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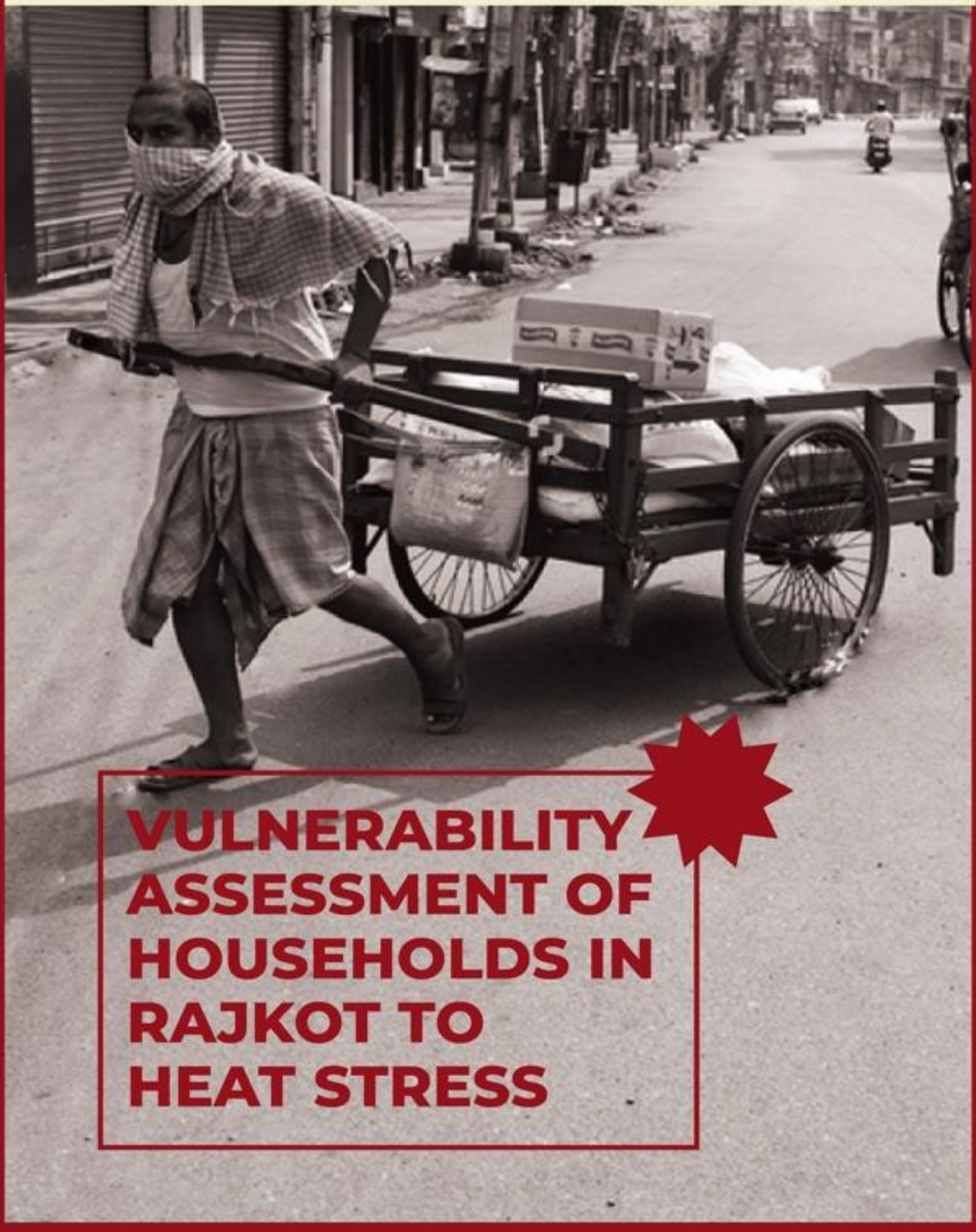

VULNERABILITY ASSESSMENT OF HOUSEHOLDS IN RAJKOT TO HEAT STRESS

Vulnerability Assessment of Households in Rajkot to Heat Stress.

Prepared by:

Integrated Research and Action for Development

Indian Institute of Public Health, Gandhinagar (IIPH-G)

Supported by:

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'Vulnerability Assessment of Households in Rajkot to Heat Stress'

Supported by: International Development Research Centre, Government of Canada (IDRC)

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Disclaimer

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Executive Summary

Extreme heat and heat stress are worsening worldwide due to worsening effects of climate change. These impacts can be felt more in the cities, where the city's physiology has concrete, brick buildings and decreased landscapes. Heat stress is especially very difficult for vulnerable population. Heat wave management and minimising populations' exposure to heat stress will be necessary to keep cities safe, resilient, sustainable (SDG 11) and support residents' income and productivity targets (SDG 8).

In India, there is a well-recognised association between heatwaves and morbidities and mortalities. There is evidence of a threshold at 40 C above which mortality increases[1]. It is one of the largest cities in Gujarat and the 28th urban agglomeration in India with a population of 1.3 million (48 percent women) (Census 2011). The variations in temperature, relative humidity in city, and increase in population increase the heat wave incidents of mortality and morbidity. Heatwaves often leads to heat-health issues. Such situations make it critical to be sensitive to the devastating impacts of climate change, especially on the vulnerable sections of society. Rajkot accommodates 118 slum pockets across the city[2]. With an increasing number of people getting affected by extreme temperature, heat wave should be treated as a calamity and need a systematic approach rather than aberration. This report captures the challenges faced by the people due to heat wave and is a vulnerability assessment of communities prone to heat stress and its associated risks.

The purpose of this report is to underline the importance of Heat Stress Action Plan (HSAP) and to generate robust evidence-based policy recommendations to integrate them into the current and future climate actions at local, state and national levels. A comprehensive index was developed comprising nine sectors and twenty-six respective sub sectors to understand the impacts of extreme heat events on health, work productivity, and livelihoods of vulnerable populations. It includes the sectors namely, Housing, Cooking, Sanitation, Water, Electricity, Health, Awareness, Transport, and their respective sub-sectors. The following indexes are selected as they are compounding risks/ impacts. They interact with the existing risk and tend to exacerbate climatic impact.

[1] V. K. Desai, S. Wagle, S. K. Rathi, U. Patel, and H. S. Desai, "Effect of ambient heat on all-cause mortality in the coastal city of Surat, India," *Current Science*, vol. 109, no. 9, pp. 1680–1686, 2015.

[2] Rajkot Municipal Corporation, 2015-16

The study identified heat and vulnerability hotspots to help city governments deploy targeted measures to mitigate impacts of heat stress. The city-level vulnerability assessment of Delhi proves that urban poor are most vulnerable to heat stress and its associated impacts. Notably, households are most susceptible to heat stress due to housing viz., the material used and its structure, lack of access to basic services such as water, and electricity. These aggravate heat and result in deterioration of health, loss of lives, and livelihoods.

A critical factor that emerged from the study is that households do not have sufficient awareness and knowledge about heat waves and local institutions' adaptive and mitigation strategies. In a scenario of low affordability for health insurance, public health systems must be improved while focusing on knowledge dissemination as part of the preparedness.

Heat stress impacts are visible through the aforementioned sectors, so, cities can combine sectoral initiatives with a well-defined and coherent framework that ties both mitigation and adaptation together. Specific sectors like public health, housing, infrastructure, and services provide entry points. The recommendations outline an overarching framework to ensure maximum impact through sector-based initiatives.

To ensure this, stakeholders need to be involved in the planning and executing heat stress minimisation interventions. Measures have to be both short-term and long term in promoting heat stress management and its planning.

The report identifies vulnerable heat hotspots among the most vulnerable localities in Rajkot to help the policymakers carry out area-specific targeted measures to mitigate the extreme impacts of heat stress in these areas of the city. The analysis of the city level vulnerability assessment of Rajkot indicates that urban poor are most vulnerable to heat stress and its associated impacts. Notably, due to heat stress, the households are most susceptible to the housing, viz., the material used and its structure, access to services such as water, and availability of services such as electricity. It aggravates the issues and results in deterioration of health and loss of lives and livelihoods among the households.

In Rajkot City, heat stress is observed almost equally indoors and outdoors during hot periods. The reasons attributed to this could be due to semi pucca structures and the use of asbestos sheets in their structures. Most of these settlements don’t even have more than one

window. Furthermore, these settlements also lack access to services of water supply and sanitation. These conditions are likely to exacerbate the heat stress among the vulnerable population, especially women. At workplaces, due to heat stress, the workers are losing about 10-15 days of their wages.

It becomes imperative that a locally appropriate strategy is developed utilising the local knowledge on heat management. The recommendations in the report also outline an overarching framework to ensure the maximum impacts of these sector-based initiatives. However, to ensure this, the stakeholders need to be involved in the planning and executing heat stress minimisation interventions. These measures have to be both short-term and long-term, which helps promote heat stress management and its planning.

Vulnerability Assessment of Households in Rajkot to Heat Stress

Climate change has already started to show its impacts with the increase in extreme weather events across the globe. The United Nation's Intergovernmental Panel on Climate Change (IPCC), in its study, maintains that there will be "Global Warming of 1.5C"[3]. As per the latest IPCC AR6, it is virtually certain that hot extremes (including heatwaves) have become more frequent and more intense across most land regions. Impacts of heat stress are more severe in urban areas due to Urban Heat Island (UHI) effect (CCA, 2016). Heat stress-induced deaths in 2100 are estimated to be about 85 per 100,000 (Climate Impact Lab 2019). It is, therefore, inevitable that there will be frequent hotter days/ temperature extremes than the normal overland areas as global mean surface temperatures increase. Heatwaves are also going to increase in frequency, duration, and intensity. It will create health impacts that include morbidity and mortality, along with causing heat stress.

Furthermore, the changes in climate and climate variability bring about significant changes in the weather extremes, creating a substantial threat to human health. In countries with adequate reporting systems, it is being registered that heatwaves are causing a large number of deaths. The World Meteorological Organization statements on the status of global climate during 2016 (March 2016) showed that global temperatures continued to increase, and the year 2016 recorded historically high- global temperature. Approximately 1.1° C/1.98 °F above pre-industrial levels, surpassing the record set in 2015. The health impacts of the heatwave range from cardiovascular, respiratory, neurological, and psychiatric diseases. In severe cases, it results in mortality. Its consequences will become more pronounced with the climate changes. It logically gives rise to critical questions. What does this increasing temperature mean for human health? How would communities cope with the extreme temperatures? Proper responses can help in minimising heat-health consequences. Therefore, public health programs will become critical to prevent the occurrence of heat-related diseases

[3] Pachauri, R. K., Allen, M. R., Barros, V. R., Broome, J., Cramer, W., Christ, R., Dasgupta, P.(2014). Climate change 2014: synthesis report. Contribution of Working Groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change:Ipcc.

caused by heatwaves (Jang et al., 2013)[4]. Heat stress-related illnesses are manageable and even preventable if proper responses and actions are taken, such as avoiding exposure to high temperatures.

The combination of rising temperatures and a large vulnerable population will exacerbate the impacts of heatwaves in India and other developing countries. As per the IPCC AR6 (2020), surface temperatures over South Asia will likely increase greater than the global average, and with projected increases of 4.6°C (3.4°C–6.0°C) during 2081–2100.

Studies show that Low and Middle-Income Countries (LMICs), including India, are most likely to bear a very high burden of deaths (World Health Organization, 2014)[5]. Further, it will lead to an impact on the availability of public services of water supply, electricity, sanitation-of water, and food availability for consumption

Heatwaves in India are declared by the Indian Meteorology Department (IMD) when a particular station reaches at least 40°C or more in Plains, 37 °C or more in coastal stations, and at least 30°C or more in Hilly regions. Mentioned below are the criteria for declaring a heatwave:

(a) Based on Departure from Normal

i) **Heat Wave**: Departure from normal is 4.5°C to 6.4°C

ii) **Severe Heat Wave**: Departure from normal is >6.4°C

Based on Actual Maximum Temperature (for plains only)

i) **Heat Wave**: When actual maximum temperature ≥ 45°C

ii) **Severe Heat Wave**: When actual maximum temperature ≥47°C

The above criteria, to declare heatwave, should be met at least in 2 stations in a Meteorological sub-division for at least two consecutive days, and it will be declared on the second day (IMD, 2018).

[4] Na W, Jang JY, Lee KE, et al. The effects of temperature on heat-related illness according to the characteristics of patients during the summer of 2012 in the Republic of Korea. J Prev Med Public Health. 2013;46(1):19-27. doi:10.3961/jpmph.2013.46.1.19

[5] World Health Organization. (2014). Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s: World Health Organization.

Indian Institute of Tropical Meteorology has given the following criteria for Heat Waves:

a) If maximum temperature is ≥ 39°C and minimum temperature ≥ 90th percentile of the observed minimum temperature for that day

b) If maximum temperature ≥ 95th percentile of the observed maximum temperature for that day, and actual maximum temperature is ≥ 39°C, and maximum temperature departure from normal is ≥ 3.5°C or maximum temperature is ≥ 44°C

c) If maximum temperature ≥ 99th percentile of the observed maximum temperature for that day, and actual maximum temperature is ≥ 39°C, and maximum temperature departure from normal is ≥ 5.5°C or maximum temperature is ≥ 46°C

Hot days(HOT): if satisfying A

Heat Wave (HW): if satisfying B

Severe Heat Waves (SHW): if satisfying C

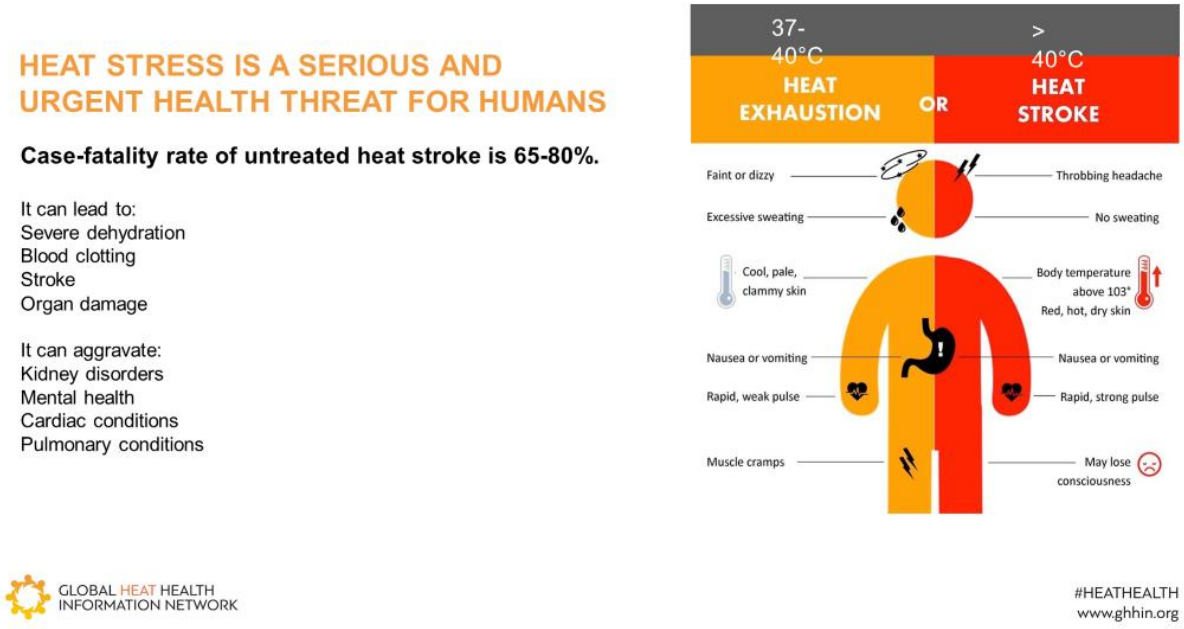
1 Heatwaves

A heatwave is a prolonged period of excessive heat along with excessive humidity. In urban areas, the "Urban Heat Island effect comes into play." It is primarily due to the absorption of solar energy by the buildings, roads, and other infrastructures, resulting in higher temperatures. The heatwaves can cause blackouts and power outages, especially in areas that experience the urban heat island effect. In India, the months between March and June are typically the hottest India, with temperatures reaching 45 degrees Celsius in certain areas. Loss of lives during a heatwave is caused by direct and indirect effects due to worsening of pre-existing conditions, the latter being far more common than the former. Utmost priority must be given to prevent heat-related illnesses in a vulnerable population, especially women, children, and the elderly, as well as the poor and marginalised (slum population, homeless). The need of the moment is to prepare comprehensive strategies to deal with adaptation to extreme temperatures. Various criteria for determining the heat waves include percentile thresholds of maximum temperature, excess heat indices (Panda et al., 2017)[6]; positive Extreme Heat Factor (EHF); Multi-measurement index (Meehal et al. 2009)[7]; and

[6] http://amir.eng.uci.edu/publications/17_JGR_HW_India.pdf
[7] Meehl, G.A., Tebaldi, C., Walton, G., Easterling, D., McDaniel, L., 2009. Relative increase of record high maximum temperatures compared to record low minimum temperatures in the US. Geophys. Res. Lett. 36 (23)

Exceedance index[8] (Fischer et al. 2010). Heat Stress is primarily classified into the following five[9] types.

1. Heat Rash
2. Heat Cramps
3. Heat Exhaustion
4. Heat Syncope
5. Heat Stroke



Heat Rash: Itchy Rash with small red bumps at pores in a setting of heat exposure; bumps can sometimes be filled with clear or white fluid

Heat Cramps: Painful contractions of frequently used muscle groups in the heat exposure setting, often with exertion.

Heat Exhaustion: Sweaty/Diaphoretic; Flushed skin; hot skin; average core temperature; +/- dazed, +/- generalised weakness, slight disorientation

[8] Fischer, E.M., Schär, C., 2010. Consistent geographical patterns of changes in high-impact European heatwaves. Nat. Geosci. 3 (6), 398–403

[9] Heat Stress - Heat Related Illness by CDC. We thank everyone who contributed to this much needed report "Vulnerability Assessment to Heat stress of Household in Delhi''. International Development Research Centre, Government of Canada, supported the Review Report.

Heat Syncope: Brief Generalised loss of consciousness in a hot setting, the short period of disorientation, if any

Heat Stroke: Flushed, dry skin (not always), core temperature ≥ 40-degree C, (103°F or higher), altered mental status with disorientation, possibly delirium, coma, seizures, tachycardia, +/- hypotension

2 Heatwave in India

Heatwave is one of the extreme weather events (EWE) (Kamaljit Ray). In 50 years (1971-2019) EWE killed 1,41,308 people. Approx. 17,362 people were killed due to heatwave — a little over 12 percent of the total deaths recorded[10]. From 1998 to 2018, the intensive occurrence of heat stress caused material damage and affected the quality of life like none in the last 100 years. Temperatures peaked around 49 to 50 °C and lasted for almost a week, resulting in a massive spike in heat strokes, other heat-related illnesses, and death. The year 2019 was the seventh-warmest year on record since nationwide meteorological records keeping commenced in 1901. Since about 50% of India's GDP is already dependent on heat - exposed work like agriculture, mining, and construction — there would be an immediate, palpable impact, one worth $250 billion[11]. The increasing impact of heatwaves is seen as around 23 states have been affected by heat stress in 2020 compared to just 9 in 2015[12]. This needs to be tackled by the Heat Action Plans through improved sensitisation, capacity building, inter-agency coordination, and enhanced data collection.

