HEAT IN BANGALORE

Systems Research and Engagement for Climate Action in Marappanapalya Ward

October 2024

SAKTHIVEL

October 2024

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Fig 1: Water Cans being filled in Marappanapalya Ward amidst the water scarcity in the summer of 2024.
Source: Project Team

Meet the Team

Manan Bhan is a Systems Researcher & Practitioner and is currently a Fellow in Residence at the Ashoka Trust for Research in Ecology and the Environment (ATREE) in Bengaluru, India. His action research work at ATREE is highly diverse as well as innovative, with sustainable land use, climate action, and human well-being at its core.

Ujjvala Krishna likes to call herself an urban researcher and works in policy research around the built environment, climate change, and housing. She is always keen to explore connections between the built, design, and policy, and negotiations between various systems involved in the process of design.

Ajay Raghavan is a lawyer turned climate ecosystem builder. He is incredibly passionate about art, science, sustainability, and well-being, and is a strong believer in empathy, design thinking, and collaborative frameworks. He has co-founded the Initiative for Climate Action and Bengaluru Creative Circus, both platforms aimed at building action climate ecosystems, and loves art, music, sport, and conversation.

Jai Warrier is the co-founder of the Initiative for Climate Action, which is making transformative systemic change through climate action to transition to regenerative paradigms. Jai is also a Sustainability Consultant, currently working with a non-profit organisation to implement their Green Strategy in the Education and Employability sectors. His professional background has been in consulting in the social sector, i.e., assisting funders (Foundations, CSRs, Private Philanthropy) to define, implement and monitor their vision, mission and activities, for on-ground economic, environmental and social impact.

Abhayraj Naik is an activist, educator, community builder, and system change practitioner. His current work focuses on de-colonial climate justice, spiritual ecology, and transformative learning. He coordinates strategy and research at Pipal Tree, and is a co-founder of the Initiative for Climate Action, a visiting faculty member at Krea University, a justice/transformation/evaluation consultant, and an advisor to a number of progressive social and environmental causes in India and other parts of the world. He is also the vision-holder for: an online resource space -"Climate Justice India", an emergent educational network called the South Asia Network for Justice Education, and an upcoming centre for spiritual ecology in Bengaluru, India.

Executive Summary

We are living through a climate emergency globally. One of the principal threats emerging from anthropogenic climate change is heat stress. Extreme temperatures over prolonged time-periods can disrupt life, cripple the economy, and overwhelm the health system.

South Asia has emerged as one of the heat hotspots globally. The number of heatwaves and other extreme heat events occurring in the region has risen exponentially every year. These hotspots are emerging even in cities not previously exposed to heat stress, or having no collective memory to deal with it. Challenges in dealing with heat stress in urban environments are unique, and state response till now has been slow and inadequate, typified by top-down climate and heat action plans.

The city of Bangalore is a case in point. The city has seen rapid urbanization over the last decades, while heat stress has also simultaneously increased at alarming levels, putting the lives of its residents at risk. To increase heat resilience, the challenge in front of urban planners and policymakers is to develop a localized understanding and engagement with residents and infrastructural systems at risk. The ward level, the smallest urban administrative unit in urban governance in India, is a useful scale to build approaches to increasing heat resilience.

We piloted a 3-part approach can be an effective way to address this challenge in the Marappanapalya ward in North Bengaluru. It included (1) a systems-level framework of heat stress, impacts and response at the ward-level, (2) technical approaches to identify areas of maximum exposure within the ward and (3) citizen sensory experiences to understand local contexts through the lens of heat stress.

Our efforts highlight the importance of appreciating local contexts in developing climate action plans and the utility of systems design approaches to fully understand local contexts, risks and vulnerabilities. One further development from our efforts have been to develop climate literacy among adolescents and teenagers from difficult and marginalized backgrounds through the use of board games rooted in their neighbourhood context. Further on-ground efforts would help build evidence of the impacts of heat stress in vulnerable neighbourhoods across both indoor and outdoor surroundings.

The systems-level framework included the development of a Heat Vulnerability Index and a Network Map of systems and stakeholders interacting under heat stress. The Index included the mapping of stakeholders, systems and natural resources existing in the ward, and their integration across 2 axes – the influence of stakeholders on the local context, and the influence of heat stress on stakeholders. The Network Map then visualized stakeholder and system relationships – demonstrating the different connections between them under the context of heat stress. This approach helped us identify the priority stakeholders to interact with further in the field.

The framework building was supported by the spatially-explicit mapping of the ward. Green cover and land surface temperature maps were developed using open-source satellite imageries available at very high resolution. It helped us identify the areas under maximum heat exposure in the summer months. This was also crucial in understanding the current state of green infrastructure in the ward.

Primary surveys of priority stakeholders revealed the diversity of perceptions about the impacts of heat stress on their lives and livelihoods. Most respondents reported a noticeable increase in temperature over recent years, with significant impacts on their daily routines and health. Commonly reported issues included heat exhaustion, and dehydration. Some respondents were also able to identify predominant causes behind increasing temperatures in the city. Interactions with local authorities revealed a lack of preparedness and response protocols.

Forms of documentation and engagement were then developed to accurately and comprehensively share our process and findings throughout the project. The documentation included the development of a website and a social media account, where all information and updates were frequently shared. The social media account has since garnered impressive views and interactions among the general public.

The Climate Vulnerability Walk was a feature of the engagement and outreach of the project. The Walk was developed as a 2-hour interactive activity, where participants were taken on a guided walk around the ward and also encouraged to share their perspectives around heat stress in their own lives and in their own neighbourhoods. The walk was successfully able to bring out various aspects of the intersections between heat stress and urban infrastructural systems were discussed at various checkpoints dotted along the walk route. A 6 minute-long film was then developed to summarize all project activities and experiences.

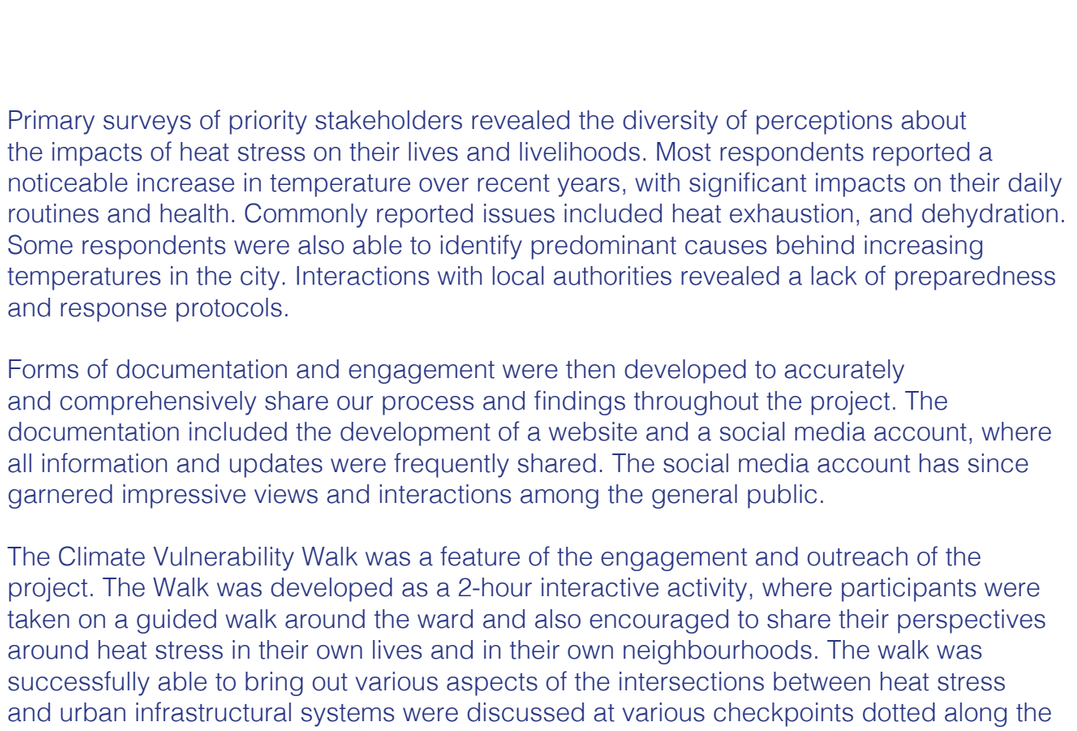


Fig 2: Northwest India just recorded the hottest March in 122 years impacting millions
Source: Hindustan Times, https://twitter.com/ParveenKaswan/status/1519173127397273607

Part 1

Understanding Where We Are

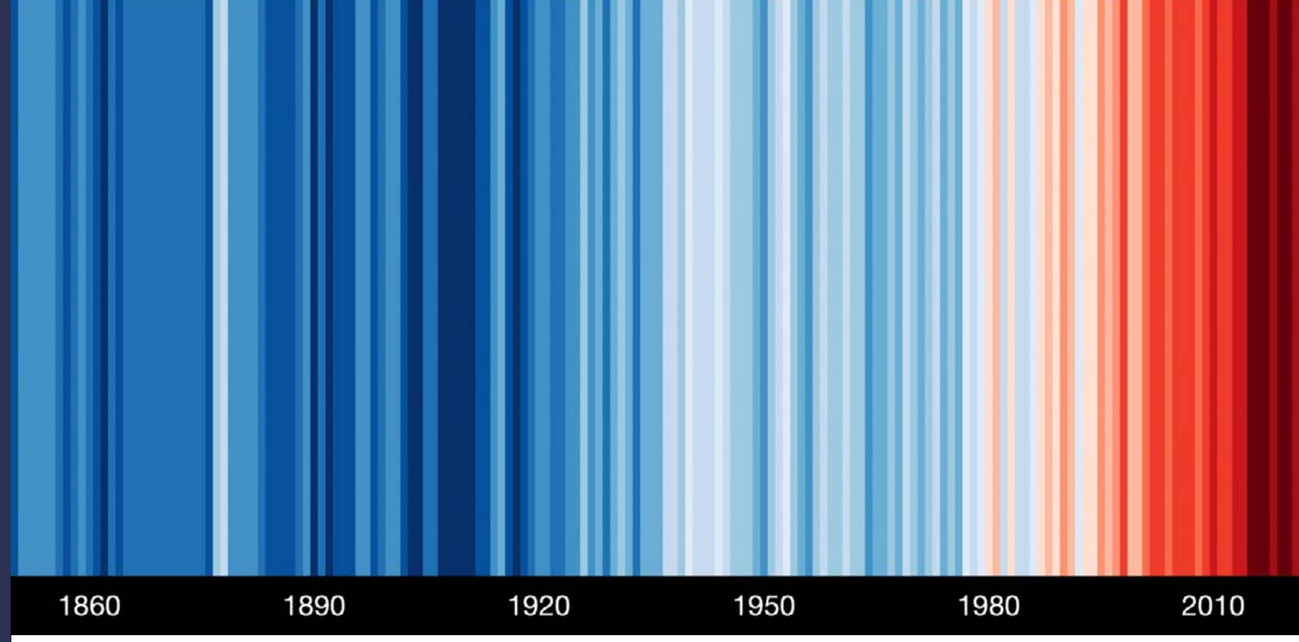


Fig 3: Global Temperature Change: the extent of global warming since 1850 summarized
Source: University of Reading, 2018

1.1 Heat Stress is a Global Climate Emergency

Heatwaves have rapidly emerged as one of the most severe and pervasive climate risks globally, marking a significant climate emergency. Over the past few decades, the frequency, intensity, and duration of heatwaves have increased dramatically, such that consecutive years over the last few decades have been the some of the warmest years ever recorded. This escalation poses grave threats to public health, ecosystems, and economies worldwide, underscoring the urgency of coordinated action.

Recent years have seen unprecedented heatwaves making headlines across the globe. In 2021, North America experienced an extraordinary heatwave, with Canada recording its highest-ever temperature of 49.6°C. This event led to hundreds of heat-related deaths and dangerous wildfires, exemplifying the devastating impact of extreme heat. Similarly, Europe faced severe heatwaves in the summer of 2022, with parts of Spain and France experiencing temperatures exceeding 40°C. These extreme conditions led to widespread health emergencies, agricultural losses, and energy shortages.

Exposure to extreme heat is likely to increase as extreme heat events continue to worsen with climate change. Climate projections indicate that heatwaves will become progressively more frequent and severe over the course of the 21st century. Such heat stress may lead to negative impacts – to an individual, community, and at a systemic level, include health and productivity losses, infrastructural damage, climate stress and economic losses. Extreme heat, due to climate change caused damage to crops, forced schools to close, and put strain on energy supplies in several areas. These impacts are not expected to be uniform, affecting vulnerable populations more.

1.2 South Asia has Emerged as one of the Heat Hotspots

South Asia has become a significant heat hotspot, experiencing some of the most extreme and persistent heatwaves globally. This region, encompassing countries like India, Pakistan, Bangladesh, Nepal, and Sri Lanka, is particularly vulnerable due to its high population density, rapid urbanization, and varying socio-economic conditions. The impacts of rising temperatures in South Asia are severe, with profound implications for public health, agriculture, water resources, and overall economic stability.

In recent years, South Asia has witnessed a marked increase in both the frequency and intensity of heatwaves. For instance, during the summer of 2023, India and Pakistan endured one of the most severe heatwaves on record, with temperatures soaring above 50°C.

1.2.1 Extreme Impacts

This extreme heat led to widespread health crises, water shortages, and significant disruptions in daily life. The health impacts of these extreme heat events are particularly concerning. Heatwaves exacerbate a range of health problems, from dehydration and heatstroke to the aggravation of cardiovascular and respiratory conditions. Agriculture, a critical sector for the economies of South Asia, is severely impacted by rising temperatures. Extreme heat can reduce crop yields, damage plantations, and negatively affect livestock, leading to food security concerns and economic losses for farmers. The World Bank has warned that rising temperatures and changing precipitation patterns could significantly reduce agricultural productivity in South Asia, further threatening the livelihoods of millions who depend on farming.

Even water resources in South Asia are also under severe strain due to heatwaves. Higher temperatures increase evaporation rates, reduce river flows, and deplete groundwater levels, exacerbating existing water scarcity issues. Moreover, rapid urbanisation in South Asia has led to the development of urban heat islands, where dense concentrations of buildings and infrastructure absorb and retain heat, making cities significantly warmer than their rural surroundings. Cities such as Delhi, Mumbai, and Dhaka experience heightened heat stress due to these urban heat islands, impacting millions of residents and increasing energy demands for cooling, despite access to cooling being low.

Fig 4: News Headlines highlighting the challenge of heatwaves and increasing heat stress in India.
Source: Various Leading News Dailies

1.3 How is Heat Stress Understood in India?

India has not been spared either - there has been an increasing trend of heatwaves in India over the past several years. India routinely experiences hot summers but, in recent years, several parts of the country have seen abnormally high temperatures. This has severely affected the well-being of citizens living in a number of cities, towns, and villages. In 2023, the country endured a relentless heatwave with temperatures soaring above 50°C. This extreme heat exacerbated water shortages and caused significant health crises, particularly among vulnerable populations. The World Meteorological Organization (WMO) noted that this heatwave was one of the hottest on record for the region, reflecting a troubling trend of rising temperatures.

In August 2021, the Intergovernmental Panel on Climate Change (IPCC) issued its sixth assessment report (IPCC, 2021). It cautions that by the middle of the century, global warming will probably approach or exceed 1.50 C. It also notes that if urgent, swift, and significant cuts in greenhouse gas emissions are not made, keeping warming to about 1.5°C or even 2°C will be difficult. The 2019 Global Climate Risk Index highlighted that heatwaves were among the deadliest natural disasters in recent years, with thousands of fatalities and high economic losses. It is projected that an additional 250,000 fatalities annually would result from heat stress, diarrhoea, malaria, and malnutrition as a direct result of climate change between 2030 and 2050.

India experienced totally over 1186 heatwave days in 22 states between 2011 to 2021 as per the Ministry of Earth Sciences, with states of Rajasthan, Odisha, and Andhra Pradesh all experiencing more than 100 heatwave days each between this period. As per the National Crime Record Bureau (NCRB), India recorded over 730 deaths due to heat/ sun stroke in 2022 alone.

As global temperatures rise, the sweltering conditions in urban regions are poised to become more severe. Heatwaves are becoming a prominent extreme weather phenomenon in many Indian cities. Heat is an agent which interacts with multiple dimensions in urban areas, placing urban citizens, infrastructure, and biodiversity at increasing risk. The negative impacts of heat stress are expected to be direct, indirect as well as cascading, stretching the existing response infrastructure in the city.

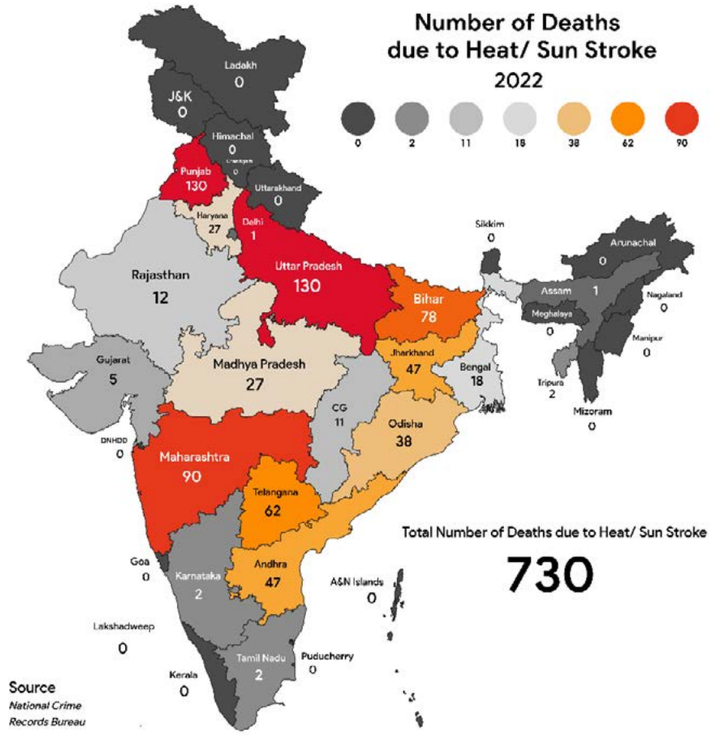
1.3.1 Defining Heatwaves

A Heatwave is a period of abnormally high temperatures, more than the normal maximum temperature. It is a condition of air temperature which, when exposed to, becomes fatal to the human body. The extreme temperatures and resultant atmospheric conditions adversely affect people living in these regions as they cause physiological stress, sometimes resulting in death. The Indian Meteorological Department (IMD) defines it based on the temperature thresholds over a region in terms of actual temperature or its departure from normal. In certain countries it is defined in terms of the heat index based on temperature and humidity or based on extreme percentile of the temperatures. Other agencies depend on the IMD to define a heatwave.

