HEAT WAVE ACTION PLAN RAJKOT CITY

Heat Wave Action Plan- Rajkot City

Prepared by:

Integrated Research and Action for Development

Supported by:

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Table of Contents

List of Figures

List of Tables

1. City Profile - Rajkot

Rajkot is the fourth largest city in the state of Gujarat with a population of 1.39 Million (2011 census of India), covering an area of 129 sq. km. The city is characterized by a semi-arid climate. The temperatures during summers often cross 42 °C, and may reach as high as 45 °C. The frequency of heat waves in Rajkot has increased substantially during the decade 2001-10, as compared to earlier decades (Ray, Chincholikar, & Mohanty, 2013). The decadal frequency of moderate heat wave days oscillated from 2 days during 1971-80 to 33 days during 2001-10. The years subsequent to 2010, have been hotter than before. Therefore, the risk associated with human life due to heat stress in the city cannot be underestimated.

1.1 Demography

Rajkot extends over an area of 104. 85 sq km. records a population of 13.9 lakh, (Census-2011) and decadal growth of 28.41%. The city population growth rate had shown a significant rise from 1991-2001 (79.12%).

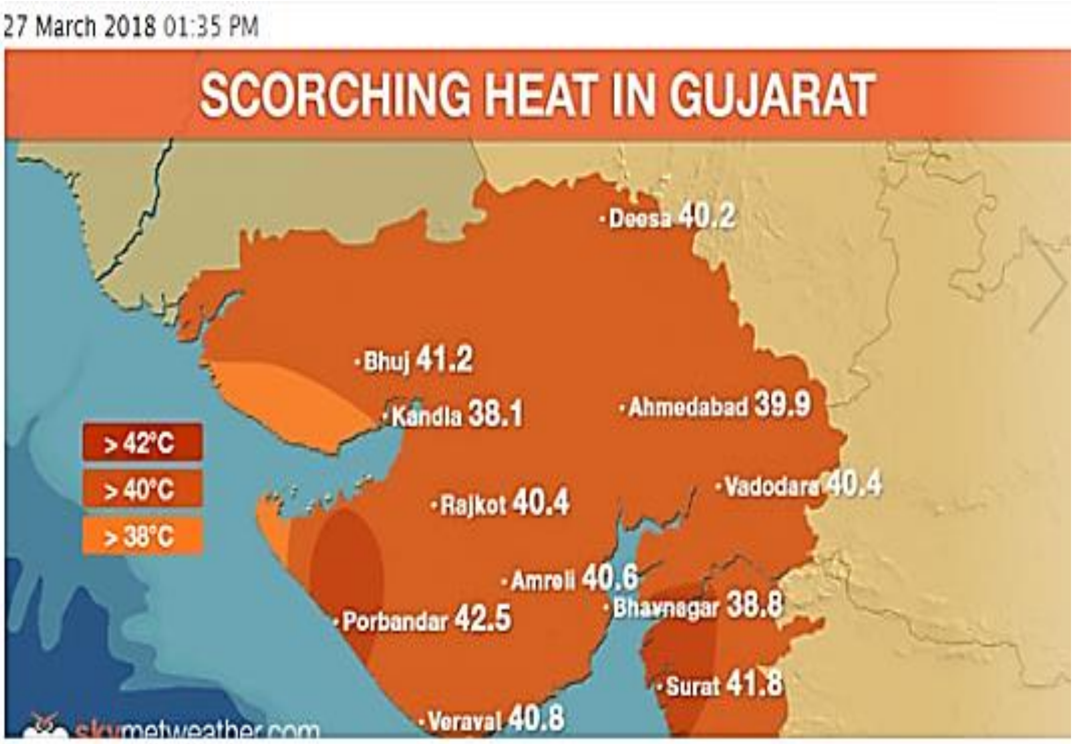


Figure 1-Heat waves condition in Saurahtra; 2017-18

Years	Rajkot City Population	Growth Rate	Density (Persons per Sq. Km.)	Area (Sq. Km.)
1981	4,45,076	48.3 %	6,450	69
1991	5,59,407	25.69 %	8,107	69
2001	10,02,000	79.12 %	9,557	104.85
2011	12,86,678	28.41 %	12,275	104.85
Source : Census of India				

Table 1-Demography Trend (1981-2011)

The **UN report**, The World Cities in 2016, reports city agglomeration population for 2016, as 16.47 lakh, which is projected to increase to 23.22 lakhs by 2030, with an annual percentage change being 2.5%. The 2018 report again predicts the population to increase to 24.16 lakh, with the average annual rate of change being 2.6 when compared to the 2018 population of Rajkot Agglomeration.

1.2 Urbanization

Over the decades Rajkot has experienced phenomenal increase in the population and size, and an all round development in education, industry, commerce, culture, etc. The city has grown in area and population over the years**. The city comprised of 23 wards spread across 104.85 sq km till 2015**, which has now increased in size engulfing the nearby villages and sub-urban areas to an area of **170 sq.km.,** with the **population density** increasing from **9,557 to 12, 275 Persons per Sq. Km**. **The wards have been rearranged and comprises of 18 wards at present.**

Population Projection	Average annual rate of Change (%)	
2030	**2000-2016**	**2016-2030**
2,322,000 (Urban Agglomeration)	**3.3 2.5**	
2030	2000-2018	2018-2030
2,416,000 (Urban Agglomeration)	**3.3**	**2.6**
Source : UN World Cities Report , 2016 & 2018		

Table 2-Population projection

The city has emerged as a major **Industrial Hub** in Saurashtra region with more than **43000 industrial units** are located in Rajkot (RUDA). This has led to rapid urbanization, triggering a pull-effect form the adjacent urban and rural areas. This has also resulted in the increase in the slum pockets and scattered settlements across the city from **118 slums in 2012** (SFPoA, Rajkot, 2012) to **145 slums as of 2017** (Gujarat Government Gazette, 2017).

2. Heat Waves and Need for Heat Action Plan

2.1 Heat Waves

As per the National Disaster Management Authority, a Heat Wave is a period of abnormally high temperatures, more than the normal maximum temperature that occurs during the summer season. According to Indian Meteorological Department (IMD), a heatwave condition is when the maximum temperature of a station reaches at least 40°C or more for Plains, 37°C or more for coastal stations and at least 30°C or more for Hilly regions.

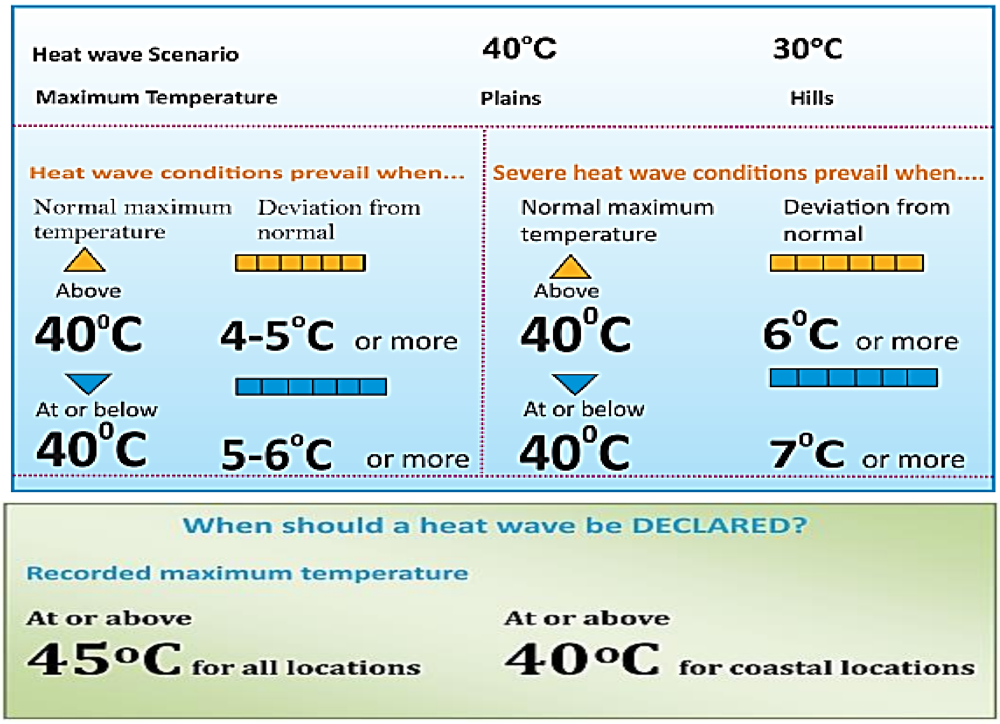


Figure 2 - Criteria for Heatwave in Plains. Coastal and Hilly Regions

YELLOW ALERT	Hot Day Advisory	41.1˚C – 43˚C
ORANGE ALERT	Heat Alert Day	43.1˚C – 44.9˚C
RED ALERT	Extreme Heat Alert Day	≥ 45˚C

Figure 3- Heat Alert Thresholds for Rajkot City (source: NDMA)

Last 50 years have witnessed a hike in the frequency of hot days, nights and heat waves in the world (IPCC, 2014). India has experienced a number of heat wave incidences, since 2006, and average temperature during 2018 was significantly above normal (+.41°C above). The year 2019 was the seventh warmest year on record since nation-wide records commenced in 1901. June and July 2019 have been the hottest month record globally, with National Oceanic and Atmospheric Administration (NOAA) confirming June 2019 being hottest on records, 0.95°C above normal average.

Under 2°C warming scenario, the frequency of heat waves in India is projected to increase by 30 times the current frequency by the end of the century. The duration of heat waves is also expected to increase 92 to 200-fold under 1.5 and 2°C scenarios. Coupled with poverty in South Asia, the impact can be severe. Future projections of temperature indicate a steady increase across the three periods (2030s, 2050s, 2080s), with anomalies reaching 4-5°C for high emission scenarios by 2080. Higher daily peak temperatures of longer duration and more intense heat waves are becoming increasingly frequent globally due to climate change. Extreme temperatures are among the most dangerous natural hazards but rarely received adequate attention.

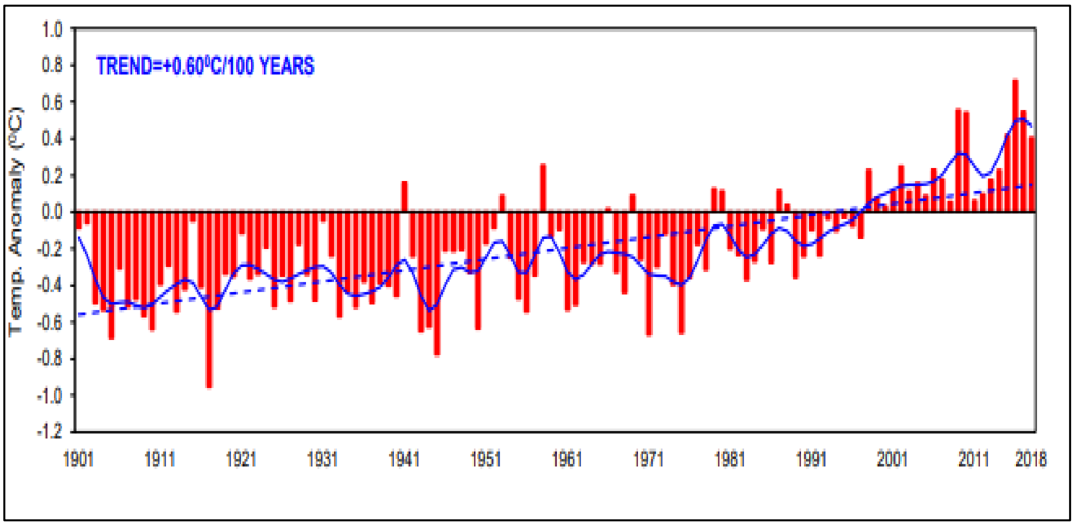


Figure 4-Annual mean land surface air temperatures anomalies 1901- 2018. IMD, 2019

2.2 Heat Waves in Rajkot

The trend of heatwave occurrence in the city during the past decades indicates a gradual increase in the heatwave days and severe heat days from 2 to 13 days (March – June). It is noteworthy that of the reference period from 2001 to 2017, heatwave was witnessed in each year from 2009 to 2017 with a higher number of days as heatwave. In comparison the earlier years showed intermittent incidence of heatwaves of relatively shorter durations.

Between 2001 and 2017, we see the increase in the frequency and the number of heatwave days. There was a 51.28 percentage increase in heatwaves between 2001-2010 and 2011-2017.

Decadal frequency of moderate heatwaves oscillated from 2 during 1971-80 to 33 during 2001-10, constituting a percentage increase of 560% in the number of heatwaves The years subsequent to 2010, have been hotter than before.

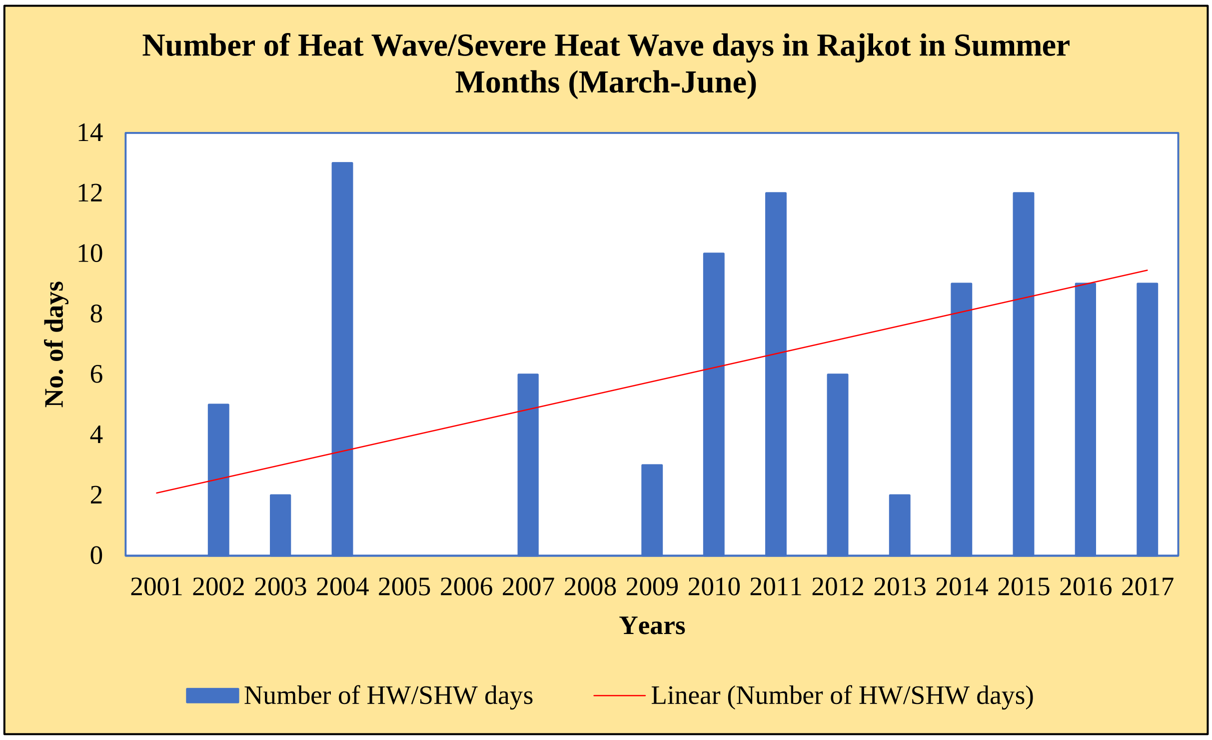


Figure 5-Trend in Heat Wave Days, Rajkot

2.3 Impacts of Heat Wave

Heat wave is a "silent disaster" and adversely affects the livelihood and productivity of people. Heat Wave has emerged as a major Health Hazard. WMO predicts Heat Wave related fatalities to double in less than 20 years. Health impacts of heat are more severe in urban areas, where residents are exposed to higher and nocturnally sustained temperatures, due to the Urban Heat Island (UHI) effect (Climate Council of Australia, 2016). Recent Study by Tata Centre of Development, University of Chicago warns that 1.5 million people may die by 2100 due to Extreme Heat due to Climate Change. Refer to Table 3 for the heat related Mortality Records. The baseline death rate due to heat induced climate change in the early 2000s in India was 550 per 100,000 of the population. There has been a 10% increase upon current death rate (*Climate Impact Lab, 2019*). In 2010 May, the city of Ahmedabad had a major heat wave, registering 1,344 additional deaths in the city with an excess of 800 deaths recorded in the week of 20-27th May.

Year	No. of Death Record due to Heat Wave
2010	1274
2011	798
2012	1247
2013	1216
2014	1677
2015	2422

2016	1111
2017	220
2018	25
Source: NDMA, Ministry of Home Affairs, GoI, 2019	

Table 3-Heat Wave Mortality Records

All-cause mortality cases during the summer months have shown a rise with the rising summer temperature in the past few years. The city's Disease Surveillance System and Death Record System does not record deaths due to heat wave or heat stress. However, due to rise in temperature in last few years in the city of Rajkot the cases related to heat stress has been increasing during summer months.

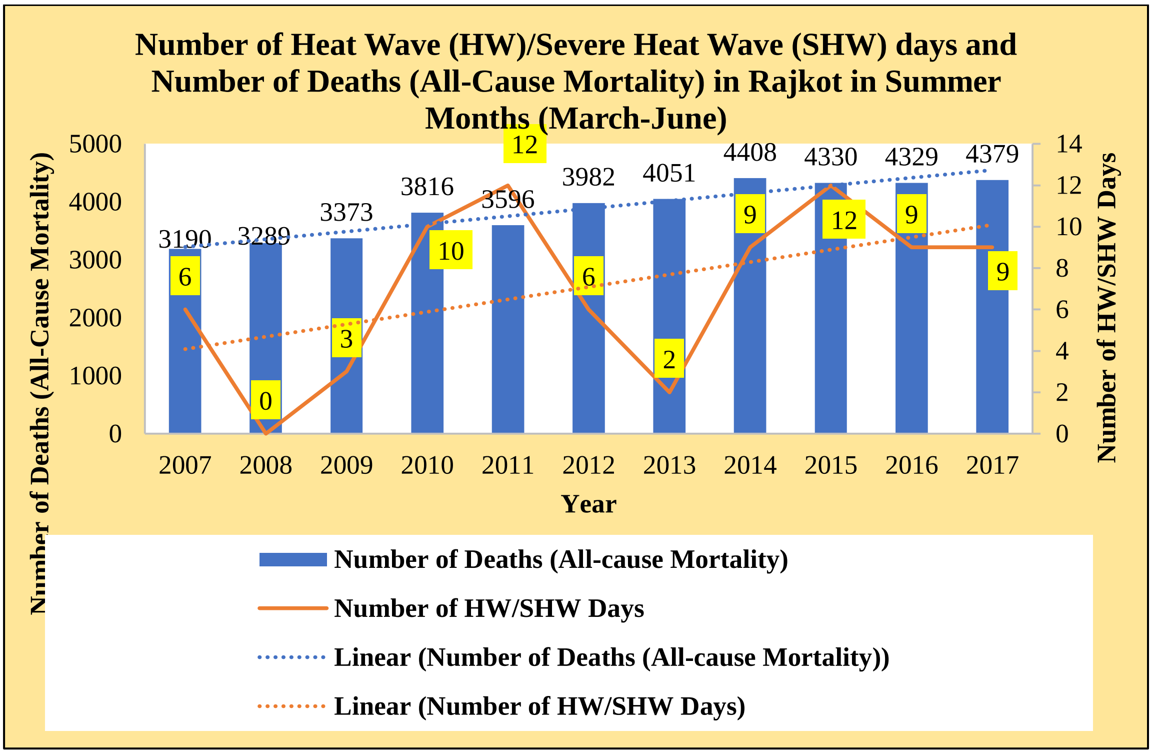


Figure 6: Co-relation between Heat Wave Days and Mortality Rate (2007- 2017)
Source: IMD & Heath Dept. Rajkot Municipal Corporation

A growing incidence of heatwaves has a significant impact on people's productivity, health and even triggers health complications that may lead to mortality. Thus Heat wave can be viewed as a major climatic hazard in the city, especially affecting the vulnerable population. Rajkot may witness thousands of deaths every year due to Extreme Heat by 2100.

2.4 Need for Climate Adaptive action plan in Rajkot

The impact of climate change on mortality from thermal stress in Rajkot may be significant. Owing to its geo-climatic, geological and physical features, Rajkot is vulnerable to all major natural hazards namely, drought, flood, cyclone, earthquake, tsunami etc. The Gujarat Hazard Risk & Vulnerability Atlas by Gujarat State Disaster Management Authority (GSDMA), Rajkot city to be prone to hazards like Floods, Droughts and Heat Wave. Along with 9 other talukas in Gujarat, Rajkot has been classified under Very High Risk to Disaster in the State of Gujarat (Composite Risk Index, GSDMA). In terms of climatic hazards recorded, Rajkot city has registered floods in 2013 and 2015, along with drought situation in 2016.

Severe heat wave gripped large parts of Gujarat since 2010, with temperatures crossing over 43°C in several parts. The decadal heat wave days over the decades have shown an increase from 21 days (1991-2000) to 33 days (2001-2010) in the city of Rajkot.

Existing Plans are generic and do not address action required at regions, wards, vulnerable groups, climatological and spatial variation of the cityscapes in planning appropriate adaption and mitigation actions.

Vulnerable population and city authorities lack the resources to adapt to heat waves. Hence, a comprehensive Heat Stress Action Plan (HSAP) is needed to combat the dangers of Heat Stress. As per the guidelines, the heat action plans underline measures like capacity building of healthcare professionals, updating records to track emergency cases, running specialized dispensaries during peak summer, collecting real-time information and regulating the timing of construction and outdoor workers concerned.

Though the impact of heat wave has been known over the decades, it was not until 2016 that NDMA formulated the 'Guidelines for Preparation of Action Plan – Prevention and Management of Heat-Wave' to help the states take a pro-active approach to mitigate the heat stress.

ALERT CATEGORY	ALERT NAME	TEMPERATURE THRESHOLD (CELSIUS)
RED ALERT	Extreme heat alert day	Greater than or equal to 45
ORANGE ALERT	Heat alert day	43.1 – 44.9
YELLOW ALERT	Hot day advisory	41.1 – 43
WHITE ALERT	No alert	40
Source: NDMA guidelines[1]		

Table 4-Heat Alerts for by NDMA

3. Climate Adaptive Heat Action Plan for Rajkot

3.1 Introduction

Integrated Research & Action for Development (IRADe) is preparing a Climate Adaptive Heat Stress Action Plan for the city of Rajkot in collaboration with Rajkot Municipal Corporation and Indian Institute of Public Health (IIPH)-Gandhinagar. The project is supported by International Development Research Centre (IDRC), Govt. of Canada. The Heat Stress Action Plan developed through this initiative will support the city in prioritizing and integrating adaptive resilience within the agenda of climate resilient smart cities.

Climate Adaptive Heat Action Plans

- Provide a framework for implementation, coordination and evaluation of extreme heat response activities in cities.
- Alert those populations at risk of heat-related illness in places where extreme heat conditions prevail.
- Include concerned departments to reduce the impact of heat waves on health as part of preventive management.

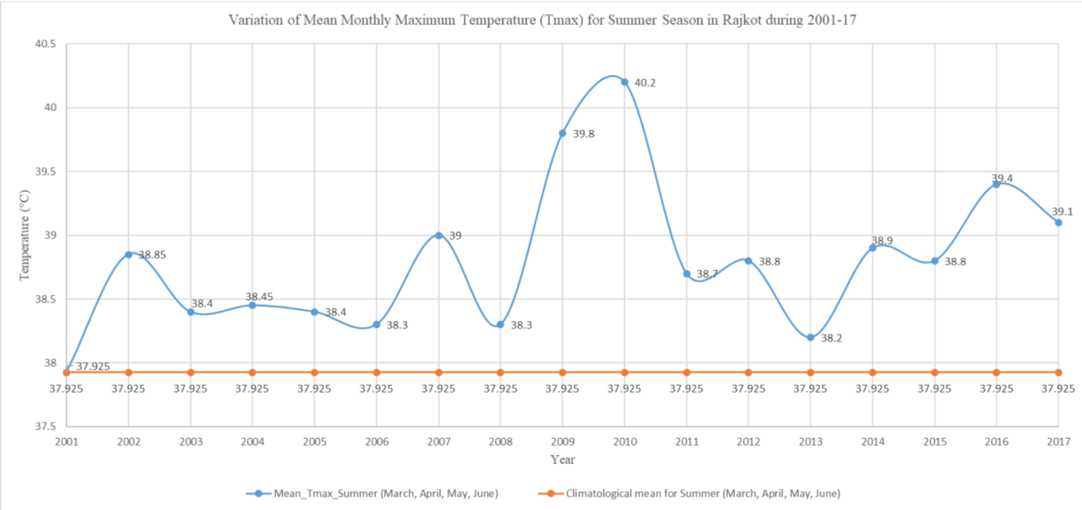
3.2 Climate change in Rajkot

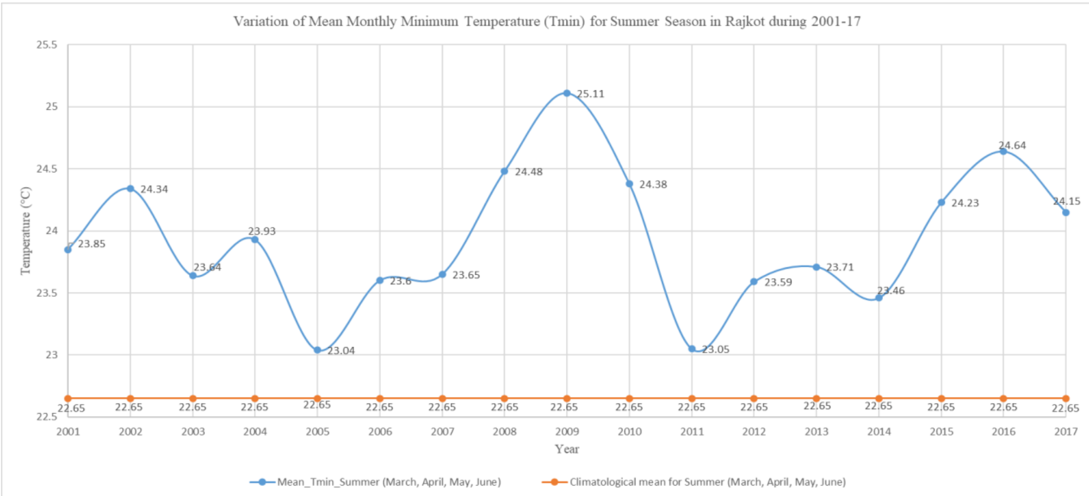
The climatological parameters that influence heat wave are high temperatures and relative humidity of a region. The climatological parameters analyzed were: Maximum Temperature (Tmax), Minimum Temperature (Tmin), Relative Humidity measured in the morning at 8:30 AM [RH (830)], and Relative Humidity measured in the evening at 5:30 PM [RH (1730)]. The mean monthly values of these parameters for the summer months of March, April, May and June were plotted against the long-term climatological mean for these parameters for the respective months, to understand the deviation in these parameters for the mentioned months over 2001-2017.