June and July month in 2019 have been the hottest months recorded globally, with National Oceanic and Atmospheric Administration (NOAA) confirming June 2019 is the hottest on records, + 0.95^{o}C above normal average temperature. On 26 May 2020, Churu in Rajasthan bagged the record of being the hottest place not just in India, but in the entire world on the same date, 10 of the 15 world's hottest sites were in India, including Delhi NCT, which recorded its hottest day of May in 18 years at 47.6 ^{o}C. Parts of North Western, Northern, and Central Plains of the country experienced severe heat waves during May.

[10] Kamaljit Ray, R.K. Giri, S.S. Ray, A.P. Dimri, M. Rajeevan, An assessment of long-term changes in mortalities due to extreme weather events in India: A study of 50 years' data, 1970–2019, Weather and Climate Extremes,Volume 32,2021,100315,ISSN 2212-0947, https://doi.org/10.1016/j.wace.2021.100315.
[11] By Jonathan Woetzel, Dickon Pinner, Hamid Samandari, Hauke Engel, Mekala Krishnan, Brodie Boland, and Carter Powis.McKinsey Global Institute. Climate risk and response: Physical hazards and socioeconomic impacts
January 16, 2020
[12] https://ndma.gov.in/sites/default/files/IEC/Booklets/HeatWave%20A5%20BOOK%20Final.pdf

The annual average temperature of our earth has risen by 2 C since 200 years until 2006, and this may further increase by another 1.5°-2 C by 2030[13]. Within 50 years, 1.2 billion people would live in areas as hot as the Sahara if greenhouse gas emissions keep rising (Chi Xu, Timothy A. Kohler et.al, 2020).

Heatwaves cause the highest number of deaths than deaths caused by any other natural hazard in Indian cities[14]. However, it needs to be highlighted that extreme temperatures can adversely impact human health and the ecosystem. Despite being one of the top three killers in the country, heat waves are not a natural calamity by the Government of India.

3 Understanding Heat Stress Vulnerabilities

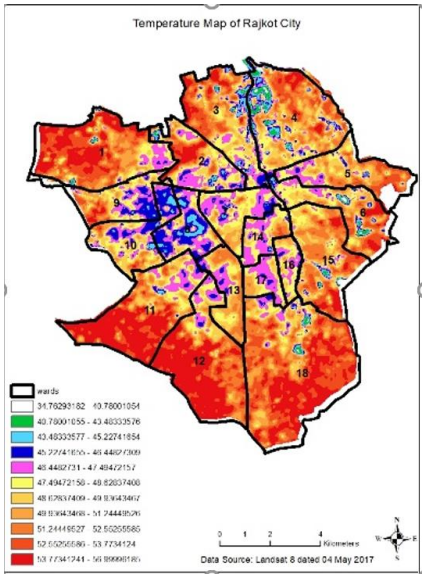
3.1 Study Area Selection

The process of selecting wards begins by identifying vulnerable areas through Land Surface Temperature (LST) maps and locating slum settlements. The LST maps intend to select the heat hotspots. The areas identified in Rajkot were with LST >42° C. Besides, data on ambient air temperature measured by Automatic Weather Stations (AWS) was procured from IMD (India Meteorological Department) and municipal corporations for mapping. A total of 9 hotspots were identified in the Rajkot.

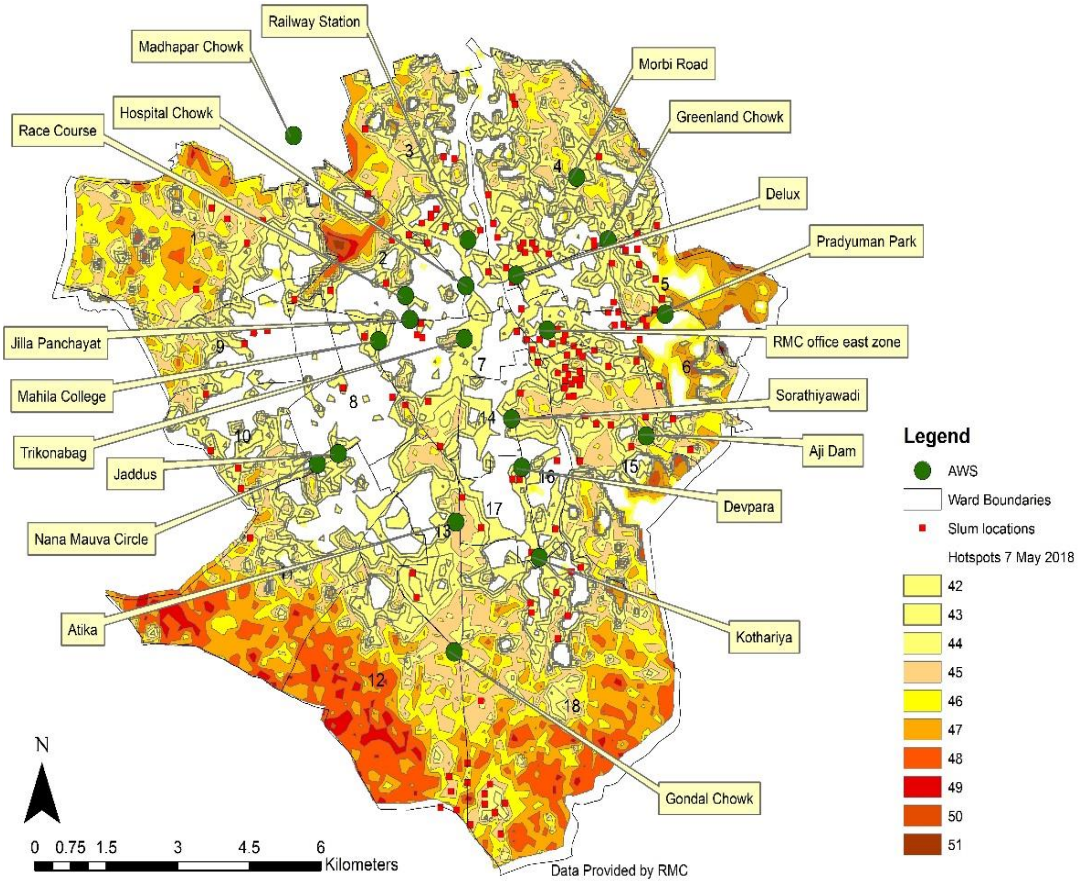
[13] IPCC, 2018: Summary for Policymakers. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. *World Meteorological Organization, Geneva, Switzerland, 32 pp*

[14] Kamaljit Ray, R.K. Giri, S.S. Ray, A.P. Dimri, M. Rajeevan, An assessment of long-term changes in mortalities due to extreme weather events in India: A study of 50 years' data, 1970–2019, Weather and Climate Extremes,Volume 32,2021,100315,ISSN 2212-0947, https://doi.org/10.1016/j.wace.2021.100315

Rajkot Surveyed Hotspots	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
Total Hotspots = 9	



Rajkot- Hotspots location & Map



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

4 Methodology

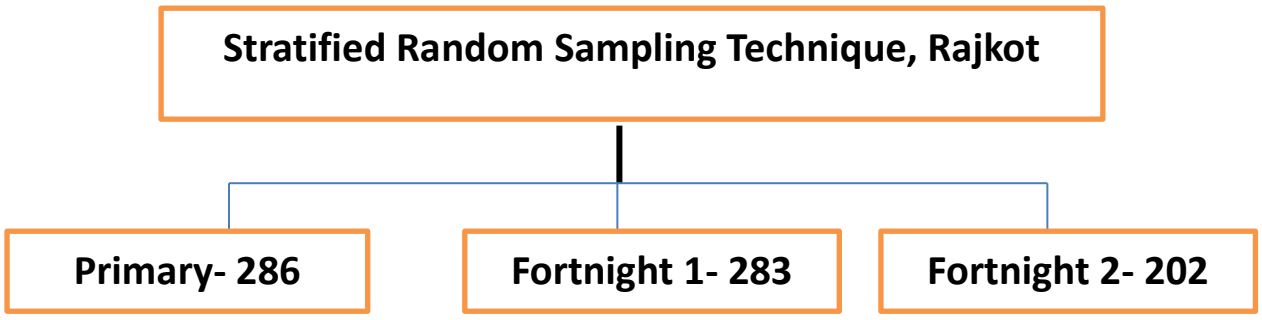
4.1 Purpose of the Study

This study aims to understand and analyse the implications of extreme heat on the health, productivity, and livelihoods of vulnerable groups, especially working population (like construction workers, vendors, rickshaw pullers, factory workers, casual labourers, maids/helpers and office workers.), women, children, and senior citizens. To select appropriate, innovative and affordable climate adaptation measures for improving health and livelihood resilience for the urban population. It would help strengthen the capacity of key stakeholders to facilitate the implementation of the Heat Stress Action Plans and their long-term sustainability in the selected areas through training. Facilitate active use of information and evidence for policymakers to drive the implementation of the Heat Stress Action Plans

into municipal disaster strategies for better preparedness. The research framed a detailed quantitative and qualitative framework for the assessment to develop a framework for heatwave mitigation and building the adaptive capacity of the people.

4.2 Selection of Participants

The identification of vulnerable populations included economically weaker sections, women, children, and elderly and working individuals such as construction workers, factory workers, transportation, sweepers, labourers, and vendors/street hawkers. Overlapping layers of identified vulnerable areas did the vulnerability mapping with vulnerable sections. Further, comprehensive household surveys were conducted in the city to measure the susceptibility to heat stress. A total of 286 households participated in the study.



4.3 Declaration

The participants were aware before the survey that the information shared will be used only for research purposes, and hence, there is no risk foreseen with the study.

4.4 Confidentiality and Participation in the survey

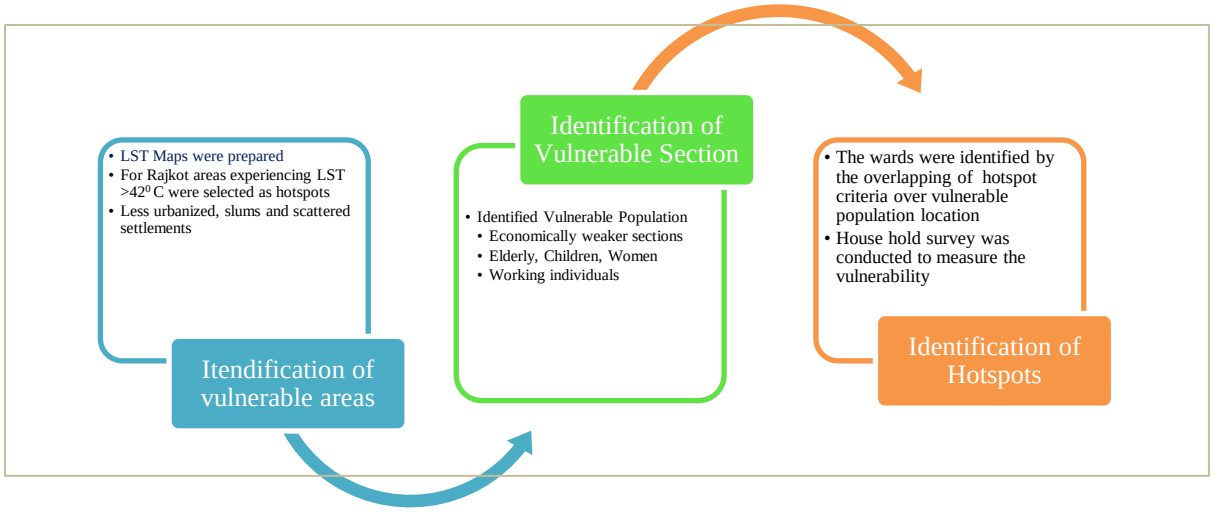
Participation in the survey was voluntary, and they could withdraw at any stage of the survey. The information gathered would be kept confidential.

4.5 Ethical consideration

Consent from participants was taken, and all the questions in the survey were verbally explained to the enrolled participants before the survey.

4.6 Survey design , Study area selection and data collection

The survey assessed the impact of heat stress on health, work productivity, and livelihood in a sample size of 300 HHs. Two sets of questionnaires/ research tools were used to capture the base information about household members and fortnight longitudinal surveys to capture the impact of heat stress in the previous 15 days on individual health, productivity, and livelihood. The surveys were initiated in the first week of May 2018 after the pilot surveys in each city. Multi-level-stratified sampling was used for selecting 300 households within the hotspots identified in each city. For better analysis, vulnerable groups were categorised and identified, such as the drivers, casual workers, shopkeepers, construction workers, slum dwellers, street vendors, children and women, and the elderly directly exposed to heat. Hotspots were identified based on the surface temperature recording, over April to May 2016 & 2017, geographic location (ward level), and the socio-economic conditions identified as hot spots, having small means to adapt to the heat stress.



Detailed questionnaires for the household-level survey were structured in epi-info software, and a stratified random sampling technique was used to conduct field surveys were conducted in the selected slums of the city. In addition, structured interviews were carried out at the household level. The investigators collected this data by going door to door and helping the identified groups respond where required.

Under the survey, the impacts of extreme heat events on the health, work productivity, and livelihoods of the vulnerable population were determined using a comprehensive index of compounding factors that exacerbate climatic impact. It comprises a total of nine sectors and

twenty-six respective sub-sectors. Services that are critical to the heatwave as listed in the table.

S.No.	SECTORS	SUB - SECTORS
1	**Sanitation**	Type of Toilet
		Individual Toilets
2	**Water**	Water Source
		Water Source Location
		Water Collection Time
		Frequency Water Supply
3	**Electricity**	Electricity Cut-off
4	**Health**	Access to Health Infra- Public/Private/Both
		Distance Hospital
		Health Insurance
5	**Transportation**	Mode of Transport
6	**Housing**	Years of Occupancy
		Number of Rooms
		Type of House
		Floor Type
		Roof Type
		Wall Type
		Number of Windows
		Wall Colour

7	**Cooking**	Cooking Place
		Cooking Fuel
8	**Awareness**	Heat Stress Awareness
		Awareness about use of Medical facilities for heat
		Awareness about availability Medical measures from ULB
9	**Heat Stress Symptoms**	Heat Exhaustion
		Heat Stroke

4.7 Data analysis

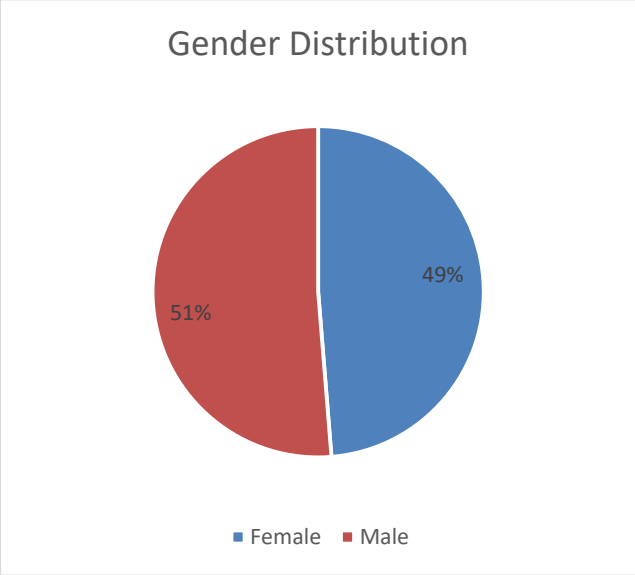
Primary survey data was collected and cleaned on the Epi-Info platform. The primary survey provided the basic household information and general knowledge about heat stress and its implications. The other set was a longitudinal tool to monitor the impact of heat stress on the selected household members over 14 days. Most of the families were Below Poverty Line (BPL), and their occupations included labour, daily wage earners, and mobile workers. The primary and fortnightly surveys conducted in each city were compiled on the Epi-info platform. Further, the data was analysed using EXCEL, SPSS, and STATA.

5 Results

5.1 General characteristics of studied participants:

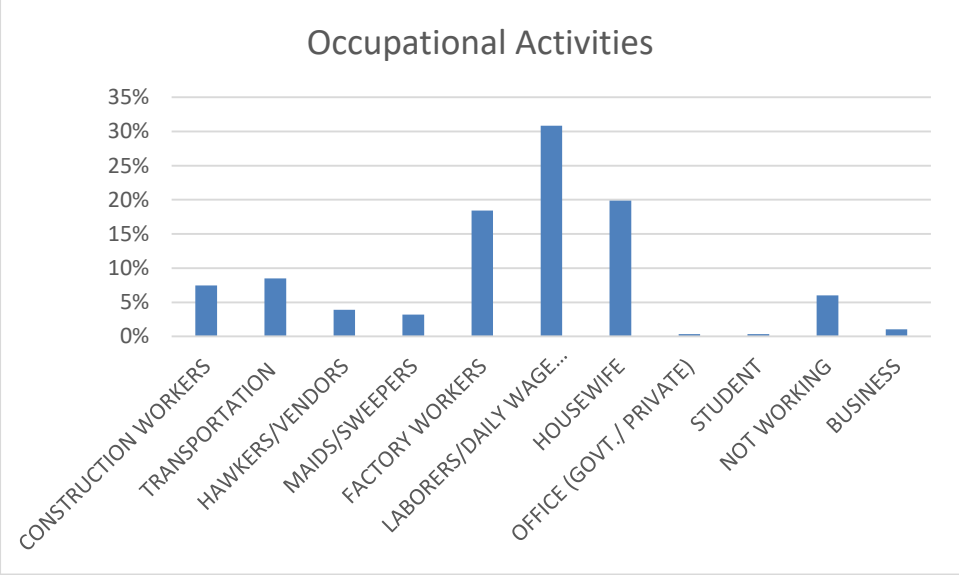
During summer, with the rising temperatures, heat stress affects the residents and has some discernible impacts, such as a rise in mortality, an increased strain on infrastructure (power, water, and transport), and ecosystem services. However, we know that the vulnerable sections, especially the poor, are more prone to heat. The economically disadvantaged and have limited access to resources and services. The synergistic effects of heat stress may, eventually, prove to be fatal for some. It must also be mentioned that type of house, its building material, the number of hours spent indoors, and cooking may also add to the heat stress. The survey conducted in poor settlements highlights how lack of critical infrastructure and services aggravates heat stress on people

5.1.1 Gender distribution:



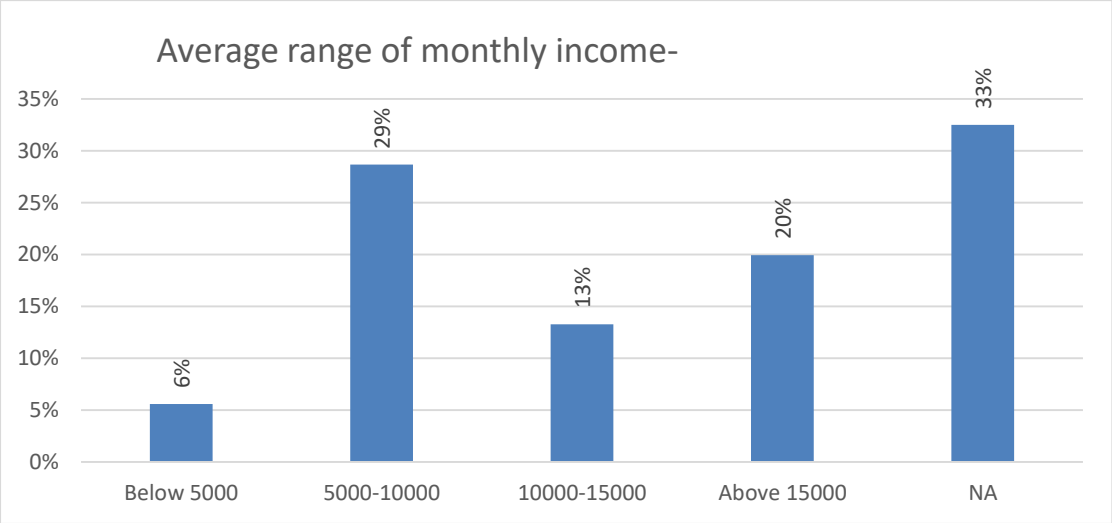
Equal gender distribution is ensured in order to capture the differential impact heat stress has on women and men. This will enable understanding of the underlying causes and help design HSAPs that take the differential impact into consideration.