The IMD has given the below criteria for defining heatwaves in India:

- Heatwave is considered if the maximum temperature of a station reaches at least 40 degree Celsius or more for Plains and at least 30 degree Celsius or more for Hilly regions.
- Based on departure from normal: Heatwave is considered if the temperature departure from normal is 5°C to 6°C. A severe Heatwave is considered if the departure from normal is 7°C or more.
- When actual maximum temperature remains 45°C or more irrespective of normal maximum temperature, heatwaves should be declared.

Fig 5: Heat affects our cities in a myriad ways as a silent disaster.
Source: Author



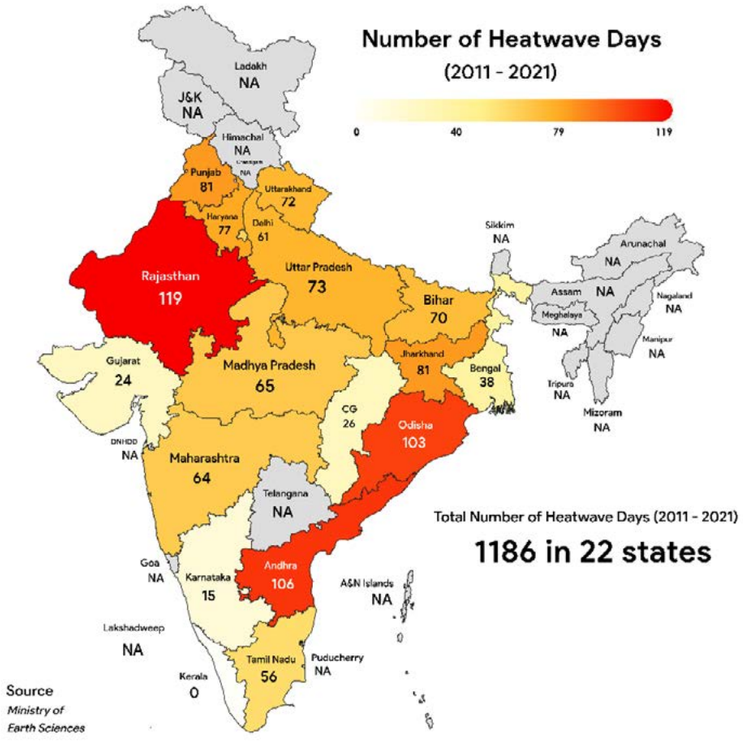


Fig 6: The first figure shows the number of heat related deaths recorded in India in 2022; the second figure shows the number of Heatwave Days between 2011 - 2021 recorded in India Source: Project Team – data from NCRB and the Ministry of Earth Sciences

1.3.2 Data on Heat Mortality

How Each Agency Collects Heatwave Data and Records Deaths:

The IMD has a large network of surface observatories across the country to measure various meteorological parameters like temperature, relative humidity, pressure, wind speed, etc. Based on daily maximum temperature station data, the normal maximum temperature data for a day for a particular station is garnered based on the data between 1981 to 2010. As per the IMD's definition of a heatwave, it declares the same over a region. Once a heatwave is declared, it is published on the India Weather Forecast Bulletin. The heatwave information is shared with the state government and media along with the health department and the power sector.

Deaths due to sunstrokes and heatstrokes are recorded by the NCRB Annual Report on Accidental Deaths and Suicides which uses data furnished by state police departments and published in the Envi Stats. Heat related illnesses are now also documented by the Integrated Health Information Platform, by the National Programme on Climate Change and Human Health. To ascertain if a death is due to heat, there exist guidelines on investigating suspected heat related illness death as published by the National Centre for Disease Control (NCDC) under the Ministry of Health and Family Welfare.

Year	Recorded deaths caused by heat waves	*Year*	Recorded deaths caused by heat waves	*Year*	Recorded deaths caused by heat waves
1992	612	*2000*	534	*2008*	616
1993	631	*2001*	505	*2009*	1071
1994	773	*2002*	720	*2010*	1274
1995	1677	*2003*	807	*2011*	793
1996	434	*2004*	756	*2012*	1247
1997	393	*2005*	1075	*2013*	1216
1998	3058	*2006*	754	*2014*	1677
1999	628	*2007*	932	*2015*	2040

Table 1: Year-wise details of recorded deaths caused by heatwaves in India between 1992 to 2015. Source: Compiled from the Revenue and Disaster Management Departments of several state governments and from IMD reports, as per the National Guidelines for Preparation of Action Plan–Prevention and Management of Heatwave (October 2019)

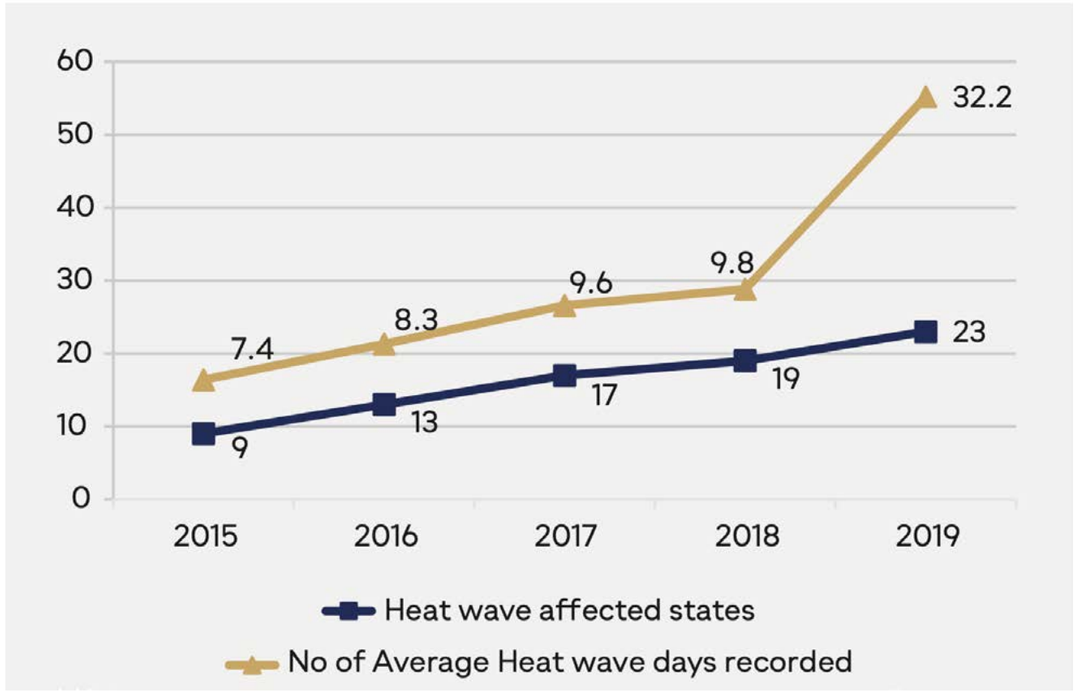


Fig 7: Heat-wave vulnerability - A trend of increasing heatwave phenomena has been recorded in the country over the past several years, whereby several states, districts and cities have been severely affected.
Source: Forecast Demonstration Project(FDP) for Improving Heatwave Warning over India, Implementation Report, 2019, IMD, New Delhi; BEATING THE HEAT – NDMA

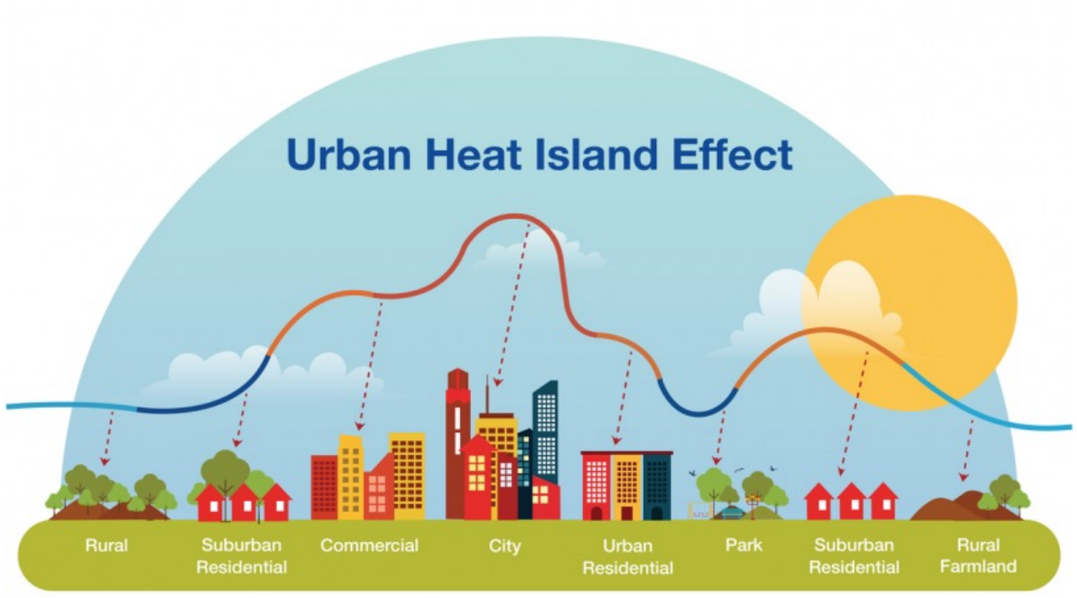


Fig 8: Urban Heat Islands significantly increase temperatures in urban centres.
Source: The Prakriti Story

Heat in Bangalore

1.4 The Urban Heat Challenge

While many places in India are exposed to heat stress, cities in India find themselves particularly exposed. because of the density of built environment. Heat stress may be exacerbated because of the absorption and re-emission of solar heat by buildings, roads, and paved surfaces, which exceeds that of natural landscapes. This phenomenon gives rise to localized hotspots known as Urban Heat Islands (UHIs). UHIs can elevate daytime temperatures by as much as 4°C and night-time temperatures by 2.5°C compared to surrounding areas.

Cities and towns experience higher temperatures due to several factors that produce urban heat islands. The UHI effect is a significant environmental concern for Indian cities, where rapid urbanization and population growth have exacerbated the phenomenon. During the day, towns and cities absorb more solar radiation than rural regions due to their high heat-conductive surfaces, such as asphalt. The absence of green spaces and vegetation in urban settings, such parks, prevents the temperature from decreasing as an outcome of evaporation from plants. Furthermore, as there are less trees, there is less shade, which only heats the ground further. Large structures in urban centres further the effect of UHI, as they trap heat and keep out wind, preventing air currents from cooling the environment. The air temperature also rises because of atmospheric pollution due to industries, vehicles, and HVAC systems, which trap solar radiation and prevent heat from dissipating. The UHI effect can raise ambient temperatures in cities by 3 - 5 °C.

Extreme heat has major consequences for public health, the environment, the economy, and community infrastructure. It increases electricity demand for cooling systems, straining energy systems across India during heatwaves. Rising temperatures affect energy production, transmission, and demand. The UHI effect increases water demand for cooling and hydration, worsening water scarcity in cities like Bangalore in 2024. UHI effect also harms urban biodiversity and lowers the quality of life for city residents.

1.5 What have Central and State Governments Typically Done About It?

The state and central governments in India have undertaken several measures to combat heatwaves, recognizing the increasing frequency and severity of extreme heat events as a significant public health and environmental concern. These measures include policy frameworks, early warning systems, public awareness campaigns, and infrastructural improvements. However, effective preparedness through integrating bottom-up and top-down adaptation approaches may mean that impact on urban populations and urban infrastructures are not inevitable. Current actions to mitigate impacts have been limited to developing actions plans, issuing advisories and sensitizing government agencies on the need to adequately prepare and respond to heatwaves.

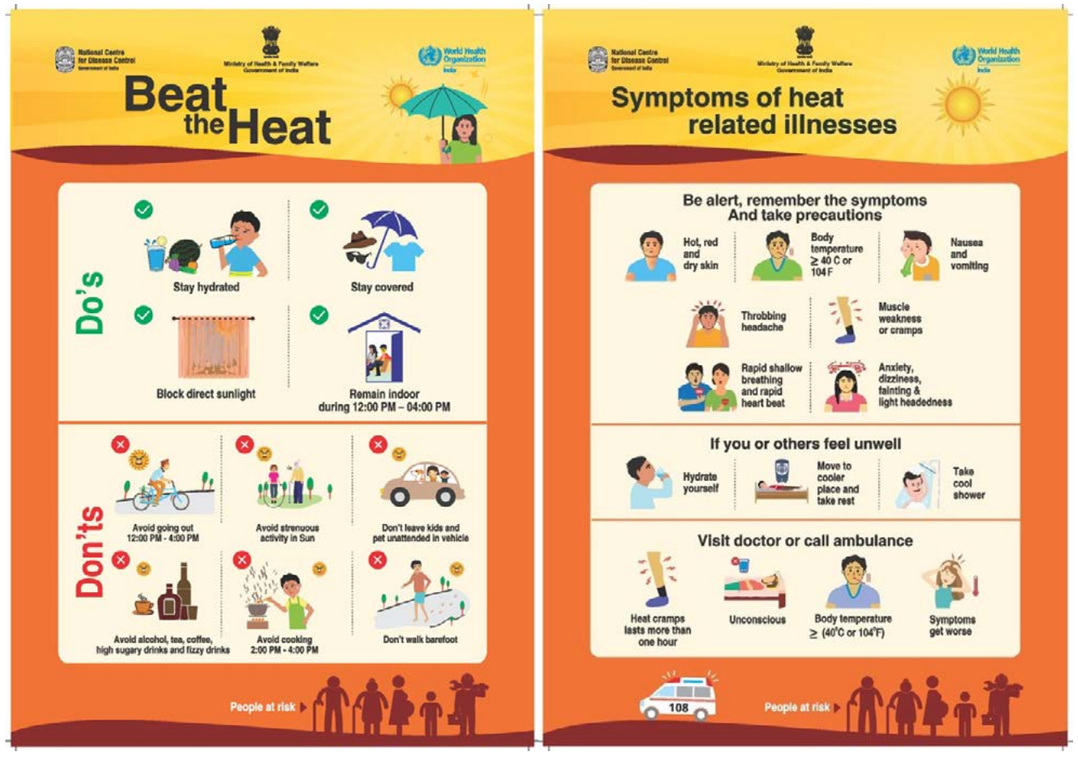


Fig 9: Beat the Heat Multimedia Content developed by the World Health Organisation listing out preparatory strategies and measures for post-heat-stress medical emergencies
Source: www.who.int/india/heat-waves

State, district, and local governments in India have developed heat action plans (HAPs) that include various preparatory activities and post-heatwave response strategies across government agencies in an effort to lessen the effects of heatwaves. The National Disaster Management Authority (NDMA) has developed guidelines for preparing HAPs, which are comprehensive frameworks to prepare, respond to, and mitigate the impacts of heatwaves. These plans include the following components - Early Warning Systems, Public Awareness Campaigns, and Capacity Building.

Fig 10: Various Heat Action Plans and Initiatives by the Central and State Governments to combat increasing heat stress in cities
Source: NDMA

One of the first comprehensive HAPs in India, the Ahmedabad Heat Action Plan launched in 2013 includes measures like establishing early warning systems, training healthcare workers, and public outreach to inform residents about how to protect themselves during heatwaves. The plan has been credited with reducing heat-related mortality in the city.

However, significant challenges in implementing HAPs were identified in a report by the Centre of Policy Research (March 2023) that analysed HAPs. These challenges included the following - nearly all HAPs are inadequate in identifying and targeting vulnerable groups; they are underfunded and have shaky legal foundations; and they are not sufficiently transparent because there is no national repository for HAPs and only a small number of HAPs are listed online.

Other initiatives include the Cool Roofs Initiative in Telangana - promoting the use of reflective, light-coloured materials for roofs to reduce heat absorption and lower indoor temperatures. This helps in mitigating the urban heat island effect and reduces the demand for air conditioning.

Fig 11: Beat the Heat Comics prepared by the government for awareness building against heatwaves.
Source: NDMA

While significant progress has been made in understanding the risks of heat, the increasing severity and frequency of heatwaves underscore the need for continuous improvement and adaptation of these plans. These actions often represent top-down thinking, and are developed without significant understanding of localised contexts. A systems approach may also consider approaches to reduce heat at local scales, reduce cooling needs and serve cooling needs efficiently, both indoors and outdoors. If one were to take a step back, some aspects that would be necessary to consider would include - how do different communities interact with heat stress?

How are urban systems impacted by heat stress?

Fig 12: Pourakarmikas (Sanitation Workers) at work in Marappanapalya Ward
Source: Project Team

1.6 Is Heat Stress even a Problem in Bangalore City?

The questions arises often – does Bengaluru even face heat stress?

Bengaluru – once known as the only metro city in India with an agreeable climate throughout the year, the city is expected to face immense heat-stress over the next few years due to climate change, exacerbated by the alarming rate of disappearance of green spaces. Signs of it are already visible - the summer months are stretching for longer and the number of severe heat days are steadily rising.

This phenomenon is driven by various factors, including climate change, the urban heat island effect, and infrastructural challenges. The impacts of heat stress are multifaceted, affecting public health, energy consumption, and overall quality of life. According to the Indian Meteorological Department (IMD), the city has seen a rise in average temperatures, with summer temperatures frequently exceeding 35°C. In 2024, temperatures hit above 39°C. The UHI effect is a significant contributor to rising temperatures in Bangalore. The city's rapid urbanization has led to the replacement of natural landscapes with concrete, asphalt, and buildings, which absorb and retain heat. This effect is more pronounced in densely built areas, leading to higher nighttime temperatures and reduced cooling.

A Snapshot of Bengaluru City

The city of Bengaluru is one of India's fastest-growing cities and is the economic centre of the state of Karnataka. The city covers and administrative area of 741 sq. kms and is home to about 8.5 million people (Census 2011). Over the last decade, the city's population density has grown by 47%, and by 2030, its population may touch 17 million.

The city is located in the semi-arid region of India at an elevation of 928 metres. Summer is the city spans the months of March, April, and May, hot temperatures in the city are now increasingly being observed in the months of October and November as well.

Bengaluru's average monthly maximum summer temperature ranges is 38.8°C, while in October and November, its average monthly high temperatures range from 18.4°C to 26.4°C.

