 to 2020 ranged between 28.79 and 44.45 degrees, with the district being most vulnerable during months of April and May.
  - The district has greater proportions of households with access to drinking water in the household premise and ownership of fan/cooler/air-conditioners, compared to all districts' averages. However, the insurance coverage and governmental program utilization was lower than the state average. This demands more programmatic attention to address the effects of extreme heat events.
  - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	42
Orange alert	85th percentile	40
Yellow alert	75th percentile	38

  - Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	42	43	42	39
Orange	40	41	40	37
Yellow	38	40	39	37

- Surendranagar
  - The district has subtropical climate and was found to be a drought-prone area.
  - Maximum temperature during summer months from 1951 to 2020 ranged between 29.39 and 46.21 degrees.
  - The highest temperatures occurred in the months of May, April and March respectively.
  - The proportion of households with drinking water facilities (~16%) was reportedly considerably lower than the state average, while the proportion of households with access to fan/air coolers/ air conditioners (~96%) was considerably higher when compared to the state average. Health insurance coverage among the households from the district was also found to be lower than the average.
  - Reception of governmental programs such as was higher than the state's average, and therefore increasing awareness of health insurance could lead to better results in the district.
  - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	43
Orange alert	85th percentile	41
Yellow alert	75th percentile	40

- Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	42	44	44	41
Orange	39	42	42	39
Yellow	38	41	41	38

- Tapi
    - Maximum temperature during summer months from 1951 to 2020 ranged between 28.89 and 45.19 degrees.
    - The district has a higher proportion of households with access to drinking water facilities within the households (~58%) while the proportion of households with ownership of fan/cooler/air conditioner (~81%) was lower compared to the state average. Furthermore, the insurance coverage among the households in the district was considerably higher (~10%) than the state average.
    - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	43
Orange alert	85th percentile	40
Yellow alert	75th percentile	39

- Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	42	43	43	40
Orange	40	42	41	38
Yellow	39	40	40	37

- Vadodra
    - The district has a tangential tropical savanna climate.
    - Maximum temperature during summer months from 1951 to 2020 ranged between 28.98 and 46.84 degrees, with the district being most vulnerable in the month of May followed by April.
    - The proportion of households in the district with access to drinking water facilities within the household premises was substantially low (~28%)

compared to the state average. Coverage of health insurance and ownership of air cooler/fans/air conditioners in the households was also borderline with the state average.

- Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	44
Orange alert	85th percentile	42
Yellow alert	75th percentile	40

- Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	43	45	45	41
Orange	41	43	43	39
Yellow	39	41	41	39

- Valsad
  - The district has a tropical savanna climate.
  - Maximum temperature during summer months from 1951 to 2020 ranged between 27.33 and 42.69 degrees.
  - The proportion of households with access to drinking water and ownership of fan/coolers/air conditioners were borderline with the state's average. However, health insurance coverage and reception of governmental programs was quite low compared to the state's average, pointing towards a need for efficient implementation.
  - Temperature Thresholds (TT in Celsius) for the period of March-June (1951-2020)

Type of alert	Cutoff criteria	Cutoff temperature
Red alert	95th percentile	40
Orange alert	85th percentile	38
Yellow alert	75th percentile	37

- Month-wise Temperature Thresholds (TT in Celsius) 1951-2020

Type of alert	Month			
	March	April	May	June
Red	40	41	40	38
Orange	38	39	38	36
Yellow	37	38	37	35

Mitigation, preparedness, and Response strategies

To tackle the adversities of heatwaves during the summers, the Report on Extreme Heat Exposure and Actions for Gujarat recommends both long term (that usually runs throughout the year) and short-term efforts (pre-heat and during heat time) by all relevant departments associated with the minimizing risk of heatwave in Gujarat.

Long term strategies (mitigation)

A coordinated long-term planning between different stakeholders (at state, district, and Taluka levels as part of a convergence scheme) to protect the people and infrastructure from the effects of heat adversities and thereby reduce the additional number of summer illness and deaths attributable to heat in the state.

It is key that all the involved departments are aware of the goals and implementation strategy of the action plan. Therefore, as part of the suggested convergence approach, it is advised to have annual meetings (at each administrative levels) to discuss the long term and short term strategies to mitigate the effects of heatwaves in Gujarat. Below are the few tenets of this approach:

The multisectoral involvement approach

Development of a multisectoral action plan in discussion with the relevant departments; based on the district specific concerns, service delivery mechanisms adopted thus far (what was learnt and what can be done differently), any interventions which have been identified to be successful (that could be replicated by other districts), how to monitor development in the area of mitigation, discussing the roles and responsibilities of each department to minimize overlaps, thus being more optimal, and feedback.