Month (2001-2017)	Tmax (° C)	Deviation from Mean Tmax (° C)	Avg Increase in Mean Tmax (° C)	Tmin (° C)	Deviation from Mean Tmin (° C)	Avg Increase in Mean Tmin (° C)
March	35.2	1.09	1.095	18	1.7	1.43
April	38.6	1.2		21.7	1.6	
May	40.3	0.84		24.8	1.2	

June	37.6	0.36		26.1	0.7	
Tmax- Maximum Temperature, Tmin – Minimum Temperature, Source: National Data Centre, IMD						

The average increase in Tmax value for entire summer period over the study duration of 17 years is 1.095°C, in Rajkot. The average increase in Tmin value for the entire summer season over the 17-year period comes out to be 1.43 °C, with maximum deviation in seasonal Tmin value was observed in March (1.7 °C).





Month (2001-2017)	RH (830)	Average Mean RH (830)	Deviation from Mean RH (830)	RH (1730)	Average Mean RH (1730)	Deviation from Mean RH (1730)
March	+69	+73.705	+1.33	+21.33	+30.66	-1.27
April	+71.33		+1.12	+21		-0.48
May	+75.16		+0.42	+30.16		-1.40
June	+79.33		+0.29	+50.16		+2.46
RH – Relative Humidity. Source: IMD						

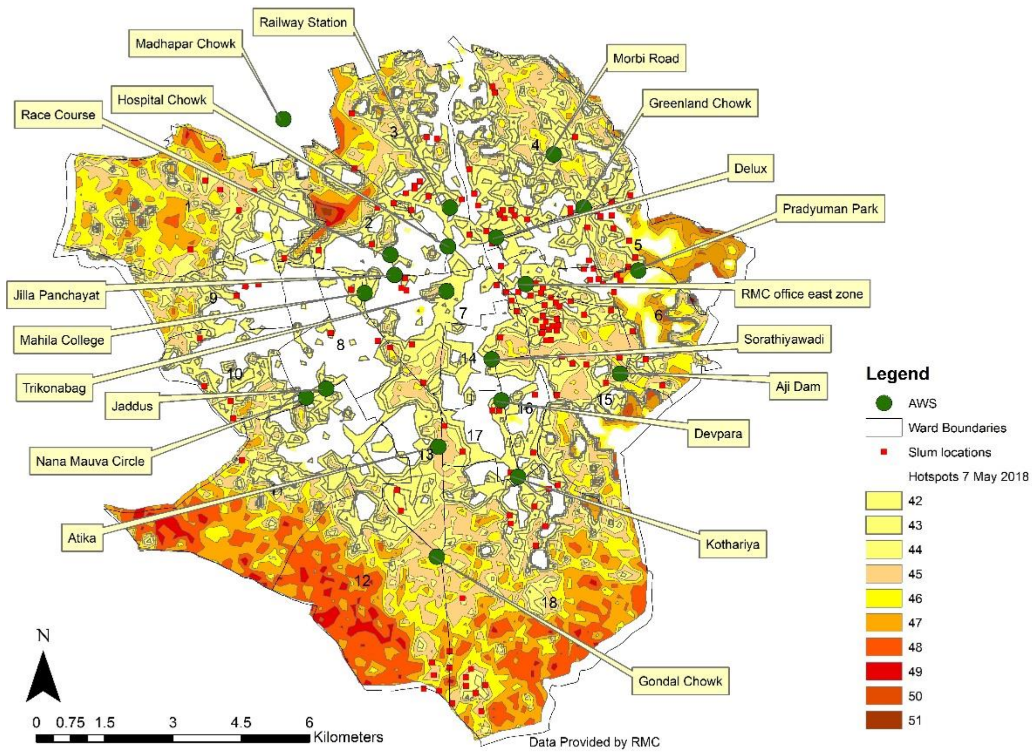
Maximum deviation for RH (830) was observed in March (+1.33), followed by April (+1.12). The average mean RH (830) over the 17-year study period comes out to be +73.705. Maximum deviation in RH (1730) was observed in June (+2.46). The average mean RH (830) over the 17-year study period was +30.66.

The climate parameters show a sharp increase in the month of March, which suggests Rajkot is experiencing relatively more heat in the month of March. Increase in minimum temperature along with humidity will lead to increase in Heat Stress.

There is clear evidence of climate variability leading to increase in number of heat wave events as well as early arrival of hot days. Local authorities need to be prepared earlier in the month of March. March is usually considered the transition month between winter and summer, and such a sharp increase in temperature and lower relative humidity in March will not provide people sufficient time to acclimatize, which may lead to an increase in human morbidity and mortality. (Refer Annexure I for more on Climatology of Rajkot).

3.3 Thermal Hotspot Maps for Rajkot

The surface temperature maps of the city are developed using **LANDSAT 8** satellite data and superimposed on the ward-boundaries map of the city to develop the city hot spot area. Wards with temperature above 42 degrees Celsius were delineated across the city.



Map: Thermal Hot Spot Map of Rajkot city with LST=/> 42°C

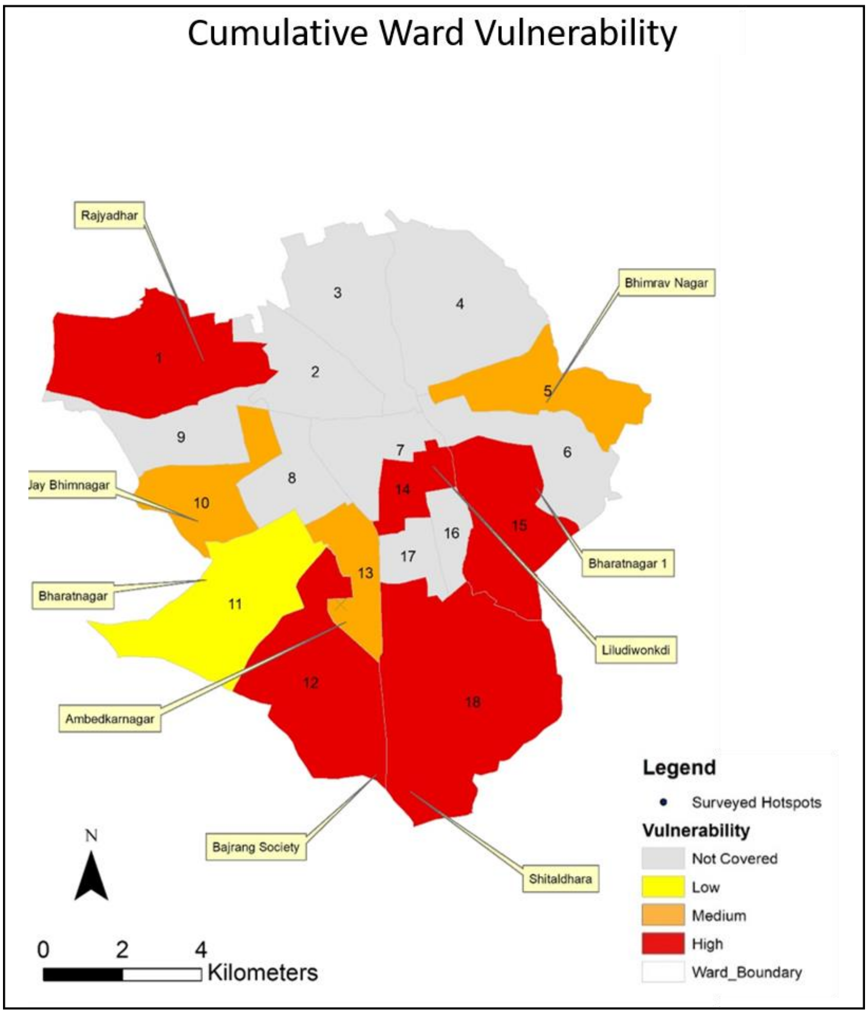
3.4 Identification of Ward- level vulnerability- Rajkot

Surveyed hotspot ward name	Ward number
Rajyadhar	1
Bhimrav Nagar, Pradyuman Park, Sadhu Vasvani Road	5
Jay Bhimnagar	10
Bharatnagar	11
Bajrang Society Rashulpura	12
Ambedkar Nagar	13
Liludiwonkdi	14
BharatNagar 1	15
Shitaldhara	18

Table 5 - Ward name and number indentified as Survey Hotspot

Heat stress vulnerability across the above identified wards in hot spot areas of Rajkot were analyzed using the comprehensive index, comprising of nine sectors - **Sanitation, Water, Electricity, Health, Transportation, Housing, Cooking, Awareness and Heat symptoms** and their respective sub sectors.

The **cumulative ward wise heat stress vulnerability analysis** (refer Annexure IV) indicated that nearly 5 wards in Rajkot are highly vulnerable and minimum basic amenities available to the vulnerable group to cope with heat stress.



Map: Cumulative ward wise heat stress vulnerability analysis of Rajkot City

Vulnerable wards	Wards Number (Out of 10 Thermal Hotspots)	Total
Low	(11)	1
Medium	(10 , 13 , 5)	3
High	(14 , 15 , 18 , 12 , 1)	5

Table 6 - Vulnerable Wards and Hotspots in Rajkot city

3.6 Wage and Productivity Loss due to Heat Stress

Occupation Wise Wage Loss: The casual labourers are most affected by the high heat days. As the maximum wage loss is reported in the daily causal labourers (35%). They are followed by the factory workers who due to prolonged working hours often experience heat exhaustion during high temperature. Hawkers, Maids and Office workers are least affected amongst the identified occupations. The average wage loss in the city falls under the category INR 1 to 999 followed by INR 3000 and above. It is observed that the occupation with average wage loss in the category 1 to 999 are majority casual workers while the ones losing in the category of above 3000 belong to the business class.

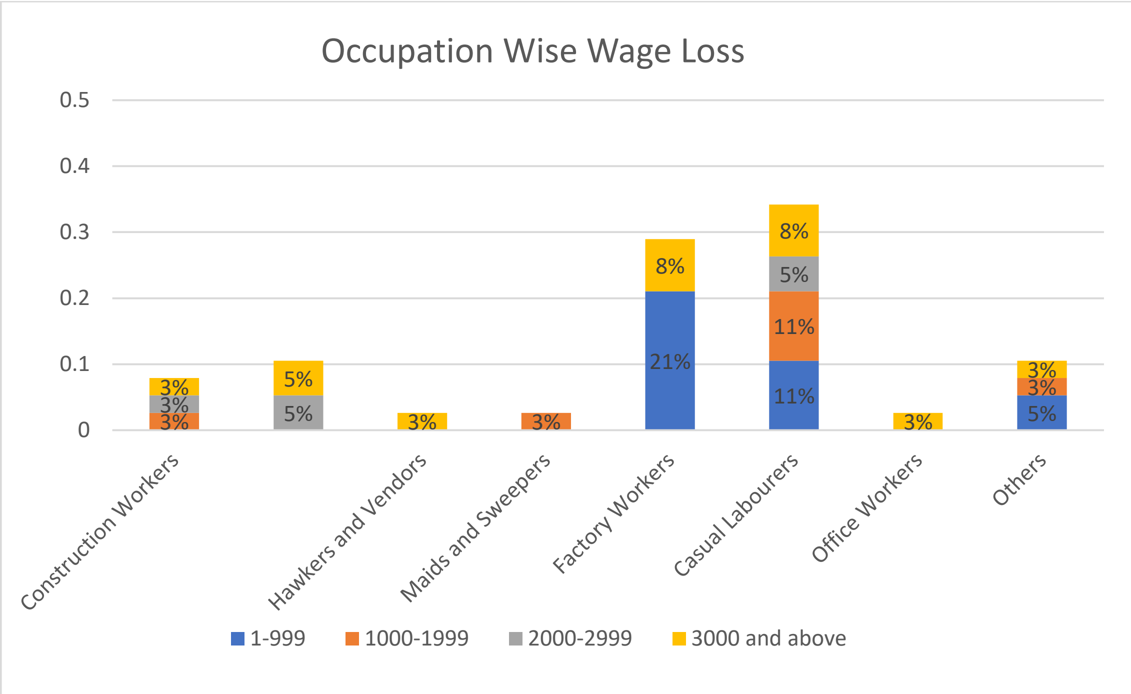


Figure 7 - Occupation wise Wage Loss

Wage loss Gender Wise: It is observed that the majority males (75% out of the total) experience wage loss due to heat as compared to the women involved in work. Most females experience wage loss in the category INR 1 to 999 while males in INR 3000 and above. The average monthly wage loss in females in INR 200 while in males is INR 2000. The genders are divided by the mentioned gap as majority males are part of business sector.

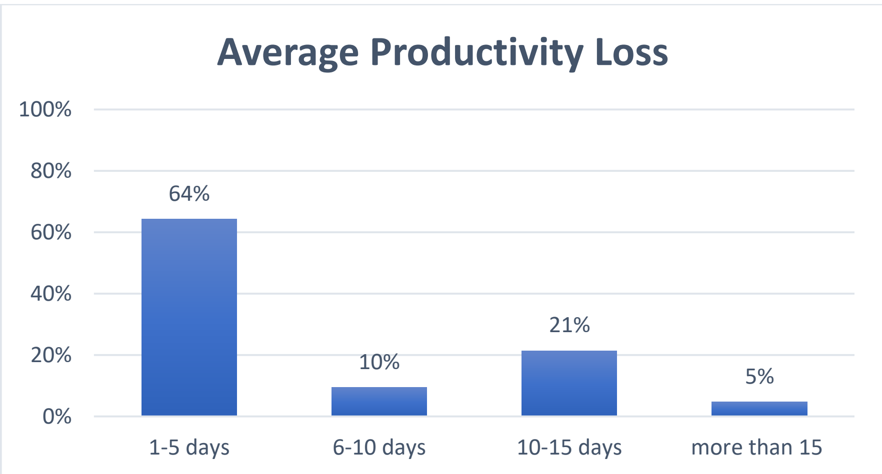


Figure 8-Average Productivity Loss

Productivity loss: With the loss in wages the productivity of the individuals is also highly affected. Majority (64%) of the working population had reported the loss in the working days by 1 to 5 days during the heat stress period followed by 10 to 15 days (21%) in a month. Males (64%) are at a greater loss as compared to females. Maximum productivity loss is reported in the factory workers (26%) followed by the casual labourers (25%). (For more on the Impact of Heat Stress on Health, Livelihood and Productivity, Refer Annexure 2)

Gender-sensitive impact of heat stress

Women and men experience thermal stress differently and gender inequalities affect women's ability to adapt. Studies on gender inequality indicate that women are more likely to suffer the various effects of climate change. Their lack of awareness of adaptation and mitigation measures and exclusion in adaptation decision-making behaviour are mutually reinforcing that increases their exposure and vulnerability.

Given lower thresholds of physical endurance and generally poor nutritional status apart from the biological factors, it is critical to know the health effects of heat stress or thermal stress among women, especially socially and economically marginalised, to draw any adaptive intervention or policy formulation to ensure their well-being and economic productivity

The study showed broad-based heat distress among the poor working women at a subsistence level of employment. Most of them reported suffering from heat exhaustion, heat rash, dehydration, fatigue and not being able to seek medical advice to avoid spending on medical consultation and medicines. Dehydration was reported by women with poor access to drinking water at the workplace.

The study done by IRADe suggests a higher vulnerability to heat stress for poor working women with inadequate access to resources and information and control over the available resources. Heat stress vulnerability of pregnant women can even be higher.

4. Mapping of Heat Hotspots

The thermal hot-spot maps give insight into the differences in hot spot distribution within cities. Identifying hot spots within a city can help focus interventions where they are most needed during heat waves.

We consider 'hot-spots' as the areas within the city which experience ambient temperature in excess of the average monthly maximum temperature.

Such thermal maps provide information about the areas which have the accumulation of hotspots, and therefore population living there is under high physiological and socio-economic risks due to thermal stress. Thus, specific measures to curb the problem of heat stress for the resident population can be taken using these maps.

The hotspot maps so generated are useful for policymakers and city administrators in analysing the local factors contributing to heat-stress in different wards and devising mitigation options to reduce heat stress in these areas.

4.1 Ward level Thermal Heat Spots

To assess spatial distribution of heat stress at ward level in Rajkot, we followed an approach when we first mapped thermal heat spots through remote sensing using LST images. Thermal hotspots maps were developed using Landsat 8 data. The LST derived from satellite data (NDVI – Normalised Difference Vegetation Index and LSE –Land Surface Emissivity) was validated with ambient air temperature recorded by IMD station within the city as well as the data received from 20 AWS stations installed within the city by RMC. Landsat 8 provided a range of open-source data at a spatial resolution of 30 m. Landsat 8 data was used for retrieval of LST. Data of May and June months of the years 2017 and 2018 were employed to map LST. For 2017, data of 04 May and 14 June were used, whereas, for 2018, data of 07 May and 08 June were used, as these dates provided images without any cloud cover. Hence clear images were derived on the particular dates. Shapefile of Rajkot municipal wards and slum distribution data was obtained by RMC. LANDSAT data captures the Land surface at 10:30 AM (IST) in the morning. The methodology flow chart is shown in Fig 16.

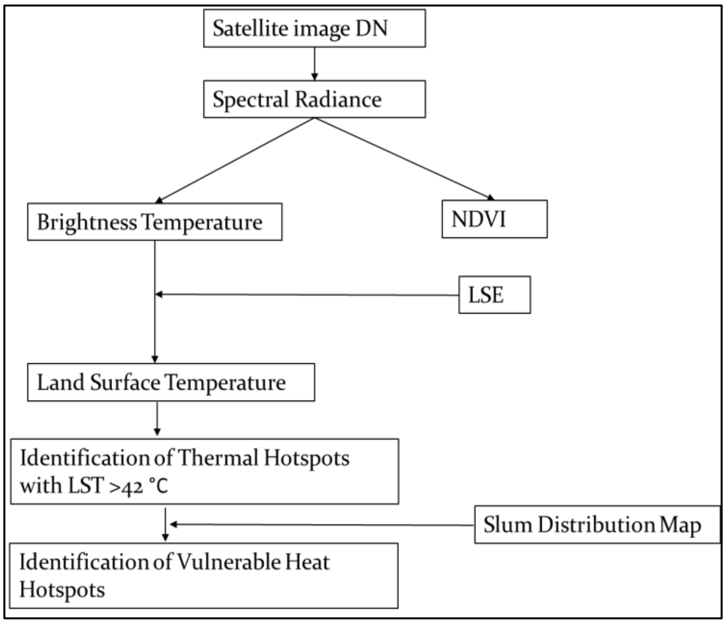


Figure 9-GIS Methodology for identification of vulnerable heat hotspots

The LST derived from satellite data was validated with ambient air temperature recorded by IMD station within the city as well as the data received from 20 AWS stations installed within the city by RMC. To mark the high temperature areas within Rajkot city, thermal hotspot maps were prepared to map areas with temperature higher than 42^{o}C, and were marked as thermal hot-spots. Landsat 8 data of May and June months of 2017 and 2018 were employed to map Land Surface Temperature (LST).

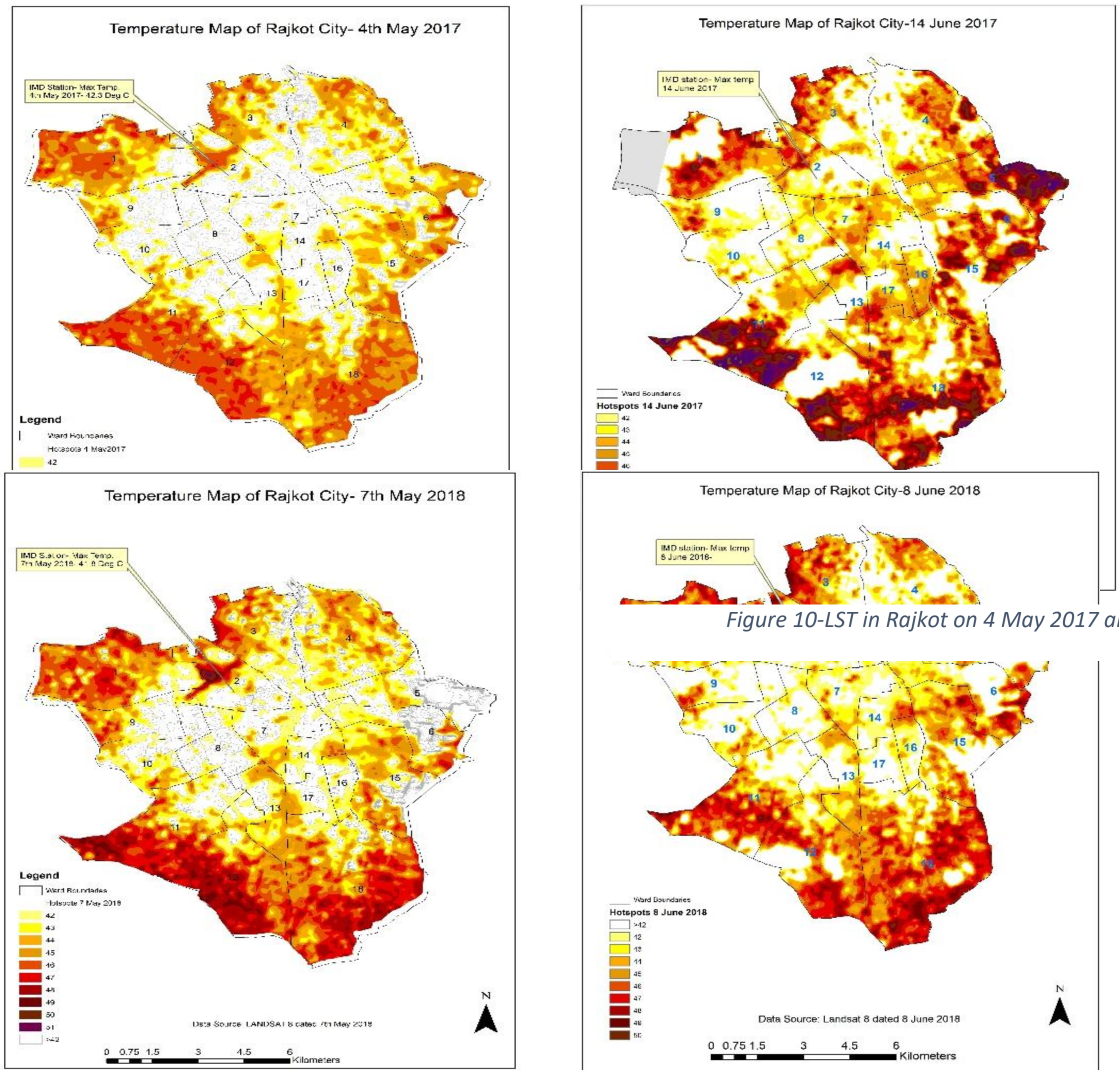


Figure 10-LST in Rajkot on 4 May 2017 and 14 June 2017

Figure 11-LST in Rajkot on 7 May 2018 and 8 June 2018

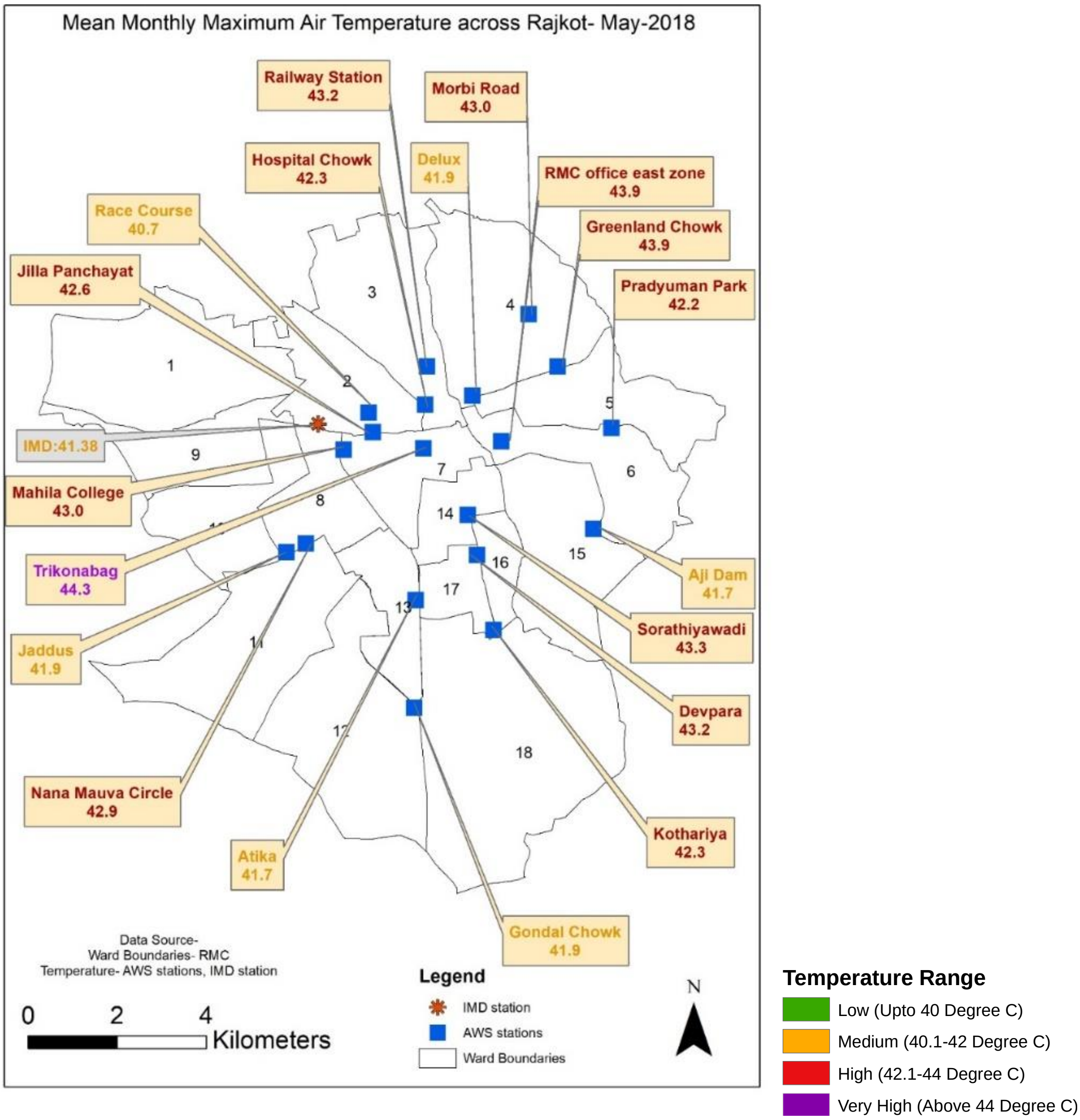
Looking at the LST maps of May and June 2017 and 2018, it is observed higher temperature is consistently experienced in ward numbers 1, 2, 3, 4, 5, 6, 9, 10, 11, 12, 15 and 18. Peripheral regions show higher temperatures than the central regions.