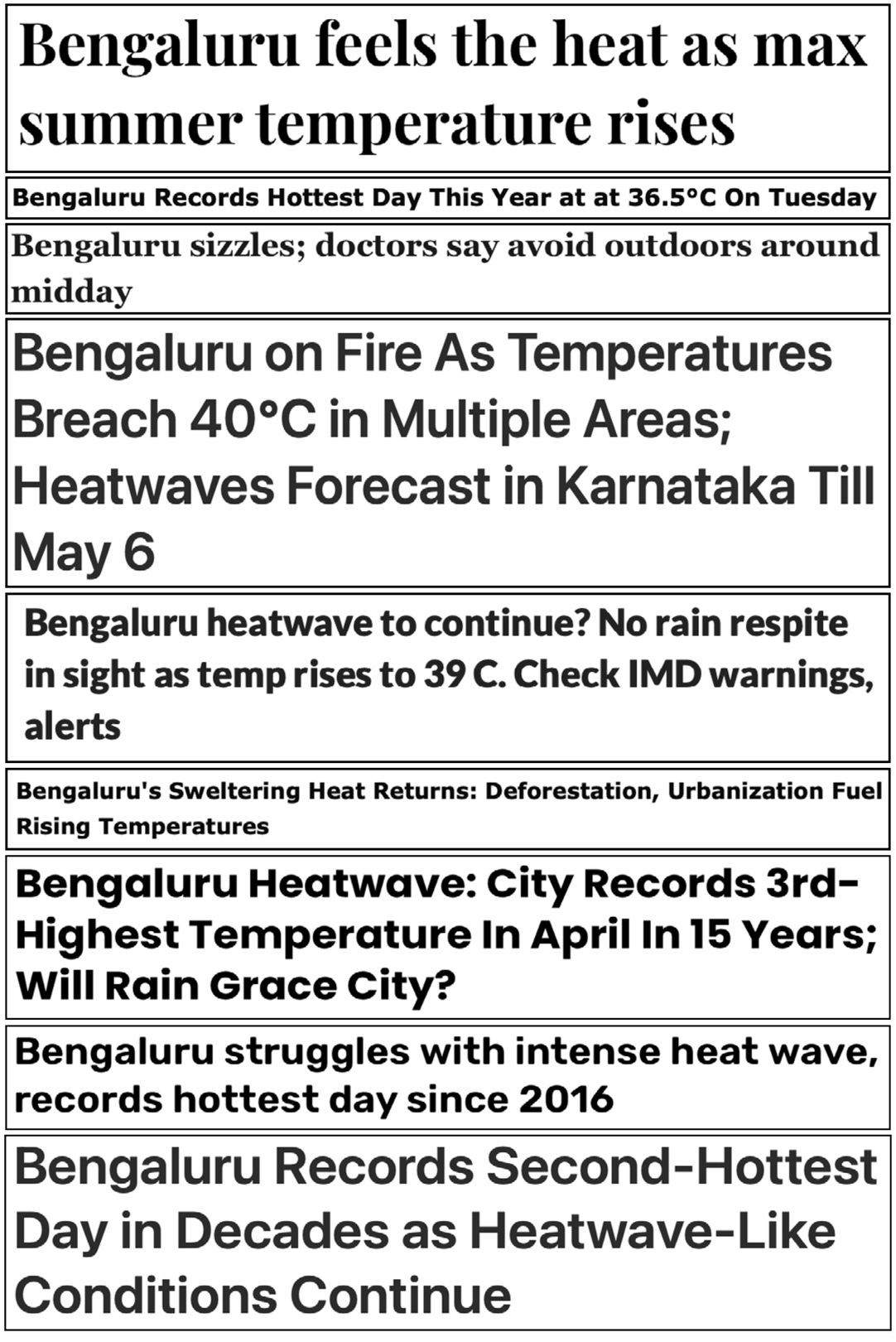


Fig 13: Heat Stress in Bangalore city
Source: Various News Platforms

News Article	Summary
No heatwave in Bengaluru	The article reports that despite rising temperatures, the India Meteorological Department (IMD) has confirmed that Bengaluru is not experiencing a heatwave. The city has seen temperatures slightly above normal, but they do not meet the criteria for a heatwave.
Heatwaves are scary, but some have it way worse	The article discusses the impact of heatwaves in Bengaluru, noting that while the city faces high temperatures, other regions in India experience far more severe conditions. The piece highlights the importance of local measures to mitigate heat stress in urban areas.
Bengaluru Sizzles: Doctors say avoid outdoors around midday	The Times of India article advises Bengaluru residents to avoid outdoor activities around midday due to the high temperatures, which are causing health concerns. Doctors emphasize staying hydrated and taking precautions against heat-related illnesses.
Heatwave Alert: Bengaluru, parts of Karnataka to witness above normal max temp	The article reports that Bengaluru and parts of Karnataka are expected to experience above-normal maximum temperatures until February 25, prompting a heatwave alert. Authorities advise residents to take precautions against heat-related health risks.
Bengaluru, parts of Karnataka to get heatwaves earlier than expected	The article states that the India Meteorological Department (IMD) has issued a heatwave alert for Bengaluru and parts of Karnataka, predicting that the heatwave conditions will arrive earlier than expected. Residents are advised to take necessary precautions against the high temperatures.
Bengaluru Records Hottest Day This Year at 36.5°C On Tuesday	The article reports that Bengaluru recorded its hottest day of the year so far, with temperatures reaching 36.5°C on a Tuesday. The high temperatures have raised concerns about heat stress and health risks for residents.
Bengaluru feels the heat as max summer temperature rises	The article highlights that Bengaluru is experiencing rising temperatures, with the maximum summer temperature increasing, causing discomfort among residents. The city's weather has been warmer than usual, leading to concerns about heat-related health risks.
May We Melt	The article discusses the rising temperatures in the city, with the mercury hitting new highs, causing concern over heatwave conditions. Experts advise residents to take precautions to avoid heat-related illnesses.
Bengaluru's Sweltering Heat Returns: Deforestation, Urbanization Fuel Rising Temperatures	The Times Now article attributes Bengaluru's rising temperatures to deforestation and urbanization, which are exacerbating the heatwave conditions. Experts warn that these factors are significantly contributing to the city's increasing heat stress.

Table 2: What does the News Report?
Source: Various News Platforms

1.7 Localised Climate Action to Combat Heat Stress

As heat stress increasingly impacts urban life, our efforts are motivated by this impending challenge and the urgent need for actions to mitigate these risks. We believe that developing preparedness and resilient actions at decentralised scales can help prevent heatwaves becoming deadly. Localised climate action in Bangalore city can play a crucial role in combating heat stress by implementing strategies that focus on urban planning, green infrastructure, public awareness, and community engagement.

We are committed to tackling three dimensions that we believe are integral to reimagining Bengaluru under climate change - citizenship, coordination, and collaboration. In this project, we aim to better understand the ways in which natural and the built infrastructures respond to heat stress and centre our efforts in a hyper-local administrative unit in the city of Bengaluru.

Our efforts would provide a framework for effective anticipatory action in a hyperlocal urban context, thus facilitating efforts to reduce disaster risk for vulnerable populations under impending climate change.

We centre our efforts at the Ward level, the smallest urban administrative unit in India, to ensure effective community participation and resource mobilisation. This allows for local risks and vulnerabilities to surface, be understood, and tackled in an effective manner. At this scale, the interactions of heat stress with local systems like health, water, economy, energy, and the built environment can be better visualised and understood. Mapping the dimensions through which heat stress interacts with these elements in such a decentralised administrative unit is a powerful form of anticipatory action. Our project proposed a multi-dimensional spatial mapping approach to bring together layers of biophysical, demographic, and socio-ecological information in a manner which enhances response capacity and preparedness to heat stress. We believe this approach would be effective in bringing together top-down scientific expertise with bottom-up needs, knowledge, and circumstances in a truly collaborative manner.

1.8 Our Interventions to Understand Heat Stress

In Part 2, we detail our processes and methods to understand increasing heat-stress at the ward level in Marappanpalya to address the growing concern of urban heat and its multifaceted impacts on vulnerable communities. We aimed to capture the spatial variability of land surface temperature and green cover through geospatial analysis, allowing us to map areas with high heat exposure and insufficient greenery. Additionally, by analysing the demographic composition of the ward, we identified groups most susceptible to heat stress, such as outdoor workers and residents in low-income neighbourhoods.

Recognizing heat stress as a network hazard, our study also examined its interconnected effects on water supply, energy consumption, livelihoods, and public health. To complement this comprehensive analysis, we conducted qualitative interviews with stakeholders who are directly impacted by heat stress, such as construction workers, street vendors, and sanitation workers, to gather nuanced insights into their experiences and coping strategies.

In Part 3, we detail our efforts to effectively share our findings and engage with the community and stakeholders, by developing several forms of outreach. We organized a climate vulnerability walk to provide a tangible and immersive experience of the ward's heat-stress hotspots and green cover areas, fostering a deeper understanding of the issue among participants. We also created a dedicated website to document our process. Additionally, we established a social media presence to disseminate key insights, updates, and engage with the community in real-time. To reach an even broader audience, we produced a short film that visually narrated our findings and highlighted personal stories from our interviews, bringing attention to the human dimension of heat stress.

Fig 14: Outdoor Businesses like Food Stalls face a decline in customers as the temperatures increase
Source: Project Team

Fig 15: Outdoor Workers like construction workers on site and haulers and coolies face increasing heat-stress.
Source: Project Team

Part 2

Our Efforts in the Marappanapalya Ward

2.1 Our Theory of Change

What is the problem we are solving?

Response to heat stress in urban India is currently dominated by top-down actions. There is a lack of a whole systems-level and decentralised understanding of the nature of impacts and the potential responses that can be evolved to tackle heat stress. This gap is especially evident at the local level in a city like Bengaluru.

Who is our key audience? What is our entry point in reaching the audience?

Our efforts are directed at local communities in the ward, urban planners, researchers, practitioners, systems designers, citizens and local as well as city-level policymakers. Our entry point is a combination of 3 approaches:
1. A systems-level framework of heat stress, impacts and response at the ward-level.
2. Technical approaches to identify areas of maximum exposure within the ward.
3. Citizen sensory experiences to understand local contexts through the lens of heat-stress.

What steps are needed to bring about change?

1. Our approach and outputs are adopted as a basis for heat stress planning and response.
2. The climate vulnerability walk is institutionalised across this ward and expanded horizontally (to focus on other risks like flood risks) and vertically (across other wards in the city). The walk is eventually able to be led by youth from local communities who can talk of personal and communal experiences in tackling heat stress.
3. City-level government agencies are able to incorporate some of our findings as a basis to advance participatory and bottom-up governance to disaster management and climate change adaptation.

What is the measurable effect of our work?

1. Framework to understand heat stress among different community groups developed.
2. Interactions of heat-stress with local systems like health, water, economy, energy, and the built environment better visualised and understood.
3. Areas particularly exposed to heat and areas without appreciable tree cover identified.
4. More than 10 participants take part and engage with the Climate Vulnerability walk each time it is organised.

What are the wider benefits of our work?

1. Development of a whole systems-level understanding of heat stress for an administrative region in Bengaluru.
2. Development of the climate vulnerability walk as a medium of communicating complex biophysical, demographic, and socio-ecological information in a manner which is engaging and participative, and helps bridge the gap between a top-down understanding of climate action, and the lived reality of adapting to climate change.

What is the long-term change we see?

Planning and response to heat stress in Bengaluru incorporates bottom-up and systems-level thinking.

2.2 Our Approach: A Spatial Understanding of the Ward

A Snapshot of Marappanapalya Ward

Our project is concentrated in the Marappanapalya ward in north Bengaluru. It is situated in the state legislative assembly constituency of Mahalakshmi Layout and the national parliamentary constituency of North Bengaluru. It has a total area of 2.05 sq. km. comprising of about 10,051 households. The ward has a total population of 40,212 persons, with 20,754 males and 19,458 females and 4,199 persons in the 0-6 age group (2011 Census of India). Existing land use in the ward is rather unique for the city of Bengaluru - apart from residential and commercial establishments, the ward includes a rapidly transforming industrial area within its boundaries.

Marappanapalya Ward, erstwhile Ward number 44 as per the delimitation of 2022 (BBMP Ward Delimitation Notification 2022). The Delimitation of Wards 2023 (BBMP) has divided the 2022 delimited boundaries and area of Marappanapalya ward into three wards – Rajiv Nagar (Ward No. 46), Mahalakshmi Puram (Ward No. 48), and Nagapura (Ward No. 49). The map below identifies this new divide of the boundaries. For ease of reference and understanding, the project report will refer to the erstwhile Marappanapalya ward as the 'project area'.

The ward is mixed-use and hence very unique to Bengaluru. It has a mix of industrial, commercial, and residential land-use (see Fig 13). This has created a unique landscape on the ground, bringing together multiple stakeholders and systems in the ward. The ward is also home to the erstwhile APMC Mandi. It has large land industrial parcels which are now being sold to real estate developers, and due to the increase in FSI (Floor Space Index), the ward has now become home to many high rise apartment complexes. Historically, the ward was part of the larger suburban Yeshwanthpur area.

The rapid urbanization of Bangalore is evident in Marappanapalya, where infrastructure development has significantly transformed the landscape. Key aspects of the ward's infrastructure include:

- **Residential Areas:** The ward has a mix of independent houses, apartment complexes, and slums. Housing development varies widely, reflecting the socio-economic diversity of its residents.
- **Commercial Zones:** Marappanapalya hosts a range of commercial activities, from small retail shops and markets to larger business establishments along with the erstwhile Agricultural Produce Yard (APMC).
- **Educational Institutions:** The ward is home to many private schools and a BBMP government school, along with a Karnataka Public School with good infrastructure.

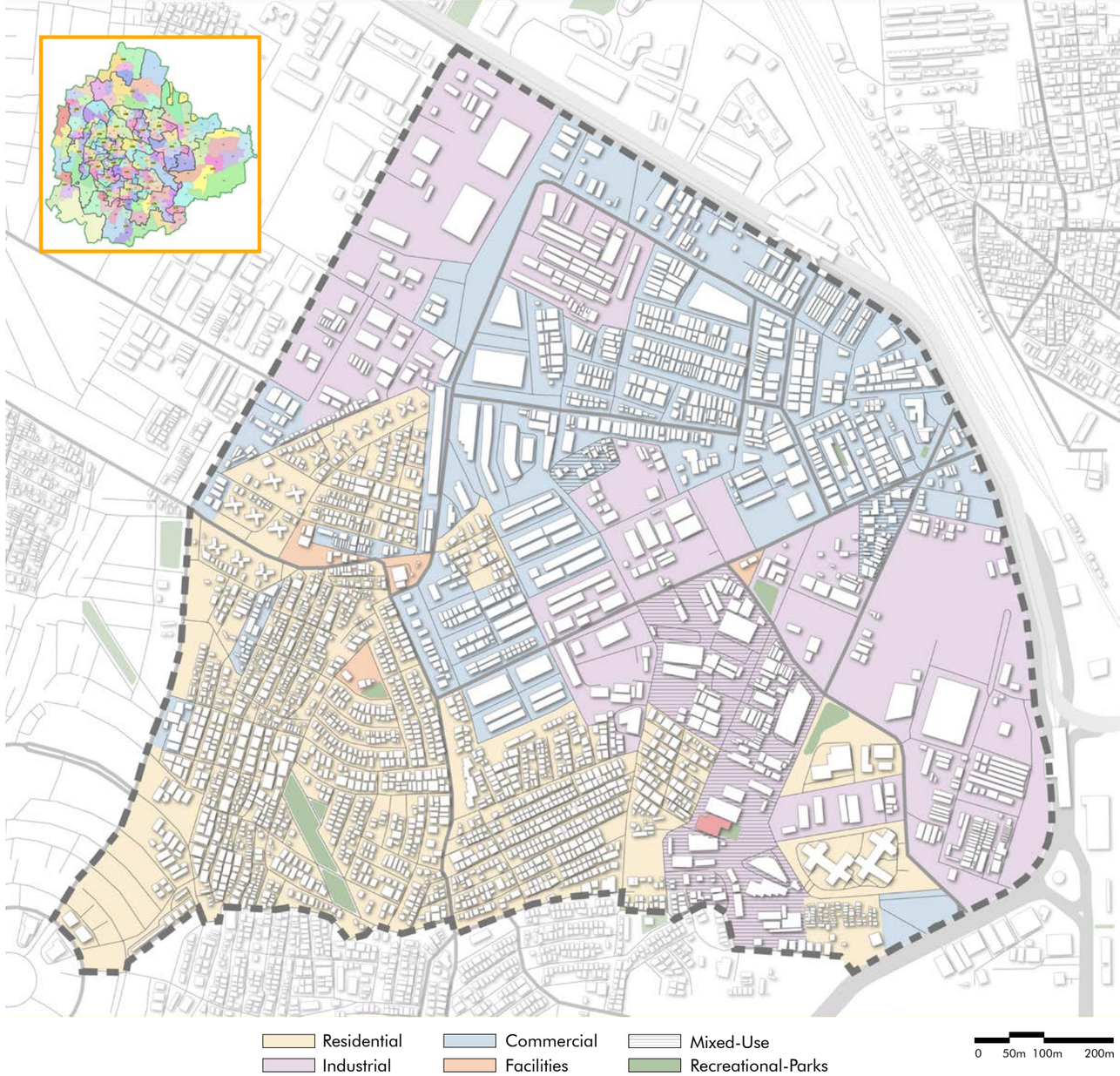


Fig 16: Erstwhile Marappanapalya Ward (50) Boundary Map showing various land use.
Source: Project Team, 2024

Like many urban areas, Marappanapalya ward also faces several environmental and public health challenges:

- **Heat Stress:** The ward experiences high temperatures, particularly during the summer months, exacerbated by the urban heat island effect. This impacts the health and well-being of residents, especially vulnerable populations such as the elderly, children, and the outdoor workers in the APMC yard and surrounding areas.

• **Water Scarcity:** Access to clean water is a significant issue, with periodic shortages affecting households and businesses. Efforts to manage and distribute water resources effectively are critical for the ward's sustainability.
• **Flooding:** The ward has a highly differential elevation profile, with many low-income settlements situated at lower elevations – increasing flood risk.
• **Waste Management:** Effective waste collection and disposal are a challenge, with the need for improved municipal services.