- The nodal agency for these annual meetings at the state level (where all the relevant state staff come together) will be the GSDMA. This meeting is advised to be organized in between September-January.

- Every year, each district will have similar meetings (as suggested by the nodal agency), where all district level officials from each department (CMO, DPO and so on) will coordinate among themselves and brief them about their roles and responsibilities. This meeting is advised to be organized in between December-February. These meetings are advised to be conducted twice a year in the bottom two quintiles of vulnerable district groups.

- The districts will recommend coordination among the Taluka level officers (Taluka Development Officer, the Child Development Project Officers, the UHCs and the PHCs, and so on) to discuss the agenda for summer preparedness for the concerned year. In this meeting, the roles and responsibilities of the frontline workers of each department will be discussed and agreed on, in addition to a progress monitoring mechanism. These meetings are advised to be conducted twice a year in the bottom two quintiles of vulnerable district groups.

1. Monitoring and tracking progress through identification of key indicators linked to the inter-departmental actions.
    - Each department will identify a series of indicators (and agree upon during the annual meetings) to monitor and track the progress. A tentative suggestive list of such indicators is attached in the Annexure.

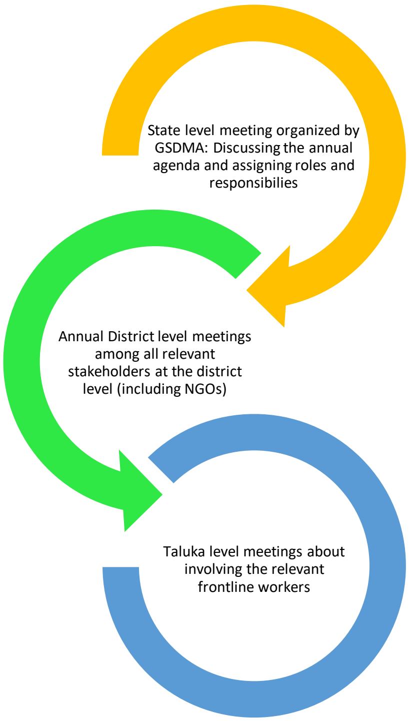

Figure 1: Step-by-step strategizing the multisectoral approach

Infrastructure

Long term hospital infrastructural improvements (Agency: Department of Health and Family Welfare)

Creating special summer emergency units/mechanisms in hospitals and PHCs/UHCs:

During the pre-heat seasons, the department of health and family welfare should check for the following:

1. A special summer attention chamber/clinic in the hospitals and PHCs/UHCs
2. The staffing is adequate and that the staff are trained with proper awareness (and mitigating strategies) related to heat-illnesses.

Designing greener built environments **(Department of Rural Development)**

1. Coo-roofing: 'Cool' roofs have a higher reflectivity compared with traditional roofs, thereby increasing the amount of reflected solar radiation. This has been seen to potentially minimize the effect of urban temperatures in the households, and may also reduce building energy consumption for cooling demand (Macintyre & Heaviside, 2019). This cool-roofing approach is a good intervention in the context of Gujarat because of the extreme heat during summers and the roof of a house receives the largest incident solar radiation, and can be the largest area of internal heat gain to the building. Innovative cool roofing strategies have already been adopted by several lower socioeconomic households from Ahmedabad (Why Innovative Cool Roofing Is Becoming Popular among Ahmedabad's Urban Poor). Different types of cool-roofs that could be adopted by **the rural development department** are coated cool roofs, membrane cool roofs, tiled cool roofs, mod roofs, and so on).

Figure 2: An innovative cool-roof strategy in poorer communities of Ahmedabad (Source: https://www.downtoearth.org.in/news/urbanisation/why-innovative-cool-roofing-is-becoming-popular-among-ahmedabad-s-urban-poor-82523)

2. Green roofing: A green roof, or rooftop garden, is a layer of plans, vegetation grown on a rooftop of a house of apartment (see figure 3). These types of roof provide shade, reduce heat from the air, and reduce, thereby minimizing the temperatures of the roof surface making life easier below the roofs. Green roof temperatures can be 30–40°F lower than those of traditional roofs (Sailor et al., 2012).