4.2 Identification of Urban Heat Islands

Urban areas typically experience higher—and nocturnally sustained—temperatures because of the "heat island" effect (Oke, 1987; Quattrochi et al., 2000).

Similar trend of urban heat islands is observed in Rajkot city due to urbanization and land use patterns. Within the city it was observed there was maximum temperature deviation up to + 3.8-degree C and similar trends were observed for the Average Minimum Temperature for which the deviation was up to +2.96 degree C.

While yellow alert is being issued in the city based on the weather observatory of IMD, early warning alerts can be provided to the heat hot spots. This will also help in prioritised actions for the heat hotpot locations within the city. The map showing distribution of ambient air temperature across Rajkot for May 2018 is shown below.



Map: Mean Monthly AAT for May 2018

5. Vulnerability Mapping

5.1 Vulnerable Areas

The hot temperatures during the heat wave often result in some parts of the city getting much hotter than rest the city. The air, surface and soil temperatures in these areas are influencing the overall temperatures often result in considerable discomfort to people occupying these spaces. Henceforth, making it important to identify such areas in order to minimize any potential medical impact. The spatial documentation of heat related health risks in addition to the biophysical vulnerabilities will help policy, planners, medical stakeholder etc. in developing heat preparedness plans at local scale in the city.

Vulnerable areas within the city is classified as under:

Slums: The poor in these areas are affected much more due to their poor coping mechanisms and limited ability of the inhabitants especially women to respond to health challenges during hot temperatures. The night time outdoor microclimatic conditions along with poor housing structure and no access to services make it extremely difficult for people to cope with heat stress. Consequently. acutely affecting the health of people living it these areas. The women of these areas faces its brunt the most as they not only have to deal with heat wave but also have to make arrangement for services such as water etc.

Low income group neighborhoods: The inhabitants of these neighborhoods constantly suffer from heat stress due to poor built up environment, limited access to basic services and poor housing material. It has been observed that people living in higher floors, with poor ventilation and bad housing material compounds the impacts of heat related impacts. People with disabilities and chronic diseases are worst suffers and women in some localities can’t even leave their front door open due to their safety and security issues.

Heat wave Vulnerability Hotspots: The hotspots identified during the vulnerability assessment of heatwaves undergo significant rise in temperatures as compared to rest of the city. These areas are most likely to have higher number of inhabitants getting affected during heat waves and experience huge heat- health implications.

(For more information on how local factors of vulnerability impact the population, refer to Annexure 3.)

5.2 Vulnerable Groups During Heat Wave

The heat wave has huge health outcomes and makes specific group of people more vulnerable to heat related mortality and morbidity. Among these, infants, children, woman, elderly, construction workers and people from economically weaker sections are affected the most.

Identification of these groups is much needed as it allows the medical professionals to efficiently prioritize actions to effectively treat heat related illnesses. This makes it even more essential to identify these vulnerable groups in order to minimize and decrease any potential threats of heat waves.

The vulnerable groups are as follows:

Infants: They are particularly sensitive to heat due to different metabolism and poor ability to adjust to changes in temperatures. The infants sweat less which considerably decreases their ability to cool their body. Infants are more susceptible to heat related deaths due to their high metabolism rate and inability to remove sheets or clothing.

Children: They are physiologically more vulnerable to heat stress unlike adults. The heat related illnesses are associated with their physical activity, production of more metabolic heat/ kilogram, in comparison to body weight, dehydration and lower cardiac output. Henceforth, strict vigilance is required during a heat wave to avoid any heat related sickness and overheating among them.

Woman: They are more at risk for heat related mortality. They are vulnerable to heat stress as their ability to thermoregulate is compromised. There are increasing evidences of still birth among pregnant women. Their heat related illnesses are further intensified due to social norms and gender discrimination embedded in society. Lack of timely access to information on heat alerts increases their risk to heat stress.

Elderly Citizens: They are at a great risk to morbidity and mortality during heat wave. With growing age there is considerable reduction in the cardiac output and capacity to circulate blood to skin, intestinal and renal circulatory beds. Aging compounds these problems which reduces the efficiency of heat dissipation by them.

Working Individuals: They perform activities both indoors and outdoors in farms, manufacturing and construction and hence are at greater risk to dehydration and heat stress. Their capacity to thermoregulate is exceeded on a regular basis and exposure to heat for long duration leads to dehydration, compromised normal activities, chronic kidney disease, cardiovascular and pulmonary illnesses. The cultural aspects such and clothing and use of PPE may also hinder worker's ability to cool itself through sweat.

Economically Weaker Sections of Society: They often lack awareness and means to undertake any measures for protecting them against any heat related illnesses. Most of the people suffer from chronic diseases which often gets aggravated with intensification of the heat wave. Poor quality housing, lack of access to basic services of water, health services and sanitation further their compounds the vulnerability during heat wave.

People with Disabilities: They are most vulnerable to heat waves as their ability to receive or respond to heat alerts is substantially reduced. In certain cases, such as spinal cord injury doesn't allow body to sweat, inhibiting body to cool from overheating. Besides, any form of physical or mental disability add to their vulnerability to heat wave. To add to this, high social risk factors further adds to these challenges. It has been observed that heat wave messages are not always designed or delivered in a way that makes it easy for them to comprehend for eg people with hearing loss, blind or reduced mental health. There by making them largely dependent on their caregivers.

Chronic Disease Patients: They are most likely to face the heat stress. Their medication not only impacts their ability to gauge changes in temperatures but also can make effect of hot temperature even worse. Patients with conditions of heart diseases, mental illnesses, poor blood circulation and obesity are more at the risk of heat related illnesses. Overweight people often tend to retain body heat which makes them vulnerable to heat stress and its associated impacts.

5.3 Ward Level Vulnerability zones

To identify high temperature areas within Rajkot city, IRADe prepared thermal maps of Rajkot. It used Land Surface Temperature (LST) imageries of April, May and June from 2016 to 2019 to delineate areas with persistent high temperature from April to July.

These thermal maps had unique application as they provided land surface temperature (LST) variations at the ward level, which was a first for the Rajkot city. As these maps are produced using high resolution satellite data (Landsat 8, having spatial resolution 30 m), the LST can be correlated with ambient air temperatures provided by on-ground sensors. The maps produced using satellite images provide city-wide variations of LST, which is very difficult to produce using handful (in many cases we have only one on-ground sensor to report temperature for entire city) of on-ground sensors. These maps are also better correlated with local land use changes as they are very sensitive to temperature variations. These maps are very helpful in identifying thermal hotspots and in determining "local" level adaptation and mitigation measures.

These thermal maps identified areas with temperature higher than 40 ^{o}C and marked them as thermal hotspots. Therefore, in the context of this report, hotspots are those parts of the city that experience ambient temperature in excess of the average monthly maximum temperature for most of the days in that month.

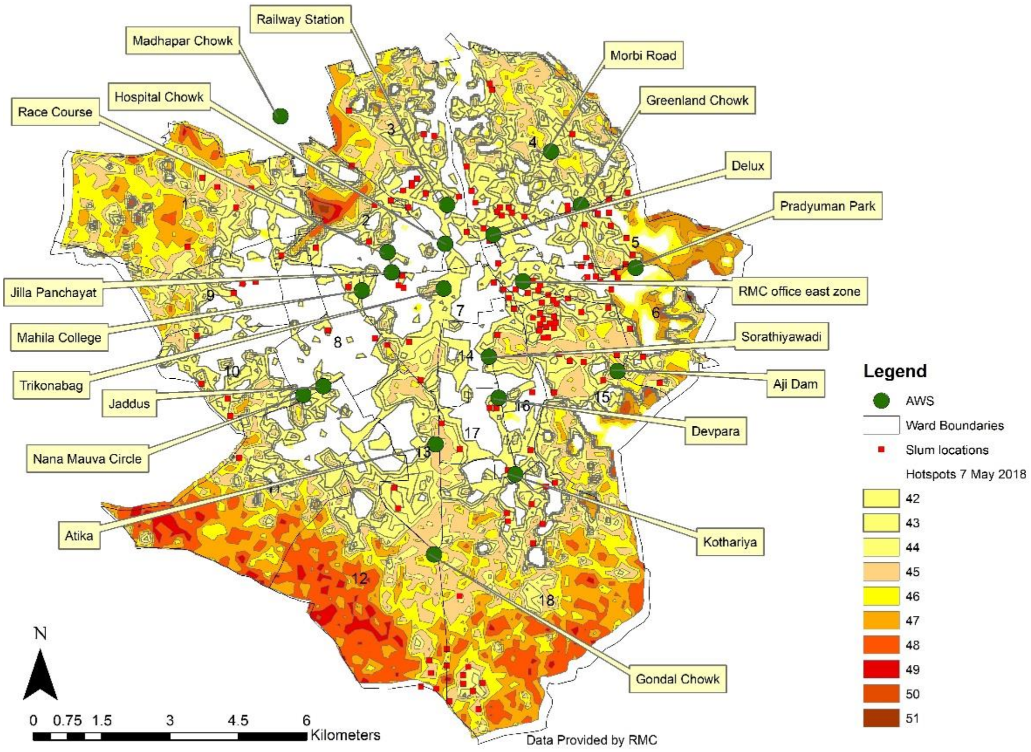
Vulnerability to heat is defined as a function of: the degree of exposure to the heat hazard, sensitivity to changes in weather/climate (the degree to which a person or system will respond to a given change in climate, including beneficial and harmful effects), and adaptive capacity (the degree to which adjustments in practices, processes, or structures can moderate or offset the potential for damage or take advantage of opportunities created by a given change in climate) (*IPCC, 2001*).

Slum distribution in Rajkot was mapped in GIS (Geographic Information System), and slum distribution map was overlaid on LST maps to identify vulnerable thermal hotspots. Satellite images of Rajkot were downloaded from Earth Explorer portal of United States Geological Survey and processed using TRS Tool Box (Thermal Remote Sensing) *(Walawender, Hajto, & Iwaniuk, 2012*) in ArcGIS software.

The various areas identified as thermal hotspots in Rajkot city include: **Ambedkar Nagar, Rashulpura, Bajrangnagar, Rajyadhar, Shitaldhar, Jay Bhim Nagar, Bharat Nagar 1, Pradyuman park and Laludiwonkdi.**

It is usually found that both men and women are affected by heat stress, with children and elderly being more susceptible to heat stress (*McGeehin, 2001)* (*Oudin Åström, 2011) (Lundgren, 2013)* (*Li, 2015)*. People with low socio economic status (Harlan, 2006), i.e. the economically weaker section, are also found to be more susceptible to heat stresses. Pregnant women are also susceptible to increasing ambient temperatures and heat waves since their ability to thermos-regulate is compromised (Wells J.C, 2002) pregnant women working in extreme heat are more prone to dizziness and fainting.

Vulnerable population in Rajkot are those who have to stay outside for work all day long and have limited options to protect themselves, for example, vendors, beggars, shopkeepers, policemen, auto/rickshaw drivers. Lack of adequate measures to combat the effects of heatwave results in health issues such as diarrhea, heat stroke, rashes, dehydration, dizziness.



MAP -Thermal hotspots in Rajkot with LST =/> 42 °C

6. Heat Action Plan — Strategy, Roles and Responsibilities

Benefits of Heat Stress Action Plan

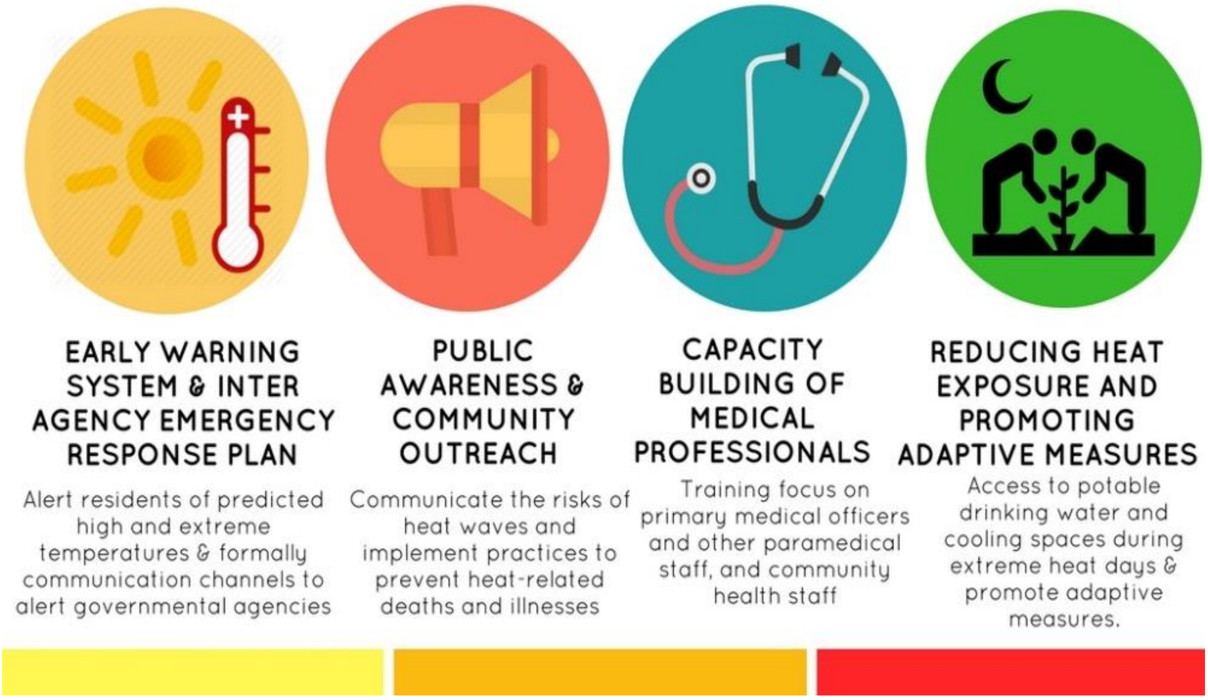
1. Prevents deaths associated with heat strokes.
2. Government commitment to protect the poor and vulnerable citizens.
3. Reduces chances of illness due to heat waves.
4. Making Indian cities future ready, Climate resilient cities.
5. Better preparedness of hospitals/health centers.
6. Economic losses- labour productivity, loss of job days, reduced labour and opportunity loss.

A Climate Adaptive Heat Stress Action Plan has been developed by IRADe to improve the management of heat-related risk in Rajkot city. The plan intends upon being more spatially oriented and gender-sensitive while supporting the city's planning especially in prioritizing and integrating adaptive resilience within the agenda towards climate resilient smart city.

The Heat Action Plan provides a framework for implementation, coordination and evaluation of extreme heat response in Rajkot and guides on mitigative and adaptive measures to avert loss of life and productivity. The Plan's primary objective is to alert populations at risk of heat-related illness, such as in places where extreme heat conditions either exist or are imminent, and to take appropriate precautions. The Heat Action Plan brings together all stakeholders for a citywide strategy in enforcing preventive, mitigative and adaptive measures to check heat-related debility among people.

This Heat Action Plan identifies:

1. Vulnerable populations and the health risks specific to each group (see section: Impact of Heat Stress on Health, Livelihood and Productivity)
2. General heat-health risks (see section: Impact of Heat Stress on Health, Livelihood and Productivity)
3. Effective strategies, agency coordination, and response planning
4. Process of activating heat alerts and the plan implementation
5. Evaluate and update the Heat Action Plan based on new learning



6.1 Strategy and Components of Heat Action Plan

Given that heatwaves can disrupt social and economic services, the local government has a critical role in designing and administering pre-emptive measures in responding to heatwaves working in tandem with all stakeholders, including health department, various institutions and community. This Heat Action Plan details coordinating role and responsibilities of RMC and the roles and responsibilities of other stakeholders, including non-government institutions and the community. It lays out the essential components of preparedness of mitigative and adaptive measures to ensure stable health and productivity in the event of heatwaves.

- **Build Public Awareness and Community Outreach** on mitigative and adaptive measures through media engagement — television and radio broadcasts, SMS, WhatsApp, social media — to prevent heat-related deaths and illnesses. Inter-personal communication may be required to reach out to very vulnerable populations.

- **Use Early Warning Weather Forecasts for Inter-Agency Coordination.** Everyday Indian Meteorological Department shares five-day weather forecast with the Heat Action Plan Nodal Officer during the heat season. The RMC, in turn, must alert the government agencies, health officials and hospitals, emergency responders, local community groups, and media outlets about high temperature or heat waves.

- **Develop Capacity Among Healthcare Professionals** to recognize and respond to heat-related illnesses, particularly during extreme heat events. Such capacity building must include primary medical officers, paramedical staff, and community health staff so that they effectively manage heat-related cases to check mortality and morbidity.

- **Reduce Heat Exposure and Promote Adaptive Measures.** Identify high-risk areas of the city. Launch advocacy on preventive, adaptive and mitigative methods to deal with heat stress; ensure access to adequate potable water and cooling spaces during extreme heat days. Collaborate with non-governmental organizations to expand outreach and communication with the city's most at-risk communities.

Other Components

- Develop heat emergency response plan
- Collaborate with non-governmental organizations and civil societies for developing 'cool public places' and improvising bus stands, building temporary shelters, providing access to cold drinking water in public areas and other similar measures to mitigate the risks of exposure to heatwaves.

6.2 Medical emergency preparedness

Heat waves creates an emergency situation in people that makes their medical attention urgent for treatment and also avoid any fatality. Such situations inevitably lead to a rapid increase in demand for hospital services which ultimately has a crippling effect on its operational capacity. This urgently calls for deployment of a quick response plan that works towards such emergency preparedness and effectively responds to health emergency along with maintaining its regular health facility.

Understanding emergency preparedness

The emergency preparedness for heat waves in hospital refers to the steps taken by it to be ready with response during emergency situation by giving adequate and emergency medical care. This would require continuous planning, coordination, capacity building, monitoring, appraising, and acting in accordance with the laid down procedures along with collaborative efforts from all the stakeholders. The hospital's emergency preparedness plan should generally take into account all aspects of heat waves including the pre, during and post heat waves.

Pre- Heat Season

1. Create and implement gender based heat health guidelines on the diagnosis and treatment of heat stress, heat exhaustion, and heat stroke to reduce and prevent mortality and morbidity. Use materials extensively for training and communication, including posters and pamphlets that inform patients about upcoming heat warnings and offer tips to prevent heat stress

2. Identify and relocate the most vulnerable hospital wards (e.g., the maternity or neonatal ward) from the top floor of hospitals, where the temperatures are highest. Move patients to cooler parts of the building
3. Measure wards' morbidity and mortality rates before and after location change to evaluate the effectiveness of intervention
4. Set up steering committee to supervise, monitor the emergency preparedness, dealing with inflow of patients during heat wave and post heat wave evaluation
5. Establish Cool Wards within the hospitals
6. Ensure bed availability especially in emergency departments and special wards for heat related illness especially among women
7. Ensure adequate storage of IVs, ORS and other medicines for heat stress treatment
8. Increase medical doctors, nursing staff to ensure full coverage in case of an increase in admissions
9. Development of training modules or multiday training for health care providers, ward leaders, and paramedics on extreme heat and health, as well as specific heat case management and diagnosis, especially during heat waves
10. Organizing a training of trainers workshops for primary medical officers so they can offer heat-specific advice (symptoms, diagnosis, and treatment including self-monitoring hydration) to their medical staff
11. Conduct workshops for link workers/front line health workers (ASHA;Anganwadi worker; community health workers) to increase gender sensitive outreach and community-based surveillance for heat illness in slum communities. Link workers should receive informational materials that cover how to counsel patients especially women, what threshold temperatures apply for different levels of treatment, and surveillance protocols
12. Collaborations with the medical service provider/ research institutes to train emergency service professionals on responding to extreme heat emergency cases
13. Increase heat stress outreach and education for women in maternity wards before they leave the hospital, since newborns are particularly vulnerable to heat stress
14. Update heat wave monitoring and management protocols and programs, including tracking of daily gender associated heat-related data as per the monitoring sheet template shared below

During Heat Season

1. Adopt gender specific heat-focused examination procedures at local hospitals and Urban Health Centers (ASHA; Anganwadi worker; community health workers).

Examination of admitted patients for signs and symptoms of heat related illnesses could become routine, adding a brief procedure during the peak-heat summer months at a minimum. The basic statistics of such patients should also be recorded to identify the locations, occupations, gender and socioeconomic status of city's residents who are most vulnerable to heat stress and illness.

2. Adapt pharmacological treatments according to Standard Treatment Guidelines (STGs). Gender aspects should be given due consideration
3. If possible, postpone non-emergency hospitalizations and surgeries.
4. Ensure high risk patients are placed in rooms with air conditioning; less critical patients should at least have access to an area with air conditioning during the hottest hours of the day.
5. Increase liquid oral and intravenous intake of patients.
6. Modify diet accordingly with increased fruit and vegetables.
7. Adjust patient bed and personal clothing according to need.
8. Start and special and adequate health and social assistance for hospital discharge of high risk patients especially new mothers with babies or postpone discharge till post-heat wave.
9. Ensure availability of adequate number of Medical Mobile Van in high risk areas of heat waves
10. Maintain record of heat wave patients and report to Urban Local Body (ULB) daily according to monitoring sheet
11. Expedite recording of cause of death certificates

Post-Heat Season

1. Share final data of gender based hospital admissions as per indicators set for reporting during heat wave with the Urban Local Body (ULB)
2. Give feedbacks in annual evaluation of heat action plan
3. To prepare a set of key learnings during heat wave to build on institutional memory and share it with other stakeholders

7. Adaptation and Mitigation Measures

The measures which have been taken by Rajkot Municipal Corporation as part of Rajkot Heat Stress Action Plan can be classified into short term, medium term and long term measures.

7.1 Short and Medium Term Measures

Awareness Campaigns

- Hoardings, posters, to be displayed by smart city LED TVs at various locations, distribution of pamphlets.
- Awareness workshops for occupationally exposed - traffic police, hawkers, street vendors, construction workers and school children.