Fig 17: The erstwhile Marappanapalya ward is a heterogeneous mix of various land uses within a 2 sq. km area that is rapidly changing – a diminishing industrial area, growing residential areas, the old APMC yard, and a growing commercial area.
Source: Project Team

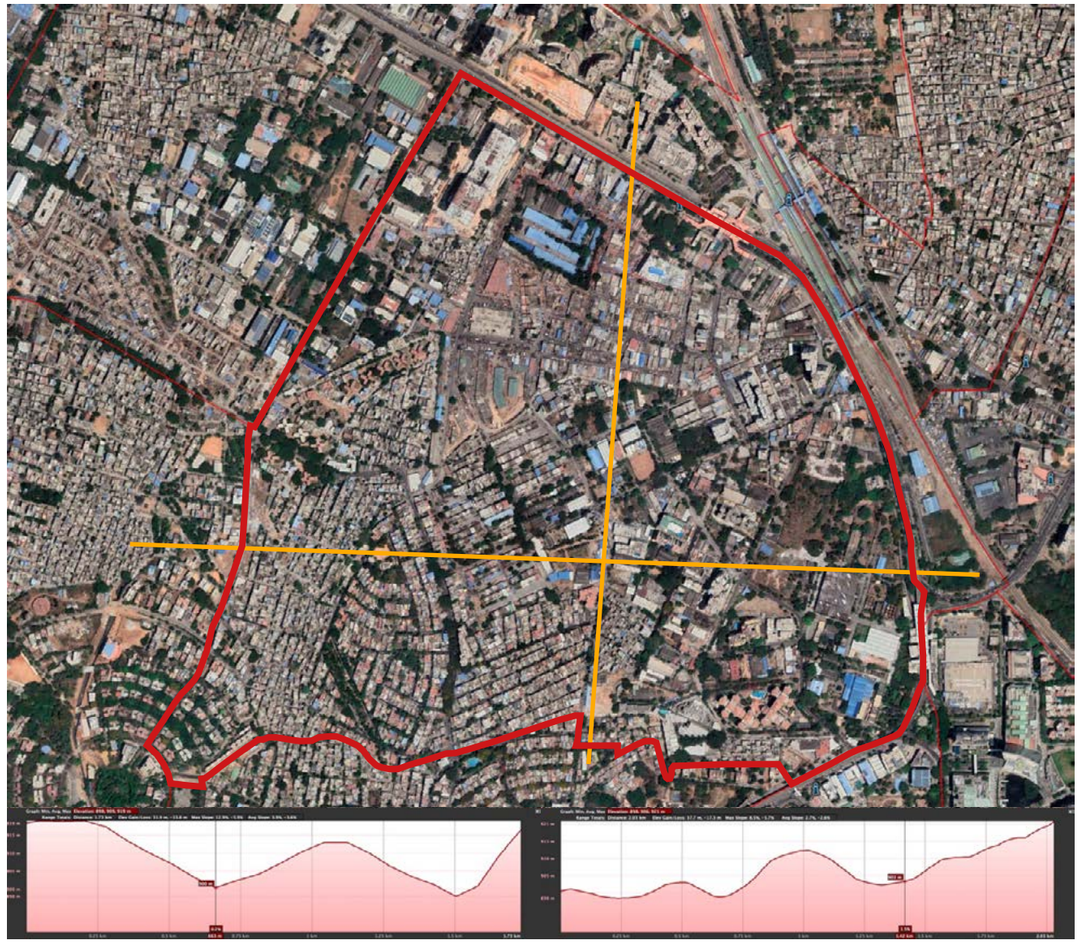


Fig 18: Through satellite imagery, one can see the ward (boundary in red) having grown into the mixed-use landscape it is today due to various factors like – increase in mobility, migrant settlements, industrial complexes, and large scale trading. It is constantly changing and in flux even today.

Elevation Profiles running from North to South (left) and East to West (right) show the varying topography of the project area. The lowest income settlement in the project area – Ashokapuram, is the lowest in elevation as well, leading to risk of other hazards like flooding.
Source: Google Earth 2023

Fig 19: Vulnerable stakeholders like Street Vendors use shade mechanisms like temporary umbrellas to shield themselves and the agricultural produce from the blazing sun during summers.
Source: Project Team

2.3 Our Approach: Mapping the Stakeholders and their Vulnerabilities

We tried to bring different types of information together (demographic, biophysical, built environment) to respond to the emerging risks of heat stress in the project area. We started by mapping all the stakeholders in the project area to project on an ad-hoc vulnerability index. Though with an internal bias, this exercise as the first step allowed us to see the number of stakeholders and those who were most vulnerable to heat stress.

This qualitative heat vulnerability index for local community groups was developed by intersecting two attributes – (1) the influence of a community group on the context and (2) influence of heat stress on the given group. The intention here is to trace how each community group interprets heat stress, along with the nature of action they take to adapt.

LIFE			SYSTEMS	NATURAL RESOURCES
Transport Personnel	Industrial Workers	Large Business Owners	Water	Biodiversity
Students	Migrants	Motorists	Energy	Animals/ Livestock
Construction Workers	Street Vendors	Autorickshaw Drivers	Waste	Land Cover
System Workforce	Shop Owners	Cyclists	Transport	Water
Water Management	Pourakarmikas	Four Wheeler Drivers	Health	Agriculture
Green Spaces Management	Residents	Bus Drivers	Infrastructure	Soil
Ward Committees	Apartment Housing	Bus Passengers	Productivity	
Blue Collared Workers	Individual Built ups	Truck Drivers	Economy	
Security Personnel	Informal Housing	Pedestrians		
Hospital Staff	Slum Dwellers	Delivery Personnel		
Theatre and Hotel Staff	Corporator and Politicians			

Fig 20: The initial step involved identifying various stakeholders and systems affected by heat stress under three categories of “life”, “systems”, and “natural resources”.
Source: Project Team

In the Heat Vulnerability Index, one can see that a construction workers has a very low influence on the context, but is affected highly by heat stress. Similarly, a resident living in an apartment building may have a high influence on the context (in terms of a say on policy or finding cooling methods), and is also affected by heat-stress lesser than a construction worker is. This vulnerability index, though simple, helped the project team start identifying the most vulnerable stakeholders in the ward.

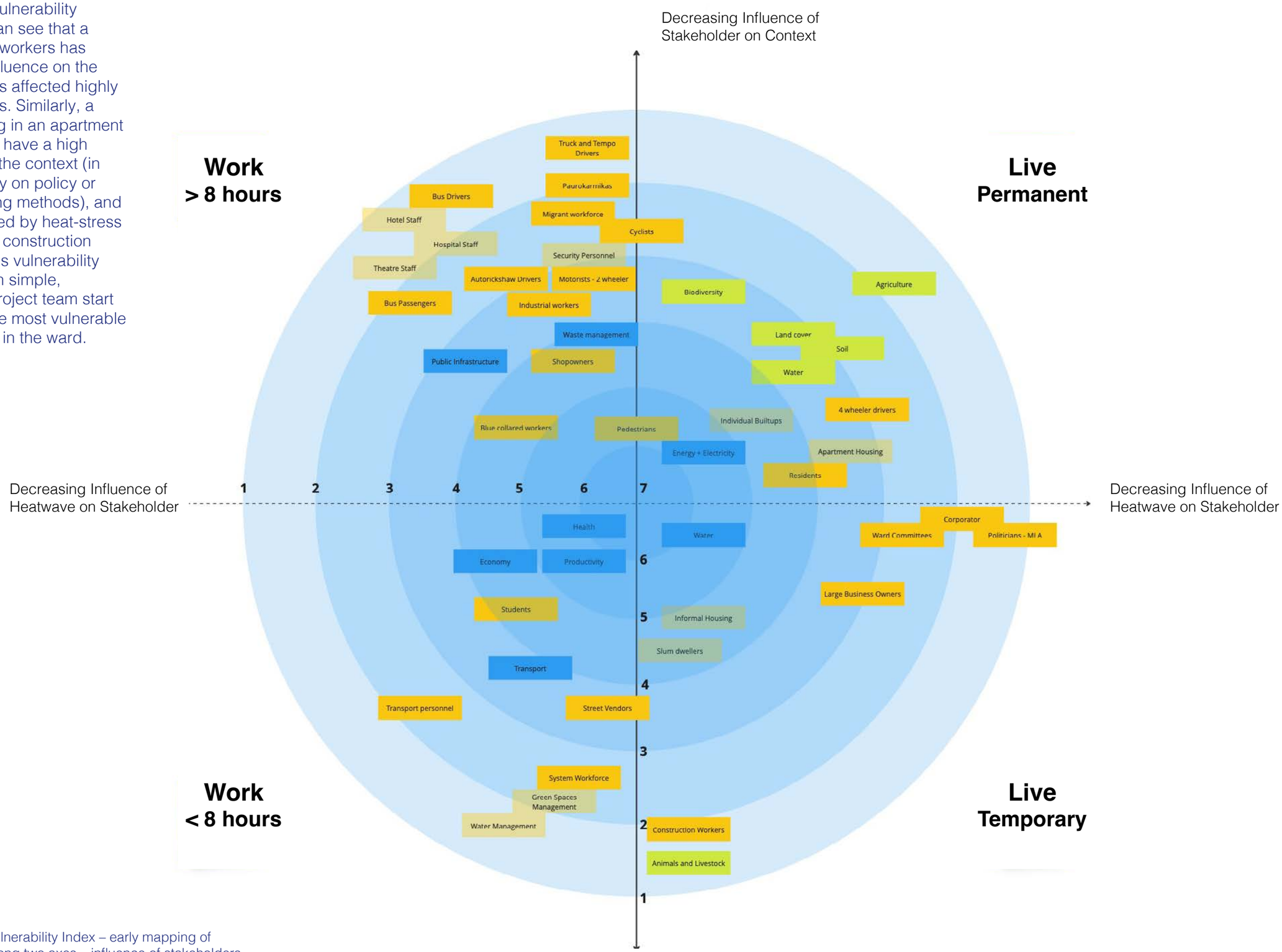


Fig 21: Heat Vulnerability Index – early mapping of stakeholders along two axes – influence of stakeholders on context, and influence of heatwaves on stakeholders. Source: Project Team

Fig 23: Outdoor workers like Pourakarmikas at work during their shift hours between 6 am to 2 pm face increasing heat-stress in Marappanapalya Ward.
Source: Project Team

2.3 Our Approach: Visualising Heat Stress as a Network Hazard

We undertook a network analysis which aimed to capture the nature and extent of relationships that exist between living elements in the ward (citizens and natural resources) and urban infrastructures, mediated and altered by heat as an agent. Conducting a network analysis of stakeholders, risks, hazards, and systems was crucial for several reasons, particularly in the context of understanding and mitigating heat risks at the ward level in the city. This comprehensive approach allows for a holistic understanding of the complex interactions and dependencies within the urban environment. This approach ensured that all relevant factors and stakeholders are considered, increasing our understanding of the context.

HAZARDS	CONTEXTS	VULNERABILITIES
High Temperatures	Transportation	Poverty
High Humidity	Housing	Building Quality
Pollution	Workplace	Materials
Infrastructure Collapse	Industry	Building Density
Productivity Loss	Construction Sites	Electricity Access
Loss of Livelihood	Outdoors	Age
	Offices	Comorbidities/ Disease
	Housing	Water Access
	Biodiversity	Work Type
		Health Access

Fig 24: The list of hazards, contexts, and vulnerabilities that we identified within Marappanapalya Ward, which enabled us to do the network analysis.
Source: Project Team

The analysis allowed us to describe the connections among all stakeholders in a single visualisation. The network analysis shows the various connections between different stakeholders, systems, and risks within the ward.

For example, susceptibility to disease is affected by access to healthcare systems, along with access to electricity, energy, water, and sanitation. Similarly, an infrastructure collapse due to a disaster (increasing heat-stress may overwhelm the capacity of the healthcare system and lead to a collapse) will affect the susceptibility to disease and access to finding measures. This would lead to a loss in productivity and a loss in livelihood, even leading to a loss of life.

Such an analysis of the network of stakeholders, systems, and risks helped the project team understand the connections, interdependencies, and the need to look at the ward from a systemic level to better understand the risks of increasing heat.

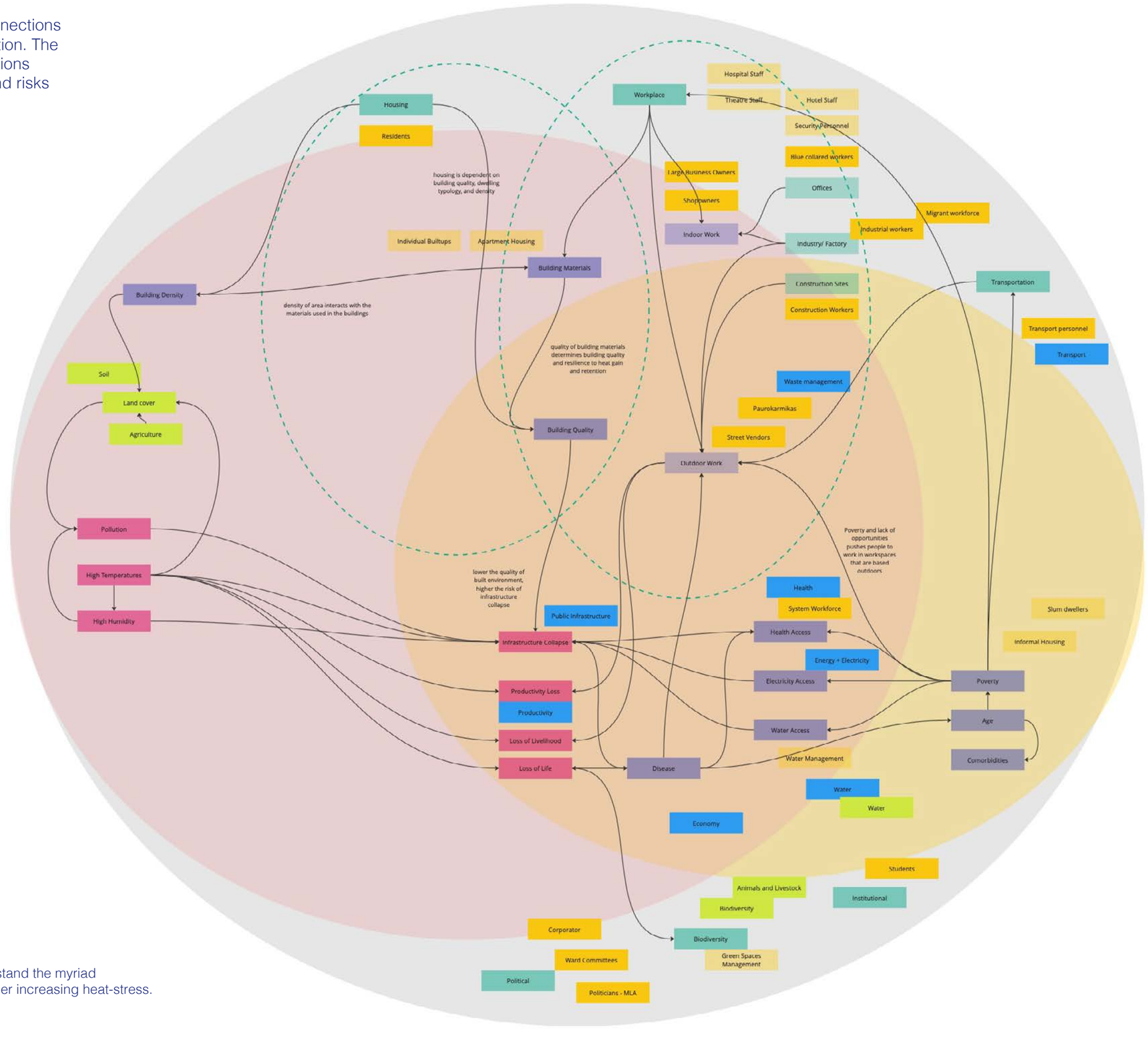


Fig 25: Initial Network Analysis undertaken to understand the myriad connections between systems and stakeholders under increasing heat-stress. Source: Project Team

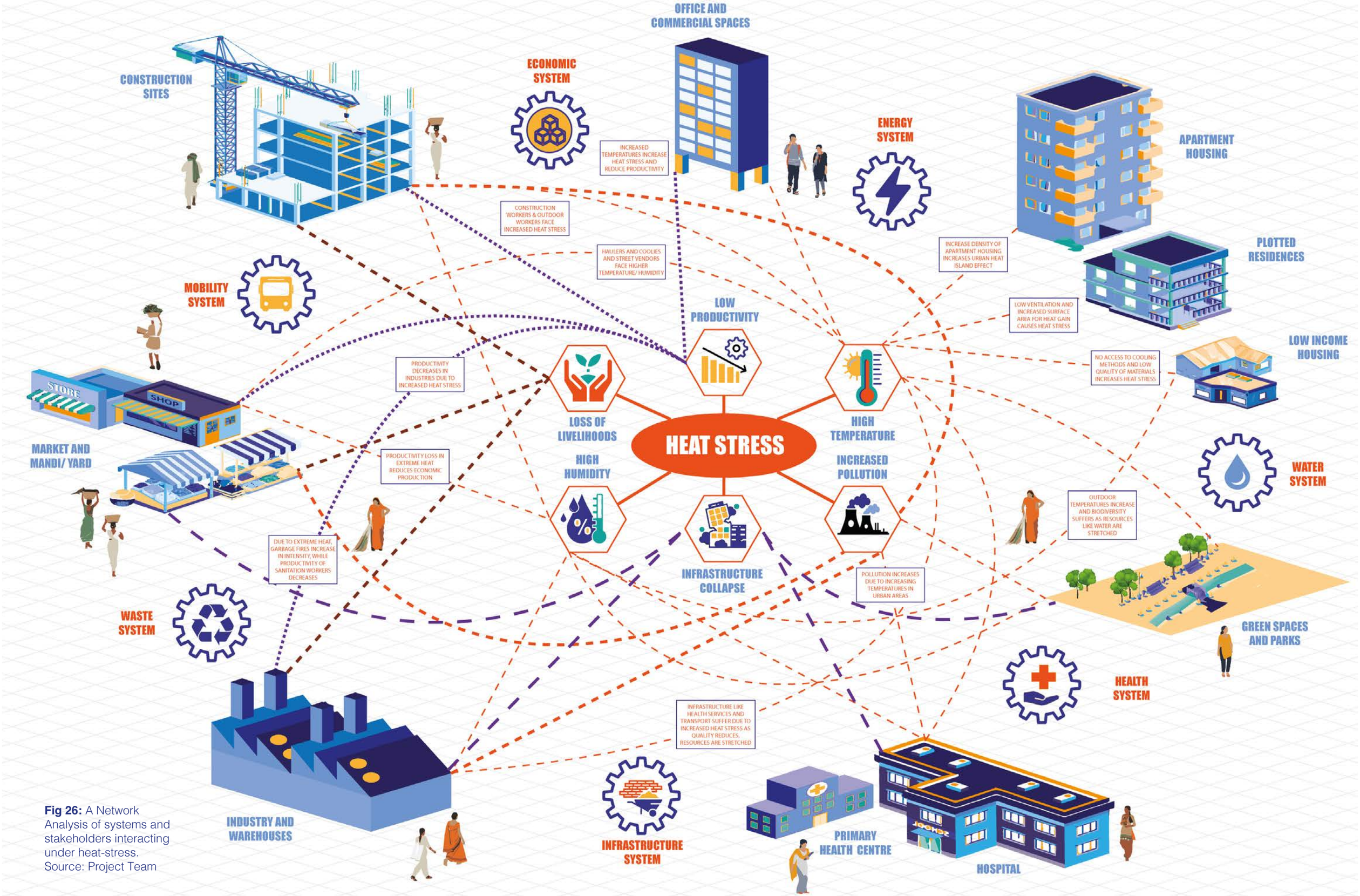


Fig 26: A Network Analysis of systems and stakeholders interacting under heat-stress. Source: Project Team

Fig 27: Various stakeholders who are increasingly vulnerable to rising temperatures in the ward. Source: Project Team

2.4 Developing a Heat Vulnerability Index

To complement the network analysis, we developed a heat impact matrix (currently under development) to capture the impact of heat stress on various elements in the ward in relation to 7 different infrastructural systems - water, energy, waste, economy, transport, built environment, and health. The elements are divided into categories of industrial, commercial, residential, transport, services, and biodiversity. The matrix is a visual representation of a Likert scale-based impact evaluation of two factors – (1) frequency of heat stress on the element and (2) level of concern of heat stress on each element vis-a-vis their interaction with the systems. The intersection of these two factors borrows from the heat vulnerability index to validate highest and lowest-impacted elements. Through prioritisation of most-impacted elements and systems in the ward, this mapping and analysis exercise helped in the development of a larger systems design framework to aid in mitigation planning among decision-makers in the ward.