Figure 3: An innovative green-roof strategy in poorer communities of Ahmedabad (Source: https://www.downtoearth.org.in/news/urbanisation/why-innovative-cool-roofing-is-becoming-popular-among-ahmedabad-s-urban-poor-82523)

Improving the building design **(Department of renewable energy, department of urban development)**

1. Plantation of trees and vegetation for shade in the compound of houses and buildings are essential and could lower surrounding temperatures as well. In the cities, where most residents are based in apartment structures, it is advisable to have a balcony garden with moderate sizes of plans (above the height of shrubs) with leafy structures to help mitigate effects of heat during summers by providing share and breeze. Previous research have shown that such gardens (terrace gardens) reduced ceiling temperature by 2–3 °C in winters and 5–7 °C in summers (Chidambaram et al., 2022).

Figure 4: An example of balcony garden (Source: https://www.designcafe.com/blog/home-interiors/balcony-garden-design-ideas/)

Increasing energy efficiency

The department of renewable energy and the ministry of transport should emphasize on optimal energy consumption for reducing the carbon footprints in the state. The state has already been performing better with reducing carbon footprints in 2022: “A release said the state reduced its carbon emissions by about 115 per cent in 2022 as compared to 2017, mainly due to an increase in the installed capacity of renewable energy in power generation.” (Carbon Emissions: Gujarat to Reduce Carbon Emissions from Power Production to 139 Million Tonnes by 2030 - The Economic Times)

Emphasizing on the implementation of water distribution programs such as the Jal Jeevan Mission (Water Resources and Water Supply Department)

Using a community engagement approach, the target of all households in Gujarat having access to clean and safe drinking water should be emphasized as drinking water is essential for survival during the summer seasons in Gujarat. Currently, the percentage of rural households in Gujarat with access to tap was is 96.51% which is a substantial increase from 71% in 2019 (see below Figure 5 for district level distribution/status of tap water access).