Mitigation measures

- Keeping gardens, cooling shelters and other possible cooling centres open with water availability.
- Availability of water and sheds at open construction sites.
- Pilot project on roof painting with white colour - cool roof and or distribution of gunny bags for putting on the tin roofs/asbestos in slums.
- Provision of water points and ORS at Construction sites, Bus stands and other Public places during processions and political and other rallies and processions during summer.
- Distribution of cool roof jackets to on-duty traffic police personnel.
- Water tanker campaign- Tankers to be made available on call in slums during orange/red alert days.

Early warning communication

- SMS and WhatsApp messages for early warning to citizens, NGOs, Citizen welfare groups, construction contractors.
- Public announcement through mikes across the city through car during orange and red alert days a day before and early on the forecasted day.
- Press Releases and campaigns on radio, TV and websites.

Medical Preparedness

- Stocking ORS and cool packs at the health centres & readiness with cooling and rehydration as well as shock management treatments.

- Medical camps on day of red alerts at hotspots.

Monitoring and Analysis

- Recording ward wise heatstroke cases, proper cause of death and monitoring daily mortality as well as daily hospital admission due to all causes and due to heat-related causes.
- Monitoring and analysis of the morning temperatures recorded from AWS sites and issue early warnings.

7.2 Long term Measures

- Heat alerts and emergency response plan needs to target vulnerable groups, high-risk areas and incorporation of the same in the City Development Plan. Planned development of urban areas ensuring appropriate amenities are available to all the residents in every location is required.
- Insulation and building standards need to be increased, with improving building bye-laws along with increasing heat tolerance for new infrastructure, retrofitting. Building bye-laws can have components of passive ventilation and cool roof technologies to increase thermal comfort and made mandatory in more vulnerable cities.
- Identifying locations for building shelters and shades in urban areas. Shelter locations for the urban poor and slum dwellers must be identified and constructed.
- Incorporation and documentation of indigenous knowledge to develop protective measures at regional and community level for sensitization and awareness generation. Local culture and physical exposure of population needs to be improvised to reduce the impact of heat stress on health and physical wellbeing.
- Capacity building at the community level, through awareness campaigns and outreach programmes. Communicating risks associated with heat stress and its impact on health, livelihood and productivity and ways to mitigate the same.
- Initiating research on micro-climate and corroborating the need to monitor temperatures in urban areas. Policy level intervention to retrieve natural eco-systems and natural shelters.
- Improvising the urban landscapes through vertical greenery, roof gardens can prove to be good alternate methods to bring down the temperature of built environment. Greening infrastructure can be an effective method to cope with heat stress. Urban forests have found to be effective for city heat mitigation. A combination of shading, reduced heat build-up in materials, humidity and wind management can provide heat refuge at street levels.
- Initiating Early warning systems, advisories and alerts against extreme heat for the communities and Urban Local Bodies. Building communication networks through Local bodies, Health officers, Health care centres, hospitals, communities and media.

- Encourage investing in water bodies, fountains in areas of mass presence and promote greeneries in urban areas along with improving green transport and energy systems.

7.3 Capacity Building

Medical Stakeholders Training cum orientation workshop was organized for health care professionals towards managing Heat-Related Illnesses in Rajkot, Gujarat. The training aimed towards orienting healthcare professionals of Rajkot city on Heat Stress Action Plan, enhancing their capacities for proper and inclusive management of heat related illnesses and health impacts. More than 50 doctors and public health professionals from Rajkot city had been a part of the training, which not only heat stress and protocols for heat-related diagnosis and treatment but towards overall preparedness for prevention and management of heat stress.

7.4 Heat Wave Advisory

DOS AND DON'TS FOR DURING HEAT WAVES

Heat wave conditions can result in fatal physiological strain. To minimize the health impacts of heat wave, the following measures are useful:

DOs

- ✓ Follow weather forecast and advisory on radio, TV, newspapers for appropriate caution.
- ✓ Drink water often, even if not thirsty.
- ✓ Wear lightweight, light-coloured, loose, and porous cotton clothes. Use protective goggles, umbrella/hat, shoes or chappals while going out in the sun.
- ✓ While travelling, carry water with you.
- ✓ If you work outdoors, use a hat or an umbrella and also use a damp cloth on your head, neck, face and limbs.
- ✓ Use ORS, homemade drinks like lassi, torani (rice water), lemon water, buttermilk, etc. which re-hydrate the body and replace mineral loss.
- ✓ Recognize the signs of heat stroke, heat rash or heat cramps such as weakness, dizziness, headache, nausea, sweating and seizures. If you feel faint or ill, see a doctor immediately.
- ✓ Keep animals in shade and give them plenty of water to drink.
- ✓ Keep your home cool, use curtains, shutters or sunshade and open windows at night.
- ✓ Use fans, damp clothing and take bath in cold water frequently.
- ✓ Provide cool drinking water at workplace.
- ✓ Caution workers to avoid direct sunlight.
- ✓ Schedule strenuous jobs to cooler times of the day.
- ✓ Increase the frequency and length of rest breaks for outdoor activities.

- ✓ Pregnant women and workers with a medical condition should be given additional attention.

DON’Ts

- ✗ Do not leave children or pets in parked vehicles.
- ✗ Avoid going out in the sun, especially between 12.00 noon and 3.00 p.m.
- ✗ Avoid wearing dark, heavy or tight clothing.
- ✗ When the outside temperature is high, avoid strenuous activities especially 12 noon and 3 p.m.
- ✗ Avoid cooking during peak hours. Open doors and windows to ventilate cooking area.
- ✗ Don’t consume alcohol, tea, coffee and carbonated soft drinks as these drinks dehydrate the body.
- ✗ Avoid high-protein food and do not eat stale food.

Heat Advisory

Figure 12- Heat Advisory Issued by Rajkot Municipal Corporation

8. Implementation of HAP

The Action Plan divides responsibilities into pre-, during- and post-event categories, detailing preparation for a heat wave (pre-event responsibilities), steps to be taken to reduce heat stress during a heat wave (during-event responsibilities) and measures to incorporate lessons learned and fill gaps found in the management of heat stress (post-event responsibilities).

Phase-I: – Pre -Heat Season (February to March) Pre-Heat Season is devoted to developing early warning systems, communication plan of alerts to the general public, health care professionals and voluntary groups (caregivers) with emphasis on training and capacity building of these groups.

Phase-II: - During the Heat Season (April to June) High alert, continuous monitoring of the situation, coordination with all the department's agencies concerned on one hand and general public & media on the other hand is the focus of this phase.

Phase-III: – Post -Heat Season (July to October) In Phase – III concentration is on evaluation and updating of the plan. It is important at the end of the summer to evaluate whether the heat health action plan has worked. Continuous updation of plan is a necessity. Global climate change is projected to further increase the frequency, intensity and duration of heat-waves and attributable deaths. Public health preventive measures need to take into consideration the additional threat from climate change and be adjusted over time.

Heat Alert Severity

Based on the Meteorology Department's weather forecast, RMC Nodal Officer, who heads Heat Action Plan, must issue heat alert based on the undermentioned thresholds of the alert severity. The Nodal Officer is also responsible for coordinating and communicating ahead of, and during, extreme heat events, and provides support staff through the Nodal Office as necessary. Approved by the Nodal Officer, the following are the roles and responsibilities of various stakeholders under the Heat Action Plan, 2020.

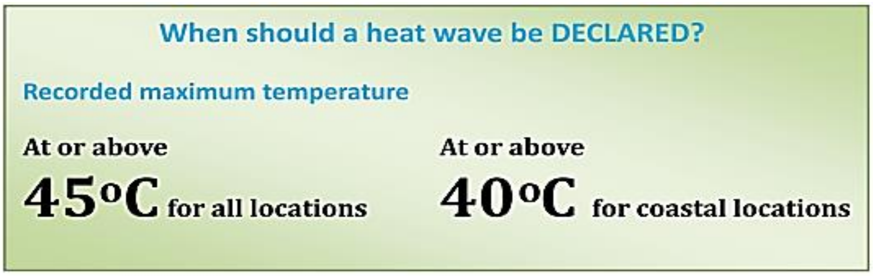


Figure 13-Heat Alert Severity

8.1 Roles and Responsibilities in Phase 1 (Pre-Heat Season January through March)

RMC Nodal Officer

- Convenes a meeting of key stakeholders (Gujarat State Disaster Management Authority, Gujarat State Surveillance Unit of IDSM, local non-government organizations, community health groups, media, health department and hospitals, departments of labour, water and sanitation, transportation, power supply and distribution, private institutions, religious places, etc.) to respond to extreme heat events (See figure titled Communication Plan When the RMC Nodal Officer Activates a Heat Alert).
- Engages state and local agencies to facilitate internal communications.
- Organizes training for health workers, link workers, health departments, school children and the local communities.

- Organizes outreach of health services to vulnerable communities.
- Undertakes publicity and awareness campaigns on health risks of heat stress through multilingual pamphlets, posters at vantage locations in hospitals, schools, and public and private institutions.
- Creates a list of high-risk areas in the city where people are more vulnerable to heatwaves for focused heat prevention measures.

Media and RMC Press Officer

- Execute campaign and awareness outreach through multilingual pamphlet and advertisements on risks of exposure to high temperature, heat stress prevention, and tips for health protection during extreme heat events with greater focus on high-risk areas.
- Ensure wide visibility of information and heat communication materials to the public.
- Increase the number of installed LED screens to display daily temperature forecasts for public view.

RMC Health Department and Medical Professionals

- Enhance targeted training programmes, capacity building efforts and communication on heat illness for medical staff at local hospitals and Urban Health Centres (UHCs) based on the framework for RMC Medical Professionals and Health Workers. These efforts should include nursing staff, paramedics, field staff and link workers.
- Ensure hospitals update their admissions and emergency case records to track heat-related morbidity and train them in recording heat stroke/ heat stress as the cause of death in certificates, if death is triggered by an illness from the exposure. This will give reliable dataset to analyse epidemiology of illnesses associated with heat stress. The training components can include information, education and communication (IEC).
- Adopt heat-focused examination procedures at local hospitals and urban health centres, more so during the summer months.
- Equip Urban Health Centres, 108 emergency centres, ambulances and hospitals with wherewithal for the treatment of illnesses associated with exposure and heat stress.
- Explore creation of ice pack dispensaries for easy access by vulnerable communities.

RMC Labour and Employment Department

- Organize training for employers, outdoor labourers and workers on the health impacts of extreme heat as well as on the mitigative and adaptive measures to prevent exposure, heat stress and associated debility.
- Identify high-risk outdoor workers and give them focussed attention in outreach and advocacy. Use irradiance map from IMD or heat island map to identify vulnerable areas/pockets. During the high-risk days, conduct publicity campaigns to these specific areas.

108 Emergency Service

- Create displays on ambulances to build public awareness.

- Identify vulnerable populations in at-risk areas and be in the state of preparedness to provide immediate relief in case of an illness reporting.

RMC, Civil Society and Individuals

- Conduct training workshops and outreach sessions with community groups and mobilizers such as Mahila Arogya Samiti, Self-Employed Women's Association (SEWA), ASHA workers, *aanganwadis*, municipal councils, etc., to help them organise community action. In such activities, RMC must take lead and involve higher education, non-profits, and community leaders.
- Provide child-relevant educative and preventative training at schools so that children avoid exposure and keep themselves adequately hydrated.
- Equip schools with materials for heat protection. Through "Teach the Teachers" workshop, give school administration training and material for insulation from heat.
- Encourage individuals to take heat stress preventive measures and seek medical care at hospital or Urban Health Centre at first experience of heat exhaustion.
- Inform fellow community members about how to keep cool and protect oneself from heat.

8.2 Roles and Responsibilities in Phase 2 (During the Heat Season March through July)

RMC Nodal Officer

- Activates the citywide **heat alert** and response mechanism based, on the Department of Meteorology's weather forecast, by notifying the key stakeholders, RMC Deputy Municipal Commissioners and the Gujarat state agencies in accordance with the Communication Plan (See figure titled Communication Plan When the RMC Nodal Officer Activates a Heat Alert).
- Monitors the **heat alert** level based on the weather temperature severity forecast (see section Heat Alert Severity). Increase in severity level necessitates the Municipal Commissioner to convene a special meeting of key agency leaders.
- Activates "cooling centres," such as temples, public buildings, malls, RMC-run temporary night shelters, etc., during a **heat alert.**
- Expands access to shaded areas for outdoor workers, slum communities, and other vulnerable populations. During heat alerts, orders night shelters be kept open through the day.
- Holds frequent, possibly daily, meetings to assess developments during a **heat alert**, and ensures that communication channels stay alert.
- Identifies key spots to set up large LED display boards to share temperature forecasts with general public.
- Ensures continuous surveillance of temperature data and forecasts for appropriate action.
- Communicates suspension of all non-essential uses of water (other than drinking, keeping cool) via the RMC Water Project's protocol procedures in cases of water shortage.
- Increases efforts to ensure adequate drinking water supply to the public. Besides,

expands potable water access during a **heat alert** at religious places, BRTS transit stations, organizes water pouch handouts to the poor and high-risk areas (identified by irradiance maps).

- Communicates local utility protocol to prioritize uninterrupted power to critical facilities (such as hospitals and UHCs).
- Notifies the Steering Committee and relevant agencies when the **heat alert** is over.

RMC Press Officer

- Issues heat alerts through WhatsApp and SMS platforms utilizing the centralized mobile databases of private sector telecom companies.
- Issues heat alerts to the public via centralized email databases.
- Sends direct heat alert messages to private medical practitioners, public hospitals and UHCs.
- Utilizes local radio FM broadcasts to disseminate heat protection tips and high temperature warnings to the city's at-risk populations.
- Explores other means of communications for outreach to vulnerable population.

RMC Health Department and Medical Professionals:

- Give tips for the treatment of heat related illness and prevention of further exposure.
- Ensure adequate medical supplies are available at all hospitals and UHCs.
- During a **heat alert,** produce weekly report of public health impact of heatwave for the RMC Nodal Officer.
- If required, increase the number of healthcare staff and doctors at hospitals and UHCs to attend to the influx of patients during a **heat alert**.
- Increase link worker and community health worker outreach to at-risk neighbourhoods during a **heat alert**.
- Frequent invigilation of UHCs by zonal health officer to ensure their preparedness to deal with the outbreak of heat-related illness and conduct case audits during heat season.

108 Emergency Service:

- Ensure adequate supply of ice packs and IV fluids.
- During a **heat alert,** disseminate SMS text messages to warn residents in the vulnerable areas.

RMC Labour and Employment Department:

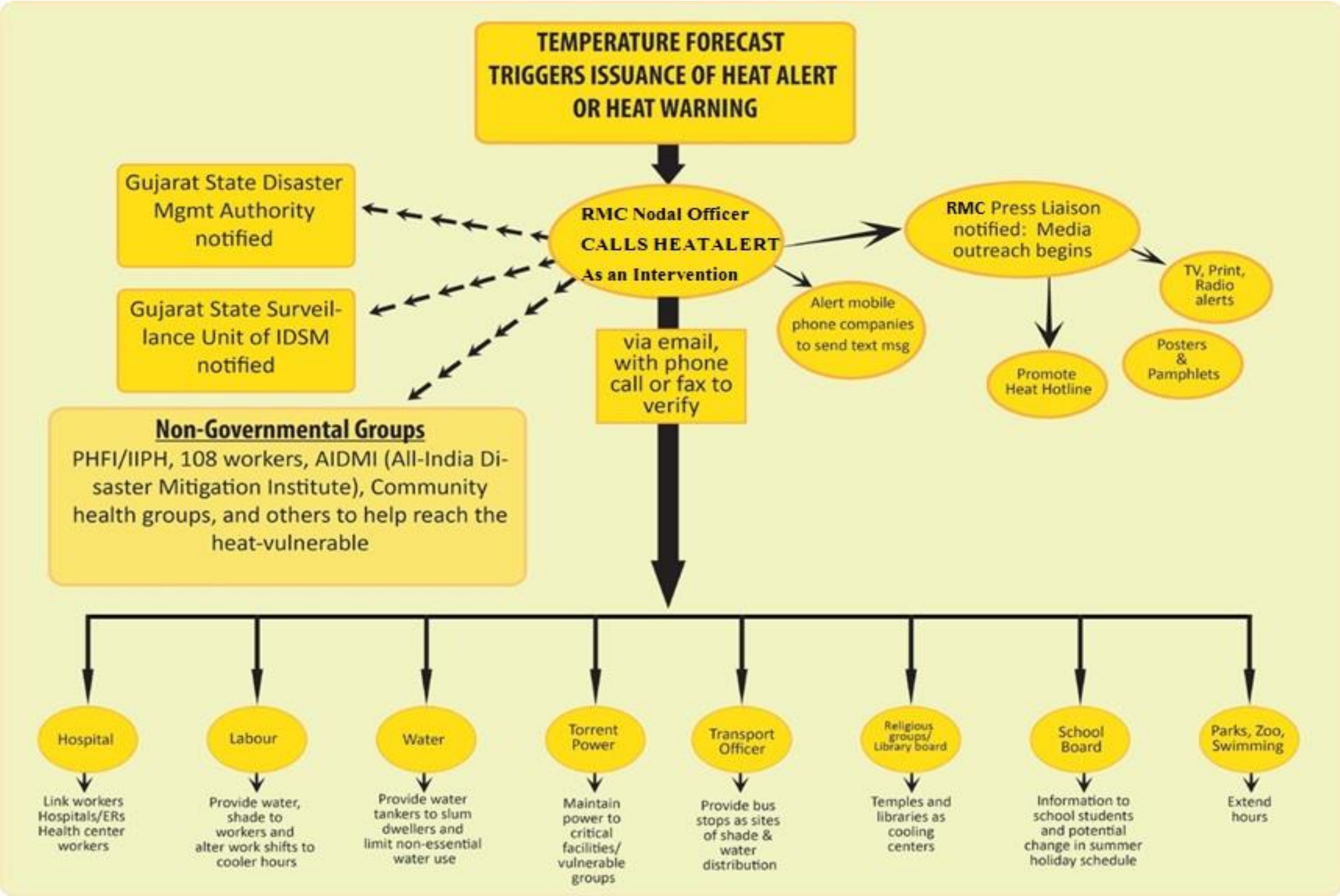
- Encourages employers to shift outdoor workers' schedules away from the peak afternoon hours (1pm – 5pm) during a **heat alert**.
- Provides emergency ice packs and heat-illness prevention materials to traffic police, BRTS transit staff and construction workers.

Community Groups and Individuals:

- Keep cool and hydrated during the heat season by drinking water, staying out of the sun, and wearing light clothing.
- Check on vulnerable neighbours, particularly during a **heat alert**.

- Limit heavy physical work under the sun and even indoors if poorly ventilated, especially during a **heat alert**.

Communication Plan When the RMC Nodal Officer Activates a Heat Alert



8.3 Roles and Responsibilities During Phase 3 (Post-Heat Season July through September)

RMC Nodal Officer:

- Organizes annual Heat Action Plan evaluation meeting with key agency leaders and relevant stakeholders.
- Evaluates the Plan process based on performance and revises accordingly.
- Evaluates the reach and impact of the Plan and revise accordingly.
- Posts the revised Plan on the RMC website ahead of the next heat season for stakeholders' feedback and opinion.
- Undertakes tree-plantation in heat hotspot areas. Encourages or incentivizes builders to plant trees.
- Establishes cool resting centres in high-risk areas around the city.

RMC Health Department and Medical Professionals

- Perform an epidemiological case review of heat-related mortalities during the summer.
- Based on average daily temperatures, gather epidemiological data on heat risk factors, illness and death.
- Incorporate data and findings into future versions of the Heat Action Plan.
- Measure mortality and morbidity rates based on data before and after the Plan's interventions.

RMC Nodal Officer

Pre-Summer

- ✓ Designates point of contact for each department
- ✓ Identifies facilitator to coordinate communications and schedule monthly meetings
- ✓ Establishes heat mortality tracking system and updates datasets
- ✓ Establishes Heat Action webpage on RMC website
- ✓ Facilitates training of schoolchildren and school staff
- ✓ Launches heat stress awareness campaigns before onset of summer
- ✓ Creates list of high-risk areas of city heat-wise

During Heat Event

- ✓ Appoints point person in each department for coordination with the RMC Nodal Office
- ✓ Coordinates Heat Action Plan activities through points person in each department
- ✓ Ensures adequate staff and supplies in each department
- ✓ Communicates locations of emergency facilities and cooling centres/shaded areas to all stakeholders
- ✓ Monitors severity of heat alert based on forecast

Post-Summer Evaluation

- ✓ Review quantitative and qualitative data for process evaluation and improvements
- ✓ Call meeting for annual evaluation of heat plan with key agency leaders and community partners
- ✓ Post revised heat action plan online for stakeholders

Medical Colleges and Hospitals

Pre-summer

- ✓ Adopt heat-focused examination materials
- ✓ Get additional hospitals beds and ambulances ready
- ✓ Update surveillance protocols and programs including tracking of daily temperature and heat-related data
- ✓ Train clinicians, medical officers and paramedics in diagnosis and treatment of health complications from heat stress

During Heat Event

- ✓ Establish treatment and prevention protocols for health issues arising from heat stress
- ✓ Equip hospitals with required medicines and equipment
- ✓ Ensure adequate medical staff to meet emergency
- ✓ Keep emergency ward in the state of readiness
- ✓ Monitor incidence of water borne diseases, malaria and dengue
- ✓ Keep stock of small reusable ice packs to apply to PULSE areas
- ✓ Report heat stroke patients to RMC daily
- ✓ In case of death from heat stroke/ exposure, mention it as the cause of mortality in death certificates

Post-summer Evaluation

- ✓ Participate in annual evaluation of Heat Action Plan
- ✓ Review revised Heat Action Plan and recommend amendments

ROLES AND RESPONSIBILITIES - HEAT ACTION PLAN

Public Health Managers

Pre-summer

- ✓ Identify vulnerable areas
- ✓ Ensure adequate inventories of medical supplies in health centres
- ✓ Ensure appropriate to health workers, para medics, clinicians, etc.
- ✓ Identify cooling centres and barriers to access cooling centres

During Heat Event

- ✓ Prepare rapid response team
- ✓ Distribute pamphlets with "Dos and Don'ts" instructions among vulnerable community
- ✓ Effectively send a "Take Care but Don't Panic!" message to community
- ✓ Ensure access to Medical Mobile Van in the Red Zone
- ✓ Ensure additional medical vans are available during red alerts

Post-summer Evaluation

- ✓ Participate in annual evaluation of Heat Action Plan
- ✓ Review revised Heat Action Plan and suggest needed amends

Urban Health Centres and Link Workers

Pre-summer

- ✓ Advice community on treatment and prevention of heat related illness
- ✓ Sensitize and train link workers
- ✓ Develop and execute school health programs with support from Department of Education
- ✓ Create awareness campaigns in slum communities
- ✓ Coordinate community outreach efforts with non-profits

During Heat Event

- ✓ Recheck management stock
- ✓ Ensure UHCs preparedness to respond to emergency
- ✓ Visit at-risk populations for monitoring and prevention
- ✓ Communicate information on tertiary care and 108 service

Post-summer Evaluation

- ✓ Participate in annual evaluation of Heat Action Plan
- ✓ Review revised Heat Action Plan and recommend needed amends

RMC Press Officer

Pre-Summer

- ✓ Secures commercial airtime slots for health advisories and public service announcements
- ✓ Identifies public areas to display health alerts during heat season
- ✓ Organizes training for health workers and medical professionals
- ✓ Activates heat telephone-hotlines
- ✓ Places temperature forecasts in newspapers
- ✓ Installs LED screens with scrolling temperature data

During Heat Event

- ✓ Issues heat-related health warnings in the media
- ✓ Contacts local FM radio and TV stations for health and weather advisories
- ✓ Releases advisories through SMS and WhatsApp platforms using centralized mobile databases
- ✓ Contacts BRTS and transport department to place warnings on buses

Post-Summer Evaluation

- ✓ Evaluates efficacy of advocacy and campaign outreach and other communications
- ✓ Participates in annual evaluation of Heat Action Plan
- ✓ Review revised Heat Action Plan and suggests amends

Labour Department

Pre-Summer

- ✓ Organize orientation for factory medical officers and general practitioners on health effects of heat stress or exposure
- ✓ Compile list of factory medical officers and contractors for heat action communications from Nodal Officer
- ✓ Prepare outreach and advocacy strategy for unorganized labour
- ✓ Use maps of construction sites to identify high-risk outdoor workers
- ✓ Conduct advocacy campaigns in high-risk areas

During the Heat Season

- ✓ Ensure water supply at work sites
- ✓ Request use of A/C at factory facilities
- ✓ Extend work hours of Occupational Health Centres
- ✓ Consider long afternoon break or change the working hours to avoid heat exposure
- ✓ Provide emergency ice packs and heat-illness prevention kit to traffic police, BRTS transit staff and construction workers

Post-Summer Evaluation

- ✓ Participate in annual evaluation of Heat Action Plan
- ✓ Review Heat Action Plan and recommend amends

108 Emergency Service

Pre-Summer

- ✓ Prepares handouts for paramedics on heat illness
- ✓ Uses informative visuals on ambulances to build public awareness
- ✓ Establishes Dynamic Strategic Deployment Plan for ambulances
- ✓ Ensures adequate supply of IV fluids
- ✓ Identifies at-risk areas
- ✓ Prepares SMS messages to disseminate during emergencies
- ✓ Identifies media point of contact

During the Heat Season

- ✓ Ensures adequate staff and stock of required medicine and equipment
- ✓ Keeps accurate record of pre-hospital care
- ✓ Sends messages to 108 Emergency Service employees on Heat Action Plan and heat alerts
- ✓ Activates Dynamic Strategic Deployment Plan for the ambulance service

Post-Summer Evaluation

- ✓ Provides data to key agency leaders
- ✓ Participates in annual evaluation of Heat Action Plan
- ✓ Review revised Heat Action Plan and recommend amends

Conclusion

Heat stress action plans are key to city adaptation strategies. With the forecast of increased frequency and intensity of heat waves in the future, a climate adaptive heat stress action plan will enable Rajkot to efficiently prepare, mitigate and adapt to the heat stress induced by climate change.