The process started with identifying 33 different stakeholders (identification on ground and through secondary research - stakeholder mapping) in the Ward who would be susceptible to heat in various forms. Heat impact is not a direct process affecting only health, but also affects various other systems. We initially identified 7 different systems – water, energy, transport, waste, infrastructure, health, and economy which are impacted by heat and with whom 33 different stakeholders interact. We later narrowed down the systems to 4 systems – infrastructure, health, built environment, and economy.

33 Stakeholders	
Infrastructure	Water, Energy, Waste, Transport
Health	Physical, Social, Mental Health
Built Environment	Materials, Quality of Buildings, Density
Economy	Productivity, Social and Economic Production

Scale	Level of Impact	Scale	Level of Concern	Scale	Impact
0 - 10	Low Impact	**1**	No Concern	**49**	Extreme Impact
11 - 20	Medium Impact	**2**	Very Unconcerned	**42**	Severe Impact
21 - 30	Concerning Impact	**3**	Low Concern	**36**	High Impact
31 - 40	High Impact	**4**	Neutral	**30**	Significant Impact
41 - 49	Severe Impact	**5**	Concerned	**25**	Intermediate Impact
		6	Very Concerned	**20**	Moderate Impact
		7	Extremely Concerned	**16**	Reduced Impact
				12	Low Impact
				9	Little Impact
				6	Neutral Impact
				2	Insignificant Impact

Table 3: Likert Scale - Developing a Measurement of Vulnerability – through scales of concern and impact.
Source: Project Team

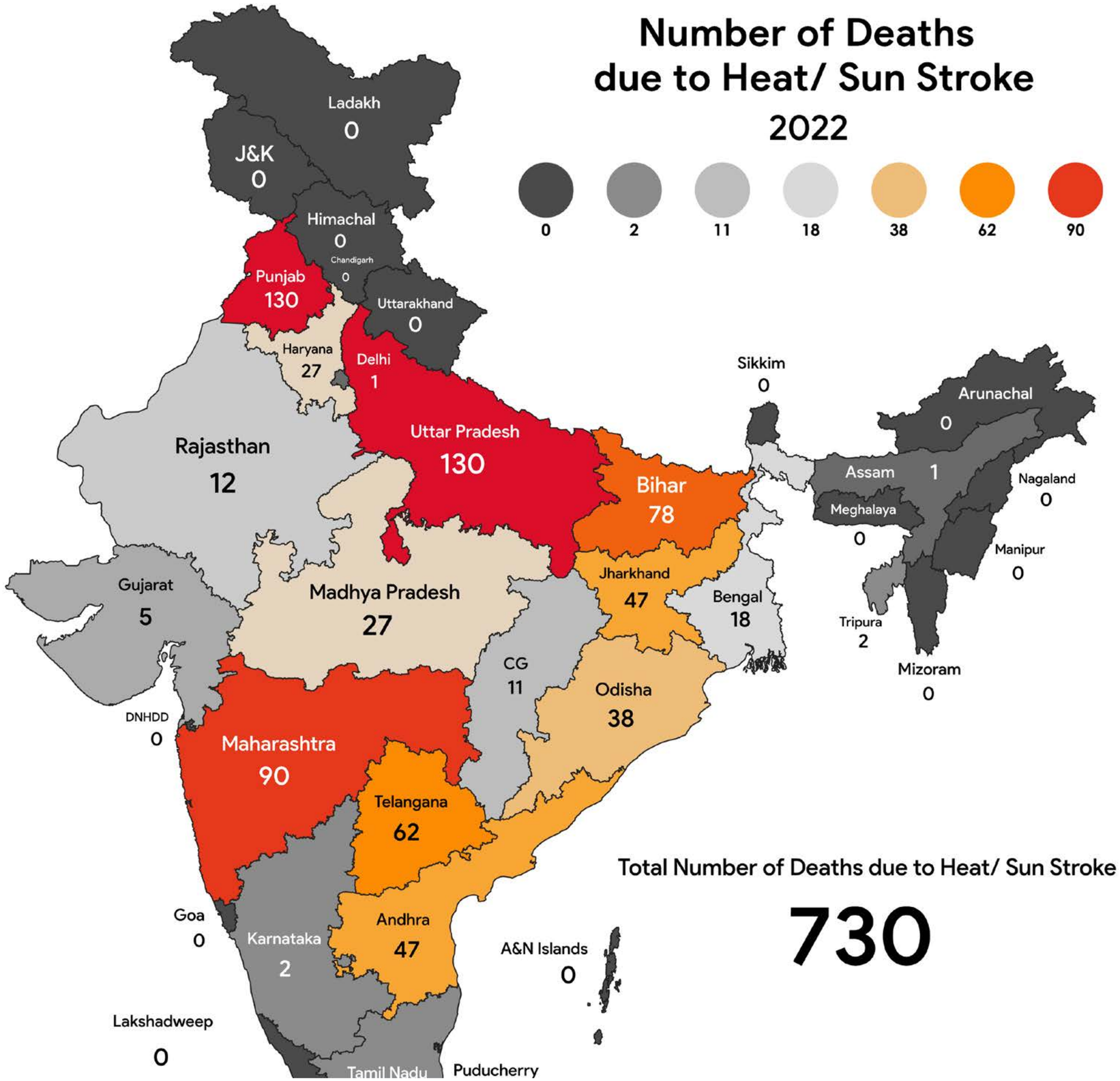
A matrix was created and filled with given numbers between 1-7 as per a Likert Scale (see Table 3) on two parameters – the Frequency of Negative Impact of Heatwaves; and the Level of Concern of Negative Impact of Heatwaves.

User	Heat Impact Matrix			
	Infrastructure	Health	Built Environment	Economy
Apartment Housing	12	16	6	9
Individual Plotted Built ups	25	25	12	12
Regularised Informal Housing	30	36	25	20
Slums	36	49	42	30
Factory Workers	36	36	36	42
Street Vendors	49	49	49	42
Security Personnel	36	49	42	28
Business Owners	25	25	16	24
Construction Workers	36	49	49	49
Students	9	20	9	2
Teachers	9	12	6	20
Hospital Staff	30	42	24	24
Theatre Staff	15	16	6	36
Hotel Staff	20	24	3	36
Pourakarmikas	36	49	49	42
Management Staff	12	12	9	20
Corporator	2	4	1	8
Politicians	1	1	1	9
Water Management	25	8	15	12
Electricity Management	25	8	12	12
Bank Personnel	12	20	9	30
Motorists	25	42	36	20
Autorickshaw Drivers	20	30	36	42
Cyclists	36	42	49	28
Four Wheeler Drivers	9	12	6	3
Bus Drivers	25	25	30	36
Bus Passengers	25	30	30	25
Truck Drivers	36	30	36	36
Goods Transport Drivers	49	42	49	49
Pedestrians	42	49	49	10
Delivery Personnel	36	49	42	49
Soil	16	36	16	12
Biodiversity	20	49	30	15

Table 4: The Heat Impact Matrix
Source: Project Team

The idea was to visually represent this matrix, by combining the Level of Concern and the Frequency of Negative Impacts of Heatwaves on individual Stakeholders while interacting with the four identified systems. By adding all stakeholders, grading them as per the Likert Scale, we combined the two factors to create a Heat Impact Matrix (see Table 4).

We further colour-coded the heat impact into various scales (as derived from the combination of Likert Scales). This helped us identify which stakeholders under which system were most vulnerable to heat, thus helping us prioritise certain stakeholders and systems, and set the trajectory of the project. We further backed our analysis through secondary data – through articles, reports, guides, etc.



High Priority
Slums
Street Vendors
Construction Workers
Pourakarmikas
Cyclists
Goods Transport
Delivery Personnel
Mid Priority
Factory Workers
Motorists
Security Personnel
Auto Drivers
Truck Drivers
Pedestrians
Biodiversity
Low Priority
Regularised Informal Housing
Hospital Staff

Fig 28: Prioritised stakeholders as per the vulnerability matrix helped us take the project forward onto the field.
Source: Project Team

Fig 29: This Radial Chart illustrates the negative impacts of heatwaves on various stakeholders. As is seen, Health is a primary system that is impacted negatively for stakeholders residing in slums.
Source: Project Team

Fig 30: A tradesperson carrying water bottles in the market in Marappanapalya Ward during the summer of 2024.
Source: Project Team

2.5 Mapping Green Cover and Land Surface Temperature

Mapping green cover and land surface temperature (LST) using satellite imagery is a critical tool for understanding and mitigating heat stress in urban areas, such as the Marappanapalya ward in Bangalore. Satellite imagery allows for precise mapping of green spaces, including trees, parks, and vegetation cover. This is crucial for understanding the current state of green infrastructure in the ward.

Satellite sensors provide high-resolution data on land surface temperatures, allowing for detailed mapping of heat distribution across the ward. This information is essential for identifying hotspots and understanding the spatial variations in temperature. By analysing LST data, we were able to identify areas with significant temperature differences, revealing the urban heat island (UHI) effect. These insights help pinpoint locations with higher heat stress, such as densely built areas with limited green cover.

It also helped us correlate the relationships between green cover and land surface temperature. Combining green cover data with LST information helped us in understanding the relationship between vegetation density, land use, and surface temperatures. This correlation is crucial for identifying areas where green cover can be increased to reduce heat stress.

Moreover, satellite imagery and heat maps are powerful tools for visualising data in a way that is easily understandable. It helped us make correlations, identify anomalies, and support the path forward in developing outcomes.

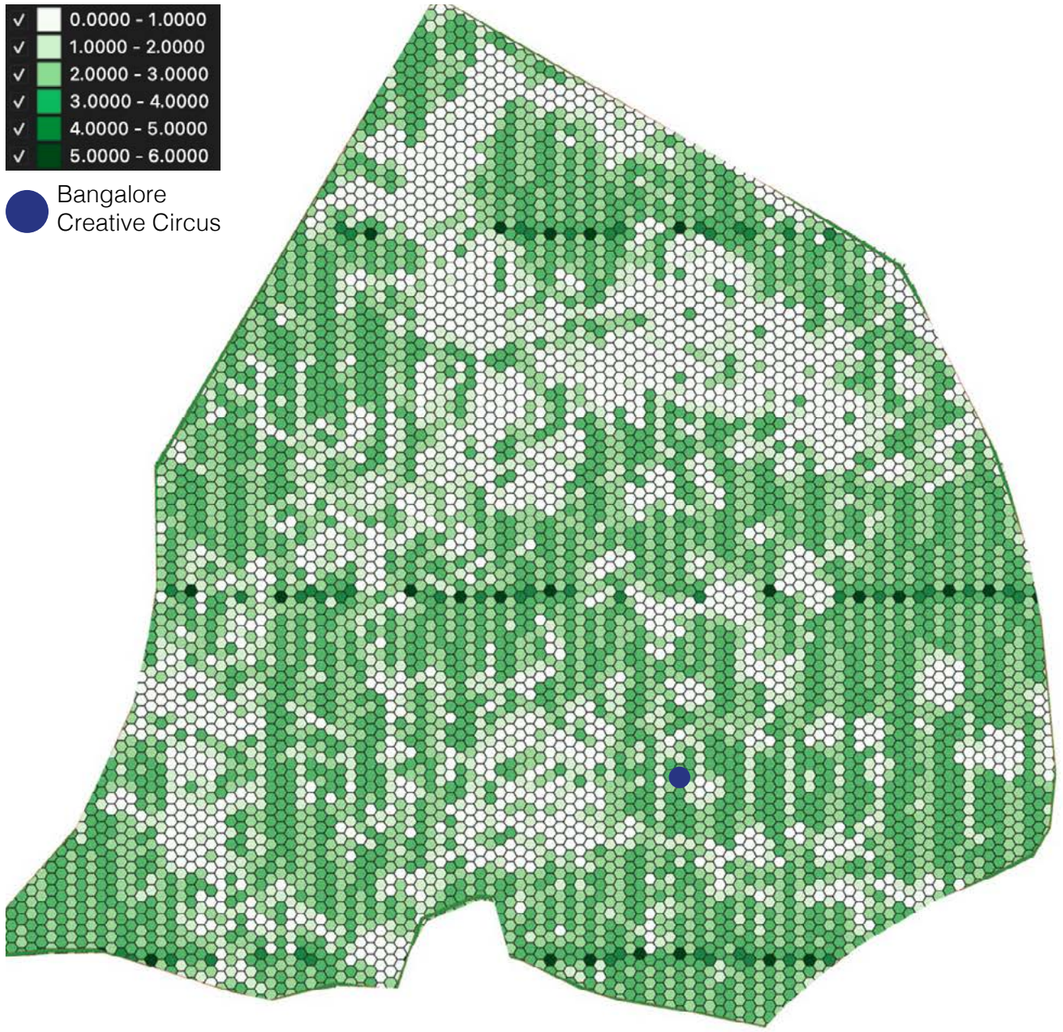


Fig 31: The **Green Cover map** used Normalised Different Vegetation Index (NDVI) data to quantify vegetation greenness and is useful in understanding vegetation density.
Source: Project Team

The green cover map of Marappanapalya Ward uses a hexagonal grid to represent the distribution of green spaces within the ward. Each hexagon appears to indicate the presence or absence of green cover, at a granular scale, showing the presence of green cover and the absence in certain areas which could be built-up areas, roads, or other non-vegetated surfaces. The map visually highlights the distribution and density of green cover in the ward, helping to identify regions with green cover - such as the Shankar Nagar Main Road and plotted residential areas, as well as areas that have lower green covers - such as the APMC Yard and the industrial areas. This type of mapping was useful in monitoring and identifying certain heat hotspots by pinpointing areas that may need more green spaces to mitigate urban heat island effects.