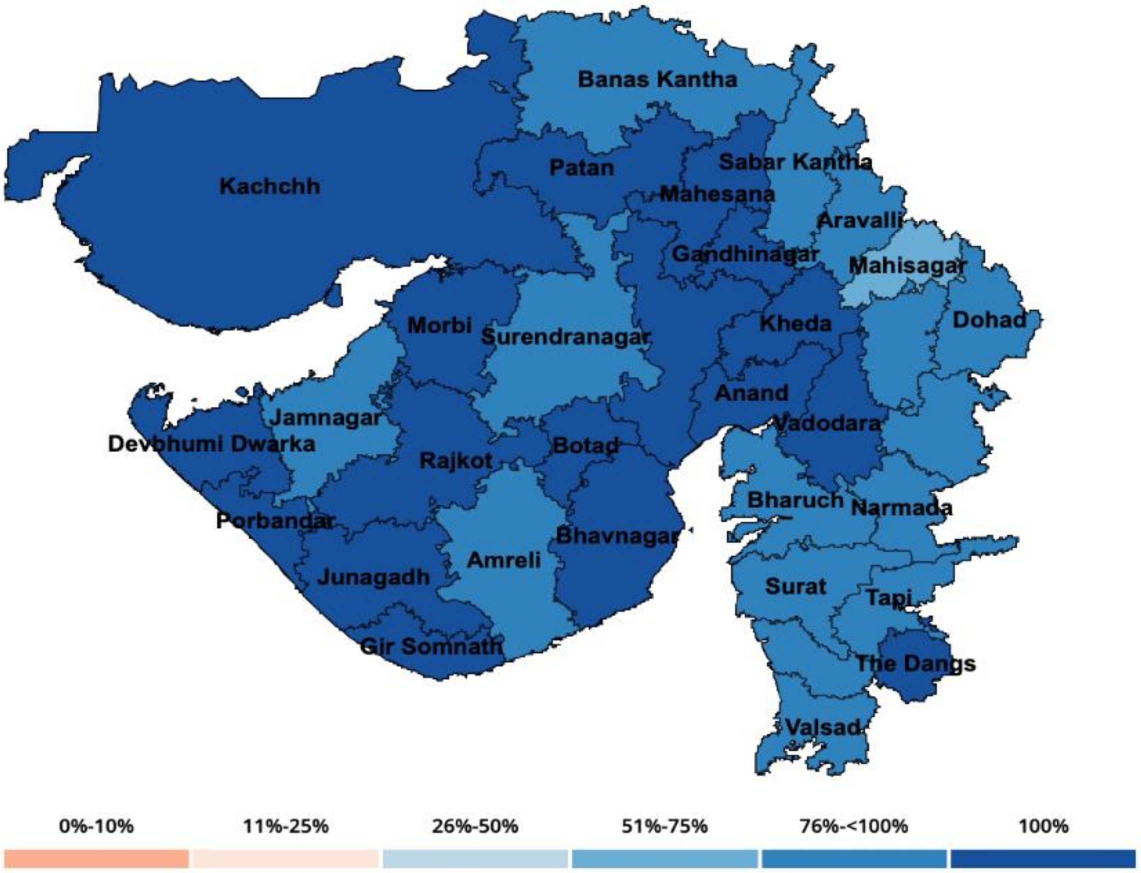

Figure 4: Status of tap water in rural households (district wise) in 2019 (Source: https://ejalshakti.gov.in/jjmreport/JJMState.aspx)

Including heat and its impacts related knowledge in the school curricula (Department of Education and Department of health and Family Welfare)

School children are vulnerable to ill-effects of heatwaves of Gujarat because of their younger age and their outdoor exposure of daily transportation to school during the summers. Therefore, separate guidelines need to be issued by the Department of Education about safer and cooler transportation, the reviewed timings of school operations, and awareness related modules are to be included in the school curriculum. These materials could be designed with the collaboration of department of health and family welfare). A list of essential topics to be included in the school curriculum (could be a shirt course given during the pre-summer season or part of the longer environmental science course):

1. Watch for common signs: Heat cramps (muscle pains, heavy sweating and so on); First Aid: Applying pressure on cramping muscles or massages. Increase the eater intake during the day but stop if nauseous.
2. Heat exhaustion: Heavy sweating, weakness, cool, clammy and pale skin. Nausea and vomiting. Normal temperatures possible. Headache, dizziness and possible muscle cramping.
3. Information of staying hydrated (regularly and consistently)
4. Information on summer hygiene (taking regular bath, removing sweat, cleaning, and so on)
5. Information on cool environment exposure and type of clothing (loose fitting, cotton, and so on)
6. Information of adequate sleep, length of outdoor exposure, outdoor sports setup and so on
7. Information on staying updated with weather alerts
8. Suggestion about talking to peers, parents, and elders and creating awareness in the community.

Emphasizing and prioritizing ways to mitigate existing population level issues such as poverty, gender-gap, education and so on that contribute to the (mal)adaptation to heat adversities.

This approach is a continuous approach that involves collaborative efforts from all relevant departments working on the raiding living conditions for the underprivileged. The Department of Labour could consider discussing better wage strategies to enhance the quality of living of the economically poor. The department of rural development could engage the public in MNREGA works that have more indoor exposure with cooling systems during work hours. The department of women and child development should continuously work on their schemes to make the lives of the women better (for instance, focusing on women empowerment, thereby efforts in reducing the gender gap in wages and household labour), in addition to the lives of children (reducing malnutrition). There should be collaborative efforts by the frontline workers of the health and Women and Child Development Department to impart knowledge about women’s safe role in decision-making during the summer about going to work, distributing child-care in the household, including roles in managing finances, and balancing the household chores.

Capacity building of all stakeholders at the supply side of programs

As discussed in the previous sections, the first step would be to educate and raise awareness about heatwave and its impacts among the higher-level officials of each relevant departments, suggestively during a collaborative workshop/annual meeting organized by the GSDMA. Next, the district officials need to be sensitized and collaboratively understand and strategize implementation of the action plan following which the Taluka level officials (including the grassroot level workers) could implement the strategies after their due training (for more information, please refer to the chapter on capacity building).

Community awareness and participation

Community participation and awareness is one of the most crucial components of a successful Heat Action Plan. A community's understanding about the impact of heatwaves is essential for their own strategies to adapt to the ill-effects of heatwaves. For instance, if an individual is not aware of the consequences of heatwaves (or is not aware of how to mitigate them), they might not be interested in investing their time and other fiscal resources for adaptation during the summers. Several studies from diverse contexts have highlighted the usefulness of television (TV), radio, newspaper and internet in dissemination of heatwave related information to the public as these sources were identified as the primary sources from which the respondents obtained information during a heatwave (Akompab et al., 2013). In addition to the efforts by the frontline workers (ASHA, ANM, AWW, AWH) in disseminating information about heatwaves, their impact, and micro-mitigation strategies through household visits in the community, the department of health and family welfare (with the help from department of telecommunication) should disseminate awareness information through SMS, social media, television (advertisements), and radio.