5.2 Occupation



Heat affects livelihood and productivity loss. It is essential to capture the type of occupation to understand this. It is observed that the majority of the working population is employed in the sectors such as daily wage workers/causal labourers, office workers, and factory workers.

5.3 Income Level:

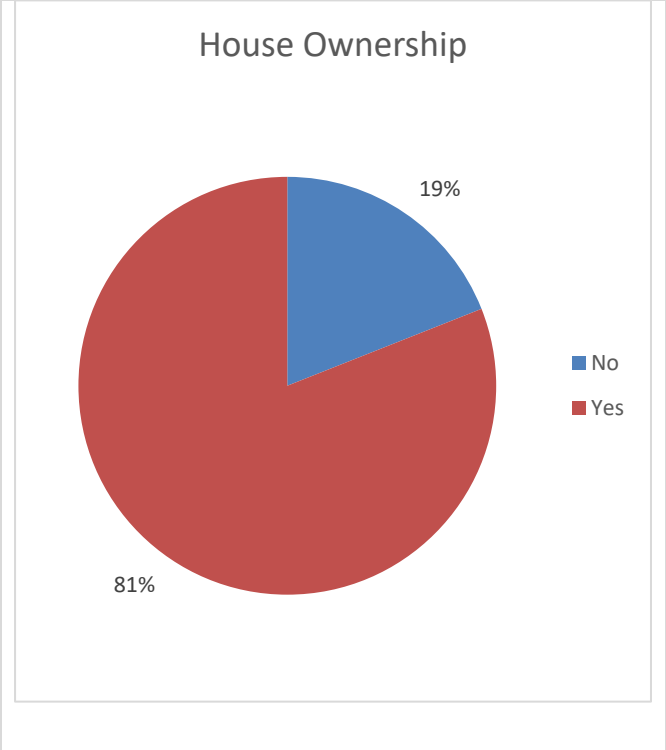


5.4 Housing

5.4.1 Ownership:

House Ownership			
Rajkot city	NO	Yes	Total
Absolute Numbers .	53	233	286
Percentage distribution (Within Options)	18.53	81.47	100

Table- 5.1.1



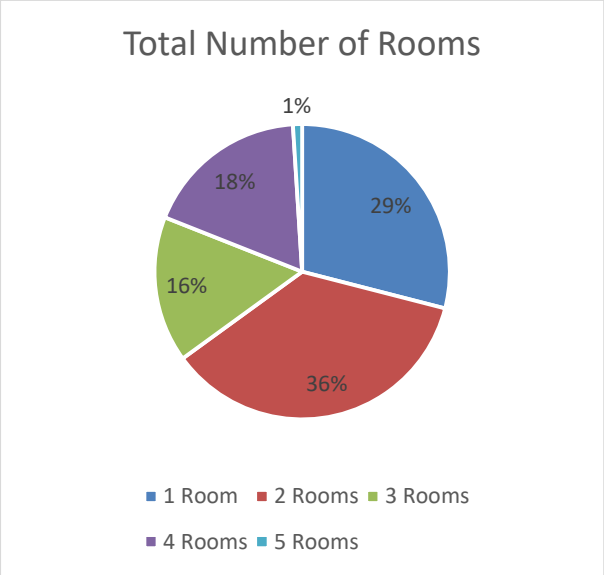
Graph- 5.1.1

It was reported that around 81% of participants own the dwelling units. It is thus easier for the house owner to introduce required structural amendments to combat the heat.

5.4.2 Total number of rooms:

Number of rooms in a dwelling unit					
Rajkot city	**1 Room**	**2 Rooms**	**3 Rooms**	**4 Rooms**	**5 Rooms**
Absolute Numbers	83	102	45	52	4
Percentage distribution (Within Options)	29.02	35.66	15.73	18.18	1.4

Table- 5.1.2



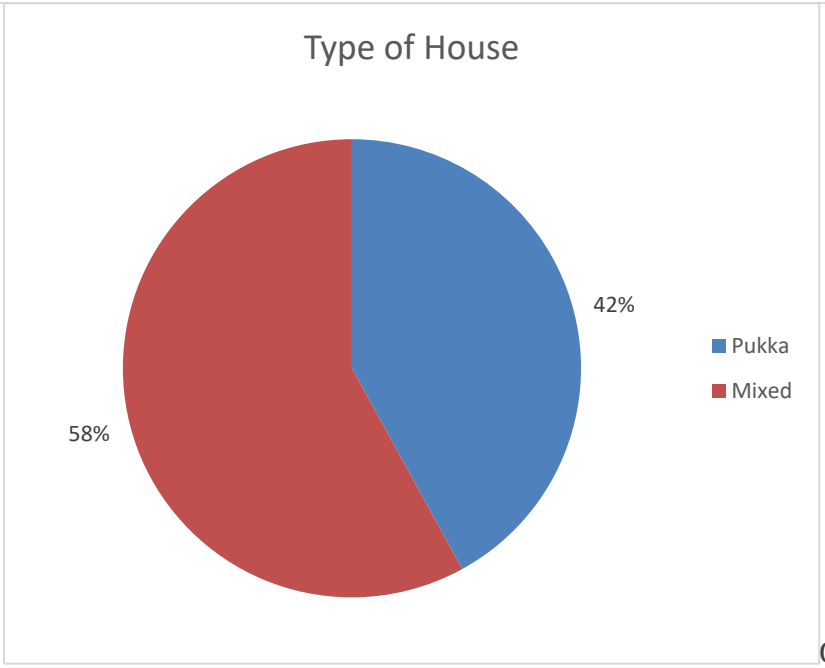
The average number of rooms in a dwelling unit for a majority of the participants is either one or two, which accounts for about 65 % of the households. Whereas only 35 % approximately have a dwelling unit with three or more rooms.

Graph- 5.1.2

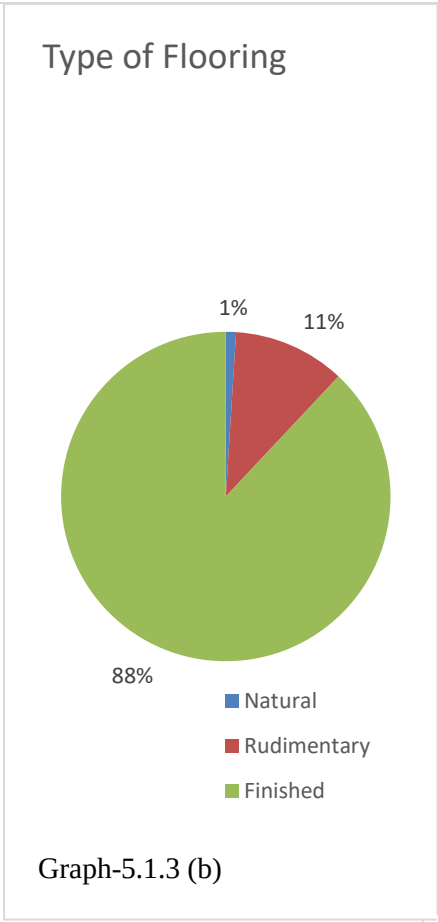
5.4.3 Type of housing structure, Floor material, wall material, and Roof material:

Type of House				
Rajkot city	**Kutcha**	**Pucca**	**Mixed**	**Total**
Absolute Numbers	1	119	166	286
Percentage distribution (Within Options)	0.35	41.61	58.04	100

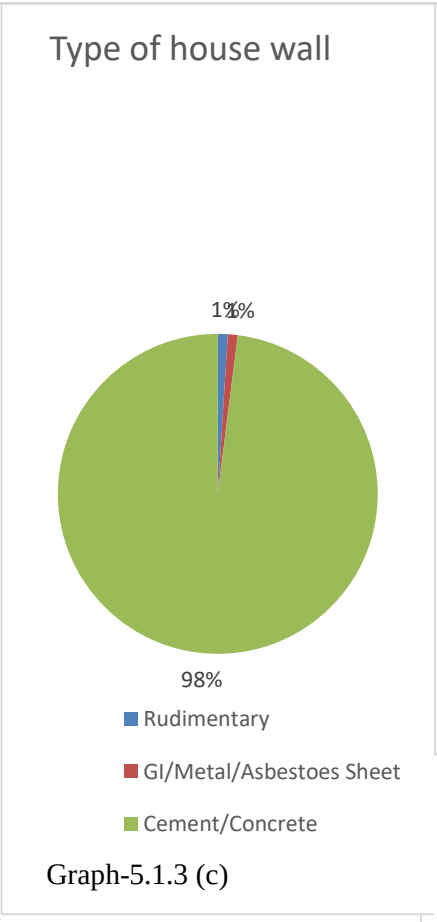
Table- 5.1.3(a)



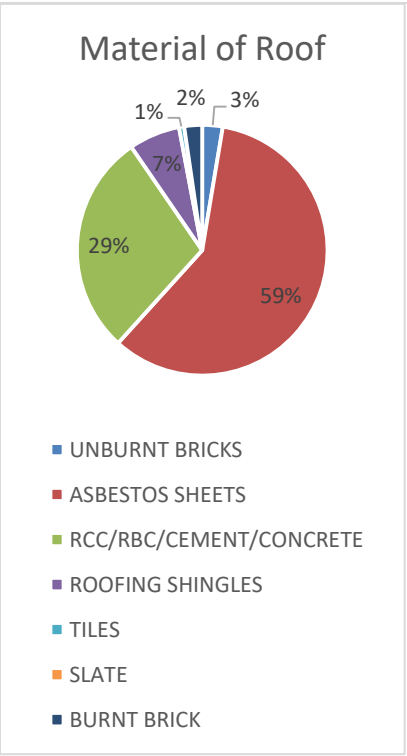
Graph-5.1.3(a)



Graph-5.1.3 (b)



Graph-5.1.3 (c)



Graph-5.1.3 (d)

Type of Flooring					
Rajkot city	**Natural**	**Rudimentary**	**Finished**	**Others**	**Total**
Absolute Number	3	31	252	0	286
Percentage distribution (Within Options)	1.05	10.84	88.11	0	100

Table- 5.1.3(b)

Type of House Wall							
Rajkot city	**No Walls**	**Natural**	**Rudimentary**	**GI/Metal/Asbestos Sheet**	**Cement /Concrete**	**Others**	**Total**
Absolute Number	0	0	2	4	280	0	286
Percentage distribution (Within Options)	0	0	0.7	1.4	97.9	0	100

Table- 5.1.3(c)

	Material of Roof							
Rajkot city	**UNBURNT BRICKS**	**ASBESTOS SHEETS**	**RCC/ RBC/CEMENT/CONCRETE**	**ROOFING SHINGLES**	**TILES**	**SLATE**	**BURNT BRICK**	**Total**
Absolute Number	8	162	87	20	2		7	286
Percentage distribution (Within Options)	3%	59%	29%	7%	1%		2%	100

According to Graph-5.1.3(a)), most of the respondent's houses(58%) in the sample are mixed type that does not provide adequate protection from the high temperatures. The most common material used for building the housing is the cement for the flooring (90%) and walls(96%). However, a majority (59%) use heat-trapping and unsustainable materials such as Asbestos sheets for roofs. (Graph- -5.1.3 (d)).

People suffer from high retention of heat due to the usage of materials like cement and asbestos. Therefore, there is a need for affordable and heat resilient alternative building materials other than the ones mentioned above. Activities such, tree plantation for reducing the urban heat island effect and improving natural cooling of existing construction through retrofitting and improving the living standards in the settlement could also be taken.

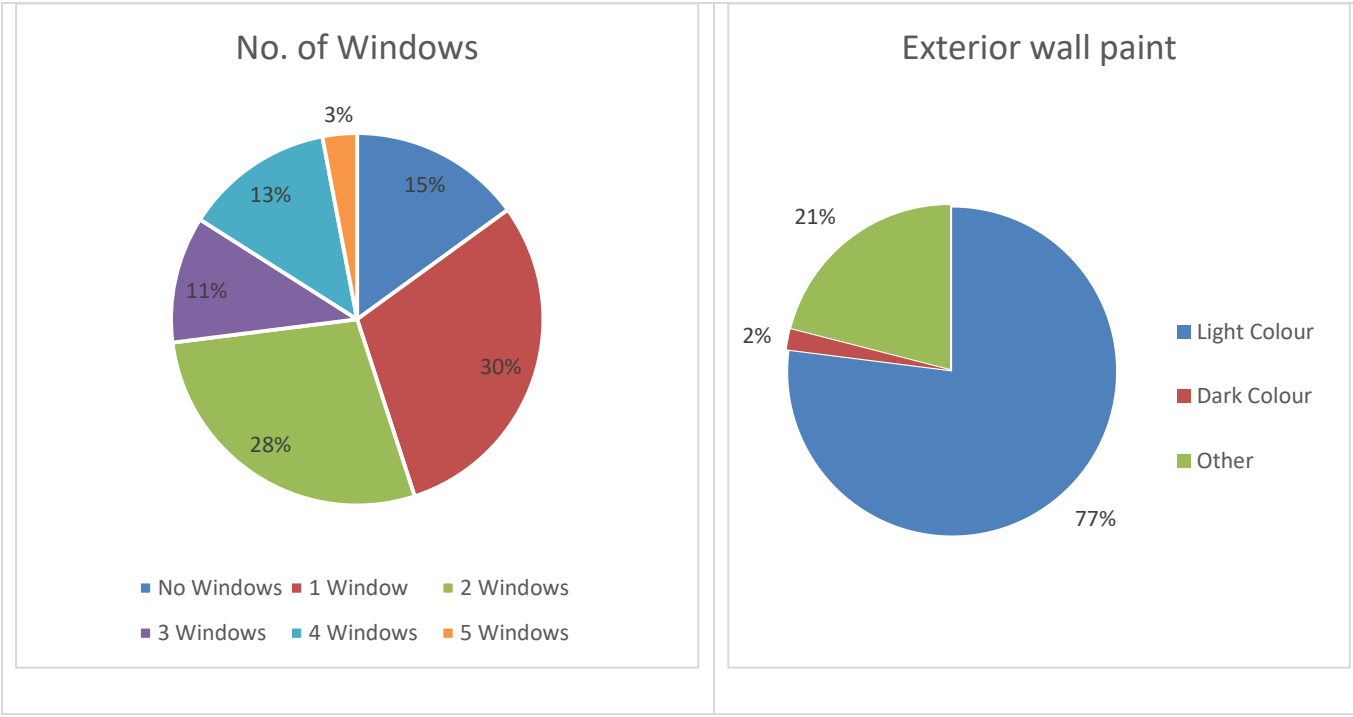
5.4.4 Number of windows, exterior wall paints:

Number of Windows in house						
Rajkot city	**No Window**	**1 Window**	**2 Windows**	**3 Windows**	**4 Windows**	**5 Windows**
Absolute Number	44	86	79	31	37	8
Percentage distribution (Within Options)	15.38	30.07	27.62	10.84	12.94	2.8

Table- 5.1.4(a)

Exterior wall paint				
Rajkot City	**Light Colour**	**Dark Colour**	**NA**	**Total**
Absolute Numnber	221	6	59	286
Percentage distribution (Within Options)	77.27	2.1	20.63	100

Table- 5.1.4(b)



Graph- 5.1.4 (a)&(b)

In the sample settlements, about 15% have no windows at all, followed by 30% have one window. In all, 73% of the sample has poor ventilation, and only 27% have more than two windows (table 5.1.4(a)). A poorly ventilated and confined dwelling unit might cause a lack of airflow, resulting in one of the causes of heat-related vulnerabilities. The exterior wall paint, however, is helping the citizens to deal with heat much better. Around 77% of the sample households have light colours on the exterior walls (table 5.1.4 (b)). This practice will help combat heat and is not an impending factor for exacerbating heat stress among the residents. However, more focus is on passive cooling techniques to allow ventilation and natural light inside the house.

Implications: The poor housing quality in terms of design and the materials used in these settlements exacerbates discomfort and potential health risks during extreme heat, particularly heatwaves. The poor housing also increases the indoor temperature as the houses heat up quickly, and in peak hot season, these houses cool down very slowly. Staying home during heatwaves may lead to other health risks in heat-vulnerable households, and overcrowding in the house might aggravate these risks.

