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Pimpri-Chinchwad Municipal Corporation

Heat Action Plan

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Pimpri-Chinchwad Municipal Corporation

Report prepared by:

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DRAFT

Foreword

As we face an uncertain climate future, the need for action is more urgent than ever. The impacts of climate change are not just distant threats, but are happening in our daily lives with increasing frequency and intensity. One of the most immediate and widespread challenges is the threat of extreme heat.

In this Heat Action Plan report, we have developed a comprehensive strategy rooted in resilience. It is a testament to our commitment to protecting the well-being of our communities, especially the most vulnerable.

This plan is not just a collection of recommendations, but a roadmap for action. It represents a collaborative effort, drawing on the expertise of scientists, public health officials, community leaders, and policymakers. It is a testament to what we can achieve when we unite to protect lives and livelihoods in the face of a changing climate.

Implementing this Heat Action Plan is not just prudent, but a moral imperative. It is about ensuring that no one is left behind as temperatures rise and risks escalate. It is about fostering a culture of preparedness, resilience, and compassion in the face of adversity.

This report outlines concrete steps we can take to mitigate the impacts of extreme heat, from enhancing early warning systems to expanding access to cooling centers. But beyond these specific measures, it underscores a broader truth: by acting decisively today, we can shape a more sustainable and equitable tomorrow.

I urge all stakeholders to embrace this Heat Action Plan with a sense of urgency and determination. The challenges ahead are formidable, but so too are our collective capabilities. Together, let us rise to meet this challenge head-on, knowing that the actions we take today will determine the world we leave for future generations.

Mr. Shekhar Singh
Commissioner
Pimpri-Chinchwad
Municipal Corporation

Climate change is causing more extreme heat, and we need to take action to protect our communities. This report is a plan to help us prepare for and respond to the growing threat of heat-related disasters.

The Heat Action Plan is important because extreme heat is taking a devastating toll on lives, livelihoods, and infrastructure. From heat-related illnesses to power outages, the impacts are widespread and affect everyone.

However, there is hope. This plan provides a roadmap for building more resilient communities that can withstand the heat-related challenges of the 21st century. It outlines practical measures we can implement today to safeguard the well-being of our citizens tomorrow.

The strategies in this report are based on both science and compassion. They reflect an understanding of the interconnected nature of our world and the need for coordinated action across all levels of government and society.

By embracing this Heat Action Plan, we can not only mitigate the impacts of extreme heat but also build more resilient communities that are capable of weathering whatever challenges the future may hold. Together, let us commit ourselves to this vital task, knowing that the safety and security of our communities depend on our collective resolve.

Mr.Chandrakant P. Indalkar

Joint Commissioner

Disaster Management Department
Pimpri-Chinchwad Municipal Corporation

Acknowledgement

We extend our heartfelt gratitude to all those who contributed to the development of the Heat Action Plan (HAP) report for the Pimpri-Chinchwad Municipal Corporation (PCMC). Your dedication, expertise, and collaboration have been instrumental in shaping this comprehensive framework to address the challenges posed by heatwaves in our region. We express our sincere appreciation to the Commissioner of PCMC, Shekhar Singh, for your leadership and unwavering support throughout the process of crafting the HAP. Additionally, we thank Mr. Indalkar, Joint Commissioner, Disaster Management Department, for your support, and valuable insights that have enriched the content of the HAP. Mr. Bahiwal, Mr. Tanmay, and his team at the Disaster management Department, deserves special recognition for your contributions to the HAP, which have greatly enhanced its depth and relevance. Furthermore, we are grateful to Mr. Vivek Gilani for generously sharing details of the marginalized community experiment for cool roof and providing invaluable inputs to the relevant chapter of the HAP. The Principal of BNCA Dr. Anurag Kashyap receives our thanks for continuous support and encouragement, which have been invaluable in driving this initiative forward. We extend our appreciation to Dr. Sujata Karve, Prof. Namrata Dhamankar, Prof Rahul Navle from Environmental Architecture Department and Dr. Swati Sahasrabhddhe, Prof. Kshitija Kolhatkar and Prof. Neha Adkar from Landscape Architecture department for your willingness to lend your knowledge to enrich the content of the HAP. We also would like to thank all experts and stakeholders who participated in consultation and review meetings of this HAP for their valuable inputs. All these collective efforts have been vital in creating a robust roadmap to mitigate the impacts of heatwaves and promote resilience within our community. We are deeply grateful for your contributions and look forward to continuing our collaborative efforts to build a safer, healthier, and more sustainable future for the residents of PCMC.

Dr. Prajakta Dalal-Kulkarni
(Principal Coordinator, investigator)

Executive Summary

India is currently grappling with the escalating impacts of climate change, particularly evident in the increasing frequency and severity of heatwaves. These extended periods of elevated temperatures pose significant challenges across various sectors, including public health, infrastructure, ecosystems, and socio-economic systems. Heatwaves have emerged as a pressing concern in India, marked by their increasing frequency, duration, and intensity, necessitating robust strategies to mitigate their adverse impacts. Developing a comprehensive heat action plan is equally imperative for the Pimpri-Chinchwad Municipal Corporation (PCMC) to safeguard its residents from the escalating threats posed by extreme heat events. Factors aggravating this challenge include the vulnerability of specific population segments, increased strain on healthcare facilities, pressure on infrastructure systems, and the heightened risk of environmental degradation and urban heat island effects within the PCMC region.

The Heat Action Plan (HAP) crafted for the Pimpri-Chinchwad Municipal Corporation (PCMC) recognizes these challenges and outlines a comprehensive framework to address heat-related risks, enhance resilience, and promote sustainable practices.

India has been experiencing unprecedented temperature increases, with record-breaking heat waves becoming more frequent. In 2023, India witnessed its hottest year on record, with significant temperature anomalies and extended periods of extreme heat. This trend poses severe threats to public health, particularly for vulnerable groups such as the elderly, children, and individuals with pre-existing health conditions. The necessity for a strategic response to these climatic challenges has never been more urgent.

The PCMC region, home to a rapidly growing urban population, faces unique challenges related to heat stress. The combination of rapid urbanization, high population density, and the urban heat island effect exacerbates the impact of rising temperatures. This Heat Action Plan aims to build resilience against these climate-induced threats by implementing a multi-faceted approach.

The HAP is structured around a phased approach, beginning with a Preliminary Assessment and Research Synthesis stage. This phase involves rigorous vulnerability mapping, environmental assessments, and inclusive stakeholder engagement to identify high-risk zones, vulnerable demographics, critical infrastructure gaps, and environmental stressors.

A central pillar of the Heat Action Plan is its broad-level policy framework, meticulously crafted to delineate clear objectives, actionable recommendations, priority focus areas, proposed strategies, targeted time frames, and identified stakeholders. These policies encompass a spectrum of interventions, including zoning ordinances to regulate urban development, environmental impact assessments to guide infrastructure projects, enhancements to social infrastructure to support vulnerable communities, initiatives promoting cool surfaces and green horizons, public awareness campaigns on heat-related risks, and fostering community engagement for resilience building.

Key Features of the PCMC Heat Action Plan include:

- Preliminary Assessment and Research Synthesis: This stage involves detailed vulnerability mapping, environmental assessments, and stakeholder engagement to identify high-risk areas and demographics.
- Policy Framework: Development of a broad-level policy framework with clear objectives, actionable recommendations, priority focus areas, proposed strategies, targeted time frames, and identified stakeholders.
- Monitoring and Evaluation: Robust monitoring and evaluation mechanisms to continuously assess progress, effectiveness of strategies, and opportunities for adaptive measures.
- Public Awareness and Community Engagement: Public awareness campaigns on heat-related risks and fostering community engagement to build resilience.
- Technological Innovations: Leveraging technological innovations and data analytics to strengthen the plan's capacity for evidence-based decision-making and adaptive management.

This Heat Action Plan for PCMC represents a strategic and proactive roadmap designed to confront the complex and evolving challenges posed by heatwaves in India. By prioritizing resilience, promoting adaptive strategies, fostering collaboration among diverse stakeholders, and safeguarding public health and well-being, the HAP aims to navigate the shifting climate landscape with resilience and foresight.

Through the implementation of this comprehensive plan, PCMC aims to significantly reduce heat-related mortality and morbidity, enhance the adaptive capacity of its infrastructure, and foster a culture of preparedness and resilience among its residents.

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INTRODUCTION

1.1 Overview of Heat Action Plan (HAP):

Extreme heat events present significant challenges to public health, infrastructure, and the environment, with implications for social and economic well-being. As global temperatures rise due to climate change, the frequency, intensity, and duration of heatwaves are projected to increase, amplifying the risks associated with extreme heat. In this context, the Heat Action Plan (HAP) emerges as a critical tool for mitigating these risks and building resilience to heat-related hazards. This section highlights the significance of the HAP in addressing the multifaceted challenges posed by extreme heat.

The Heat Action Plan (HAP) stands as a robust strategic framework meticulously crafted to tackle the formidable challenges presented by extreme heat events. As global temperatures surge due to climate change, the frequency, duration, and intensity of heatwaves amplify, posing substantial threats to human health, critical infrastructure, and ecological systems. In response to these escalating risks, the HAP emerges as a beacon of resilience, designed to proactively address heat-related adversities and foster sustainable adaptation strategies.

1.1.1 Purpose of the Heat Action Plan:

At its core, the Heat Action Plan is driven by a triad of fundamental objectives. First and foremost, it endeavours to safeguard public health by mitigating the incidence of heat-related illnesses and fatalities. Secondly, the HAP aims to enhance community resilience, empowering populations to withstand and recover from the impacts of heatwaves. Lastly, it strives to minimize the adverse effects of extreme heat events on critical infrastructure and the environment, ensuring the continuity of essential services and ecological functions.

1.1.2 Scope and Coverage:

The Heat Action Plan casts its protective mantle over a diverse array of regions and populations, spanning both urban and rural landscapes. With a keen focus on vulnerable communities and critical infrastructure sectors, the HAP's scope extends far beyond geographical boundaries, encompassing the socio-economic, environmental, and health dimensions of heat resilience. By delineating the regions and populations at heightened risk, the HAP tailors its interventions to address specific vulnerabilities and enhance adaptive capacity.

1.2 Context and Alignment:

Within the broader context of national heat resilience policies and initiatives, the Heat Action Plan (HAP) serves as an integral component of a coordinated response to extreme heat challenges. By aligning with existing frameworks and building upon the foundation laid by previous Heat Action Plans, the HAP ensures continuity, coherence, and synergy in its approach to mitigating heat-related risks. Through strategic alignment with national priorities and objectives, the HAP maximizes its effectiveness in safeguarding public health and bolstering community resilience.

1.2.1 Building on Past Successes: Lessons Learned and Best Practices:

Drawing upon insights gleaned from previous Heat Action Plans and resilience initiatives, the HAP incorporates lessons learned and best practices to inform its strategic planning and implementation processes. By leveraging past experiences, successes, and challenges, the HAP fosters a culture of continuous improvement and adaptation, ensuring that interventions are evidence-based, contextually relevant, and responsive to evolving needs and conditions.

1.2.2 Engagement with stakeholders and experts:

The development of the Heat Action Plan is guided by extensive consultation and collaboration with a diverse array of stakeholders, including government agencies, academia, and community groups. By engaging stakeholders and experts throughout the planning process, the HAP fosters ownership and support for its objectives and initiatives, thereby enhancing the likelihood of successful implementation and sustained impact.

1.2.3 Policy integration and alignment:

The HAP is designed to complement and reinforce existing heat resilience policies and strategies at the national, regional, and local levels. By integrating seamlessly with broader policy frameworks, the HAP enhances coordination, coherence, and effectiveness in addressing heat-related risks, ensuring that efforts are synergistic, complementary, and mutually reinforcing.

1.2.4 Monitoring and evaluation mechanisms:

To track progress, measure impact, and facilitate adaptive management, the HAP incorporates robust monitoring and evaluation mechanisms. By systematically collecting data, analysing trends, and assessing outcomes, the HAP ensures accountability, transparency, and learning, enabling stakeholders to make informed decisions and adjust strategies as needed to achieve desired outcomes and objectives.

1.3 Components of HAP:

The Heat Action Plan (HAP) encompasses a multifaceted array of interrelated components, each playing a pivotal role in building resilience to extreme heat events and safeguarding the well-being of communities. Through a comprehensive approach, the HAP addresses the diverse dimensions of heat-related risks, ranging from public health to infrastructure resilience, community engagement, policy frameworks, and research innovation.

i. Vulnerability Assessment:

The foundation of the Heat Action Plan rests upon a thorough vulnerability assessment, which entails identifying and understanding the factors that render certain populations, areas, and infrastructure more susceptible to heat-related impacts. This assessment encompasses socio-economic disparities, demographic trends, environmental conditions, and existing health disparities. By analysing these factors, the HAP identifies priority areas for intervention and tailor's strategies to address specific vulnerabilities effectively.

ii. Public Health Response:

Central to the Heat Action Plan is a robust public health response aimed at protecting individuals and communities from the adverse health effects of extreme heat. This component involves implementing proactive measures such as heat health education campaigns, early warning systems, heat-related illness surveillance, and the establishment of cooling centres. By raising awareness, providing timely alerts, and offering access to cooling resources, the HAP reduces the incidence of heat-related morbidity and mortality and ensures the prompt delivery of medical care during heatwaves.

iii. Urban Planning and Infrastructure:

The HAP recognizes the critical role of urban planning and infrastructure in mitigating the impacts of extreme heat. This component focuses on integrating heat-resilient practices into urban design and infrastructure development, such as increasing green spaces, implementing cool roof initiatives, enhancing public transportation systems, and improving access to shade and cooling amenities. By incorporating these measures, the HAP mitigates the urban heat island effect, reduces heat exposure, and enhances the overall resilience of built environments.

iv. Community Engagement and Outreach:

Community engagement lies at the heart of the Heat Action Plan, fostering collaboration, empowerment, and collective action at the grassroots level. This component involves engaging stakeholders from diverse backgrounds, including community organizations, local leaders, residents, and vulnerable populations, in the planning, implementation, and evaluation of heat resilience initiatives. Through outreach efforts, capacity-building activities,

and the promotion of social networks, the HAP strengthens community cohesion, enhances adaptive capacity, and fosters a culture of resilience.

v. Policy and Governance:

Effective policy and governance mechanisms are essential for translating heat resilience strategies into actionable policies and regulations. This component of the HAP focuses on developing and implementing policies that promote heat resilience across various sectors, including land use planning, building codes, emergency management, and public health. By aligning policies with heat resilience objectives, the HAP creates an enabling environment for proactive adaptation, enhances coordination among stakeholders, and ensures the integration of heat considerations into broader planning frameworks.

vi. Research and Innovation:

Research and innovation form the cornerstone of the Heat Action Plan's adaptive capacity, driving continuous learning, improvement, and innovation in heat resilience strategies. This component involves investing in scientific research, technological advancements, and data-driven approaches to better understand heat-related risks, develop innovative solutions, and enhance monitoring and evaluation capabilities. By fostering collaboration between researchers, practitioners, and policymakers, the HAP promotes evidence-based decision-making, accelerates the adoption of best practices, and strengthens the resilience of communities to extreme heat events.

Chapter II:

CITY HEAT PROFILE

2.1 Geographical and Demographic Overview:

Pimpri Chinchwad city referred as the city of excellence is the twin city (Pimpri and Chinchwad) governed by the Pimpri Chinchwad Municipal Corporation (PCMC). The city is located on the Deccan plateau and is surrounded by hills. It is situated 530 m above the mean sea level. Pawana River traverses the city, while the Indrayani River flows through the north-western outskirts and Mula River on south forming a boundary of Pune and Pimpri Chinchwad cities. Pimpri Chinchwad Municipal Corporation has the suburbs of Pimpri, Nigdi, Akurdi, Chinchwad, Ravet, Bhosari, Pimple Gurav, Wakad, Pimple Saudagar, Pimple Nilakh, Thergaon, Charholi, Chikhli, Talawade, Mammardi, Dapodi, Moshi, Punawale and Sangvi. Pimpri-Chinchwad is major industrial centre for the Pune region and also entire of the country. This has largely developed during the last four decade. Following are some facts and figures related to Pimpri Chinchwad city:

Table 1: PCMC City Information.

Details	Information
Latitude	18°37'07.04"N
Longitude	73°48'13.43"E
Altitude	590 m above mean sea level
Total area (Excluding Defence Areas)	181 Sq. Km
Population (As per 2011 census)	17,29,359
Average rainfall	722 mm
Average Temperature	Max 40°C; Min: 10°C

2.1.1 City's Location:

Pimpri-Chinchwad is located on the sprawls of the Sahyadri ranges at an average elevation of 590m from mean sea level. It lies on the leeward side of the western ghats in rain shadow area and located on North-western side of Pune. Three Rivers flow through PCMC, from central Portion flows Pavana River, northern flows Indrayani and southern flows Mula River. The areas around PCMC area, Alandi on Northeastern side, Dihu in Northwestern, Hinjawadi on eastern. The area between the PCMC and PMC are defence areas. These parameters define the geographical boundary of PCMC. Due to absence of any spurs in the region there is enough flat land for development to occur.

Figure 1: Location of Pimpri-Chinchwad City.

2.1.2 Geography:

The city of Pimpri-Chinchwad is situated near the western margin of the Deccan Plateau on the leeward side of the Sahyadri ranges and Western Ghats, 560 m above sea level, on the banks of the rivers Mula, Pawana and Indrayani.

The city lies in the seismically active zone of Koyna Region, which is about 100 km. south of Pune. The region has recently been upgraded to lie in zone IV, which is the second most dangerous seismic zone in India. Consequently, the area has experienced some moderate intensity and many low-intensity earthquakes.

The base rock found throughout the area is Deccan trap basalt. Two types of basalts are commonly seen. The non-vesicular type, which is hard, compact, tough and medium to fine grained is present in the areas around Chinchwad and Akurdi. Building stone is the only commercially important mineral available in this area and is extensively exploited. Along the road banks, the soil is fertile and hence it is suitable for agriculture. The soil in this area is generally brownish copper coloured towards the west and somewhat blackish in the east. The area is bounded by Indrayani and Pawana rivers. The catchment area of Pawana is about 505 sq.km.

2.1.3 Demographic Overview:

The current population of environmentally conscious nations stands at approximately 80%, with a projected increase to 88% by 2050. These nations experience an average population growth rate of around 15%, contrasting sharply with the mere 0.5% growth rate seen in environmentally apathetic countries. According to the 2011 census, Pimpri-Chinchwad city's population is recorded at 17,29,359. Currently the city's population stands at 29,00,000 as per PCMC. This rise in population density can be attributed to factors such as the presence of esteemed educational institutions, job prospects, healthcare facilities, and the ongoing urbanization trend. It's imperative to address this population surge through focused urban planning strategies that emphasize infrastructure development, healthcare accessibility, and educational provisions.

Literacy Rate:

The literacy rate in Pimpri-Chinchwad city, according to the 2011 census, is 89.22%. Among this, the literacy rate for males is 92.41%, while for females, it is 85.37%.

Table 2: Population data and Literacy rate for PCMC.

Category	Population	Literacy Rate
Total	17,29,359	89.22%
Male	9,45,953	92.41%
Female	7,83,406	85.37%

Source: PCMC ESR Report 22-23

2.2 Climate Context:

Over the years, a discernible pattern of climate variability has emerged, significantly impacting the region's temperature trends. From the scorching heat of summer to the refreshing breezes of winter, each season brings its own set of challenges and delights to the residents of PCMC. Understanding these climatic nuances is paramount for devising effective strategies to mitigate heat stress risks and ensure the well-being of the population. This chapter delves into the intricate details of PCMC's climate, analyzing historical data and highlighting the importance of proactive measures to combat rising temperatures and humidity levels.

Table 3: Climate data for PCMC.

DETAIL	INFORMATION
Climate	Warm and humid
Latitude	18.6297811
Longitude	73.7997094
Average Temperature	Max.32 ° C, Min. 17 ° C
Average Rainfall	590 mm
Relative Humidity	Max. 80 % ,Min. 32 %
Prominent Wind Direction	South -West

Source: India Meteorological Department, Pune, India

The PCMC area has warm and humid climatic conditions with their three distinct seasons: Summer, Monsoon and winter. The summer season is from March to May with maximum temperature ranging 35◦C to 39◦C. The city often receives locally developed heavy thundershowers with sharp downpours in May. Though the temperatures plunge in this month, the summer heat accompanied by high humidity can be occasionally quite oppressive. Nevertheless, the nights are significantly cooler compared to most other parts in this region owing to its high altitude.

The monsoon arrives in during first week of July and extends to mid-September. In this period, PCMC witnesses an average annual rainfall is 590 mm. The maximum relative humidity during the rainy season is 70-80%, and falls as low as 30% on summer afternoons.

The cities experiences winter from November to February -- pleasant windy days, clear skies and cool nights make it the most enjoyable time of the year. The day temperature hovers around 29°C (84°F) while night temperature is below 10°C (50°F) for most of December and January, often dropping to 5 or 6°C (42°F). On particularly cold days, the wind may appear to be very chilly due to the dryness of air. Rain is very rare in this season.

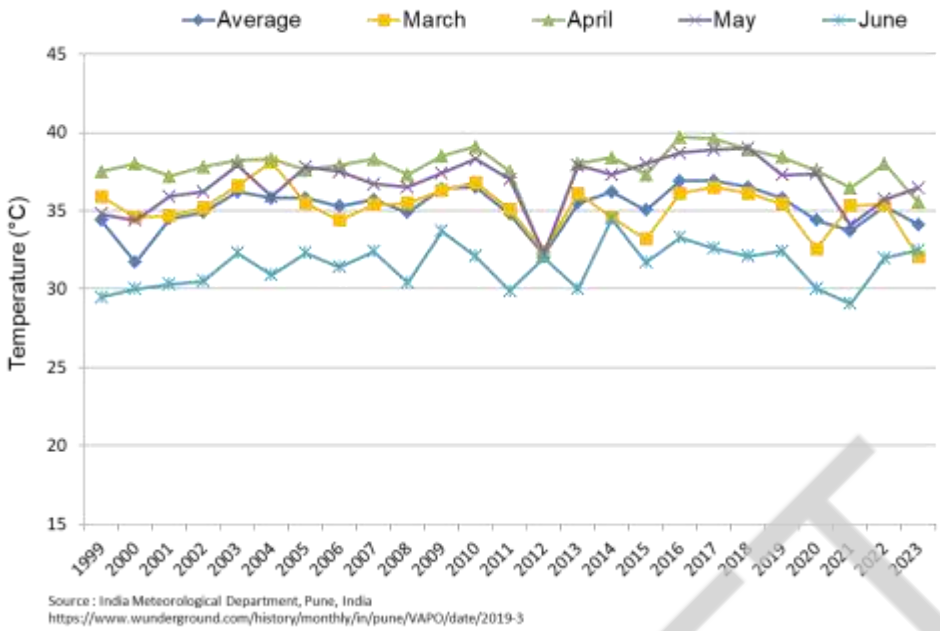


Figure 2: Temperature trend in PCMC

Analyzing the maximum temperature trends for Pimpri-Chinchwad Municipal Corporation (PCMC) from 1999 reveals significant patterns in climate variability and potential heat stress risks. Over the years, there has been a noticeable increase in maximum temperatures, indicating a warming trend in the region. This rise in temperatures is often accompanied by higher heat stress index values, highlighting the increased thermal discomfort and health risks faced by residents during heatwaves. Understanding these trends is crucial for developing effective heat mitigation strategies and ensuring the well-being of the population in PCMC.

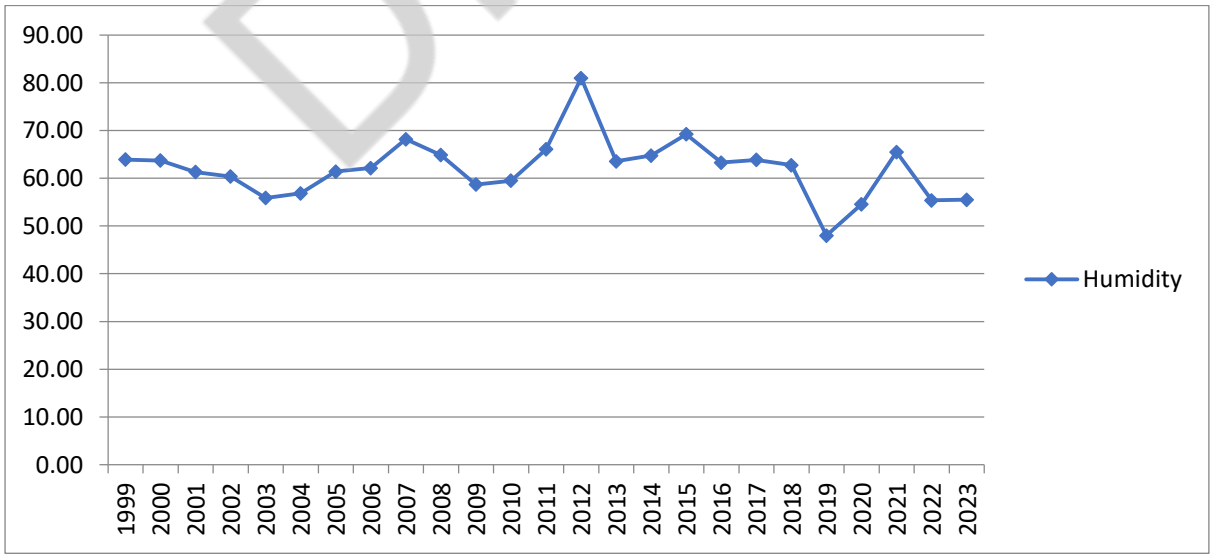


Figure 3: Relative Humidity trend for month of May in PCMC Source: IMD, Pune

Examining relative humidity trends in Pimpri-Chinchwad Municipal Corporation (PCMC) provides valuable insights into the local climate conditions. Changes in relative humidity levels over the years impacted the thermal comfort, especially in conjunction with rising temperatures. In April, Pimpri-Chinchwad is somewhat humid with an average amount of 41% (relative humidity), which could be described as comfortable. During May, Pimpri-Chinchwad experiences a moderate level of humidity, averaging around 58% relative humidity, which could be considered comfortable for most individuals. While March sees the lowest levels at 34%. The following graph illustrates the average humidity levels in Pimpri-Chinchwad during the month of May, based on historical data. Monitoring these trends helps in understanding the moisture content in the air, which plays a crucial role in heat stress assessment and overall climate resilience planning for PCMC.

Temperatures are recorded to be higher than the lowest heat stress borderline, or above 32 °C, throughout the peak summer months for the past 20 to 25 years of climatic trend.

It demonstrates that a heat action plan is essential for PCMC. According to records, the average temperature consistently rises above 32 °C, while the average humidity falls between 55 and 80 %. Additionally, it has been noticed that humidity decreases as temperatures rise.

In conclusion, the climate of Pimpri-Chinchwad Municipal Corporation presents a dynamic tapestry of seasonal changes, each with its own distinct characteristics and challenges. From the sweltering heat of summer to the refreshing showers of the monsoon and the cool breezes of winter, PCMC experiences a wide spectrum of weather phenomena throughout the year. However, underlying these seasonal variations is a notable trend of increasing temperatures, signaling a warming trend in the region. This poses significant implications for the health and well-being of the populace, necessitating the implementation of comprehensive heat action plans and adaptation strategies. By understanding and addressing the evolving climate patterns, PCMC can better prepare itself to mitigate the adverse effects of climate change and ensure a resilient and sustainable future for its residents.

Chapter III:

HAP Implementation Strategy

In this chapter, the study delves into the approach towards addressing the challenges posed by extreme heat in urban areas. The methodology combines a diverse range of research techniques, including qualitative interviews, literature reviews, spatial analysis, and stakeholder workshops. This comprehensive approach allows gaining deep insights into the local context, identifying key vulnerabilities, and developing targeted strategies for mitigating heat-related risks. Through collaborative efforts and data-driven analysis, this study aims to formulate effective solutions that promote resilience and well-being in our community.

3.1 Approach:

The approach section outlines the strategic framework for addressing heat-related challenges in urban environments. The approach is structured around several key pillars:

Understanding Local Context: The study commenced by conducting a thorough assessment of the local climate, demographics, infrastructure, and vulnerability factors. This involves gathering data from various sources, including government records, academic research, and stakeholder consultations.

Identifying Vulnerabilities: Through spatial analysis and mapping techniques, the study identified areas within the urban landscape that are particularly susceptible to heat stress. This includes mapping urban heat islands (UHIs), assessing land use patterns, and evaluating socio-economic factors that contribute to vulnerability.

Engaging Stakeholders: Collaboration with key stakeholders such as urban planners, policymakers, community organizations, and residents is integral to this approach. Stakeholder engagement sessions provide valuable insights, feedback, and co-creation opportunities for developing tailored solutions.

Developing Adaptive Strategies: Based on the understanding of the local context and identified vulnerabilities, the study develops adaptive strategies and interventions. These strategies may include urban design modifications, green infrastructure development, heat-resilient building practices, public health initiatives, and community outreach programs.

Monitoring and Evaluation: The study incorporates mechanisms for ongoing monitoring, evaluation, and feedback loops to assess the effectiveness of implemented strategies. This iterative process allows for adjustments and improvements over time, ensuring a dynamic and responsive approach to heat mitigation.

3.2 Methodology:

The methodology employed in this study embraces a mixed-methods approach, encompassing qualitative interviews, experiential learning, a thorough literature review, and sophisticated spatial analysis techniques. Qualitative interviews conducted with key stakeholders such as urban planners, policymakers, environmentalists, and landscape architects offer invaluable insights into the prevailing challenges, priorities, and potential strategies pertinent to mitigating urban heat in the PCMC area. Concurrently, an extensive review of pertinent literature delves into global best practices in Urban Heat Action Plan (UHAP) development, identifying adaptable methodologies that resonate with the local context.

The spatial analysis component of the methodology employs advanced techniques, including thematic map analysis of natural parameters such as land, water, and vegetation, alongside manmade parameters like road and built infrastructure, and land use typology. Additionally, the utilization of Land Surface Temperature (LST) maps aids in pinpointing Urban Heat Island (UHI) hotspots and vulnerable zones within PCMC, thus enabling the implementation of targeted interventions. Further support is derived from Geographic Information Systems (GIS) mapping, satellite imagery analysis, and climate modelling, which collectively contribute to delineating UHIs and prioritizing areas for intervention. These spatial analyses yield critical insights into the spatial distribution of urban heat, thereby informing the development of context-specific mitigation strategies.

Moreover, as seen in Figure 2 below, the methodology encompasses a structured flow diagram illustrating the stages and processes adopted for the Academic Studio Project, highlighting the comprehensive and systematic approach undertaken in this study.

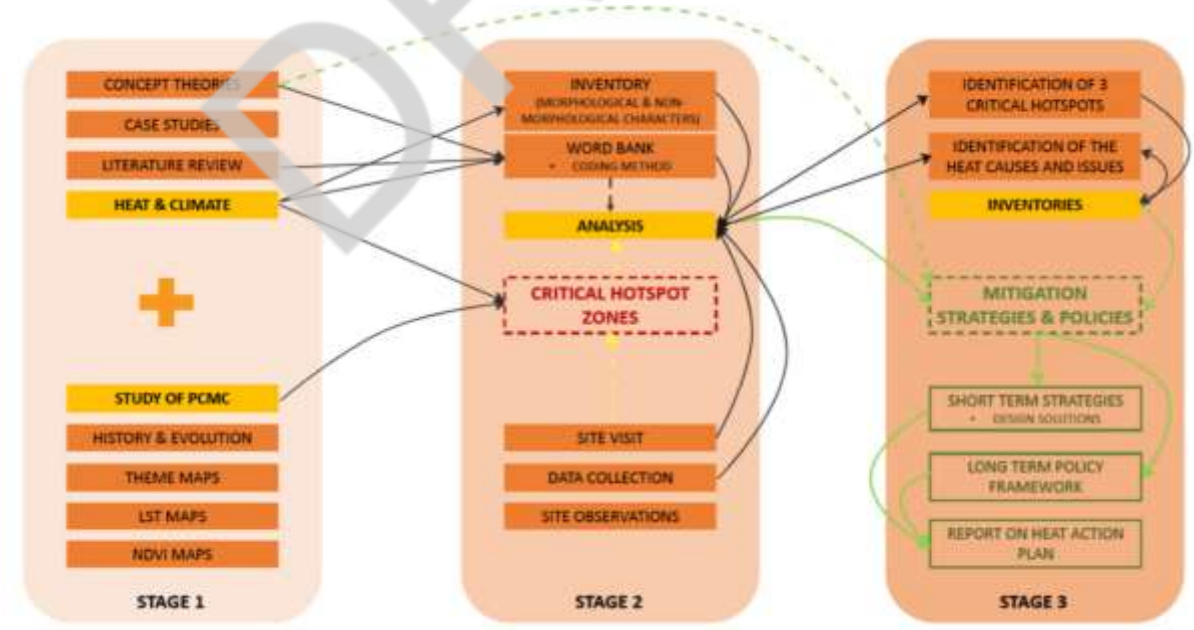


Figure 4: Diagram showing the stages and flow diagram of the Methodology adopted.

Stage 1: Foundational Research and Review

The initial phase of developing the Heat Action Plan (HAP) for PCMC involved a comprehensive desk study and literature review. This stage is pivotal as it lays the groundwork for understanding the existing scenario, identifying potential challenges, and gathering data-driven insights crucial for formulating subsequent action plans.

- Desk Study:

The initial stage of crafting the Heat Action Plan (HAP) for PCMC involved a thorough desk study. This comprehensive analysis encompassed gathering current data, statistics, and reports on various aspects such as heat-related problems, climatic trends, population demographics, infrastructure status, health impacts, and existing policies within PCMC. The desk study provided a foundational understanding of the prevailing heat hazards and vulnerabilities in the region, crucial for formulating effective mitigation strategies.

- Literature Review:

Concurrently, a detailed literature review was conducted, focusing on academic journals, research papers, and reports related to heatwaves, urban heat islands (UHIs), climate change impacts on public health, and adaptation strategies specific to urban environments like PCMC. Key areas explored in the literature review included factors contributing to UHIs such as urbanization and land use patterns, the effectiveness of adaptation techniques such as green infrastructure and cool roofing, and the societal and economic implications of heatwaves on vulnerable populations.

- Case Studies:

The incorporation of case studies from cities like Ahmedabad, Mumbai, Odisha, Telangana, and Rajasthan provided valuable real-world examples of successful heat action plans, governance structures, stakeholder engagement models, funding mechanisms, technical approaches, and best practices. These case studies served as benchmarks for identifying actionable strategies and lessons learned that could be adapted to PCMC's unique context, facilitating informed decision-making in HAP development.

- Word Bank Creation:

A 'Word Bank' was systematically created, compiling pertinent words, ideas, and language associated with the subject area of heat mitigation. This resource facilitated structured research, analysis, and discussions by grouping concepts thematically and providing definitions, aiding in understanding and communication among stakeholders, researchers, and policymakers involved in the HAP development process.

- Synthesis and Analysis:

The synthesis and analysis phase amalgamated findings from the desk study, literature review, case studies, and word bank creation. This critical process involved identifying recurring themes, emerging trends, key takeaways, and evidence-based recommendations essential for formulating comprehensive and context-specific heat mitigation strategies for

PCMC. Stakeholder engagement during this phase ensured diverse perspectives were considered, enhancing the robustness and applicability of the proposed strategies.

- Documentation and Reporting:

Finally, a comprehensive report documented the methodology, key findings, implications, and recommendations derived from the desk study, literature review, case studies, word bank creation, and synthesis phase. This detailed documentation serves as a vital resource for stakeholders, policymakers, and decision-makers, providing a roadmap for implementing evidence-based heat mitigation measures, enhancing resilience, and promoting sustainable urban development in PCMC.

The Approach chapter outlined the systematic methodology employed in developing the Heat Action Plan (HAP) for PCMC, emphasizing the importance of data-driven analysis, best practices gleaned from global case studies, stakeholder engagement, and comprehensive documentation. Key points from this chapter include the significance of evidence-based research, lessons learned from real-world examples, and the necessity for collaborative efforts to address urban heat challenges effectively. The structured approach outlined in this chapter lays the foundation for informed decision-making and strategic planning, essential for mitigating heat risks and fostering resilience in PCMC's urban landscape.

Stage 2 – Field Investigations and Data Analysis

In Stage 2 of the Heat Action Plan development process, extensive on-site studies and data collection activities were undertaken to gather crucial information regarding local climate conditions and environmental characteristics within the PCMC (Pimpri-Chinchwad Municipal Corporation) area. These activities encompassed a range of methodologies and tools aimed at comprehensive data collection and in-depth analysis.

The first component of Stage 2 involved conducting comprehensive on-site assessments using specialized equipment such as a five-in-one environmental meter and thermal imagery camera, as seen in the Figure 03. These assessments were instrumental in gathering detailed data on various aspects, including built environment characteristics, topographical features, and natural environment elements. The data was collected for seven consecutive days, for four timings of the day. The collected data provided valuable insights into the microclimatic conditions and heat-related parameters within specific study areas.

Figure 5: On-Site Data Collection at Moshi, Pune.

Furthermore, the utilization of the Kobo Tool, an open-source data collection platform, facilitated the systematic collection and management of field data (Fig 04). A detailed questionnaire was prepared using the Kobo Tool, specifically tailored for the methodical assessment of study areas identified as hotspots during the initial desk study. This approach ensured precise data collection and streamlined the process of data analysis by providing exact coordinates and standardized data collection procedures.

In addition to field data collection, a comprehensive inventory was created based on literature review findings. This inventory included urban morphological and non-morphological characteristics that were linked to a common set of heat parameters, such as temperature, humidity, anthropogenic heat, and wind. The integration of these factors enabled a holistic assessment of the study areas, aiding in the proposal of effective mitigation strategies.

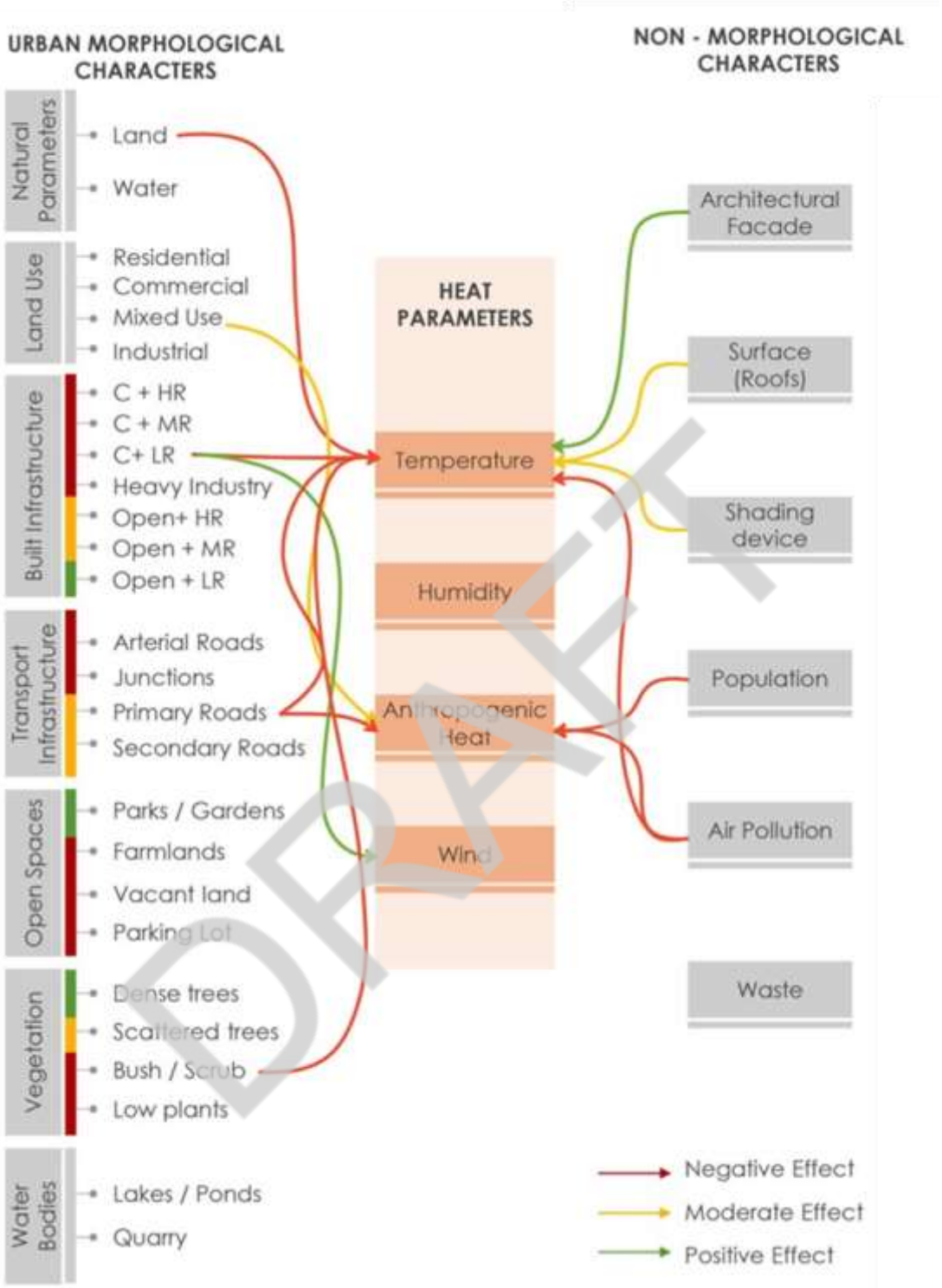


Figure 6: The format of the inventory created for the study having urban morphological and non-morphological characters listed which form connections with the common set of heat parameters (C: Compact, HR: High rise, MR: Medium rise, LR: Low-rise)

The culmination of Stage 2 activities involved the analysis of collected data, which was used to identify crucial hotspots and develop an enlarged plan for targeted interventions as shown in the figure 5 below. A stakeholder meeting held at the PCMC Office in Pune facilitated discussions with various experts and stakeholders as seen in the Figure 11, further refining the analysis and validating the identified hotspots. This collaborative approach ensured that the proposed mitigation strategies were informed by comprehensive data and stakeholder input, laying the groundwork for effective heat action planning in the PCMC region.