While the awareness of the public is important, it is also equally important to include them in designing the strategies. Since the ultimate goal is to help the community adapt to the heatwave effects in the state of Gujarat, it is crucial to involve them and incorporate their understanding, experiences, and skills in designing the strategies to overcome the heat related challenges. Therefore, the Taluka-level officials could conduct need assessments with the help of the field functionaries, while including the community perspectives. One technique to understand the concerns of the community dwellers could be the Participatory Rural Appraisal (PRA) technique which have shown high reliability and validity of data previously(Chambers, 1994). Involving the community in designing and implementation of strategies could result in better outcomes since it will minimize the gaps in expectations between the demand and supply side stakeholders.

8.2. Preparedness (short term strategies and adaptation)

The following points are suggestively essential for preparedness:

1. Hospital/PHC/UHC infrastructure

1.Check for the stock of basic equipment's and medicines required for heat related illnesses.

1.Ensure sufficient accommodation of in-patients and out-patients in the PHCs and UHCs.

1.Ensure the training of staff is completed and have good number of staff associated with each PHC and UHC, especially among the most vulnerable districts.

1.Establish a district level Rapid Response Team (RRT) to ensure anxious calls related to heat gets attended.

1.Establish outreach remote clinics that reach the most vulnerable populations.

Annual multisectoral meetings

Annual multisectoral meetings (at the district-level) is suggested in around September-January where all the concerned departments discuss their plans to address heat related issues in the upcoming summer season. This meeting will enable the key authorities to be aware of the agenda of all the departments and take appropriate actions accordingly in crucial times. This has been discussed in detail in a previous section.

State-level portal to stay up-to date

The reports suggests the activation of a state level portal managed by the GSDMA where each district (department wise) will update the status of progress made thus far according to the deadlines/milestones of the plan. This portal will be accessible to all the officials until the Taluka-level to inform what has been lacking and what needs to be prioritized in their respective district/Taluka.

Visiting the communities (authorative personnel)

Some frequent (once in two weeks during the summer season) visits by the district level authorities (collaborative of all key departments) to the vulnerable regions of the districts (in terms of exposure or population) to conduct an on-field first-hand assessment during the pre-summer season is suggested. This will be additional to the annual Taluka level assessments (Taluka level officials such as the BDO will conduct annual assessment to identify the location of the most vulnerable groups, their proximity to PHCs/UHCs, and the status on awareness campaigns). Such presence of an authorative figure will create more trust of the community on the information shared by the governmental schemes.

Tracking the vulnerable population

A thorough monitoring of the vulnerable groups for indicators identified to be suggestive of heat vulnerability (through NGOs, and Taluka/field level functionaries) is recommended.

a. The Taluka level officials are advised to conduct annual identification of regions with most vulnerable populations (undernourished children, socioeconomically weaker communities such as slums, elderly population, arid lands in the region, remote locations where the nearest PHC is low on infrastructure or situated at a longer distance, and so on)
b. Such an assessment could be carried out with the help of volunteering organizations, NGOs, and the fieldworkers of different government departments

For instance, the health department could update if the stockings of all relevant equipment have been assessed (with a progress indicating tentatively when it should get completed) or

Government-NGO collaboration

It is warranted that the governmental departments have frequent discussions at the district and sub-district (Taluka/village) levels with local NGOs and taking their inputs in addressing local-level concerns of the people regarding adaptation. The NGOs working in the areas of vulnerable population would have interesting/crucial insights that might help the implementation of programs/policies better. Furthermore, the governmental agencies could strategies deploying the manpower resources the NGOs offer in community awareness campaigns and relief related strategies.

Enhanced capacity building

This plan suggests training of existing staff (district, Taluka, and GP levels) rapidly during the heat season. Further, there is a need to assess the appropriate healthcare and the physical environments before summer. Therefore, the staff at the Taluka and village level needs to be trained to conduct proper in-field vulnerability assessment (identifying the population that might be at risk, for instance, the undernourished children, outdoor workers from the socioeconomically weaker communities, the pregnant and lactating mothers, the elderly, and the specially abled). The community mobilizers need to be also trained in strategies to send messages regarding the adaptation strategies suggested by the health department (for instance, keeping oneself hydrated regularly during the summers, avoiding long-term exposure to heat outside, and so on). This enhanced capacity building approach should be prioritized in the most vulnerable districts.

Hearing the community

A plan to involve the community in the design and implementation of the plan is already discussed earlier. However, one short-term goal will be to discuss issues and concerns related to heat during the Gram Sabha meetings which is either held once in three months or semi-annually in the context of Gujarat. These meetings are attended by both village community and district officials, therefore, is a great avenue for dialogues.