5.5 Cooking

5.5.1 Type of fuel

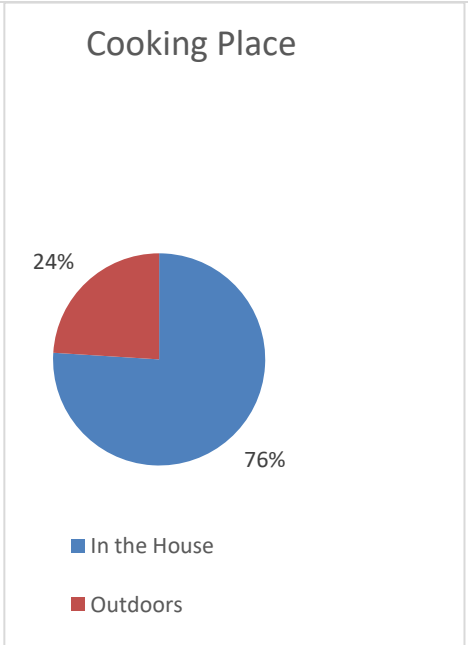
Type of Fuel									
Rajkot city	**Electricity**	**LPG/Natural Gas**	**Biogas**	**Kerosene**	**Coal/Lignite**	**Charcoal**	**wood**	**Animal Dung**	**Total**
Absolute Number	2	158	1	44	2	3	75	1	286
Percentage distribution (Within Cities)	15.38	21.64	16.67	91.67	66.67	75	46.58	100	29.61

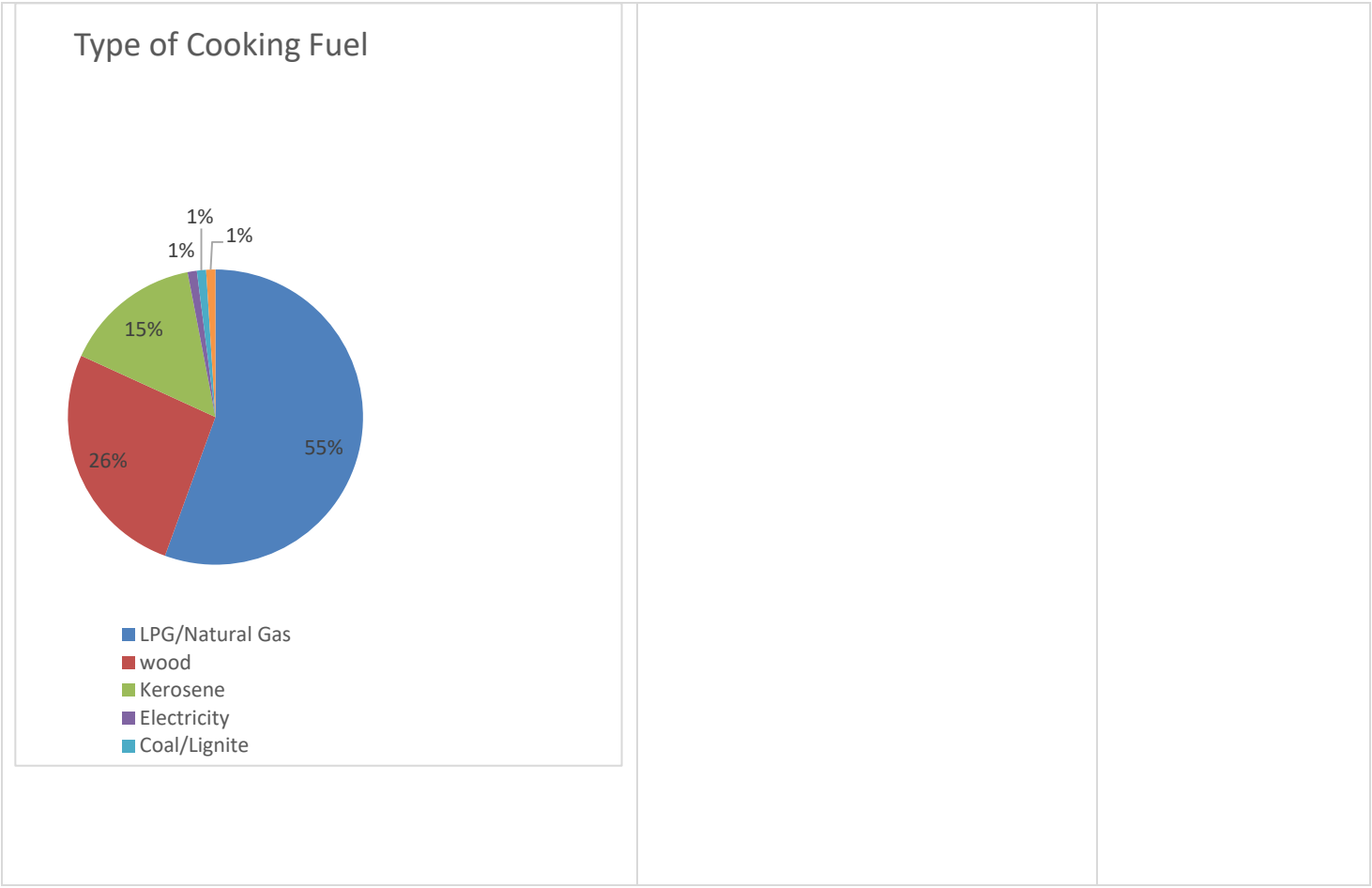
Table- 5.2.1(a)

Cooking Place				
Rajkot city	**In the House**	**In a separate Building**	**Outdoors**	**Total**
Absolute Number	217	1	68	286
Percentage distribution (Within Options)	75.87	0.35	23.78	100

Table- 5.2.1(b)

The 5.2.1(a) is not clear at all





Graph- 5.2.1(a), (b),(c)

Table 5.2.1 (a) indicates that the majority of the households surveyed (55%) have access to LPG/ Natural Gas for cooking purposes. Just 1% either use electricity or Biogas—both clean energy sources. However, 41 % still depend on wood, kerosene, and coal for cooking. It may lead to heat getting trapped, resulting in increased vulnerability. 76% of the households have a facility to cook food in the house. It is found that above 98% of adult females cook food in the house, and the ones using wood for cooking are most vulnerable. Clean energy promotes better preparedness towards heat and decreases the cooking time with almost no health impacts on the households. Cooking time has a bearing on heat exposure of females in households. Hence, while cooking fuels may not be a critical factor impacting heat stress, heat exposure could exacerbate heat stress.

Implications: The females in the households are exposed to extreme heat while cooking. During a hot period, cooking increases heat exposure and makes women vulnerable to heat stress. The location of the kitchen within the premises also increases the risk of a rise in indoor temperatures and pollution due to their ill-designed housing structure, poor ventilation, and availability of few windows, and the type of fuels used in the cooking

5.6 Sanitation:

5.6.1 Access to toilet

Type of Toilet Facility						
Rajkot city	Flush Toilet	Pit Latrine	No Facility/Uses Bush/ Field	Composting toilet	Other	Total
Absolute Number	56	178	41	0	11	286
Percentage distribution (Within Options)	19.58	62.24	14.34	0	3.85	100

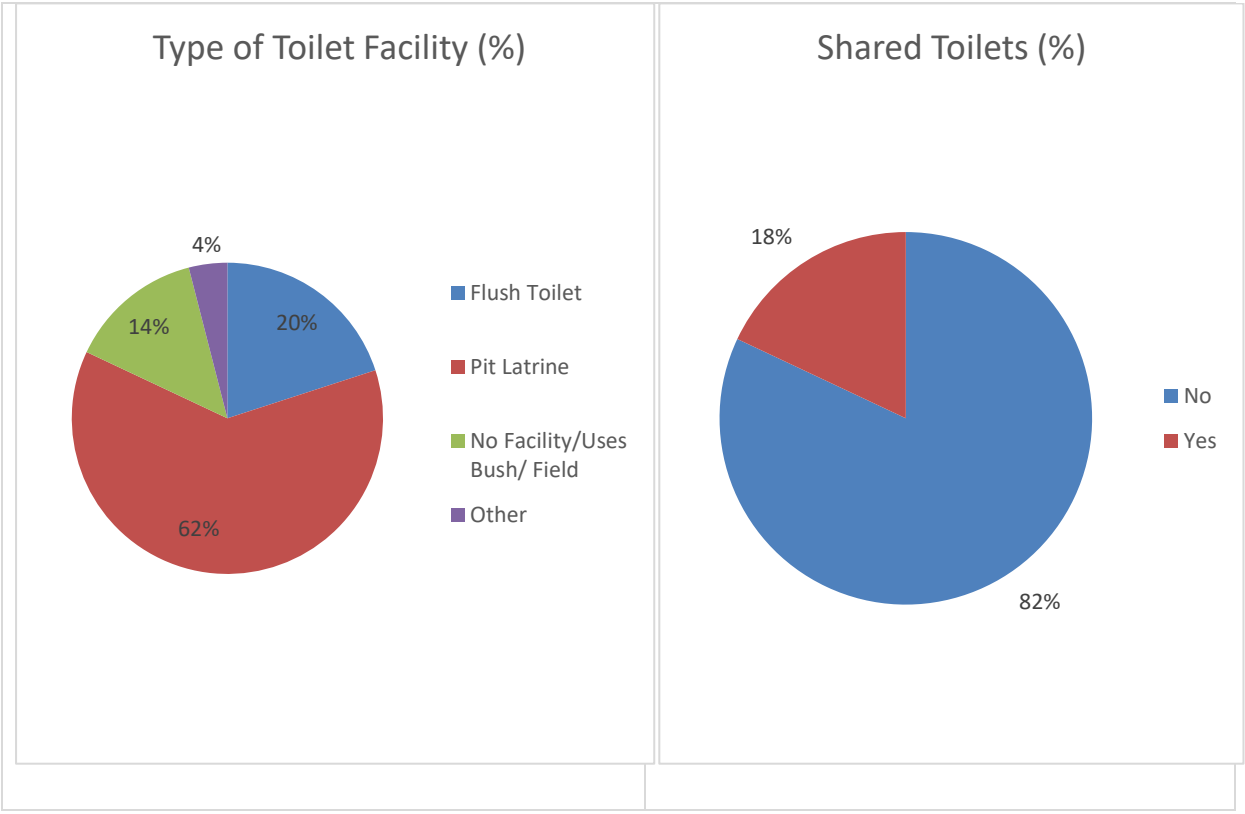
Table- 5.3.1(a)

The sample survey shows that 81% of the households have access to either pit latrines or flush toilets. 81%, making the majority, do not use a shared facility for sanitation purposes (table-5.3.1 (a,b)). Since there is already an awareness of hygiene among households, no actions are needed in the majority; however, 14% with either no toilet or composting toilet facilities should be empowered to continue to transition as they are under high risk. Sustained efforts should be taken to maintain consistency of hygiene. However, sanitation is not a critical factor leading to heat stress.

Implications: Availability of sanitation is not a critical factor in combatting heat stress for the majority; however, the focus should be on those with no toilet facility. As its absence might create numerous health issues, especially for women and children. Access to sanitation services is important for the health of heat-vulnerable households.

Shared Toilet			
Rajkot city	No	Yes	Total
Absolute No.	201	45	246
Percentage distribution (Within Options)	81.71	18.29	100

Table-5.3.1(b)



Graph-5.3.1(a), (b)

5.7 Water:

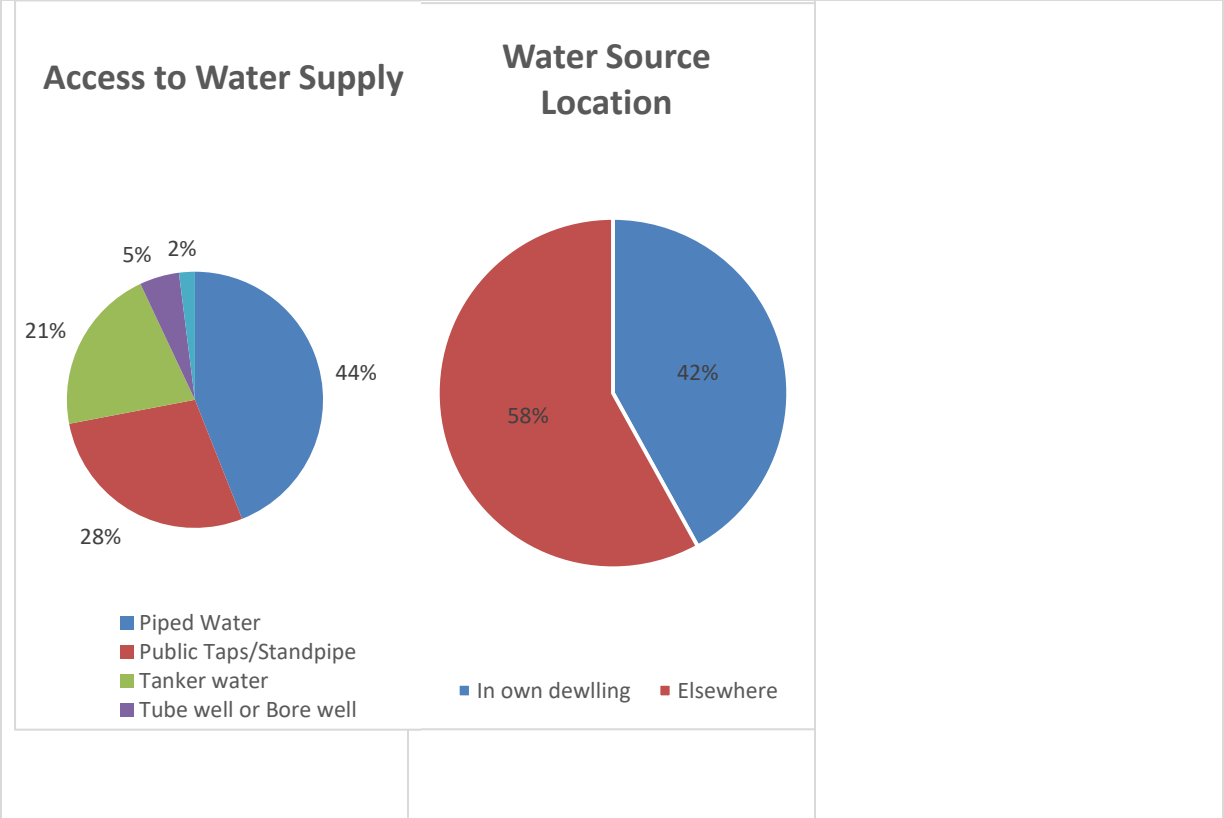
5.7.1 Access to water supply:

Access to Water Supply									
Rajkot city	**Piped Water**	**Public Taps/Standpipe**	**Tube well or Bore well**	**Dug Well**	**Tanker water**	**Surface Water**	**Bottled Water**	**Other**	**Total**
Absolute No.	127	79	13	0	61	0	0	6	286
Percentage distribution (Within Options)	44.41	27.62	4.55	0	21.33	0	0	2.1	100

Table-5.4.1 (a)

Water Source Location			
Rajkot city	**In own dwelling**	**Elsewhere**	**Total**
Absolute No.	120	166	286
Percentage distribution (Within Options)	41.96	58.04	100

Table-5.4.1 (b)



Graph- 5.4.1 (a), (b), (c)

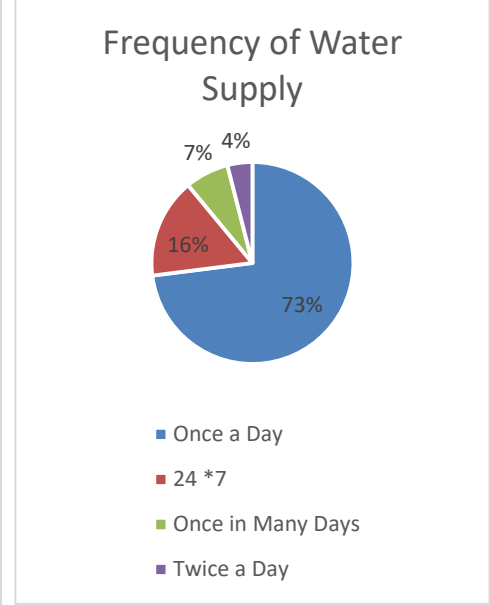
Table 5.4.1 (a) shows that 44% of the sample households have access to the piped water supply. Rest fetch water from unsustainable sources like public taps, tankers, bottled water, nearby streams, dug wells, groundwater, and supply. For 42%, the water source is within the premises. For the rest,58%, water source is elsewhere (table-5.6.1 (b)). It may lead to vulnerability towards heat and other health implications such as diarrhoea, cholera, diarrhoea, dysentery, hepatitis A, typhoid. There may be limited water supply during the hot season due to poor low-pressure access to water from different sources, pointing to increased water demand or scarcity. Mitigation actions should be included for affordable user tariffs, adding

more households in the distribution network, water dispensing trucks, and water storage facilities at the community level.

5.7.2 Water Supply (litres):

Frequency of water Supply					
Rajkot city	**24 *7**	**Twice a Day**	**Once a Day**	**Once in Many Days**	**Total**
Absolute Number	45	12	209	20	286
Percentage distribution (Within Options)	15.73	4.2	73.08	6.99	100

Table- 5.4.2



Graph- 5.4.2

According to table 5.4.2 (a), 73% of the sample households are supplied water once a day. The frequency of water supply needs to increase to avoid risk on high heat days. Measures such as spreading awareness on the water conservation techniques among the households could be adopted to mitigate water shortage.

Implication: Access to safe and affordable water available to all is critical during heat stress. Its paucity might result in securing water from unreliable sources. It not only increases public health risk but raises the issue of water security.

5.8 Electricity:

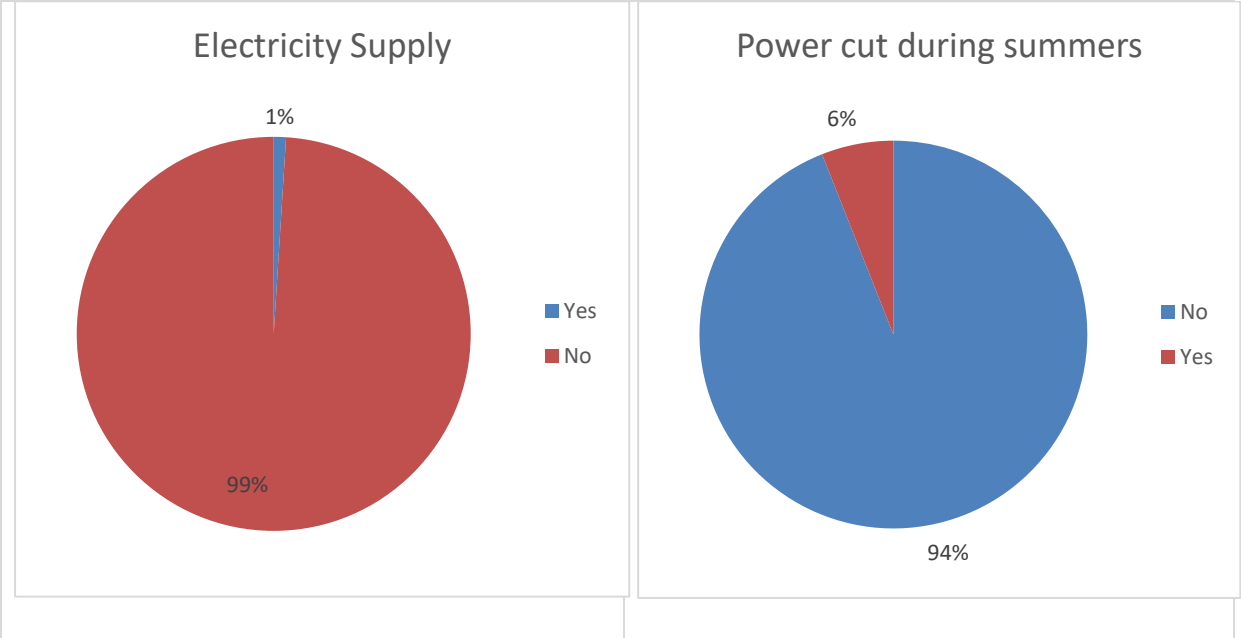
5.8.1 Electricity supply, and Frequency of Power cut in summer months:

Electricity Supply			
Rajkot city	**No**	**Yes**	**Total**
Absolute No.	3	283	286
Percentage distribution (Within Options)	1.05	98.95	100

Table- 5.5.1(a)

Power Cut			
Rajkot city	**No**	**Yes**	**Total**
Absolute No.	267	16	283
Percentage distribution (Within Options)	94.35	5.65	100

Table- 5.5.1(b)



Graph- 5.5.1 (a), (b)

99% of households are connected to the grid (have legal electricity connection). Therefore, it is not a disrupting factor. However, the survey shows, 6% of the sample households claim

that they face power cuts (Table 5.5.1 (a)). Solar power may be harnessed. The government should also ensure power supply during hot periods in the summer season.