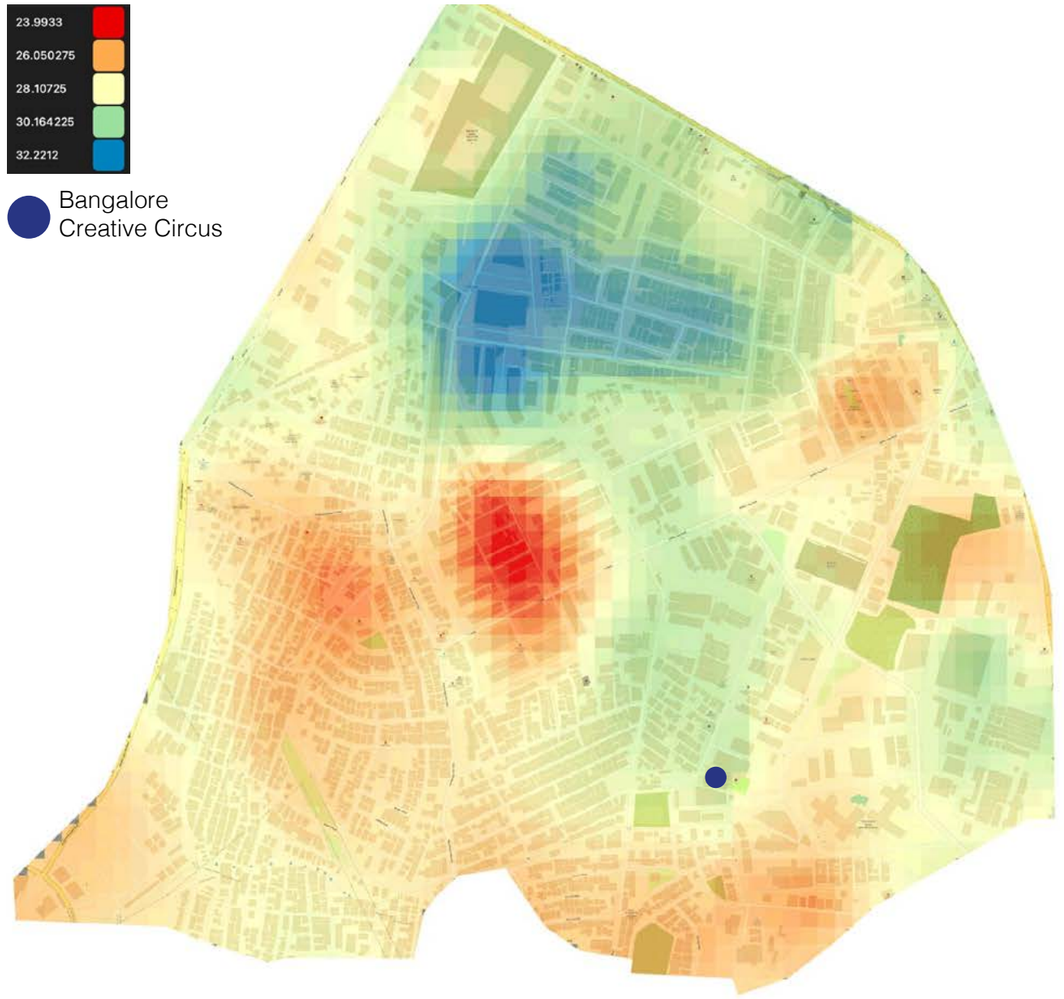


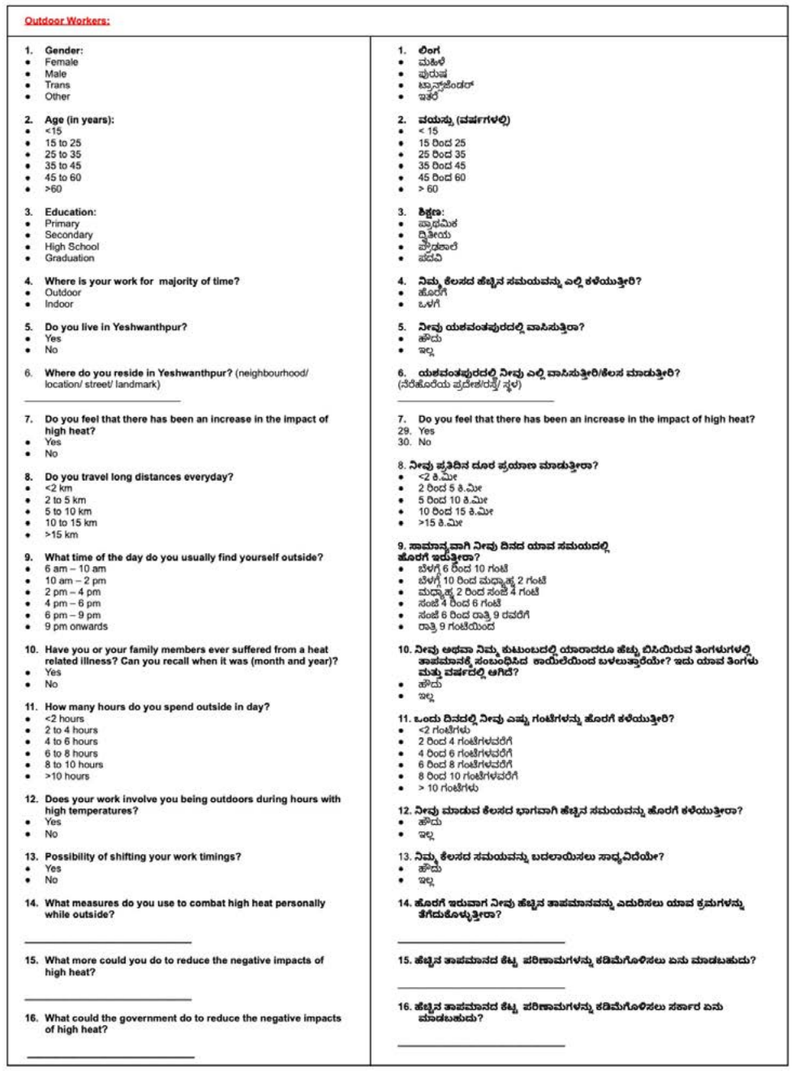
Fig 32: The **Land Surface Temperature map** shows the temperature difference between different areas of the ward - The APMC Yard (in red) is 9 degrees warmer than the BCC/ Industrial area (in green).
Source: Project Team

The Land Surface Temperature map of Marappanapalya Ward uses colour gradients to represent different temperature levels across the ward. The blue areas represent cooler regions with lower surface temperatures. These areas are likely to have more green cover, while the red areas indicate hotter regions with higher surface temperatures. These areas might be densely built-up, have less vegetation, or be heat islands with significant concrete and asphalt surfaces. The yellow areas represent moderate temperatures, transitioning between the cooler blue areas and the hotter red areas. The map shows varying temperatures across the ward, highlighting specific hotspots and cooler zones, helping us identify potential urban heat island effect spots, where built-up areas tend to be significantly warmer. When superimposed with the Green Cover map, this allowed us to gain insights into the relationship between vegetation and surface temperatures, and identify heat hotspots - such as the APMC yard which exposes many outdoor workers to heat.

2.6 Understanding Perceptions of Heat on Ground

The project team undertook a comprehensive field study in the Marappanpalya ward to gather qualitative data on the perceptions of heat and increasing heat stress among various stakeholders. This study involved conducting 50 interviews with individuals from diverse occupational and socio-economic backgrounds to ensure a holistic understanding of the community's experiences and concerns related to heat stress.

Interview Preparation: The project team developed a structured interview guide with open-ended questions to facilitate a range of responses (see Fig). Questions were tailored to each stakeholder group, focusing on their specific experiences and challenges. The team along with a field translator and facilitator conducted face-to-face interviews at various locations within the Marappanapalya ward.



Outdoor Workers:

1. **Gender:**
   - Female
   - Male
   - Trans
   - Other
2. **Age (in years):**
   - <15
   - 15 to 25
   - 25 to 35
   - 35 to 45
   - 45 to 60
   - >60
3. **Education:**
   - Primary
   - Secondary
   - High School
   - Graduation
4. **Where is your work for majority of time?**
   - Outdoor
   - Indoor
5. **Do you live in Yeshwanthpur?**
   - Yes
   - No
6. **Where do you reside in Yeshwanthpur?** (neighbourhood/ location/ street/ landmark)

   _____
7. **Do you feel that there has been an increase in the impact of high heat?**
   - Yes
   - No
8. **Do you travel long distances everyday?**
   - <2 km
   - 2 to 5 km
   - 5 to 10 km
   - 10 to 15 km
   - >15 km
9. **What time of the day do you usually find yourself outside?**
   - 6 am – 10 am
   - 10 am – 2 pm
   - 2 pm – 4 pm
   - 4 pm – 6 pm
   - 6 pm – 9 pm
   - 9 pm onwards
10. **Have you or your family members ever suffered from a heat related illness? Can you recall when it was (month and year)?**
    - Yes
    - No
11. **How many hours do you spend outside in day?**
    - <2 hours
    - 2 to 4 hours
    - 4 to 6 hours
    - 6 to 8 hours
    - 8 to 10 hours
    - >10 hours
12. **Does your work involve you being outdoors during hours with high temperatures?**
    - Yes
    - No
13. **Possibility of shifting your work timings?**
    - Yes
    - No
14. **What measures do you use to combat high heat personally while outside?**

    _____
15. **What more could you do to reduce the negative impacts of high heat?**

    _____
16. **What could the government do to reduce the negative impacts of high heat?**

    _____

1. **ಲಿಂಗ**
   - ಮಹಿಳೆ
   - ಪುರುಷ
   - ಟ್ರಾನ್ಸ್‌ಜೆಂಡರ್
   - ಇತರೆ
2. **ವಯಸ್ಸು (ವರ್ಷಗಳಲ್ಲಿ)**
   - < 15
   - 15 ರಿಂದ 25
   - 25 ರಿಂದ 35
   - 35 ರಿಂದ 45
   - 45 ರಿಂದ 60
   - > 60
3. **ಶಿಕ್ಷಣ:**
   - ಪ್ರಾಥಮಿಕ
   - ದ್ವಿತೀಯ
   - ಪ್ರೌಢಶಾಲೆ
   - ಪದವಿ
4. **ನಿಮ್ಮ ಕೆಲಸದ ಹೆಚ್ಚಿನ ಸಮಯವನ್ನು ಎಲ್ಲಿ ಕಳೆಯುತ್ತೀರಿ?**
   - ಹೊರಗೆ
   - ಒಳಗೆ
5. **ನೀವು ಯಶವಂತಪುರದಲ್ಲಿ ವಾಸಿಸುತ್ತಿರಾ?**
   - ಹೌದು
   - ಇಲ್ಲ
6. **ಯಶವಂತಪುರದಲ್ಲಿ ನೀವು ಎಲ್ಲಿ ವಾಸಿಸುತ್ತೀರಿ/ಕೆಲಸ ಮಾಡುತ್ತೀರಿ?** (ನೆರೆಹೊರೆಯ ಪ್ರದೇಶ/ರಸ್ತೆ/ ಸ್ಥಳ)

   _____
7. **Do you feel that there has been an increase in the impact of high heat?**
29. Yes
30. No
8. **ನೀವು ಪ್ರತಿದಿನ ದೂರ ಪ್ರಯಾಣ ಮಾಡುತ್ತೀರಾ?**
   - <2 ಕಿ.ಮೀ
   - 2 ರಿಂದ 5 ಕಿ.ಮೀ
   - 5 ರಿಂದ 10 ಕಿ.ಮೀ
   - 10 ರಿಂದ 15 ಕಿ.ಮೀ
   - >15 ಕಿ.ಮೀ
9. **ಸಾಮಾನ್ಯವಾಗಿ ನೀವು ದಿನದ ಯಾವ ಸಮಯದಲ್ಲಿ ಹೊರಗೆ ಇರುತ್ತೀರಾ?**
   - ಬೆಳಗ್ಗೆ 6 ರಿಂದ 10 ಗಂಟೆ
   - ಬೆಳಗ್ಗೆ 10 ರಿಂದ ಮಧ್ಯಾಹ್ನ 2 ಗಂಟೆ
   - ಮಧ್ಯಾಹ್ನ 2 ರಿಂದ ಸಂಜೆ 4 ಗಂಟೆ
   - ಸಂಜೆ 4 ರಿಂದ 6 ಗಂಟೆ
   - ಸಂಜೆ 6 ರಿಂದ ರಾತ್ರಿ 9 ರವರೆಗೆ
   - ರಾತ್ರಿ 9 ಗಂಟೆಯಿಂದ
10. **ನೀವು ಅಥವಾ ನಿಮ್ಮ ಕುಟುಂಬದಲ್ಲಿ ಯಾರಾದರೂ ಹೆಚ್ಚು ವಿಪರೀತವಿರುವ ತಿಂಗಳುಗಳಲ್ಲಿ ತಾಪಮಾನಕ್ಕೆ ಸಂಬಂಧಿಸಿದ ಕಾಯಿಲೆಯಿಂದ ಬಳಲುತ್ತಾರೆಯೇ? ಇದು ಯಾವ ತಿಂಗಳು ಮತ್ತು ವರ್ಷದಲ್ಲಿ ಆಗಿದೆ?**
    - ಹೌದು
    - ಇಲ್ಲ
11. **ಒಂದು ದಿನದಲ್ಲಿ ನೀವು ಎಷ್ಟು ಗಂಟೆಗಳನ್ನು ಹೊರಗೆ ಕಳೆಯುತ್ತೀರಿ?**
    - <2 ಗಂಟೆಗಳು
    - 2 ರಿಂದ 4 ಗಂಟೆಗಳವರೆಗೆ
    - 4 ರಿಂದ 6 ಗಂಟೆಗಳವರೆಗೆ
    - 6 ರಿಂದ 8 ಗಂಟೆಗಳವರೆಗೆ
    - 8 ರಿಂದ 10 ಗಂಟೆಗಳವರೆಗೆ
    - > 10 ಗಂಟೆಗಳು
12. **ನೀವು ಮಾಡುವ ಕೆಲಸದ ಭಾಗವಾಗಿ ಹೆಚ್ಚಿನ ಸಮಯವನ್ನು ಹೊರಗೆ ಕಳೆಯುತ್ತೀರಾ?**
    - ಹೌದು
    - ಇಲ್ಲ
13. **ನಿಮ್ಮ ಕೆಲಸದ ಸಮಯವನ್ನು ಬದಲಾಯಿಸಲು ಸಾಧ್ಯವಿದೆಯೇ?**
    - ಹೌದು
    - ಇಲ್ಲ
14. **ಹೊರಗೆ ಇರುವಾಗ ನೀವು ಹೆಚ್ಚಿನ ತಾಪಮಾನವನ್ನು ಎದುರಿಸಲು ಯಾವ ಕ್ರಮಗಳನ್ನು ತೆಗೆದುಕೊಳ್ಳುತ್ತೀರಾ?**

    _____
15. **ಹೆಚ್ಚಿನ ತಾಪಮಾನದ ಕೆಟ್ಟ ಪರಿಣಾಮಗಳನ್ನು ಕಡಿಮೆಗೊಳಿಸಲು ಏನು ಮಾಡಬಹುದು?**

    _____
16. **ಹೆಚ್ಚಿನ ತಾಪಮಾನದ ಕೆಟ್ಟ ಪರಿಣಾಮಗಳನ್ನು ಕಡಿಮೆಗೊಳಿಸಲು ಸರ್ಕಾರ ಏನು ಮಾಡಬಹುದು?**

    _____

Fig 33: Sample Questionnaire created for qualitative interviews in Marappanapalya Ward. Vulnerable stakeholders like outdoor workers, residents, businesses owners, etc. were identified, and questionnaires were created for each. Source: Project Team

Most respondents reported a noticeable increase in temperature over recent years, with significant impacts on their daily routines and health. Commonly reported issues included heat exhaustion, and dehydration.

Some responses around perceptions of heat and increasing heat-stress are detailed below:

Construction Worker

"It was less hot then but we have to come out in the sun to work, don't we?"

Auto Rickshaw Driver

"The number of customers goes down. Nobody likes to go outside in the sun. Therefore, the number decreases."

School Children

"My younger son feels more tired than usual in the summer. He comes back with fatigue from school."

Resident of a Low-Income Settlement

"The electricity supply keeps getting interrupted… Yes, the electricity bill increases during summers when compared to winter season."

Officials at the Yeshwanthpur Fire Station

“The climate has been changing continuously. It did not rain last year. It is extremely hot this year.”

“People litter everywhere. Most of the incidents arise due to garbage. People tend to throw away their beedis and cigarettes. It is usually hot and little ignition is enough to start the fire. These are the incidents reported to us mostly. Wastage fires.”

Nursery Workers

“Yes, plants die and that amounts to a loss to us. When heat increases, we either sit in the shade or drink more water. There is no other facility per se.”

Resident

“It is very hot now. I feel very tired. I become very thirsty. There are power outages often. Especially in the summer.”

Factory Worker

“When it is hot, I am unable to travel or even walk outside for a while. The fan keeps running… so electricity bill increases.”

Fruit Vendor

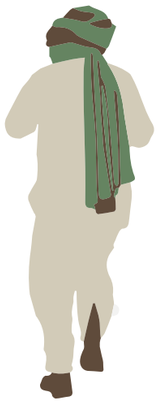
“There is no water in the borewells this year. There is no water this year.”

Business Owner

“We are eight members. We could not bear the heat. We can not stop using the fan just because the bill increases or stop eating because the prices increase.”

Hauler Coolie

“The reason why the weather has changed is because there are not many trees and plants. As I have seen over the years, there is a decline in their number. There used to be several trees here. We used to do coolie work and then sleep under the shade of those trees. Weather then used to be good.”



“Plants and trees are essential for the growth of crops. If they keep chopping it down, how will there be rain? How will the weather be cool?”

As was observed, there was inherent understanding amongst the citizens and workers around the reasons behind increasing temperatures and heat-stress. Many pointed out that decreasing number of trees and increasing concretisation along with increasing water scarcity is affecting the temperatures in urban areas – the UHI effect.

Fig 34: A street vendor selling watermelons covers her produce under straw mats to protect it from the intense and harsh sunlight.
Source: Project Team

Part 3

Forms of Engagement to Share Findings

3.1 Developing a Website to Document our Process

We developed a website to disseminate insights on Bangalore's impending heat crisis. Through the website, we have been able to expand our outreach, facilitated knowledge dissemination, and documented our process of addressing the challenges posed by rising temperatures in the city.

The website was developed keeping the following outputs in mind:

- **Enhanced Accessibility:** The creation of a website has provided a centralized platform for individuals to access information related to our project and its outcomes.
- **In-depth Insights:** The website was conceptualised as a repository for in-depth articles, research findings, and data visualizations, we have been able to provide a more comprehensive documentation of our process.
- **Documentation of Process:** The website serves as a valuable tool for documenting our process of addressing the issue of heat in Bangalore. From outlining our research methodologies and data collection techniques to sharing our strategies, initiatives, and progress reports, the website offers an easy access to our project.
- **Long-term Impact:** Unlike social media posts that have a limited lifespan, the content published on our website has the potential for long-term impact and relevance.

Visit our website here:
https://bangaloreheatwaveguide.wordpress.com

Fig 35: A Snapshot of the Website Bangalore Heatwave Guide
Source: Project Team

3.2 Developing a Climate Vulnerability Walk

Fire Station

"People litter everywhere. Most of the incidents arise due to garbage. People tend to throw away their beedis and cigarettes. It is usually hot and little ignition is enough to start the fire."

Coolie

"There used to be several trees here. We used to do coolie work and then sleep under the shade of those trees. Weather then used to be good."

Small Shop Owner

"Customers find it difficult to come in the sun. They do not come because of heat. This causes some decrease in business too."

Fig 36: A stitched panorama from the ward showing the extent of the ward from the Fire station to the market - a range of land-uses and stakeholders are affected by increasing heat-stress.
Source: Project Team

2.2.1 Understanding the Context

Through various walks in the project area (Marappanapalya Ward) during the initial research period, it became clear that the context is heterogeneous, diverse, and different aspects would respond to heat-stress differently.

Understanding heat stress through network mapping – how that threw up ideas of heat affecting various systems and stakeholders – became apparent only on site.

Walking the ward became a method of understanding the context and heat stress for the project team because it provided an immersive, on-the-ground perspective that can't be fully captured through data alone. By physically walking through different neighbourhoods within the Marappanapalya ward, the project team could directly observe and experience the various environmental and social conditions that contribute to heat stress. This method allowed us to identify various land-use within the ward, possibility of heat islands, variations in building materials, access to green spaces, and the availability of shade and cooling resources. It allowed us to connect the various systems we came across to the impending risks of increasing heat-stress. This comprehensive, contextual understanding was crucial for developing effective, localized interventions and an understanding to mitigate heat.