Actions to minimize heat-exposure

Action by the district administration to ensure reduced indoor heat exposure (such as the implementation of programs that offers safe cooling practices (for instance, a subsidy to purchase solar electric fan/cooler and so on) and drinking water facilities, especially among the disadvantaged groups)

Summer hotline

The plan recommends the introduction of an exclusive summer hotline (state level) managed by the GSDMA in collaboration with the health and family welfare department. The rapid hotline is suggested to deliver the following services:

1. Information about daily temperature (region wise), do-s and don'ts.

2. Able to guide patients about mitigating heat-effects (first aid, or connecting to nearest PHC/UHC/hospital

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Annexure 1: Methodology for Temperature Threshold (TT) analysis

Extreme heat events are increasingly being related to adverse health outcomes, including death (Azhar et al., 2014). The pre-monsoon season (March–June) is known to be the hottest time of any year for entire South Asian region, especially the Gujarat region. During the pre-monsoon (March-June) season, the Indian region experiences increased solar radiation which results in high temperatures in general. Heat events are found to be more prevalent in May compared to June, however, only a few occurs in the months of March and April (Kothawale & Rupa Kumar, 2005). In the state of Gujarat, hot weather events (heat waves) are one of the most frequently occurring natural hazards which have shown to have serious societal impacts, particularly on human health (Azhar et al., 2014). Further, these extreme heat events could be characterized by daily temperature levels that exceeds tolerable limits, in addition to their duration and amplitude. In fact, the IPCC suggests "a climate extreme (extreme weather or climate event)" to be "the occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) end of the range of observed values of the variable (Barros et al., 2012)."

There are several methods to obtain the critical temperatures of a region, that has the potential to cause adverse health and societal effects. For instance, in regions with low climate variability, the use of arbitrary threshold method has been often cited (Jones et al., 1999; A. M. G. Klein Tank & Können, 2003). However, with greater geographic variability and climatic variability, the extent and impact of any climatic event might not be uniform in India (Kothawale & Rupa Kumar, 2005). Therefore, one method often cited frequently is the percentile method. Such a method, recommended by the IPCC ("IPCC, 2012: Summary for Policymakers," 2019) and WMO (A. B. G. Klein Tank & Zwiers, 2009) allow us to compare the results across different regions and seasons. Further, recent guidelines from the WMO and WHO (Heatwaves and Health: Guidance on Warning-System Development, 2015) suggested the use of percentile-based threshold (for instance 95^{th} percentiles and 99^{th} percentiles) for developing action-based threshold values in the absence of health, mortality, or extreme bio-metrological data (McGregor et al., 2015). It is to be noted that while the 99th percentile deals with a probability of the identification of extreme events that are expected to have serious affects to the society and human health, the likelihood of occurrence of such an extreme event could be rare (Zhang et al., 2011). This means that such analysis could sometime ignore the "non-extreme" events which could also have a greater adverse impact on human life and livelihood. Further, allowing such events in the analysis could enhance the comprehensiveness of a dataset. Therefore, going by this, and especially since we did not have access to daily data on health outcomes or mortality, we identified the 75^{th}, 85^{th}, and the 95^{th} percentile values of the daily Temperature maximum (obtained from air temperature data, IMD[4]) in the period March-June from 1951 through 2020 for our threshold analysis. Further, these temperature

[4] Outliers have been removed from our analyses and all analyses were carried out in STATA version 12.

thresholds were separately calculated on the basis of the percentiles for each pre-monsoon month (March-June) and each district of Gujarat. We further present the trend of the maxima of Tmax and Tmin of these months from 1951 through 2020. The district wise results of the temperature threshold analysis are presented below. Further, a higher minimum temperature (night-time temperature) of a region could be related to a greater power consumption in the region, and thus is likely related to the socioeconomic vulnerability of the region. Therefore, following the findings of a previous study on mortality risk of high temperatures in Ahmedabad (Wei et al., 2021), we also present the night-time temperatures cutoffs (95^{th} percentile values) in our threshold analysis.