The action plan short, medium and long term strategies to counter the impact of heat stress. The spatially differentiated Heat Stress Action Plans (HSAPs) will serve to support Rajkot's medium-term development planning especially in prioritizing and integrating adaptive resilience within the agenda of climate-resilient smart cities.

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ANNEXURES

Annexure 1 - Climatology

Rajkot has a semi-arid climate, with hot, dry summers from mid-March to mid-June and the wet monsoon season from mid-June to October, with an average rainfall recorded of 66.7cm and average annual days being 29 days.

The city records an average annual Maximum temperature of 34.1°C and minimum of 20.9 °C throughout the year. The maximum temperature recorded in the city was 47.9 °C on 13th March, 1997 and lowest at -0.6 °C recorded on 16 Jan 1935.

Temperature	
Average annual Maximum Temp	34.1 °C
Average annual Minimum Temp	20.9 °C
Rainfall	
Average annual Rainfall	66.7 cm
Average annual Rainy days	29
Mean monthly highest rainfall observed in July	23 cm
Source: IMD, Pune	

Table 7-Rainfall Records, Rajkot City

1.1 Summer climatology

In order to analyze the changing weather patterns in Rajkot, IRADe conducted a study of Rajkot climatology for the summer season (March, April, May and June) from 2001 to 2017.

IRADe study on Summer Climatology of Rajkot revealed a significant increase in the city's temperature and decline in its humidity levels — indicating that the city is getting drier and hotter over time.

Based on data from Indian Meteorological Department (IMD) for temperature and the regional IMD centre, Rajkot, for relative humidity, IRADe analyzed the city's temperature data from 2001 to 2017 to determine its trends in maximum temperature (Tmax) and minimum temperature (Tmin) for the summer months ((March, April, May, and June) and compared it against the city's long-term climatological mean Tmax and Tmin (mean of 1905 to 2000) for the corresponding months to determine the deviation in the city's temperature trends. Similarly, it analyzed trends in morning (08:30) and evening (17:30) relative humidity for the summer months (March, April, May, and June) from 2004-2017 against the long-term climatological mean relative humidity.

Further, the study determined the variation in these climate parameters for the entire summer season (for all 122 days together) for the study duration. Table 1 gives the mean climatological values (based on IMD data from 1905 to 2000) for temperature and relative humidity for the summer months.

Month	Tmax (° C)	Tmin (° C)	RH (8:30) (%)	RH (17:30) (%)
March	35.2	18	69	21.33
April	38.6	21.7	71.33	21
May	40.3	24.8	75.16	30.16
June	37.6	26.1	79.33	50.16

Table 8- Mean monthly climatological value of temperature and relative humidity in Rajkot (Source: IMD)

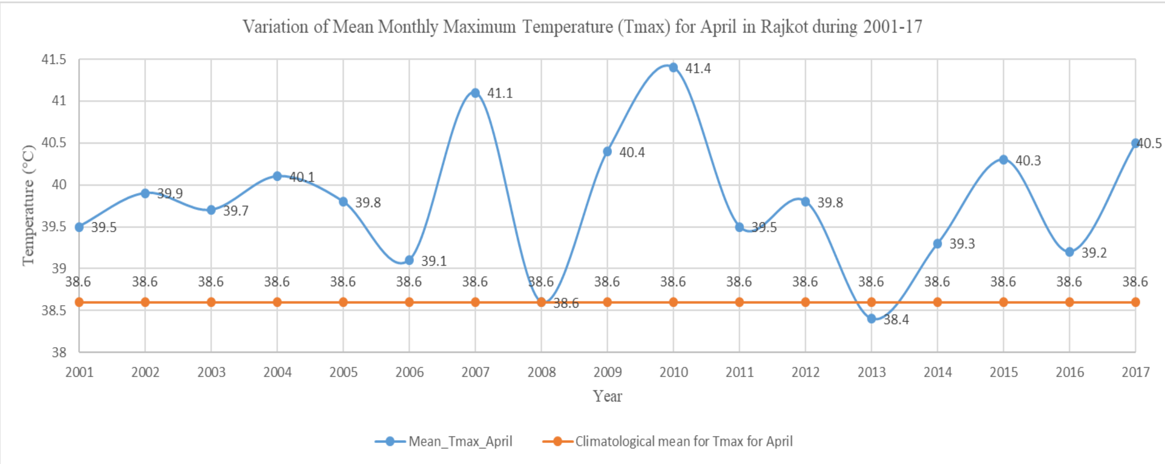


Figure 14- Variation of Tmax for April in Rajkot from 2001 to 2017

2. Higher seasonal Tmax in 16 of 17 summers studied

i. The average increase in Tmax value for the summer months of years 2001 to 2017 was 1.095 °C.
ii. Out of the 17 summers studied, 16 showed Tmax values above the climatological mean (38 °C).

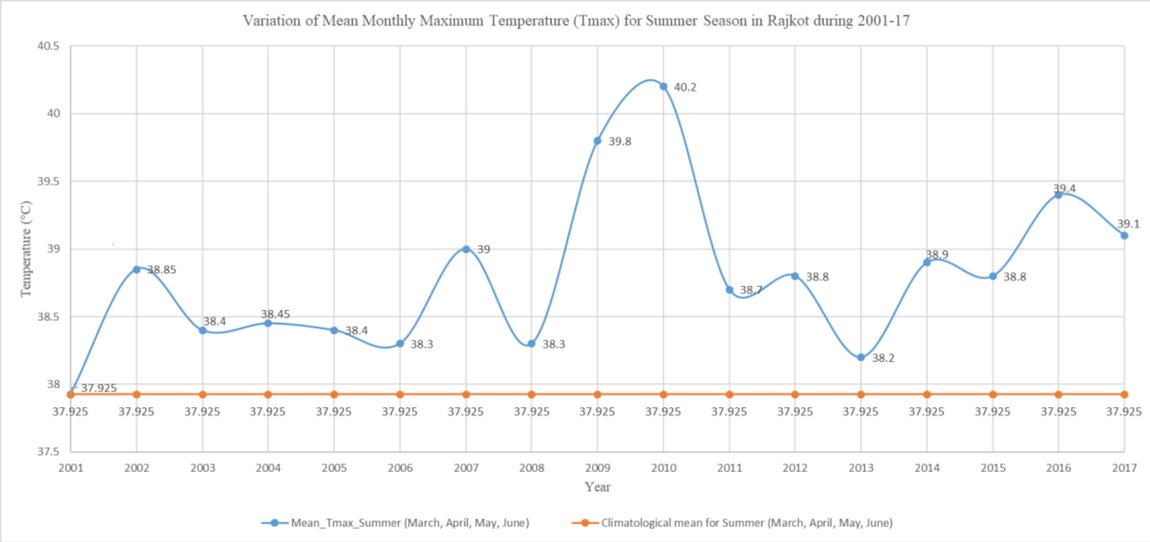


Figure 15- Variation of Tmax for the entire summer season in Rajkot from 2001 to 2017

3. Increase in minimum temperature

i. Trends in Tmin were found to be similar to trends in Tmax.
ii. The maximum deviation (increase) in Tmin value was observed for March (1.7 °C) and April (1.6 °C). Thus, March and April see increase in both minimum and maximum temperatures in comparison to reference climatological mean.
iii. Throughout, the summer months of the reference years — 2001 to 2017— show Tmin higher than the long-term climatological mean minimum temperature.
iv. March (1.7 °C) showed maximum increase in temperature followed by April (1.6 °C), June (1.2 °C) and May (0.7 °C).
v. The Tmin values for March and May were above the climatological mean for all the years studied. For March, maximum deviation (increase) was observed in 2016 (3.2 °C). For April, maximum increase was in 2015 (2.9 °C). For May and June, the maximum increase was in 2009 — 2.4 °C and 1.7 °C, respectively.

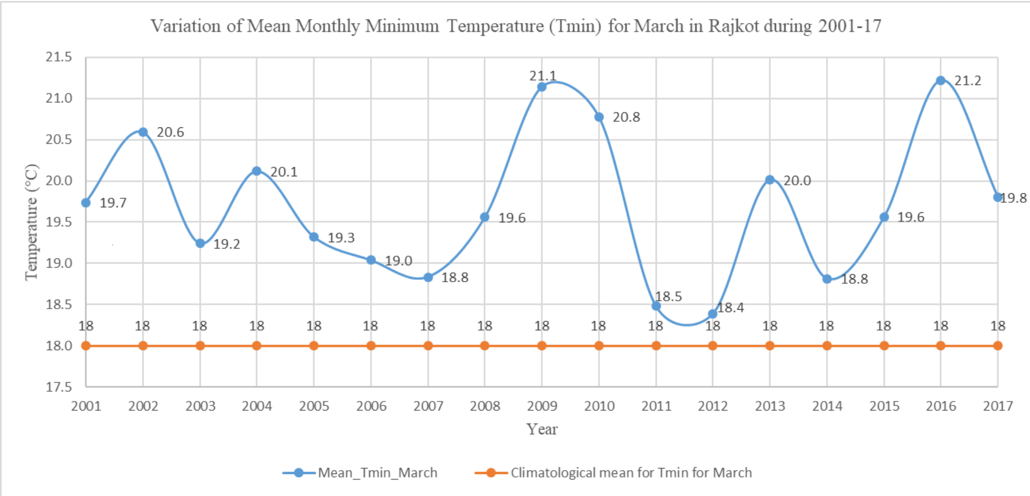


Figure 16-Variation in Tmin for March in Rajkot from 2001 to 2017

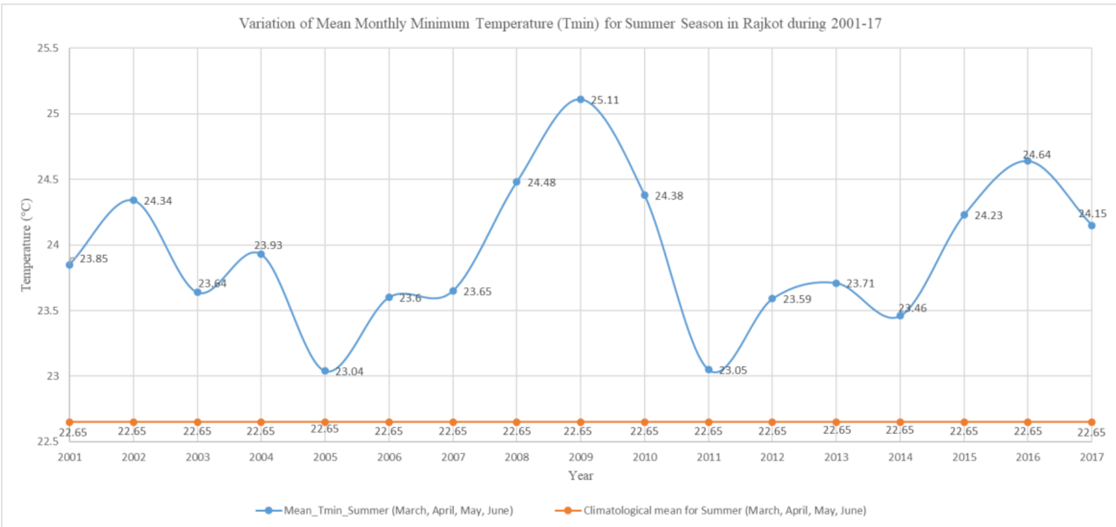


Figure 17-Variation in Tmin for the entire summer season in Rajkot from 2001 to 2017

Relative Humidity

Month (2004-2017)	RH (08:30) (%)	Average Mean RH (08:30) (%)	Deviation from Mean RH (08:30) (%)	RH (17:30) (%)	Average Mean RH (17:30) (%)	Deviation from Mean RH (17:30) (%)
March	+69	+73.705	+1.33	+21.33	+30.66	-1.27
April	+71.33		+1.12	+21		-0.48
May	+75.16		+0.42	+30.16		-1.40
June	+79.33		+0.29	+50.16		+2.46

Table 9-Rajkot's mean monthly relative humidity value (2001-1017) and deviation from long-term climatological mean for respective months (1905-2000)

5. March, May, and June are becoming drier

i. Mean monthly RH in the morning at 8: 30 hrs has decreased by nearly 1.33% in March, 0.42% in May and 0.29% in June for reference years 2004 to 2017. However, an increase of 1.12% was noticed for the month of April.
ii. March showed highest positive deviation was observed in 2009 (8.68%), whereas highest negative deviation was noticed in 2004 (-9.19%).(Can we not replace word for in the table)
iii. For April, highest positive deviation was observed in 2016 (7.54%), whereas highest negative deviation was noticed in 2005 (-13.36%).
iv. For May, highest positive deviation was observed in 2008 (3.39%), whereas highest negative deviation was noticed in 2004 (-6.93%).
v. For June, highest positive deviation was observed in 2013 (5.14%), whereas highest negative deviation was noticed in 2016 (-5.43%).
vi. Except April, morning humidity values show declining trend in the last four years (2014-17). It seems morning in Rajkot are becoming drier.

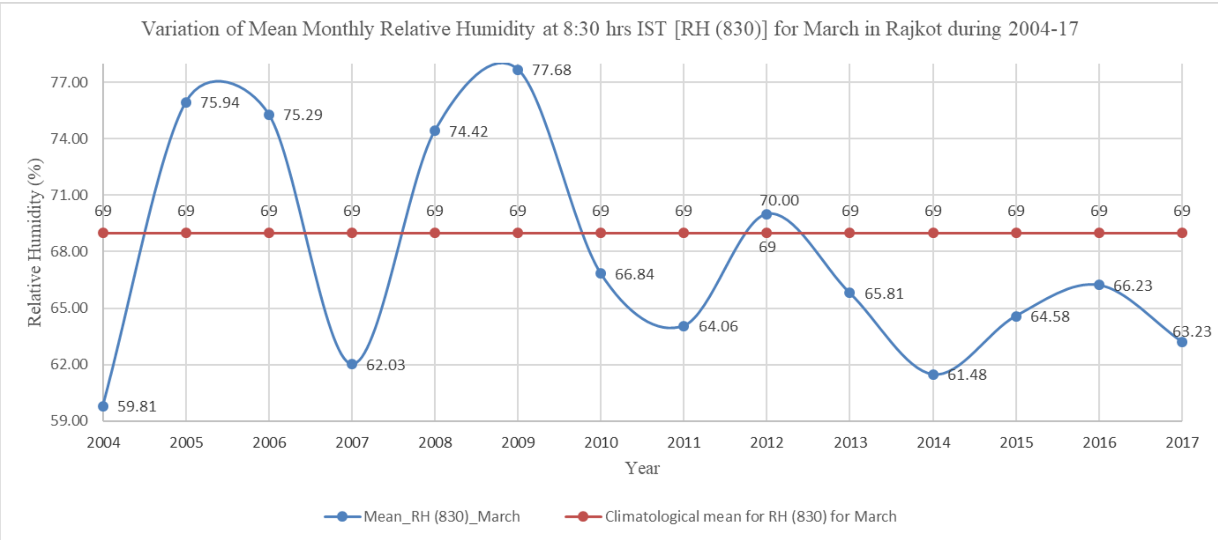


Figure 18-Variation in RH at 8:30 hrs for March in Rajkot from 2004 to 2017

6. Decline in morning relative humidity

i. The RH values measured in the mornings were below the climatological mean for 9 out of 14 years studied.
ii. Maximum positive deviation was observed in the summer of 2008 (4.75 %), whereas maximum negative deviation was observed in 2017 (-5.05 %).
iii. The mornings of the last four summers (2014-2017) were drier, recording the RH values consistently below the climatological mean.

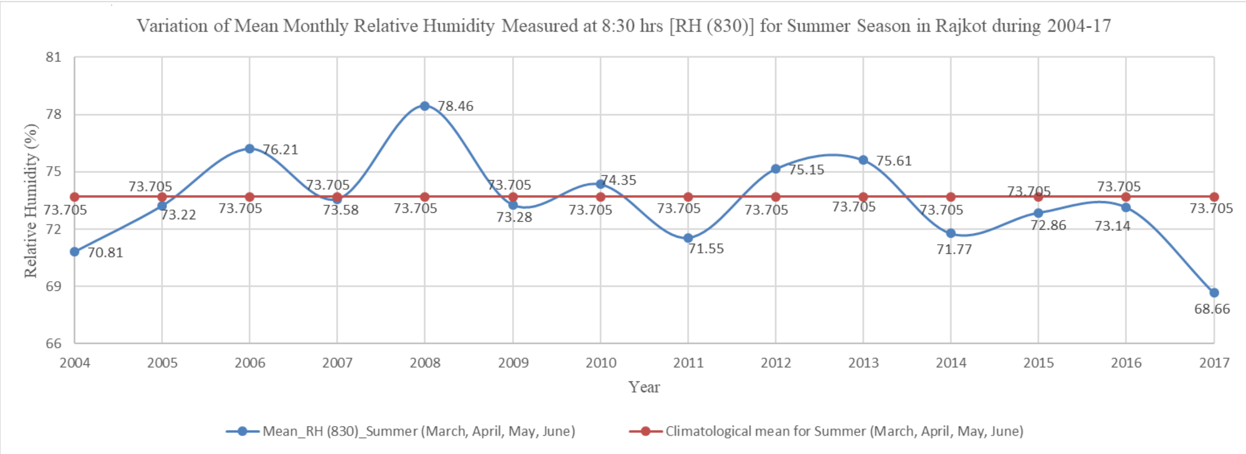


Figure 19-Variation in RH at 8:30 hrs for entire summer period in Rajkot from 2004-2017

7. March, April, and May show decline in evening mean relative humidity

i. Average change in the mean monthly evening relative humidity (measured at 17:30 hrs) for March, April, May and June months of the 14-year study period was -1.27%, -0.48%, -1.40%, and +2.46% respectively.

ii. Out of the four summer months studied, only June had shown positive deviation for the reference period.

iii. Among the four summer months analyzed, March is relatively more 'drier' having negative deviations across 11 years, out of 14 studied.

iv. It is also noteworthy that May has shown negative deviations continuously in the last five years.

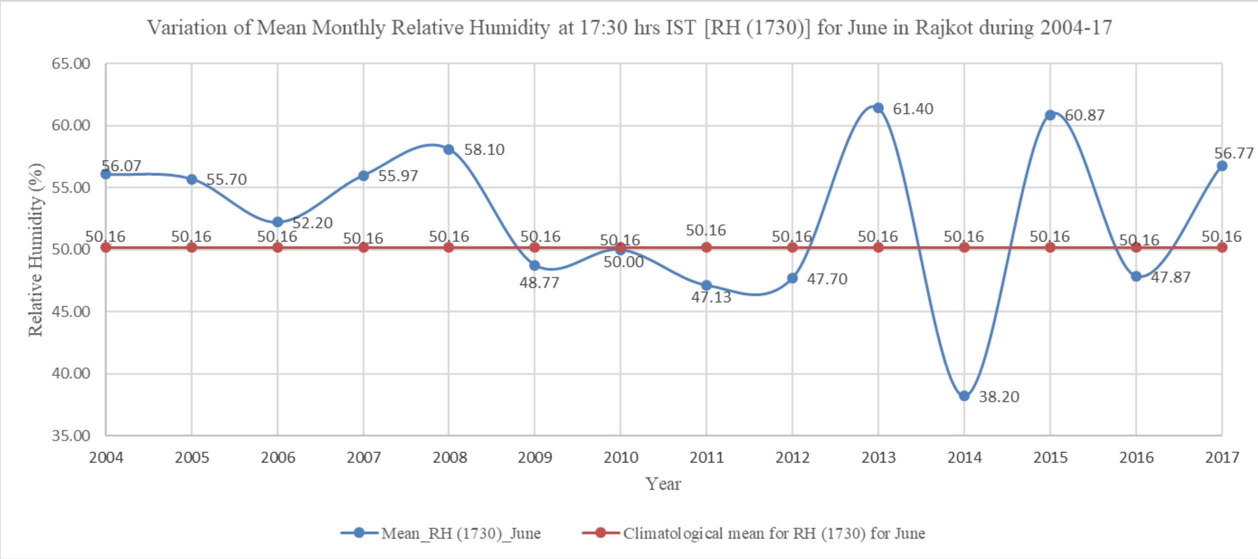


Figure 20-Variation of RH at 17:30 hrs for June in Rajkot during 2004-17

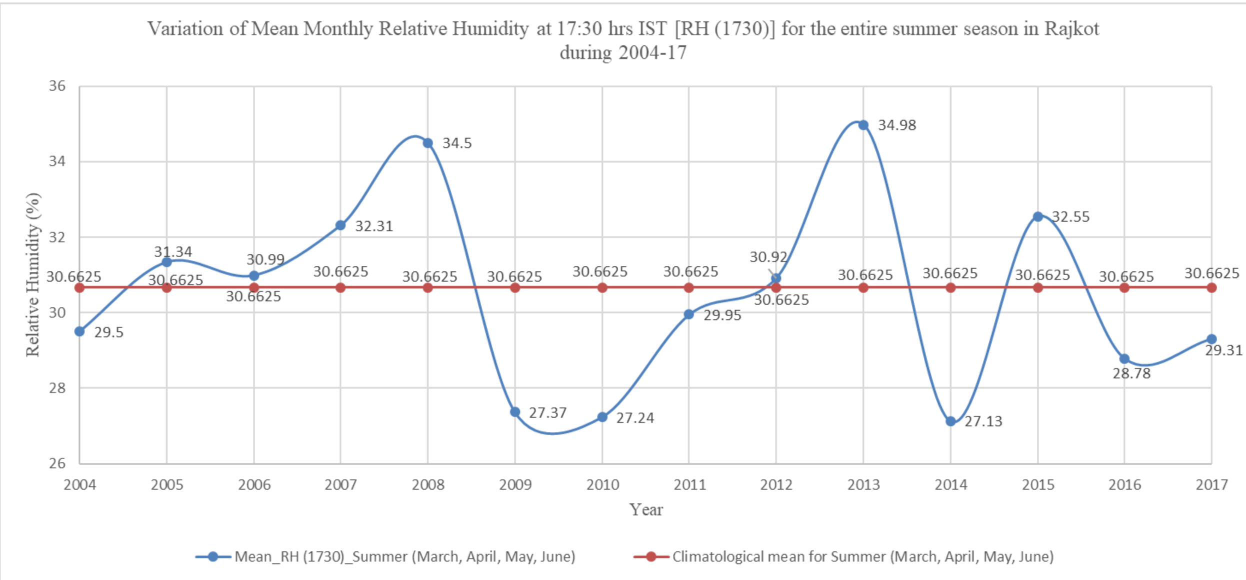


Figure 21-Variation of RH at 17:30 hrs for entire summer period in Rajkot during 2004-17

Summary

i. Climate has become hotter and drier in Rajkot.
ii. March and April months recorded significant rise in mean Tmax and Tmin.
iii. During 2001-2017, the mean Tmax for each of the summer months was above the climatological mean (1905 to 2000).
iv. Summers between 2014 and 2017 were the driest, with below average RH values.

Conclusion

The analysis of climatological parameters Tmax, Tmin and relative humidity (RH) presents a trend that indicates hotter and drier climate in Rajkot. This heating trend is more pronounced for March and April months with significant rise in mean Tmax and Tmin and decline in relative humidity. For the reference period (2001-2017), mean Tmax for each of the summer months was above the climatological mean (based on 1905 to 2000) in 16 out of 17 years. Further, for all reference years mean seasonal (March to June) minimum temperature was in excess of climatological mean. It is also worth mentioning that the last four summers (2014-2017) were, in particular, drier in the morning hours, recording the RH values consistently below the climatological mean. Though the average deviation in the RH values (for both morning as well as evening) were very less, drier years were noticed in the latter half of the study duration.

Annexure 2 –

Impact of Heat Stress on Health, Livelihood and Productivity

Low-income groups living in the slums were particularly vulnerable as the thermal hotspot in the city were in the slums and squatter settlements. The survey selected 9 thermal hotspots, where one primary and two socio-economic surveys were conducted. The primary survey included 286 households; economic survey included 282 and 202 households in the first and second fortnight surveys, respectively.

The surveyed households included construction workers, street vendors, domestic helpers and sweepers. An average household comprised 4 members. The survey captured information on the resident population's occupation, working hours, occupational pattern, mode of transportation, the impact of heat stress, and their coping capacity.

Health Impact of Heat Stress

The survey respondents found the month of May to be the hottest in Rajkot. Around 55 percent reported they feel acute discomfort between 1-2 pm. The most common problems identified were headache, excessive perspiration and thirst, fatigue, heat rash and nausea.

As per the survey, the common health issues faced by the respondents during the summer months from March to July were heat cramps — reported by 64% of respondents.