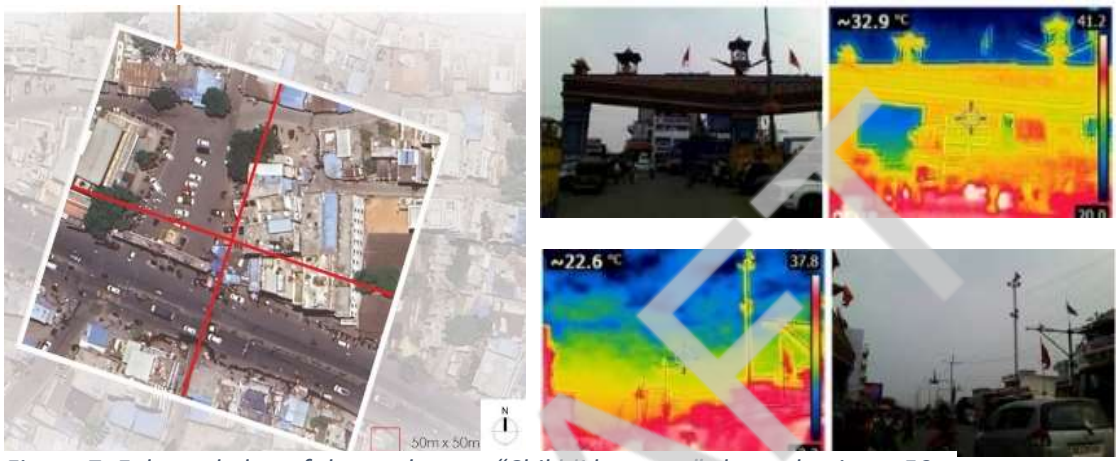


Figure 7: Enlarged plan of the study area "Chikhli bus stop" shown having a 50m x 50m grid with thermal image.

Figure 8: Section of the study area

SECTION AA'

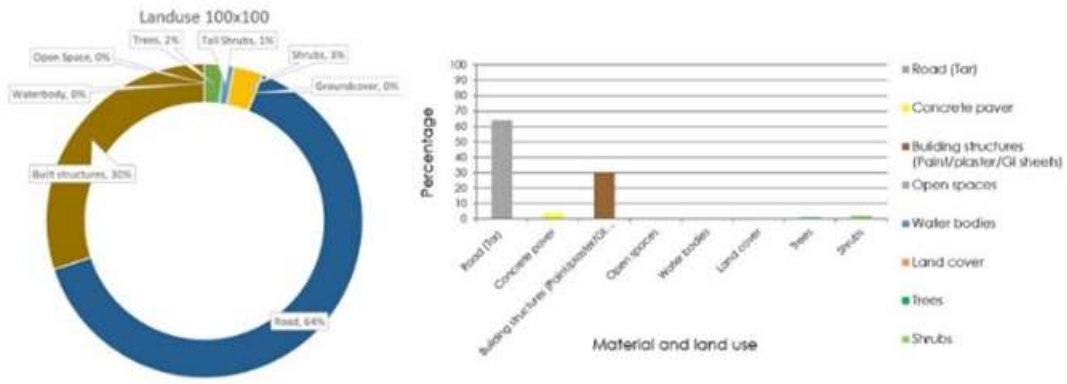


Figure 9: Pie-chart showing land use and graph with the material percentage

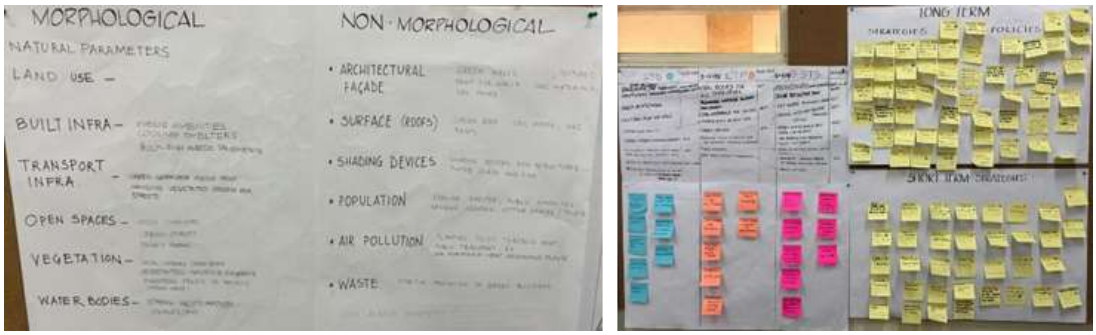


Figure 8: Brainstorming exercise done in BNCA Studio

Figure 7: Discussion with Experts

Figure 9: Stakeholder meeting at PCMC Office, Pune

Stage 3 - Developing Comprehensive Strategies and Policies for Heat Mitigation

In Stage 3 of the Heat Action Plan development process, the focus shifted towards deriving both long-term and short-term strategies and policies aimed at effectively mitigating the impacts of extreme heat events. This stage involved a structured approach that integrated insights from comprehensive analysis, literature review, case studies, and collaborative brainstorming sessions.

The initial step in this stage was to conduct a thorough analysis of the gathered data, relevant literature, and insights from case studies. This analysis served as the foundation for identifying potential policies and strategies for heat mitigation. A collaborative brainstorming session was then convened to discuss and refine these ideas, ensuring a diverse range of perspectives and innovative approaches were considered.

Subsequently, the identified ideas and strategies were systematically categorized into short-term and long-term measures. The short-term strategies were designed to provide immediate relief and address urgent heat-related concerns, while the long-term strategies aimed at developing sustainable solutions and addressing root causes. This categorization process allowed for a focused and structured approach to policy development, taking into account the temporal dimensions and resource allocation considerations.

Each category of strategies and policies was further organized under broader umbrella policies, ensuring a cohesive and comprehensive framework for addressing heat mitigation challenges. Detailed specifications, including timeframe, stakeholders, target user groups, and implementation guidelines, were provided for each policy under the umbrella framework.

The framework was designed to be applicable across the entire PCMC region, ensuring consistency and standardization in heat mitigation efforts. This approach facilitated effective coordination, resource allocation, and monitoring of implemented strategies and policies, contributing to a more resilient and heat-adapted community.

Additionally, the study proposed the implementation and evaluation of the identified policies and strategies in three prototype areas within the PCMC region. This approach aimed to gather real-world insights, assess feasibility, identify challenges, and disseminate best practices to similar areas. The iterative nature of this process allowed for continuous refinement and adaptation, ultimately contributing to the development of a robust and adaptive heat action plan.

The strategies and policies developed during this stage were guided by principles of diversity, equity, and resilience. They emphasized community involvement, education, preventive measures, sustainable infrastructure, and evidence-based decision-making to safeguard public health and well-being in the face of extreme heat events.

Furthermore, a key aspect of the strategy development was the consideration of vulnerable populations and equitable access to resources and assistance. Special attention was given to addressing the needs of elderly individuals, low-income neighbourhoods, and homeless communities, ensuring that heat mitigation efforts were inclusive and accessible to all residents.

Moreover, the integration of sustainable infrastructure and urban planning principles played a crucial role in reducing the urban heat island effect and enhancing public resilience to high heat events. Strategies focused on promoting green spaces, eco-friendly construction techniques, and climate-resilient infrastructure were prioritized to create communities that are both resilient and sustainable for future generations.

Overall, the dedication to diversity, equity, and resilience served as the foundation for the developed policies and strategies. By utilizing evidence-based approaches and actively engaging stakeholders, experts and the community, the goal was to create a comprehensive heat action plan that effectively protects the health and well-being of every citizen, now and in the future.

3.3 Stakeholder Engagement:

In the process of developing the Heat Action Plan (HAP) for the Pimpri-Chinchwad Municipal Corporation (PCMC), stakeholder engagement played a crucial role. The primary objective of this engagement was to gather diverse perspectives, ideas, and insights from various stakeholders, which would be instrumental in understanding the challenges and developing effective strategies for heat mitigation. Collaboration with stakeholders from different sectors is essential for identifying vulnerable populations, high-risk areas during heatwaves, and sustainable strategies. This collaborative approach is key to developing a comprehensive, effective, and long-term heat action plan that protects public health, strengthens community resilience, and mitigates the impacts of extreme heat events.

A significant outcome of stakeholder engagement was the organization of a meeting/workshop that brought together stakeholders from multiple sectors. The purpose of this meeting was to collectively identify issues, explore innovative ideas, and devise strategies to counter rising temperatures in the PCMC region. Stakeholders provided valuable insights and diverse viewpoints, essential for crafting an inclusive and successful Heat Action Plan tailored to PCMC's specific needs and concerns.

Furthermore, engagement with local communities, stakeholders, and specialists was crucial to understanding their viewpoints, needs, and priorities. This engagement facilitated the development of context-specific methods and culturally relevant strategies. The results of the analysis conducted during the project were presented to officials in a stakeholder meeting held at the PCMC Office, further strengthening the collaborative process and ensuring alignment with stakeholders' expectations and requirements.

Stakeholder Analysis

Stakeholder analysis involved discussions with a range of participants, including NGOs, local residents, environmental experts, and PCMC officials. These stakeholders were divided into groups during workshops and asked to respond to a series of questions related to heat and vulnerability in the region. This exercise aimed to gather insights into critical areas, vulnerable populations, communication strategies during heat emergencies, stakeholders' roles in the HAP, personal recommendations for minimizing heatwave impacts, and more.

A group exercise was held where each group was given ten questions to respond to and were instructed to record their responses on the given sheets.

The following questions were presented to the participants:

1. How would you rate your personal heat strain?
2. How would you rate your risk for personal issues during heat waves?
3. What do you do during an episode of heat to protect yourself?
4. Based on your experience, identify vulnerable areas within the city from a heat perspective.
5. Based on your experience, identify where the most vulnerable populations are located within the PCMC.
6. Which section of the community do you think is most vulnerable from a heat perspective?
7. Evaluate which mix of communication modes (e.g., radio, billboards, television, flyers, social media), languages, and messengers will be most effective in reaching your people in case of heat emergency.
8. What could be your role in HAP, and what assistance is expected?
9. What are your personal recommendations that could have, or which can in the future, minimize the extent of heatwave impact?

All of the questions were designed to help determine which communities, places, and populations needed immediate solutions and mitigation measures, as well as what level of heat the stakeholders were experiencing. The results to this exercise are attached in annexure

Figure 10: Group Discussions at PCMC Office

These inquiries made it easier to identify and map the city's crucial hotspots, which are stated below:

- Chikhali
- Charoli
- Mukai Chowk
- Moshi
- Dehu-Alandi Road
- MIDC Bhosari
- Slum areas
- Open Lands
- Spine Road – Moshi
- Open areas
- Bhumkar Chowk

The stakeholders' meeting led to the finalization of critical zones that need heat mitigation measures. A meeting was held with field experts to get their feedback on the approach and the progressive work done on the Heat Action Plan for PCMC. The experts comprised an Urban Designer, an Environmental Architect, and a representative from a non-governmental organization. These specialists provided useful feedback, including a deep understanding of the various aspects of heat vulnerability of the population, improvements in the structuring of the approach, and inclusion of policies focusing on community engagement.

Overall, stakeholder engagement was instrumental in:

- Identifying critical areas and vulnerable populations.
- Prioritizing heat mitigation efforts based on community needs and feedback.
- Addressing challenges and barriers to implementation.
- Enhancing community resilience and readiness for heat emergencies.
- Promoting equitable access to resources and assistance.
- Leveraging technology for improved heat resilience and response.
- Raising public awareness and readiness through effective communication strategies.

In conclusion, the stakeholder consultation process has been pivotal in shaping the policy framework and establishing a clear roadmap for the implementation of the Heat Action Plan. By actively engaging with stakeholders and experts, we have leveraged their valuable inputs to develop a comprehensive strategy that addresses the immediate needs pf the community while also laying the groundwork for long-term resilience.

The collaborative efforts of stakeholders and experts have enabled the team to formulate a robust policy framework that prioritizes the protection of vulnerable populations, the promotion of equitable access to resources, and the implementation of effective heat mitigation measures. Their diverse perspectives and expertise have enriched decision making process, ensuring that the Heat Action Plan is both responsive to community needs and grounded in scientific evidence.

Chapter IV:

HEAT RISKS ASSESSMENT

The Heat Risks Assessment chapter delves into a comprehensive analysis of heat-related risks within the Pimpri-Chinchwad Municipal Corporation (PCMC) region. This assessment goes beyond surface-level evaluations, encompassing a detailed examination of factors contributing to heat vulnerability, exposure levels, adaptive capacities, and potential impacts on various sectors and communities. Through advanced methodologies and data-driven approaches, this chapter aims to provide a nuanced understanding of heat risks, guiding targeted interventions and resilience-building strategies within the region.

4.1 Comprehensive Heat Risk Analysis:

In this chapter, we conduct a thorough evaluation of historical data and predictive models to assess heat-related risks in the Pimpri-Chinchwad Municipal Corporation (PCMC) region. The aim is to provide a comprehensive understanding of the magnitude and distribution of heat risks, enabling informed decision-making and targeted interventions to mitigate the impacts of extreme heat events.

Evaluation of Historical Data:

Historical data on temperature trends, heatwaves, and heat-related health outcomes are analysed to identify patterns and trends in heat exposure and associated impacts. This analysis includes examining temperature records from meteorological stations, hospital admissions data for heat-related illnesses, and mortality records during heatwaves. By analysing historical data, we gain insights into past heat-related events and their impacts on human health and well-being.

Spatial Analysis:

Spatial analysis techniques are employed to assess spatial variability in heat risks across the PCMC region. Geographic Information System (GIS) tools are used to analyse spatial patterns of temperature, heat exposure, and vulnerability factors such as population density and land use. This spatial analysis helps identify hotspots of heat exposure and vulnerable populations, guiding the prioritization of interventions and resource allocation.

As part of our spatial analysis, we have conducted Land Surface Temperature (LST) mapping for the Pimpri-Chinchwad Municipal Corporation (PCMC) area from the years 2017 to 2023. These maps provide a visual representation of temperature variations across the region over the specified time period. By integrating LST mapping with other spatial data layers, such as population density and land use, we gain valuable insights into the spatial distribution of heat risks and vulnerable populations. The following images depict the results of our LST mapping analysis and contribute to a comprehensive understanding of heat-related risks in the PCMC region.

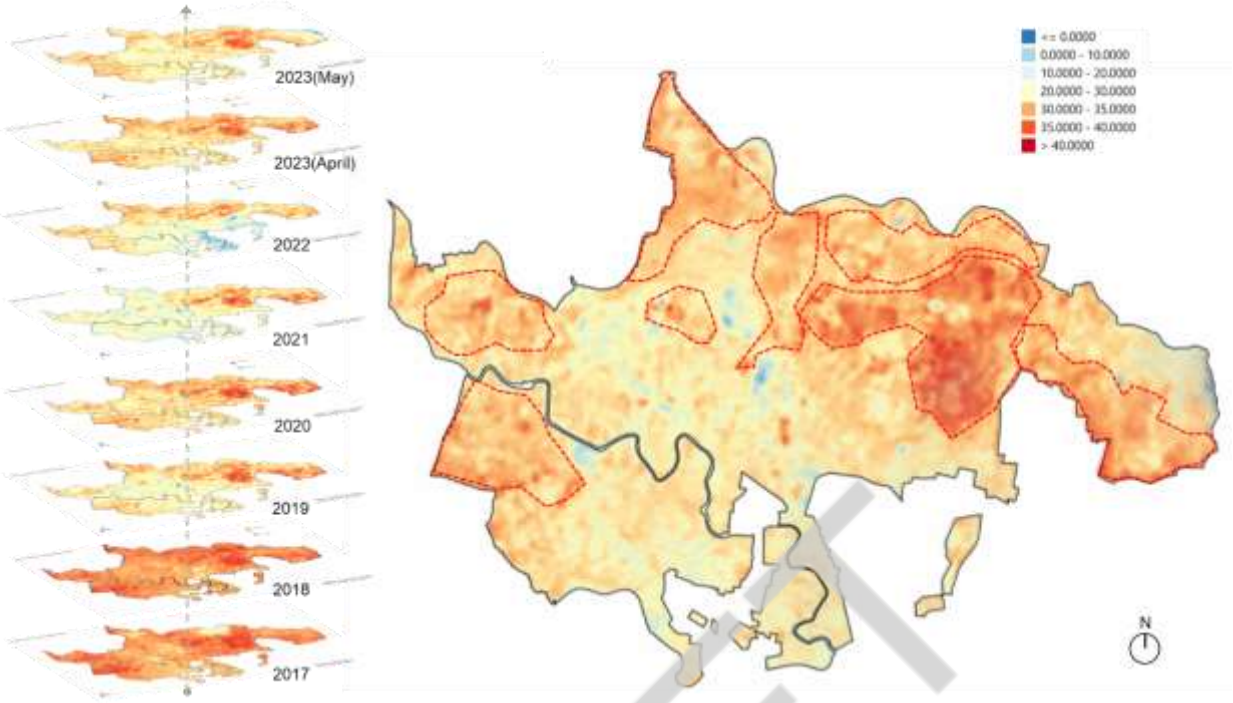


Figure 11: Land Surface Temperature Mapping for the Years 2017 to 2023.

In the above spatial analysis, several significant inferences emerge from the Land Surface Temperature (LST) mapping conducted for the Pimpri-Chinchwad Municipal Corporation (PCMC) area. Firstly, marked zones consistently exhibit higher surface temperatures over a span of more than four years, starting from 2017. This trend is further emphasized by the notable increase in the highest recorded surface temperature, rising from 34°C to 44°C over the course of seven years, from 2017 to 2023. Approximately 50% of the PCMC's surface area demonstrates an average surface temperature of 42°C, indicating widespread heat exposure across the region. These identified zones primarily comprise vacant lands, farmlands, industrial areas with GI roofing, slums, and densely populated residential areas. This analysis underscores the spatial distribution of heat risks within the PCMC area and provides valuable insights for prioritizing interventions and resource allocation to mitigate the impacts of extreme heat events.

Environmental Assessment:

In the later part of the analysis, the study utilized ENVI-met, an environmental simulation software, to assess the effectiveness of the heat reduction strategies implemented. This approach involved simulating various scenarios to evaluate the impact of urban design interventions, such as cool surfaces, green spaces, and shading structures, on local microclimates. By utilizing ENVI-met, the study gained valuable insights into how these strategies influence temperature distribution, heat stress levels, and thermal comfort for residents. This environmental assessment methodology enhances our ability to optimize heat mitigation strategies and create more resilient urban environments in the PCMC region.

Integration of Socio-Economic Factors:

In addition to environmental factors, socio-economic factors are considered in the heat risk assessment. Socio-economic indicators such as income level, housing quality, access to healthcare, and social vulnerability are integrated into the analysis to understand the differential impacts of extreme heat on different segments of the population. This socio-economic analysis provides insights into underlying vulnerabilities and informs equitable adaptation strategies.

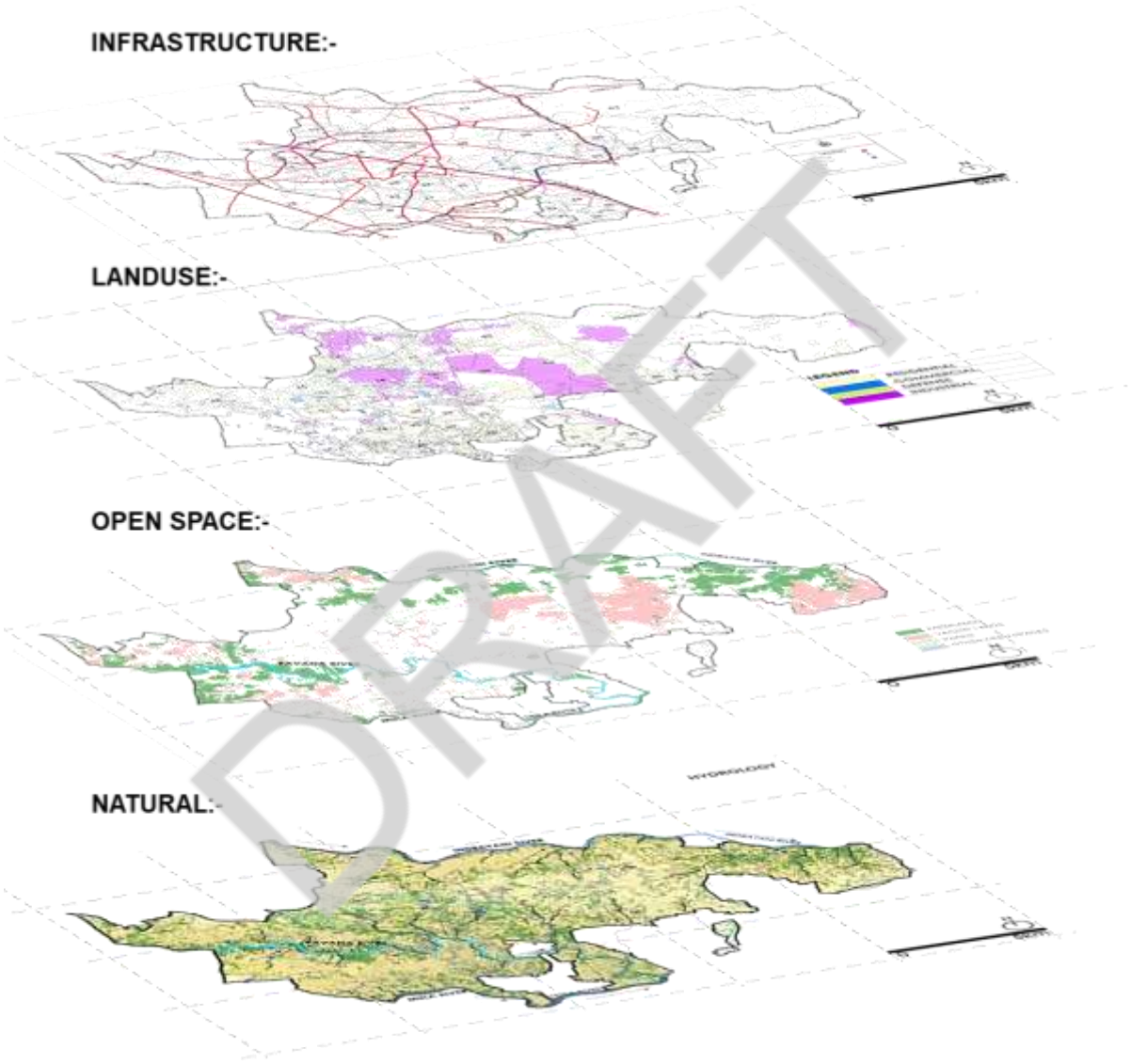


Figure 12: Spatial Understanding plan for PCMC

Infrastructure: There are 3 major highways: - Mumbai - Bangalore highways, old Mumbai - Pune, Pune - Nashik highway. Railway routes and metro routes runs along the Old Mumbai - Pune Highway through the centre of PCMC.

Land use: The growth of the city was commenced from the industrial development in Pimpri- Chinchwad area. We can see that the central portion of the city is largely dedicated to the industrial areas. The areas along the industries are residential areas with respect to the infrastructure needs. The agricultural areas along the north-eastern and western and Open spaces have scope to be developed into the new residential and commercial areas.

Open Space: The central part of PCMC towards SW and NW is dominated by residential areas which have led to development of parks & gardens. The eastern part is dominated by farmlands and barren lands making it a hot zone but with scope for minimal mitigation measure due to the land use in that area. Out of the 181sq.km of the overall PCMC area, open spaces cover 46.82Sq.km contributing to around 26%. The western part has a mix of farmlands and residential zones providing some scope for mitigation measures to be proposed.

Natural/ Topography: Average elevation at 590m from mean sea level. The east-west ridge running midway between Indrayani and Pavana rivers separate this area into two parts. The northern portion slopes towards Indrayani River while the southern portion slopes towards Pavana and Mula river.

Analyzing Thermal Patterns and Vegetation Dynamics

The following analysis presents a comprehensive overview of temperature patterns and vegetation cover in the Pimpri-Chinchwad Municipal Corporation (PCMC) region. Through the integration of Land Surface Temperature (LST) and Normalized Difference Vegetation Index (NDVI) data, the study gained insights into the environmental dynamics and urban development trends impacting PCMC.

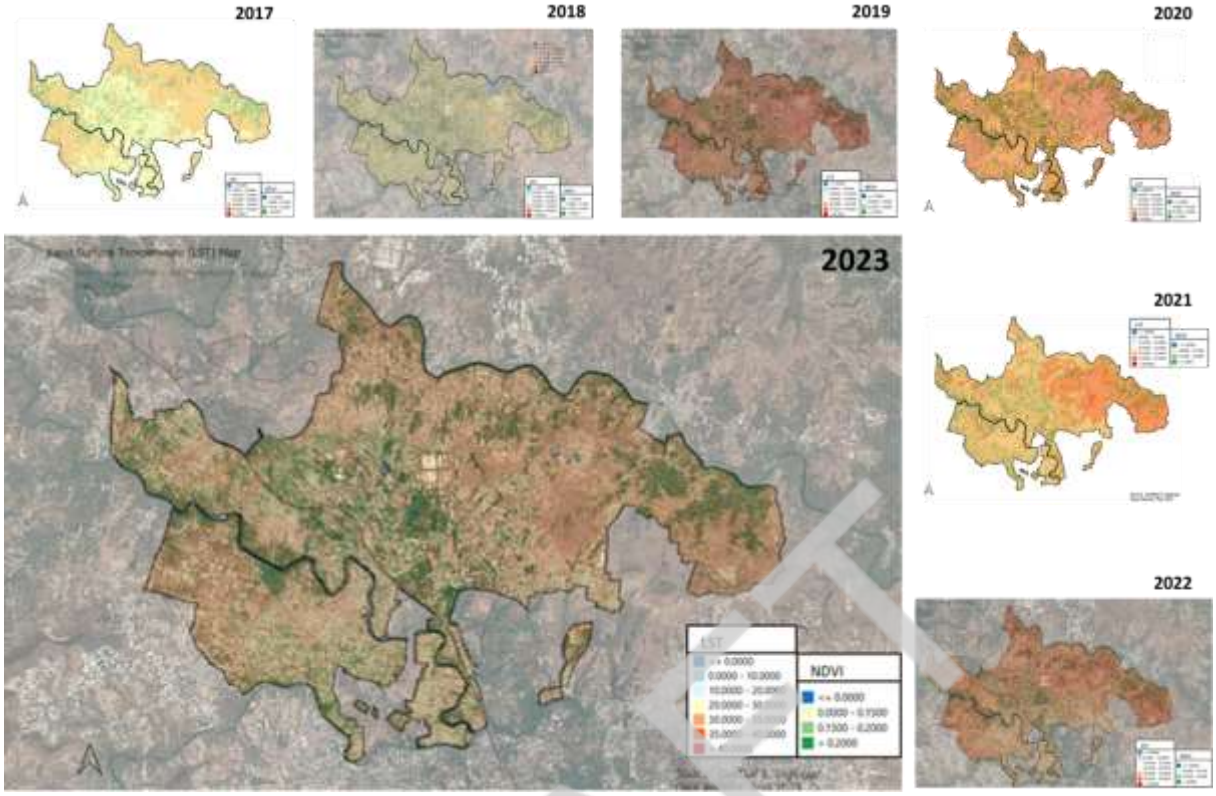


Figure 13: Integrated map of LST and NDVI for PCMC

- 2017: The analysis revealed a consistent temperature distribution across PCMC without significant hotspots. However, there was a noticeable lack of vegetation in many areas.
- 2018: Moderate temperature levels were observed, with hotspots in specific regions. Vegetation cover decreased slightly but remained consistent in certain zones.
- 2019: A notable increase in high-temperature areas was observed, especially in densely built-up regions. Efforts to improve greenery were evident in localized areas.
- 2020: High temperatures persisted in built-up areas, emphasizing the need for green infrastructure. Some areas showed moderate vegetation cover, indicating ongoing mitigation efforts.
- 2021: Temperature levels remained relatively stable, with a slight decrease compared to the previous year. Thermal patterns were uniform across the region.
- 2022: The thermal pattern remained consistent, with an expansion of high-temperature zones suggesting changes in land use. Overall, vegetation density decreased.
- 2023: Half of PCMC experienced elevated temperatures, particularly in certain areas. A significant portion showed moderate temperatures, contributing to the overall thermal profile. Moderate vegetation cover increased slightly, indicating ongoing green initiatives. Regions with higher vegetation density also saw improvements, albeit in smaller areas.

The analysis reveals a gradual increase in high-temperature areas over the years, emphasizing the importance of heat mitigation strategies. Efforts to enhance greenery are noticeable, although more focus is needed to address elevated land surface temperatures in built-up zones.

Synthesis of existing Scenario:

To pinpoint areas vulnerable to heat within the city, a comprehensive analysis was conducted by overlaying multiple maps. These included Land Surface Temperature (LST) maps, infrastructure data, natural topography, land use classifications, open space distributions, and imagery depicting the Normalized Difference Vegetation Index (NDVI). By integrating these diverse datasets, a holistic understanding of the urban environment was achieved. This approach enabled the identification of key areas where factors such as limited vegetation cover, high levels of impervious surfaces, and dense urban development contribute to heightened heat exposure and potential risks to residents.

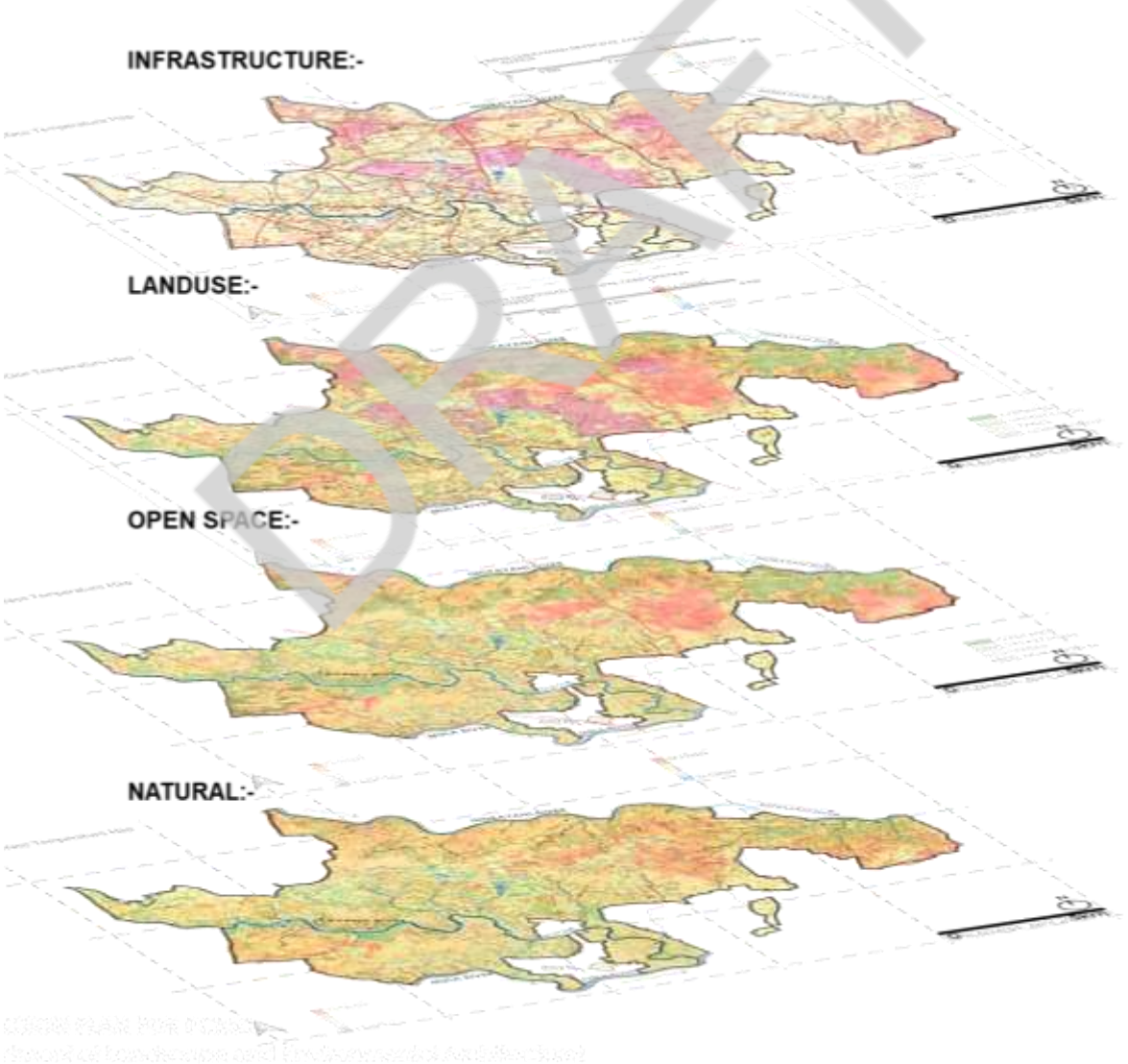


Figure 14: Map overlays for PCMC.

Natural + Infrastructure + LST: Residential areas in western side of PCMC is quite hot due to vast opening with on- going construction and less of vegetation. Also, NH48 passes through the western part of the region, which is very polluted transit zone due to heavy traffic. All these factors contribute to heavy traffic in the region. The south eastern portion of the region has majority of vacant lands and also Pune- Nashik highway, leading to increase in humidity and temperature in the following areas.

Natural + Land use + LST: Central and South Western part consists of residential, open spaces (parks and gardens) with a fair amount of vegetation and presence of Pawana river, lowering the land surface temperature. However, the north- western part of the region is a developing residential area with high land surface temperature. Vacant lands with agricultural fields and flat lands in south- eastern portion of the region, results in higher land surface temperatures

Natural + Open Space + LST: Through central and South Western zone of PCMC, we can see presence of open spaces in the form of parks and neighbourhood gardens with fair amount of vegetation. Hence, Land surface temperature is lower in the following areas. Vacant and flat land can be seen in terms of eastern portion of PCMC; hence, Land surface temperature increases towards the eastern part of the region.

Natural + LST: Being at a higher elevation, having no vegetation cover, this zone tends to have higher LST. The presence of vacant land, quarries contribute to the increasing LST in eastern region of PCMC.

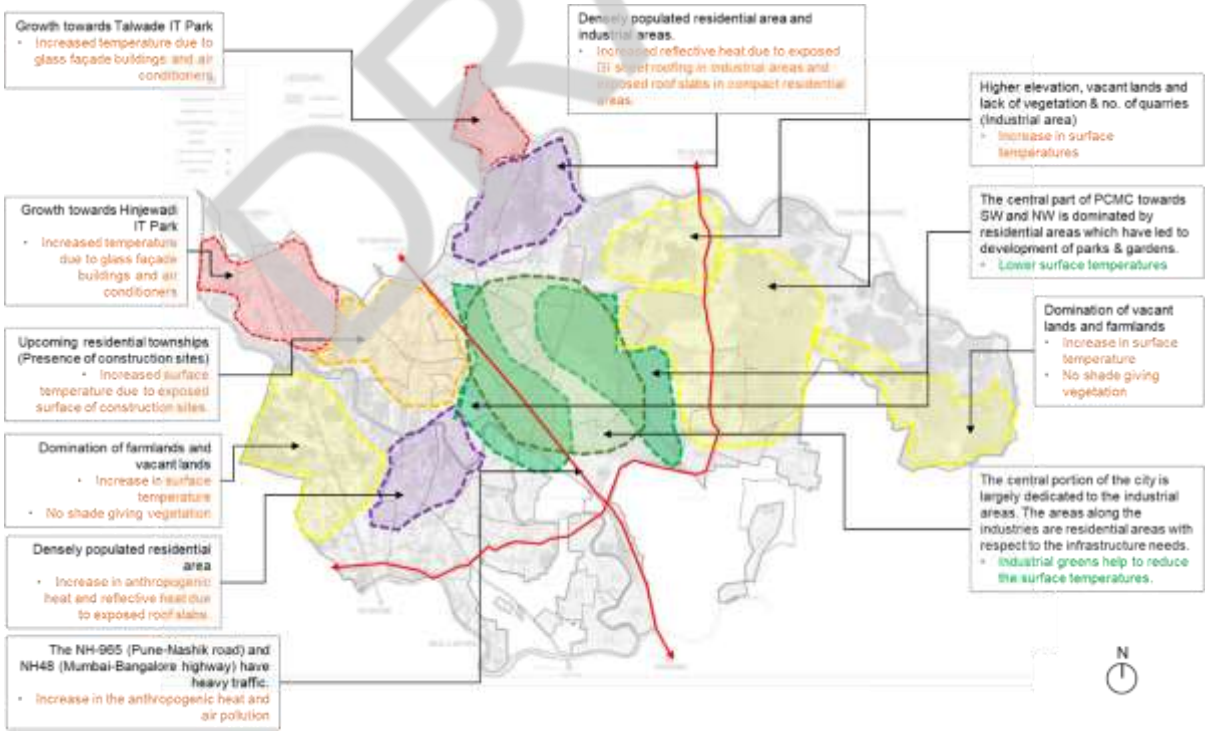


Figure 15: Synthesis map for PCMC

The synthesis plan provides a comprehensive overview of the pre-study findings for the PCMC region, categorizing areas into high, medium, and low heat zones based on detailed analysis and environmental assessments. It highlights the factors contributing to temperature variations, including land use patterns, population density, vegetation cover, and urban infrastructure. By synthesizing this information, the plan aims to identify priority areas for heat mitigation interventions and strategic planning, focusing on enhancing thermal comfort, reducing heat stress risks, and fostering sustainable urban development practices in PCMC.