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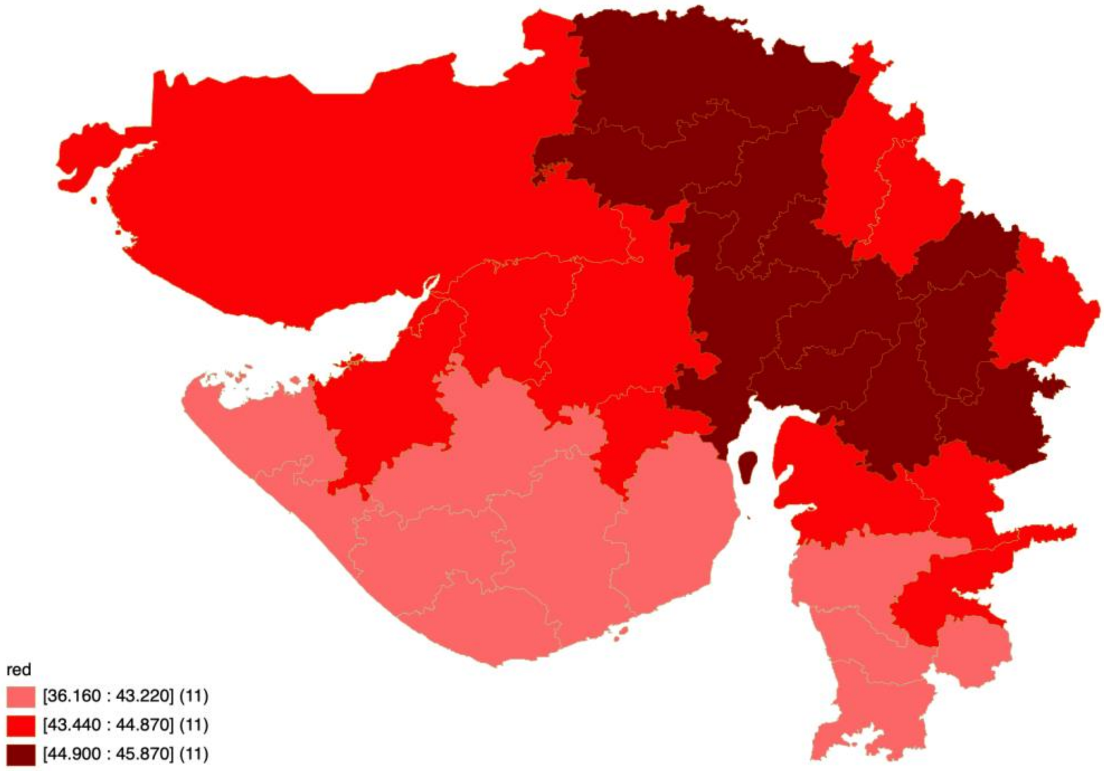
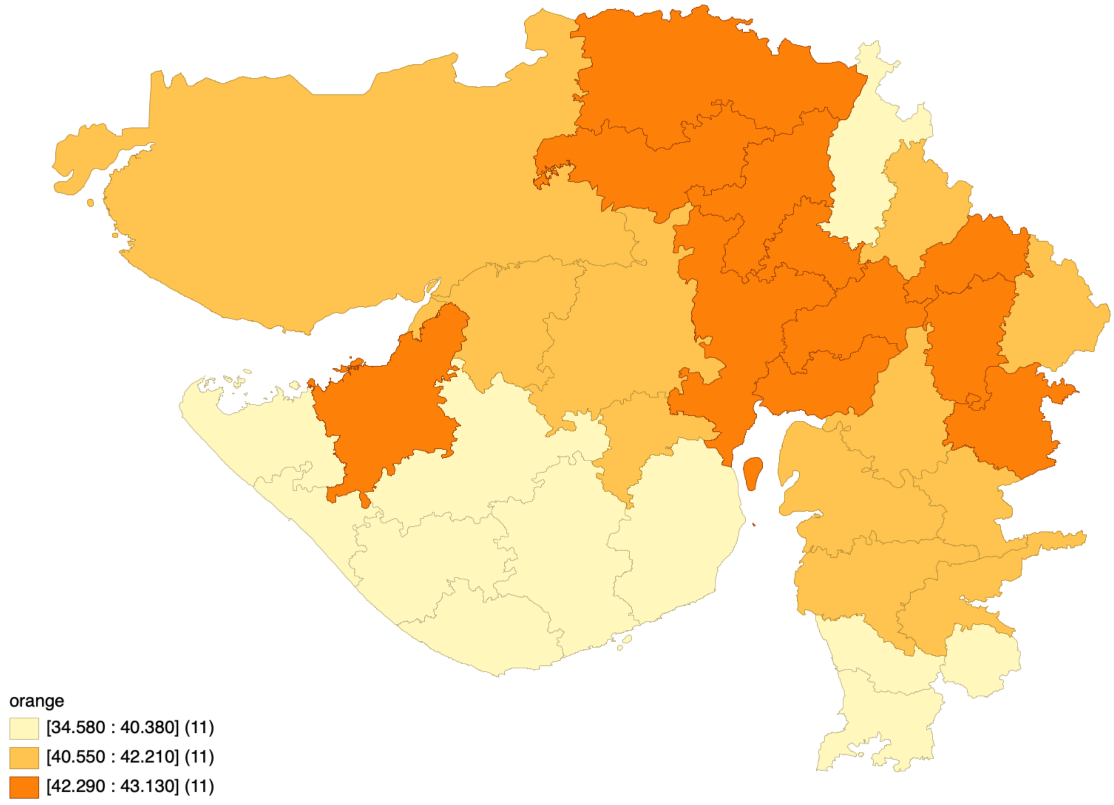
Annexure 2: Spatial results of the temperature threshold analysis