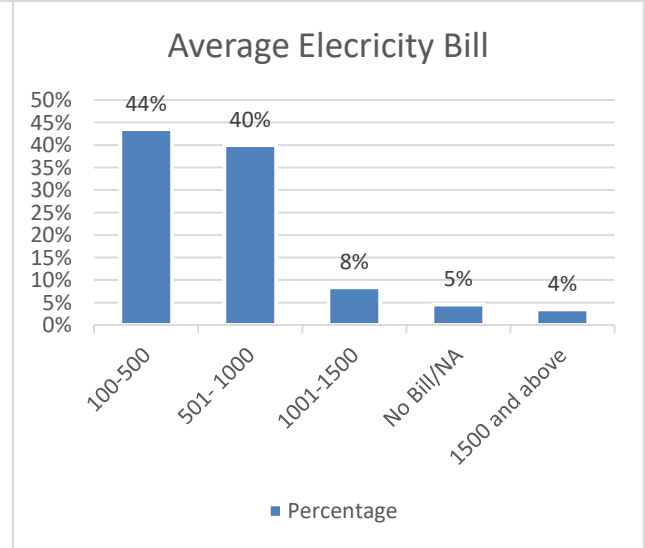
5.8.2 Types of electric appliances used and Electricity Bill:

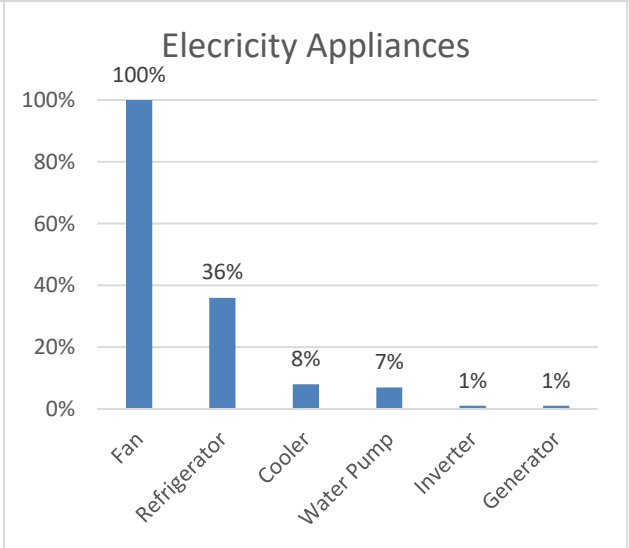
Electricity Appliances							
Rajkot city	**AC**	**Fan**	**Cooler**	**Refrigerator**	**Water Pump**	**Inverter**	**Generator**
Absolute No.	1	285	22	103	20	3	3
Percentage distribution (Within Options)	0.35	99.65	7.69	36.01	6.99	1.05	1.05

Table- 5.5.2 (a)

Average electricity expense						
Rajkot city	**No Bill/NA**	**100-500**	**501- 1000**	**1001-1500**	**1500 and above**	**Total**
Absolute No.	13	124	114	24	10	285
Percentage distribution (Within Options)	4.56	43.51	40	8.42	3.51	100

Table- 5.5.2 (a)





Graph- 5.5.2 (a)

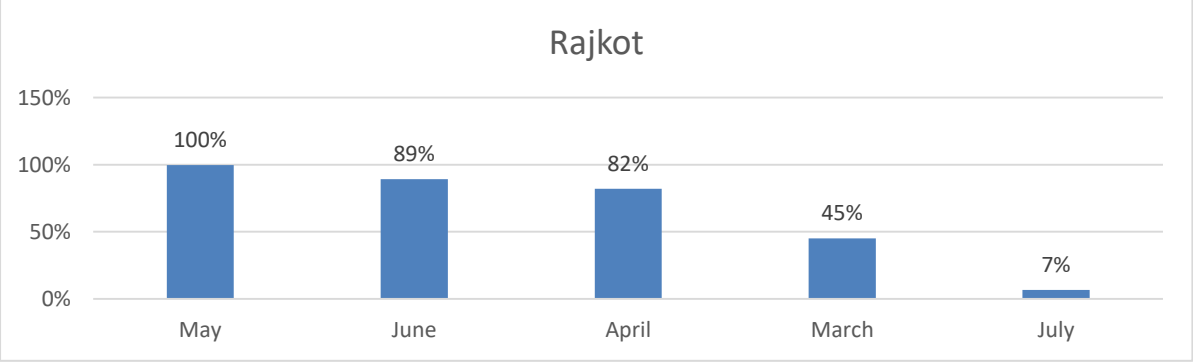
The majority of the households have fans, followed by refrigerators and coolers (table- 5.5.2). 44% had expenses in the range of INR 100-500 (table- 5.5.2). A majority (57%) of the respondents incurred higher than INR 500 as the expense. Households should be trained about harnessing natural resources for mitigating heat stress. This will also help the households in minimising their electricity costs.

Implication: Accessibility to electricity helps to minimise the acute impacts of heat stress, especially during the heatwave. High temperatures exacerbate energy insecurity for those living in poor neighbourhoods, as these communities typically bear the brunt of the heat.

5.9 Health:

5.9.1 Mapping the High Heat period

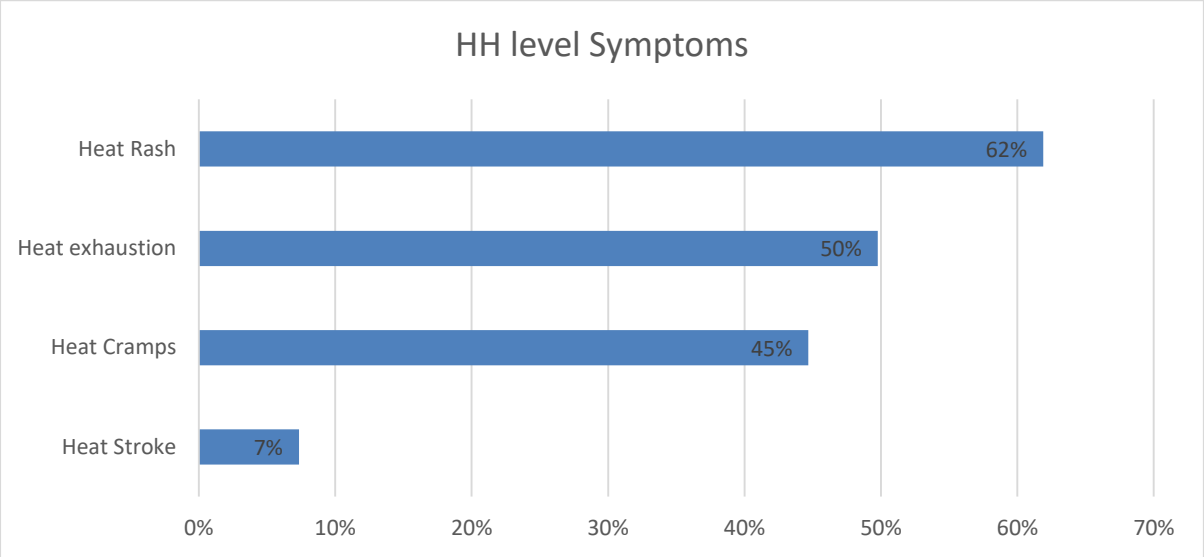
HEAT STRESS MONTHS								
Rajkot city	**Jan**	**Feb**	**March**	**April**	**May**	**June**	**July**	**August**
Absolute No.	4	5	629	1142	1391	1243	94	9
Percentage distribution (Within Options)	0.29	0.36	45.12	81.92	99.78	89.17	6.74	0.65



Rajkot experiences summer from March to July; the hot season intensifies in April, May, and June. During this period, the temperatures peak and result in severe heatwave conditions, deterioration in public health, and causing heat stress. During these months, extreme caution has to be adopted, and the government should share heat stress advisory among the households.

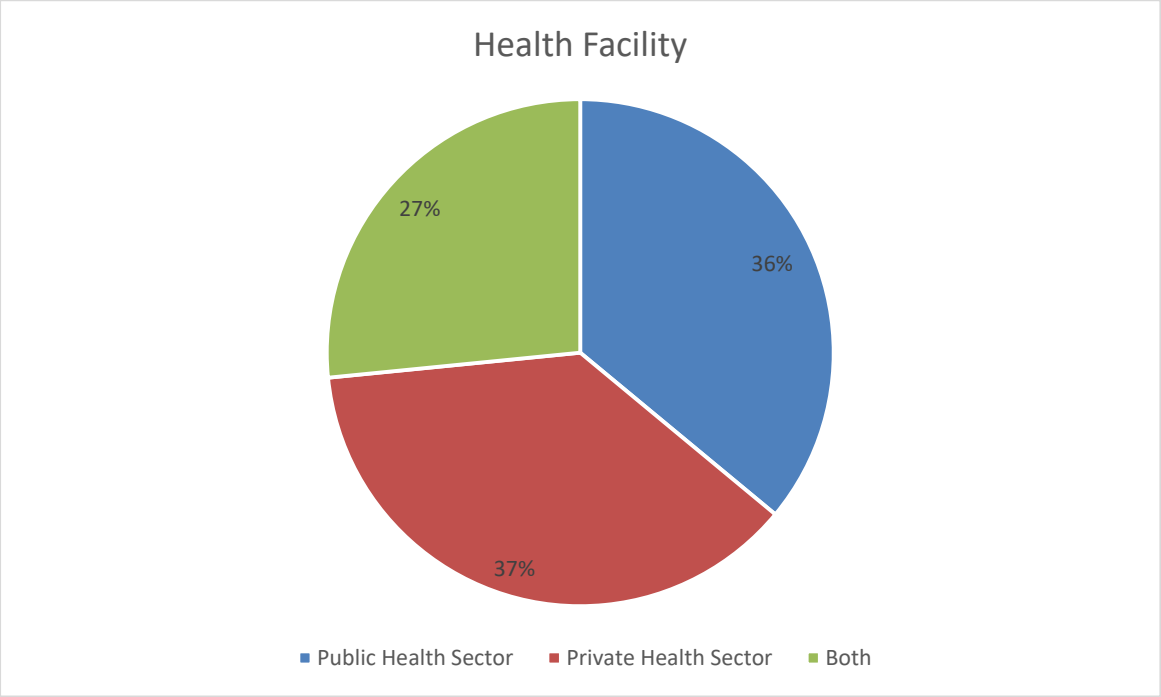
5.9.2 Time of heat discomfort during the day: (Dot graph to be retrieved from Probal Sir, Image of the graph)

5.9.3 Household reporting heat stress symptoms



Households reported heat stress symptoms— 62 % reported heat rashes, 50 % said they suffered heat exhaustion, 45 % bore heat cramps. The figures indicate that heat stress is a growing public health issue.

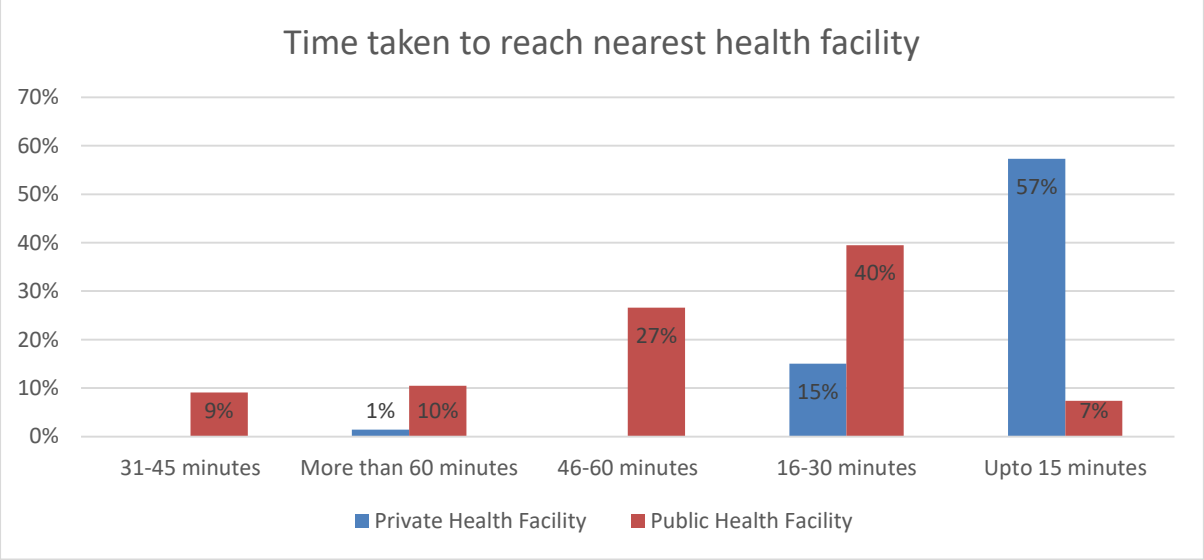
5.9.4 Access to health infrastructure:



Graph- 5.6.1

About 36 % of the households accessed public health care., whereas 37 %accessed only private health care. It was highlighted that better services are being provided by the private health care providers to the sample households. 27 % accessed both public and private health care facilities due to their affordability.

5.9.5 Distance from nearest health centre



Graph- 5.6.2

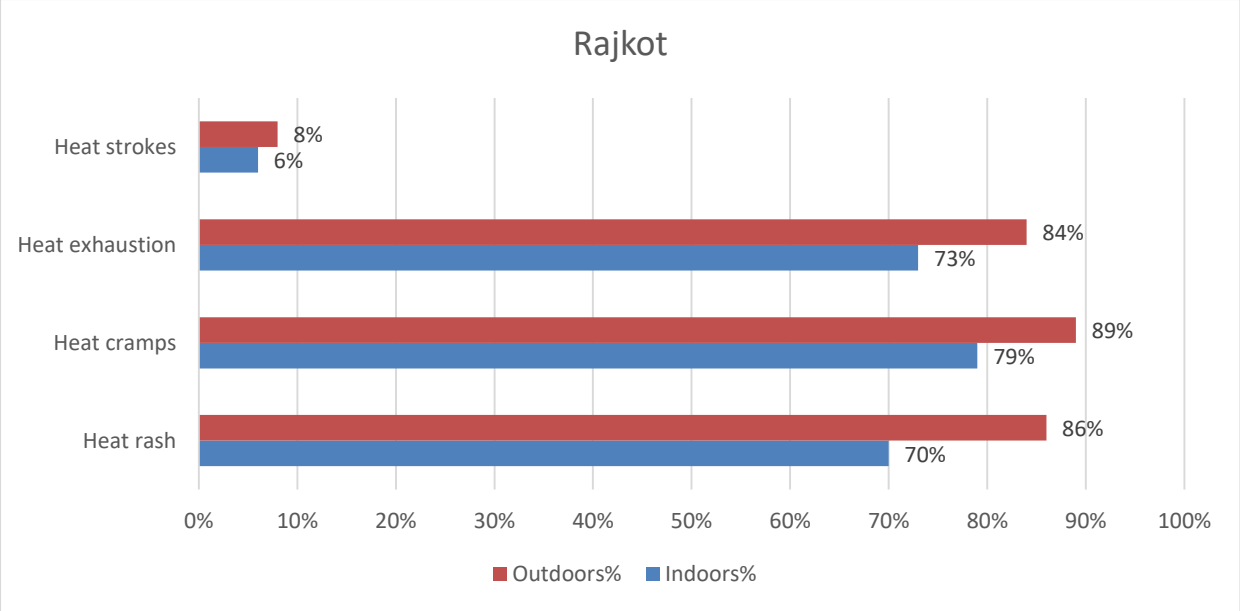
About 57 % had private health facilities within 15 minutes from their home, and only 7 % of public health facility users took up to 15 minutes. Similarly, about 40 % of private health facility users and 15 % of public health facility users took 16-30 minutes. It indicates that there is limited access to public health facilities. If it is corroborated with percent of households accessing public health facilities, it suggests that people travel a long distance to visit available facilities due to their low affordability.

Table- 5.6.3

5.9.6 Occupation Wise Symptoms

	Heat rash		Heat Cramps		Heat Exhaustion		Heat Stroke	
Rajkot	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor
Absolute Number	296	714	334	739	309	699	27	65
Percentage distribution (Within Options)	70.14	85.82	79.15	88.82	73.22	84.01	6.4	7.81

Table- 5.6.6



Graph-5.6.6

The outdoor workers suffer more (graph- 5.6.6) than indoor workers in Rajkot city. Indoor workers suffer most through Heat cramps (79%) followed by Heat exhaustion (73%). Similarly, Heat Cramps (89%) and heat rash (86%) are the most common symptoms in outdoor workers.

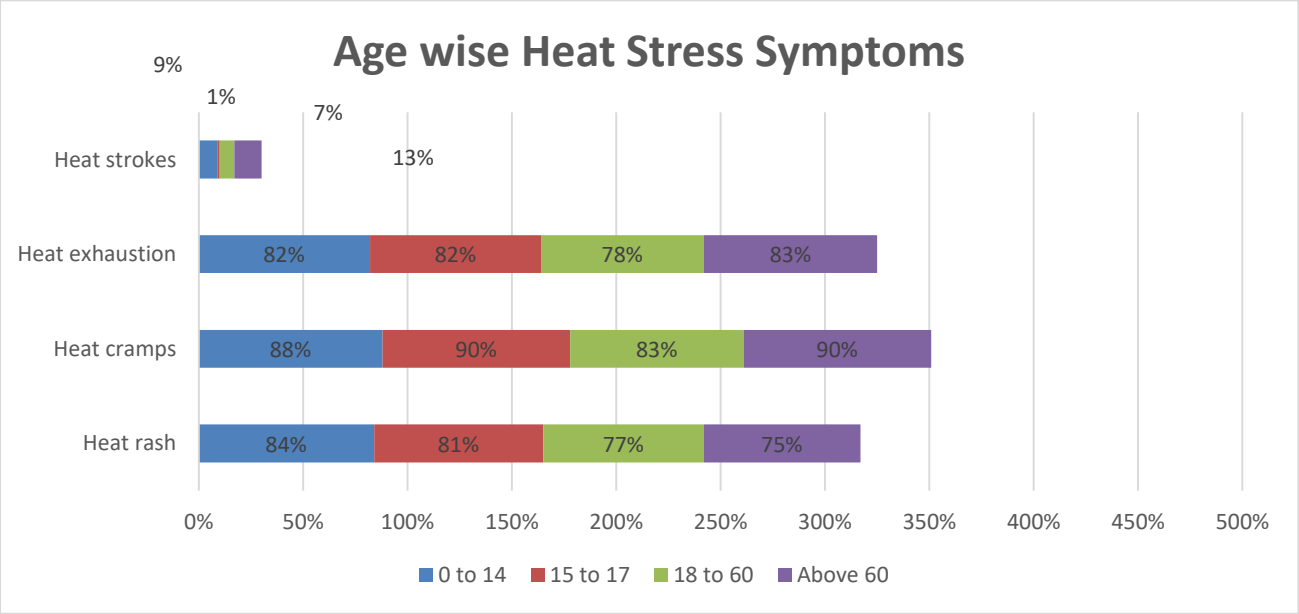
Occupation type	1st Heat stress Symptoms	2nd Heat stress Symptoms
Outdoor workers	Heat cramps	Heat Rash
Indoor Workers	Heat cramps	Heat Exhaustion

5.9.7 Age wise Heat Stress Symptoms

Rajkot	Heat rash				Heat Cramps				Heat Exhaustion				Heat Stroke			
	0 to 14	15 to 17	18 to 60	Above 60	0 to 14	15 to 17	18 to 60	Above 60	0 to 14	15 to 17	18 to 60	Above 60	0 to 14	15 to 17	18 to 60	Above 60

Absolute Number	334	92	649	30	352	102	698	36	329	93	654	33	34	1	58	5
Percentage distribution (Within Options)	83.5	81.42	77.2	75	88	90.27	83	90	82.3	82.3	77.76	82.5	8.5	0.88	6.9	12.5

Table- 5.6.7



Graph- 5.6.7

The graph-5.6.7, heat cramps followed by heat exhaustion and heat rash were the most common symptoms. Children (0 to 14) and adolescents (15 to 17) reported symptoms of heat cramps the most. The majority of adults, working-class, reported suffering from Heat Cramps, followed by heat exhaustion and heat rashes. Similarly, senior citizens struggled with Heat cramps and heat exhaustion the most.