Chapter V:

HEAT VULNERABILITY MAPPING

This chapter is a critical component of understanding and addressing the unique challenges posed by heatwaves in the Pimpri-Chinchwad Municipal Corporation (PCMC) region. This chapter focuses on identifying areas within PCMC that are particularly vulnerable to heat-related impacts. By conducting a thorough analysis of various parameters such as land use, population density, and vulnerability indicators, this mapping exercise aims to pinpoint zones where communities are at heightened risk of heat-related health issues and other adverse effects. Through the identification of vulnerable zones, targeted interventions and strategies can be developed to enhance resilience and mitigate the impacts of extreme heat events in these areas.

5.1 Identification of Vulnerable Zones:

Introduction:

Vulnerability mapping is a critical tool for understanding and preparing for the unique challenges faced by different groups within a population. In PCMC, this mapping is essential for effective resource allocation and policy-making, especially in the context of urban planning and disaster management.

Vulnerability Population Definition:

Vulnerable populations are those at a heightened risk of poor physical and social health outcomes. This encompasses disparities in physical abilities, economic standing, and social health when compared to the dominant population.

Target Population for Vulnerability in PCMC:

The vulnerability assessment targets several key groups within the population:
- Children
- Outside Workers
- People with Disabilities
- Outdoor & Manual Workers
- The Less Abled and Pregnant Individuals
- Older Adults
- Slum dwellers

Methodology:

The methodology adopted for the vulnerability mapping in PCMC was a systematic approach aimed at comprehensively analyzing and identifying vulnerable zones within the population. The study utilized several key parameters to assess vulnerability across the area.

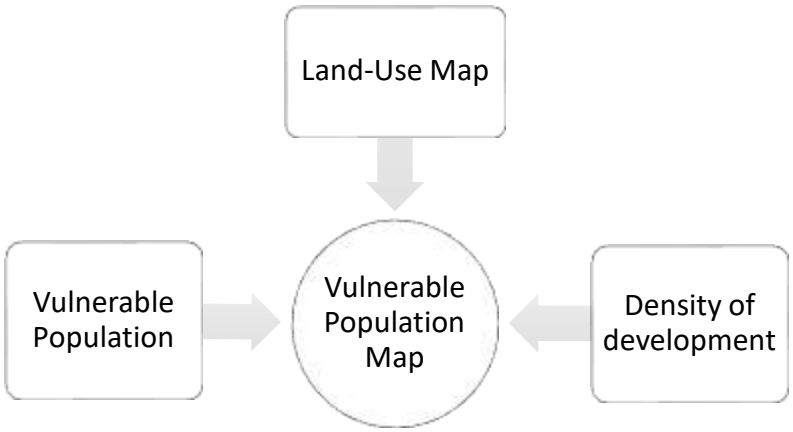


Figure 16: Parameters considered for vulnerability mapping

Land-Use Mapping:

This phase involved utilizing Geographic Information System (GIS) technology to conduct a comprehensive analysis of the land-use patterns within the PCMC region. The study focused on categorizing land use into urban, industrial, and agricultural zones, considering factors such as building density, land coverage by vegetation, and types of infrastructure present.

Urban Areas: These zones typically exhibited high building density, commercial activities, residential complexes, and essential infrastructure like hospitals, schools, and transportation networks. The concentration of people and activities in urban areas contributes to higher population densities, increased heat absorption due to concrete structures, and limited green spaces, all of which can amplify vulnerability during heatwaves or environmental emergencies.

Industrial Zones: The analysis also examined areas designated for industrial activities, including manufacturing units, warehouses, and industrial parks. Industrial zones often have a higher concentration of workplaces and workers, exposure to hazardous materials, and limited access to amenities like healthcare facilities or green spaces, making them susceptible to heat stress and other occupational health risks.

Agricultural Zones: These zones encompassed agricultural lands, rural settlements, and areas with significant vegetation cover. While agriculture zones may have lower population densities compared to urban or industrial areas, they are vital for food production and ecosystem services. However, changes in land use, such as urban encroachment into agricultural areas, can impact food security, alter microclimates, and contribute to heat island effects.

By mapping out these different land-use categories, the study aimed to correlate land use with population density and the associated risks during heatwaves, emphasizing the need for tailored interventions and urban planning strategies to mitigate vulnerability.

Density Assessment:

The study conducted a detailed assessment of population density and infrastructure development across various parts of the PCMC region. This assessment involved analysing spatial data on population distribution, building footprints, road networks, and public amenities to understand the concentration of people and assets in different zones.

High-Density Areas: Zones characterized by high population density and extensive infrastructure, such as commercial centres, residential complexes, and industrial hubs, were identified as high-density areas. These areas face challenges related to limited open spaces, increased heat retention due to buildings and pavement surfaces, and higher energy consumption for cooling systems.

Medium-Density Areas: Certain zones exhibited moderate population density and infrastructure development, including mixed-use neighbourhoods, educational institutions, and recreational spaces. While these areas may have better access to amenities and green spaces compared to high-density zones, they still experience heat-related risks due to urbanization trends and land-use patterns.

Low-Density Areas: The analysis also identified zones with lower population densities, such as suburban areas, open lands, and agricultural zones. These areas typically have more green cover, lower building densities, and reduced heat island effects. However, they may still face vulnerability challenges related to access to services, transportation networks, and climate change impacts.

The density assessment provided insights into how population distribution and infrastructure development contribute to vulnerability, guiding the formulation of targeted interventions and resilience strategies.

Vulnerable Population Mapping:

A key component of the methodology was identifying and mapping vulnerable groups within the PCMC population. This process involved field visits, gathering demographic data, health indicators, socio-economic factors, and accessibility information to identify groups at heightened risk during heatwaves and other environmental stresses. This map visually represents the distribution of vulnerable groups across the PCMC area. This mapping helped in identifying specific locations where vulnerable populations were more concentrated, enabling targeted interventions and resource allocation.

By mapping out these vulnerable groups across the PCMC area, the study could pinpoint areas with higher concentrations of vulnerability and assess the specific challenges faced by each group. This data-driven approach informed the development of targeted interventions, emergency response plans, and community outreach strategies to enhance resilience and reduce heat-related risks among vulnerable populations.

Ward-Wise Vulnerability Distribution

The vulnerability is further broken down by wards within the PCMC:

- The most vulnerable populations are spread across several wards, notably with high numbers in wards that experience significant industrial activity and dense residential living.
- Wards identified as least vulnerable, such as wards 3, 6, and 25, are characterized by open spaces which contribute to a reduced vulnerability profile as seen in the Figure 16 below.

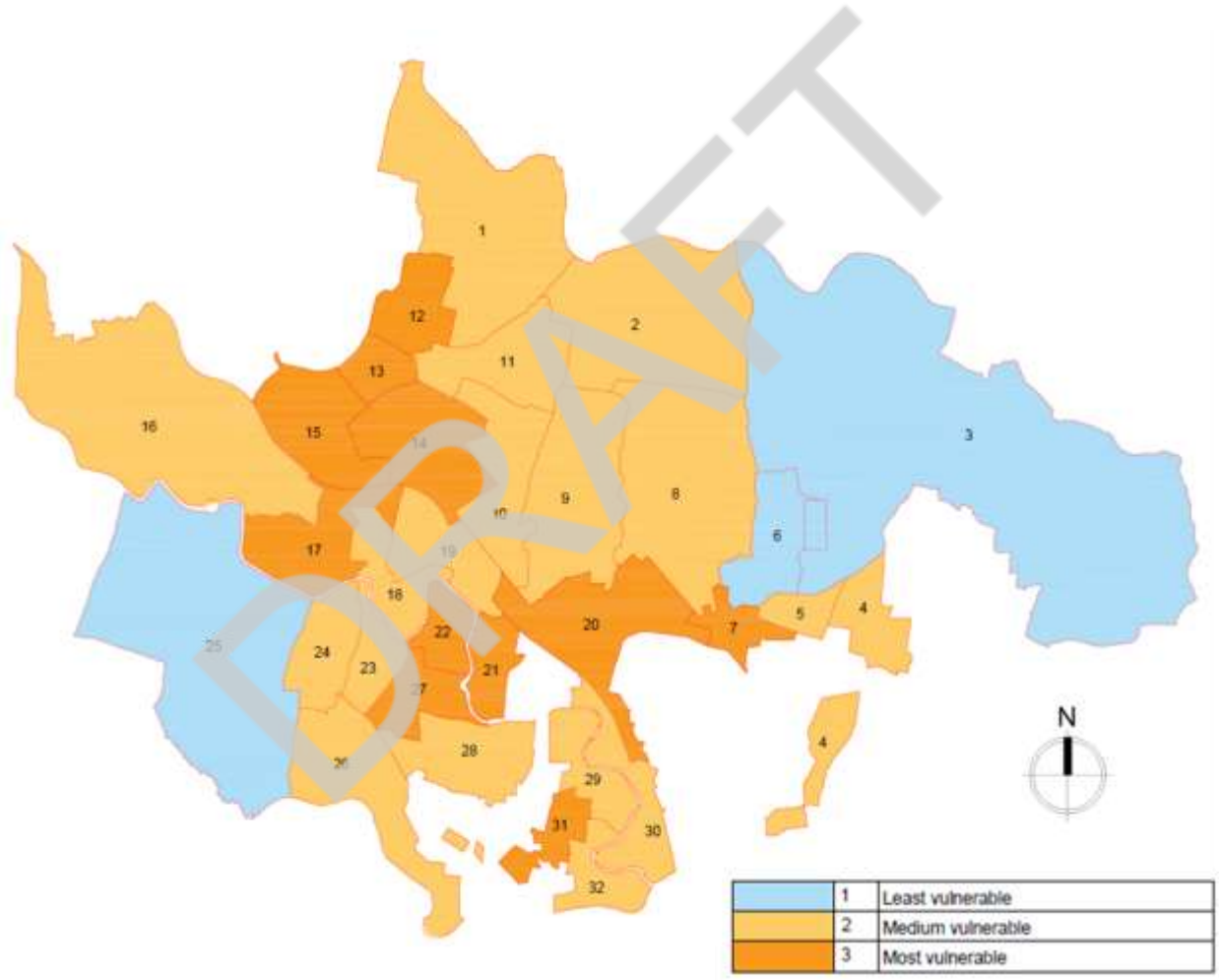


Figure 17: Ward-Wise Vulnerable Population mapping

Vulnerability Mapping Results

The results of the vulnerability mapping as seen in the figure 14 & 15 are as follows:

- Most Vulnerable Population: Constitutes 33% of the area, primarily consisting of industrial workers and residents in high-density residential zones.

- Medium Vulnerable Population: Accounts for 58% of the area, indicating a moderate level of vulnerability across various parameters.

- Least Vulnerable Population: Makes up 9% of the area, largely located in wards with open lands and farmlands, indicative of lower risk exposure.

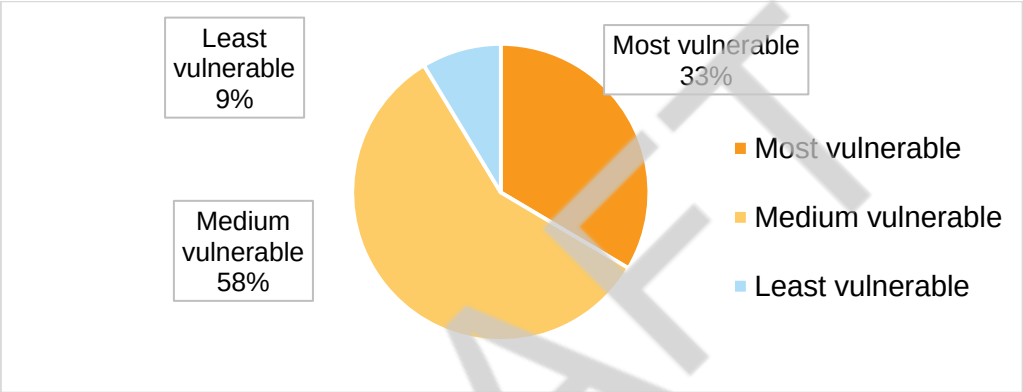


Figure 18: Vulnerable Population results.

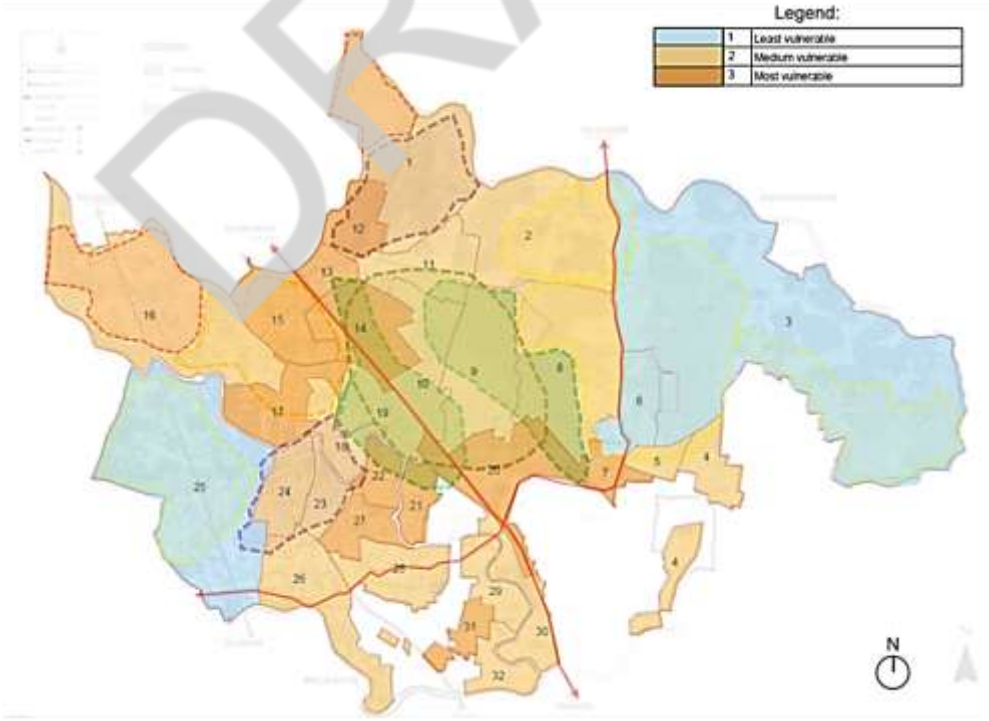


Figure 19: Synthesis Plan overlapping Vulnerability mapping, PCMC region

The synthesis plan derived was overlapped with this vulnerable population analysis map to understand heat vulnerable areas comprehensively. Densely populated residential and industrial areas witness increased anthropogenic heat, air pollution, and reflective heat from exposed roofing. In contrast, central PCMC exhibits a mix of industrial and residential zones. Parks and gardens in residential areas mitigate surface temperatures, while industrial greens contribute to cooling. However, vulnerable populations, mainly industrial workers and residents in high-density areas, face heightened risks. Ward nos. 3, 6, and 25, characterized by open lands and farmlands, have the least vulnerable populations. Overall, the urbanization trend brings challenges such as increased temperatures, but pockets of greenery and planning efforts can help mitigate these effects.

Conclusion

This detailed vulnerability mapping exercise for the PCMC area highlights the need for targeted interventions to protect and empower the most vulnerable segments of the population. The insights derived from this study are critical for devising strategies that enhance resilience and ensure equitable resource distribution.

In conclusion, the exhaustive vulnerability mapping (Figure 19) exercise conducted for the PCMC area underscores the imperative for tailored interventions aimed at safeguarding and empowering the community's most vulnerable segments. The insights gained from this comprehensive study serve as indispensable guides for formulating strategies that encourage resilience and promote equitable distribution of resources.

By meticulously identifying areas of heightened vulnerability and populations at increased risk, this mapping exercise lays the foundation for targeted interventions that address specific needs and challenges. It illuminates the intricacies of vulnerability within the community, enabling policymakers and stakeholders to prioritize interventions where they are most urgently needed. The vulnerability mapping exercise serves as a cornerstone of the Heat Action Plan's commitment to proactive and evidence-based decision-making. It underscores the importance of understanding the diverse needs and challenges faced by different segments of the population, and of tailoring interventions accordingly. By leveraging these insights, the Heat Action Plan can ensure that no segment of the population is left behind, and that all community members are equipped to withstand and recover from the impacts of extreme heat events.

Chapter VI:

DERIVATIVES FROM RISK ASSESSMENT

This chapter delves into the actionable insights derived from the comprehensive heat risk assessment, particularly focusing on mapping vulnerable areas within the Pimpri-Chinchwad Municipal Corporation (PCMC) region. By synthesizing data from the risk assessment process, this chapter aims to visualize and identify specific geographic locations and communities that are most susceptible to heat-related risks. This mapping of vulnerable areas serves as a foundational step in developing effective strategies and policies to enhance resilience and protect vulnerable populations during heatwave events.

Mapping Vulnerable Areas:

As part of the risk assessment, detailed mapping and study of selected vulnerable areas within the PCMC region have been conducted. Based on the desk study, stakeholder consultation and field study analysis, 3 zones were identified as seen in the Figure 20 below. These 3 zones are the representative zones as per land use falling under the typology of Industrial, Mixed-use and Residential. Additionally, the regions selected facilitate the implementation of heat mitigation measures.

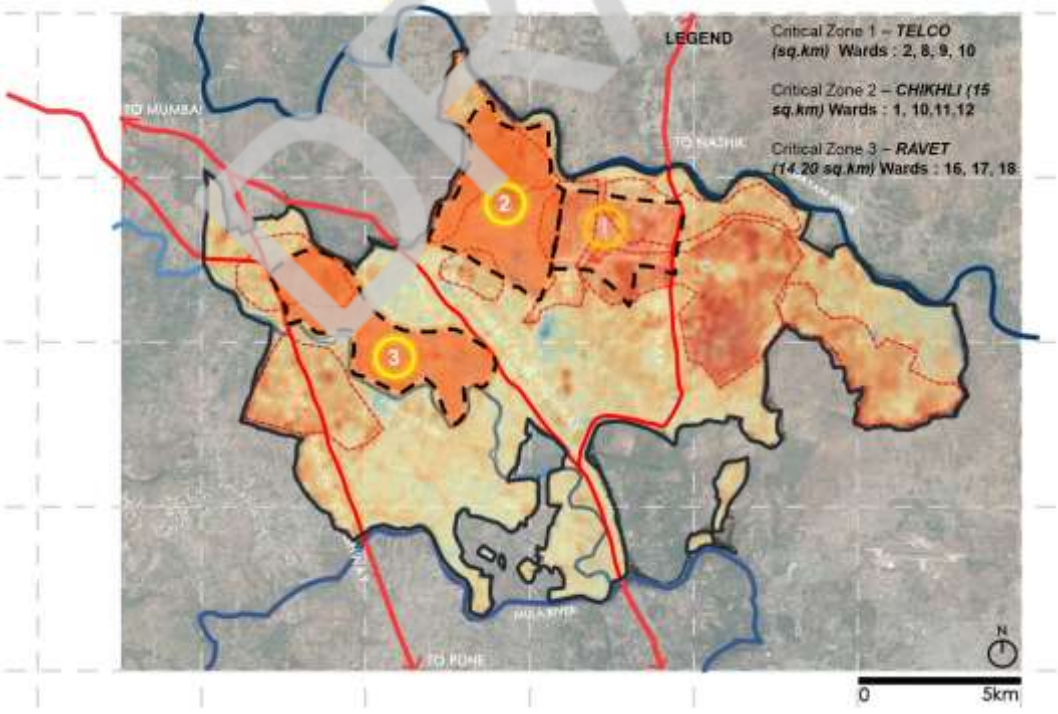


Figure 20: Selected zones as per desk study, stakeholder meeting and field study

These maps highlight areas as seen in Figure 21 with heightened susceptibility to heat-related risks, such as high population density, inadequate green spaces, and limited access to essential services. By identifying these areas, targeted interventions can be implemented to address vulnerabilities effectively.

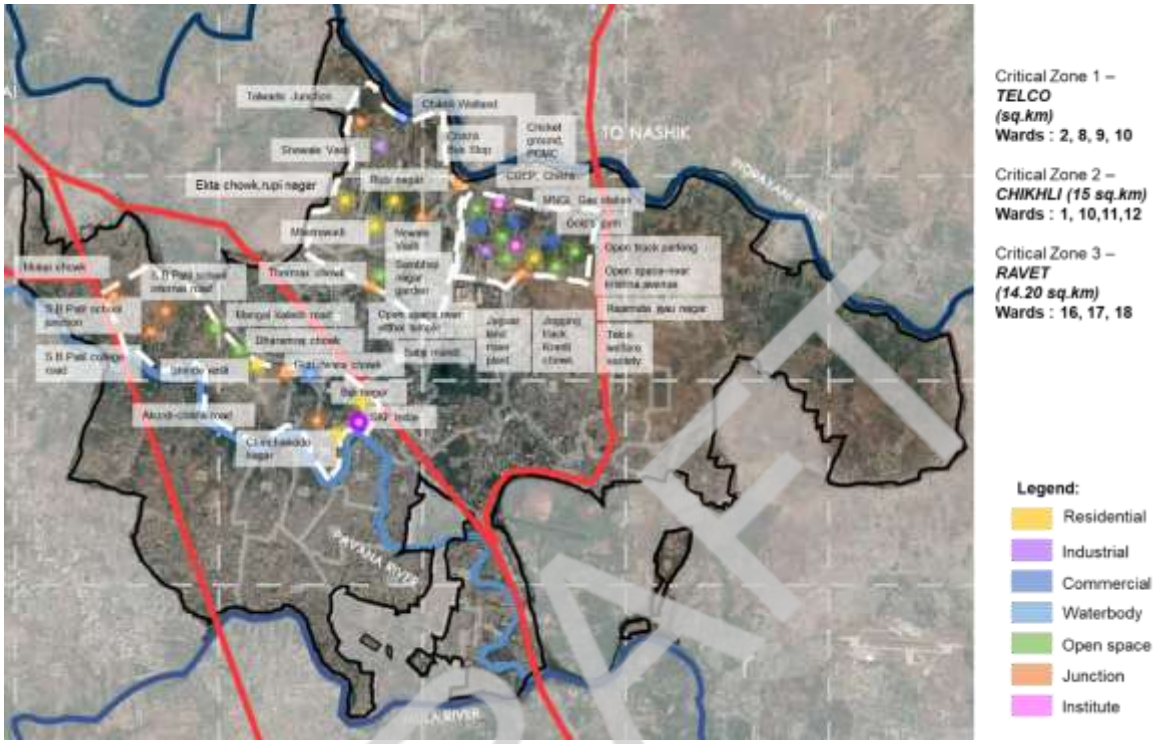


Figure 21: Study locations for the PCMC region.

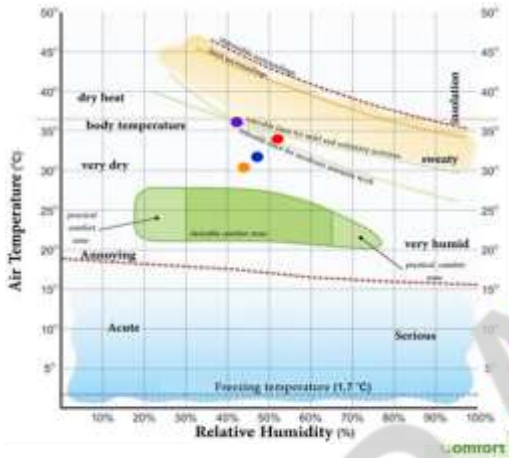
Figure 21 shows the selected areas within the zones of PCMC region which were mapped for the study. These visual representations provide valuable insights into the spatial distribution of heat vulnerability factors and serve as a basis for prioritizing interventions and resource allocation. Following is the detailed analysis of these selected areas from heat perspective.

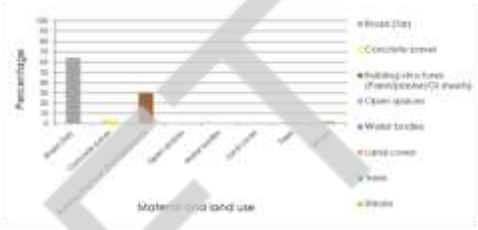
For each selected area, the readings were taken for Temperature, Humidity, Wind and Thermal imaging on 7 consecutive hottest days for four timings of the day. Other parameters contributing to heat such as Land use, Material Specification, Vegetation etc. were documented. The inventory of morphological and non-morphological parameters was prepared to understand parameters contributing to heat for the selected area. The shadow pattern for 3 different times of the day was analysed. The comfort conditions were analysed using IMD's experimental Heat index and Bioclimatic chart for outdoor comfort. Following are details of the selected areas within the zones of PCMC region.

CHIKHLI BUS STOP (Ward 10)

Chikhli bus stop and the surrounded areas are dominated by **Residential areas.**

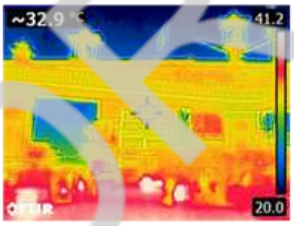
Landuse Typologies : Residential, mixed use
Average road width : 15 -18m
Average building height : G + 2

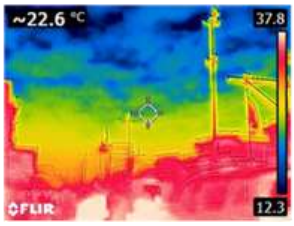




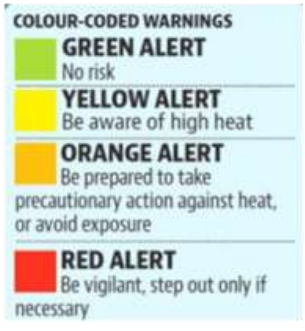
Morning(8am – 9am), Temp:32.50 °C, Humidity:48.92 %
Afternoon(12pm-1pm), Temp: 36.02 °C, Humidity: 41.94 %
Evening(4pm-5pm), Temp: 34.57 °C, Humidity: 51.05 %
Night(7pm- 8pm), Temp: 30.95 °C, Humidity: 44.23 %

Comfort range:
Temp: 20-27 °C Humidity: 30% -65 Wind speed: 1.5-2.4 m/s





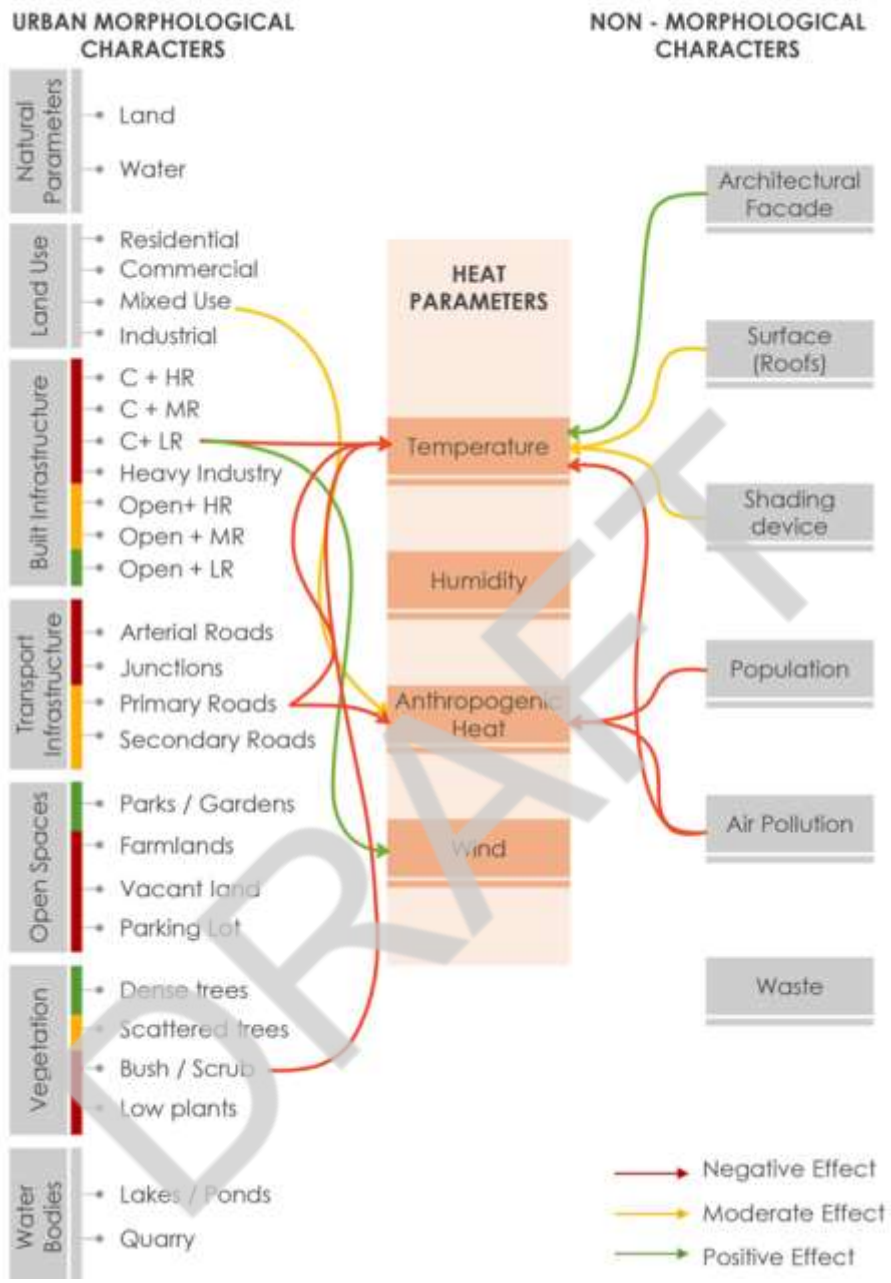
Color Codes for Experimental Heat Index for India	
Morning (8 A.m - 9 A.m)	Heat Index : 34.8°C
Afternoon (12 P.m - 1 P.m)	Heat Index : 39.5°C
Evening (4 P.m - 5 P.m)	Heat Index :40°C
Night (7 P.m - 8 P.m)	Heat Index : 31.5°C



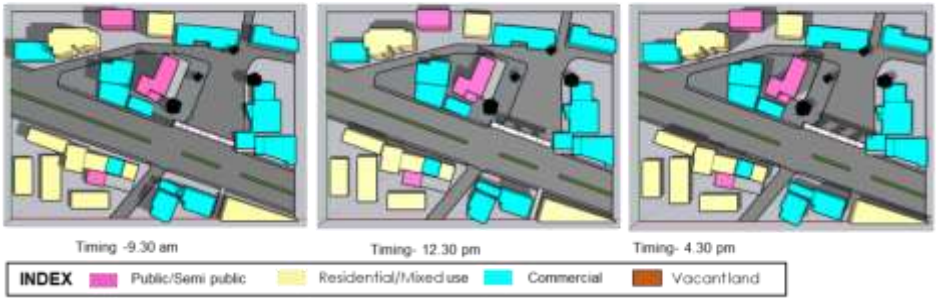
Green: Below 35°C
Yellow: Range of 36-45°C
Orange: Range of 46-55°C
Red: Above 55°C

Figure 22Heat Index (Experimental) IMD

Source: PIB 1941012 Press release



SHADOW PATTERN ANALYSIS



Inferences:

i. Impact of Vegetation and Building Structure: The absence of layered vegetation and the prevalence of low-rise buildings contribute to the lack of shade and shadow cast on the surface of roads. This absence exacerbates the increase in surface temperature, particularly during peak daylight hours.

ii. Contributors to Anthropogenic Heat and Air Pollution: The heavily populated roads, frequented by heavy-duty trucks, buses, light motor vehicles, and street vendors, contribute significantly to the rise in anthropogenic heat and air pollution at junctions. The constant movement of vehicles and people further exacerbate these factors, resulting in elevated surface temperatures and reduced air quality.

iii. Shadow analysis: The road area is exposed to the sun with no shading while exposed concrete roof areas of built structures contribute to heat. Implementing shading solutions can help lower surface temperatures and create more comfortable conditions for pedestrians and commuters.

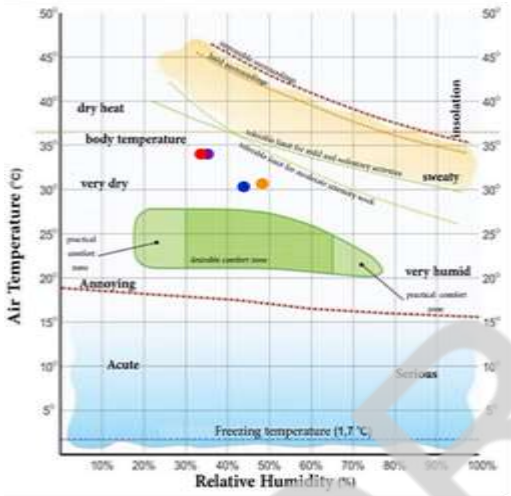
iv. Bioclimatic Chart Analysis: Analysis of the bioclimatic chart reveals that afternoon temperatures tend to be significantly higher compared to the evening. This temperature disparity is attributed to the heating of tar roads during the afternoon, contributing to discomfort levels. Additionally, all temperature readings fall within the heat stress zone, indicating conditions that may pose health risks to exposed individuals.

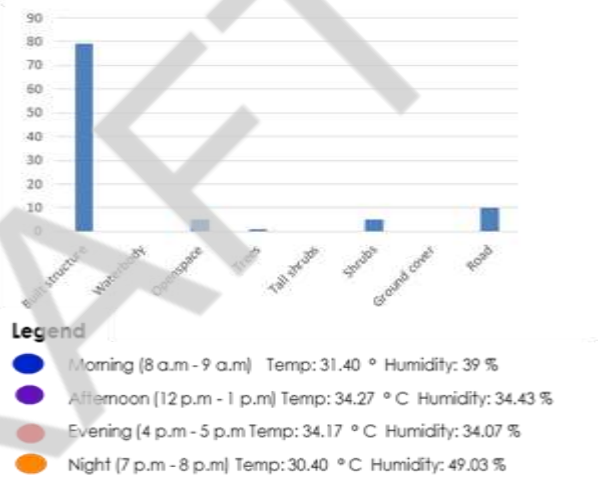
v. Stress Heat Index: The stress heat index, further highlights the severity of heat-related risks in the studied areas. This index exceeds recommended thresholds, signalling potential health hazards and discomfort for individuals exposed to prolonged periods of elevated temperatures, mainly in afternoon and evening.

MHETREWADI (Ward 1)

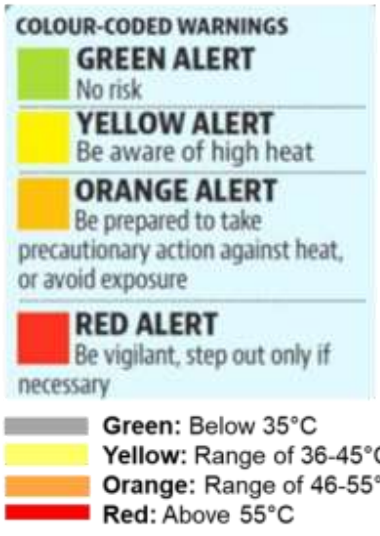
Mhetrewadi is a densely populated residential area having linear placement of houses & apartments.

Landuse Typologies: Residential
Average road width : 3-6 m
Average building height : G + 3

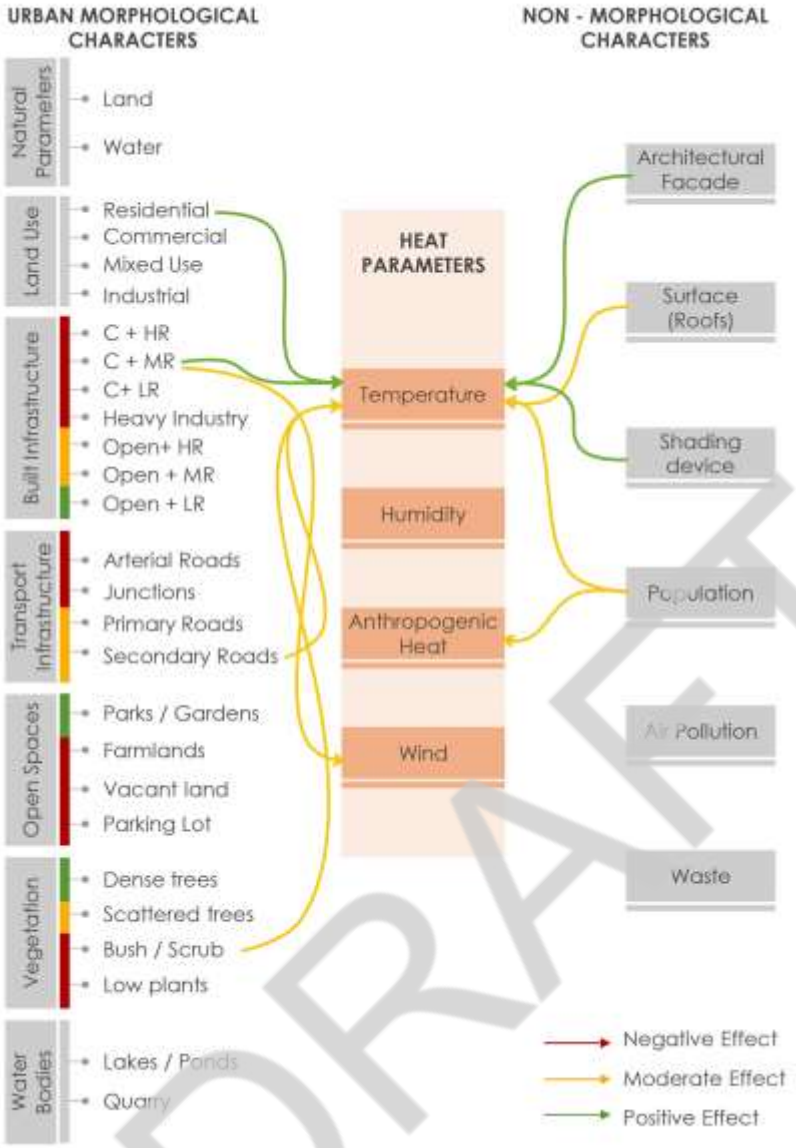




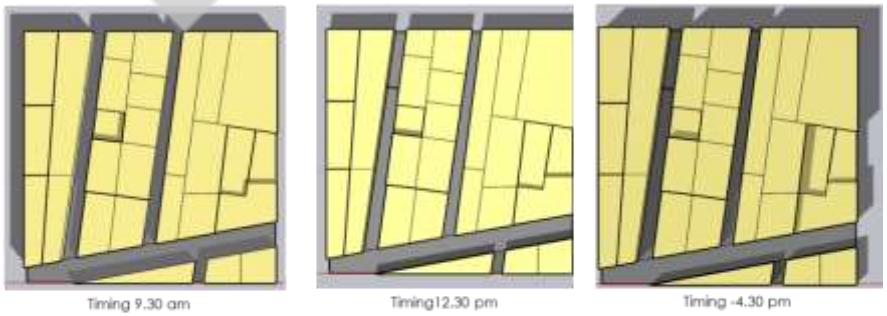
Color Codes for Experimental Heat Index for India	
Morning (8 A.m - 9 A.m)	Heat Index : 34.8°C
Afternoon (12 P.m - 1 P.m)	Heat Index : 39.5°C
Evening (4 P.m - 5 P.m)	Heat Index :40°C
Night (7 P.m - 8 P.m)	Heat Index : 31.5°C



Green: Below 35°C
Yellow: Range of 36-45°C
Orange: Range of 46-55°C
Red: Above 55°C



SHADOW PATTERN ANALYSIS:



Inferences:

i. Effect of Building Orientation on Shadowing: The east-west orientation of buildings results in nearby internal roads being shadowed during the day. This shading effect helps mitigate the impact of direct sunlight, thereby lowering surface temperatures and improving human comfort levels in the shaded areas.

ii. Enhanced Wind Flow Due to Low-Rise Buildings: The presence of low-rise buildings contributes to unhindered wind flow, which improves overall human comfort within the vicinity. Unobstructed wind flow helps dissipate heat and reduces the sensation of warmth, resulting in lower surface temperatures and enhanced comfort for pedestrians and commuters.