Case Definitions

Clinical Entity	Case Definition
Heat rash	Diffused, pruritic, maculopapular or vesicular rash in the setting of heat exposure, often with insulating clothing or swaddling
Heat cramps	Painful contractions of frequently used muscle groups in the setting of heat exposure, often with exertion
Heat exhaustion	Syndrome of generalized weakness and or exhaustion, often with light headedness, limiting functioning in a hot environment, without history of recent infection. May or may not be exertional.
Heat syncope	Brief loss of consciousness in the setting of heat exposure without evidence of seizure activity, stroke, or medication overdose.
Heat stroke	Altered mental status (including disorientation, delirium, seizure, obtundation) with elevated core body temperature ≥ 40°C in the setting of heat exposure, without signs of stroke, history of infection, or signs of medication overdose. May or may not be exertional.

Heat Illness- Typical Presentations

Clinical Entity	Age Range	Setting	Cardinal Symptom	Cardinal Signs	Pertinent Negatives	Prognosis
Heat Rash	All, But frequently children	Hot environment; +/- insulating clothing or swaddling	Itchy Rash with small red bumps at pores in setting of heat exposure; bumps can sometimes be filled with clear or white fluid	Diffuse maculopapular rash, occasionally pustular, at hair follicles; pruritic	Not focally distributed like a contact dermatitis; not confluent patchy; not petechial haemorrhages	Full recovery with elimination of exposure and supportive care
Heat Cramps	**All**	Hot environment typically with exertion; +/- insulating clothing or swaddling	Painful spasms of large and frequently used muscle groups	Uncomfortable appearance may have difficulty fully extending affected limbs /joints	No contaminate wound/tetanus exposure; no seizure activity	Full recovery with elimination of exposure and supportive care
Heat Exhaustion	**All**	Hot environment; +/- exertion; +/- insulating clothing or swaddling	Feeling overheated, lightheaded, exhausted and weak, unsteady, nauseated, sweaty and thirsty, inability to continue activities	Sweaty/Diaphoretic; Flushed skin; hot skin; normal core temperature; +/- dazed, +/- generalized weakness, slight disorientation	No coincidental signs and symptoms of infection, no focal weakness, no aphasia, /dysarthria, no overdose history	Full recovery with elimination of exposure and supportive care; progression if continued exposure
Heat Syncope	Typically, adult	Hot environment; +/- exertion; +/- insulating clothing or swaddling	Feeling hot and weak; light-headedness followed by brief loss of consciousness	Brief Generalized loss of consciousness in hot setting, short period of disorientation if any	No seizure activity, no loss of bowel or bladder continence, no focal weakness, no aphasia/dysarthria	Full recovery with elimination of exposure and supportive care, progression if continued exposure

Heat Stroke	**All**	Hot environment; +/- exertion; +/- insulating clothing or swaddling	Severe overheating, profound weakness, disorientation, obtundation, seizures or other altered mental status	Flushed dry skin (not always), core temperature ≥ 40-degree C, altered mental status with disorientation, possibly delirium, coma, seizures, tachycardia, +/- hypotension	No coincidental signs and symptoms of infection; no focal weakness; no aphasia/dysarthria, no overdose history	25-50% mortality even with aggressive care, significant morbidity if survive

2.1 Gender-specific Vulnerability

Men, women, pregnant women, children and elderly may have different levels of endurance for heat stress. In this survey, the male respondents mostly reported heat rash while majority of the women reported heat exhaustion, heat rash and heat cramps during the summer months. Most children and senior citizens also complained of heat rash as well as heat exhaustion. This indicates greater vulnerability of children, women and senior citizens.

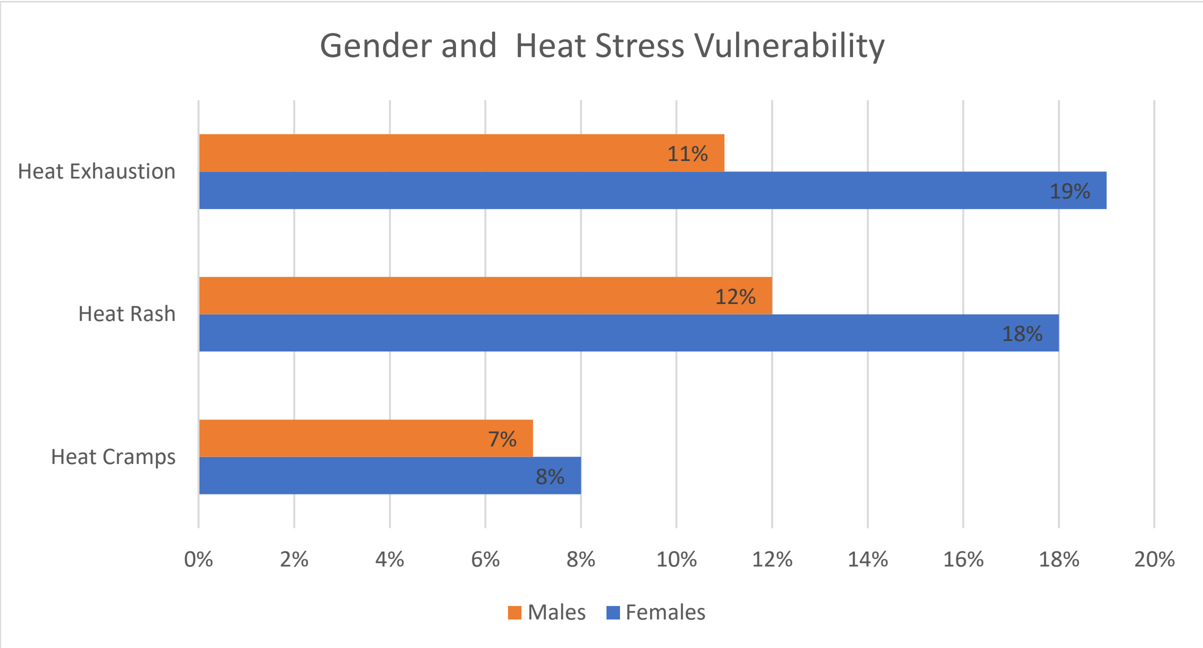


Figure 22-Gender and Heat Stress Vulnerability

Whereas most common heat stress effect reported among men were heat rash (12%), heat exhaustion (11%) and heat cramps (7%), among the women it was heat exhaustion(19%), heat rash (18%) and heat cramps (8%), indicating greater vulnerability and acuteness of the symptoms.

5.2 Age-specific Vulnerability

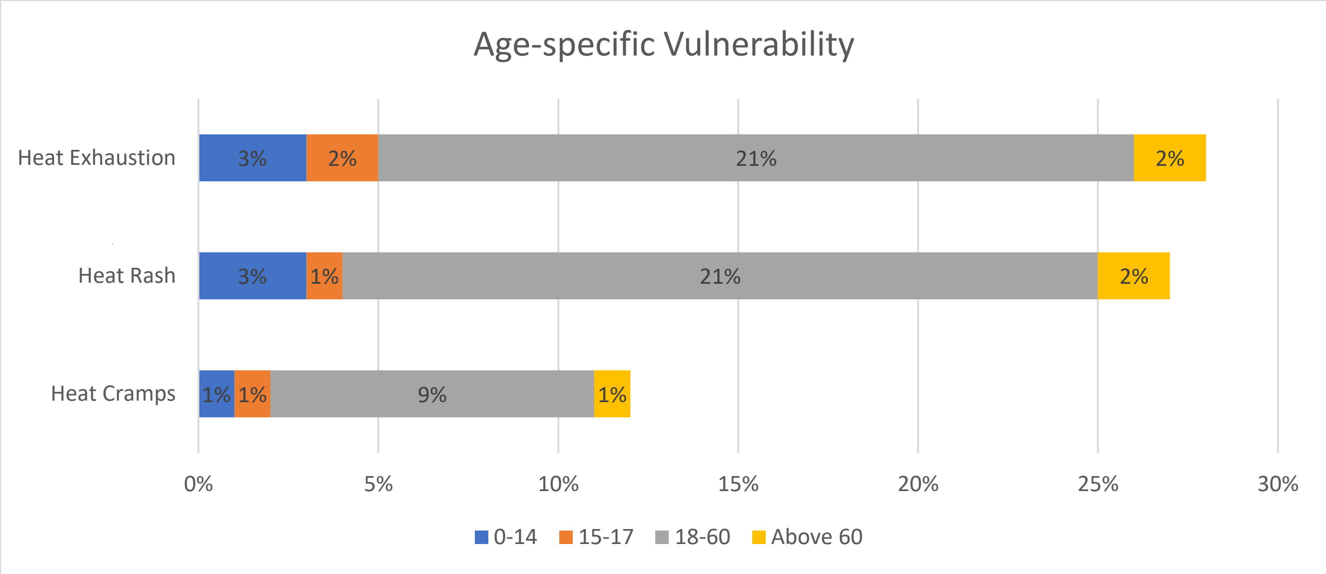
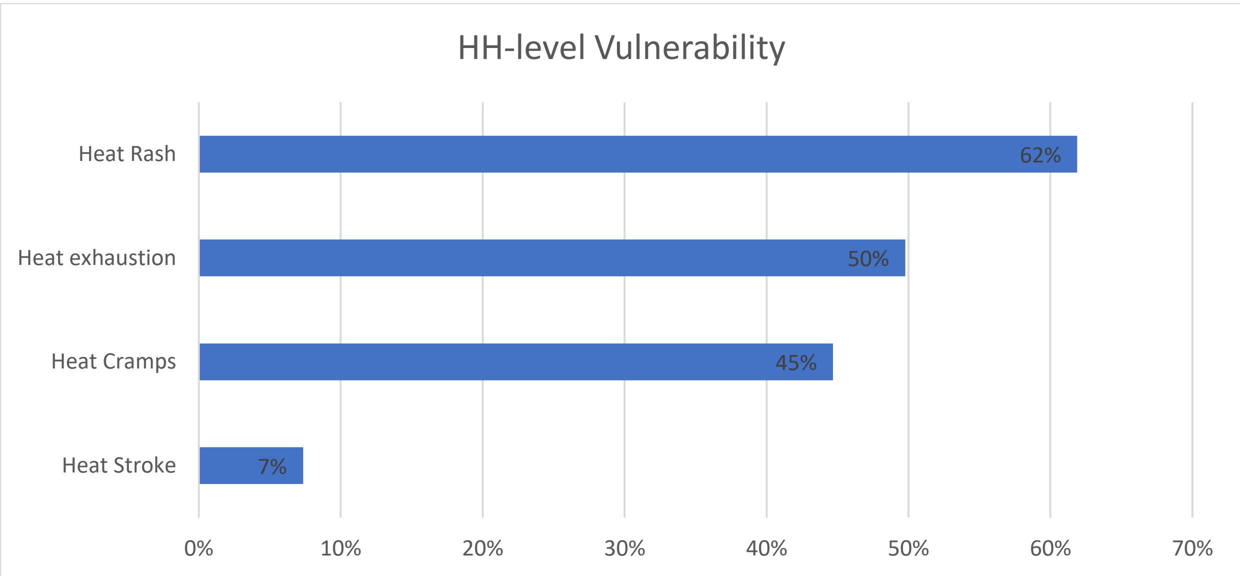


Figure 23-Age-specific Vulnerability

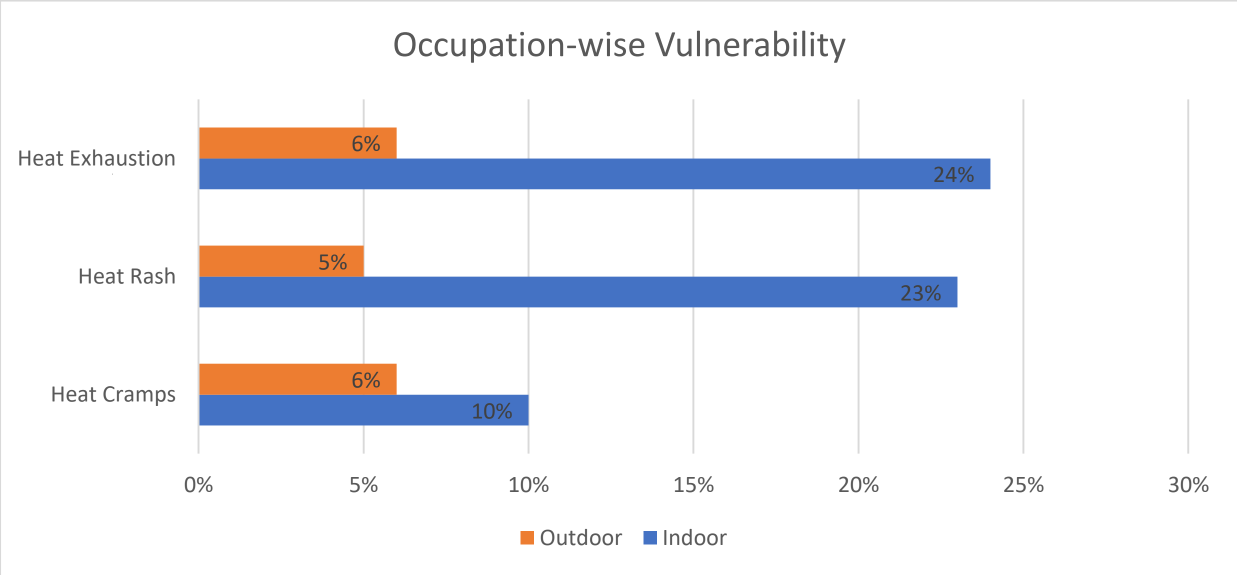
In the sample population surveyed, 3% children suffered each from heat exhaustion and heat rash, which is higher than 2% incidence of heat exhaustion among the adolescents. Adults report maximum incidence of heat exhaustion (21%), heat rash (21%) and heat cramps (9%), perhaps given their greater exposure. Senior citizens reported heat rash and heat exhaustion at 2% each.

5.3 Household-level Heat Stress Vulnerability



At household level, 62% respondents reported heat rashes, the first sign of heat stress; 45% households reported heat cramps, the second stage of heat stress. Heat Exhaustion, the third stage, was reported by 50% Households, and alarmingly heat stroke incidence was reported by 7% households.

5.4 Occupation-wise Vulnerability



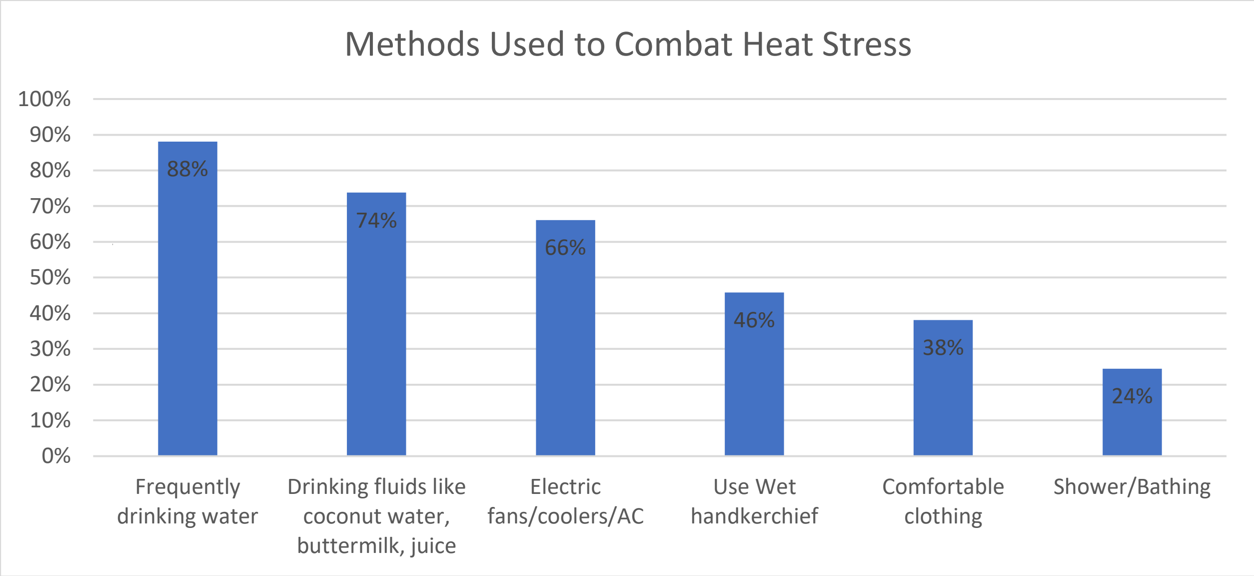
Significantly, the vulnerability of indoor workers to heat stress was found to be significantly higher than that of outdoor workers. The incidence of heat stress symptoms among the indoor workers were heat rash 23%, heat exhaustion 24% and heat cramps 10% compared against heat stress incidence rate among the outdoor workers at heat rash 5%, heat exhaustion 6% and heat cramps 6%.

5.5 Impact on Livelihood and Productivity

Around 11% of the sample population reported that they get sick within one month of the summer onset. Of these, 3% respondents said that heat-related debility forces them to abstain from work for 1 to 5 days during the peak summer. The survey also found the population working for 6 to 10 hours decreased from 50% to 49% in summers and around 2% altered work hours due to heat. About 1% of the respondents said that the work timing adjustments led to wage loss of up to Rs. 100 a day.

5.6 Coping with Heatwave

The survey found that the population in the thermal hotspots had little means for coping with high temperature or heatwaves. Over 90% of the respondents had peak summer month electricity bill of under INR 1000. To beat the heat, most respondents sleep on the floor (58%) and soak the walls and floor with water to cool it down (12%).



The other coping strategies identified by the respondents were drinking water frequently (88%), drinking fluids like coconut water, buttermilk, other juices (74%), using electric fans/coolers/ACs (70%), using hand fans (66%), using wet handkerchief (46%), wearing comfortable clothing (38%) and taking shower/bath (24%).

Annexure 3 –

Local Factors of Vulnerability and Adaptation Strategies

After identifying the 9 hotspots in Rajkot city, IRADe surveyed the wards to assess the housing infrastructure including the size of housing units, ventilation, cooking area, water supply, sanitation, and access to clean fuel, electricity as well as their awareness of the health complications from heat stress, and access to medical facilities and the health impacts of high temperature or heatwaves among the residents. All these factors influence the community's resilience and preparedness for high temperature or heatwaves.

This section analyses the specific vulnerabilities of nine thermal hotspots based on the above criteria. Local adaptive and mitigating action to address these vulnerability concerns can have a positive impact in developing the city's resilience to heatwaves. The following sections discuss the survey findings and suggest adaptive measures.

Table 1: The 9 thermal hotspots in Rajkot city

Surveyed hotspot ward name	Ward number
Rajyadhar	1
Bhimrav Nagar, Pradyuman Park, Sadhu Vasvani Road	5
Jay Bhimnagar	10
Bharatnagar	11
Bajrang Society Rashulpura	12
Ambedkar Nagar	13
Liludiwonkdi	14
BharatNagar 1	15
Shitaldhara	18

Vulnerability Factors

Access to weather conducive housing is a very vital factor for developing a city's resilience to high temperature and heatwaves. Factors like the type of housing, building material used, ventilation, location of cooking area, number of rooms, type of the flooring and roof, type of walls and colour of walls all influence heat absorption and retention. Each of these factors (see Figure 1) were individually analysed in assessing the resident's vulnerability.

6.1 Nature of housing

Cement was the main wall material in 98% of homes. Cement also was the common material (64%) used for the flooring. Houses also used tiles, polished stones and brick as flooring material. Asbestos sheet was the dominant type of roof material followed by RCC, RBC, cement and concrete. Thus most homes are prone to high Urban Heat Island effect and prone to expose the residents to the impact of heat wave.

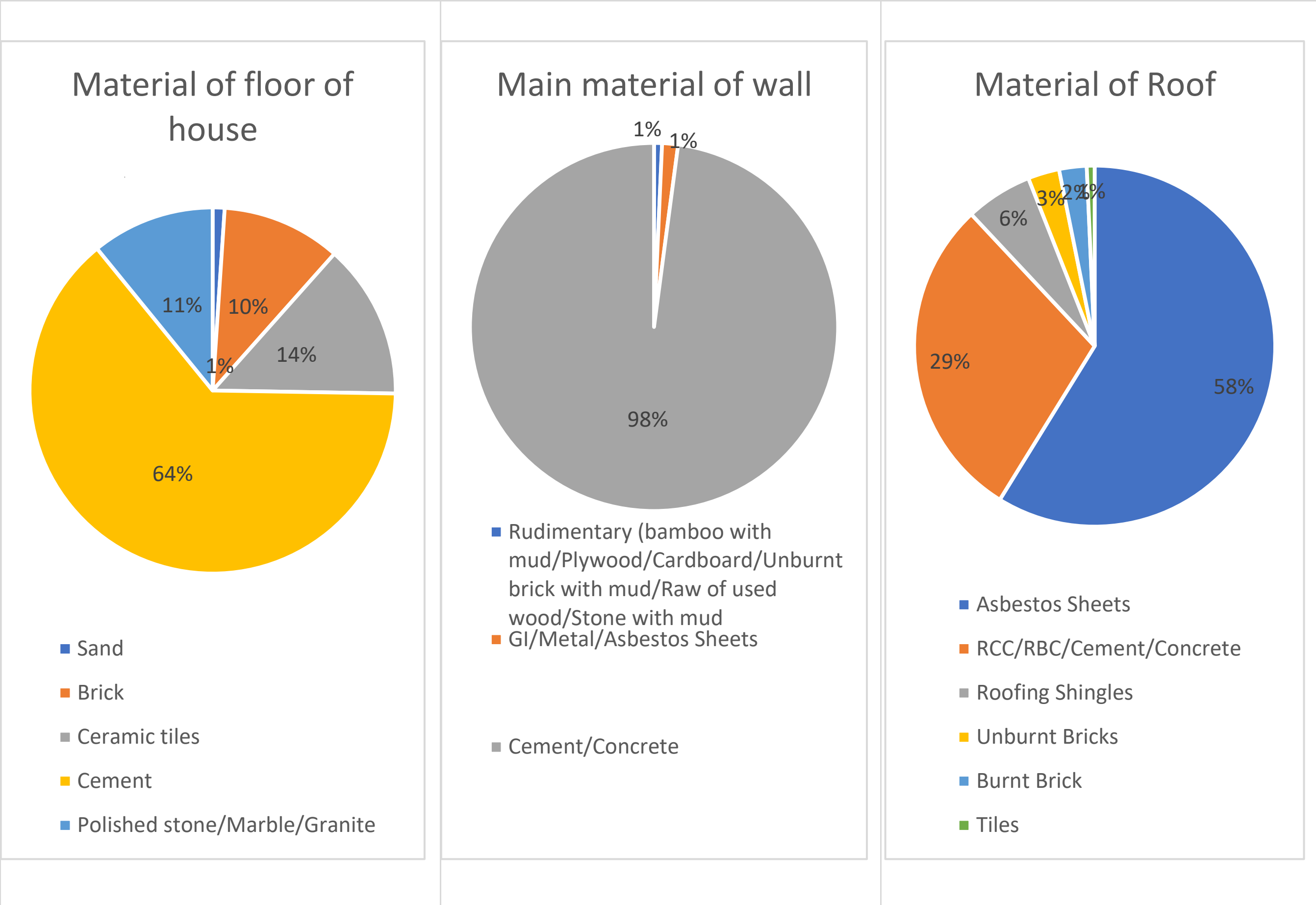


Figure 24-Building material in use

6.2 Better Ventilation and Heat Reflective Outer Wall

Ventilation was almost absent in the surveyed and were therefore found to be highly vulnerable to heatwaves. About 11 percent of the surveyed households had no windows altogether; 30 percent had only one window and 28 percent had 2 windows (See Figure 2). Lack of ventilation or poor ventilation leads to heat build-up. This can acerbate heat related illness. Of the surveyed houses only 77% used reflective exterior paint or wall coat to control heat absorption. As a well-ventilated house provides cooling through aeration and heat dissipation, RMC housing design byelaws need to make it mandatory as an adaptive and mitigative measure.