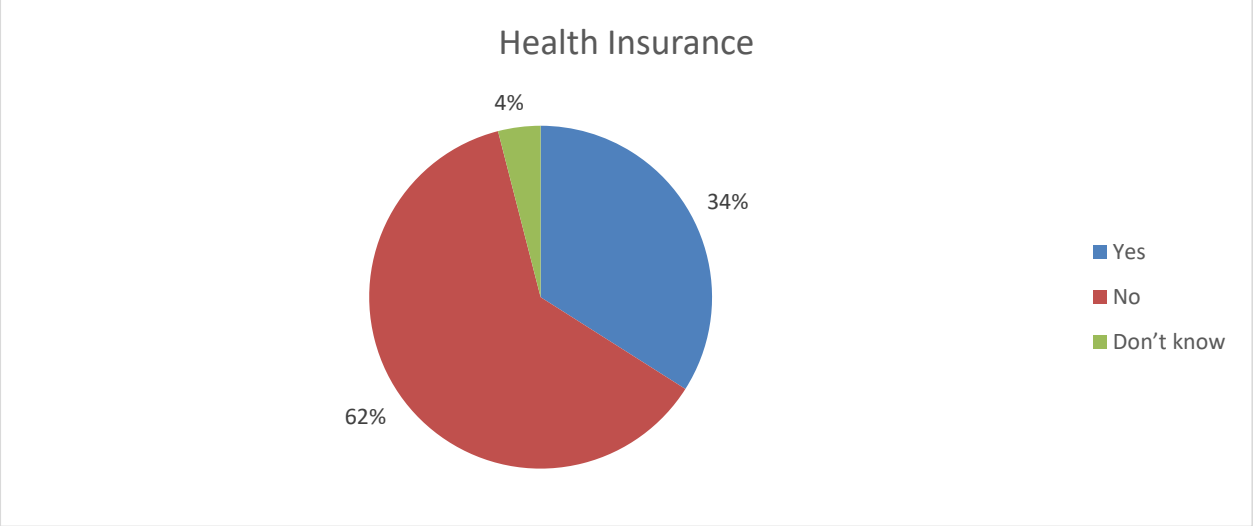
Age group	1st Heat symptoms	2st Heat symptoms

0 to 14	Heat cramps	Heat Rash
15 to 17	Heat cramps	Heat exhaustion
18 to 60	Heat cramps	Heat exhaustion
Above 60	Heat cramps	Heat exhaustion

5.9.8 Health insurance

Health Insurance				
Rajkot city	**Yes**	**No**	**Don't know**	**Total**
Absolute Number	97	177	12	286
Percentage distribution (Within Options)	33.92	61.89	4.2	100

Table- 5.7.1



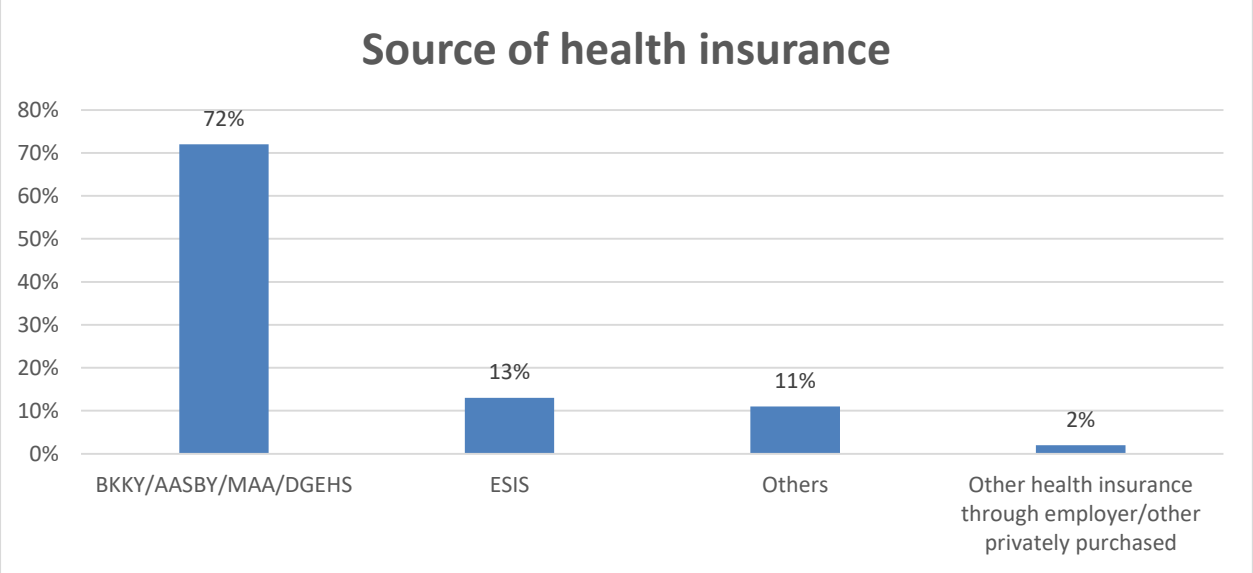
Graph- 5.7.1

62% of the people do not have access to health insurance (graph 5.7.1). Due to affordability, most households are out of the insurance network and have very poor awareness about the govt sponsored medical schemes such as Ayushman Bharat Pradhan Mantri Jan Arogya Yojana. To improve access to health insurance, the government should develop insurance schemes for people significantly below the poverty line, and the local government hospitals should treat heat stress illnesses free of cost.

5.9.9 Source of health insurance

Source of health insurance								
Rajkot **city**	**ESIS**	State Health Insurance Scheme / Aam Aadmi Bima Yojana Mother Absolute Affection / Delhi Government Employees Health Scheme	**CHIP**	**SMART CARD**	**Other health insurance through employer/other privately purchased**	**Medical reimbursement from employer**	**Others**	**Total**
Absolute Number	13	70	0	0	2	1	#	#
Percentage distribution (Within Options)	13.4	72.2	0	0	2	1	#	#

Table- 5.7.2



Graph- 5.7.2

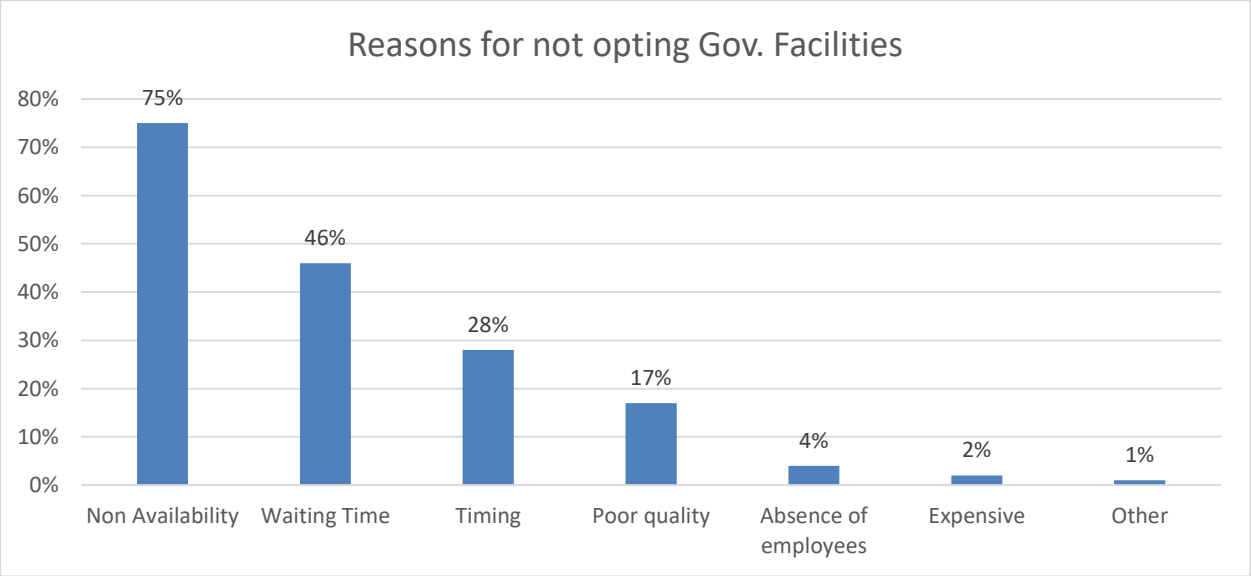
Graph- 5.7.2 indicates that about 72% have State Health Insurance and another 26%with smart health cards, private health insurances, and other miscellaneous sources. The

government-sponsored schemes help economically weaker sections of society to access medical care. While some households have health insurance, bringing more people under the health insurance net by improving access, making schemes affordable, and increasing awareness about benefits.

5.9.10 Reasons for lack of access to government health facilities

Reasons for lack of access to Government health facility							
Rajkot city	**Non Availability**	**Timing**	**Absence of employees**	**Waiting Time**	**Poor quality**	**Expensive**	**Other**
Absolute Number	80	30	4	49	18	2	1
Percentage distribution (Within Options)	74.77	28.04	3.74	45.79	16.82	1.87	0.93

Table- 5.7.3



Graph- 5.7.3

Graph- 5.7.3 indicates that the non-availability of government hospitals (75%) is one of the major reasons for people not opting for government hospitals as an option. The other reasons are long waiting time (46%), Inconvenient timing of the facility (28%), and poor quality of care (17%)

5.10 Women-specific impacts of heat stress

The impact of heat stress on women is manifold. Many factors, both physiological and environmental aspects, play a critical role in causing more heat stress among women and putting them more at risk for heat-related mortality. Through the studies conducted on Gender inequality, it is inferred that women are more likely than men to be affected by climate change. Female mortality due to heat-stroke shows an increasing trend since 2011 in the age group of below 14 years, whereas male mortality has been reducing continuously. With the growing heat stress, women become vulnerable as their ability to thermoregulate is compromised. There are increasing heat-related illnesses and stillbirth among pregnant women, which further intensify due to social norms and gender discrimination embedded in society. Moreover, pregnant and postpartum women and their infants are uniquely vulnerable to the health impacts of climate change due to the many physiologic and social changes that occur as a result of pregnancy. Also, it is observed that high temperatures can give rise to air pollutants causing chronic health effects, such as respiratory diseases and allergic reactions.

Among the working women from economically weaker sections, the heat stress vulnerabilities are high, and it further increases due to resource crunch and insufficient adaptive capacities. Low-income women are disproportionately vulnerable to the ill-effects of climate variability and change, in part because of gender inequalities (e.g., unequal political, social, economic, and cultural rights; lower levels of access to resources, information, and education; and lower levels of participation and influence in shaping policies and decision-making processes at all levels, including the household). It has also been observed that high temperatures can give rise to air pollutants causing chronic health effects, such as respiratory diseases and allergic reactions. For the working women, the factors affecting their thermal comforts, such as air temperatures, radiant temperature, humidity, and air movement, expose them to various health risks. Besides, there are personal factors that affect thermal comfort are viz, clothing insulation and metabolic heat. Furthermore, outdoor workers are also vulnerable to urban heat island effects. It has also been observed that high temperatures can give rise to air pollutants causing chronic health effects, such as respiratory diseases and allergic reactions.

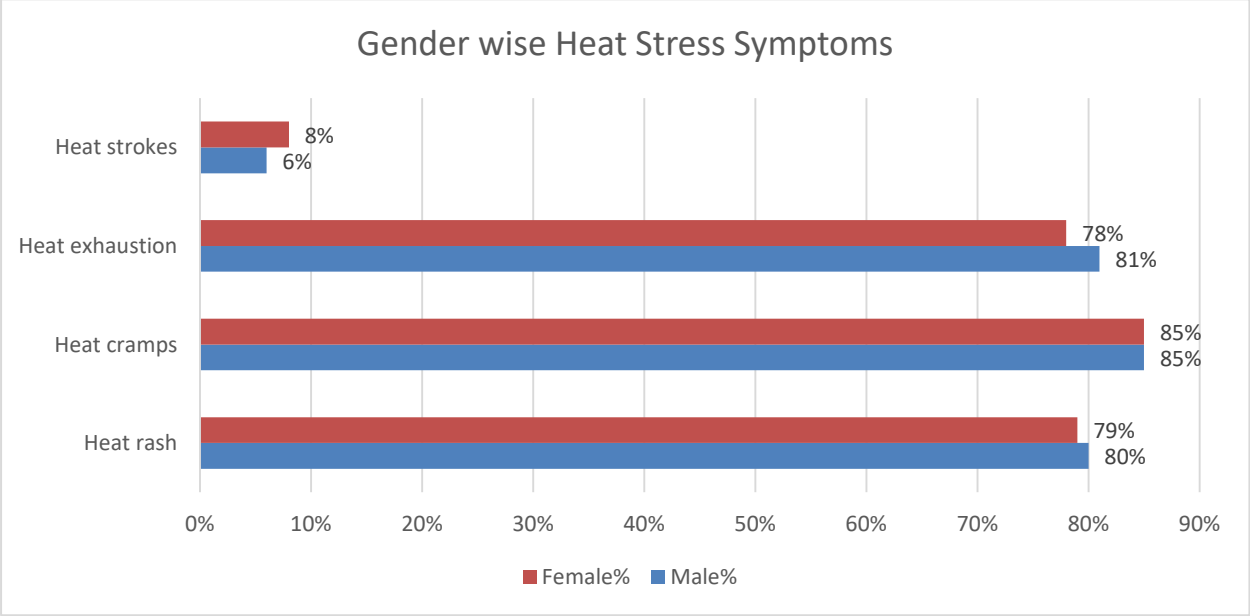
Furthermore, the lack of timely access to information on heat alerts increases their risk of heat stress. Their exclusion in decision-making and adaptation behavior adds to their vulnerability, making them less aware of adaptation strategies and mitigation measures.

5.10.1 Differential Impact of heat on Gender

	Heat rash		Heat cramps		Heat Exhaustion		Heat Stroke	
Rajkot	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Absolute Number	540	565	576	612	550	559	44	54
Percentage distribution (Within Options)	79.65	78.91	84.96	85.47	81.12	78.07	6.49	7.54

Table- 5.8.1

Acc. to the table - 5.8.1, it is observed that both males and females are equally affected by each of the heat stress symptoms.



Graph- 5.8.1

The survey highlights that the women are equally vulnerable to the heat stress symptoms. They are most affected by heat cramps (85%) followed by heat rash (79%), and heat exhaustion (78%). The table above shows that males and females experience similar heat stress symptoms. It is observed that Heat rash is more common in males, while heat stroke is more common in females. Cases of heat strokes are higher in women as they stay indoors,

and the factors of social norms, housing design, and its material aggravate heat-stroke conditions and other public health concerns.

6 Livelihood – Wage and Productivity loss:

Due to the rise of heat stress, its impact is, directly and indirectly, reflected on the wage and productivity loss amongst the working population, specially in vulnerable sections of the society.

6.1 Wage Loss:

6.1.1 Average wage loss

Average Wage loss						
	No wage loss	**1-999**	**1000-1999**	**2000-2999**	**3000 and above**	**Total**
Rajkot						
Absolute Number	504	14	7	5	12	542
Percentage distribution (Within Options)	92.99	2.58	1.29	0.92	2.21	100
Percentage distribution (Within Cities)	41.93	5.47	26.92	26.32	60	35.59
Total	1,202	256	26	19	20	1,523
	78.92	16.81	1.71	1.25	1.31	100
	100	100	100	100	100	100

Note: No Wage Loss was not considered while calculating the Average Wage Loss.

The average wage loss in the city falls under the category INR 1 to 999 followed by INR 3000 and above.

6.1.2 Gender Wise Wage Loss:

Wage loss code						
Gender	**No wage loss**	**1-999**	**1000-1999**	**2000-2999**	**3000 and above**	**Total**
Female	113	6	2	1	3	125
	90.4	4.8	1.6	0.8	2.4	100
	22.42	42.86	28.57	20	25	23.06
Male	391	8	5	4	9	417
	93.76	1.92	1.2	0.96	2.16	100
	77.58	57.14	71.43	80	75	76.94
Total	504	14	7	5	12	542
	92.99	2.58	1.29	0.92	2.21	100
	100	100	100	100	100	100

Note: No Wage Loss was not considered while calculating the Gender Wise Wage Loss.

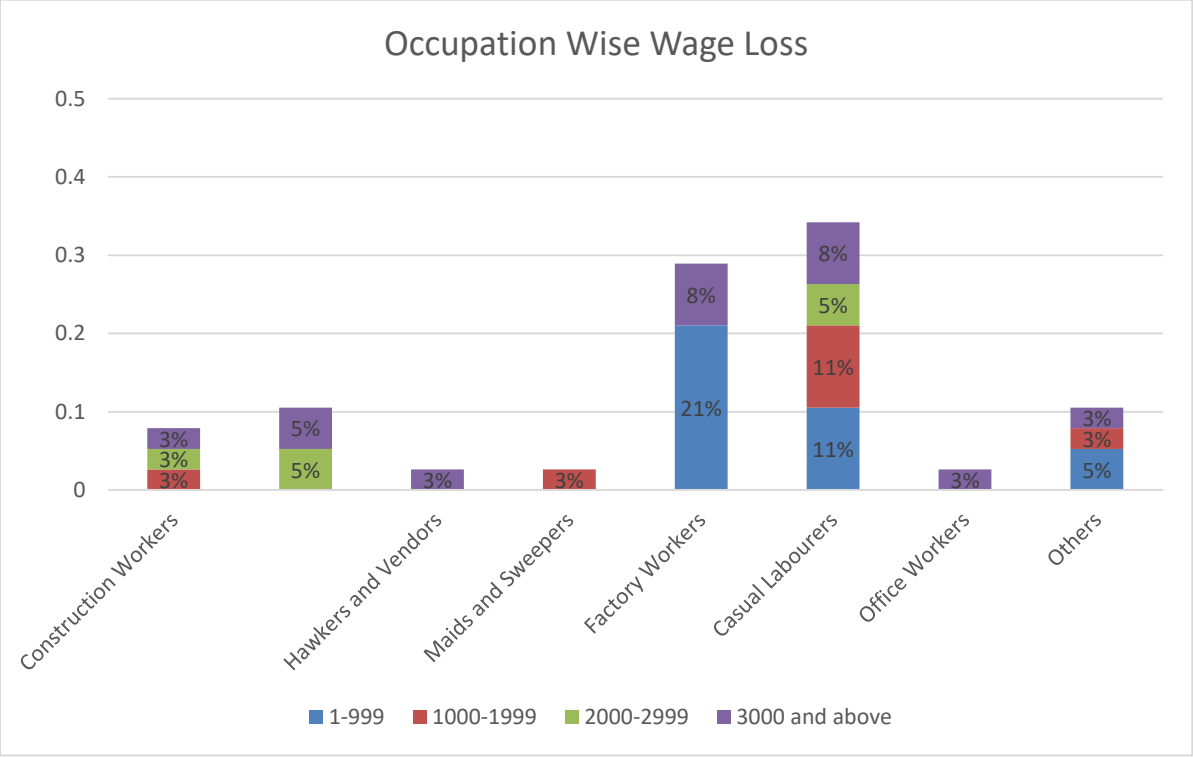
It is observed that the majority of males (75% out of the total) experienced wage loss due to heat as compared to the women involved in work. Most females experience wage loss in the category INR 1 to 999 while males in INR 3000 and above. The average monthly wage loss in females is INR 200 while in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

6.1.3 Occupation wise Wage Loss:

	Wage loss code					
Occ code	**No wage loss**	**1-999**	**1000-1999**	**2000-2999**	**3000 and above**	**Total**
Construction Workers	46	0	1	1	1	49
Transportation Workers (Rickshaw/Auto likewise)	35	0	0	2	2	39
Hawkers and Vendors	15	0	0	0	1	16
Maids and Sweepers	39	0	1	0	0	40
Factory Workers	146	8	0	0	3	157
Casual Labourers	166	4	4	2	3	179
Office Workers	5	0	0	0	1	6
Traffic Police	1	0	0	0	0	1
Business	3	0	0	0	0	3
Others	47	2	1	0	1	51

Note: No Wage Loss was not considered while calculating the Occupation Wise Wage Loss.