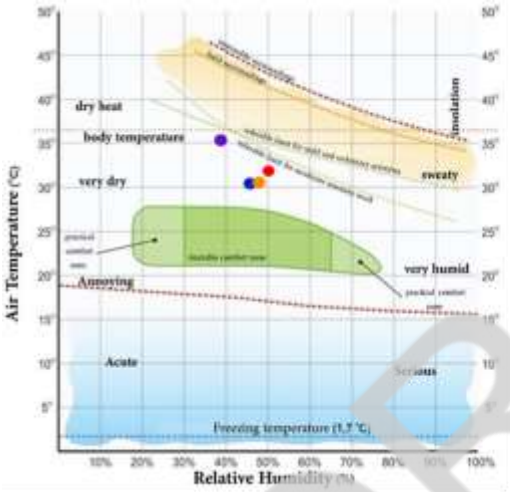
iii. Analysis of Discomfort Zone: Zones within the vicinity are categorized within the discomfort zone based on temperature readings taken. This classification indicates conditions that may cause discomfort or pose health risks to individuals exposed to elevated temperatures for prolonged periods.

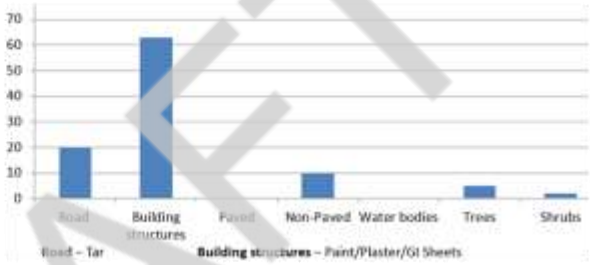
iv. Temperature Trends: Analysis of temperature trends reveals an increase in temperatures during the afternoon and evening hours. This temperature rise can be attributed to the lack of vegetation and building structures, which contribute to increased heat absorption and retention within the built environment. This can be observed from Heat index and bioclimatic chart.

SHEWALE WASTI (Ward 1)

Shewale vasti is an industrial area consisting of manufacturing industries and warehouses.

Landuse Typologies:
Industrial
Average road width : 3 -6m
Average building height :
G + 2

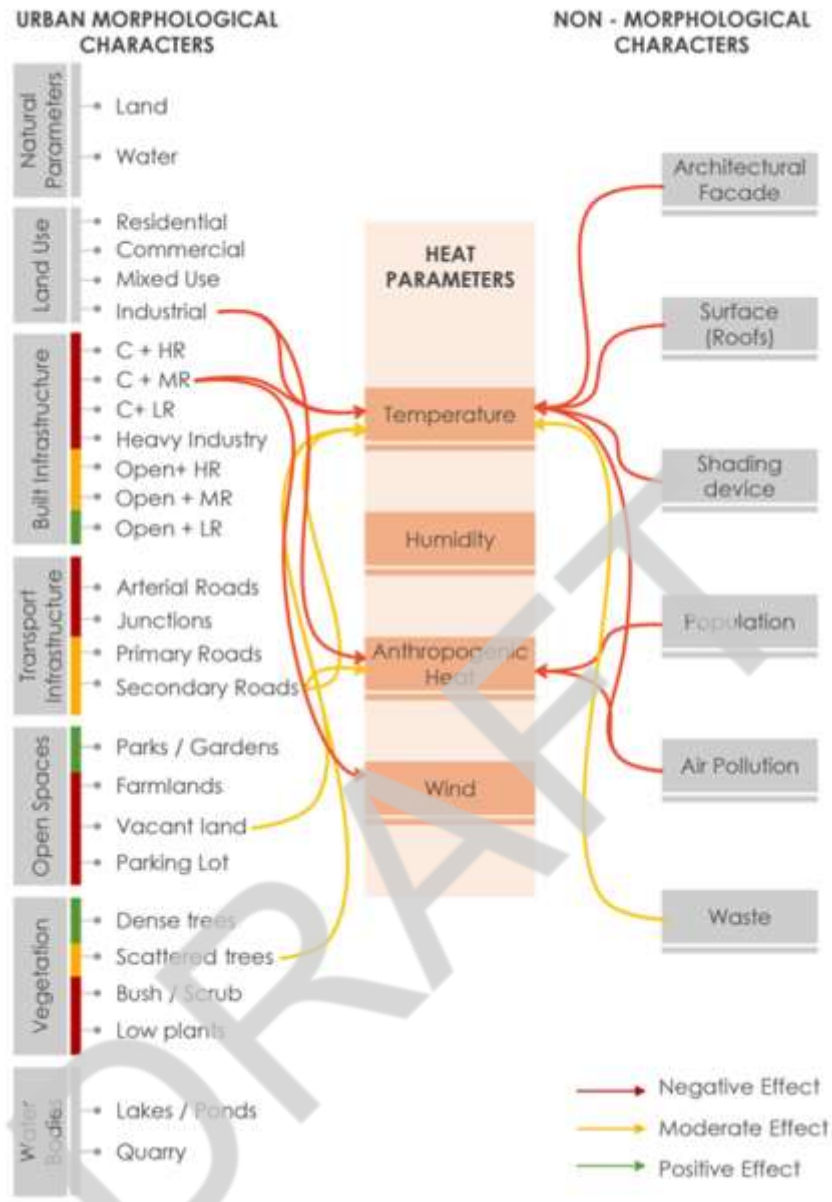




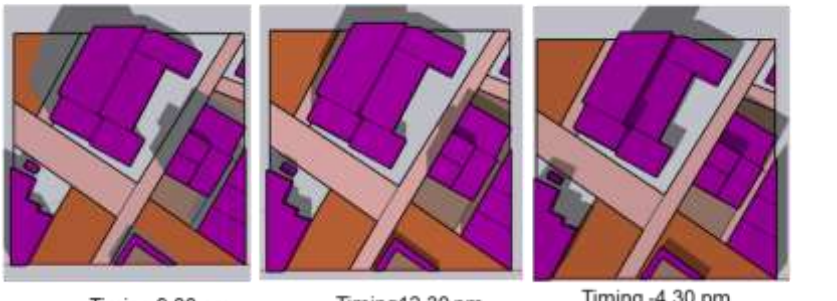
- Morning (8 a.m - 9 a.m) Temp: 31.64 °C Humidity: 46.70 %
- Afternoon (12 p.m - 1 p.m) Temp: 35.60 °C Humidity: 39.28 %
- Evening (4 p.m - 5 p.m) Temp: 33.12 ° C Humidity: 50.04 %
- Night (7 p.m - 8 p.m) Temp: 31.72 ° C Humidity: 48.64 %

Color Codes for Experimental Heat Index for India	
Morning (8 A.m - 9 A.m)	Heat Index : 34.8°C
Afternoon (12 P.m - 1 P.m)	Heat Index : 39.5°C
Evening (4 P.m - 5 P.m)	Heat Index :40°C
Night (7 P.m - 8 P.m)	Heat Index : 31.5°C

Green: Below 35°C
Yellow: Range of 36-45°C
Orange: Range of 46-55°C
Red: Above 55°C



SHADOW PATTERN ANALYSIS:



Timing 9.30 am | Timing12.30 pm | Timing -4.30 pm

Inferences:

i. Impact of GI Sheet Surfaces and Traffic Flow: Surfaces and roofs made of GI sheets contribute significantly to reflective heat, while the heavy flow of traffic exacerbates air pollution and anthropogenic heat. These factors collectively contribute to elevated surface temperatures and degraded air quality in the vicinity.

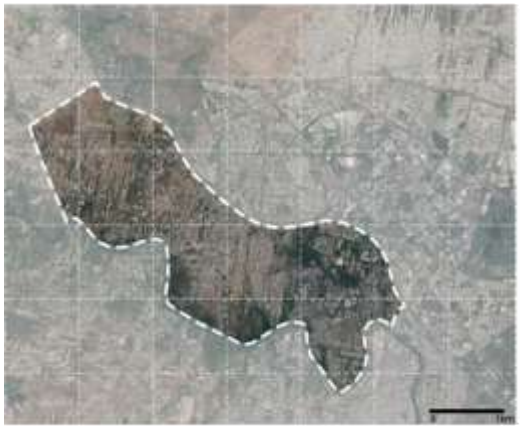
   To mitigate the adverse effects of reflective heat and air pollution, curative measures such as shading roads and minimizing heat reflection from surfaces should be suggested.

ii. Effect of Industrial Areas on Temperature and Air Quality: The presence of industrial areas within the region leads to an increase in both temperature and air pollution levels. To address these challenges, curative measures should be applied to control these parameters effectively. Implementing strategies to mitigate industrial emissions and regulate air quality can help improve environmental conditions in industrial zones.

iii. Analysis of Bioclimatic Chart: Examination of the bioclimatic chart reveals that afternoon temperatures consistently surpass other measured temperatures. This temperature disparity results in conditions falling within the discomfort zone, indicating potential health risks associated with prolonged exposure to elevated temperatures.

iv. Exceedance of Heat Stress Threshold: The observed temperature increase exceeds the heat stress threshold, indicating conditions that may pose health risks and discomfort to individuals exposed to prolonged periods of elevated temperatures. Implementing curative measures to lower surface temperatures and ambient temperatures is imperative to mitigate heat-related risks effectively.

GURUDWARA CHOWK (Ward No. 16)

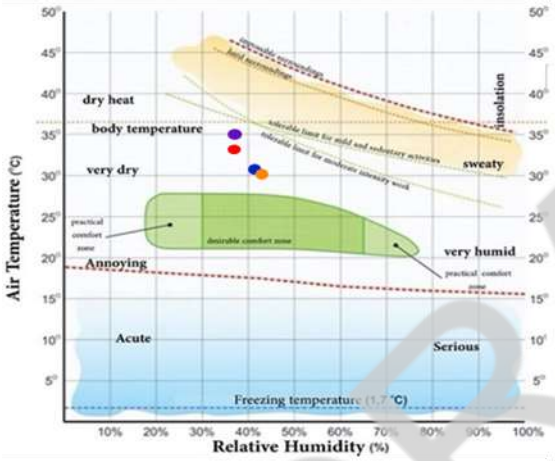


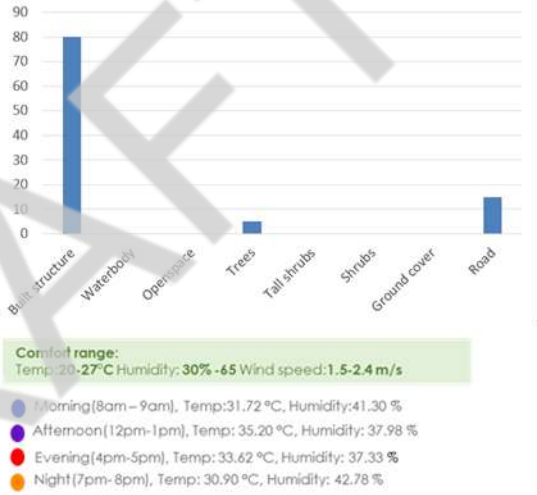
LANDUSE – Commercial

AVG ROAD WIDTH – 12m

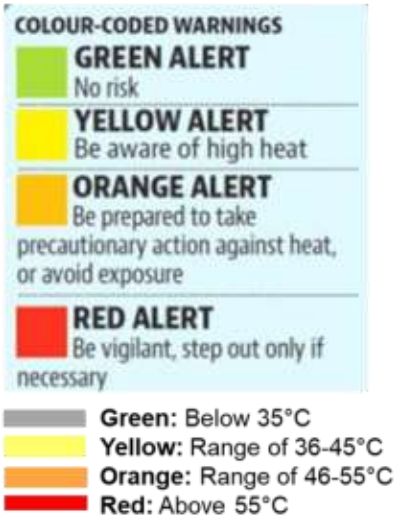
AVG BUILT HEIGHT – G + 2

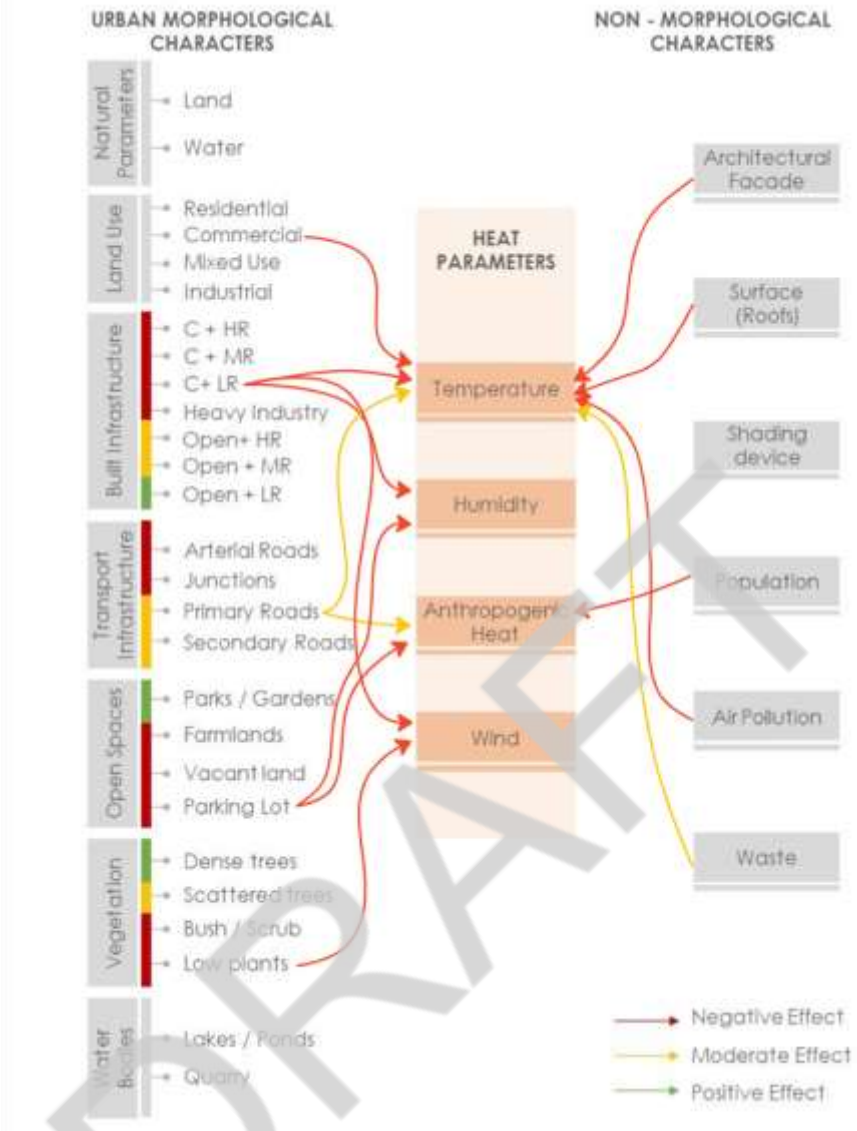
- This area has commercial shops and a few residential buildings.
- Disorderly parking on the streets.
- No vegetation
- Secondary road connecting to the Akurdi-Chikhli road.



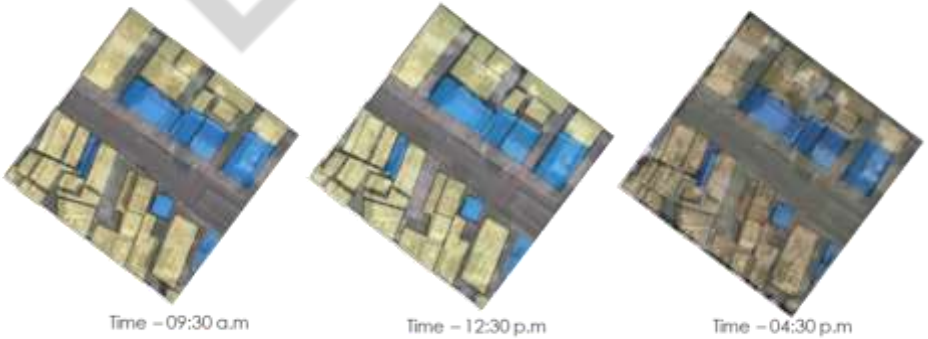


Color Codes for Experimental Heat Index for India		
Morning (8 A.m - 9 A.m)		Heat Index : 34.8°C
Afternoon (12 P.m - 1 P.m)		Heat Index : 39.5°C
Evening (4 P.m - 5 P.m)		Heat Index :40°C
Night (7 P.m - 8 P.m)		Heat Index : 31.5°C





SHADOW PATTERN ANALYSIS :



Inferences:

i. Mixed Land Use and Commercial Dominance: The area exhibits a mixed land use, with the majority of space occupied by commercial shops and a few compact low-rise residences. This combination contributes to high surface temperatures, as the zone is utilized throughout the day by users of all age groups, resulting in increased anthropogenic heat emissions.

ii. Connectivity to Arterial Road: The presence of a secondary road, approximately 9-12 meters in width, provides connectivity to the arterial road named Akurdi-Chikhli. This connectivity facilitates a considerable number of vehicles passing through the zone, contributing to elevated surface temperatures and anthropogenic heat generation.

iii. Chaotic Parking Situation: The absence of designated parking spaces has resulted in chaotic parking of vehicles on the roads within the area. This haphazard parking arrangement further exacerbates heat levels by reducing airflow and increasing heat retention on the road surface.

iv. Lack of Vegetation: Minimal to no vegetation in the area contributes to the rise in surface temperature and humidity. The absence of greenery reduces shading and evaporative cooling effects, allowing heat to accumulate and persist within the built environment.

v. Analysis of Bioclimatic Chart: Examination of the bioclimatic chart reveals that afternoon temperatures consistently surpass other measured temperatures. This temperature disparity results in conditions falling within the discomfort zone, indicating potential health risks associated with prolonged exposure to elevated temperatures.

vi. Exceedance of Heat Stress Threshold: The observed temperature increase exceeds the heat stress threshold, indicating conditions that may pose health risks and discomfort to individuals exposed to prolonged periods of elevated temperatures.

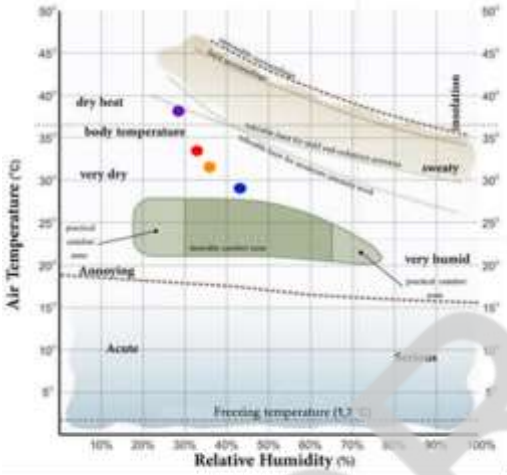
RAJAMATA JIJAU NAGAR (Ward 2)

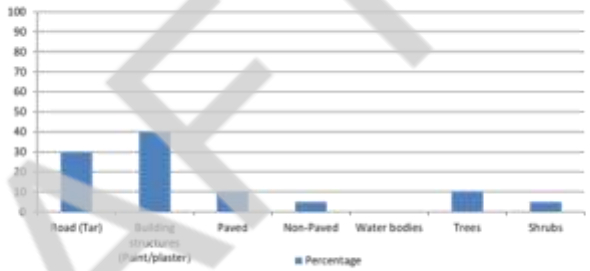
The residential is situated on the north of the telco company. There are no seats accessible along the walkway either.

Land use Typologies : residential use

Average road width : 15 - 18m

Average building height : 15-20m



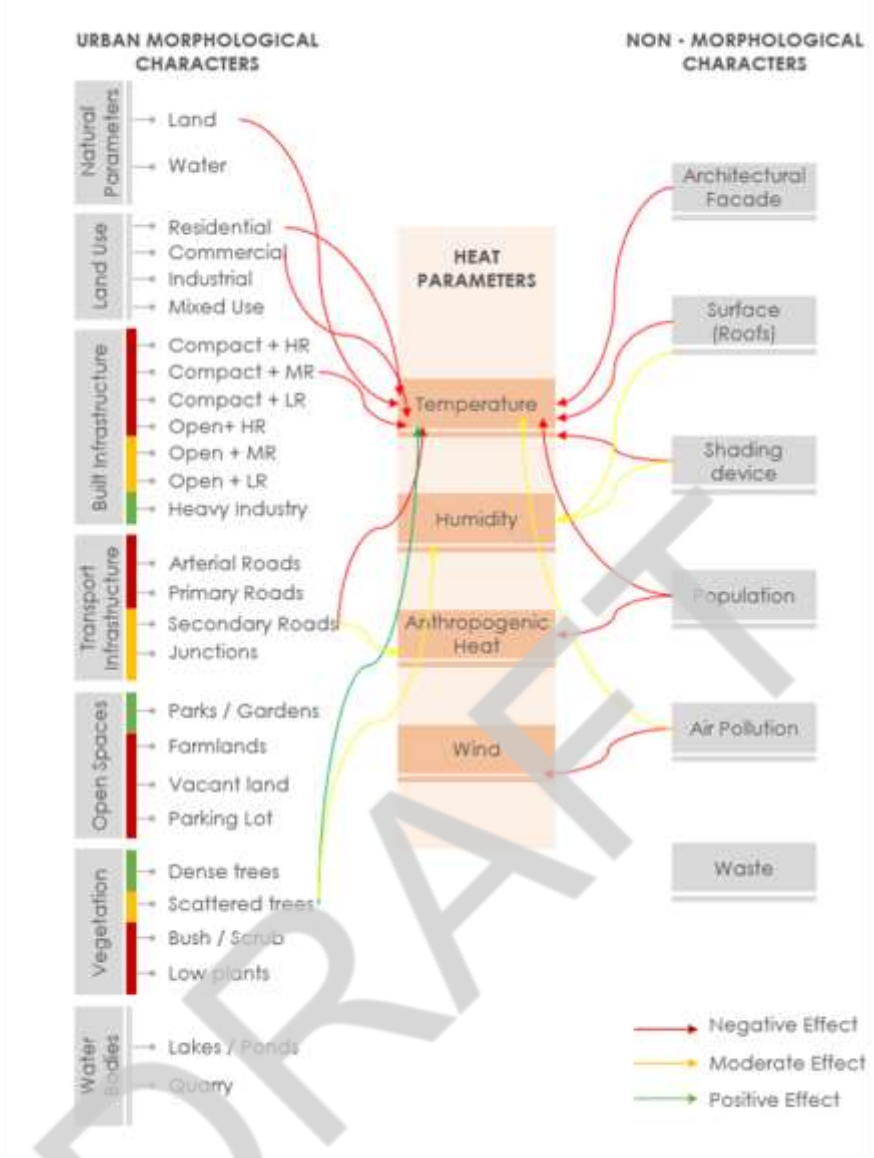


Comfort range:
Temp: 20-27°C Humidity: 30% -65 Wind speed:1.5-2.4 m/s

- Morning(8am – 9am), Temp:30.76 °C, Humidity:44.1 %
- Afternoon(12pm-1pm), Temp: 38.14 °C, Humidity: 27.14 %
- Evening(4pm-5pm), Temp: 34.1 °C, Humidity: 30.86 %
- Night(7pm- 8pm), Temp: 32.12 °C, Humidity: 37.74 %

Color Codes for Experimental Heat Index for India	
Morning (8 A.m - 9 A.m)	Heat Index : 34.8°C
Afternoon (12 P.m - 1 P.m)	Heat Index : 39.5°C
Evening (4 P.m - 5 P.m)	Heat Index :40°C
Night (7 P.m - 8 P.m)	Heat Index : 31.5°C

Green: Below 35°C
Yellow: Range of 36-45°C
Orange: Range of 46-55°C
Red: Above 55°C



SHADOW PATTERN ANALYSIS:-

Timing 9.30 am

Timing12.30 pm

Timing -4.30 pm

Inferences:

i. Residential Dominance: The largest portion of the area is covered by residential buildings, leading to mutual shading that contributes to relatively cooler temperatures within the vicinity.

ii. Shaded Pathways: Pathways within the residential area are shaded by trees, providing relief from direct sunlight and reducing surface temperatures.

iii. Central Road Greenery: The centre of the road features small shrubs that provide shading, effectively lowering the ambient temperature and enhancing pedestrian comfort.

iv. Moshi High Street Road Exposure: Moshi high street road is exposed to solar radiation for most of the day. The presence of dark-coloured asphalt exacerbates heat absorption and radiation, resulting in elevated temperatures.

v. Temperature Patterns: Afternoons and evenings exhibit warmer temperatures attributed to the prolonged exposure of the road and vehicles to solar radiation. This phenomenon contributes to increased surface temperatures and ambient heat levels during these periods.

vi. Road Surface Temperature:

Morning: Road surface temperature is consistent with air temperature.
Afternoon: Hottest temperatures occur between noon and 5 PM, with dark-coloured asphalt retaining and radiating heat.
Night: Stored heat from the road surface is released, leading to an increase in ambient temperature.

vii. Analysis of Bioclimatic Chart & Heat Index: The analysis indicates that afternoon and evening temperatures are significantly higher compared to morning and night. This temperature disparity is attributed to the heating of the tar road surface during the afternoon, with additional heat contributed by vehicular activity.

In conclusion, this section explores the practical findings resulting from the thorough assessment of heat-related risks, with a specific emphasis on delineating vulnerable zones within the PCMC area. The detailed mapping and study of selected vulnerable areas provide invaluable insights into the complex interplay of factors that contribute to heightened susceptibility to heat-related risks. By pinpointing areas with specific vulnerabilities, policymakers and stakeholders can prioritize interventions and allocate resources where they are most urgently needed.

It is noteworthy that the selected areas are representative of typical areas in PCMC, such as junctions, slums, highways, etc. Therefore, the suggested interventions aimed at addressing vulnerabilities in these areas can serve as models for similar locations across the region. By implementing targeted interventions in these representative areas, the Heat Action Plan can

effectively address heat-related risks on a broader scale, ensuring that all areas within the PCMC region benefit from enhanced resilience measures.

By addressing vulnerabilities at the local level and implementing targeted interventions, the Heat Action Plan can ensure that all community members are adequately protected during heatwave events, regardless of their socio-economic status or geographic location. In essence, this chapter lays the groundwork for a more equitable and resilient approach to heat risk management within the PCMC region, ultimately contributing to the well-being and safety of all residents.

Chapter VII:

MUNICIPAL COORDINATION AND RESPONSE PLAN

This chapter outlines a strategic framework for coordinated actions and effective responses to heatwave events within the Pimpri-Chinchwad Municipal Corporation (PCMC) region. This chapter focuses on the collaborative efforts among various municipal departments, stakeholders, and community organizations to mitigate heat-related risks and ensure a well-coordinated response during emergencies.

7.1 Plan Implementation Committee at Municipal Level

The Plan Implementation Committee (PIC) within the PCMC is a collaborative effort involving various departments and stakeholders. It includes representatives from disaster management, health, education, environmental engineering, local governance bodies, and community organizations. This committee is responsible for coordinating and implementing strategies to address heatwave challenges effectively.

The questionnaire conducted with PCMC departments has provided valuable insights into their roles, responsibilities, and capabilities in heatwave preparedness and response. These responses form the foundation for collaborative planning, resource allocation, and decision-making within the PIC framework. The PIC ensures that all departments work together seamlessly to enhance the city's resilience to heatwaves. The questionnaire conducted with PCMC departments and their responses are attached in the annexure 2.

Based on the responses received from various departments of the PCMC, several key inferences and takeaways can be drawn:

Inter-Departmental Collaboration: There is a strong emphasis on inter-departmental coordination and collaboration, especially during heatwave events and other disasters. Mechanisms such as regular meetings, data sharing, and joint decision-making processes are in place to ensure effective response and resource mobilization.

Community Engagement: Departments are actively engaging with local communities, NGOs, and stakeholders to raise awareness about heatwave preparedness, provide training programs, and implement outreach initiatives. Efforts are being made to involve citizens in decision-making processes and to empower them with knowledge and resources for heat-related risks.

Capacity Building and Training: Several departments are conducting capacity-building programs, training sessions, and awareness campaigns to enhance community resilience, emergency response capabilities, and public health preparedness during heatwaves. Specialized training for healthcare professionals, school administrators, and outdoor workers is being emphasized.

Infrastructure and Resource Allocation: Departments are prioritizing infrastructure development, resource allocation, and public services to address heatwave impacts, such as uninterrupted water supply, provision of medical facilities, maintenance of drainage systems, and deployment of emergency services like fire brigade and ambulance support.

Technology Integration: Efforts are being made to leverage technology, such as GIS, remote sensing, and digital platforms, for heatwave monitoring, early warning systems, data analysis, and decision-making. However, there are opportunities for further integration of smart technologies and innovative tools to optimize energy distribution, improve forecasting accuracy, and enhance public access to real-time information.

Policy and Planning: While there are existing policies and regulations in place, such as building codes, environmental standards, and disaster management plans, there is a need for continuous evaluation, adaptation, and integration of heatwave resilience measures into broader public health planning, urban development strategies, and climate change adaptation initiatives.

Public Awareness and Communication: Departments are actively communicating heatwave advisories, guidelines, and precautionary measures to the public through various channels such as newspapers, digital boards, campaigns, and mobile applications. Public engagement and participation in heatwave preparedness initiatives are being encouraged.

In summary, the responses highlight a comprehensive approach by the PCMC departments to address heatwave challenges through a combination of infrastructure development, community engagement, capacity building, technology integration, policy planning, and public awareness initiatives. Continued collaboration, data-driven decision-making, and adaptive strategies will be crucial for enhancing heatwave resilience and protecting public health in the PCMC region.

7.2 Heat Early Warning System

The India Meteorological Department (IMD) employs specific criteria to determine and declare a heatwave in different regions across India. These criteria are essential for accurately identifying and alerting authorities and the public about impending heatwave conditions. The factors considered by IMD include:

Temperature Thresholds:

a. Plains: A heatwave is declared in the plains when the maximum temperature reaches at least 40 degrees Celsius.

b. Coast: Along the coast, a heatwave is declared when the maximum temperature reaches at least 37 degrees Celsius.

c. Hilly Regions: In hilly regions, a heatwave is declared when the maximum temperature reaches at least 30 degrees Celsius.

Temperature Deviations from Normal:

- Based on Departure from Normal:

Heat Wave/Severe HW: Departure 4.5°C to 6.4°C / >6.4°C IF

- Based on Actual Maximum Temperature:

  Heat Wave/Severe HW: Maximum Temperature ≥ 45°C / ≥47°C

Coastal stations: Tmax dep ≥4.5°C & actual Tmax is ≥ 37°C.

Additionally, a heatwave is defined as an event where the maximum temperature of a station reaches at least 40°C or more for Plains regions and at least 30°C or more for Hilly regions. The criteria based on departures from normal and actual maximum temperatures are as follows:

Heat Wave: Departure from normal is 4.5°C to 6.4°C; actual maximum temperature ≥ 45°C.

Severe Heat Wave: Departure from normal is >6.4°C; actual maximum temperature ≥ 47°C.

Warm nights are also considered, defined when the minimum temperature remains 40°C or more. The criteria for warm nights based on departures from normal are:

Warm Night: Minimum Temperature Departure is 4.5°C to 6.4°C.

Severe Heat Wave: Minimum Temperature Departure is >6.4°C.

The Indian Meteorological Department (IMD) issues the following colour codes for heatwave warnings, providing a visual guide to the severity levels of heatwave conditions.

Table 4: IMD: Heat wave warning colour codes

Colour Code	Alert	Warning	Impact	Suggested Actions
Green (No action)	Normal Day	Nil	Comfortable temperatures	No cautionary
Yellow Alert (Be updated)	Heat Alert	Heat wave conditions at district level, likely to persist for 2 days	Heat is tolerable for general public but moderate health concern for vulnerable people e.g. infants, elderly, people with chronic diseases.	Avoid heat exposure
Orange Alert (Be prepared)	Severe Heat Alert for the day	i. Severe heat wave conditions likely to persist for 2 days. ii. ith varied severity, heat wave is likely to persist for 4 days or more.	Increased likelihood of heat illness symptoms in people who are either exposed to sun for a prolonged period or doing heavy work. High health concern for vulnerable people e.g. infants, elderly, people with chronic diseases.	Avoid heat exposure– keep cool. Avoid dehydration
Red Alert (Take Action)	Extreme Heat Alert for the day	I.Severe heat wave likely to persist for more than 2 days. I.Total number of heat/ severe heat wave days likely to exceed 6 days.	Very high likelihood of developing heat illness and heat stroke in all ages.	Extreme care needed for vulnerable people.

Source: India Meteorological Department.

Nodal Officer and Interagency Coordination

PCMC appoints a PCMC Nodal officer to head the coordination of stakeholders and ensure implementation of the Heat Action Plan. The appointed nodal officer is responsible for coordinating and communicating actions ahead of, and during, extreme heat events, and provides support staff for HAP functions through the Nodal Office as necessary.

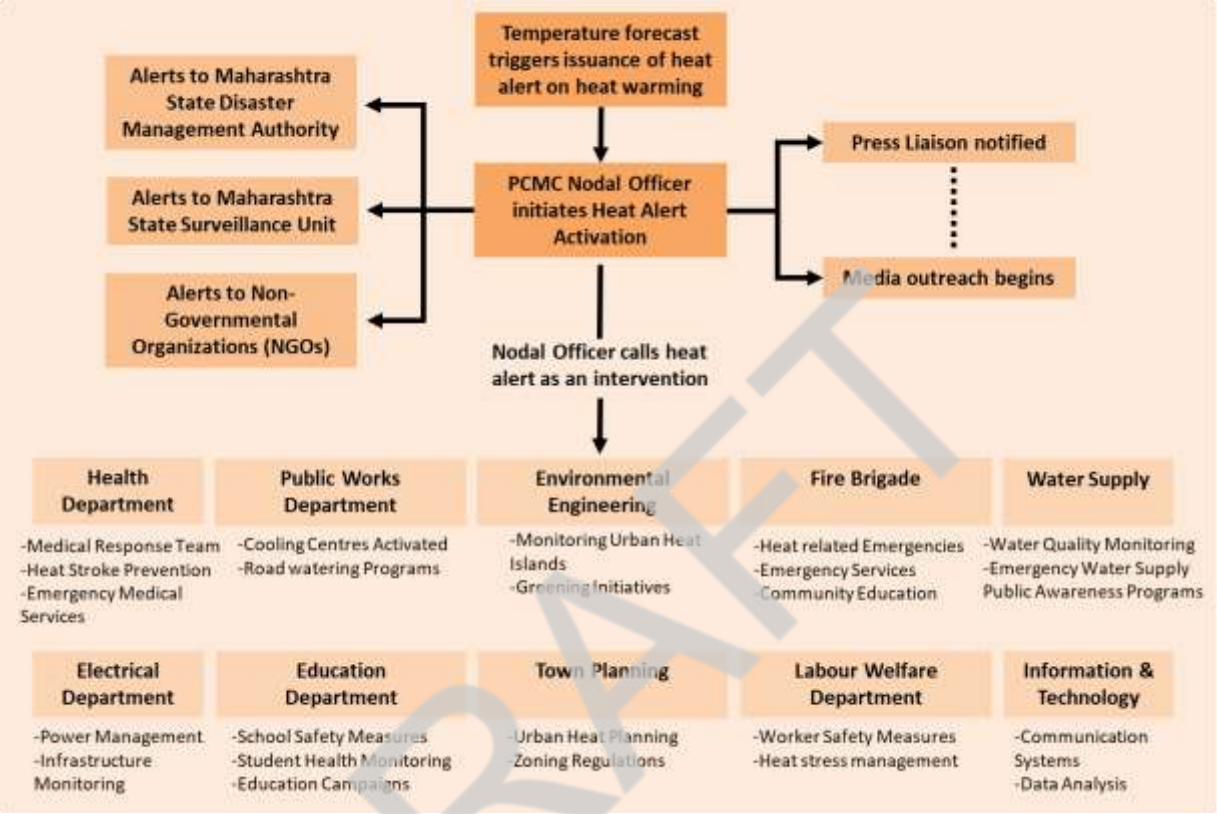


Figure 23: Communication plan of Nodal Officer with various Department Officials

7.3 Strategies and Activities (Pre-Heat Season)

A: Warning System and Inter-Agency Coordination

- Establish an Early Warning System and foster inter-agency coordination.
- Identify key agency leaders, tourist boards, market associations, worker associations, etc.
- Facilitate internal communication among community groups, local agencies, district officials, and the urban local body.
- Purchase and distribute reusable soft plastic ice packs in each ward, urban health centres, and ambulances.
- Publish and disseminate Information, Education, and Communication (IEC) materials suited to the local context.

- Organize trainings for healthcare workers, teachers, community members, and school children.
- Conduct awareness/education sessions, distribute pamphlets, and display temperatures in high-risk areas.
- Identify NGOs/CSOs and community leaders for partnership and mobilization.
- Conduct capacity building initiatives for immediate response and long-term adaptation.

B: Capacity Building through Training Programmes for Health Care Professionals

- Organize training programs focusing on heat-related illnesses for healthcare professionals.
- Conduct workshops to enhance skills in diagnosing and treating heat-related ailments.
- Educate healthcare workers on the dos and don'ts during extreme heat conditions.
- Provide training on early recognition of heat-related illnesses and prompt treatment measures.
- C - Sensitization of Public/Communication, Outreach, and Awareness Messages
- Develop and disseminate awareness messages through various media channels.
- Conduct outreach programs to educate the public about heatwave risks and preventive measures.
- Utilize local media, community influencers, and leaders to spread awareness.
- Distribute informative materials in local languages for better understanding.
- Organize community engagement activities to foster public participation in heatwave mitigation.

D: Collaborate with NGOs and Civil Societies

- Partner with NGOs and civil society organizations for community mobilization.
- Collaborate on public awareness campaigns, capacity building, and community resilience programs.
- Engage NGOs in monitoring and evaluation of heatwave preparedness and response activities.
- Leverage civil society networks for effective communication and outreach to vulnerable populations.

7.4 Strategies and Activities (Heat Season)

A: Warning System and Inter-Agency Coordination

- Maintain and enhance the Early Warning System for timely heatwave alerts.
- Strengthen coordination among agencies, emergency services, and community stakeholders.
- Conduct periodic reviews and updates of the heatwave warning system based on feedback and data analysis.
- Establish clear protocols for communication and response during heatwave events.

B: Surveillance, Monitoring & Evaluation, and Reforestation and Increase of Shade Cover

- Enhance surveillance and monitoring systems for heat-related illnesses and impacts.
- Evaluate the effectiveness of heatwave response measures through regular assessments.
- Collaborate with environmental agencies for reforestation initiatives and increasing shade cover.
- Implement tree plantation campaigns in high-risk areas to mitigate heat effects and improve air quality.

C: Collaborate with NGOs and Civil Societies

- Continue collaboration with NGOs and civil society groups for ongoing heatwave response.
- Engage NGOs in heatwave monitoring, evaluation, and community support initiatives.
- Support civil society efforts in advocating for heat-resilient infrastructure and urban planning.
- Foster partnerships for sustainable heatwave adaptation and mitigation strategies.

7.5 Heat Action Plan (HAP) Execution Checklist

The primary objective of this Heat Action Plan (HAP) Execution Checklist is to ensure a coordinated and effective response to heat-related emergencies within the municipality. This checklist is designed to provide a clear framework for monitoring and executing various tasks associated with the HAP, ensuring that all departments are aligned and proactive in mitigating the impacts of extreme heat events.

Scope:

This checklist covers tasks and actions for each relevant department involved in the HAP. It outlines specific tasks, responsible roles, and key actions required to ensure comprehensive implementation and effective response to heat emergencies. The checklist aims to provide a systematic approach to managing heat risks, protecting public health, and enhancing the municipality's resilience to extreme heat conditions.

Role and responsibilities of Heat Action Plan Committee for Pimpri Chinchwad Municipal Corporation (PCMC):

Nodal Officer: Disaster Management Department / Chief Disaster Management Officer

Role:

- To lead and coordinate the Heat Action Plan (HAP) for PCMC.
- To act as the primary point of contact for all heat-related activities and information dissemination.
- To ensure collaboration among various departments and stakeholders for effective implementation of the HAP.
- To monitor and evaluate the effectiveness of the HAP and make necessary adjustments.
- Develop and implement emergency response plans specific to heatwaves.
- Conduct training and drills for effective disaster management during heatwaves.