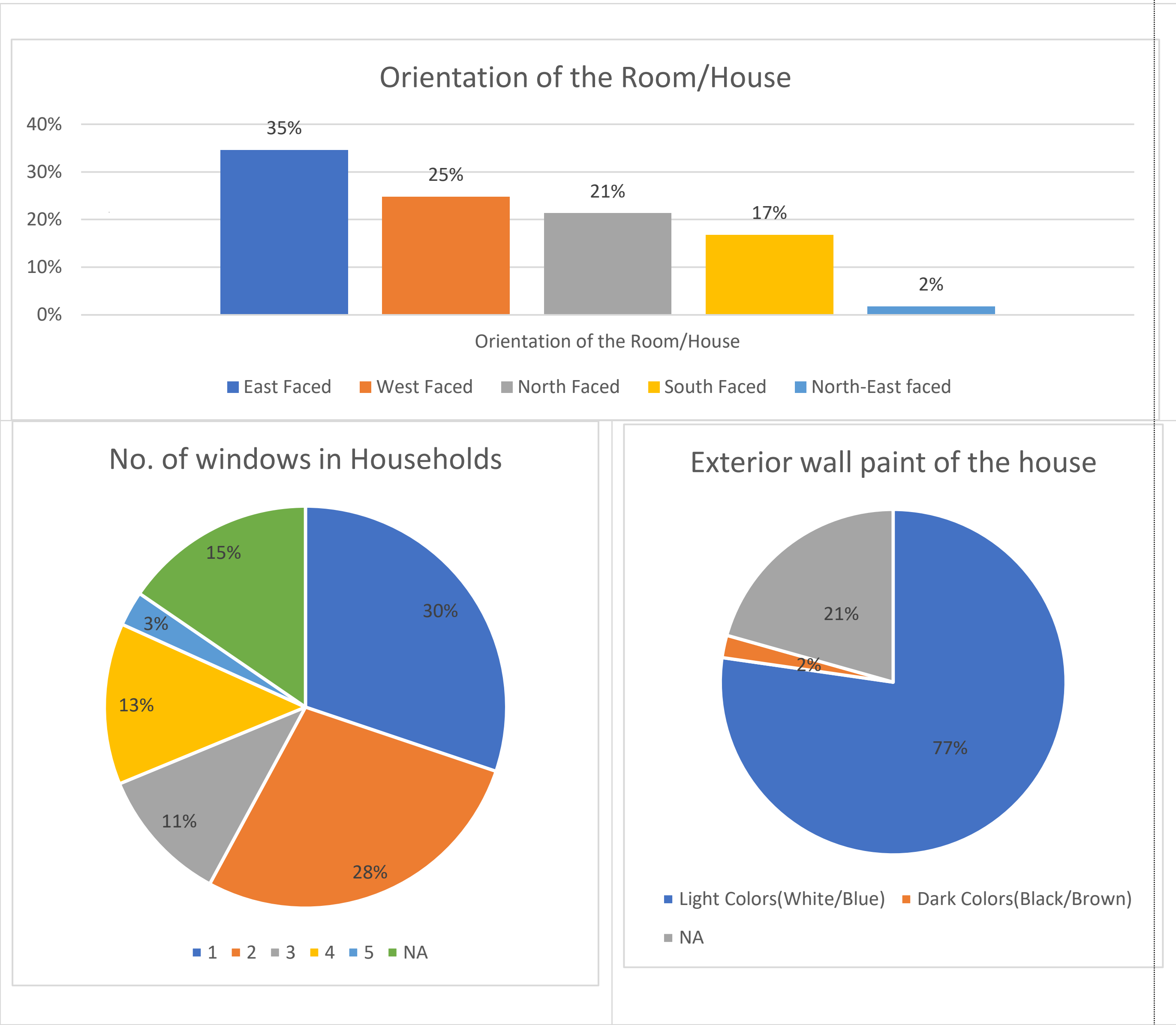


Figure 25-Housing unit orientation, ventilation, and use of reflective wall paint

6.3 Cooking Fuel and Cooking Area

All surveyed households use clean fuel — 96% households use LPG, 3% use electricity and 1% biogas. Therefore, the cooking fuels used are not the matter of concern. However, unplanned or improper location and ventilation of cooking area can trap heat in the living area. This is of concern particularly in small housing units.

6.4 Access to Piped Water

Of the surveyed houses, only 44% had access to piped water supply and only 42% houses had supply inside the house. The remaining 58% houses sourced water for their needs from public taps, tube-wells, or tankers (See Figure 3). Those who did not have piped water supply inside their house, spent from a few minutes to over an hour in collecting water.

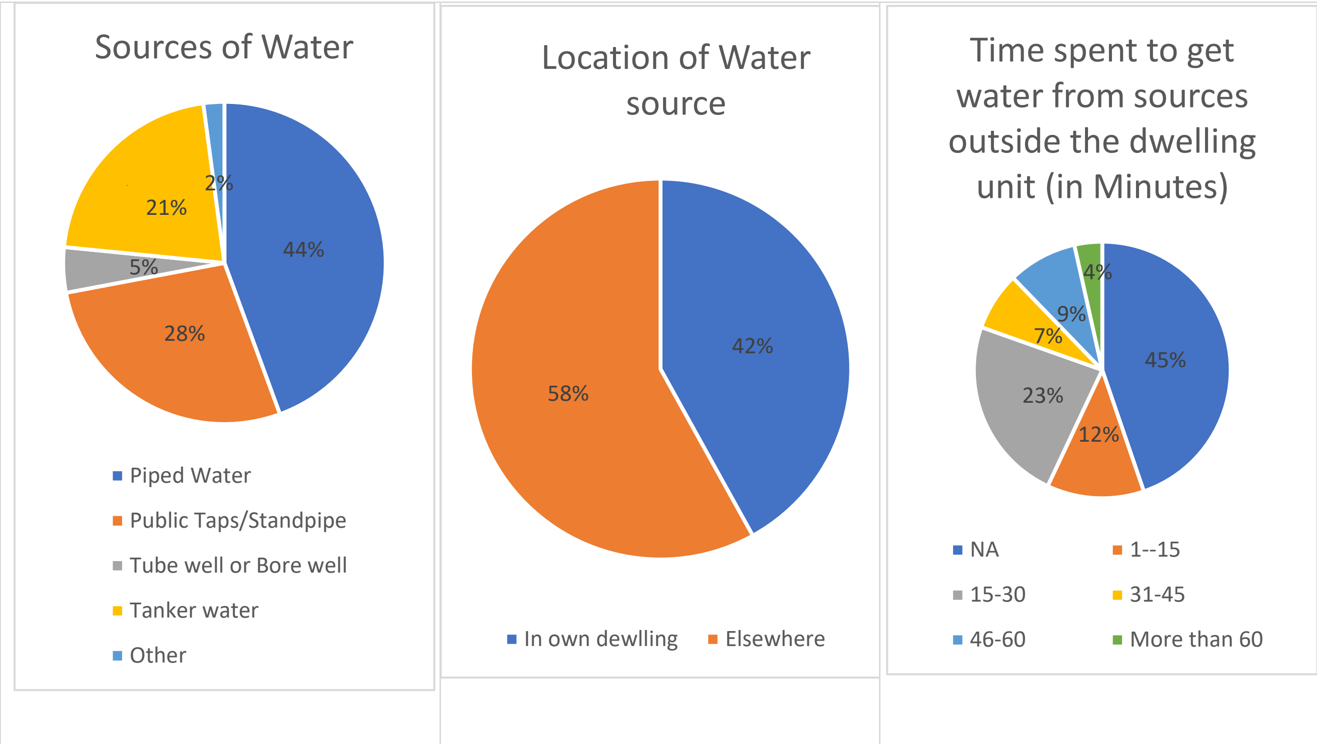


Figure 26-Source of household water supply

Further, 73% of the surveyed households get water supply once a day, 7% once in many days, 4% houses get it twice a day and 16% have 24-hour supply. Also noteworthy is the household water storage capacity, which was found to be far below the service level benchmark (See Figure 4).

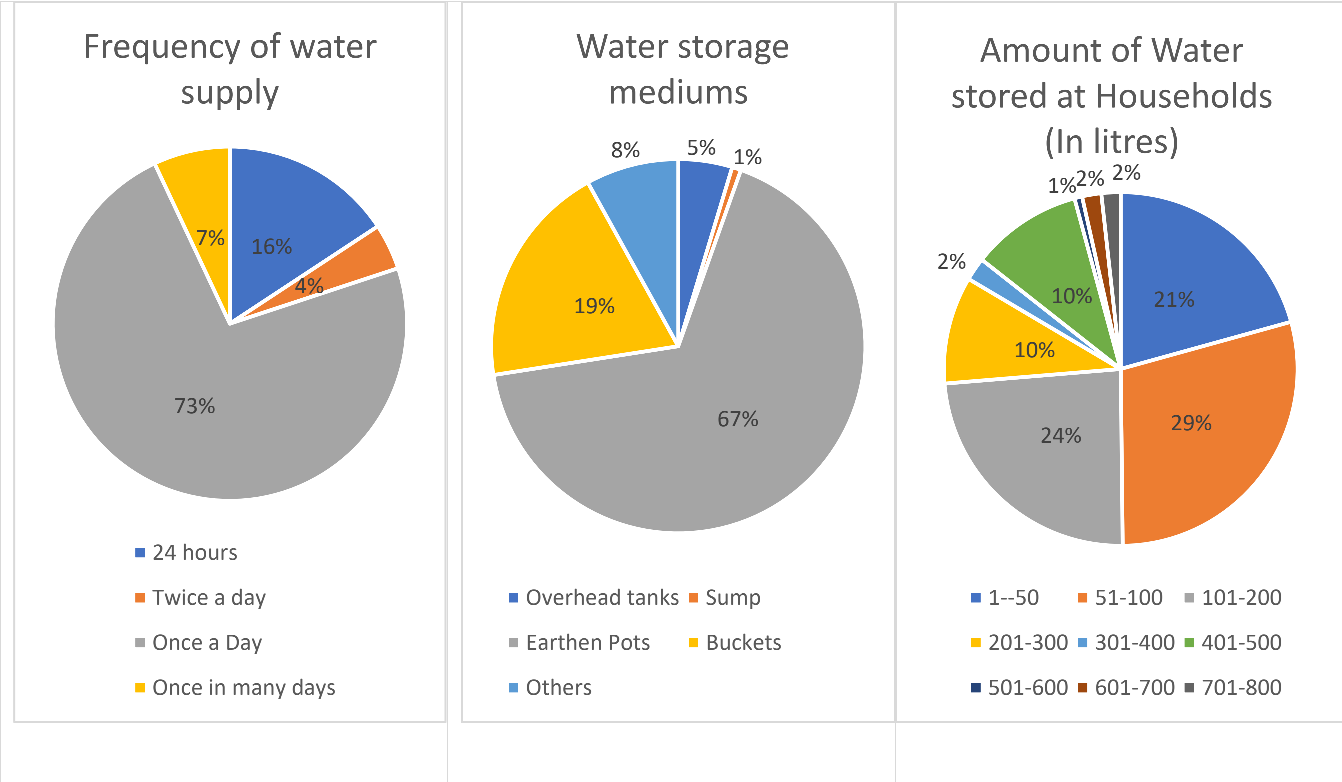


Figure 27-Frequency of water supply and household water storage capacity.

6.5 Access to Sanitation

The survey showed that only 82% of the households had toilets, either pit latrines or flush toilets. Of these, about 16% of households shared toilets. Members of 14% households either used community toilets or practiced open defecation (See Figure 5). Access to sanitation and piped water supply for all households is major step for checking peak summer disease caseloads.

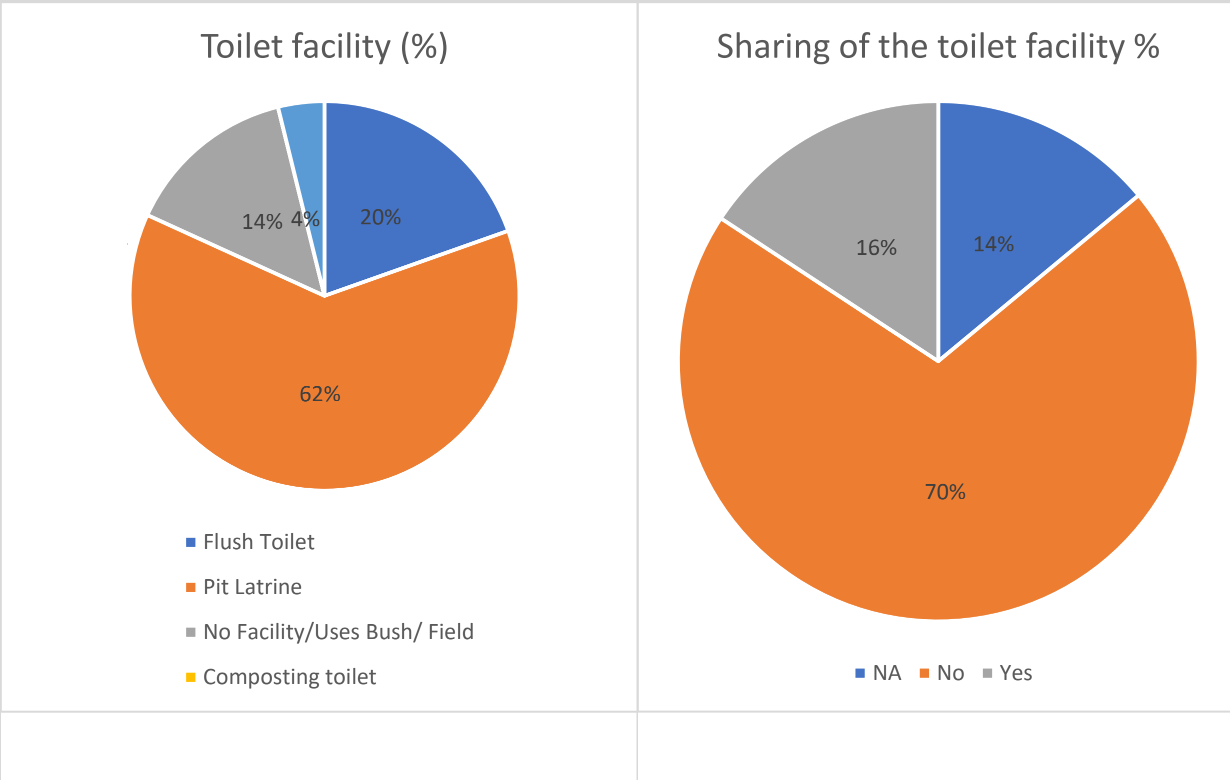


Figure 28-Access to sanitation in 9 hotspot wards

6.6 Access to Electricity

Rajkot was found to have a reliable electricity supply to all areas. Of the surveyed households 98% reported uninterrupted access to electricity. Of the remaining 2% households, 1% did not have electricity connection and the other 1% reported electricity supply for 15 hours a day. About 7% of the sampled households reported minor outages during summers (see Figure 6). This factor, therefore, poses low vulnerability.

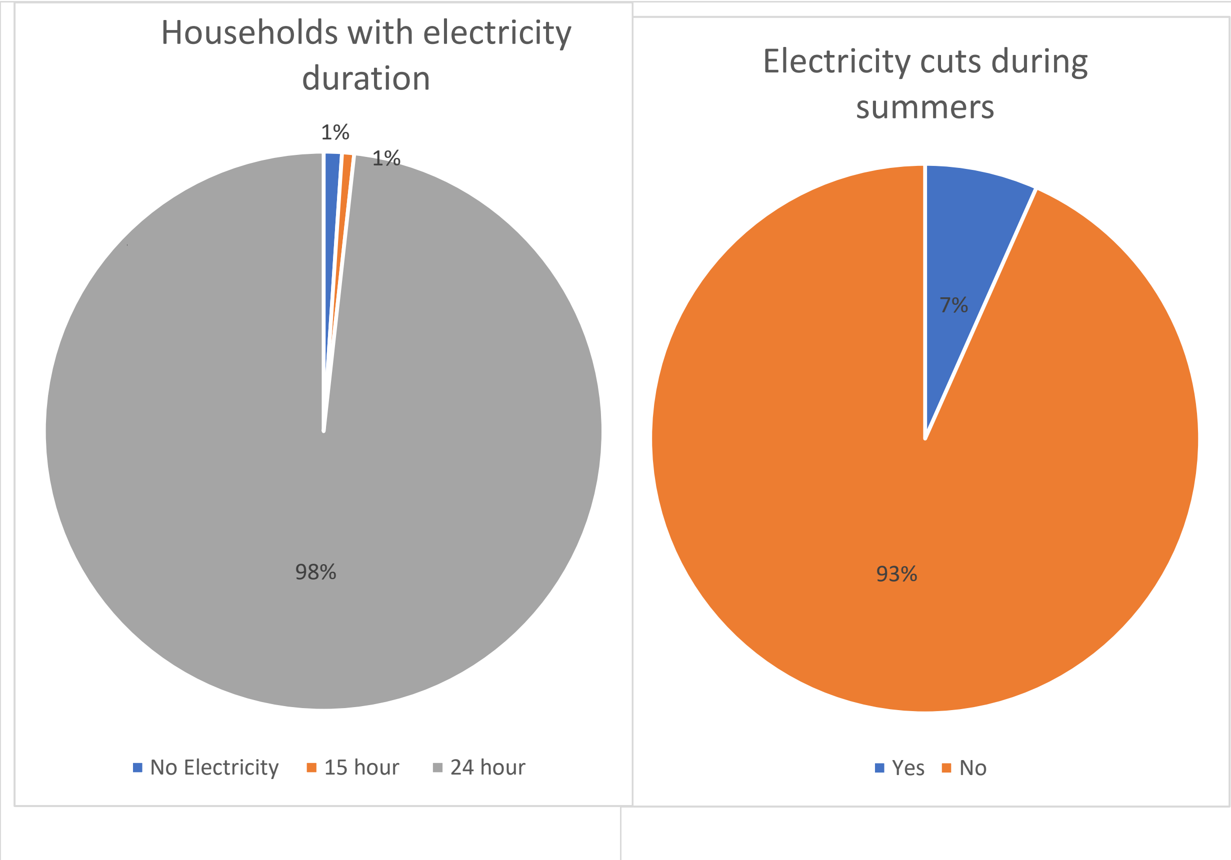


Figure 29-Access to electricity

6.7 Awareness of Heat Stress, treatment and Mitigative Adaptive Strategies

General awareness of heat stress, heat sickness treatment and mitigation strategies among the surveyed households was found to be abysmal. The following the key highlights of the survey findings:

Only 16% the sample population was aware of the term heat stress.

About 32% of the sample households knew that medical facilities offer treatment for heat stress.

Only 5% of the sample households were aware of the adaptive mitigation strategies followed by the government.

Only 32% surveyed households had health insurance.

63% households affected by heat stress did not access government facilities for treatment owing to long distance, long waits, facility OPD timing, poor care, and absenteeism of healthcare staff.

Annexure 4 - Assessment of Ward Wise Vulnerability

Total 9 hotspots were identified in Rajkot city. To study the impacts of extreme heat events on health, work productivity and livelihoods of vulnerable population is determined using comprehensive index which includes the sectors namely ***Sanitation, Water, Electricity, Health, Transportation, Housing, Cooking, Awareness and Heat symptoms*** and their respective sub sectors (

Table *10*), IRADe surveyed the wards. All these factors influence the community's resilience and preparedness for high temperature or heatwaves

This section analyses the specific vulnerabilities of nine thermal hotspots based on the above criteria. Local adaptive and mitigating action to address these vulnerability concerns can have a positive impact in developing the city's resilience to heatwaves. The following section discusses the survey findings of each hotspot in respective sectors.

SECTORS	SUB - SECTORS
Sanitation	Type of Toilet
	Separate Toilets
Water	Water Source
	Water Source Location
	Water Collection Time
	Frequency Water Supply
Electricity	Electricity Cut-off
Health	Access to Health Infra- Public/Private/Both
	Distance Hospital
	Health Insurance
Transportation	Preferred Mode of Transport
Housing	Years of Occupancy
	Number of Rooms
	Type of House
	Floor Type
	Roof Type
	Wall Type
	Wall Colour
Ventilation	Number of Windows
Cooking	Cooking Place
	Type of Cooking Fuel
Awareness	Heat Stress Awareness
	Aware of Medical facilities for Heat
	Aware of Medical measures ULB
Heat Stress Symptoms	Heat Exhaustion

Table 10 Established Sectors and Sub - Sectors to determine ward wise vulnerability

Ward Wise vulnerable zones:

Cumulative ward Vulnerability

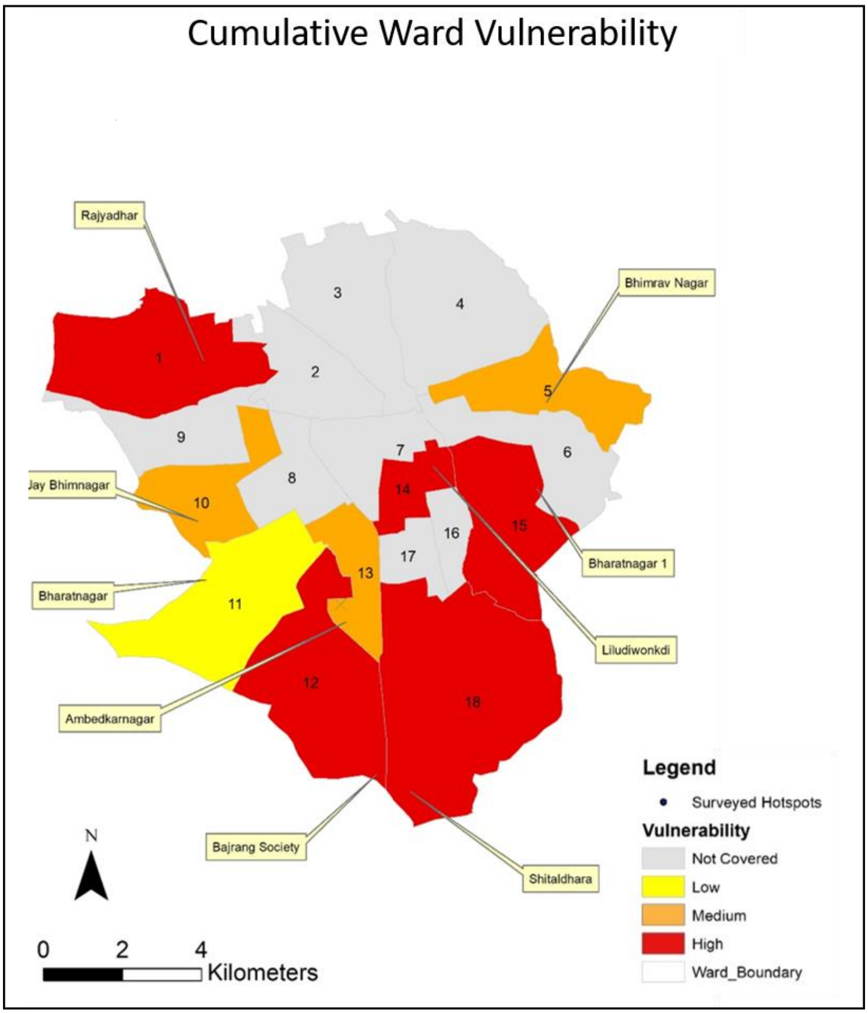


Figure 30 Map Depicting Cumulative Ward Vulnerability in identified Hotspots

Vulnerable wards	Wards Number	Total
Low	(11)	1
Medium	(10 , 13 , 5)	3
High	(14 , 15 , 18 , 12 , 1)	5

Table 11 Table depicting the nature of ward Vulnerability

The ward wise cumulative vulnerability provides the overall vulnerability of identified hotspots in the city.

Factoring in all vulnerability factors, 5 of 9 wards were found to be highly vulnerable. Three wards presented medium vulnerability and one ward presented low vulnerability.

Housing Condition: *Nature of Housing*

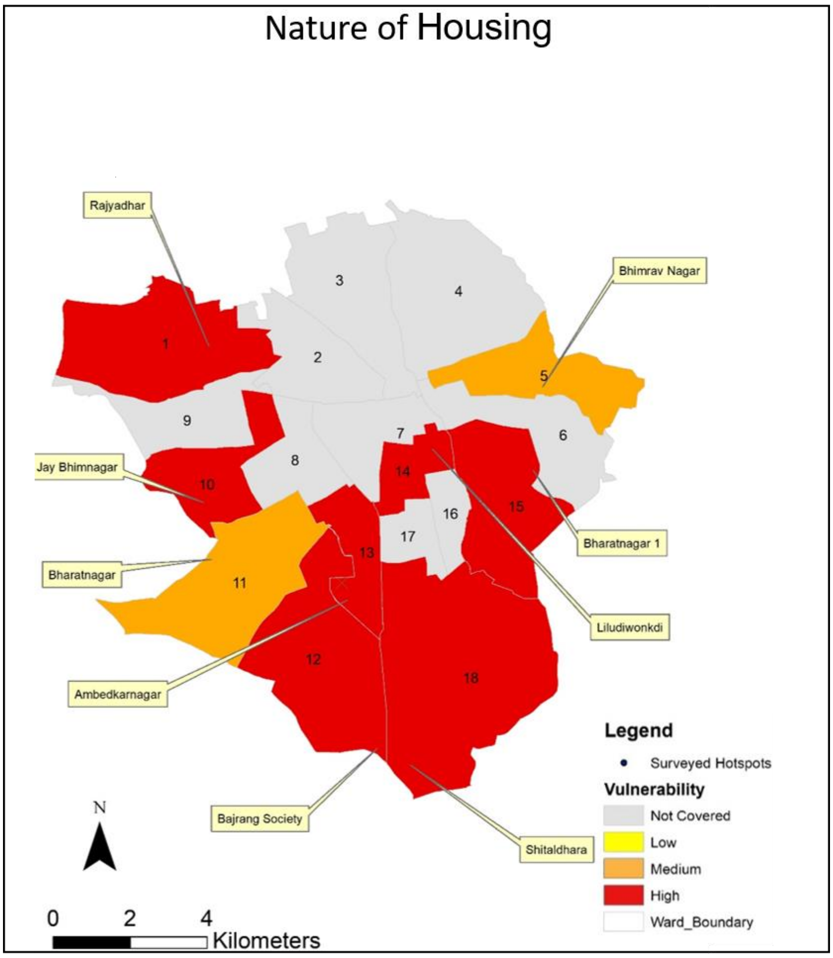


Figure 31 Map Depicting the Nature of housing in identified Hotspots

Vulnerable ward	Wards Number	Total
Low	Nil	**Nil**
Medium	(5, 11)	**2**
High	(1, 10 , 12 , 13 , 14 , 15 , 18)	**7**

Table 12 Table depicting the nature of ward Vulnerability

Access to weather conducive housing is a very vital factor for developing a city's resilience to high temperature and heatwaves. Factors like the type of housing, building material used, ventilation, location of cooking area, number of rooms, type of the flooring and roof, type of walls and colour of walls all influence heat absorption and retention. Each of these factors were individually analysed in assessing the resident's vulnerability.