Numerous occupations were considered while calculating the occupation-wise wage loss in the city.



The casual labourers are most affected by the high heat days. As the maximum wage loss is reported in the daily causal labourers (35%). This is due to the high share of involvement and low share of income. They are followed by the factory workers who often experience heat exhaustion during high temperatures due to prolonged working hours. Hawkers, Maids, and Office workers are least affected amongst the identified occupations

6.2 Impact of Heat Stress on Livelihoods and Productivity

6.2.1 Average Productivity Loss:

Average Productivity Loss						
Rajkot city	**No absence**	**1-5 days**	**6-10 days**	**10-15 days**	**more than 15**	**Total**
Absolute Number	500	27	4	9	2	542
Percentage distribution (Within Options)	92.25	4.98	0.74	1.66	0.37	100

Table- 5.9.1 Note: No Absence was not considered while calculating the Average Productivity.

Graph- 5.9.1

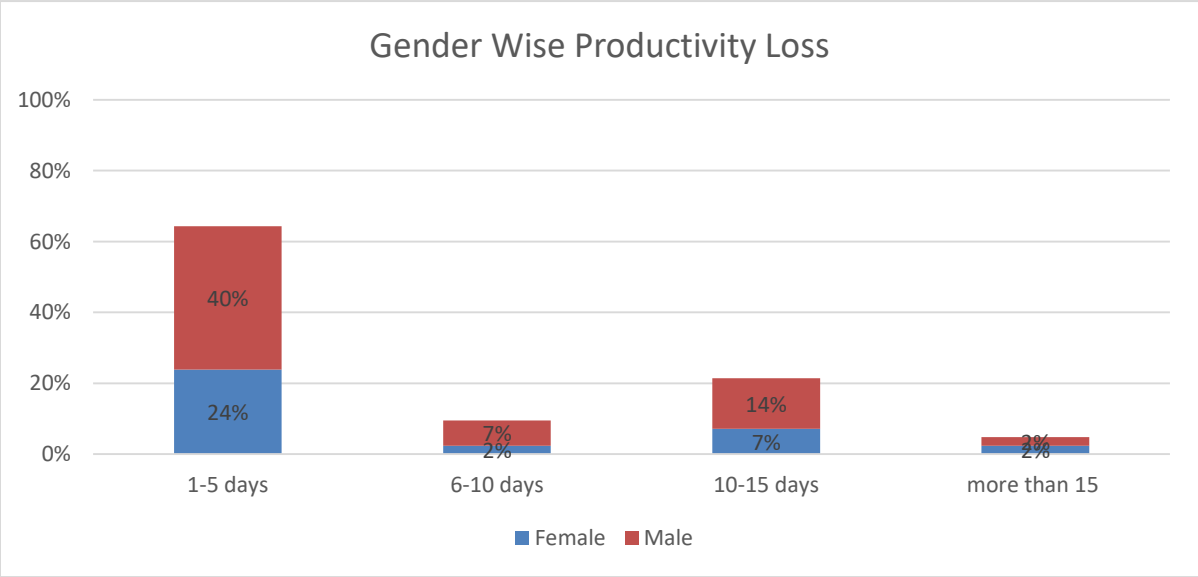
Graph- 5.9.1 shows that with the loss in wages, the productivity of the individuals is also highly affected. A majority (64%) of the working population had reported the loss in the working days by 1 to 5 days during the heat stress period, followed by 10 to 15 days (21%) in a month.

6.2.2 Gender Wise Productivity Loss:

	Gender Wise Productivity Loss					
Gender	**No absence**	**1-5 days**	**6-10 days**	**10-15 days**	**more than 15**	**Total**
Female	110	10	1	3	1	125

	88	8	0.8	2.4	0.8	100
	22	37.04	25	33.33	50	23.06
Male	390	17	3	6	1	417
	93.53	4.08	0.72	1.44	0.24	100
	78	62.96	75	66.67	50	76.94
Total	500	27	4	9	2	542
	92.25	4.98	0.74	1.66	0.37	100
	100	100	100	100	100	100

Table- 5.9.2 Note: No Absence was not considered while calculating the Gender Wise Productivity.



Graph- 5.9.2

Acc. to the graph- 5.9.2 wage loss among males (64%) is at a greater loss than females due to productivity loss. The majority of males and females experience productivity loss in 1 to 5 days. The average number of days lost due to high temperature is one day for males, while for women, it is 12 hours in a month.

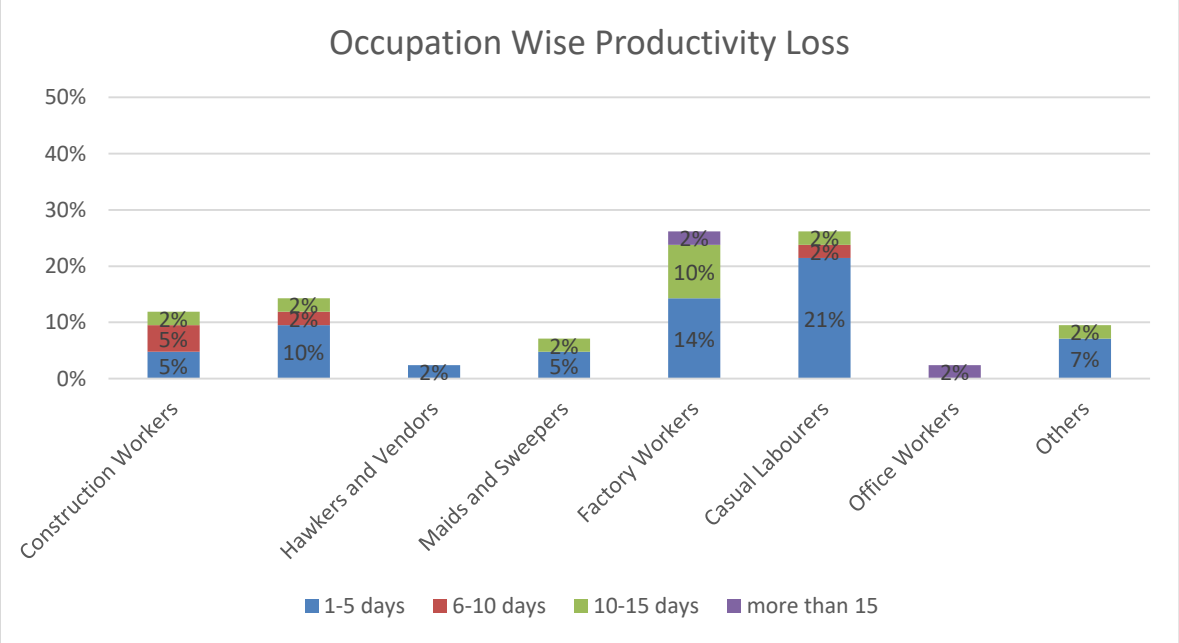
6.2.3 Occupation wise productivity Loss:

Occupation wise productivity Loss						
Occ type	**No absence**	**1-5 days**	**6-10 days**	**10-15 days**	**more than 15**	**Total**

Construction Workers	44	2	2	1	0	49
Transportation Workers (Rickshaw/Auto likewise)	33	4	1	1	0	39
Hawkers and Vendors	15	1	0	0	0	16
Maids and Sweepers	37	2	0	1	0	40
Factory Workers	146	6	0	4	1	157
Casual Labourers	168	9	1	1	0	179
Office Workers	5	0	0	0	1	6
Traffic Police	1	0	0	0	0	1
Business	3	0	0	0	0	3
Others	47	3	0	1	0	51

Table- 5.9.3 Note: No Absence was not considered while calculating the Occupation Wise Productivity.

The occupations considered while calculating the occupation wise productivity loss in the city are:



Graph- 5.9.3

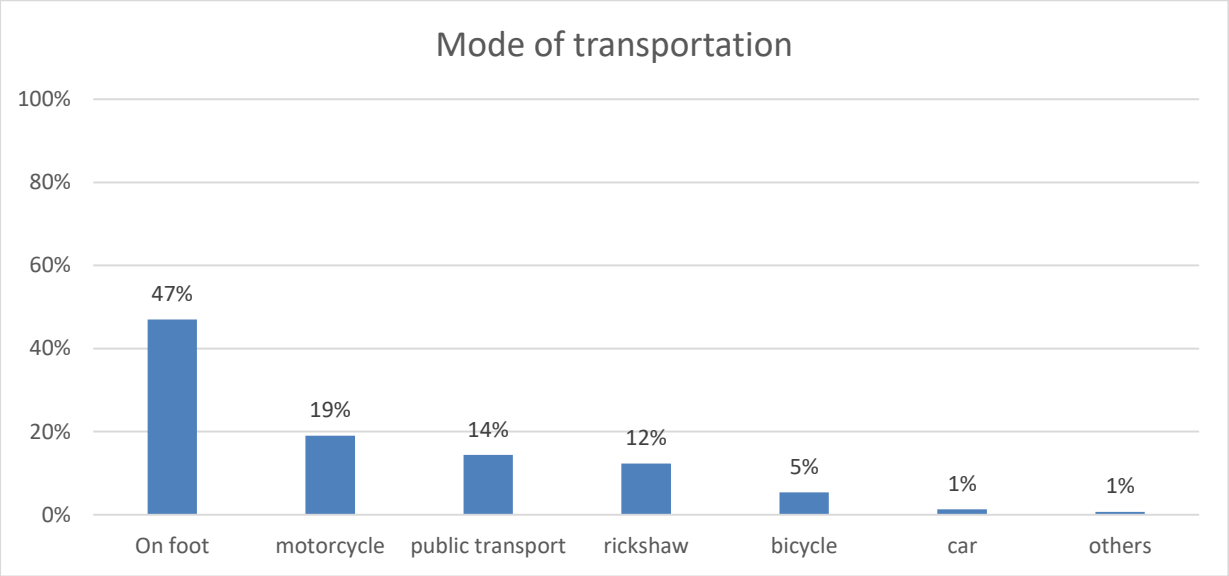
Graph-5.9.3 shows that Factory workers and casual labourers are most affected during high-temperature days as the maximum productivity loss is reported in the factory workers (26%) followed by the casual labourers (25%). Prolonged working hours, unsuitable working conditions, and lack of sensitisation are some reasons behind the loss. It is observed that hawkers and office workers are the least affected amongst the identified occupations.

6.3 Transport:

6.3.1 Methods used for commuting (workplace/school):

MODE OF TRANSPORT								
Rajkot city	**On foot**	**bicycle**	**motorcycle**	**car**	**public transport**	**rickshaw**	**others**	**Total**
Absolute Number	484	55	196	13	148	127	7	1030
Percentage distribution (within options)	46.99	5.34	19.03	1.26	14.37	12.33	0.68	100

Table- 5.10.1



Graph- 5.10.1

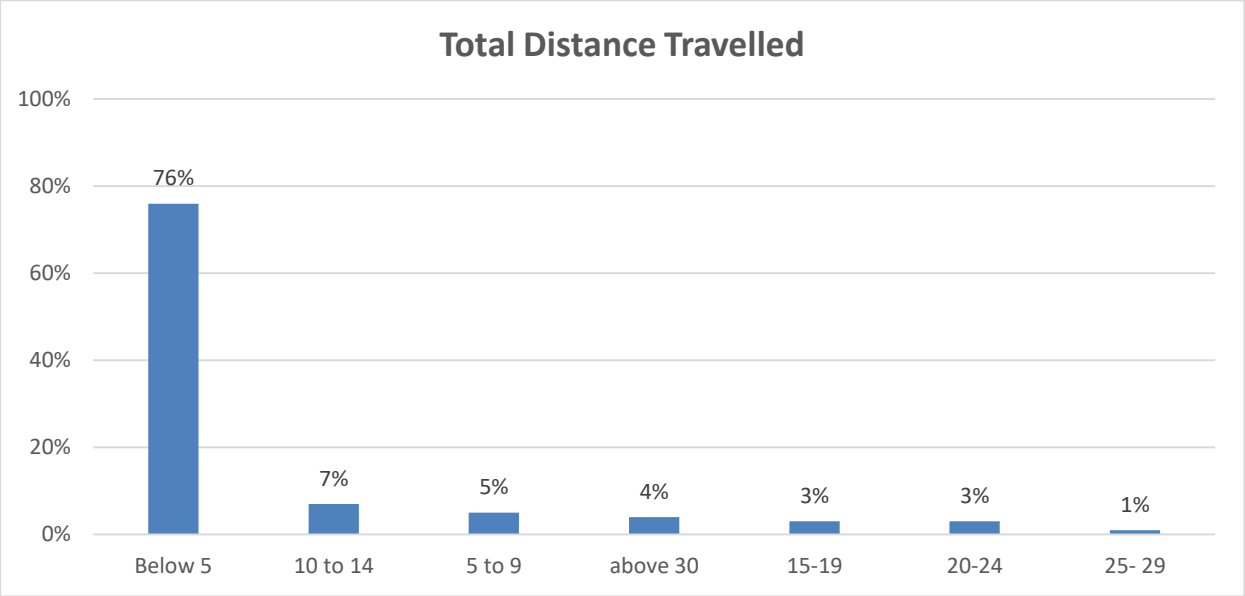
Graph- 5.10.1 shows the mode of transportation used by the households. About 47% of the residents travel on foot, 19% use Motorcycle and14% use Public Transport as a most common way to commute to work and schools.

6.3.2 Total Distance Travelled:

Distance Travelled								
Rajkot city	**Below 5**	**5 to 9**	**10 to 14**	**15-19**	**20-24**	**25- 29**	**above 30**	**Total**
Absolute Number	1060	76	95	36	46	19	62	1394

Percentage distribution (Within Options)	76.04	5.45	6.81	2.58	3.3	1.36	4.45	100

Table- 5.10.2



Graph-5.10.2

Acc. to the graph-5.10.2, a majority (76%) of sample households travel within the vicinity of 5 Km to reach their respective workplaces/schools. At the same time, the maximum distance of above 30 km is traveled by 4% of the population.

The survey result highlight that given the underlying poverty, they prefer going on foot. The place of work/school is found within 5 Km; the vulnerability of the people can be more during the peak summer while walking on the foot/cycling to their workplace. Building awareness about mitigation measures like promoting umbrellas, head cover, and carrying water are cost-effective measures for these communities.

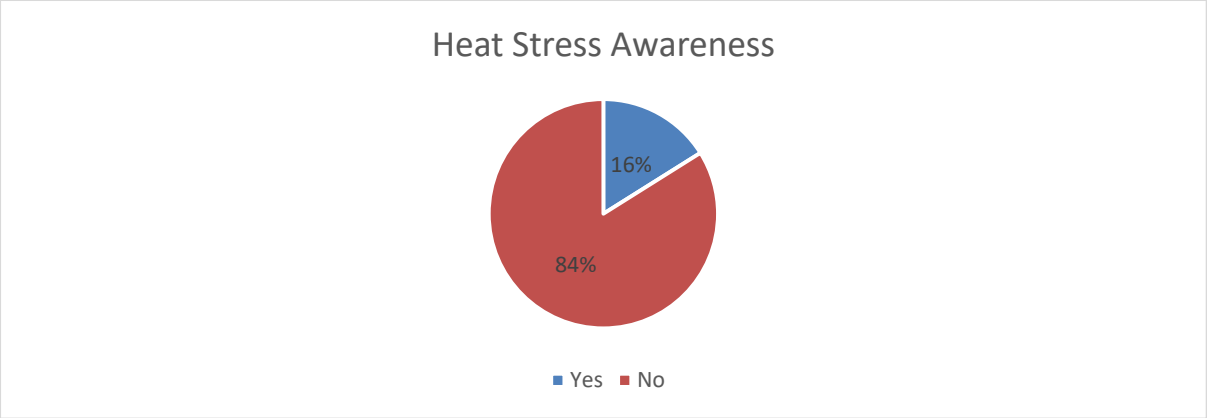
Implications: The opportunities and challenges of increasing transportation access are not well understood by the city. Poor affordability forces people to walk long distances and makes it important to have more green public spaces.

6.4 Awareness:

6.4.1 Aware of the term "Heat Stress"

HEAT STRESS AWARENESS			
Rajkot city	**No**	**Yes**	**Total**
Absolute No.	240	46	286
Percentage distribution (Within Options)	83.92	16.08	100

Table- 5.10.1



Graph- 5.10.1

The graph- 5.10.1 an astonishing number 84% of households are aware of the term heat stress. Only 16% of the total population knows heat and its associated impacts. It brings to the fore that there is a strong need to have more awareness of Heat Stress in Rajkot.

6.4.2 Aware about Medical facilities offering treatment for heat stress

Aware of Medical facilities offering treatment for heat stress				
Rajkot city	**Yes**	**No**	**Don't know**	**Total**
Absolute No.	92	164	30	286
Percentage distribution (Within Options)	32.17	57.34	10.49	100

Table- 5.11.2

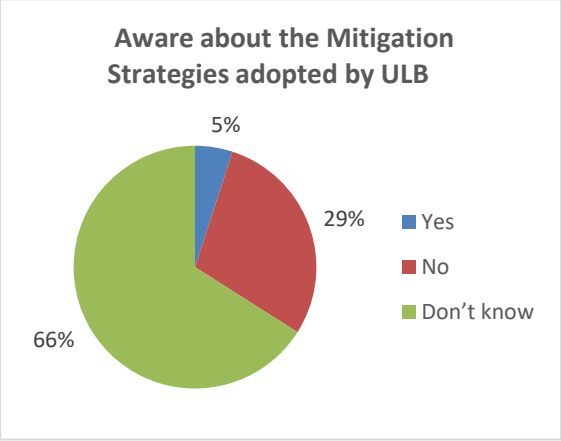
About 57%, the majority of the sample households are not aware of the medical facilities offering treatment for heat stress. However, for the remaining 32 %, it can't be ascertained that they are completely aware of the medical facilities/ hospitals available for the treatment of heat stress issues.