Committee Members and Their Roles

1. **Office of Commissioner**
    - Provide overall guidance and support to ensure the HAP aligns with municipal policies and objectives. Facilitate inter-departmental coordination.
2. **General Administration**
    - Assist in administrative coordination and ensure that all necessary resources are allocated efficiently. Facilitate communication and documentation.

3. **Civil Department (Development and Buildings)**
    - **Development:** Ensure that infrastructure projects incorporate heat-mitigating features such as shaded pathways, green cover, and heat-reflective materials.
    - **Buildings:** Promote and enforce building codes that include cool roofs and energy-efficient designs in coordination with environment department.
4. **Building Permission and Unauthorised Construction Control Department**
    - Monitor and control unauthorized constructions that may exacerbate heat effects.
    - Ensure that new buildings comply with guidelines for heat mitigation.
5. **Medical Department**
    - Coordinate with healthcare facilities to ensure preparedness for heat-related illnesses.
    - Develop and prepare a Standard Operating Procedure (SOP) as part of the Heat Action Plan committee.
    - Training of Medical Staff on Heat related illness from experts.
    - Raise public awareness about heat-related health risks and preventive measures.
    - Provide data on heat-related health incidents for monitoring and evaluation.
6. **Water Supply Department**
    - Ensure uninterrupted and adequate water supply during heatwaves.
    - Promote water conservation and efficient use practices among residents.
7. **Health Department**
    - Maintain cleanliness and sanitation to prevent outbreaks of diseases during heatwaves.
    - Ensure effective waste management.
8. **Drainage Department**
    - Ensure the drainage system is efficient to prevent water stagnation, which can contribute to heat-related issues.
9. **Electrical Department**
    - Maintain and enhance the reliability of electrical supply, especially during peak heat periods.
    - Promote the use of energy-efficient appliances and support initiatives for cooling centers.

10. **Town Planning Department**
    - Incorporate heat-mitigation strategies in urban planning.
    - Develop green spaces and ensure proper zoning regulations to reduce urban heat islands.
11. **Education Department**
    - Educate students and staff about heatwave risks and safety measures.
    - Implement heat safety protocols in schools.
12. **Department of Information and Technology**
    - Develop and maintain a digital platform for heatwave alerts and information dissemination.
    - Support data collection and analysis for monitoring the effectiveness of the HAP.
13. **Citizen's Facilitation Center**
    - Serve as a point of contact for citizens to report heat-related issues and receive guidance on heatwave preparedness.
14. **Social Development Department**
    - Implement welfare schemes to support vulnerable populations during heatwaves, including provision of shelters and resources.
15. **Garden Department**
    - Develop and maintain green spaces to reduce the urban heat island effect.
    - Promote tree plantation and maintenance.
16. **Fire Brigade**
    - Provide emergency response services for heat-related incidents and ensure public safety during heatwaves.
17. **Public Relations Office**
    - Develop and Disseminate Public Awareness Campaigns to inform the public about heat-related risks and protective measures.
    - Coordinate with Media and Stakeholders to ensure timely and accurate dissemination of heat-related information.
    - Ensure heat alerts and warnings are promptly communicated to the public, and provide consistent updates on weather conditions and recommended actions.
    - Evaluate Communication Efforts and Update Strategies.

Responsibilities of the committee:

- **Coordination and Communication:** Regular meetings and updates among committee members to ensure smooth implementation and address any challenges promptly.
- **Public Awareness Campaigns:** Joint efforts to educate the public about heatwave risks and safety measures.
- **Resource Allocation:** Ensure necessary resources such as water, medical supplies, and cooling centers are available and accessible.
- **Monitoring and Evaluation:** Continuously monitor the effectiveness of the HAP and make necessary adjustments based on data and feedback.
- **Emergency Response:** Ensure a quick and efficient response to heat-related emergencies, including medical assistance and public safety measures.

The committee will work together to ensure a comprehensive and effective response to heatwaves, prioritizing the health and safety of the residents of Pimpri Chinchwad.

Based on the above organizational structure, checklist for all the departments is created, to ensure the proper review and execution of the Heat Action Plan (HAP). The tasks are mentioned as per Pre-Heat season (Dec-Feb), Heat Season (March-May) and Post heat season (June onwards).

Actions & Tasks of Nodal Officer:

Disaster Management Department / Chief Disaster Management Officer

Task Description	Completion Status	Comment/Notes
Pre-Heat Season		
- Verify temperature forecasts and alerts. - Initiate the heat alert activation. - Establish a communication plan among various departments and agencies. - Ensure regular updates and coordination meetings - Notify the Press Liaison. - Begin media outreach.		
Heat Season		
- Coordinate with all departments for immediate actions. - Monitor the implementation of HAP measures. - Ensure regular updates to the public and stakeholders. - Ensure regular updates and coordination meetings		
Post-Heat Season		
- Compile data on heat-related incidents. - Review the effectiveness of implemented measures. - Comprehensive report on the heat season's impact and responses. - Report on findings and recommendations. - Conduct all department meeting to report findings. - Identify areas for improvement and update the Heat Action Plan accordingly.		

Actions and tasks of Committee members:

Medical Department

Task	Description	Completion Status	Comment/Notes
Pre-Heat Season			
Establish Medical Response Teams	Form and deploy teams to respond to heat-related medical emergencies.		
Prepare Heat Health Guidelines	Develop and distribute guidelines for heat health safety.		
Enhance medical	Ensure comprehensive readiness of		

resource readiness	medical resources		
Conduct Training Sessions	Train medical staff on heat-related health issues.		
Public Awareness Campaigns	Launch campaigns to educate the public on heat safety.		
Heat Season			
Deploy Medical Response Teams	Activate response teams for heat emergencies.		
Implement Heat Stroke Prevention Measures	Distribute resources and guidelines to prevent heat strokes.		
Activate Emergency Medical Services	Ensure EMS is operational and responsive.		
Monitor Health Impacts	Track and report heat-related health incidents.		
Post-Heat Season			
Review and Analyze Health Data	Analyze data collected during the heat season.		
Evaluate Response Effectiveness	Assess the effectiveness of medical responses and strategies.		
Update Heat Health Guidelines	Revise guidelines based on lessons learned.		
Conduct Public Feedback Sessions	Gather feedback from the public on health measures.		

Civil Department

Task	Description	Completion Status	Comment/Notes
Pre-Heat Season			
Identify Water Supply Points	Identify and prepare water supply points for public use.		
Inspect Civil Infrastructure	Ensure civil infrastructure is prepared for heat conditions.		
Plan Street Cleaning Programs	Develop schedules and routes for street cleaning and debris removal.		
Inform Public	Launch campaigns to inform the public about available water supply points.		
Heat Season			
Activate Water Supply Points	Ensure water supply points are operational and accessible.		
Monitor Infrastructure	Check for any heat-induced damage to civil infrastructure.		
Provide Public Information	Update the public on available water supply points.		
Post-Heat Season			
Review Water Supply Points	Assess the effectiveness of water supply points.		
Conduct Infrastructure	Inspect civil infrastructure for any		

Inspections	residual heat damage.		
Update Civil Works Plans	Revise plans based on lessons learned during the heat season.		

Environmental Engineering Department

Task	Description	Completion Status	Comment/Notes
Pre-Heat Season			
Weather monitoring at local level	Ensure weather monitoring systems are set up.		
Conduct Urban Heat Island Studies	Identify and map urban heat islands (micro level studies).		
Plan Greening Initiatives	Develop plans for increasing green spaces.		
Prepare Air Quality Monitoring Systems	Ensure air quality monitoring systems are ready.		
Launch Sustainable Practices Campaign	Educate the public and businesses about sustainable practices.		
Heat Season			
Weather monitoring at local level	Daily weather monitoring to understand local heat conditions and dissemination of heat alerts		
Monitor Urban Heat Islands	Conduct continuous monitoring of urban heat areas.		
Implement Greening Initiatives	Execute greening projects to mitigate heat.		
Monitor Air Quality	Ensure continuous air quality monitoring.		
Promote Sustainable Practices	Encourage sustainable practices in urban planning.		
Post-Heat Season			
Review Monitoring Data	Analyze data collected from urban heat and air quality monitoring.		
Evaluate Greening Initiatives	Assess the effectiveness of greening projects.		
Update Sustainable Practices Guidelines	Revise guidelines based on lessons learned.		
Public Feedback Sessions	Gather feedback on environmental measures.		

Fire Brigade Department

Task	Description	Completion Status	Comment/Notes
Pre-Heat Season			
Prepare Heat Emergency Plans	Develop plans for heat-related emergencies.		

Train Fire Brigade Staff	Conduct training on heat-related emergency response.		
Community Education Programs	Launch programs to educate the community on heat safety.		
Prepare Emergency Services	Ensure emergency services are heat-ready.		
Heat Season			
Respond to Heat Emergencies	Actively respond to heat-related emergencies.		
Provide Emergency Services	Ensure continuous availability of emergency services.		
Educate the Community	Conduct ongoing community education about heat safety.		
Monitor Emergency Calls	Track and report heat-related emergency calls.		
Post-Heat Season			
Review Emergency Response	Assess the effectiveness of emergency responses.		
Analyze Emergency Call Data	Analyze data collected from emergency calls.		
Update Emergency Plans	Revise emergency plans based on lessons learned.		
Conduct Public Feedback Sessions	Gather feedback on fire brigade measures.		
Coordinate with other departments	Share the analysis Report of fire incidents to respective departments for their further action. e.g. building department		

Water Supply Department

Task	Description	Completion Status	Comment/Notes
Pre-Heat Season			
Prepare Water Quality Monitoring Systems	Ensure systems are ready for continuous monitoring.		
Develop Emergency Water Supply Plans	Plan for emergency water supply during heatwaves.		
Launch Public Awareness Programs	Educate the public on water safety and availability.		
Coordinate with Health Department	Develop coordinated plans for water-related health issues.		
Heat Season			
Monitor Water Quality	Ensure monitoring of water quality.		
Manage Emergency Water Supplies	Ensure availability and distribution of emergency water supplies.		
Public Awareness Updates	Provide regular updates on water safety and availability.		
Coordinate with Health	Address water-related health issues		

Department	in collaboration.		
Post-Heat Season			
Review Water Quality Data	Analyze data collected during the heat season.		
Evaluate Emergency Water Plans	Assess the effectiveness of emergency water supply plans.		
Update Public Awareness Programs	Revise programs based on lessons learned.		
Conduct Public Feedback Sessions	Gather feedback on water supply measures.		

Electrical Department

Task	Description	Completion Status	Comment/Notes
Pre-Heat Season			
Inspect Power Infrastructure	Ensure infrastructure is ready for high demand.		
Develop Power Management Plans	Prepare for load management during peak heat.		
Conduct Public Awareness Campaigns	Inform public about energy conservation during heatwaves.		
Coordinate with Other Departments	Plan for power supply in coordination with other services.		
Heat Season			
Monitor Power Demand	Track and manage power demand in real-time.		
Implement Power Management Plans	Execute load management and emergency plans.		
Infrastructure Monitoring	Continuously monitor power infrastructure for issues.		
Public Awareness Updates	Provide regular updates on energy conservation.		
Post-Heat Season			
Review Power Demand Data	Analyze data collected during the heat season.		
Evaluate Power Management Plans	Assess effectiveness of load management and emergency plans.		
Update Public Awareness Programs	Revise programs based on lessons learned.		
Conduct Public Feedback Sessions	Gather feedback on power supply measures.		

Education Department

Task	Description	Completion Status	Comment/Notes
Pre-Heat Season			
Develop School Safety Measures	Prepare safety plans for schools during heatwaves.		
Launch Student Health Monitoring Programs	Initiate programs to monitor student health.		
Plan Education Campaigns	Create campaigns to educate students and parents on heat safety.		
Conduct Staff Training Sessions	Train school staff on heat safety measures.		
Heat Season			
Implement School Safety Measures	Execute heat safety plans in schools.		
Monitor Student Health	Continuously monitor and report on student health.		
Conduct Education Campaigns	Run ongoing campaigns on heat safety.		
Update Staff on Safety Measures	Provide regular updates and training to school staff.		
Post-Heat Season			
Review Safety Measures	Assess the effectiveness of school safety plans.		
Analyze Student Health Data	Review data collected from student health monitoring.		
Update Education Campaigns	Revise campaigns based on lessons learned.		
Conduct Feedback Sessions	Gather feedback from students, parents, and staff.		

Town Planning Department

Task	Description	Completion Status	Comment/Notes
Pre-Heat Season			
Conduct Urban Heat Mapping	Identify and map urban heat zones.		
Develop Zoning Regulations	Plan zoning regulations to mitigate heat.		
Plan Heat Resilient Urban Design	Design urban spaces to withstand heatwaves.		
Coordinate with Environmental Dept.	Collaborate on greening initiatives.		
Heat Season			
Monitor Urban Heat	Continuously monitor heat zones.		

Zones			
Implement Zoning Regulations	Ensure compliance with zoning regulations.		
Oversee Urban Design Implementation	Monitor implementation of heat-resilient designs.		
Collaborate on Greening Projects	Work with Environmental Dept. on projects.		
Post-Heat Season			
Review Urban Heat Data	Analyze data collected from heat zones.		
Evaluate Zoning Regulations	Assess effectiveness of zoning regulations.		
Update Urban Design Plans	Revise plans based on lessons learned.		
Conduct Public Feedback Sessions	Gather feedback on urban planning measures.		

Labour Welfare Department

Task	Description	Completion Status	Comment/Notes
Pre-Heat Season			
Develop Worker Safety Measures	Prepare safety plans for workers during heatwaves.		
Initiate Heat Stress Management Programs	Start programs to manage heat stress among workers.		
Launch Education Campaigns	Educate workers on heat safety.		
Train Supervisors	Train supervisors on monitoring and managing heat stress.		
Heat Season			
Implement Worker Safety Measures	Execute safety plans for workers. Ensure implementation of work hour adjustments for outdoor labourers.		
Monitor Heat Stress Management	Ensure continuous management of heat stress.		
Conduct Education Campaigns	Run ongoing campaigns on heat safety.		
Update Supervisors on Safety Measures	Provide regular updates and training to supervisors.		
Post-Heat Season			
Review Safety Measures	Assess the effectiveness of worker safety plans.		
Analyze Heat Stress Data	Review data collected from heat stress management.		
Update Education Campaigns	Revise campaigns based on lessons learned.		

Conduct Feedback Sessions	Gather feedback from workers and supervisors.		

Information & Technology Department

Task	Description	Completion Status	Comment/Notes
Pre-Heat Season			
Prepare Communication Systems	Ensure systems are ready for heat-related alerts.		
Develop Data Analysis Plans	Plan for continuous data collection and analysis.		
Launch Public Information Campaigns	Inform the public about heatwave preparedness.		
Coordinate with Other Departments	Plan for coordinated communication and data sharing.		
Heat Season			
Monitor Communication Systems	Ensure systems are operational and responsive.		
Implement Data Analysis Plans	Conduct continuous data collection and analysis.		
Public Information Updates	Provide regular updates and information to the public.		
Coordinate Communication Efforts	Work with other departments on communication.		
Post-Heat Season			
Review Communication Data	Analyze data collected during the heat season.		
Evaluate Communication Plans	Assess the effectiveness of communication strategies.		
Update Public Information Campaigns	Revise campaigns based on lessons learned.		
Conduct Feedback Sessions	Gather feedback on communication efforts.		

Committee Review Process

Monthly Review Meetings:

- Conduct monthly meetings before the heat season for preparedness of the heat season .
- Conduct bi-monthly meetings during the heat season to review progress.
- Discuss challenges faced and adjustments needed.
- Monitor ongoing activities and resource allocation.

End-of-Season Review:

- Hold a comprehensive review meeting at the end of the heat season.
- Analyze data on heat-related illnesses, fatalities, and infrastructure performance.
- Gather detailed feedback from all stakeholders, including the public.

Effectiveness Assessment:

- Compare pre-season goals with actual outcomes.
- Assess the performance of public awareness campaigns, infrastructure readiness, and emergency responses.
- Identify gaps and areas for improvement.

Reporting and Documentation:

- Prepare a detailed report summarizing the season's activities, challenges, and outcomes.
- Document best practices and lessons learned.
- Update the Heat Action Plan based on review findings and prepare for the next season.

Continuous Improvement:

- Develop action items for addressing identified gaps.
- Plan for training and capacity-building activities.
- Schedule periodic follow-ups (monthly meetings) to ensure implementation of improvements.

This comprehensive approach will ensure that the Heat Action Plan is effectively implemented, monitored, and improved, thereby enhancing the city's resilience to extreme heat events.

Chapter VIII:

MITIGATION AND ADAPTATION STRATEGIES

This chapter presents a comprehensive approach to address heat-related challenges and build resilience in the Pimpri-Chinchwad Municipal Corporation (PCMC) region. This chapter outlines a broad strategy framework that includes a range of policies, actions, and recommendations aimed at reducing heat risks, enhancing adaptive capacity, and promoting sustainable development.

8.1 Broad-Level Policy:

The following section outlines the broad-level policy framework aimed at addressing heatwave impacts and promoting resilience in the PCMC region. The policies presented here are structured to align with the overarching goals of mitigating heat-related risks, enhancing adaptive capacity, and fostering sustainable development within the community. The details of each policy are listed below in annexure 6.

A) GREEN NETWORK

Building a green network for PCMC will mitigate the impact of the heat island effect, enhance air quality, promote environmental sustainability, and build livable, resilient urban areas).

B) PUBLIC GREEN AFFABILITIES

Implementing green public Affability's like bus stops, public toilets, street furniture, pause points etc. and cooled transit stations that promote human thermal comfort through design/ addition–alteration/ retrofitting.

C) PUBLIC AWARENESS & COMMUNITY ENGAGEMENT

Building Public awareness programs in PCMC will help the population mitigate the impact of the heat on individual health during a heat wave

C) SMART GROWTH SYSTEMS

To implement comprehensive urban development strategies that prioritize resilience and sustainability, optimizing land use, infrastructure provision, and environmental impact assessments to mitigate the effects of extreme heat events while fostering equitable and thriving communities.

E) COOL SURFACES

Building cool surfaces for PCMC will mitigate the impact of the heat island effect, with the help of materials that reflect a large fraction of incoming solar radiation, reducing the absorbed solar radiation; reduce the heat flow into the building, and decrease cooling demand.

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F) BUILDING RESILIENCE

Building heat resilience as a policy in the heat action plan for PCMC will establish a comprehensive framework to integrate innovative architectural and structural solutions, enhance public awareness, and implement stringent building codes.

G) GREEN HORIZONS

Providing vegetation for open/ vacant lands or open grounds for PCMC will reduce the area exposed to direct heat hence resulting in lower temperatures.

Broad Policy 1:

A. DEVELOPING GREEN NETWORK

The table 5 below outlines a comprehensive set of policies and strategies for developing Green Network, including objectives, recommended actions, focus areas, proposal types, time frames, and stakeholders, aimed at addressing key challenges and achieving targeted outcomes within the specified context.

Building a green network for PCMC will mitigate the impact of the heat island effect, enhance air quality, promote environmental sustainability, and build liveable, resilient urban areas.

Table 5: Policy: Green Network

Measure	Action/ Recommendations	Objective focus	Proposal type	Time frame	Stakeholder / Department	Funding
GREEN NETWORK: **To mitigate the impacts of extreme heat events by reducing temperatures, improving air quality, enhancing biodiversity, promoting community resilience, and providing recreational and aesthetic benefits.**						
GREEN CORRIDOR 1. Developing green corridor for 18m – 30m wide roads connecting junctions or notable natural / Man-made spaces in PCMC.	L1)Developing street infrastructure by implementing footpath, cycling track, tree pits and parking bays along 18m – 30m wide road.	Mitigation & Adaptation	Policy	Long Term	Urban Planning Department, Road Department Civil Department, Project Department	PCMC
2. Developing green streets for width 9m – 18m.	L2) Implementing cool pavements for parking bays for road width of 18m – 30m.	Mitigation & Adaptation	Policy	Long Term	Road Department, Civil Department	PCMC
	S1) Planting layered vegetation, like trees, shrubs and groundcovers along the road width of 9m – 18m.	Mitigation & Adaptation	Project	Short Term	Garden Department	PCMC / CSR

Objectives	Action/ Recommendations	Objective focus	Proposal type	Time frame	Stakeholder / Department	Funding
GREEN NETWORK						
GREEN WAYS 1. Developing green ways for roads above 30m having medians minimum 3m wide to create a linear biodiversity corridor.	L1) Developing greenways on large medians with a minimum width of 5m, by planting various layers of vegetation which would also act as an absorbent for air and noise pollution.	Mitigation & Adaptation	Policy	Long Term	Garden Department	PCMC / CSR
	S1) Developing medians that are minimum of 3m width and above with specific planting that would be a habitat for various flora and fauna along roads having width above 30m.	Mitigation & Adaptation	Project	Short Term	Garden Department / Civil - Garden	PCMC

Sub Policy 1:

A1. GREEN CORRIDOR

Developing green corridor for 18m – 30m wide roads connecting junctions or notable natural / Man-made spaces in PCMC.

Developing green streets for width 9m – 18m.

Strategy:

Long term

L1) Developing Street infrastructure by implementing footpath, cycling track, tree pits and parking bays along 18m – 30m wide road.

L2) Implementing cool pavements for parking bays for road width of 18m – 30m.

Short term

S1) Planting layered vegetation, like trees, shrubs and groundcovers along the road width of 9m – 18m.

Figure 1 Typical Plan for 18-30m Wide Road

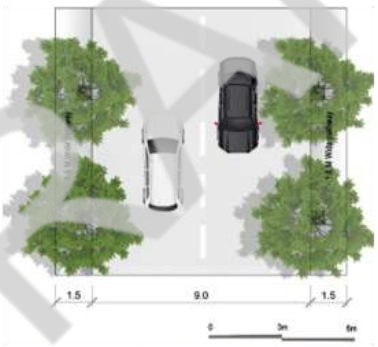

Figure 2 Typical Plan for below 9m Wide Road

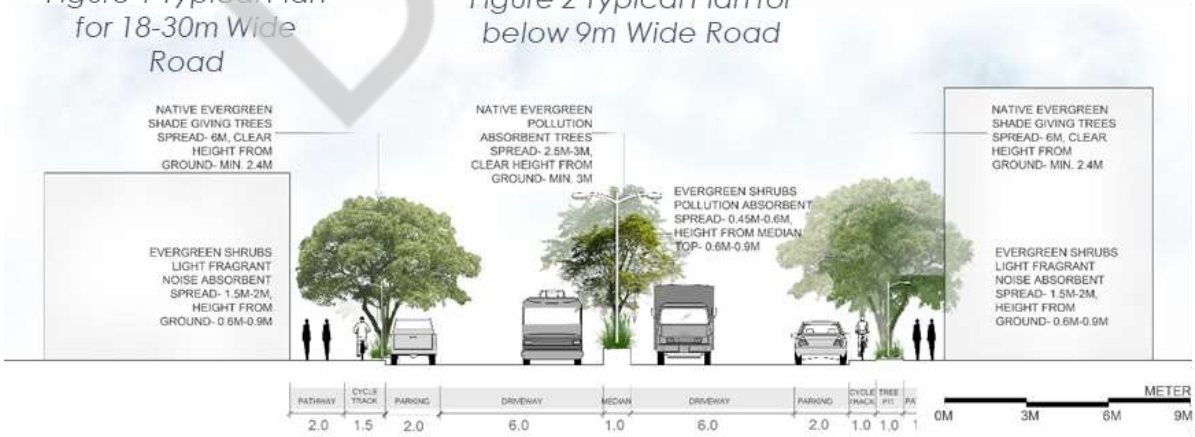

Figure 24: 3 Typical Sections for 18-30m wide road in PCMC

Sub Policy 2:

A2. GREEN WAYS

Developing green ways for roads above 30m having medians minimum 3m wide to create a linear biodiversity corridor.

Strategy:

Long term

L1) Developing greenways on large medians with a minimum width of 5m, by planting various layers of vegetation which would also act as an absorbent for air and noise pollution.

Short term

S1) Developing medians that are minimum of 3m width and above with specific planting that would be a habitat for various flora and fauna along roads having width above 30m.

Figure 25 Green Ways for Spine Road in PCMC

Broad Policy 2:

B) PUBLIC AFFABILITIES

Implementing modular designs of public amenities like bus stops, public toilets, street furniture, pause points etc. that promote human thermal comfort through design/ addition–alteration/ retrofitting. The table 6 below outlines a comprehensive set of policies and strategies, including objectives, recommended actions, focus areas, proposal types, time frames, and stakeholders, aimed at addressing key challenges and achieving targeted outcomes within the specified context.

Table 6: Green Affability Policy

Objectives	Action/ Recommendations	Objective focus	Proposal type	Time frame	Stakeholder / Deaprtment	Funding
PUBLIC AFFABILITIES **To promote human thermal comfort through design/ addition–alteration/ retrofitting**						
Public amenities for cooling: Implementing modular designs of public amenities like bus stops, public toilets, street furniture, pause points etc. that promote human thermal comfort	L1) Introducing modular toilet design on urban streetscapes that absorb less heat through use of heat reflective materials, light paints, cool roofs, green screens etc. thus enhancing human thermal comfort.	Mitigation & Adaptation	Policy	Long Term	1. Health 2. Garden	CSR funds / SBM / 15th FC
	L2) Initiating covered/semi-covered pause points like gazebos, seats with pergola, tensile structures etc. at regular intervals on streets, parks and other public places for vulnerable population (senior citizens, kids, patients, physically challenged people, road side workers) to rest in shade during extreme conditions like heat wave	Mitigation & Adaptation	Policy	Long Term	1. Civil 2. Garden	CSR funds
	L3) Introducing community cooling centers at regular intervals that absorb less heat through use of heat reflective materials, light paints, cool roofs, green screens etc. for vulnerable population (senior citizens, kids, patients, physically challenged people, road side workers, pedestrians)	Mitigation & Adaptation	Project	Long Term	1. Civil 2. Garden	CSR funds

Objectives	Action/ Recommendations	Objective focus	Proposal type	Time frame	Stakeholder / Department	Funding
PUBLIC AFFABILITIES						
	S1) Introducing drinking water facilities in form of drinking water fountain, public taps, water dispensers, on streets, parks and other public places for vulnerable population at regular interval of 200m to 300m. thus promoting public health (easy availability of drinking water may reduce the heat strokes).	Mitigation & Adaptation	Policy	Short Term	1. Civil 2. Health	CSR funds
	S2) Initiating street furniture with high albedo materials on streets, parks and other public places for vulnerable population (senior citizens, kids, patients, physically challenged people) to act as pause points.	Mitigation & Adaptation	Policy	Short Term	1. Civil - Garden	CSR funds

Sub Policy 1:

A1. MODULAR PUBLIC AMENITIES

Implementing modular designs of public amenities like bus stops, public toilets, street furniture, pause points etc. that promote human thermal comfort through design/ addition–alteration/ retrofitting.

Strategy:

Long term

L1) Introducing modular toilet design on urban streetscapes that absorb less heat through use of heat reflective materials, light paints, cool roofs, green screens etc. thus enhancing human thermal comfort.

L2) Initiating covered/semi-covered pause points like gazebos, seats with pergola, tensile structures etc. at regular intervals on streets, parks and other public places for vulnerable population (senior citizens, kids, patients, physically challenged people, road side workers) to rest in shade during extreme conditions like heat wave

L3) Introducing community cooling centers at regular intervals that absorb less heat through use of heat reflective materials, light paints, cool roofs, green screens etc. for vulnerable population (senior citizens, kids, patients, physically challenged people, road side workers, pedestrians)

Short term

S1) Introducing drinking water facilities in form of drinking water fountain, public taps, water dispensers, on streets, parks and other public places for vulnerable population at regular interval of 200m to 300m. thus promoting public health (easy availability of drinking water may reduce the heat strokes).

S2) Initiating Street furniture with high albedo materials on streets, parks and other public places for vulnerable population (senior citizens, kids, patients, physically challenged people) to act as pause points.

Figure 27: Section showing the scenarios of Rajamata Jijaunagar (Before)

Figure 26: Section showing the scenarios of Rajamata Jijaunagar (After)

Figure 28:
LEFT- Plan showing the scenarios of Rajamata Jijaunagar (before)
RIGHT- Plan showing the scenarios of Rajamata Jijaunagar (after)


Figure 29: LEFT- Modular Bus stop & RIGHT- Mist spray

Broad Policy 3:

C. PUBLIC AWARENESS AND COMMUNITY ENGAGEMENT:

Building Public awareness programs in PCMC will help the population mitigate the impact of the heat on individual health during a heat wave. The table 7 below outlines a comprehensive set of policies and strategies, including objectives, recommended actions, focus areas, proposal types, time frames, and stakeholders, aimed at addressing key challenges and achieving targeted outcomes within the specified context.

Table 7: Public Awareness and Community Engagement Policy

Objectives	Action/ Recommendations	Objective focus	Proposal type	Time frame	Stakeholder / Department	Funding
PUBLIC AWARENESS AND COMMUNITY ENGAGEMENT **To educate and involve residents, stakeholders, and organizations in understanding the risks of extreme heat events, fostering proactive participation in heat mitigation efforts, and promoting collective action towards building resilient communities that prioritize the well-being and safety of all individuals.**						
COMMUNITY OUTREACH: Implementing public awareness programs at community to individual level for protection of individuals and community against heat wave in different formats like spreading awareness about safety measures against excess heat through media, advertisements, public workshop, etc. which tend to reduce the adverse health effects of heat waves on human health.	S1)Announcing public workshops that spread awareness about protection of the community as well as individual at community level like housing societies, senior citizens' groups etc. before the summer begins.	Mitigation & Adaptation	Policy	Short Term	1. PRO 2. Disaster Management 3. CSR	CSR funds / PCMC
	S2)Introducing lectures/workshops in schools, colleges and other institutes regarding defencing and protecting oneself from rising temperatures during a heat wave.	Mitigation & Adaptation	Policy	Short Term	1. Education	CSR funds
	S3)Introducing workshops on construction sites for the workers to protect them against extreme heat.	Mitigation & Adaptation	Policy	Short Term	1. PCMC	CSR funds
	S4)Introducing workshops at community level for slum dwellers to protect them against extreme heat during summers.	Mitigation & Adaptation	Policy	Short Term	1. PCMC	CSR funds

Objectives	Action/ Recommendations	Objective focus	Proposal type	Time frame	Stakeholder / Department	Funding
PUBLIC AWARENESS AND COMMUNITY ENGAGEMENT						
EARLY WARNING AND COORDINATION Introducing alarm/warning systems in public spaces to alert the residents about the extreme heat conditions and protect themselves from the adverse health effects due to heat wave.	L1)Introducing Heat Alarm Systems with information about the duration and severity of the heat wave at significant public places, signals, public buildings etc. for alerting people about the raised temperature during a heat wave and directing vulnerable communities to cooling resources in the community.	Mitigation & Adaptation	Policy	Long Term	1. Smart City 2. Disaster Management 3. PRO	CSR funds / PCMC
	L2)Introducing Heat Alert Response Systems(HARS) to help them prepare for and respond to extreme heat by promoting community mobilization and engagement, an alert protocol, a communications plan, a community response plan, and an evaluation plan.	Mitigation & Adaptation	Policy	Long Term	1. Smart City 2. Disaster Management 3. PRO	CSR funds / PCMC
	S5) weather stations: Thresholds to declare heat waves are not adequately tailored for local conditions in cities or habitations, and do not adequately incorporate indicators like humidity, hot nights etc. Installation weather stations in PCMC can help understand various climatic indicators and help in mitigation strategies	Mitigation	Project	Short term	1. Smart City 2. Disaster Management 3. Environment dept.	CSR Funding SDMF

Objectives	Action/ Recommendations	Objective focus	Proposal type	Time frame	Stakeholder	Funding
PUBLIC AWARENESS AND COMMUNITY ENGAGEMENT						
PUBLIC AWARENESS Introducing awareness through advertisements, media, etc. to alert the residents about the extreme heat conditions and protect themselves from the adverse health effects due to heat wave.	L1)Spreading awareness through advertisements, newspapers, media, brochures, public announcements to make people aware about actions to be taken after a person undergoes a heat strokes and to prevent a heat stroke.	Mitigation & Adaptation	Policy	Long Term	1. Disaster Management 2. PRO	PCMC
	L2)Creating guidelines, toolkits, and handbooks to educate the public on heat risk. Launch awareness campaign on diverse platforms like social media, websites, and media outlets	Mitigation & Adaptation	Policy	Long Term	1. Education 2. Disaster Management	CSR funds
	L3)Establishing a program for community members to report idling vehicles to prevent vehicles emitting lot of heat.	Mitigation & Adaptation	Policy	Long Term	1. Environment / RTO	CSR funds

Objectives	Action/ Recommendations	Objective focus	Proposal type	Time frame	Stakeholder	Funding
PUBLIC AWARENESS AND COMMUNITY ENGAGEMENT						
PUBLIC SERVICE AID Establishing a public aid services to cure the affected cases during extreme heat conditions.	S1)Establishing a telephonic helpline to provide real- time advice and assist to the vulnerable communities and other residents on extreme heat and resources for cooling.	Mitigation & Adaptation	Policy	Short Term	1. PRO 2. Telecom 3. Disaster Management	CSR funds
	S2) Creating a voluntary check-up supported by targeted outreach for individuals to sign up to be checked on during extreme heat events.	Mitigation & Adaptation	Policy	Short Term	1. Medical	CSR funds / PCMC
	S3) Alerting the health staffs and worker regarding the heat stress and monitoring the situation on hospitals, dispensaries, etc.	Mitigation & Adaptation	Policy	Short Term	1. Medical	CSR funds / PCMC

Sub Policy 1:

C1. Community outreach

Implementing public awareness programs at community to individual level for protection of individuals and community against heat wave in different formats like spreading awareness about safety measures against excess heat through media, advertisements, public workshop, etc. which tend to reduce the adverse health effects of heat waves on human health.

Strategy:

Short term

S1) Announcing public workshops that spread awareness about protection of the community as well as individual at community level like housing societies, senior citizens' groups etc. before the summer begins.

S2) Introducing lectures/workshops in schools, colleges and other institutes regarding defencing and protecting oneself from rising temperatures during a heat wave.

S3) Introducing workshops on construction sites for the workers to protect them against extreme heat.

S4) Introducing workshops at community level for slum dwellers to protect them against extreme heat during summers.

Sub Policy 2:

C2. Early warning and coordination

Introducing alarm/warning systems in public spaces to alert the residents about the extreme heat conditions and protect themselves from the adverse health effects due to heat wave.

Long term strategies: -

L1) Introducing Heat Alarm Systems with information about the duration and severity of the heatwave at significant public places, signals, public buildings etc. for alerting people about t he raised temperature during a heat wave and directing vulnerable communities to cooling resources in the community.

L2) Introducing Heat Alert Response Systems (HARS) to help them prepare for and respond to extreme heat by promoting community mobilization and engagement, an alert protocol, a communications plan, a community response plan, and an evaluation plan.

Sub Policy 3:

C3. Public awareness

Introducing awareness through advertisements, media, etc. to alert the residents about the extreme heat conditions and protect themselves from the adverse health effects due to heat wave.

Long term strategies: -

L1) Spreading awareness through advertisements, newspapers, media, brochures, public announcements to make people aware about actions to be taken after a person undergoes a heat stroke and to prevent a heat stroke.

L2) Creating guidelines, toolkits, and handbooks to educate the public on heat risk. Launch awareness campaign on diverse platforms like social media, websites, and media outlets.

L3) Establishing a program for community members to report idling vehicles to prevent vehicles emitting lot of heat.

Sub Policy 4:

C4. Public service aid

Establishing a public aid service to cure the affected cases during extreme heat conditions.

Short term strategies: -

S1) Establishing a telephonic helpline to provide real- time advice and assist to the vulnerable communities and other residents on extreme heat and resources for cooling.

S2) Creating a voluntary check-up supported by targeted outreach for individuals to sign up to be checked on during extreme heat events.

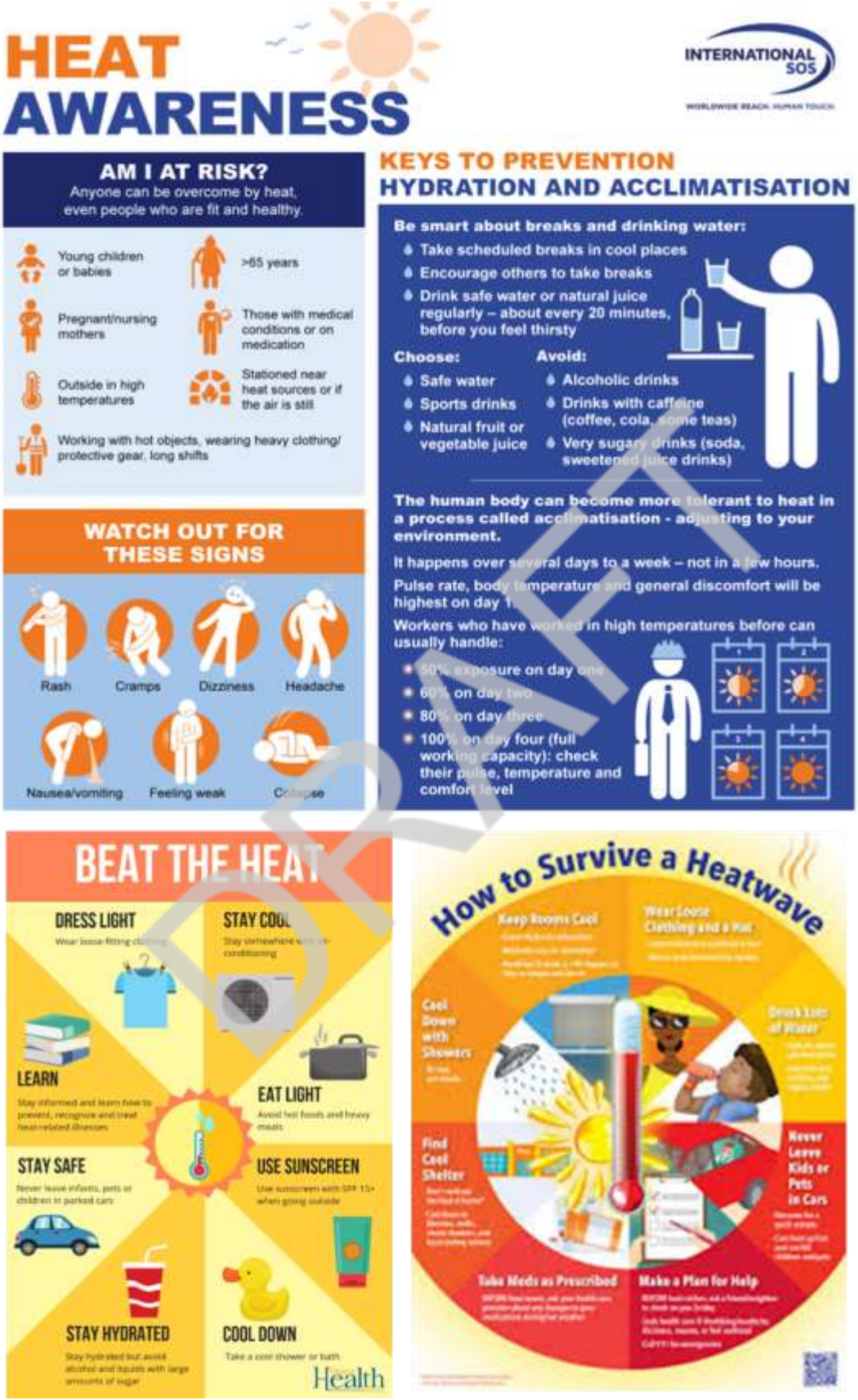

Figure 30: Heat awareness poster Source: internationalsos.com

Broad Policy 4:

D. SMART GROWTH SYSTEMS

Smart growth includes a combination of strategies within the urban development framework aimed at implementing health, protecting the environment, promoting economic sustainability, and making communities attractive. Smart growth values long-range, regional considerations of sustainability over a short-term focus. The table 8 below outlines a comprehensive set of policies and strategies, including objectives, recommended actions, focus areas, proposal types, time frames, and stakeholders, aimed at addressing key challenges and achieving targeted outcomes within the specified context.