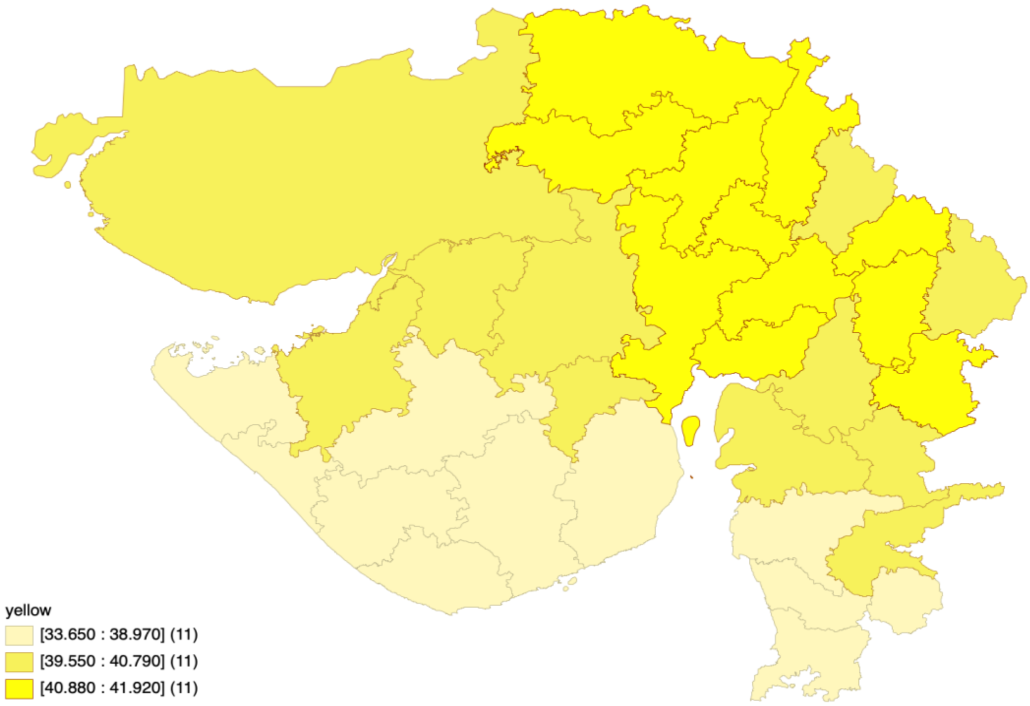
The following is the spatial distribution of the red alerts (categorized in tertiles) across the state of Gujarat



The following is the spatial distribution of the orange alerts (categorized in tertiles) across the state of Gujarat



The following is the spatial distribution of the yellow alerts (categorized in tertiles) across the state of Gujarat



The spatial representation of the red alerts clearly showed a clear pattern with higher temperatures clustered around Banas Kantha, Mehasana, Patan, Ahmedabad and so on while the lowest tertile of the red alert zoned around the Saurashtra region. The orange alert distribution was found to be quite similar to the distribution of the red alerts, with smaller exceptions such as Vadodara being no longer part of the top tertile, and Jamnagar being included in the top tertile. However, the distribution of the yellow alert zones again followed a similar pattern as the red zone distribution. These spatial distribution graph clearly suggests the higher temperature around the Banas Kantha, Mehasana, Patan, Ahmedabad, Kheda, Gandhinagar regions, while the Saurashtra regions are less likely to experience frequent exposure to extremes compared to the above listed districts.

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CLIMATE CHANGE DEPARTMENT
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