Graph - 5.11.2

6.4.3 Awareness about adaptive mitigation strategies adopted by ULB

Aware about the Mitigation Strategies adopted by ULB				
Rajkot city	**Yes**	**No**	**Don't know**	**Total**
Absolute Number	13	84	189	286
Percentage distribution (Within Options)	4.55	29.37	66.08	100

Table- 5.11.3



Graph- 5.11.3

The graph- 5.11.3, a majority (66%) of the sample population are not aware of the adaptive mitigation strategies adopted by the government. It calls for mitigation actions of broader sharing of information on heat stress and steps to combat this.

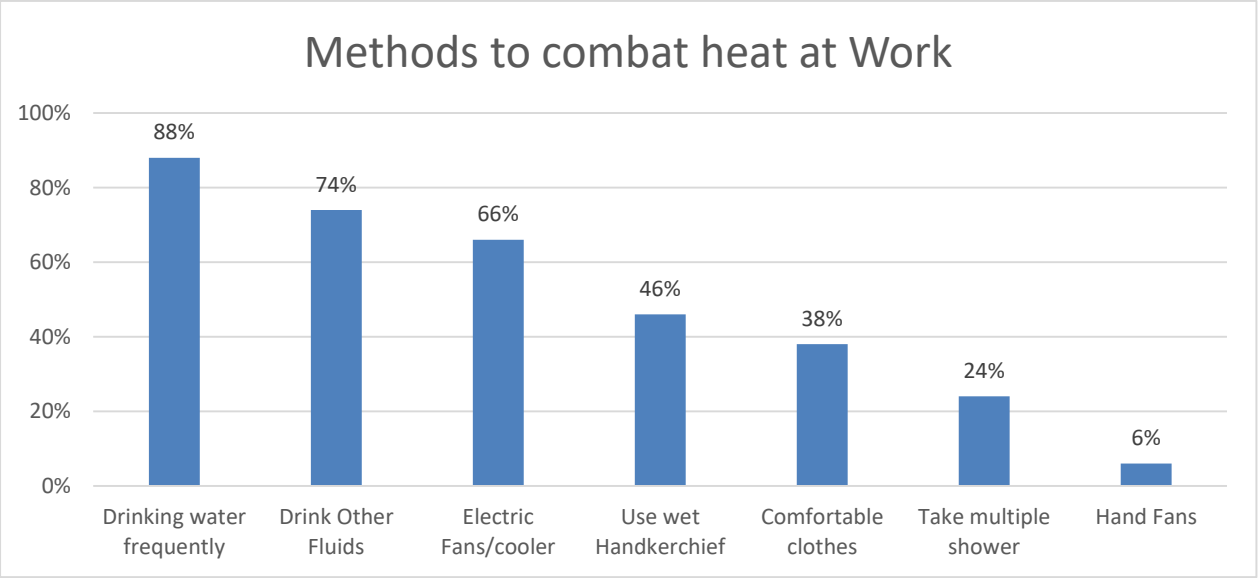
Implications: Awareness about heat stress is generally very low, and people have limited knowledge about the precautions to protect against heatwaves.

6.5 Adaptation:

6.5.1 Coping of heat related discomfort at work

Coping Heat At Work								
Rajkot city	**Comfortable clothes**	**Hand Fans**	**Electric Fans/cooler**	**Drinking water frequently**	**Use wet Handkerchief**	**Drink Other Fluids**	**Take multiple shower**	**Other Measures**
Absolute Numbers	109	17	189	252	131	211	70	4
Percentage distribution (Within Options)	38.11	5.94	66.08	88.1	46	73.78	24.48	1.4

Table- 5.12.1



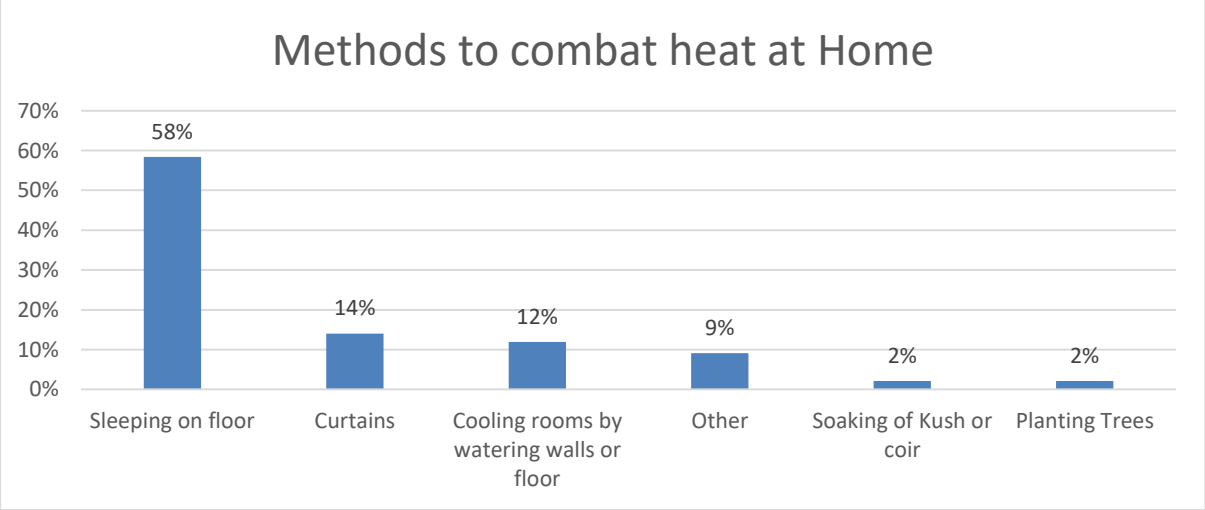
Graph- 5.12.1

Among the respondents, graph- 5.12.1 shows that the most convenient way to cope with heat-related discomfort at work is drinking water frequently (88%), followed by drinking fluids like coconut water, buttermilk, other juices (74%).

6.5.2 Initiatives at HH level to combat heat

METHODS TO COMBAT HEAT AT HOME										
Rajkot city	**Window blinds**	**Curtains**	**Soaking of Kush or coir**	**Sleeping on floor**	**False Ceiling**	**Green roof**	**Covering of roof with shed**	**Planting Trees**	**Cooling rooms by watering walls or floor**	**Other**
Absolute Numbers	4	40	6	167	3	3	4	6	34	26
Percentage distribution (Within Options)	1.4	13.99	2.1	58	1.1	1.05	1.4	2.1	12	9

Table- 5.12.2



Graph- 5.12.2

Acc. graph- 5.12.2 the most preferred methods to combat heat at the household level are – Sleeping on the floor (58%), followed by hanging curtains (14%), and cooling the room by watering walls or floor (12%).

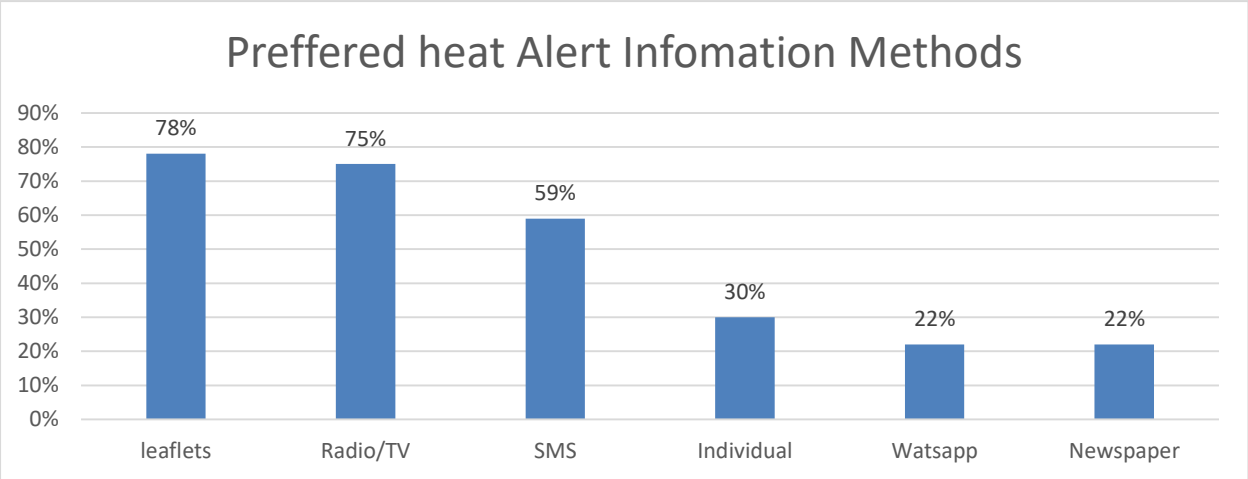
7 Preferred communication strategies:

7.1 Medium of communication for receiving alerts

PREFERRED COMMUNICATION STRATEGIES								
Rajkot city	SMS	Whats App	Leaflets	Newspapers	Radio/ TV	Individual	Others	Don't Know
Absolute Numbers	171	62	222	63	214	87	3	3
Percentage distribution (Within Options)	59.79	21.7	77.6	22	74.8	30.4	1.05	1.05

Table- 6.10.1

Table- 6.10.1 indicates that as per most responses, Leaflets and Pamphlets (78%) are the most preferred medium for communication alerts. This is followed by Radio/TV (75%), SMS alerts (59%) information from individuals (30%), WhatsApp alerts (22%) and newspaper (22%).



Graph- 6.10.1

As per the majority, leaflets are the most preferred medium for alerts, followed by information from radio/TV. The information dissemination methods could use this knowledge for dissemination on heat stress, including women. It will also improve information sharing at the community level.

Implications: The preferred medium, as the survey shows radio/TV, for information sharing should be used by the city-level authorities to spread awareness about heatwaves and advisories to deal with its associated health impacts.

8 Conclusions and Key recommendations

The analysis of the city-level vulnerability assessment of Rajkot indicates that urban poor are most vulnerable to heat stress and its associated impacts. Notably, due to heat stress, the households are most susceptible to the housing viz., the material used and its structure, access to services such as water, and availability of services such as electricity. It aggravates the issues and results in deterioration of health and loss of lives and livelihoods among the households. However, a critical factor that emerged from the study is that the households have very little knowledge and awareness about the adaptive and mitigation strategies adopted by the local institutions. In a scenario of low affordability for health insurance among households, the public health systems must be improved and focus on knowledge dissemination about heat stress.

While the impacts of heat stress are visible through the sectors, the cities can combine sectoral initiatives with a well-defined and coherent framework that ties mitigation and adaptation together. These provide entry points to combat heat stress in specific public health sectors, housing, infrastructure, and services. The recommendations also outline an overarching framework to ensure the maximum impacts of these sector-based initiatives.

8.1 Public Health

8.1.1 Key challenges

1. The households don't have access to public health facilities in immediate areas. They were thereby making it difficult to access public health facilities in case of an emergency.
2. Most households prefer to visit public hospitals due to their affordability or trust in the public health care system.
3. Among the household members, senior citizens struggle the most from heat cramps and heat exhaustion, indicating that indoor heat stress is a huge challenge.
4. The effects of heat stress are causing public health issues among households, and access to public health in the vicinity is essential.

8.1.2 Way Forward

1. The public health centers may be built closer in the neighborhood to cater to all the people. These centers should be provided, especially in the identified heat vulnerability zones of the city.
2. Awareness of the potential effects of heat stress and ways to mitigate it should be disseminated to the households.
3. The line workers such as Angawadi and Asha workers should routinely visit the senior citizen to monitor their health. For this necessary sensitisation and training should be done for these workers.

8.2 Transport

8.2.1 Key challenges

1. Since most of the residents live close to their working place, most of them walk to their place of work. However, walking is problematic because the footpaths are poorly constructed, poorly lit, or broken and lack greenery to maintain thermal comfort.
2. During the peak summer season, public health risks might increase for the people walking to their work. It may cause thermal discomfort and could lead to a loss of workdays. The heat-vulnerable people, e.g., older people or pregnant women, might not be in a situation to travel.
3. Roads in extreme heat can cause it to melt and concrete surfaces to distort and rip. It makes cycling very difficult for people working in neighbouring areas.

8.2.2 Way Forward

1. Construction of footpaths to ensure people walk with ease to their work allows people to walk on the shaded surface due to greenery. It needs to be highlighted here that it helps lower surface and air temperatures by providing shade and evapotranspiration.
2. Green plantations may be carried around the pavements and designated places to sit to cool foot walkers.
3. Building awareness about mitigation measures like promoting use of umbrellas, head cover, and carrying water are cost-effective measures for these communities.
4. It is improving the road quality to better deal with the changing temperatures and allow the vehicles to move.

8.3 Housing

8.3.1 Key challenges

1. The un-affordability to buy houses has forced people to stay in small houses, often resulting in many people living in small spaces and an increase in indoor temperatures. Among the informal settlements, investment is still lower due to high rental tenure and inadequate housing finance.
2. The design, materials, and construction methods are often inappropriate, given the increased exposure to heat stress vulnerabilities. These structures are particularly exposed to the effects of rising temperatures and trapping of heat inside the house and allow very little ventilation.
3. The microclimate needs to be made better, livable and thermally comfortable. Existing housing options may not meet the needs of vulnerable sections of society, especially the elderly.

8.3.2 Way forward

1. Provide support to mitigate the extreme impacts of heat stress by painting the roof white, increasing the intake of fluids, and wearing cotton clothes.
2. On-site upgrading may be undertaken to improve heat stress vulnerabilities due to housing by improving the building design and material.
3. Encourage pro-poor housing finance by making traditional markets and credit mechanisms accessible to the urban poor.

8.4 Water

8.4.1 Key Challenges

1. Due to rising temperatures, there is often water shortage, and there may be limited water availability of water due to low pressure.
2. There are challenges with the reliability of the availability of water from different sources.
3. The local watersheds are severely stressed, and dry spells due to heat stress do not enable recharge.

8.4.2 Way forward

1. Widen the network of municipal water supply to the households to ensure adequate water availability.

2. Improve water availability and its quality to minimise the dependence of households on other sources of water supply.
3. Educate people to prepare for water shortages by using less water and using it wisely too.
4. Implement affordable water tariffs for households to improve water access.

8.5 Electricity

8.5.1 Key Challenges

1. High demands for electricity in the peak summer season The electricity demand tends to increase during heat stress, which strains existing systems and potentially leads to shortages. It often results in frequent power cuts and blackouts.
2. The power tariffs may be too high for low households making it less affordable among poor households.
3. Electricity cuts can leave people vulnerable, mostly elderly, kids, and women, to the risks of heat and have cascading impacts on other urban services.

8.5.2 Way forward

1. Focus on being paid both on the electricity generation but also on connecting more households in its network.
2. Technological alternatives for electricity should be explored to ensure energy efficiency.
3. Electricity conservation measures may be shared with the households.
4. Heat stress awareness and Adaptive measures

8.6 Heat stress awareness and Adaptive measures

8.6.1 Key Challenges

1. Low-income residents often have sparse information on vulnerability due to heat stress. Lacking information on the risks inherent because of extreme temperatures and heat stress is enormous stress, especially in the informal settlements.
2. The households have insufficient knowledge of the adaptive and mitigation measures to be undertaken to deal with heat stress, such as households are not aware of the

medical facilities offering treatment for heat stress. They have very little information on such measures being undertaken by their ULB.

3. Due to unaffordability, most of the households are out of the insurance network. It decreases the ability of households to take care of medical expenses and limits their ability to access private medical facilities in case of emergency.

8.6.2 Way forward

1. Use social media platforms to increase access to information on heat alerts, heat stress advisories.
2. The govt. Hospitals to organise health check-ups/sensitisation workshops with households in the community.
3. Develop affordable health insurance schemes, especially for the vulnerable sections of society, such as the elderly, poor, and women.

8.7 Livelihood and productivity

8.7.1 Key challenges

1. The majority of workers suffer a lot due to heat stress as they lose their wages and lose their man-days of work.
2. The growing heat stress and extreme outdoor temperatures make it difficult for the outdoor workers, and the causal workers are most at risk of losing wages.
3. Travelling to the workplace may also lead to office workers experiencing heat exhaustion during high temperatures.
4. Along with the loss in wages, the productivity of the individuals is also positively affected.

8.7.2 Way forward

1. The focus should be on improved urban design, and sustainable planning can help in increasing the green spaces, and cooling the environment is critical to minimising heat-health issues.
2. Develop an early warning system for heat stress that helps in preparedness strategies and activities.
3. There should be flexibility in working hours, especially for outdoor workers during the hot peak period. It will also improve the worker's productivity.

9 The overarching framework for Sustainable heat stress response

The coherent measures taken in each of the identified sectors will help minimise the extreme impacts of heat stress vulnerabilities among the households. Along with this, a macro framework is much needed that will help in further strengthening these measures and built in the policymaking process to address these challenges and adapt for future challenges. These measures include viz, governance and institutional framework, local institutional capacity; resilient infrastructure; improving socio-economic conditions, encouraging public-private partnership. Their components are detailed in the table below.

Table: Macro- Framework for reducing Heat stress vulnerability

Macro- framework component	**Short Term Actions**	**Long Term Actions**
Governance and institutions	-Heat Action Plans -Health-system preparedness Monitoring and health surveillance -Clarity of role and coordination among agencies - - -Cool roofs Public awareness and community outreach Uninterrupted access to the basic services	-Climate risk reduction in alignment with heat reduction -Policy development -Post heatwave review on the existing plan and updating the plan -Minimising vulnerability due to heat stress

Macro- framework component	Short Term Actions	Long Term Actions
Local institutional capacity	-Building capacity for better system response and preparedness -Early warning system - Temperature forecast	-Strengthening existing system structures to make it more responsive -Community engagement for the inclusion of vulnerable household -Emergency preparedness
Resilient infrastructure	-Pooling resources -Improving coverage and service delivery -Social infrastructure: Capacity building communities, community-based organisation, and mobilisers such as Mahila Arogya Samiti, Self-Employed Women's Association (SEWA), ASHA workers, aanganwadis	-Setting heat standards and implementation for urban planning, infrastructure, industries, services like transport, building design, road, water resource management, etc -Revising the existing building Regulation Encouraging the passive building designs -Affordable tariffs
Improving socio-economic conditions	-Implementation of central/state-sponsored schemes on services and housing	-Redevelopment of the households below the poverty line to combat heat. Measures like cool roofs - Access to basic services
Encouraging public-private partnership	-Collaboration with non-government and civil society -Private hospitals to provide treatment for heat stress -Resource mobilisation	-Health insurance for the vulnerable, especially the poor, elderly, and women -Joint venture for infrastructure development / service delivery

Heat stress has to be managed at the local level remain. which necessitates comprehensive planning and coordination. A macro framework that will consider the sector-specific initiatives and tie them well within the macro framework to ensure its sustainability and effective management.

However, to ensure this, the stakeholders need to be involved in the planning and executing heat stress minimisation interventions. These measures have to be both short-term and long-term, which helps promote heat stress management and its planning. The outcomes of such steps are:

1. Transparent allocation of roles and responsibilities of all the stakeholders for better preparedness and prompt response to heat stress.
2. Identify vulnerable hotspots in the city and take measures specific to those areas.
3. Knowledge dissemination and capacity building of the communities, including the institution and the stakeholders.
4. Heat stress management plans to mitigate any impacts of heat stress effectively.