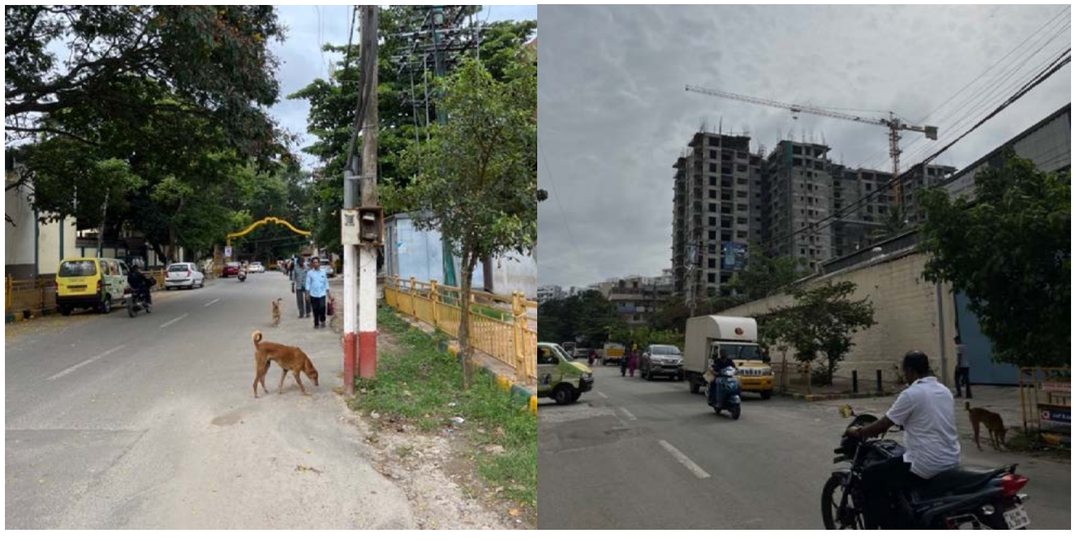


Fig 37: Images from initial walks in the ward undertaken by the project team. Walking the context became crucial in understanding the ground reality of heat-stress within the ward.
Source: Project Team

2.2.2 Walk as a Method

The Climate Vulnerability Walk was conceived as an innovative method to enhance both understanding and communication of the impacts of increasing heat-stress on various systems within Marappanpalya ward. This immersive, on-the-ground approach provided a unique opportunity for participants to experience first-hand the spatial realities of heat exposure and its multifaceted effects on the community. By physically walking through the ward, participants could directly observe the areas most affected by heat stress, such as zones with limited green cover, densely populated low-income neighbourhoods, and hotspots of economic activity like street vendor clusters.

This experiential method was particularly effective in highlighting the interconnected nature of heat stress impacts on systems such as water supply, energy consumption, and public health. Participants could see how inadequate shade and high temperatures strain water resources, increase electricity demand for cooling, and exacerbate health issues among vulnerable populations.

The walk has also facilitated real-time discussions and reflections, enabling participants to contextualise data and analysis with tangible observations. Additionally, participants from different sectors and backgrounds could relate to the personal stories and lived experiences shared during the walk.

This method proved invaluable in bridging the gap between technical research and community engagement, making the complex issue of climate vulnerability more accessible and actionable for diverse audiences.

2.2.3 Developing the Walk as an Output

From our experience in Marappanapalya, the walk acts as a way to surface four kinds of dynamics which may otherwise remain hidden. It can help understand and appreciate the dependencies and feedbacks that exist among different stakeholders and systems in the ward (‘What kind of relationships?’). It can also help us to identify local community groups which are most vulnerable to heat stress (‘Who is vulnerable? How?’). The preparatory phase of designing the walk can enable local ward residents to share their perceptions of space and heat-stress in the ward, helping us better understand existing risks and preparedness (‘Early warning for who? Impact mitigation, how?’). Finally, it can help develop context specific adaptation and mitigation-based early warning systems for heatwaves in the city. Our efforts have made us realise that Walks can be powerful mediums of vigilant action.

As the negative impacts of heat are increasingly being felt across the country, the city of Bengaluru will remain no stranger to high temperatures either. As we face extremely hot days with increasing frequency, it is important that citizens better understand vulnerability to heat stress and get to think about how we can respond effectively to mitigate its impacts at the local level.

The ‘Understanding Climate Vulnerability in Marappanapalya’ walk is an effort to make the citizens of Bengaluru (students, architects, researchers, general public) aware of how prepared (or unprepared) we are to face heatwaves in the city, and how vulnerability may be determined by how you live and what you do.

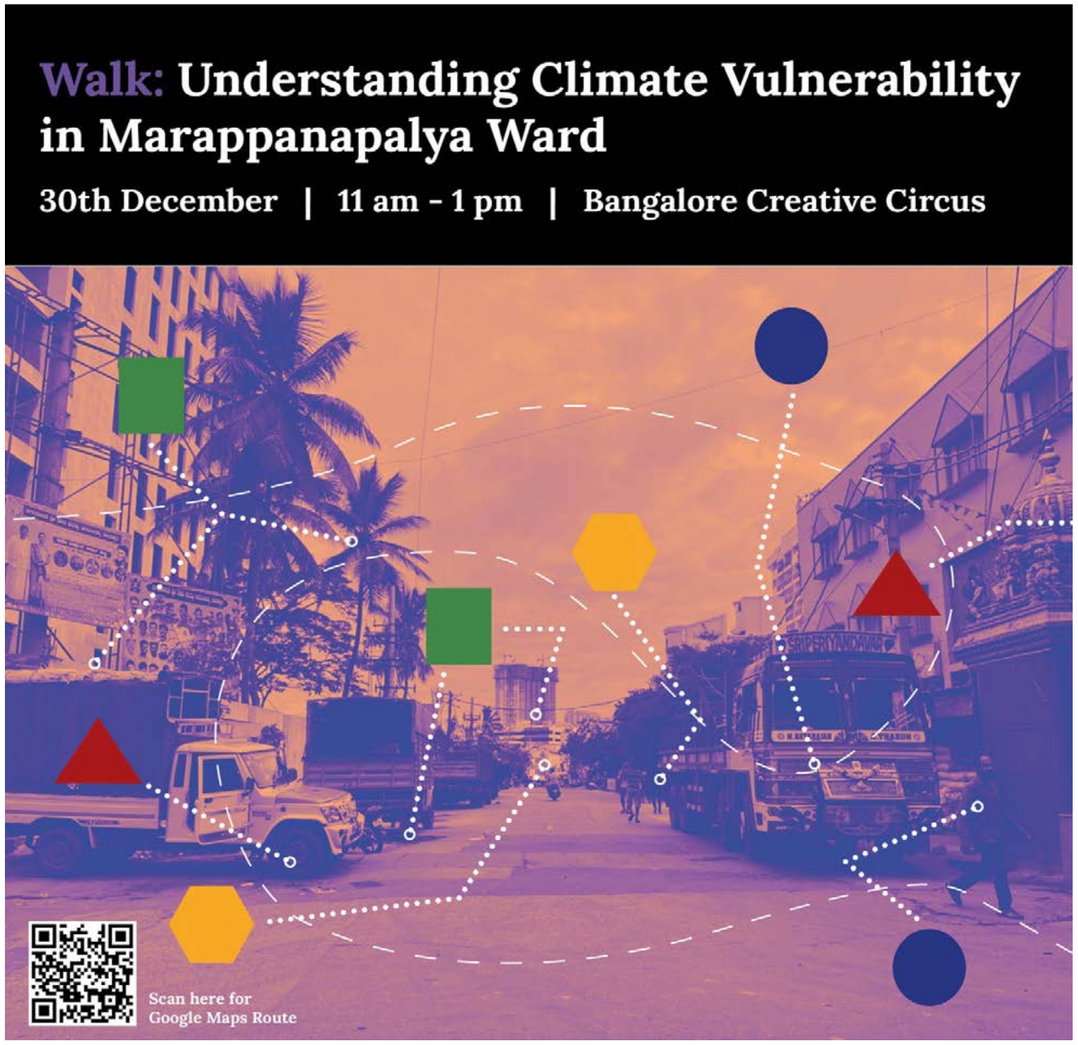


Fig 38: Invitation Poster for the Climate Vulnerability Walk developed for December 2023 which had a varied group of ecologists, PhD students, architects, visual designers, and photographers join.
Source: Project Team

Although a ward is the smallest administrative unit in the city, many citizens and even residents of the ward may be unaware about its composition, heterogeneity, and size. By connecting these dots with local infrastructure systems (health, water, energy, economy, built environment), the walk is an effort to help participants visualise how heat stress and these systems combine to create vulnerability, or mitigate it. The walk is aimed to act both as a method and as an output - a method to better understand vulnerability to heat among local communities, and as an output for creating awareness about the impending challenges among the citizens of Bengaluru.

The walk route passes through various neighbourhoods, letting participants see these various land uses and the built environment. During the walk, the walk leaders initiate conversations which try to relate the personal experiences of the participants with the existing ward dynamics they observe. This helps participants understand how heat stress

Parts of the Walk		
Theme	**Discussion Points**	**Time**
Why climate action?	How do you think climate change will affect your life?	*4 mins*
Heat and You!	How does heat affect you? What do you do to cope?	*3 mins*
Why are we here?	What is climate vulnerability? Why this walk? What is its intention?	*3 mins*
Handout	Handing out Stickers and Map Introduction to the Ward Explaining Task and Route Map	*5 mins*
Mobilizing	Water/ toilet breaks etc.	*5 mins*
Ward Walk	7 checkpoints	*70 mins*
Pre-debrief	Refreshments, gather your thoughts	*10 mins*
Debrief	Tell us about the ward you saw?	*15 mins*
Feedback	Comments for the walk leaders	*5 mins*
		~ 120 minutes

Table 5: The various parts of the Climate Vulnerability Walk that takes participants through the ward.
Source: Project Team

interacts with different infrastructure systems, and how a changing ward means changing vulnerabilities to heat stress. The walk also hopes to acquaint participants with how interconnected different hazards (for example, floods) are, and how local stakeholders currently perceive heat stress.

The Walk takes participants through seven checkpoints through the project area, covering a diverse area of varied land use – residential, industrial, and commercial. Each participant is handed an activity sheet with the walk route on Google Maps, the names of the 7 checkpoints, and a sticker exercise to mark points on the map while walking the route. Participants are asked to use the stickers of “Stakeholder”, “Boundary”, and “Resources” to mark site impressions. The aim is to develop a comprehensive understanding of the ward through a marked map via personal/ individual/ communal knowledge, which when overlapped with other maps, will generate common knowledge and questions.

Site Impressions Activity Stickers		
Aspect	**Examples**	**Sticker**
BOUNDARY	Change in land use, change in building typology, change in infrastructure, etc.	
STAKEHOLDER	Stakeholders involved in outdoor work like pourakarmikas, construction workers, etc.	
RESOURCES	Measures to mitigate heats-stress – potential and tangible – shelter over a stall, umbrella over street vendors, water ATM, etc.	

Table 6: The Walk activity is based on site impressions of mapping vulnerable stakeholders and boundaries in land-use, building type, etc. and resources used to combat heat-stress.
Source: Project Team

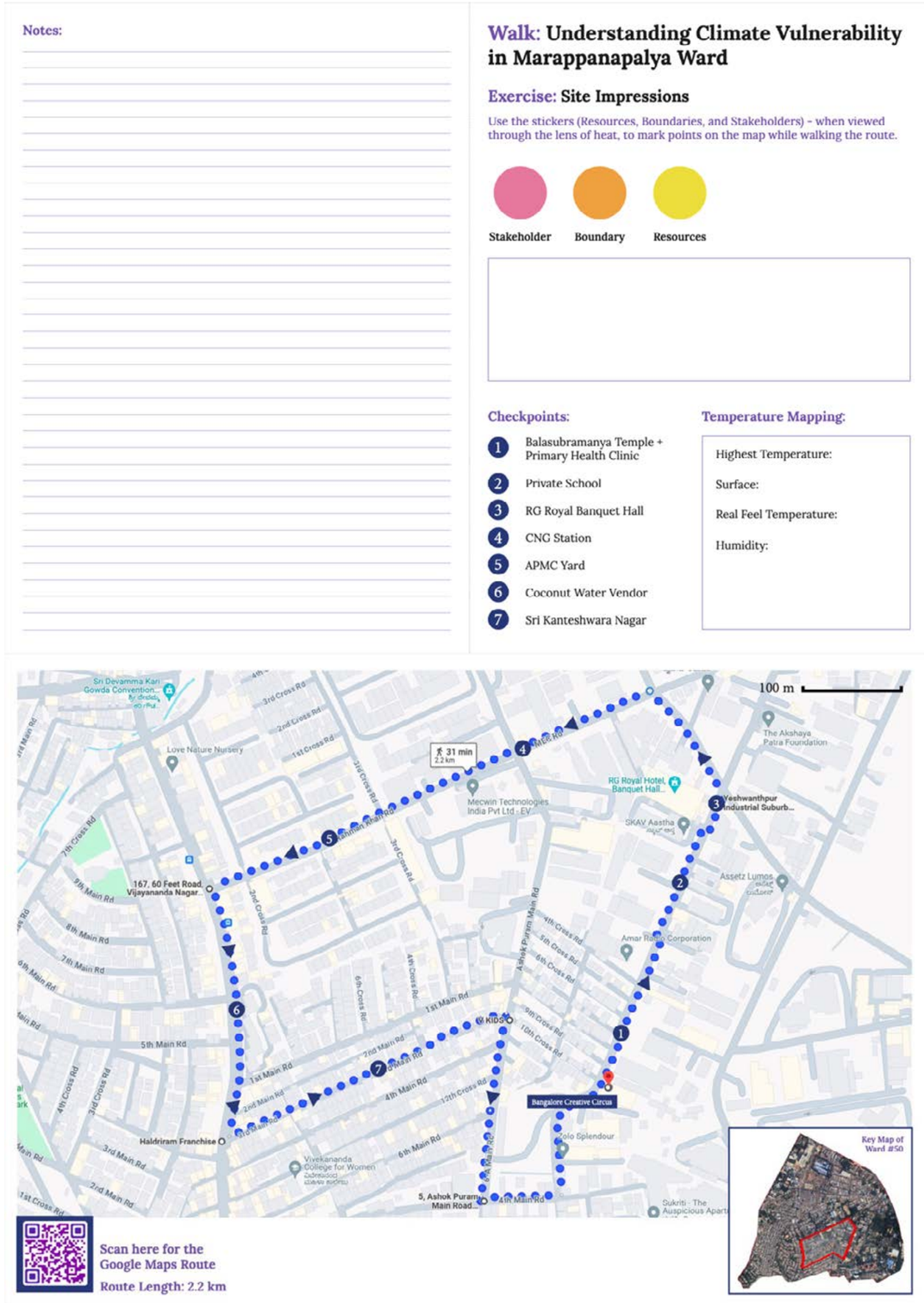


Fig 39: Activity Handout with Site Impressions exercise and Route Map for Participants
Source: Project Team

Fig 40: The pilot walk in Marappanapalya ward on 30th December 2023 had participants from the fields of social science, ecology, law, architecture and design. The diverse group of participants brought out interesting observations from the project site, drawing parallels to contextualising climate vulnerability within their own contexts.
Source: Project Team

Checkpoints of the Walk		
S. No.	**Checkpoint**	**Remarks**
1	**Temple + Primary Health Centre**	Heat and Health • History of the Ward and a Rapidly-changing ward environment • What health issues typically arise from heat? • Number of Heat Deaths in India. • What are Primary Health Centres?
2	**Private School**	Heat as a Disaster • Were you taught disaster management in school? • Was heat ever taught as a disaster? • How does built-form relate to heat stress? • Did you or your parents ever come to this part of the city?
3	**Banquet Hall**	Heat and Urban Environments • Real feel temperature – under shade and without • Urban Heat Island Effect (UHI)
4	**CNG Station**	Heat and Jobs • Are you feeling tired already? • What is Wet-bulb temperature? • Who are the people working in the heat who would be most vulnerable? • Productivity loss in industries and sectors
5	**APMC Yard**	Heat and Agriculture and Local Economy • How does heat affect agricultural produce? • How are heatwaves and water crisis linked • Loss in economic output
6	**Plotted residential area**	Heat and the Individual at Home • How does one combat heat? An increase in electricity demand, water demand, health services demand • How do people (residents) perceive heat? • What is the extent of advisory that exists? Do you think these are enough?
7	**End of Ashoka Puram**	Heat as part of other Systems • What is systems design? • Heat and other hazards - systematic, transferable, inter-connected • Which agencies look after these different risks? • Climate action and disaster management

Table 7: The Climate Vulnerability Walk has seven checkpoints where the participants discuss various effects of heat on different systems.
Source: Project Team

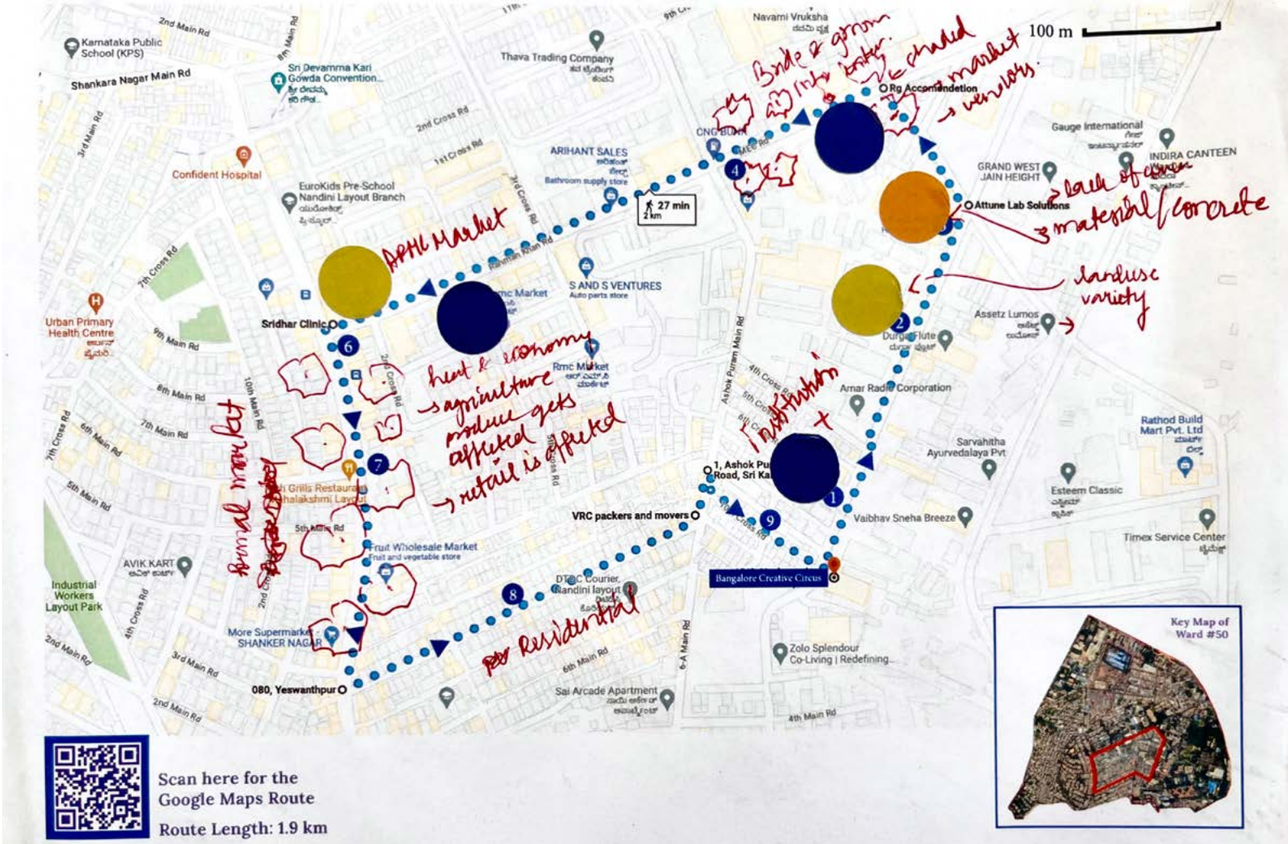


Fig 41: A participant's notes from the walk. The Climate Vulnerability Walk asks participants to engage with the context by using stickers as markers to document potential vulnerabilities, stakeholders, and land use boundaries when viewed from the lens of heat stress.
Source: Project Team

Fig 42: Participants during the briefing and debriefing sessions of the Climate Vulnerability Walk in Marappanapalya ward discussing their observations and perceptions. This also serves as a feedback loop for us to modify and adapt the walk to mobilise collective action.
Source: Project Team

3.3 Our Engagement with Other City-level Forums

Our engagement with city-level forums such as Ellara Bengaluru and Climate Asia has been instrumental in expanding our network, enhancing our research capabilities, and fostering collaborative implementation strategies for addressing heat stress in Marappanapalya ward. These partnerships have significantly broadened our access to expertise, resources, and innovative solutions, strengthening our overall approach to urban climate resilience.