Table 8: Smart Growth Systems Policy

Objectives	Action/ Recommendations	Objective focus	Proposal type	Time frame	Stakeholder	Funding
SMART GROWTH SYSTEMS **To implement comprehensive urban development strategies that prioritize resilience and sustainability, optimizing land use, infrastructure provision, and environmental impact assessments to mitigate the effects of extreme heat events while fostering equitable and thriving communities**						
ZONING ORDINANCE Implementing local modification in Zoning laws. Modifying zoning ordinances to increase the density of development and redevelopment allowed in or near existing towns and neighbourhoods and/or restrict new development in outlying or environmentally sensitive areas	L1. Reductions in or elimination of parking minimums or imposition of parking maximums can also reduce the amount of parking built with new development increasing land available for parks and other community amenities.	Mitigation & Adaptation	Policy	Long Term	1. Civil 2. Town Planning	CSR funds / PCMC
	L2 . Additional density incentives can be offered for development of brownfields and grey fields land or for providing amenities such as parks and open space.	Mitigation & Adaptation	Policy	Long Term	1. Town Planning 2. Building Permission	PCMC
	L3. Take advantage of compact architectural design - Based on the actual concept of mixed use, designing compact buildings covers different requirements under a single structure, based on vertical expansion and green spaces. Prior planning enables more open spaces to be maintained	Mitigation	Project	Long Term	1. Town Planning 2. Building Permission 3. Civil	PCMC
	L4. Mixed land use - They are based on the urban and social analysis of land use and buildings, to provide them with a multi-functional purpose	Mitigation	Project	Long Term	1. Town Planning 2. Building Permission 3. Civil	PCMC

Objectives	Action/ Recommendations	Objective focus	Proposal type	Time frame	Stakeholder	Funding
	SMART GROWTH SYSTEMS					
	S1. Providing laws for the newly sanctioned ongoing projects with rules while construction related to air pollution and working hours limitation for the labors	Mitigation & Adaptation	Policy	Short Term	1. Legal 2. Civil	
	S2. Rules and timing regarding the transportation activity for materials delivery and debris disposal.	Mitigation	Policy	Short Term	1. Civil 2. Environment	
ENVIRONMENTAL IMPACT ASSESSMENT Implementing EIA as compulsion for lawmakers to require prospective developers to prepare EIA of their plans as a condition for state and/or local governments to permit them to build their buildings.	**L1.** Introducing EIA as a compulsion for government buildings, commercial buildings, industries, and residential with more than 5000 sq m area. The builder or developer is to be provided with some incentives.	Mitigation & Adaptation	Policy	Long Term	1. Civil 2. Environment	PCMC
	L2. Preserve open space, farmland, natural beauty, and critical environmental areas - Open natural spaces have an incalculable value and form part of a city's heritage and that of its residents. They must be at the center of any strategy. The plan includes analyzing natural ecosystems and not promoting projects that threaten biodiversity.	Mitigation & Adaptation	Policy	Long term	1. Town Planning 2. Environment 3. Civil	PCMC

Objectives	Action/ Recommendations	Objective focus	Proposal type	Time frame	Stakeholder	Funding
SMART GROWTH SYSTEMS						
D3) SOCIAL INFRASTRUTURE Implementing systematic provision of infrastructure such as schools, libraries, sporting facilities and community facilities is an integral component of the city land use planning.	L1. Direct development towards existing communities - With the foregoing, it is more desirable, given the benefits, to make use of existing infrastructures, if they prove to be functional, restoring them for the usage.	Mitigation & Adaptation	Policy	Long Term	1.CREDAI 2. Building Permission PCMC	
	L2. Provide a variety of transportation options – Promote public transport. promoting the efficiency of public transportation or providing infrastructures that support the use of eco-friendly transportation methods such as bikes or electric vehicles.	Mitigation	Policy	Long Term	1.PCMC	
	S1. Introducing different social platforms for better community and stakeholder collaborations.	Mitigation & Adaptation	Policy	Short Term	1. PRO 2. Smart Cities	CSR funds
	S2. Protect the local and natural heritage	Mitigation & Adaptation	Policy	Short term	1. PCMC	CSR funds / PCMC

Sub Policy 1:

D1. ZONING ORDINANCE

Implementing local modification in Zoning laws. Modifying zoning ordinances to increase the density of development and redevelopment allowed in or near existing towns and neighbourhoods and/or restrict new development in outlying or environmentally sensitive areas.

Strategy:

Long term

L1) Reductions in or elimination of parking minimums or imposition of parking maximums can also reduce the amount of parking built with new development increasing land available for parks and other community amenities.

L2) Additional density incentives can be offered for development of brownfields and grey fields land or for providing amenities such as parks and open space.

L3) Take advantage of compact architectural design - Based on the actual concept of mixed use, designing compact buildings covers different requirements under a single structure, based on vertical expansion and green spaces. Prior planning enables more open spaces to be maintained.

L4) Mixed land use - They are based on the urban and social analysis of land use and buildings, to provide them with a multi-functional purpose.

Short term

S1) Providing laws for the newly sanctioned ongoing projects with rules while construction related to air pollution and working hours limitation for the labors.

S2) Rules and timing regarding the transportation activity for materials delivery and debris disposal.

Sub Policy 2:

D2. ENVIRONMENTAL IMPACT ASSESSMENT

Implementing EIA as compulsion for lawmakers to require prospective developers to prepare EIA of their plans as a condition for state and/or local governments to permit them to build their buildings.

Strategy:

Long term

L1) Introducing EIA as a compulsion for government buildings, commercial buildings, industries, and residential with more than 5000 sq m area. The builder or developer is to be provided with some incentives.

L2) Preserve open space, farmland, natural beauty, and critical environmental areas - Open natural spaces have an incalculable value and form part of a city's heritage and that of its residents. They must be at the centre of any strategy. The plan includes analysing natural ecosystems and not promoting projects that threaten biodiversity.

Sub Policy 3:

D3. SOCIAL INFRASTRUTURE

Implementing systematic provision of infrastructure such as schools, libraries, sporting facilities and community facilities is an integral component of the city land use planning.

Long term

L1) Direct development towards existing communities - With the foregoing, it is more desirable, given the benefits, to make use of existing infrastructures, if they prove to be functional, restoring them for the usage.

L2) Provide a variety of transportation options - In this regard shared vehicle platforms are extremely relevant, promoting the efficiency of public transportation or providing infrastructures that support the use of eco-friendly transportation methods such as bikes or electric vehicles

Short term

S1) Introducing different social platforms for better community and stakeholder collaborations.

S2) Make development decisions predictable, fair, and cost-effective - The role of governments is to facilitate processes, ensure the transparency of the same and protect the local and natural heritage.

Broad Policy 5:

E. COOL SURFACES

Building cool surfaces for PCMC will mitigate the impact of the heat island effect, with the help of materials that reflect a large fraction of incoming solar radiation, reducing the absorbed solar radiation, and as result will reduce the heat flow into the building, and decrease cooling demand. The table 9 below outlines a comprehensive set of policies and strategies, including objectives, recommended actions, focus areas, proposal types, time frames, and stakeholders, aimed at addressing key challenges and achieving targeted outcomes within the specified context.

Table 9: Cool Surfaces Policy

Objectives	Action/ Recommendations	Objective focus	Proposal type	Time frame	Stakeholder	Funding
COOL SURFACES **To mitigate the urban heat island effect and enhance human thermal comfort by strategically deploying reflective materials and heat-reducing surfaces in urban areas, thereby reducing surface temperatures, lowering energy consumption, and minimizing heat-related health risks for residents.**						
1.COOL ROOFS : Implementing COOLROOFS SYSTEMS for the internal hardscapes of the campuses and footpaths along the road	L1. Introducing Solar panels / solar shingles on the roof which acts as a shading device for the existing roof.	Mitigation & Adaptation	Project	Long Term	1. Environment 2. Civil 3. Building Permission 4. CREDAI	PCMC / CSR funds
	S1. Introducing lighter color options and SRI paints for the roof surfaces for existing and new structures. S2 Introducing misting systems for the roofs to keep it cool in summers .	Mitigation & Adaptation	Project	Short Term	1. Environment 2. Civil 3. Building Permission 4. CREDAI	PCMC / CSR funds
2.COOL FACADES : Implementing COOL FACADE systems to reflect more sunlight to reduce building heat retention from the vertical surfaces.	L1. Introducing the use of natural materials like terracotta tiles for the facade of the buildings L2. Orientation of the buildings to be done east-west, south side facade should not have any reflective materials .	Mitigation & Adaptation	Policy	Long Term	1. Environment 2. Civil 3. Building Permission 4. CREDAI	PCMC / CSR funds

Objectives	Action/ Recommendations	Objective focus	Proposal type	Time frame	Stakeholder	Funding
COOL SURFACES						
	S1. Introducing lighter color options and SRI paints for the surfaces for existing and new structures.	Mitigation & Adaptation	Project	Short Term	1. Environment 2. Civil 3. Building Permission 4. CREDAI	PCMC / CSR funds
3. COOL PAVEMENTS : Implementing COOL PAVEMENT systems to reflect more sunlight to reduce building heat retention.	**L1.** Introducing appropriate surface coating material or light color aggregates as the binder material. High solar reflectance (albedo) and a low thermal emissivity, meaning they can reflect more sunlight and emit less heat than conventional pavements.	Mitigation & Adaptation	Project	Long Term	1. Environment 2. Civil	PCMC / CSR funds
	S1. Introducing lighter color options and SRI paints for the roof surfaces for existing and new structures. **S2** Introducing misting systems for the roofs to keep it cool in summers . **S3.** Introducing shading devices like trellis, pergolas on the pavements.	Mitigation & Adaptation	Project	Short Term	1. Environment 2. Civil 3. Smart City	PCMC / CSR funds

Objectives	Action/ Recommendations	Objective focus	Proposal type	Time frame	Stakeholder	Funding
COOL SURFACES						
4. GREEN ROOFS : Implementing GREEN ROOF systems for surrounding air and reducing building heat through a layer of vegetation or other plants. To remove heat from the air through the process of evapotranspiration, and also act as insulators for buildings, reducing the energy needed to provide cooling and heating.	L1. Introducing Intensive green roof -Also known as a roof garden, this is the most 'involved' roof type which can be designed to be like a garden environment L2. Introducing Semi - Intensive green roof- Leaning towards roof gardens, but without the weight of an intensive roof. You have greater design scope, and these roofs can also be used recreationally .	Mitigation & Adaptation	Project	Long Term	1. Environment 2. Civil 3. Building Permission 4. CREDAI	CSR funds
	S1. Introducing Extensive green roof- The biodiversity value differs according to the soil depth, but as they are often pre-planted with sedums (small, hardy succulents), moss, herbs and grasses, extensive living roofs tend to have lower biodiverse value.	Mitigation & Adaptation	Project	Short Term	1. Environment 2. Civil 3. Building Permission 4. CREDAI	CSR funds

Objectives	Action/ Recommendations	Objective focus	Proposal type	Time frame	Stakeholder	Funding
COOL SURFACES						
5. GREEN FACADES : Implementing GREEN FAÇADE are panels of plants, grown vertically using hydroponics, on structures that can be either free-standing or attached to walls.	L1. Introducing moss walls that will provide environmental benefits, such as improving air quality and reducing noise pollution, reduction in air borne dust. L2 . Introducing living walls that is used to directly shade a building's surface. A cooling effect occurs when solar radiation is absorbed into the plants for photosynthesis rather than into the wall itself.	Mitigation & Adaptation	Project	Long Term	1. Environment 2. Civil 3. Building Permission 4. CREDAI	CSR funds
	S1. Introducing green options with creepers and climbers for the compound walls of the plots. S2. Introducing vertical self-standing walls for temporary aluminum structures, existing flyover columns, parking lots.	Mitigation & Adaptation	Project	Short Term	1. Environment 2. Civil 3. Building Permission 4. CREDAI	CSR funds

Objectives	Action/ Recommendations	Objective focus	Proposal type	Time frame	Stakeholder	Funding
COOL SURFACES						
6. GREEN PAVEMENTS : Implementing GREEN PAVEMENT SYSTEMS for the internal hardscapes of the campuses and footpaths along the road. .	L1. Introducing vegetated pavements materials that support the growth of plants on or within the pavement, such as grass, moss, or sedum. Vegetated pavements can reduce the heat flux from the pavement and the air temperature, as well as provide aesthetic, ecological, and social benefits	Mitigation & Adaptation	Project	Long Term	1. Environment 2. Civil	CSR funds
	S1. Introducing permeable and water retention pavements in order to allow water to flow through into the sub surface	Mitigation & Adaptation	Project	Short Term	1. Environment 2. Civil	CSR funds

Sub Policy 1:

E1. COOL ROOFS

Implementing COOL ROOFS SYSTEMS for the internal hardscapes of the campuses and footpaths along the road

Strategy:

Long term

L1) Introducing Solar panels / solar shingles on the roof which acts as a shading device for the existing roof.

Short term

S1) Introducing lighter color options and SRI paints for the roof surfaces for existing and new structures.

S2) Introducing misting systems for the roofs to keep it cool in summers.

Sub Policy 2:

E2. COOL FACADES

Implementing **COOL FAÇADE systems** to reflect more sunlight to reduce building heat retention from the vertical surfaces.

Long term strategies: -

L1) Introducing the use of natural materials like terracotta tiles for the façade of the buildings

L2) Orientation of the buildings to be done east-west, south side façade should not have any reflective materials.

Short- term Strategies: -

S1) Introducing lighter color options and SRI paints for the roof surfaces for existing and new structures.

Sub Policy 3:

E3. Cool Pavements

Implementing COOL PAVEMENT systems to reflect more sunlight to reduce building heat retention.

Long- term strategies: -

L1) Introducing appropriate surface coating material or light color aggregates as the binder material. High solar reflectance (albedo) and a low thermal emissivity, meaning they can reflect more sunlight and emit less heat than conventional pavements.

Short- term strategies: -

S1) Introducing lighter color options and SRI paints for the roof surfaces for existing and new structures.

S2) Introducing misting systems for the roofs to keep it cool in summers.

S3) Introducing shading devices like trellis, pergolas on the pavements

Sub Policy 4:

E4. Green Roofs

Implementing GREEN ROOF systems for surrounding air and reducing building heat through a layer of vegetation or other plants. To remove heat from the air through the process of evapotranspiration, and also act as insulators for buildings, reducing the energy needed to provide cooling and heating.

Long- term strategies: -

L1) Introducing Intensive green roof -Also known as a roof garden, this is the most 'involved' roof type which can be designed to be like a garden environment.

L2) Introducing Semi - Intensive green roof- Leaning towards roof gardens, but without the weight of an intensive roof.

Short- term strategies: -

S1) Introducing Extensive green roof- The biodiversity value differs according to the soil depth, but as they are often pre-planted with sedums (small, hardy succulents), moss, herbs and grasses, extensive living roofs tend to have lower biodiverse value.

Sub Policy 5:

E5. Green Facades

Implementing **GREEN FAÇADE** i.e. panels of plants, grown vertically using hydroponics, on structures that can be either free-standing or attached to walls.

Long- term strategies: -

L1) Introducing moss walls that will provide environmental benefits, such as improving air quality and reducing noise pollution, reduction in air borne dust.

L2) Introducing living walls that is used to directly shade a building's surface. A cooling effect occurs when solar radiation is absorbed into the plants for photosynthesis rather than into the wall itself.

Short- term strategies: -

S1) Introducing green options with creepers and climbers for the compound walls of the plots.

S2) Introducing vertical self-standing walls for temporary aluminum structures, existing flyover columns, parking lots.

Sub Policy 6:

E6. Green Pavements

Implementing **GREEN PAVEMENT SYSTEMS** for the internal hardscapes of the campuses and footpaths along the road.

Long- term strategies: -

L1) Introducing vegetated pavements materials that support the growth of plants on or within the pavement, such as grass, moss, or sedum. Vegetated pavements can reduce the heat flux from the pavement and the air temperature, as well as provide aesthetic, ecological, and social benefits.

S1) Introducing permeable and water retention pavements in order to allow water to flow through into the sub surface.

Short- term strategies: -

S1) Introducing permeable and water retention pavements in order to allow water to flow through into the sub surface.

Broad Policy 6:

F. BUILDING RESILIENCE

Establishing resilience against rising temperatures takes centre stage in PCMC's Heat Action Plan. This framework encompasses innovative architectural and structural solutions, heightened public awareness, and the implementation of stringent building codes. The goal is to ensure the city's preparedness in mitigating the impacts of rising temperatures, safeguarding the well-being of its residents, and fostering sustainable urban development.

The table 10 below outlines a comprehensive set of policies and strategies for building resilience, including objectives, recommended actions, focus areas, proposal types, time frames, and stakeholders, aimed at addressing key challenges and achieving targeted outcomes within the specified context.

Table 10: Building Resilience Policy

Objectives	Action/ Recommendations	Objective focus	Proposal type	Time frame	Stakeholder	Funding
BUILDING HEAT RESILIENCE **To implement measures that improve the ability of buildings and infrastructure to withstand extreme heat events, including strategies such as insulation, shading, and the use of heat-resistant materials, to minimize heat-related health risks, maintain indoor comfort, and enhance overall community resilience to heatwaves.**						
Building Envelope Design	L1) Horizontal and Vertical Louvers – Implementing designs that incorporate horizontal and vertical louvers can significantly contribute to reducing heat gain within buildings	Mitigation & Adaptation	Policy	Long Term	1. Environment 2. Civil 3. Building Permission 4. CREDAI	
	L2) Fins – Architectural fins can be strategically placed to control solar penetration and improve thermal comfort	Mitigation & Adaptation	Policy	Long Term	1. Environment 2. Civil 3. Building Permission 4. CREDAI	
	L3) Shading from Adjacent Buildings – Designing urban layouts to take advantage of natural shading from surrounding structures is a sustainable and cost-effective method	Mitigation & Adaptation	Project	Long Term	1. Environment 2. Civil 3. Building Permission 4. CREDAI	
	L4) Punched Windows – Incorporating punched window designs is an effective way to balance the need for natural light and the reduction of heat gain.	Mitigation	Project	Long Term	1. Environment 2. Civil 3. Building Permission 4. CREDAI	
	L5) Energy Efficiency – Upgrading buildings to use energy-efficient systems and appliances	Mitigation	Policy	Long Term	1. Environment 2. Civil 3. Building Permission 4. CREDAI	

Objectives	Action/ Recommendations	Objective focus	Proposal type	Time frame	Stakeholder	Funding
BUILDING HEAT RESILIENCE						
	L6) Certified Green Building Materials – Encouraging the use of certified green building materials, products, and equipment is an essential step toward reducing the environmental impact of construction.	Mitigation & Adaptation	Policy	Long Term	1. Environment 2. Civil 3. Building Permission 4. CREDAI	MEDA
	S1) Review of Material Selection – Undertake a short-term evaluation and selection of green materials for immediate construction projects.	Mitigation & Adaptation	Policy	Short Term	1. Environment 2. Civil 3. Building Permission 4. CREDAI 5. Green rating authorities 6. MEDA (ECBC Cell)	
	S2) Training for Green Building Standards – Conduct workshops and training sessions for builders and architects on green building practices.	Mitigation	Policy	Short Term		
	S3) Pilot Projects – Initiate pilot projects to showcase the viability and benefits of green building guidelines.	Mitigation	Project	Short Term		

Green Building Guidelines – Enhancing Sustainability and Energy Efficiency

As part of this initiative, the incorporation of green building guidelines emerges as a crucial sub-policy. These guidelines are designed to enhance environmental sustainability and ensure energy efficiency in construction practices.

Sub Policy –

Long Term Strategies:

L1) Horizontal and Vertical Louvers –

- Implementing designs that incorporate horizontal and vertical louvers can significantly contribute to reducing heat gain within buildings.
- Louvers can effectively block direct sunlight while allowing for natural ventilation.
- This strategy not only enhances thermal comfort but also promotes energy efficiency by reducing the reliance on air conditioning systems.

L2) Fins –

- Architectural fins can be strategically placed to control solar penetration and improve thermal comfort.
- By adjusting the orientation and size of the fins, it is possible to optimize shading during peak sunlight hours.
- This approach not only mitigates heat gain but also adds an aesthetically pleasing architectural element to the buildings.

L3) Shading from Adjacent Buildings –

- Designing urban layouts to take advantage of natural shading from surrounding structures is a sustainable and cost-effective method.
- Planning the placement of buildings to create shaded areas can help reduce the overall heat island effect in the city.
- Additionally, this strategy encourages a more thoughtful and integrated approach to urban planning.

L4) Punched Windows –

- Incorporating punched window designs is an effective way to balance the need for natural light and the reduction of heat gain.
- This approach involves strategically placing smaller windows with appropriate shading elements to minimize direct sunlight exposure.
- It ensures that buildings remain well-lit while managing interior temperatures.

L5) Energy Efficiency –

- Upgrading buildings to use energy-efficient systems and appliances is a crucial long-term strategy. Adoption of ECBC.
- This may include the installation of high-efficiency HVAC systems, smart thermostats, and energy-efficient lighting.
- Conducting energy audits and retrofitting existing structures with the latest technologies can significantly contribute to overall energy conservation.

L6) Certified Green Building Materials –

- Encouraging the use of certified green building materials, products, and equipment is an essential step toward reducing the environmental impact of construction.
- This can involve promoting sustainable sourcing, recycling, and the use of materials with low embodied energy.
- Certification programs like LEED or BREEAM can be adopted to ensure adherence to green building standards.

The long-term strategies for building heat resilience relies on the active participation and collaboration of the stakeholders like Urban Planning Department, Construction Industry Leaders, Environmental Agencies CSR Initiatives and Local Government Bodies, emphasizing the collaborative effort required for successful implementation.

Short Term Strategies:

S1) Review of Material Selection –

- Undertake a short-term evaluation and selection of green materials for immediate construction projects.
- This swift action ensures that ongoing projects align with sustainability goals and reduce the environmental footprint.

S2) Training for Green Building Standards –

- Conduct workshops and training sessions for builders and architects on green building practices.
- Short-term training initiatives ensure that professionals in the construction industry are equipped with the knowledge and skills required for sustainable building practices.

S3) Pilot Projects –

- Initiate pilot projects to showcase the viability and benefits of green building guidelines.

These small-scale endeavours serve as tangible examples, promoting the wider adoption of sustainable practices within the community.

These short-term strategies are integral components of the overall plan for building heat resilience in PCMC. By engaging with stakeholders from the Construction Industry, Environmental Agencies, CSR Initiatives, and Local Government Bodies, these initiatives aim to create immediate positive impacts and pave the way for a more sustainable and resilient urban environment.

Broad Policy 7:

G. GREEN HORIZONS

Providing vegetation for open/ vacant lands or open grounds for PCMC will reduce the area exposed to direct heat hence resulting in lower temperatures. The table 11 below outlines a comprehensive set of policies and strategies, including objectives, recommended actions, focus areas, proposal types, time frames, and stakeholders, aimed at addressing key challenges and achieving targeted outcomes within the specified context.

Table 11: Green Horizons Policy

Objectives	Action/ Recommendations	Objective focus	Proposal type	Time frame	Stakeholder	Funding
GREEN Horizons **To strategically introduce vegetation with the aim of reducing the surface area exposed to direct heat to mitigate rising temperatures, lower the urban heat island effect, enhance human thermal comfort, and contribute to the overall resilience of communities to extreme heat events.**						
Providing vegetation - Providing vegetation for open lands/ vacant lands / open grounds' and farmlands to reduce the surface area exposed to direct heat to help mitigate the rising temperatures.	L1) Providing vegetation (shade trees) along the boundary/periphery of open space/ vacant lands/ grounds at regular intervals.	Mitigation & Adaptation	Policy	Long Term	• Town Planning • Environment • NGO's • CSR Initiatives	CSR

Sub Policy 1:

G1. Providing vegetation

Providing vegetation for open lands/ vacant lands / open grounds and farmlands to reduce the surface area exposed to direct heat to help mitigate the rising temperatures.

Long term strategies: -

L1) Providing vegetation (shade trees) along the boundary/periphery of open space/ vacant lands/ grounds at regular intervals.

Figure 31: Plantation along edges of open spaces

The following pages outlines overall policy framework for selected representative zones in PCMC.

Policy Framework- Zone 1

Figure 32: Policy framework for Rajmata Jijaunagar, Kranti Chowk, Before After images

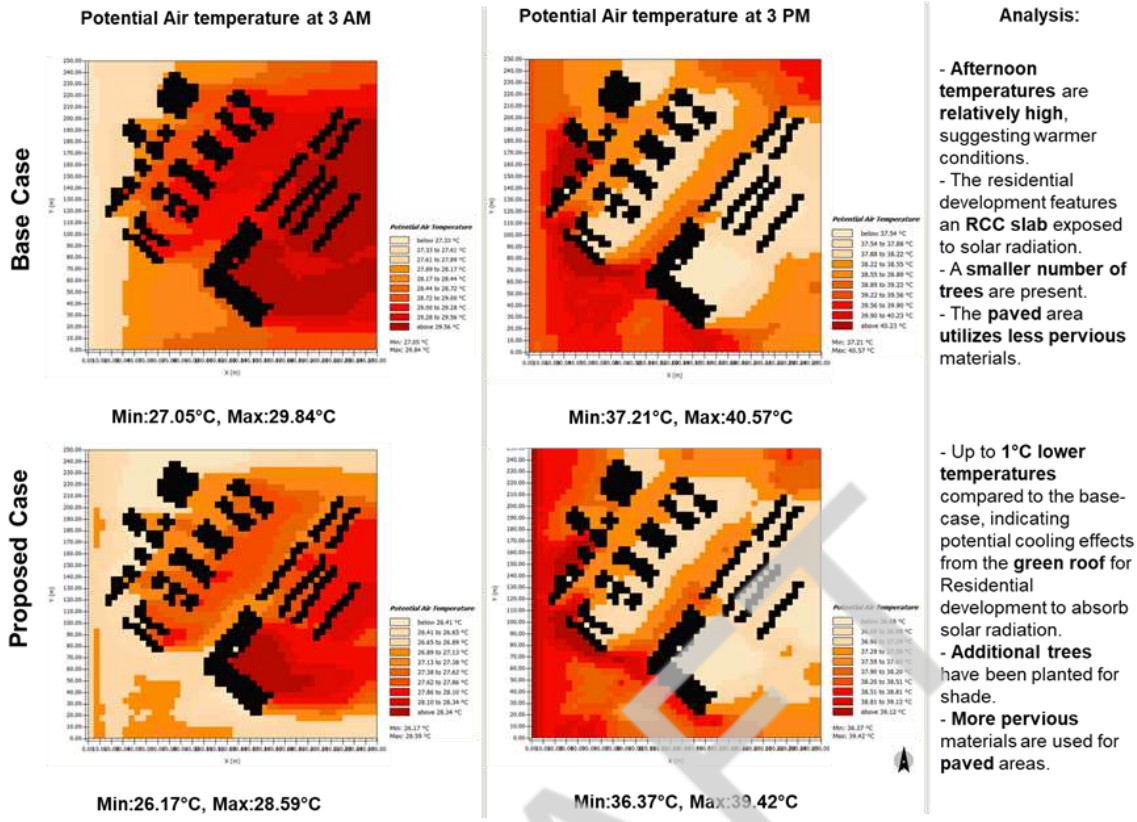

Figure 33: Microclimate analysis; Base case and Proposed case scenario for Rajmata Jijaunagar, Kranti Chowk, Before After images

Inferences:

I. Residential Zoning Policy: Implement zoning ordinances to encourage mutual shading among residential buildings, creating cooler microclimates.

ii. Tree Planting Initiative: Launch a tree planting program along walkways to provide natural shade, reducing direct sunlight exposure and surface heat.

iii. Green Infrastructure Mandate: Introduce a mandate for green infrastructure in central road medians, using shrubs and trees to lower ambient temperatures and enhance pedestrian comfort.

iv. Heat-Reflective Surfaces Policy: Enforce the use of heat-reflective materials on roads, especially on high-exposure streets like Moshi High Street, to minimize heat absorption and radiation.

v. Heat Mitigation Awareness Campaign: Conduct public awareness campaigns on heat mitigation strategies, including cool surfaces, cool roofs, cool pavements, cool facades, and green horizons, to promote community involvement in reducing urban heat island effects.

vi. Bioclimatic Planning Integration: Integrate bioclimatic design into urban planning processes to guide the design of streets and public spaces that minimize heat retention and optimize cooling effects.

vii. Green Infrastructure Funding: Allocate resources for green infrastructure projects aimed at creating shaded areas, improving thermal comfort, and mitigating heat-related challenges in urban environments.

Policy Framework- Zone 2

Figure 34: Policy implementation- Chikhli Bus Stop: Before , After scenario

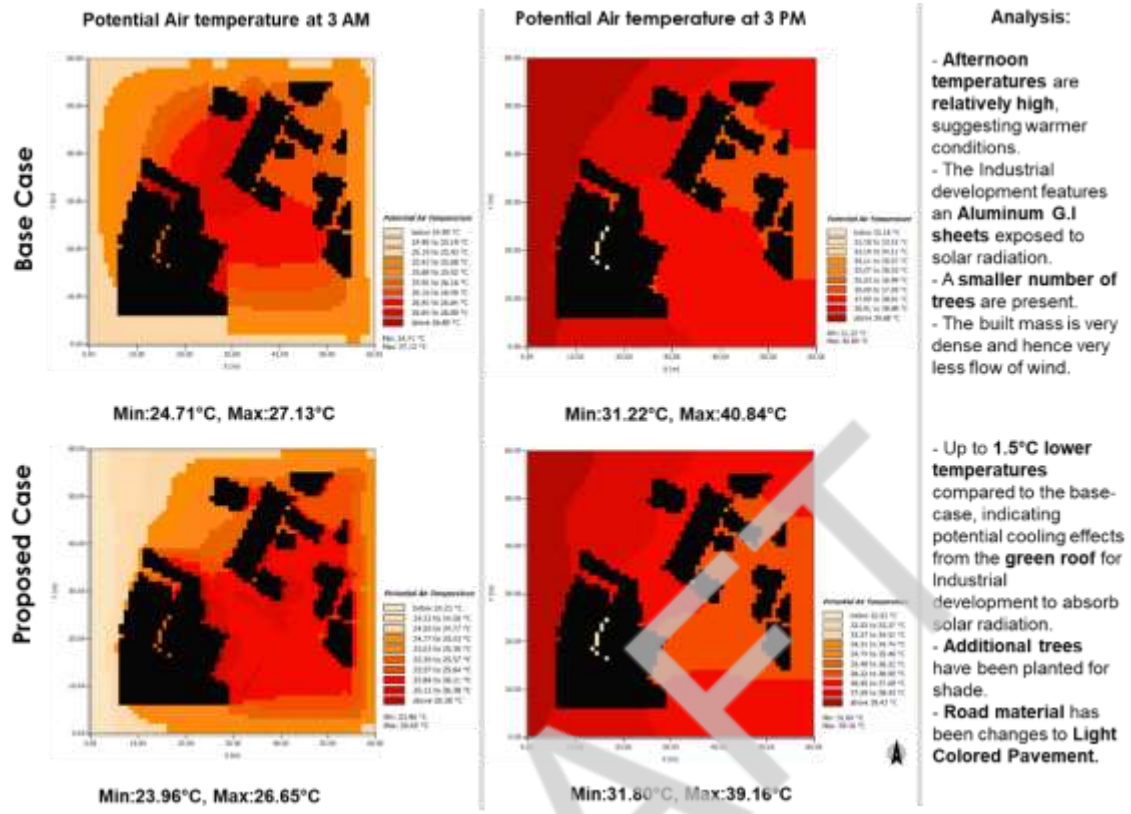

Figure 35: Microclimate; Basecase and Proposed case scenario for Chikhli Bus Stop

Inferences:

I. Vegetation and Building Structure Policy: Introduce policies to promote layered vegetation and shade-providing building designs along roads to reduce surface temperatures during peak daylight hours.

ii. Transportation Emissions Reduction: Implement measures to reduce anthropogenic heat and air pollution from heavy-duty vehicles and other sources, including promoting cleaner transport options and optimizing traffic flow to minimize congestion-related emissions.

iii. Shading Infrastructure Initiative: Launch an initiative to install shading structures along roads, especially at junctions and heavily populated areas, to mitigate surface temperature increases and improve pedestrian comfort.

iv. Bioclimatic Planning Integration: Incorporate bioclimatic design into urban planning guidelines to design streets and public spaces that minimize heat stress and prioritize human comfort.

v. Heat Stress Monitoring and Alert System: Develop a heat stress monitoring and alert system to notify the public and relevant authorities when temperatures exceed safe thresholds, enabling timely interventions to protect public health.

Policy framework- Zone 3

Figure 36: Policy framework for Gurudwara Chowk, Ravet- Before, After scenario

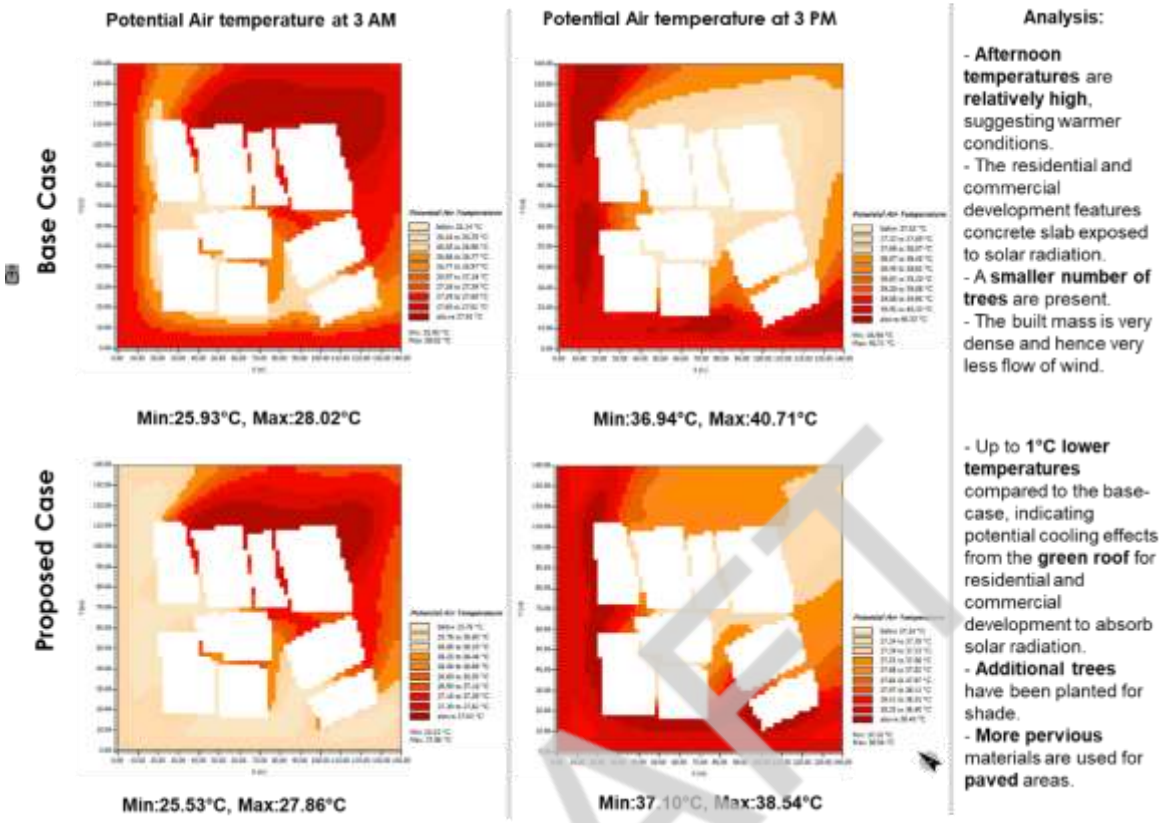

Figure 37: Microclimate; Basecase and Proposed case scenario for Gurudwara chowk

Inferences:

I. Land Use and Zoning Policies: Implement mixed land use policies that balance commercial activities with residential areas, incorporating green spaces and shade-providing structures to reduce heat buildup in densely occupied zones.

ii. Transportation and Traffic Management: Introduce measures to improve traffic flow and reduce congestion, such as designated parking areas and efficient public transport options, to minimize vehicular emissions and heat generation.

iii. Urban Greening Initiatives: Launch initiatives to increase vegetation cover within the area, including tree planting programs, green roofs, and vertical gardens, to enhance shading, promote evaporative cooling, and improve air quality.

iv. Heat-Resilient Infrastructure Design: Encourage the design and construction of heat-resilient infrastructure, including cool pavements, permeable surfaces, and reflective materials, to mitigate surface temperature increases and create more comfortable urban environments.

v. Community Engagement and Awareness: Engage local communities through awareness campaigns on heat mitigation strategies, sustainable urban development practices, and the importance of green spaces in enhancing urban liability and resilience.

Policy Application in Vulnerable Areas:

The following section presents a comprehensive overview of policies applied across the entire PCMC (Pimpri-Chinchwad Municipal Corporation) area. The maps provided here showcase both the existing scenario and the proposed scenario, offering a visual representation of the changes brought about by the policy applications.

In the earlier segment, specific vulnerable areas were rigorously tested using Envimet to assess the effectiveness of the proposed policies. This included detailed analysis and simulations to understand how the policies would impact these vulnerable zones in terms of heat reduction and environmental resilience.

The maps included below encapsulate the broader implications of these policies across the entire PCMC region, providing insights into the potential outcomes and benefits of implementing these strategic measures..