Housing was found to be a major concern in all of nine wards. Of these, seven wards are highly vulnerable — 1, 10, 12, 13, 14, 15 and 18, and two wards — 5 and 11— showed medium range of vulnerability.

Better Ventilation

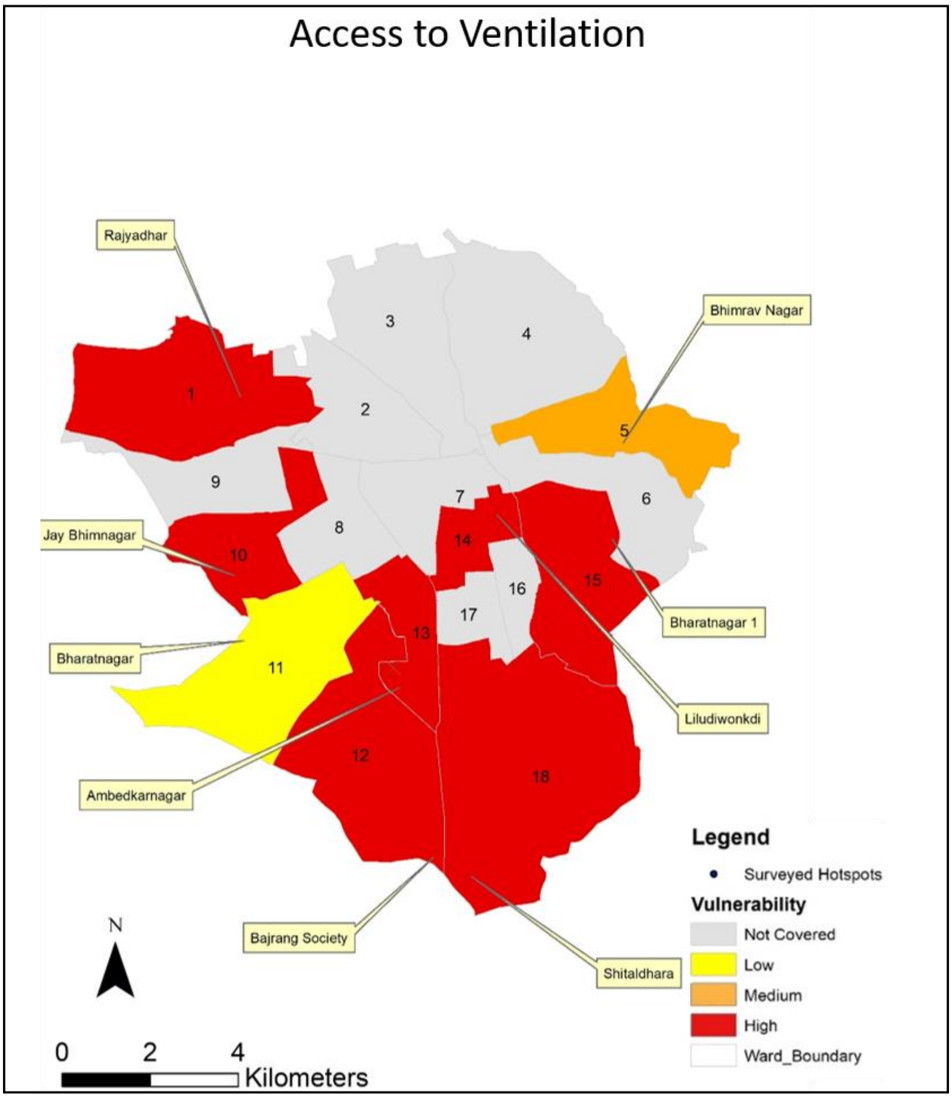


Figure 32 Map Depicting the Access to Ventilation in identified Hotspots

Vulnerable wards	Wards Number	Total
Low	(11)	1
Medium	(5)	1
High	(1 , 10 , 12 , 13 , 14 , 15 , 18)	7

Ventilation was almost absent in the surveyed houses in ward numbers 1, 10, 12, 13, 14, 15, and 18, and were therefore found to be highly vulnerable to heatwaves. Similarly, ward number 5 showed medium vulnerability and ward number 11 showed low vulnerability.

As a well-ventilated house provides cooling through aeration and heat dissipation, RMC housing design byelaws need to make it mandatory as an adaptive and mitigative measure.

Table 13 Table depicting the nature of ward Vulnerability

Infrastructure Services: ***Access to Water***

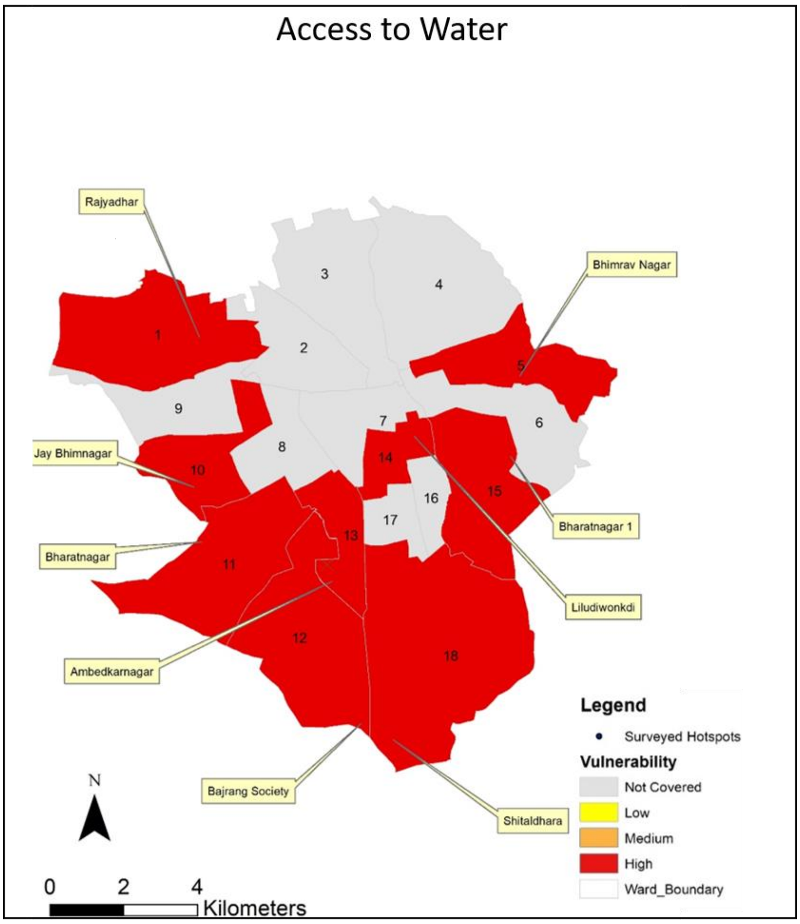


Figure 33 Map Depicting Access to water in identified Hotspots

Vulnerable wards	**Wards Number**	**Total**
Low	Nil	**Nil**
Medium	Nil	**Nil**
High	(1, 5, 10 , 11 , 12 , 13 , 14 , 15 , 18)	**9**

All the nine hotspots in the city — ward numbers 1, 5, 10, 11, 12, 13, 14, 15 and 18 — are vulnerable to the lack of access to water. The factors responsible for the high vulnerability includes unsustainable water sources such as tanker water, water source location situated outside the premises, irregular frequency of water supply which includes water being supplied once a day and likewise.

Table 14 Table depicting the nature of ward Vulnerability

Access to Sanitation

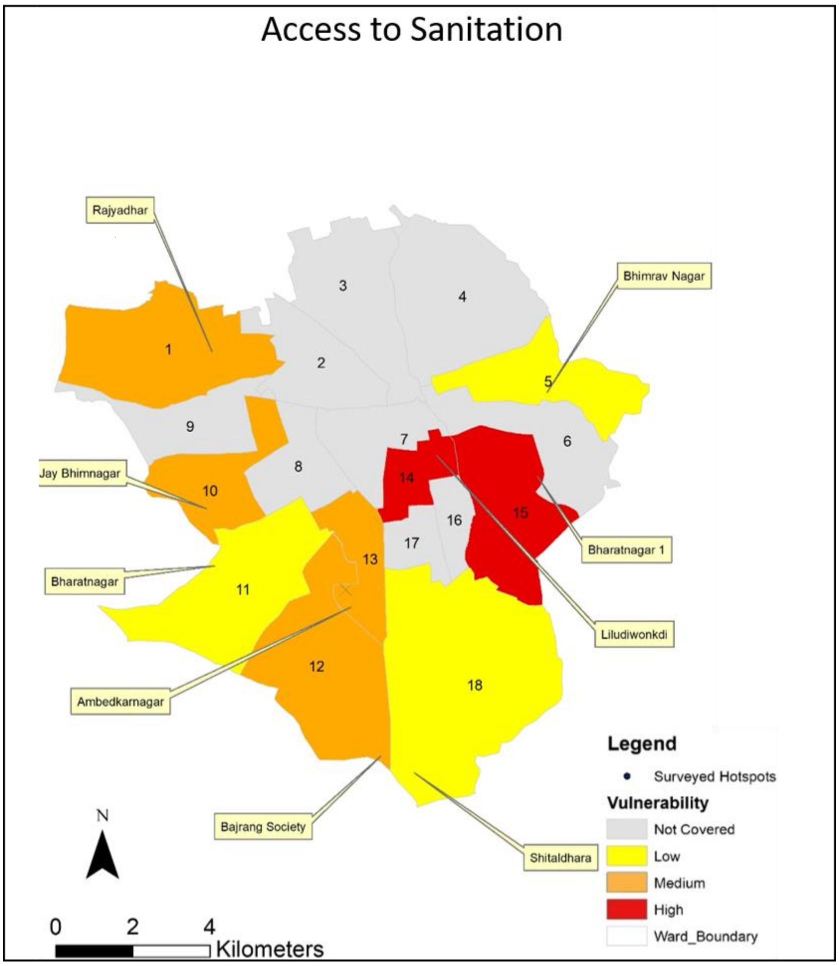


Figure 34 Map Depicting Access to Sanitation in identified Hotspots

Vulnerable wards	Wards Number	Total
Low	(5 , 11 , 18)	**3**
Medium	(1 , 10 , 12 , 13)	**4**
High	(14 , 15)	**2**

Table 15 Table depicting the nature of ward Vulnerability

Poor access to sanitation was more prevalent in ward numbers 14 and 15 indicating high vulnerability. Ward numbers 1, 10, 12 and 13 showed medium vulnerability and ward numbers 5, 11 and 18 showed low vulnerability. The highly vulnerability wards are due to no toilet facility in the premise.

Access to sanitation and piped water supply for all households is major step for checking peak summer disease caseloads.

Access to Electricity

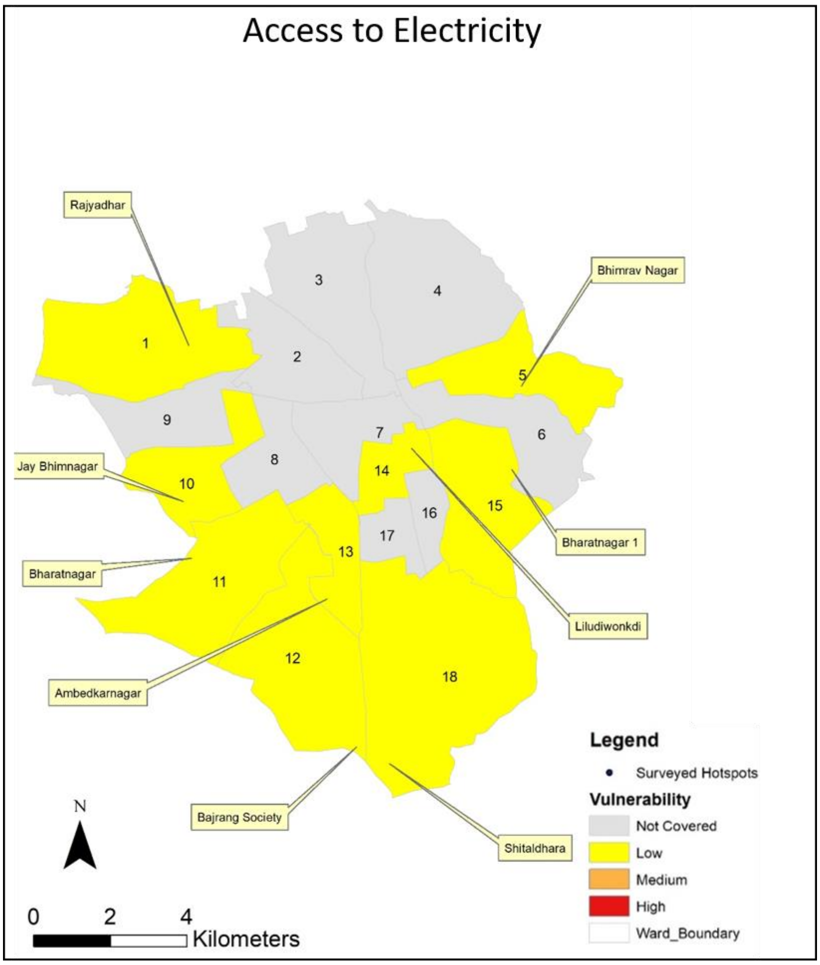


Figure 35 Map Depicting Access to Electricity in identified Hotspots

Vulnerable wards	Wards Number	Total
Low	(1, 5, 10 , 11 , 12 , 13 , 14 , 15 , 18)	**9**
Medium	Nil	**Nil**
High	Nil	**Nil**

It is observed that Rajkot has a very good electricity supply within the city. All nine hotspots fall under the category of Low vulnerability. The wards have decent electricity supply with very few electric cuts during the summer season.

Table 16 Table depicting the nature of ward Vulnerability

Access to Cooking Facilities

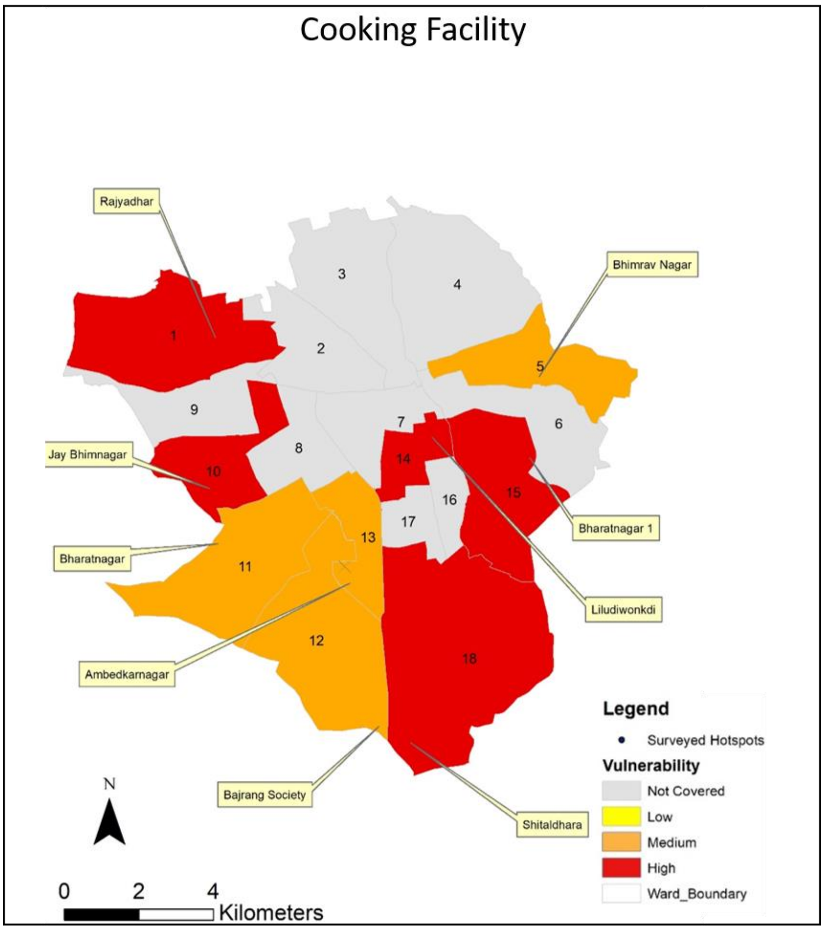


Figure 36 Map Depicting Cooking Facility in identified Hotspots

Vulnerable wards	Wards Number	Total
Low	Nil	**Nil**
Medium	(5 , 11 , 12 , 13)	**4**

High	(1 , 10 , 14 , 15 , 18)	**5**

Majority of the wards are inclined towards high vulnerability. In the surveyed houses the wards – 1,10,14,15 and 18 are highly vulnerable to heatwaves due to use of wood as cooking fuel inside the premises. Additionally, the wards 5,11,12 and 13 showed medium vulnerability with their improved choice of cooking fuel.

Table 17 Table depicting the nature of ward Vulnerability

Health Services: Access to Health Services

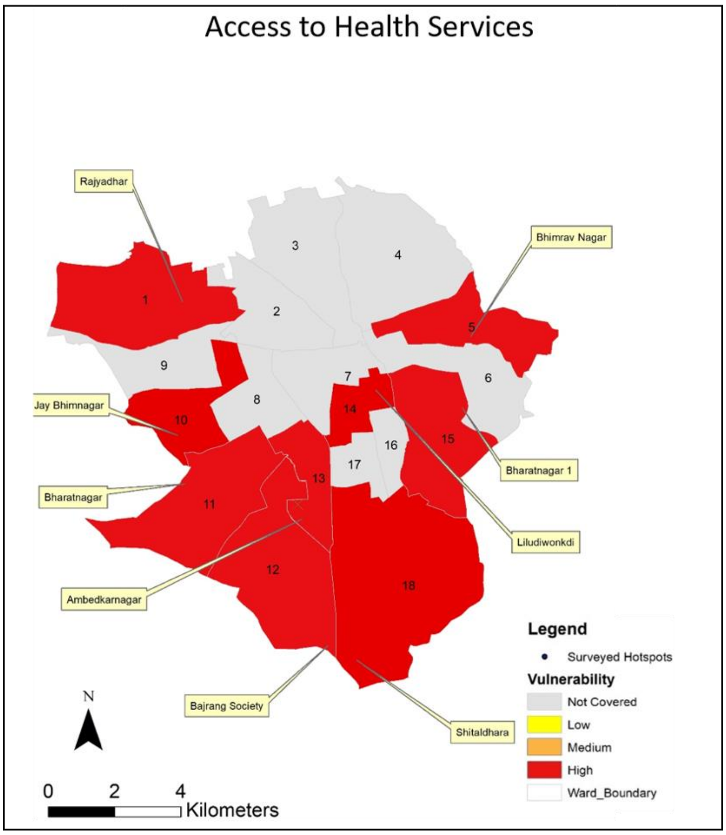


Figure 37 Map Depicting Access to Health Services in identified Hotspots

Vulnerable wards	Wards Number	Total
Low	Nil	Nil
Medium	Nil	Nil
High	(1, 5, 10 , 11 , 12 , 13 , 14 , 15 , 18)	9

All nine wards are highly vulnerable in access to health services. This is due to the unviability of decent public health care centre in the vicinity, longer distances from the nearest public health centre and substantially low coverage of health insurance resulting in high susceptibility during high heat alert days.

Table 18 Table depicting the nature of ward Vulnerability

Existing Awareness: ***Access to Awareness***

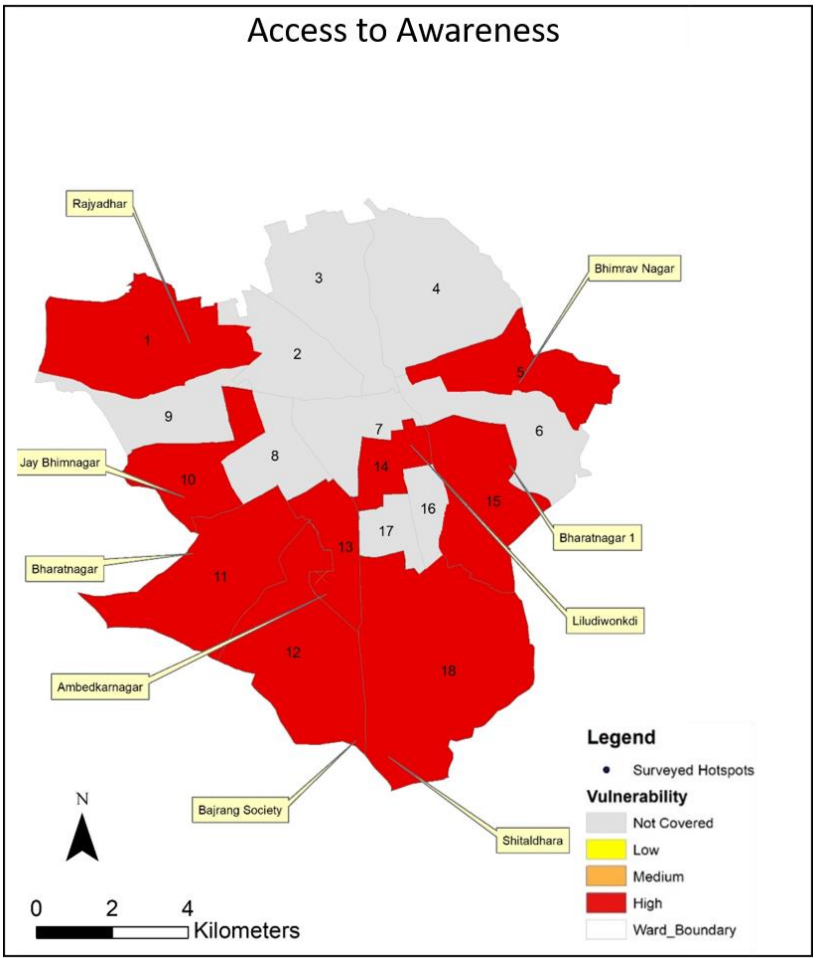


Figure 38 Map Depicting Access to Awareness in identified Hotspots

Vulnerable wards	Wards Number	Total
Low	Nil	Nil
Medium	Nil	Nil
High	(1, 5, 10 , 11 , 12 , 13 , 14 , 15 , 18)	9

Table 19 Table depicting the nature of ward Vulnerability

All the wards ion the city represents a very low awareness to heat stress. It is observed that all nine wards are highly vulnerable to heat stress. The wards have ill awareness due to not familiar with the heat stress condition, unaware of the medical facilities treating such condition and the required steps taken by the ULB.

Heat stress symptoms

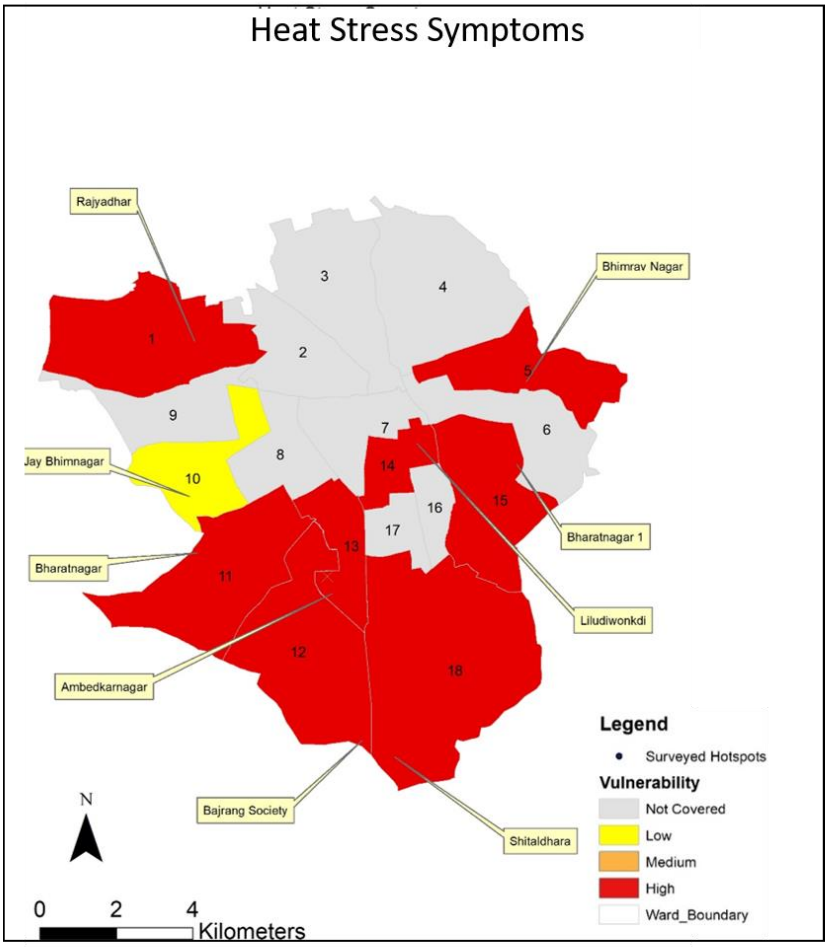


Figure 39 Map Depicting Heat Stress Symptoms in identified Hotspots

Vulnerable wards	Wards Number	Total
Low	(10)	1
Medium	Nil	Nil
High	(1, 5 , 11 , 12 , 13 , 14 , 15 , 18)	8

Table 20 Table depicting the nature of ward Vulnerability

Except for one (10) all the eight wards show high vulnerability top the heat stress symptoms. The wards are highly susceptible to condition such as heat exhaustion.