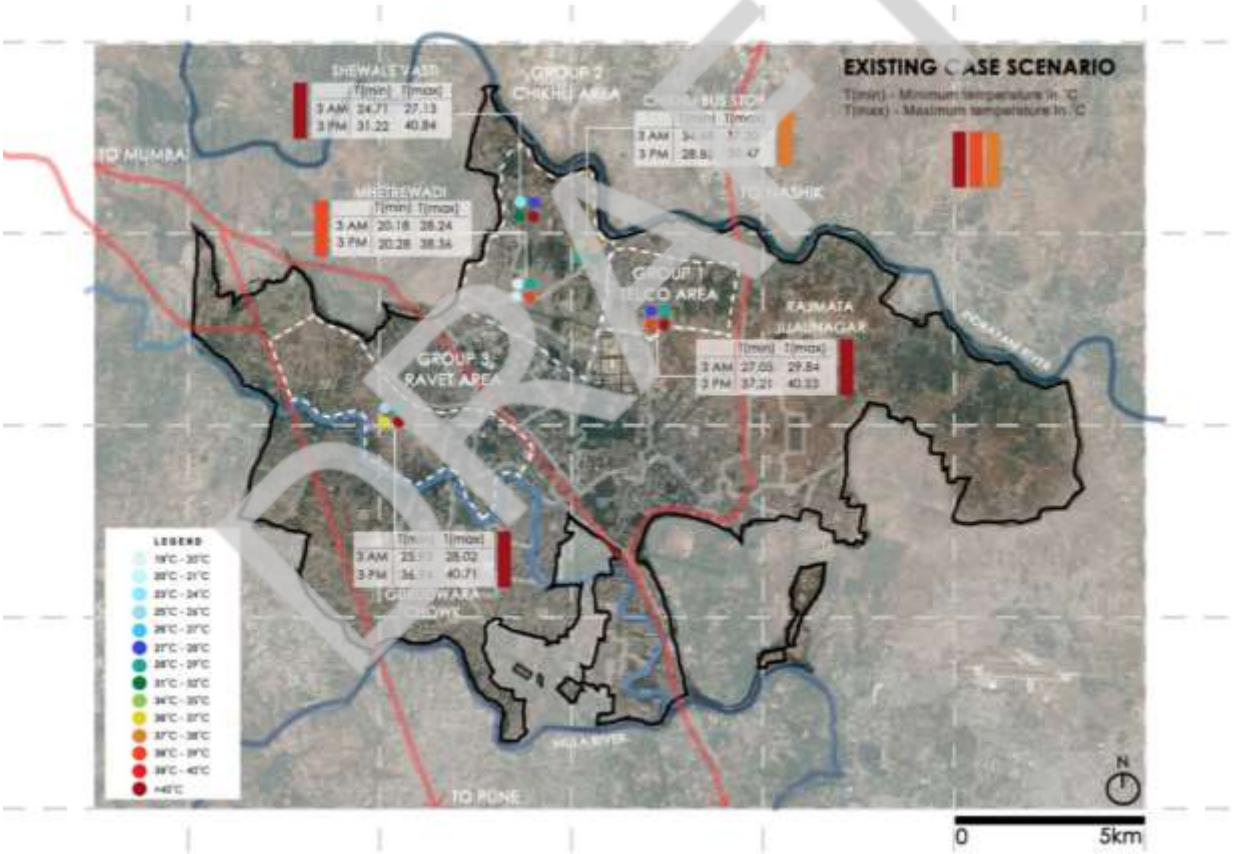

Figure 38: Existing case scenario; Vulnerable areas, PCMC

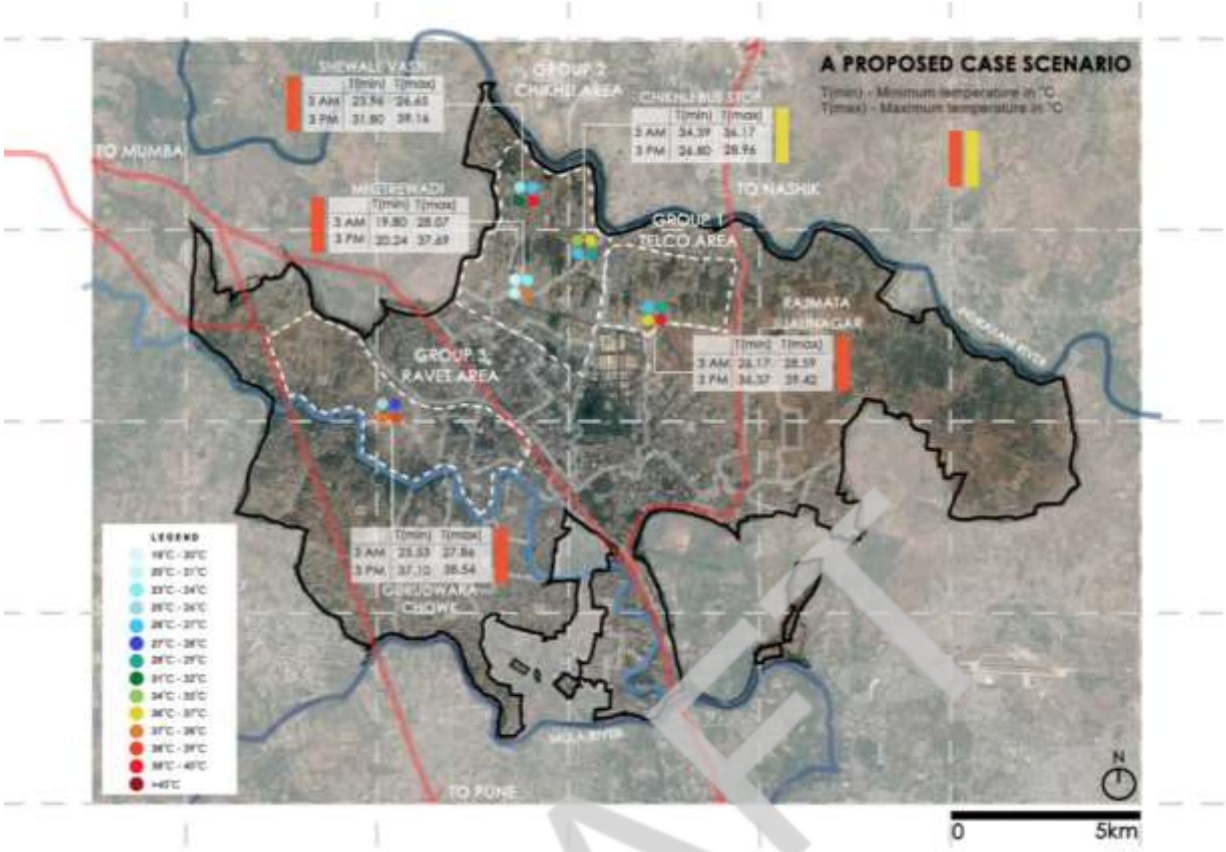

Figure 39: Proposed case scenario; Vulnerable areas, PCMC

8.2 Recommendations for Informal Settlements:

Within the broader framework of the heat action plan, addressing the vulnerabilities of informal settlements stands as a critical imperative. Informal settlements, often characterized by densely populated areas with inadequate infrastructure and limited access to essential services, are disproportionately impacted by extreme heat events. In recognition of this pressing issue, this section presents recommendations tailored specifically to mitigate the heat-related challenges faced by residents of informal settlements. Importantly, these recommendations are not theoretical; they stem from rigorous experimental research.

Policy Recommendations:

8.2.1 Facilitate the implementation of a diversity of indoor cooling strategies through a contextual approach in marginalised urban settlement structures.

8.2.1.1 Indoor Cooling Strategies

Thermal measurements of informal structures in Indian cities have revealed roof temperatures in excess of 50 degree Celsius when air temperatures are 32 degrees Celsius. Insides are too hot to inhabit and often do not cool down adequately till about 12 midnight. The research has revealed that inhabitants suffer intense thermal stress compounded by lack of adequate rest and sleep, from spending time outdoors while waiting for tolerable internal temperatures. This disproportionately affects women dwellers who must often wake up much earlier than most household members to fetch water from municipal taps and cook food for the household and hence suffer protracted sleep deprivation.

To address this, contextually relevant indoor cooling in informal settlement structures must be facilitated through the availability of a diverse set of material and mechanism options that are deployed ‘in consultation with’ house inhabitants as opposed to a ‘one-size-fits all top-down approach’. A holistic overview of interlinked issues, challenges, etc. need to be considered for context-appropriate implementation e.g. A singular strategy to cool roofs of all homes in a city won’t work given that roofs are used for a plurality of purposes by residents. Additionally, heat stress solutions cannot be implemented in isolation from other structure related issues e.g. Water ingress from the roof during monsoons will need to be factored into the implementation of roof retrofit based thermal comfort solutions to avoid augmenting the vulnerability of low-income households that are already socio-economically and climatically disadvantaged.

The indoor cooling strategies described below encapsulate a diversity of passive cooling mechanisms such as roof insulation, roof shading, roof radiant barriers, night-sky radiation, evaporation and thermal mass (e.g. as made possible by Green roofs) in addition to low-cost active cooling appropriate technologies which can be implemented and maintained through support from an informal housing thermal comfort local service ecosystem comprising local material suppliers, fabricators, installation persons, women's cooperatives and financial institutions (as needed) as detailed under the implementation strategy section (ref 1.2).

i. Thermal Mass

Thermal mass is the ability of a material to absorb and store heat energy. When incorporated on the roof of the house it will absorb heat during the day and release it by night to cooling breezes or clear night skies

Appropriate Technologies

a. **Water Filled PET bottles:** Water has the highest specific heat capacity than any liquid. Specific heat is defined as the amount of heat one gram of a substance must absorb or lose to change its temperature by one degree Celsius. For water, this amount is one calorie, or 4.184 joules. Thus, it can absorb a lot of heat before its temperature rises. This trait helps it to stabilise temperature in its surroundings. To benefit from this heat resisting property of water, locally available discarded PET bottles are filled with water and stuck on the roof. This low cost, zero energy passive thermal comfort solution increases the thermal mass of the roof i.e., its ability to store heat, for a longer duration before letting it seep into the house through the day and reversing the heat transfer process of the water during the night, since the warmed water during the day gets cooled during the night due to the drop in ambient temperature, which in turn keeps the roof cool the next morning even when the sun starts to heat up.

Figure 40 Water-filled PET bottles on a tin-roof

ii. Thermal Mass and Shading

A combination of thermal mass (i.e. the ability of a material to absorb and store heat energy. When incorporated on the roof of the house it will absorb heat during the day and release it by night to cooling breezes or clear night skies) and shading incorporated over the roof can reduce indoor temperatures.

Appropriate technologies

a. **Rooftop Gardens**: Rooftop Gardens comprise a layer of vegetation cultivated in diverse ways on the roof e.g. in pots, brick beds, wooden crates, grow bags, etc. They facilitate cooling in informal housing structures through shading from the vegetation that facilitates reduction of heat ingress (i.e. passive cooling) through shading provided by the leaf foliage of plants, thermal mass of the soil, and evaporation/evapotranspiration (adiabatic cooling) effect of water evaporation from the soil and leaf surface enabling conductive heat loss from the roof sheet below which in-turn reduces mean radiant temperature of the occupied space below, in addition to serving as a source of food for the household.

Figure 40: Rooftop Garden (on a tin-roofed house)

iii. Radiant Barrier

Radiant barriers consist of a highly reflective material that reflects radiant heat rather than absorbing it thereby reducing indoor temperature when retrofitted to the roof. They can be installed as static barriers (under the roof) and also dynamic over the roof barriers i.e. they can be opened and closed, thereby facilitating cooling through shading the roof from the sun's heat when closed during the day and from night-sky radiation when opened at night.

Appropriate Technologies

a. **Alufoil Static Installation:** Alufoil a cross-linked polyethylene foam (also known as XLPE) is a closed-cell foam characterised by a compact feel and resistance to water. It is covered with a low-emissivity and high reflectivity aluminium coating on one side which ensures no heat is emitted to the surrounding surfaces. When stuck under the roof with a strong adhesive with its shiny side facing downwards alufoil supports insulation and ensures that the heat coming through the roof doesn't get transferred to the house as the shiny side facing down doesn't emit the heat absorbed by the foam. In the context of the material used, explore and substitute currently used industrially produced alufoil with local and reused inorganic waste materials such as reused inner reflective lining of MLP packets.

Figure 41: Alufoil Static (under a tin-roof)

b. **Alufoil Pipe Motor:** Alufoil a cross-linked polyethylene foam (also known as XLPE) is a closed-cell foam characterised by a compact feel and resistance to water. It is covered with a low-emissivity and high reflectivity aluminium coating on one side which ensures no heat is emitted to the surrounding surfaces. The pipe motor installation comprises an alufoil sheet (configured as a folded 'accordion' horizontally deployed 'curtain') that extends over the entire primary roof in its closed position, functioning as a radiant barrier that blocks solar radiation during the day time i.e. the roof is 'shaded' through this mechanism in the day time. After sun-down, to promote radiation of internally accumulated heat embedded in the roofing material and re-radiation of ambient heat absorbed during the day, the Alufoil sheet retracts, eliminating any impediment to heat transfer that is achieved by exposing the primary roofing material to the cool night sky which facilitates the process of natural cooling through night sky radiation. This diurnal cycle of operation restores thermal comfort conditions within the structure below to acceptable conditions that promote human wellbeing. In the context of the fabrication of this installation and the material used,

explore alternatives for local fabrication through the deployment of appropriate technology and substitute currently used industrially produced alufoil with reused inorganic waste, biodegradable hand-crafted materials (e.g. khadi, sheep wool, rice-husk, areca nut leaf-based panels with reused inner reflective lining of MLP packets).

Figure 42: Alufoil Pipe Motor (on a tin-roofed house)

c. **Alufoil Chain Sprocket:** Alufoil a cross-linked polyethylene foam (also known as XLPE) is a closed-cell foam characterised by a compact feel and resistance to water. It is covered with a low-emissivity and high reflectivity aluminium coating on one side which ensures no heat is emitted to the surrounding surfaces. The chain sprocket installation comprises an exo-skeletal structure (functioning as an operable 'second' roof) that extends over the entire primary roof in its closed position, functioning as a radiant barrier that blocks solar radiation during the day time i.e. the roof is 'shaded' through this mechanism in the day time. After sun-down, to promote radiation of internally accumulated heat embedded in the roofing material and re-radiation of ambient heat absorbed during the day, the panels assume a vertical position, eliminating any impediment to heat transfer that is achieved by exposing the primary roofing material to the cool night sky which facilitates the process of natural cooling through night sky radiation. This diurnal cycle of operation restores thermal comfort conditions within the structure below to acceptable conditions that promote human wellbeing. In the context of the fabrication of this installation and the material used, explore alternatives for local fabrication through the deployment of appropriate

technology and substitute currently used industrially produced alufoil with reused inorganic waste, biodegradable hand-crafted materials (e.g. khadi, sheep wool, rice-

Figure 43: Alufoil Chain Sprocket (on a tin-roofed house)

husk, areca nut leaf-based panels with reused inner reflective lining of MLP packets)

d. **Alufoil Sliding:** Alufoil a cross-linked polyethylene foam (also known as XLPE) is a closed-cell foam characterised by a compact feel and resistance to water. It is covered with a low-emissivity and high reflectivity aluminium coating on one side which ensures no heat is emitted to the surrounding surfaces. The sliding installation comprises an exo-skeletal structure (functioning as an operable 'second' roof) that extends over the entire primary roof in its open position, functioning as a radiant barrier that blocks solar radiation during the day time i.e. the roof if 'shaded' through this mechanism in the day time. After sun-down, to promote radiation of internally accumulated heat embedded in the roofing material and re-radiation of ambient heat absorbed during the day, the installed apparatus folds into a stack of panels in its closed position, thereby exposing a majority of the primary roofing material to the cool night sky which facilitates the process of natural cooling through night sky radiation. This diurnal cycle of operation restores thermal comfort conditions within the structure below to acceptable conditions that promote human wellbeing. In the context of the fabrication of this installation and the material used, explore alternatives for local fabrication through the deployment of appropriate technology and substitute currently used industrially produced alufoil with reused inorganic

waste, biodegradable hand-crafted materials (e.g. khadi, sheep wool, rice-husk, areca nut leaf-based panels with reused inner reflective lining of MLP packets)

Figure 44: Alufoil Sliding (on a tin-roofed house)

iv. Insulation

Thermal insulation reduces heat transfer and helps minimise indoor temperatures when incorporated in a house structure.

Appropriate Technologies:

a. **Wood Wool Panel:** Wood Wool Panel is an environment-friendly, recyclable material made from wood wool, cement and water. It is installed under the roof. It supports insulation and ensures that the heat coming through the roof doesn't get transferred to the house. Other insulation materials e.g. Reused inorganic waste, hand-crafted materials etc can be explored with alternatives for local fabrication through deployment of appropriate technology.

Figure 45: Wood Wool Panel (under a tin-roof)

v. Ventilation

Ventilation makes use of natural forces such as wind and thermal buoyancy to circulate air to and from an outdoor space, facilitating indoor cooling.

Appropriate Technologies:

a. **Dormer Window:** Dormer window is a hump shaped window that is designed to be retrofitted onto existing corrugated steel/tin/cement roofs. It is made of fibreglass moulded into a hump to be retrofitted. The pane is made of translucent plastic to diffuse light and avoid glare. The mechanism works on the principle of convective ventilation where warm air rises up and vents out of the Dormer window. The window ideally needs to be fit on the highest available height for the principle to function. The fibre reinforced plastic is moulded into a hump with an opening at the bottom towards the interior of the house to allow warm air to circulate and vent. The gap is covered with a metal net to prevent insects and other animals from getting in the house. The translucence of the fibre-glass material used for fabricating the moulded window also enables the ingress of natural light into the interior space. In the context of fabrication, alternatives for local fabrication should be explored through deployment of appropriate technology, and industrial materials should be substituted with reused inorganic waste, biodegradable hand-crafted materials, as appropriate.

Figure 46: Dormer windows

vi. Low-cost modular active cooling

Active cooling mechanisms are dependent on energy sources (i.e. electric, solar, etc) to facilitate cooling. Low-cost modular sustainable active cooling mechanisms are more energy-efficient, affordable and less ecologically destructive than conventional energy guzzling, climate polluting air-conditioners.

Appropriate Technologies:

a. **DIY (Do-It-Yourself) Structure Cooling 'Kit':** A structure cooling system removes the heat in the structure by way of water flowing through pipes. It impedes solar heat gain from roof and floors by absorbing it before causing thermal discomfort to occupants. The system comprises piping, storage tank, a cooling system and a pump which are locally available. The only active elements are a pump & fan that use negligible energy that a Solar PV Panel can address.

b. **DIY Evaporative Cooling Kit:** These systems work on the principle that water (like all liquids) extracts heat from the surrounding environment when it undergoes phase-change from a liquid to a vapor. In these systems, a fan draws hot outside air through the water-soaked pads. Adding heat to this water evaporates it. When this evaporated water vapor is combined in the air, the air temperature is reduced. A temperature reduction of as much as 20 degrees can be achieved using this system of cooling. These DIY coolers can be made from readily available local hardware materials and can be assembled by residents of informal settlements if supported through assembly instruction manuals developed through human-centric design processes.

c. **DIY Desiccant Dehumidification Wheel Kit:** Desiccant dehumidifiers contain a desiccant wheel with a silica gel surface, a drive motor and belt, a small heater (which can be solar-thermal powered to reduce dependence of electrical energy), and a blower. Damp outdoor air is drawn into the dehumidifier, passing through the slowly turning desiccant wheel where moisture is adsorbed and collected on the silica gel. Most of the dry air enters the indoor space in informal settlement homes while a small portion of the dry air is reactivated by heating through the solar thermal panel. This warmed, dry air, called regeneration air, is passed through the desiccant wheel to dissipate the moisture collected on its surface, regenerating the silica gel on the wheel. These low-energy dehumidification systems will become imperative to respond to extreme thermal stress (caused by a combination of high air temperatures and high humidity) in informal settlements in Indian cities which might be currently classified as belonging to hot-dry climatic zones (e.g. Pune) but are anticipated to experience acute increases in humidity and precipitation as climate change effects intensify in the coming years and decades. The periods when high temperature and humidity intersect are significantly more hazardous to human health than when either one of these effects are dominant. At these times, merely relying on passive cooling solutions will not achieve adequate mitigation of heat stress that protects human health and wellbeing, and these active cooling solutions which can address extreme humidity, will become essential. Most elements of these DIY desiccant dehumidifiers can be made from readily available local hardware materials, regionally produced solar panels, and small amounts of industrial chemicals (silica-gel) and can be assembled by residents of informal settlements if supported through assembly instruction manuals developed through human-centric design processes.

d. **DIY Thermostorage 'Ice-Box' ACs:** These systems hinge upon the use of either chilled phase-change-materials (e.g. silica gel packs used for household remedies for healing inflammations etc.) or ice blocks to achieve cooling and dehumidification of indoor spaces. The primary mechanism employed in these systems is the blowing of ambient air over these cold surfaces (configured as portable replaceable cartridges that can hold the gel packs or reusable plastic ice cubes) placed in insulated boxes (e.g. thermocol boxes) and the re-directing of this cold air through tubes ducts etc. towards occupants of the indoor space (i.e. point of use cooling, similar to systems employed in automobiles and aircrafts which rely upon directly cooling the air volume around the occupant rather than cool the entire volume of air in the space) The regeneration of the functional materials that have exhausted their cooling capacity can be accomplished at local small-scale solar-thermal energy based chilling plants (using Solar VAM Technology) and be operated by women's cooperatives as a micro-scale local business.

8.2.1.2. Implementation Strategy

The strategy is rooted in knowledge-sharing, collaboration and network building to facilitate creating space for residents' perspective integration to enable context-appropriate needs-based thermal comfort technology implementation.

It comprises 'annual' awareness drives, capacity building trainings and the development of an online 'PCMC-Informal Housing Thermal Comfort One-Stop-Shop (OSS)' and offline ward-based OSS centres, to:

a. Enable self-implementation of appropriate cooling technologies by residents.

b. Establish an 'Informal Housing Thermal Comfort' service ecosystem comprising women's cooperatives, fabricators, welders, material suppliers, microfinance institutions and other service providers.

i. PCMC- Informal Housing Thermal Comfort Digital One-Stop-Shop (OSS):

Integrate an 'Informal Housing Thermal Comfort OSS' digital portal on the PCMC website (similar to the Citizen Facilitation Centre portal) through the Department of Information and Technology to:

a. Provide citizens and service providers with technical information on thermal comfort providing appropriate technologies for self-implementation.

b. Provide citizens with technical service provider contacts (e.g. suppliers, fabricators, house auditors, electricians, installation persons, etc)

c. Provide citizens with financial service provider contacts (e.g. microfinance institutions, etc)

d. Provide citizens with a platform to apply for and track progress of 'thermal comfort retrofit service implementation and maintenance' by women's cooperatives (Responsibilities of women's cooperatives are detailed in Annexure 5)

e. Provide women's cooperatives, suppliers, fabrication and installation persons, financial institutions and other service providers with a platform to indicate their availability to support citizens with thermal comfort retrofit implementation and maintenance.

f. Create a platform for women's cooperatives to access financial resources from CSRs, city electric utility driven DSM programs[1], microfinance institutions, impact investment platforms, etc.

g. Enable residents (i.e. people inhabiting informal settlements in PCMC) and other non-resident thermal comfort practitioners (e.g. researchers, research institutes, etc) to notify the PCMC of new thermal comfort innovations and share details of the same

through the OSS platform, which can be reviewed by the PCMC (e.g. by the Environmental engineering department) and cleared for updating to the OSS.

(A draft suggestive design for the OSS portal is detailed in Annexure 4)

ii. OSS - Physical centre establishment and operation:

Set up ward-level physical OSS centres and operate them year-round for people without access to and experience with digital technology (e.g. smartphone, computers, etc.) to:

a. Share thermal comfort retrofit information through print mediums such as pamphlets, posters, booklets, etc.

b. Facilitate registration to the OSS portal through a digital system (e.g. computer, smart phone), as requested by a resident or service provider.

iii. Annual awareness drives to inform citizens about thermal comfort retrofits and the OSS:

1. Train and contract local NGOs to conduct annual physical ward-level awareness drives (preferably during every October heat period i.e. when the thought of summer-heat is alive, to enable proactive implementation and maintenance of thermal comfort solutions before the peak summer period) to inform people about the availability of cooling measures, the OSS digital and physical centres.
2. Conduct digital and print media awareness campaigns through the Department of Information and Public Relations, to inform people about the availability of indoor cooling measures, OSS digital portal and physical centres, annually (preferably during every October heat period i.e. when the thought of summer-heat is alive and to enable proactive installation and maintenance of thermal comfort retrofits before the peak summer period)

iv. Annual awareness drives to inform service providers about thermal comfort retrofit based skill building certificate programs:

1. Contract local NGOs to conduct physical awareness drives to inform fabrication, installation persons, house auditors and women's cooperatives of thermal comfort intermediate technology service providing technical and management skills certificate programs, before every annual training program period.
2. Conduct digital and print campaigns through the Department of Information and Public Relations to inform fabrication, installation persons, house auditors and women's cooperatives of thermal comfort intermediate technology service providing technical and management skills certificate programs, before every annual training program period.

v. Thermal comfort retrofit service provider skill building through annual certificate training programs:

1. Contract experienced thermal comfort retrofit design and social engagement practitioners to conduct technical, safety supervision and social engagement Training of Trainer (TOT) workshops of cooling interventions, with relevant vocational training partners (e.g. CSOs, ITI institutes, etc). These trainings can be supported by CSR programs, impact investment platforms etc.
2. Contract experienced vocational training CSOs and government training institutes (e.g. ITI institutes) to conduct annual thermal comfort retrofit certification training programs for fabrication and installation persons, house auditors, women's cooperatives etc. These trainings can made accessible to program participants for a minimal refundable fee (this is to ensure accountability by participants through the training process) or full scholarship (in cases where participants are unable to pay the refundable fee). Training costs can be supported majorly by government schemes, CSR programs, impact investment platforms, city utility DSM programs, etc.
3. Contract vocational training CSOs to conduct Women's Cooperative vocational training management certification programs, annually. These trainings can made accessible to program participants for a minimal refundable fee (this is to ensure accountability by participants through the training process) or full scholarship (in cases where participants are unable to pay the refundable fee). Training for women's cooperatives can be supported through already existing PCMC schemes e.g. PCMCs 'Entrepreneurship development program' (Scheme No.7). CSR programs, impact investment platforms etc. can be other sources of funding to enable management training for women's cooperatives through full scholarships.

8.2.2. Facilitate the implementation of outdoor cooling strategies through a contextual approach in marginalised urban settlements.

8.2.2.1. Outdoor Cooling Strategies

Informal settlements in urban spaces are most vulnerable to the 'Urban Heat Island effect' resulting from high density of built mass, and hardscaping of pavements, open spaces and roads with concrete blocks that absorb and retain heat contributing to increased outdoor temperatures in a city.

Restoration of degraded water bodies and the integration of rainwater harvesting infrastructure with the use of local materials and intermediate technology to support groundwater recharge are recommended to facilitate thermoregulation of the microclimate in informal settlements and cities as a whole. These are to be implemented in consultation with stakeholders from the community through a participatory approach.

i. Rainwater Harvesting (RWH)

Drastic reduction in underground moisture and groundwater table diminishes thermal mass, and the beneficial dampening effect of a terrain which inflames the urban heat island effect. Water deprivation further severely undermines the possibility of urban agriculture, and rooftop gardening atop homes; both of which are field-verified solutions to address extreme indoor heat stress and contributors to food resilience amongst marginalised communities. Rainwater harvesting for groundwater recharge is an urban heat-island effect minimising strategy in the micro-climate of informal settlements. The implementation strategy for this intervention is mentioned under section 8.2.2 (A).

Appropriate Technologies:

Rainwater harvesting for groundwater recharge can be facilitated by installing an MLP/Jute/Bamboo-panel based 'pergola' for rainwater capture atop structurally supported metal & cement-asbestos sheet roofs with/without rooftop garden and storing the rainwater using rubber 'bellows' and/or storage bags and a network of recharge pits. In houses with rooftop gardens, the groundwater can be directed upwards through a network of ring wells and submersible pumps.

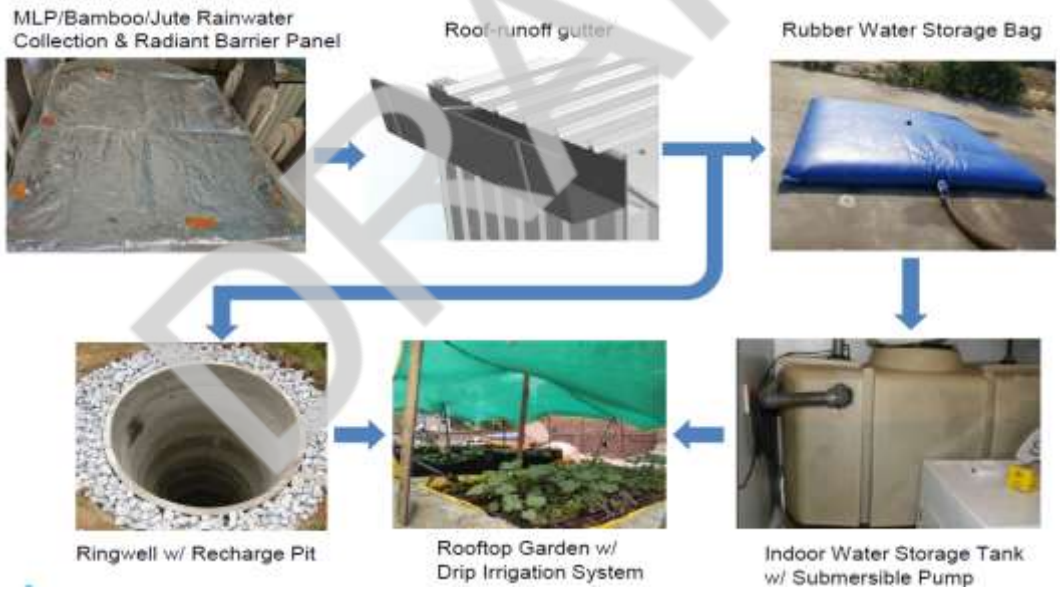

Figure 47: Rainwater Harvesting System (Preliminary Design)

ii. Waterbody Revival

Presently most water bodies in urban areas manifest deterioration due to pollution and concretization of the water body e.g. walls around the edges and, concrete paved banks, etc. which negatively impact temperature regulation among other life-supporting abilities by these ecosystems.

Restoration and conservation of nature-based solutions such as water ecosystems located in (e.g. ponds, lakes etc.) and passing through (e.g. rivers, rivulets, streams,) informal settlements, with a socio-ecologically sensitive manner through participatory engagement processes should be prioritised to facilitate heat island effect mitigation in informal settlements.

Nature Based Solutions:

Naturally occurring water bodies are ecosystems comprising the water itself, the water-bank, the bed of the water body, local flora and fauna. From a thermal comfort perspective water facilitates cooling through evaporation and heat absorption, while the flora supports cooling through evapotranspiration in addition to shading from trees. The water banks additionally facilitate groundwater recharge which supports temperature reduction, as described in section 8.2.1.1. Water Bodies as a whole therefore contribute to the creation of more comfortable environments by mitigation of the Urban Heat Island effect. They also offer co-benefits such as carbon sequestration and storm water management in addition to other ecosystem services.

Restoring a waterbody should involve simulating its natural form including its vegetation, terrain, etc. When undertaken in the context of informal settlements, such processes should be facilitated through a participatory approach primarily in consultation with informal housing community members among other stakeholders and conservation should be supported through the incorporation of governance mechanisms. For the implementation strategy refer to 8.2.2 (B)

8.2.2.2. Implementation Strategy

A. Rain Water Harvesting

1. **Integrate RWH infrastructure with local materials and intermediate technologies as part of already existing PCMC initiatives:**
    1. Integrate RWH system deployment through local materials and intermediate technology as part of the PCMCs Sustainability Cells' 'Environment Conservation Initiative' that mandates Rain Water Harvesting in institutional establishments.
    2. Integrate incentivization of RWH through local materials and intermediate technologies in informal settlements as part of the 'Sustainable Urban Landscape' initiative of PCMCs Sustainability cell which incentivizes RWH.
2. **Integrate RWH as part of OSS services:**

    Incorporate RWH technical trainings as detailed under the indoor cooling strategy implementation plan (ref 1.2) to contract trained personnel e.g. Engineers, plumbers, women's cooperatives etc. for RWH system implementation and maintenance. (Ref. 8.2.1.2.V)

3. Integrate RWH as part of annual awareness drives to inform service providers about thermal comfort service-based skill building certificate programs (ref 1.2.)**:**

1. Contract local NGOs to conduct physical awareness drives to inform fabrication, installation persons, house auditors and women's cooperatives of thermal comfort intermediate technology service providing technical and management skill certificate programs, before every annual training program period.
2. Conduct digital and print campaigns through the Department of Information and Public Relations to inform fabrication, installation persons, house auditors and women's cooperatives of thermal comfort intermediate technology service providing technical and management skills certificate programs, before every annual training program period.

4. Integrate RWH as part of annual awareness drives to inform citizens about thermal comfort intervention options and OSS portal (ref 1.2)**:**

1. Train and contract local NGOs to conduct annual physical ward-level awareness drives to inform people about the availability of indoor cooling and outdoor cooling measures (including RWH), the OSS digital and physical centres (preferably during every October heat period i.e. when the thought of summer-heat is alive, to enable proactive implementation of thermal comfort solutions before the peak summer period).
2. Conduct digital and print media awareness campaigns through the Department of Information and Public Relations, to inform people about the availability of indoor cooling measures and outdoor cooling measures (including RWH), OSS digital portal and physical centres, annually (preferably during every October heat period i.e. when the thought of summer-heat is alive and to enable proactive installation of thermal comfort retrofits before the peak summer period)

B. Waterbody Revival

1. Incorporate 'Waterbody Revival and Conservation' in informal settlements as part of already existing conservation initiatives by PCMC:

E.g. Incorporate revival of waterbodies located in and passing through informal settlements as part of the PCMC Sustainability Cells 'Environment Conservation Initiatives'.

2. Integrate water body revival in the narrative of annual cooling awareness drives:

1. Train and contract local NGOs to conduct annual physical ward-level awareness drives to inform people about the availability of indoor cooling and outdoor cooling measures (including RWH) and the need for water body revival, as applicable to their contexts.
2. Conduct digital and print media awareness campaigns through the Department of Information and Public Relations, to inform people about the availability of indoor cooling and outdoor cooling measures (including RWH) and the need for water body revival, as applicable to their contexts.

3. **Co-create waterbody revival plans and undertake implementation 'with' the community to avoid exacerbating problems faced by already vulnerable inhabitants of informal settlements**:

Co-create a plan and undertake a contextually relevant implementation process (i.e. a process that is sensitive to the socio-economic, ecological and climatic context) developed through a participatory approach i.e. 'in consultation and with support from residents' who are knowledgeable about their context, in collaboration with practitioners who have experience with water body revival through nature-based solutions, intermediate technologies and other related restoration and conservation activities (e.g. social scientists, ecologists, health department, environmental engineering department, garden department etc)

4. **Facilitate the development of water body governance systems as part of conservation efforts:**

Contract social science practitioners to facilitate the establishment of local water body governance institutions (e.g. water cooperatives, federations etc) with representation from stakeholders located along the water body including informal housing residents, ward representatives and other entities etc. for grassroots ownership to cultivate sustained reciprocity towards the water body for its life-supporting services (flood control, cooling, mental and physical health revival, etc)

Short Term and Long-Term Actions for Indoor and Outdoor Cooling in Informal Settlements based on Policy Recommendations

1. **Short-term Actions:**

Timeframe- 1.5 years (max)

Action Steps:

1. Undertake implementation of rooftop gardens in public schools in PCMC similar to the School Kitchen Gardening Initiative by the BMC[2] through a context-based implementation approach i.e. in consultation with users of the space.
2. Undertake pilot demonstrations of indoor cooling thermal comfort retrofit solutions in each PCMC ward (e.g. installations in a minimum of 15 houses per ward of which a minimum of 3 houses are retrofitted with the same or similar intermediate technologies).
3. Undertake foundation building for long term actions (e.g. networking, collaborations, OSS digital portal creation, etc)

2. Long-term Actions:

Timeframe - Annual

Action steps:

1. Operate the online and offline Informal Housing Thermal Comfort One-Stop-Shop portals.
2. Conduct annual awareness drives to inform citizens about thermal comfort intervention options and OSS portal.
3. Conduct annual awareness drives on thermal comfort training certificate programs.
4. Conduct annual capacity building certificate programs for informal housing thermal comfort service providers.
5. Facilitate conservation activities for degraded water bodies 'with' residents from informal housing communities.

Management Timeline:

The management plan for PCMC focuses on short-term and long-term measures. In the short term (1-3 years), actions include providing drinking water points, installing mist sprays, shading public spaces, using tinted windows in public transport, and implementing early heat warning systems. Planting trees, building shelters, installing green roofs/facades, and promoting light/bright colours are also priorities.

Long-term efforts involve greening streets, unsealing surfaces, implementing green building guidelines, developing green infrastructure, promoting public transport, and enhancing urban planning for parks, tree cover, and walkability. These measures aim to reduce heat stress and create a healthier urban environment.

1-3-year prioritization of work

- **Drinking water**
  Provision of drinking water points on major roads where pedestrian movement is seen maximum.

- **Water Mist spray**
  Installation of mist sprays in public places like traffic junctions and bus stops to provide temporary relief from heat
  .

- **Shading of public spaces**
  Shading roads exposed to direct heat with green nets such as at major traffic junctions.

- **Tinted windows public transport**
  Installation of tinted windows for public transport to provide effective sunshade and reduce cooling energy consumption.

- **Early heat warning**
  Implement early heat warning systems across different communication channels such as social media, apps and T.V.

- **Trees for greening and shading**
  Plant trees along walking and cycling routes to provide shade and create a natural habitat for wildlife.

- **Bus/tram shelters**
  Building shelters in most of the public transport stops to give passengers a space for relaxation out of the extreme heat.

- **Installing weather stations** in PCMC
  Defining heat waves lack specificity for local contexts within cities. Installing weather stations in PCMC would enable a better understanding of various climatic indicators and facilitate the development of more effective mitigation strategies.

- **First Aid services**
  Ensure provisioning of first-aid kit, ice packs, drinking water at specific intervals. Also offer information and advice to help individuals plan and adapt to hot weather conditions.

- **Light/bright colours**
  Consider using light/bright colours for surfaces as they have low heat absorption and turnover. Apply light/bright colours for pathways, building exteriors to reduce absorbed solar radiation.

Long term prioritization of work

- **Greening of streets**
  Planting trees on streets and developing liveable streets.

- **Unsealing the surfaces**
  To reduce the impervious surfaces that store the heat and add to the urban heat island effect.

- **Implementing green building guidelines**
  To implement the green building guidelines while planning and constructing the new buildings.

- **Green infrastructure**
  To implement the green infrastructure measures such as parks, urban gardens, green roofs etc which promote biodiversity and ecosystem health. It aids stormwater management that captures and filters rainwater into the ground.

- **Public Transport**
  Promotion of public transport to reduce air pollution and heat.

- **Critical urban planning**
  Securing parks and playgrounds, having abundant tree cover, and making more walkable and bicycle-friendly. Provision of infrastructure for heat periods while planning new areas e.g. parks can have provision of poles for installing temporary shelters, water fountains etc.

Chapter IX:

Implementation, Monitoring, and Evaluation of the Heat Action Plan

Introduction

As climate change intensifies, the frequency and severity of heatwaves pose significant challenges to urban communities worldwide. In response to these threats PCMC has taken up an initiative to develop comprehensive heat action plan to safeguard the health and well-being of their residents. However, the effectiveness of such plans relies not only on their design but also on their implementation, monitoring, and evaluation. At the heart of any successful heat action plan lies a commitment to continuous monitoring – a vigilant and proactive approach to tracking the plan's progress and outcomes. This chapter delves into the pivotal role of implementation and monitoring in ensuring the efficacy of a city's heat action plan. By delineating key steps and strategies, cities can navigate the complexities of heatwave preparedness and response with precision and effectiveness.

Implementation and Monitoring

Implementation and monitoring are the essentials of effective heatwave preparedness and response. By establishing robust monitoring mechanisms, fostering transparent communication, and embracing adaptive management practices, cities can navigate the complexities of extreme heat events with resilience and efficacy.

Continuous monitoring of the activities listed under the heat action plan is critical to ensure its effectiveness. The following steps outline the key aspects of implementation and monitoring:

1. Continuous Monitoring: Continuous monitoring is the cornerstone of effective heat action plan implementation. A dedicated team will be responsible for monitoring the execution of activities outlined in the heat action plan. This involves regular surveillance of weather forecasts of dedicated weather stations in PCMC, heat-related incidents, and the implementation progress of preventive measures. By maintaining a constant vigil, cities can proactively identify emerging threats and swiftly mobilize resources to mitigate potential risks.

2. Stakeholder Updates: Regular communication channels can be established to provide stakeholders and authorities with timely updates on plan implementation. Transparency and collaboration are fundamental to the success of any heat action plan. This open dialogue not only enhances transparency but also fosters a sense of shared responsibility and ownership among all stakeholders. By keeping stakeholders informed and engaged, cities can leverage

collective expertise and resources to confront the challenges posed by extreme heat effectively.

3. Problem Identification: In the dynamic landscape of heatwave response, challenges and obstacles are inevitable. The monitoring process will identify any problems or bottlenecks encountered during implementation. This could include logistical challenges, resource constraints, or unforeseen obstacles. Through adaptive management practices, cities can adjust their strategies and practices to navigate unforeseen obstacles and ensure the seamless execution of the heat action plan.

4. Adjustment of Practices: Upon identifying issues, the team will adjust practices as appropriate to resolve problems and ensure the best outcomes. Flexibility and adaptability are key in responding effectively to changing circumstances.

Evaluation

In the realm of urban resilience and disaster preparedness, "what gets measured gets managed" holds particular significance. For cities striving to confront the escalating threat of extreme heat events, evaluating the efficacy of their heat action plans is not just prudent but imperative. The evaluation process serves as a critical mechanism for gauging the impact of interventions, identifying areas for improvement, and enhancing overall resilience to heatwaves.

At the heart of the evaluation process lies a comprehensive examination of processes, outcomes, and impacts – each offering valuable insights into the performance and effectiveness of the heat action plan.

Process Evaluation: Unveiling Operational Efficiency

Process evaluation delves into the operational intricacies of the plan, scrutinizing communication strategies, logistical arrangements, and implementation procedures. Key questions guide this inquiry, probing the efficacy of various processes, soliciting feedback from partners and participants, assessing cost-effectiveness, and pinpointing bottlenecks to communication and logistics. By unravelling the operational dynamics, cities can identify strengths, weaknesses, and opportunities for streamlining future interventions.

Following are some key questions to guide the inquiry under Process Evaluation:

- Communication Strategies:

How effective were the communication strategies in disseminating information about heatwave preparedness and response measures?

Were the communication channels accessible and comprehensible to all segments of the population?

Did the messaging resonate with the target audience, fostering understanding and awareness?

- Logistical Arrangements:

How efficiently were resources allocated and distributed during the implementation of the heat action plan?

Were logistical arrangements robust enough to support timely responses to heatwave events?

Were there any logistical challenges or constraints encountered, and how were they addressed?

- Implementation Procedures:

Were the implementation procedures clearly defined and understood by all stakeholders involved?

How well were the various components of the heat action plan executed, from early warning systems to emergency response protocols?

Were there any deviations from the planned implementation, and if so, what were the reasons behind them?

- Cost-Effectiveness:

Was the implementation of the heat action plan cost-effective, considering both financial resources and personnel time?

Were resources allocated efficiently to achieve the desired outcomes?

Were any cost-saving measures identified or implemented without compromising effectiveness?

- Bottlenecks to Communication and/or Logistics:

Were there any bottlenecks or inefficiencies in communication channels, hindering the dissemination of critical information?

Did logistical bottlenecks impede the swift and effective implementation of response measures during heatwave events?

How were these bottlenecks identified and addressed, and what strategies were employed to prevent recurrence in the future?

Outcome and Impact Evaluation: Measuring Real-World Effects

Outcome and impact evaluation pivot towards assessing the tangible effects of the heat action plan on the ground.

Did the Plan Function as Envisioned? To what extent did the outcomes of the heat action plan align with the anticipated goals and objectives?

Were there any unforeseen consequences or unintended outcomes resulting from the implementation of the plan?

How effectively did the heat action plan address the needs and vulnerabilities of at-risk populations, such as the elderly, children, and individuals with pre-existing health conditions?

Were there any disparities in access to resources or services among different demographic groups, and if so, how were they addressed?

What trends do scientific data and health records reveal regarding heat-related illnesses, hospital admissions, and mortality rates during the implementation period of the heat action plan?

Are there any discernible patterns or correlations between the implementation of specific interventions and changes in health outcomes?

Can the implementation of the heat action plan be linked to measurable reductions in morbidity and mortality rates attributable to heat-related illnesses?

Are there any indicators or metrics that demonstrate a decrease in adverse health outcomes as a result of the plan's interventions?

To what extent did the heat action plan contribute to raising awareness about heatwave risks and promoting adaptive behaviours among residents?

Were there observable changes in public attitudes, behaviours, or preparedness levels in response to the plan's communication and outreach efforts?

What perceptions and feedback were expressed by residents, community organizations, and the media regarding the effectiveness and impact of the heat action plan?

Were there any notable success stories, challenges, or areas for improvement identified through community feedback and media coverage?

These questions form the crux of outcome and impact evaluation, offering a nuanced understanding of the plan's real-world effects. By examining changes in awareness, behaviours, and media perceptions, cities can gauge the broader societal impact of their interventions.

Guided by Feedback and Data

Central to the evaluation process is the synthesis of feedback from residents, partners, and scientific data. This multifaceted approach provides valuable insights into the plan's performance, offering a holistic perspective that transcends mere metrics. By leveraging qualitative and quantitative data sources, cities can derive actionable insights, refine strategies, and chart a course towards greater resilience to heatwaves.

Plan Improvement

Based on evaluation findings, the heat action plan undergoes iterative improvement. Lessons learned and evaluation results inform updates to strategies, resource allocation, and partnerships. The plan is refined to remain relevant and effective in addressing evolving heat-related challenges. Dissemination of the updated plan ensures widespread awareness and engagement among officials and participants, fostering collective action in heat preparedness and response efforts.

Based on the evaluation findings, changes will be identified to improve outcomes and processes for the next heat season. These changes may include updates to strategies, allocation of resources, or strengthening partnerships.

1. Updating the Plan: The heat action plan will be updated based on the lessons learned and evaluation results. This ensures that it remains relevant and effective in addressing heat-related challenges.

2. Dissemination of Updated Plan: The updated plan will be disseminated to officials and participants to ensure widespread awareness and engagement in heat preparedness and response efforts.

A robust monitoring and evaluation framework are indispensable in the effective implementation and assessment of a city's heat action plan. By continuously monitoring activities, evaluating processes, outcomes, and impacts, and iteratively improving the plan, cities can enhance resilience to heatwaves and protect the health and well-being of their residents.

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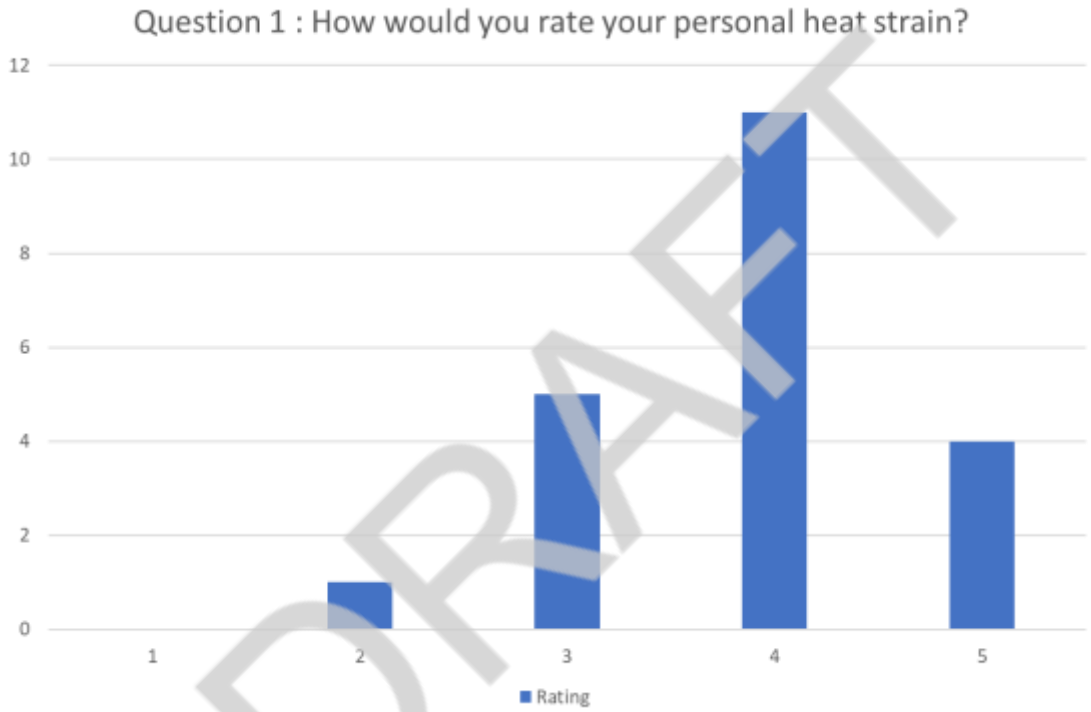
Annexures:

Annexure 1:

The attached annexure presents the consolidated results of the from the stakeholder consultation meeting providing valuable insights from stakeholder engagement across distinct stakeholder groups.



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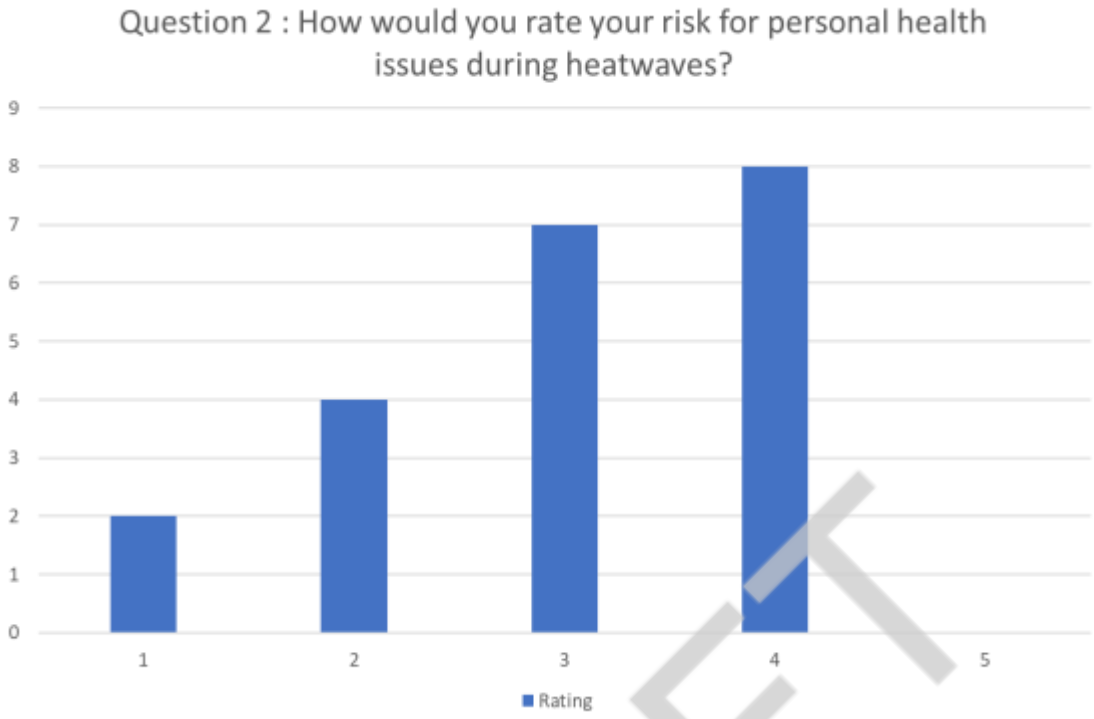
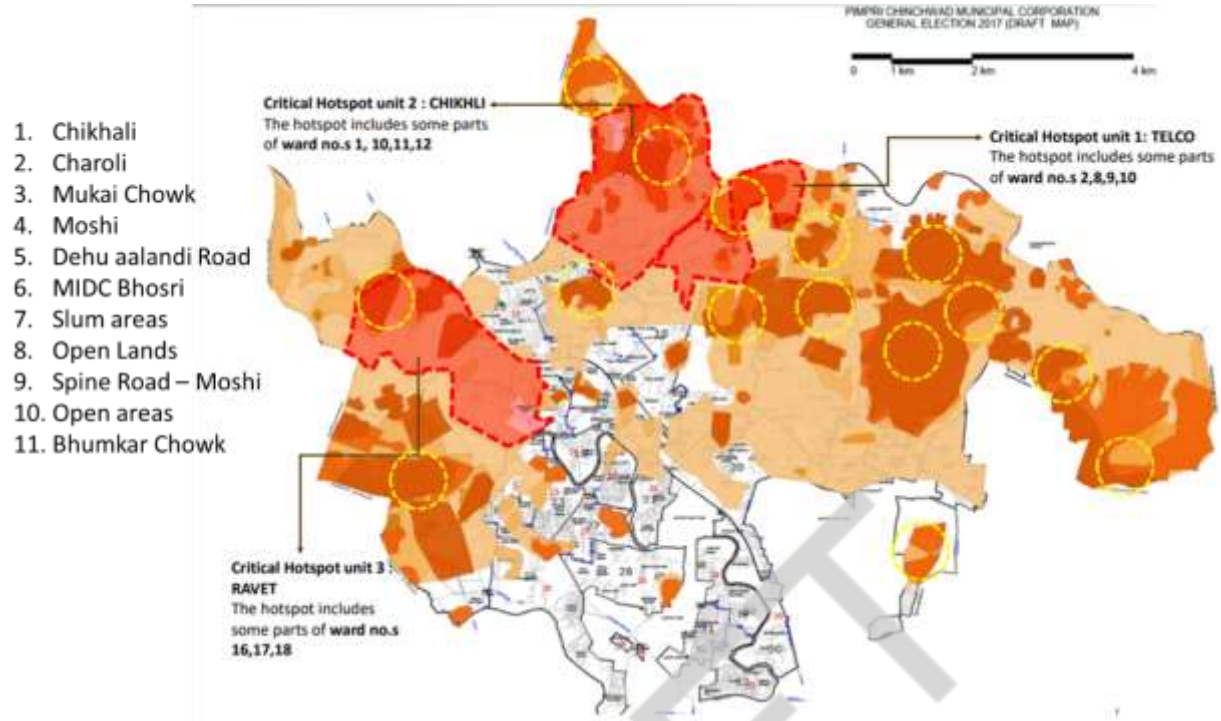
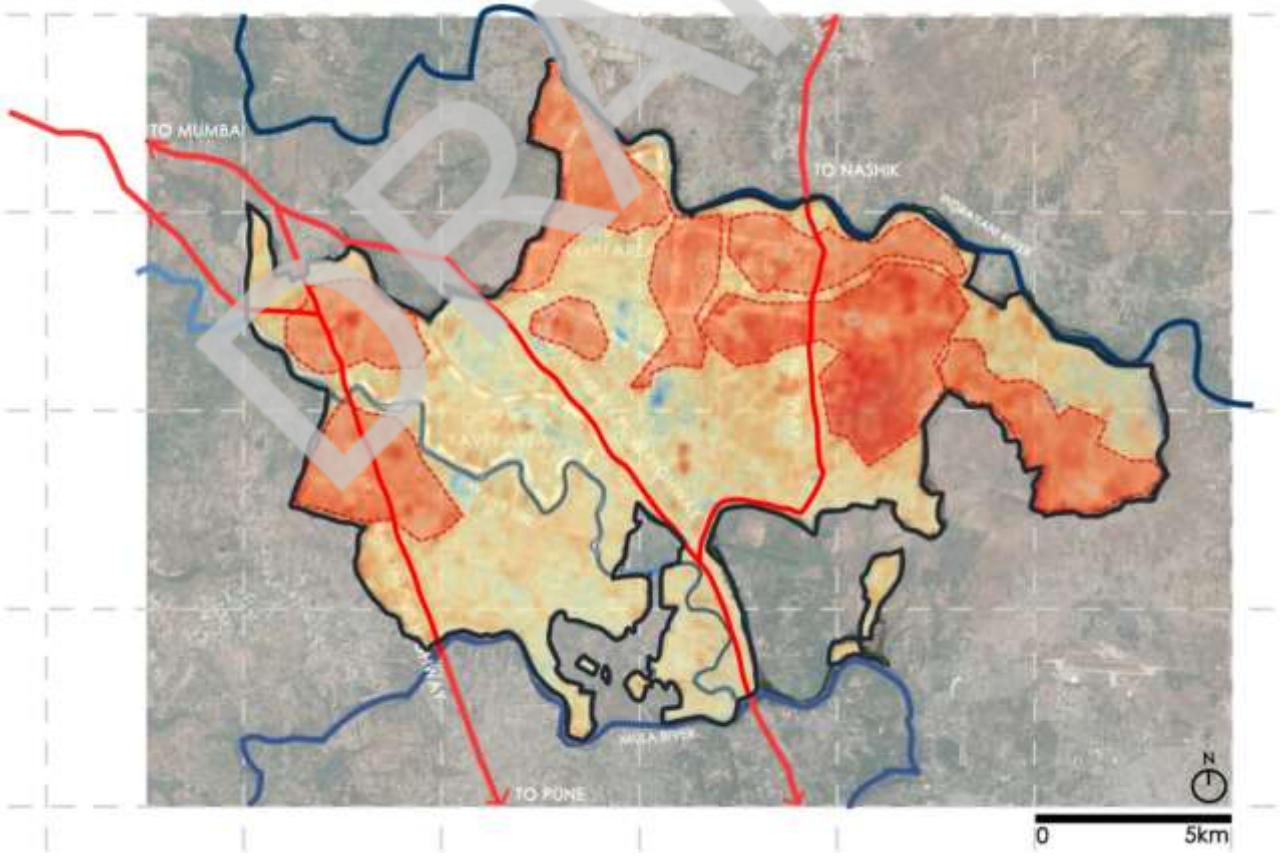


1= Low 5= High

Question 3: What do you do during an episode of heat to protect yourself?

Question 4: Based on your experience, Identify vulnerable areas within the city from heat perspective.





Question -7: Evaluate which mix of communication modes (e.g., radio, billboards, television, flyers, social media), languages and messengers will be most effective in reaching your people in case of heat emergency

Question -8: What could be your role in HAP and what assistance is expected?


Plantation of native trees
Drink plenty water
Stay at home
Zero carbon emissions
Green roof
Reflective paint on roof
Public garden to be kept for long period
Watering the plants
Permeable surfaces
Watering the plants
Ground water recharge
Trees along the road
RECYCLE
REUSE
REDUCE
No waste
Strengthen mobility
Vertical garden for tall building

Annexure 2:

Table 12: Responses from PCMC Municipal Departments

PCMC Departments				Responses
1	Chief Operating Officers (CORs	1. What are the CORs' roles and responsibilities in coordinating disaster preparedness, response, and recovery efforts in the PCMC region? 2. How does the CORs office collaborate with relevant stakeholders, including government departments, NGOs, and community organizations, to ensure effective coordination and resource mobilization during emergencies?	1. What mechanisms are in place for inter-departmental coordination, information sharing, and decision-making in response to heatwave events and other disasters? 2. How does the CORs office facilitate capacity-building, training programs, and awareness campaigns to enhance community resilience and emergency response capabilities in the PCMC area?	
2	Office of Commissioner	1. How does the Office of the Commissioner coordinate with other departments during heatwave events? 2. What measures are in place to disseminate heat-related information and advisories to the public?	1. How does the office collaborate with local communities to raise awareness about heatwave preparedness and response?	
3	Medical	1. What medical facilities and services are available to address heat-related illnesses and emergencies in PCMC? 2. How does the medical department collaborate with other agencies to provide medical assistance during heatwave events? 3. What protocols are in place for monitoring and reporting heat-related illnesses?	1. Can the Medical department conduct training programs for healthcare professionals on identifying and treating heat-related illnesses? 2. How does the department ensure adequate staffing and resources during periods of increased demand for medical services due to heatwaves? 3. What strategies are in place for integrating heatwave health impacts into long-term public health planning?	Running IDSP (Integrated Health Information Platform), NP (national programme), CC (climate change), HH (Human health) like that national programme on climate change and human health. No, medical department does not collaborate with other agencies to provide medical assistance during heatwave events. Nine departments are placed for monitoring and reporting heat-related illnesses. Provision of medical hospitals that follow the protocols from IDSP (Integrated Health Information Platform), training programme through NPCC reports that collects data of heat strokes before 1st march and submit it to PCMC. Provision of 1200-1300 staff from every hospital is been provided. No long-term strategies are provided for integrating heatwave health impacts. In the future, planting will need to be done in areas like Talwade, Chikhali, and Bhosari in order to lower the temperature and provide basic services like hydration, medications, and vaccinations.

4	Water Supply	1. How does the Water Supply department ensure uninterrupted water supply during heatwave events? 2. What measures are in place to address potential water shortages or increased demand during extreme heat conditions? 3. How does the department monitor water quality and safety during heatwave events?	1. Can the Water Supply department implement water conservation measures to mitigate the impact of heatwaves on water resources? 2. How does the department prioritize water distribution to vulnerable populations, such as elderly or low-income residents, during heatwave emergencies? 3. What initiatives are undertaken to enhance water infrastructure resilience and adaptability to climate change?	The 24/7 programme will be operational during the heatwave. No plans for conserving water in the future to lessen the effect of heatwaves on water supplies. To prevent leakage from water sources and taps. Providing a water treatment facility in case of a heatwave and cleaning plants and resources every three months. Water supply is provided for the population that is at risk. Access to water in all regions where there is a shortage. Every location has coolers and misters available during heatwaves.
5	Health	1. How does the health department monitor heat-related illnesses and health impacts within PCMC? 2. What public health initiatives are implemented to prevent heat-related illnesses and promote heatwave preparedness? 3. How does the department ensure adequate staffing and resources for heatwave response?	1. Can the Health department collaborate with community organizations to conduct outreach programs on heatwave awareness and prevention? 2. How does the department assess the effectiveness of heatwave interventions and adjust strategies based on emerging health trends? 3. What strategies are in place for integrating heatwave health impacts into broader public health planning and policies?	Only the collection and transportation of sanitary waste are under the authority of the health department. To recycle and reuse the waste in order to reduce waste while implementing the 3R strategy. There are no plans in place to include the health effects of heatwaves into more comprehensive public health planning or policies.
6	Drainage	1. How does the Drainage department address issues related to urban flooding during heatwave events (unpredicted rains during summer)? 2. What measures are in place to ensure proper drainage and prevent waterlogging? 3. How does the department coordinate with other agencies to manage stormwater runoff? 4. Apart from stormwater drains which other infrastructure available / constructed which can help harvest stormwater (bio-swales, green medians etc)?	1. How does the department incorporate climate projections into drainage system planning to account for potential increases in precipitation intensity and frequency? 2. What strategies are in place for enhancing the resilience of drainage infrastructure to climate change impacts, including heatwaves and heavy rainfall events?	Only after there is some complaint, the department appoints staff with the machines that are required. Sewers are been cleaned on everyday basis with the machine that covers almost 100-150m of the area. The department co-ordinates with different agencies to ensure proper drainage and prevent water logging. Strategies as if every day cleaning of sewers is done, sufficient no of staff is available, and machines that are in good condition are made available.

7	Electrical	1. How does the Electrical department ensure the reliability and stability of the power grid during heatwave events? 2. What measures are in place to prevent power outages and minimize disruptions to essential services during extreme heat conditions? 3. How does the department communicate with the public about energy conservation and load management during heatwaves?	1. Can the Electrical department implement smart grid technologies to optimize energy distribution and reduce peak demand during heatwave periods? 2. What initiatives are undertaken to promote renewable energy sources and reduce greenhouse gas emissions from the power sector in response to heatwave challenges?	There is no load shedding during summers in PCMC. The MSEB bill copies features the save energy program for public awareness. There is no smart grid technology implementation to optimize energy distribution. Currently, there are no initiatives or precautions taken by the electrical dept for the heatwave situation.
8	Town Planning	1. How does the Town Planning department integrate heat mitigation strategies into urban development plans and zoning regulations? 2. What measures are in place to promote green spaces, shade provision, and building design features that reduce heat buildup in urban areas? 3. How does the department engage with developers and stakeholders to incorporate climate resilience principles into new construction projects?	1. Can the Town Planning department conduct heat vulnerability assessments to identify priority areas for heat mitigation interventions and adaptation measures? 2. How does the department promote transit-oriented development and compact urban form to minimize heat island effects and encourage sustainable transportation options?	There is no such provision in planning for the heat as of now. The rules and regulations by UDCPR are followed by the town planning Department. The precautionary measure can be taken at local authority level. As per UDCPR Open space or recreational space provision is provided. Suggestions are considered by various expertise in all the fields, CREDI, Local people, Environmental consultants, Architects. Climate Chapter is taken into consideration while planning.
9	Secondary Education	1. How does the Secondary Education department ensure the safety and well-being of students and staff during heatwave events? 2. What measures are in place to provide heatwave awareness and preparedness training to school administrators, teachers, and students? 3. How does the department communicate heatwave advisories and guidelines to educational institutions?	1. Can the Secondary Education department incorporate climate change and heatwave resilience topics into the school curriculum to educate students about environmental challenges and adaptive strategies? - **YES** 2. How does the department collaborate with local health authorities and emergency management agencies to develop heatwave response plans for schools?	During summers, school hours are adjusted, with morning shifts. Health centres are located near schools and colleges for convenient access during the summer or heatwaves. During an excessive heat wave, schools and colleges can provide facilities such as air conditioning, fans, and drinking water coolers. Schools and colleges are closed during significant heat waves, and the government can declare a holiday. Educational advisors are given preparedness guidelines in meetings prior to the heatwave.

	Primary Education	1. What measures are in place to provide heatwave awareness education and training to students, teachers, and administrators? 2. How does the Primary Education department ensure the safety and well-being of students and staff in schools during heatwave events?	1. How does the department integrate heat-related curriculum content and outdoor activity guidelines into educational materials and school policies to promote student health and safety? 2. What initiatives are undertaken to engage parents, caregivers, and community stakeholders in supporting schools with heatwave resilience measures and emergency response protocols? 3. Can the Primary Education department develop heatwave preparedness and response plans tailored to different school settings, such as urban, suburban, and rural areas?	During summers, school hours are adjusted, with morning shifts. Health centres are located near schools and colleges for convenient access during the summer or heatwaves. During an excessive heat wave, schools and colleges can provide facilities such as air conditioning, fans, and drinking water coolers. Schools and colleges are closed during significant heat waves, and the government can declare a holiday. Educational advisors are given preparedness guidelines in meetings prior to the heatwave.
10	Department of Information and Technology	1. How does the Department of Information and Technology utilize technology for heatwave monitoring and early warning dissemination? 2. What measures are in place to ensure the reliability and accessibility of heat-related information and resources through digital platforms? 3. How does the department support data collection and analysis efforts relate to heatwave impacts and response activities?	1. Can the Department of Information and Technology develop innovative digital tools or applications to empower citizens with real-time heatwave information and adaptive recommendations? 2. What strategies are in place for leveraging artificial intelligence or machine learning algorithms to improve the accuracy and timeliness of heatwave forecasts and risk assessments?	
11	Citizen's Facilitation Center	1. How does the Citizen's Facilitation Center provide assistance and support to residents during heatwave events? 2. What measures are in place to ensure that residents have access to heatwave advisories, emergency contacts, and relevant services through the centre? 3. How does the centre facilitate community engagement and participation in heatwave preparedness initiatives?	1. How does the centre collaborate with local NGOs, volunteers, and community groups to implement neighbourhood-based heatwave response plans and support vulnerable populations?	The Citizen Facilitation department is mainly works on the Concerns which are shared by people. There are 93 CFC centres are placed throughout PCMC. The Problems, complaints of local people are shared through letters and forms then those letters are analysed and issues are shared with concerned departments. The department will solve the issue and then it will share to people by Citizen facilitation department. The jansanwad Sabha is arranged at zone offices. Sarathi app is provided.

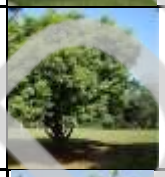
12	Garden	1. How does the Garden department manage public green spaces to mitigate heat island effects and enhance urban cooling? 2. What measures are in place to maintain and expand tree canopy coverage and vegetation diversity in PCMC to provide shade and reduce heat buildup? 3. How does the department engage with communities to promote active participation in greening initiatives and tree planting programs?	1. How does the department integrate climate-resilient landscaping practices, such as xeriscaping and native plantings, into park and garden designs to conserve water and adapt to changing climate conditions? 2. What strategies are in place for fostering partnerships with corporate sponsors, educational institutions, and civic organizations to support urban greening projects and sustainable land management practices?	
13	Fire Brigade	1. How does the Fire Brigade department respond to heat-related emergencies, such as wildfires or building fires exacerbated by extreme heat? 2. What measures are in place to enhance firefighter safety and operational effectiveness during heatwave conditions?	1. Can the Fire Brigade department develop specialized training programs and equipment for responding to heatwave-related incidents, such as heat exhaustion or heatstroke emergencies? 2. How does the department integrate heatwave risk considerations into building code enforcement, fire safety inspections, and urban planning processes to reduce fire hazards and enhance community resilience? 3. What initiatives are undertaken to raise public awareness about fire prevention strategies, evacuation procedures, and emergency preparedness measures specific to heatwave conditions?	There are no specialized equipment's available with the department. Some of the areas which are prone to catching fire due to heat are: Defence lands, garbage dump yards and open barren lands with mainly grasses. The source of the fire listed are mainly due to electricity, cigarette flames, industrial waste and the unmonitored burning of garbage. The grass fires are observed to be between 12pm – 3pm. The main problem the department faces in extinguishing wildfires is that people call for them after the fire has spread beyond control. Necessary safety provisions are given to the fire fighters. The proposed measures required for the better functioning and effective operations of the Fire & Emergency Services Department suggested by the Dept. are: Public Awareness through various platforms like newspaper articles, digital hoardings, etc.; Better system of education by including the awareness about the fire risks from early years; Legal action against the rule breakers; Dedicated space provision for industrial wastes; Controlled Fires; Herbicides for controlling grass growth.
14	Labour Welfare	1. How does the Labour Welfare department ensure the health and safety of outdoor workers exposed to heatwave conditions? 2. What measures are in place to provide heat stress awareness training and personal protective equipment to labourers working in high-risk environments? 3. How does the department monitor	1. How does the department conduct outreach and engagement activities to empower workers with knowledge and resources for recognizing and mitigating heat-related health risks?	The department ensures that the workers working outdoors have shelters to operate under and that they are provided with aprons. Health care facilities are given by health centres in the same area where they work. During the summer, first-aid kits are sent to workers leaders. A circular might be distributed to the heads to raise awareness ahead of the heatwaves. The department communicates with the HOD's or workers' heads to monitor the health and safety of workers while also having the terms and conditions signed by the heads assigned by the department.

		compliance with heat-related occupational health and safety regulations and guidelines?		
15	Environmental Engineering	1. How does the Environmental Engineering department monitor air quality and ambient temperatures during heatwave events? 2. What measures are in place to assess and mitigate the impacts of heatwaves on local ecosystems, water resources, and biodiversity? 3. How does the department regulate and enforce environmental standards to reduce heat-related pollution and protect public health? 4. How does the department conduct ecological assessments and habitat restoration projects to enhance the resilience of natural systems to heatwave impacts and climate change?	1. What strategies are in place for promoting sustainable waste management practices and reducing heat emissions from industrial sources to mitigate environmental degradation and heat island effects?	Every two years, the NPCC Department records the ambient temperature and air quality during heatwaves and produces a report. There are no policies in place to counteract environmental degradation and the effects of heat islands by encouraging sustainable waste management practices and lowering heat emissions from industrial sources. River and devoid of reserves, resources, and water bodies that are also preserved The Environmental Department is working on developing policies to lessen pollution caused by heat waves and safeguard public health. Following the creation of the policies, the programme and restoration procedure are implemented when a research basis is identified.
16	Disaster Management	1. What measures are in place to develop and implement heatwave early warning systems and evacuation plans for vulnerable populations? 2. How does the department conduct risk assessments and scenario planning to anticipate and prepare for heat-related disasters? 3. How does the Disaster Management department coordinate emergency response efforts during heatwave events? 4. With which other departments DM	1. How does the department leverage technology, such as geographic information systems (GIS) and remote sensing, to enhance heatwave monitoring, forecasting, and decision-making capabilities? 2. Can the Disaster Management department conduct vulnerability mapping and social impact assessments to identify high-risk areas and populations susceptible to heatwave hazards?	Everyday IMD provides the climate data to Disaster management department so that heat wave can be predicted earlier for upcoming days. Only IMD data is considered as the main source. Mausam is one of the groups for daily updates. With help of that data Disaster management department manages to provide facilities to people with help of Concerned Departments like Medical. Heat Wave Precautionary Awareness is done by Newspaper, VMD flex on roads, Digital Boards, Campaign at various spots. The Various facilities are provided to tackle with heat wave are Fogging machine for sprinkling of water, Air ventilation coolers, Shaded Sit out area, tree plantation, drinking water for bird's animals, Drinking water for people. If there are open meetings is happening the distribution of ORS sachet, freshly cooked food, medical treatment kit at venue, Ambulance in Emergency is

		department coordinate during heat wave event?		provided. Dos and Don'ts are always shared through department Every time.

Annexure 3:

The table below provides tree inventory for various typologies in PCMC which can help mitigate Heat.

TYPOLOGY : ROADS					
TREES					
		Cassia fistula	Bahava	Deciduous	Native
		Azadirachta indica	Neem	Evergreen	
		Bahunia purpurea	Gulabi kanchan	Evergreen	Native
		Bahunia blakeana	Kanchan raj	Evergreen	Native
		Syzium Cumini			
		Crateva religiosa	Varun	Deciduous	Native
		Michelia Champaca	Sonchapha	Evergreen	Native
		Saraca indica	Sita Ashoka	Evergreen	Native

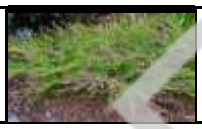
		Bauhinia tomentosa	Yellow bell ordchid	Evergreen	Native
		Mimusops elengi	Bakul	Evergreen	Native

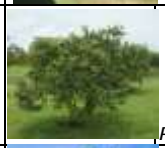
		Albazia lebbeck (Shirish)	Shirish	Evergreen	Native
		Drypetes roxburghii	Putranjiva	Evergreen	Native
		Thespesia populnea	Portia tree	Evergreen	Native
		Ailanthus excelsa	Mahrukh	Deciduous	Native
		Terminalia arjuna	Arjun	Deciduous	Native
		Anthocephalus cadamba	Kadamb	Evergreen	Native
		Terminalia katappa	Badam	Evergreen	Native
		Morus alba	Tuti	Evergreen	Native

		Emblica offcinalis	Amla	Evregreen	Native
SHRUBS					
SR. NO.	IMAGE	BOTANICAL NAME	COMMON NAME	EVERGREEN/ DECIDUOUS	NATIVE/ NONNATIVE
		Cascabela thevetia	Bitti	-	Non-native
		Bougainvillea	Boganvel	-	Non-native
		Euphorbia milii	Crown of Thorns	-	Non-native
		Ficus christina	ficus	-	Non-native
		Nerium oleander	Kanher	-	Native
		Duranta erecta	Duranta	-	Non-native
		Plumbago auriculata	Cape leadwort	-	Non-native
		Dracaena reflexa	Song of India	-	Non-native

		Tabernaemontana divaricata	Tagar	-	Native
		Allamanda cathartica	Golden trumpet	-	Non-native
		Gardenia jasminoides	Ananta	-	Native
		Pseuderanthemum maculatum	yellow-vein eranthemum	Evergreen	Non-native

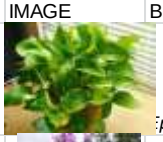
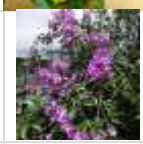
		Stachytarpheta	Indian snakeweed	-	Non-native
		Caesalpinia pulcherrima	Shankhasur	Evergreen	Non-native
		Murraya paniculata	Kamini	-	Native
		Cassia biflora	Desert Cassia	-	Non-native
		Excoecaria Bicolor	Ganga Jamuna	-	Non-native
GROUNDCOVER					

SR. NO.	IMAGE	BOTANICAL NAME	COMMON NAME	EVERGREEN/ DECIDUOUS	NATIVE/ NONNATIVE
		Tradescantia spathacea			
		Tradescantia zebrina	Wandering jew		
		Chlorophytum laxum	False lily turf		
		Paspalum vaginatum	Paspalum		Native
		Tradescantia pallida	Purple heart	-	Non-native
		Cuphea hyssopifolia	False Heather		

TYPOLOGY : GREEN ROOFS					
TREES					
SR. NO.	IMAGE	BOTANICAL NAME	COMMON NAME	EVERGREEN/ DECIDUOUS	NATIVE/ NON-NATIVE
		*Rhapis excelsa*	Raphis palm	-	Non- native
		*Dypsis lutescens*	Areca palm	-	Non- native
		*Plumeria alba*	Chafa		Non native
		*Psidium guajava*	Guava	Evergreen	Non native
		*Citrus limon*	Lemon	Evergreen	Native

GROUNDCOVER/ CREEPER/ CLIMBER					
SR. NO.	IMAGE	BOTANICAL NAME	COMMON NAME	EVERGREEN/ DECIDUOUS	NATIVE/ NON-NATIVE
		*Epipremnum aureum*	Money plant		
		*Mansoa alliacea*	Garlic creeper		
		*Clitoria ternatea*	Gokarna		
		*Thunbergia grandiflora*	Bengal clock vine		
		*Thunbergia mysorensis*	Site chi veni		
		*Trachelospermum jasminoides*	Star jasmine		
		*Tinospora cordifolia*	Gulvel		

SHRUBS					
SR. NO.	IMAGE	BOTANICAL NAME	COMMON NAME	EVERGREEN/ DECIDUOUS	NATIVE/ NON-NATIVE
		*Bergera koenigi*	Curry leaves		
		*Cymbopogon citratus*	Lemon grass		
		*Solanum lycopersicum*	Tomato		
		*Justicia adhatoda*	Adulsa		
		*Hibiscus rosa-sinensis*	Hibiscus		
		*Canna indica*	Canna		
		*Rosa indica*	Rose		
		*Mentha arvensis*	Mint		
		*Tabernaemontana divaricata*	Tagar		
		*Crossandra infundibuliformis*	Aboli		
		*Ocimum tenuiflorum*	Tulsi		
		*Jasminum polyanthum*	Kunda		
		*Curcuma longa*	Haldi		
		*Gardenia jasminoides*	Ananta		
		*Hedychium coronarium*	Sontakka		

TYPOLOGY : GREEN WALLS					
GROUNDCOVER					
SR. NO.	IMAGE	BOTANICAL NAME	COMMON NAME	EVERGREEN/ DECIDUOUS	NATIVE/ NON-NATIVE
		*Epipremnum aureum*	Money plant		
		*Mansoa alliacea*	Garlic creeper		
		*Clitoria ternatea*	Gokarna		
		*Thunbergia grandiflora*	Bengal clock vine		
		*Thunbergia mysorensis*	Site chi veni		
		*Trachelospermum jasm*	Star jasmine		
		*Tinospora cordifolia*	Gulvel		

Annexure 4::

OSS digital portal draft suggestive design:

<table>
<tr><td colspan="4">User Registration/Login Page</td></tr>
<tr><td colspan="4">Choose type of service:
• Self-Implementation
• Implementation through Women’s Cooperative
• Service Provider Registration
• Thermal Comfort Innovation Proposal Upload</td></tr>
<tr><td>Self-implementation page</td><td>Implementation through women’s cooperative page</td><td>Service provider registration page</td><td>Thermal Comfort Proposal Upload Page</td></tr>
<tr><td>Links to
1. Installation planning material and contacts:
a. Cooling Solution Details
b. Structure Audit Template
c. Cost estimate template
d. Directory of Microfinance Institutions
e. Directory of structural auditors
f. Directory of solution-specific fabricators
g. Directory of</td><td>1. Select Time slot for household and structure audit
2. Status of Application page indicating:
a. Notification of house audit request to Ward Level Women’s Cooperative
b. Completion of household and structure audit visit
3. Payment page for audit services.
4. Installation recommendation download page
5. Indicate willingness to proceed with installation
6. MFI contact</td><td>1. Select type of service
2. Upload ‘Training Certificate’ (not applicable for material suppliers)
3. Add contact details
4. Information Review
5. Upload details</td><td>1. Page to enter thermal comfort innovation details:
a. Name of Innovation
b. Brief description of innovation
c. Benefits of innovation
d. Downsides of innovation (if any)
e. List of materials
f. Guidelines on how to fabricate/install/implement</td></tr>
</table>

solution-specific installation persons h. Directory of electricians I. Directory of suppliers 2. Safety checklist and related contacts: a. Installation Safety-Checklist b. Directory of fire stations c. Directory of hospitals. d. Child Rights NGOs e. Women's Rights NGOs 3. For grievance registration: a. Ward-level Grievance redressal officer contact b. Grievance submission page	details for loan approval (as needed) 7. MFI loan approval status indication page 8. Pre-installation payment page 9. Status of Application page indicating: a. Initiation of fabrication and installation b. Completion of fabrication and installation 10. post-installation payment page 11.Installation maintenance support request page 12.Grievance submission page		innovation g. Guidelines on how to operate the innovation *(as applicable)* h. Maintenance guidelines 2. Page to upload images of thermal comfort innovation 3. Reference links (if applicable) 4. Click Submit to notify the PCMC of your innovation idea