By leveraging the expertise, resources, and networks of these platforms, we have enhanced our project's scope, increasing both our awareness of the scale of solutions possible, plus gauging interests of various stakeholders.

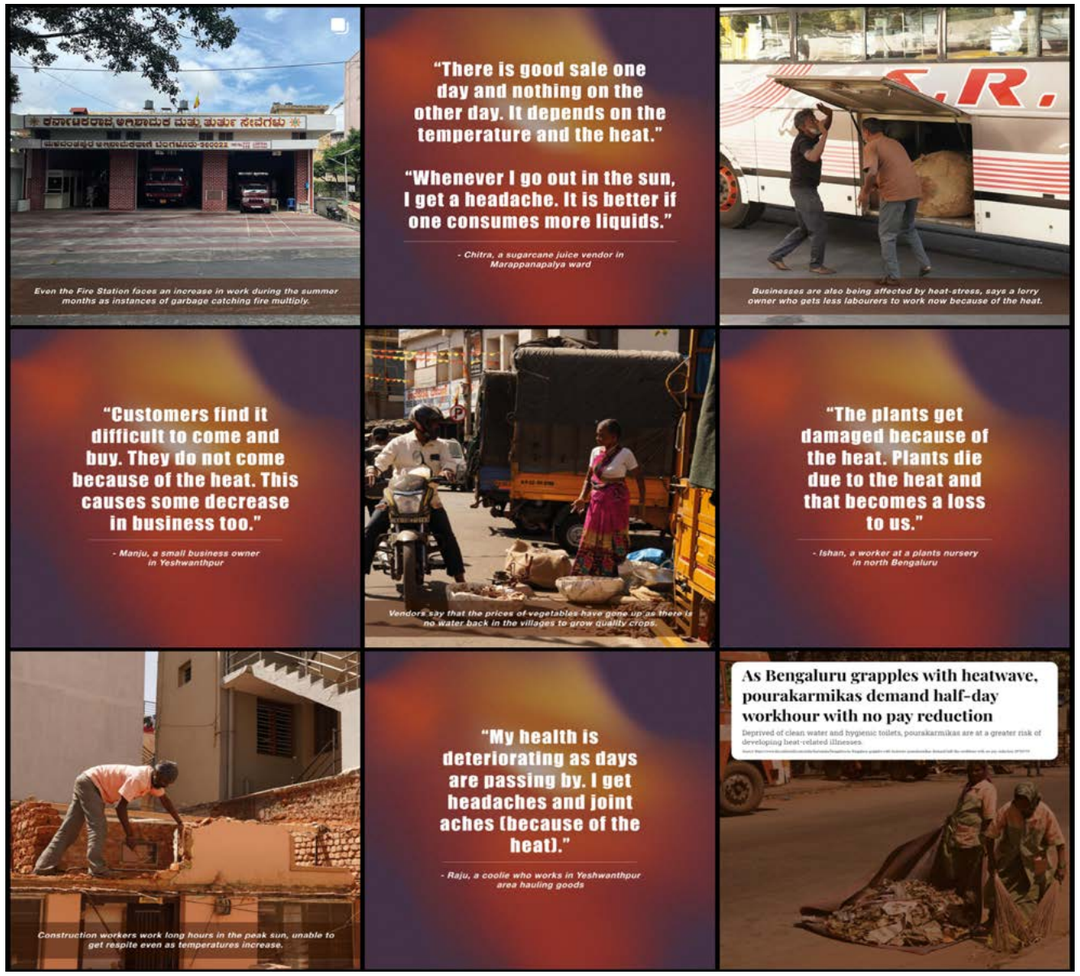
3.4 Developing a Social Media Presence

Leveraging Instagram to disseminate insights on Bangalore's Heat: by strategically leveraging this platform, we have successfully expanded our reach, engaged with our audience, and disseminated valuable insights regarding the challenges posed by rising temperatures in the city.

We have managed to accomplish the following:

- **Enhanced Reach:** The creation of an Instagram page dedicated to discussing heat in Bangalore has enabled us to reach a wider audience beyond our traditional channels. We have attracted individuals interested in the topic from diverse backgrounds and demographics.
- **Increased Engagement and Awareness:** The interactive nature of Instagram has facilitated meaningful engagement with our audience. By consistently sharing insights, updates, and content related to Bangalore's heat, we have succeeded in raising awareness about the issue among our followers. The visually appealing nature of Instagram has enabled us to communicate complex information in an accessible and engaging manner.
- **Community Building:** Our Instagram page has served as a platform for building a vibrant community centred around the discussion of heat in Bangalore. By fostering a sense of belonging and encouraging participation, we have created a space where individuals can share their experiences, learn from one another, and collectively work towards addressing the challenges posed by rising temperatures.

Fig 43: A snapshot of our Social Media Page where we share insights from our work – perceptions of heat from the ground, and our efforts towards awareness building and advocacy.
Source: Heat in Bangalore Instagram



3.5 Film: Creeping Heat in Bangalore's Neighbourhoods

Collaborators: ATREE, Chetan Toliya, Amulya N.

Heat affects various systems like health, energy, water, and livelihoods. Exploring the scorching impact of heat - from sizzling infrastructure to parched landscapes, our project in Marapannapalya Ward in North Bengaluru looked at the direct and indirect impacts of heat.

The film captured interviews from stakeholders across the ward – residents in low-income neighbourhoods, street vendors, construction workers, health workers, fire station officials, and haulers and coolies – on their perceptions of heat-stress. We spoke to residents and workers in the Ward about their experiences of heat, combating and adapting to heat, and the effects of heat on their health and livelihoods.

The film captures these instances and more, and lays out our experience of working in the Ward.

The film can be seen on our Instagram page here:
https://www.instagram.com/p/C6nwJsiopNu/

Fig 44: A worker in the large APMC Yard within the ward washed their feet after a day's work from a local water tank.
Source: Project Team

Part 4

Where do we Go From Here?

4.1 Targets for the Future

Target 1:

The Climate Vulnerability Walk becomes a regular feature of events organised by the BCC in the ward. The Walk expands in scope + execution by bringing in more local perspectives, featuring youth from local communities in the ward to describe their experiences and lead a part of the walk.

Target 2:

There is greater recognition of the existence and applicability of heat action plans at the ward level. Interested people start looking at, reading and reviewing heat risk management plans, laws and policies, and take steps to ensure that they reduce climate change impacts and exposure on people and the environment.

Target 3:

Such systems design approaches are expanded both horizontally and vertically. Such a heatwave study is expanded into other wards, while also expanded to include other hazards, including floods.

4.2 Developing Climate Literacy around Heat Stress in Government Schools in the Ward

As the impact of climate change intensifies, increasing awareness and understanding of heat stress among schoolchildren is crucial. Developing climate literacy around heat stress in government schools in the Marappanapalya ward is essential for building a resilient and informed future generation. We hope to continue our work to integrate engaging educational tools, such as games and education toolkits, to make learning about heat stress interactive, enjoyable, and impactful.

We are currently in the process of developing three physical boardgames around climate change aimed at raising awareness of climate change hazards and potential solutions to mitigate the impacts, for schoolchildren aged between 8 to 18 years of age. The games are based on familiar games like Ludo and Monopoly.

The three games are:

1. Metropolis: This engaging board game focuses on building sustainable neighbourhoods. Players work together to design and construct sustainable neighbourhoods, balancing resources, green spaces, and infrastructure to create a thriving city. The game encourages strategic thinking and collaboration, promoting awareness of sustainable urban development practices and the needs of a neighbourhood.

2. Climate Crusader: Set in Bangalore, this board game presents players with various seasonal disasters that they must navigate and overcome. Players must cross the city, facing challenges like floods, heatwaves, storms, and droughts. The game highlights the impact of climate change on urban areas and encourages players to think critically about disaster preparedness and resilience.

3. Ready to Act: In this dynamic card game, players are tasked with presenting solutions to impending risks in their neighbourhood. Each player proposes actions to tackle specific challenges, such as rising temperatures, water shortages, or waste management issues. The game fosters creativity and problem-solving, inspiring players to think proactively about addressing climate risks in their communities based on time.

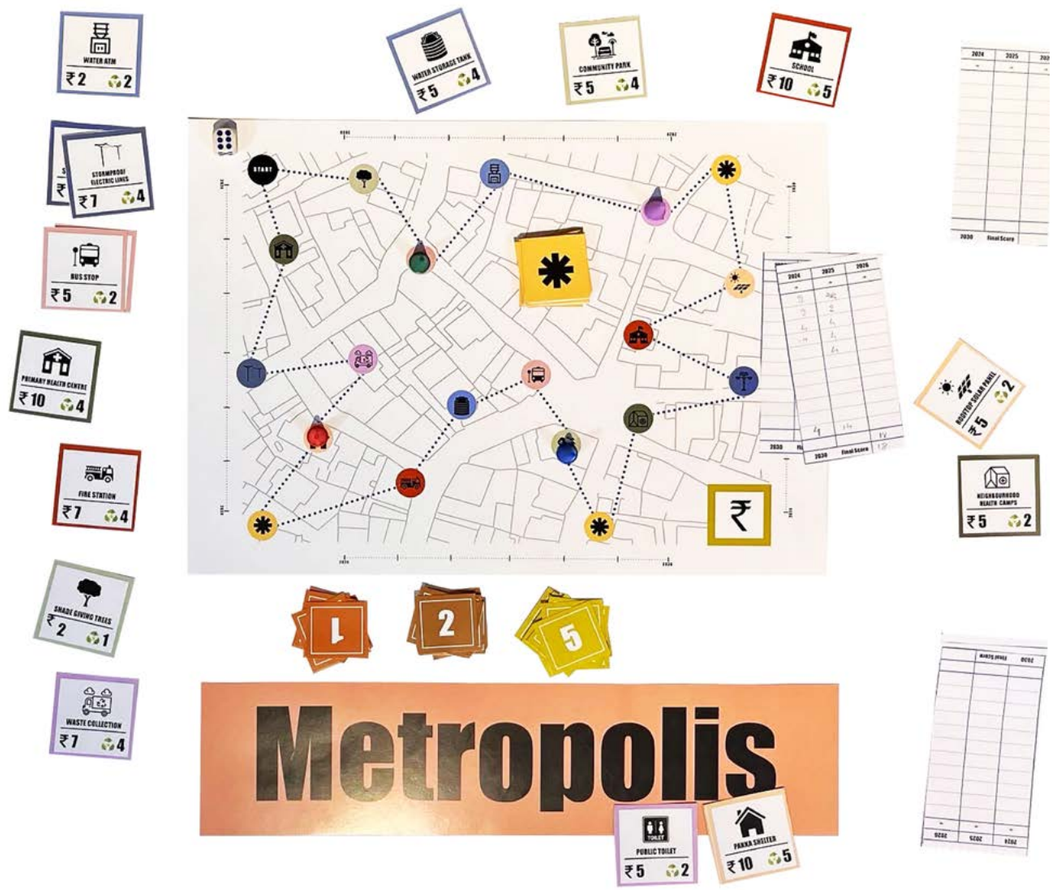


Fig 45: Metropolis Game
Source: Project Team

The game '**Metropolis**' challenges players as leaders of a neighbourhood who must strategically plan and develop their neighbourhood. They have access to a variety of services and infrastructure of various categories like housing, mobility, greening, services, etc. The ultimate goal of Metropolis is to build a world-class neighbourhood that takes care of the needs of everyone. The game offers players an experience that combines creativity and strategy. By building their neighbourhood by adding services to it, players gain a deeper understanding of the challenges and opportunities in creating more sustainable and resilient cities.

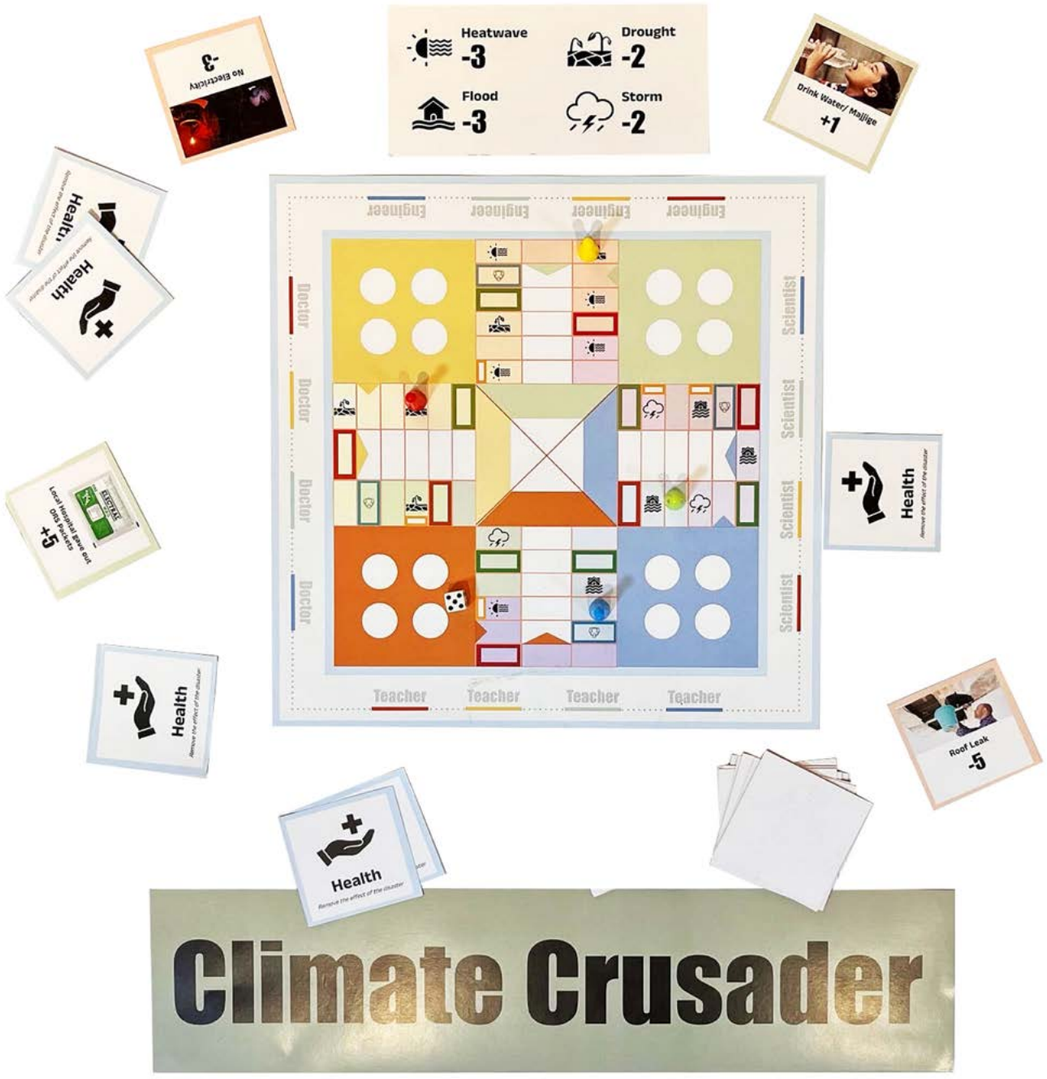


Fig 46: Climate Crusader Game
Source: Project Team

The game '**Climate Crusader**' asks players to traverse various climate change challenges through the year, confronting various disasters and understanding their impacts on your neighbourhood and Bangalore city. Through collaboration and finding solutions, players have to fight the negative impacts of climate change, rallying neighbouring communities to join forces against this common threat. As they journey through the seasons, gathering vital information and implementing strategies to combat climate change, their ultimate goal is to compile a comprehensive report for the corporator to contribute to the formulation of the Bangalore Climate Action Plan, a united effort by all Corporators to safeguard the city's future against climate change.

Fig 47: Ready to Act Game
Source: Project Team

The game '**Ready to Act**' is a card game that challenges players to present solutions to impending risks in their neighbourhood.It asks players to propose what should be done to tackle these challenges. The game features three types of cards:
1. Scenario Cards: These cards present real-life challenges and risks due to climate change in a neighbourhood;
2. Solution Cards: These cards offer a range of actions and solutions. A players goal is to match the most effective solution to the given scenario; and
3. Time Cards: These cards set the time frame. The urgency of the time card can change the strategy.

Fig 48: Various Gameplay Sessions with our Partner Organisation APSA were conducted to design and develop the games.
Source: Project Team

4.3 On-ground Mapping of the Heat Hotspots using Thermal Sensors

This is the next step in our project journey: mapping heat hotspots using thermal sensors is a pivotal strategy for understanding and mitigating heat stress in urban areas like Marappanapalya ward. This approach leverages advanced technology to collect detailed, real-time data on land surface temperatures (LST), along with data from local temperature sensors, enabling precise identification of critical areas requiring intervention.

Thermal sensors provide high-resolution, localized temperature data, allowing us to pinpoint exact locations with elevated temperatures. This granularity is essential for identifying microclimates within the ward that are particularly vulnerable to heat stress. By deploying thermal sensors at strategic points, we can create detailed heat maps that highlight hotspots and temperature gradients across the ward. These maps are instrumental in visualizing heat distribution patterns and understanding the spatial dynamics of heat stress.

By providing precise, real-time data, this method enhances our ability to identify critical areas for intervention and implement effective, small-scale solutions. This approach not only improves our understanding of the local heat dynamics but also empowers the community and stakeholders to actively participate in creating a cooler, more resilient urban environment.

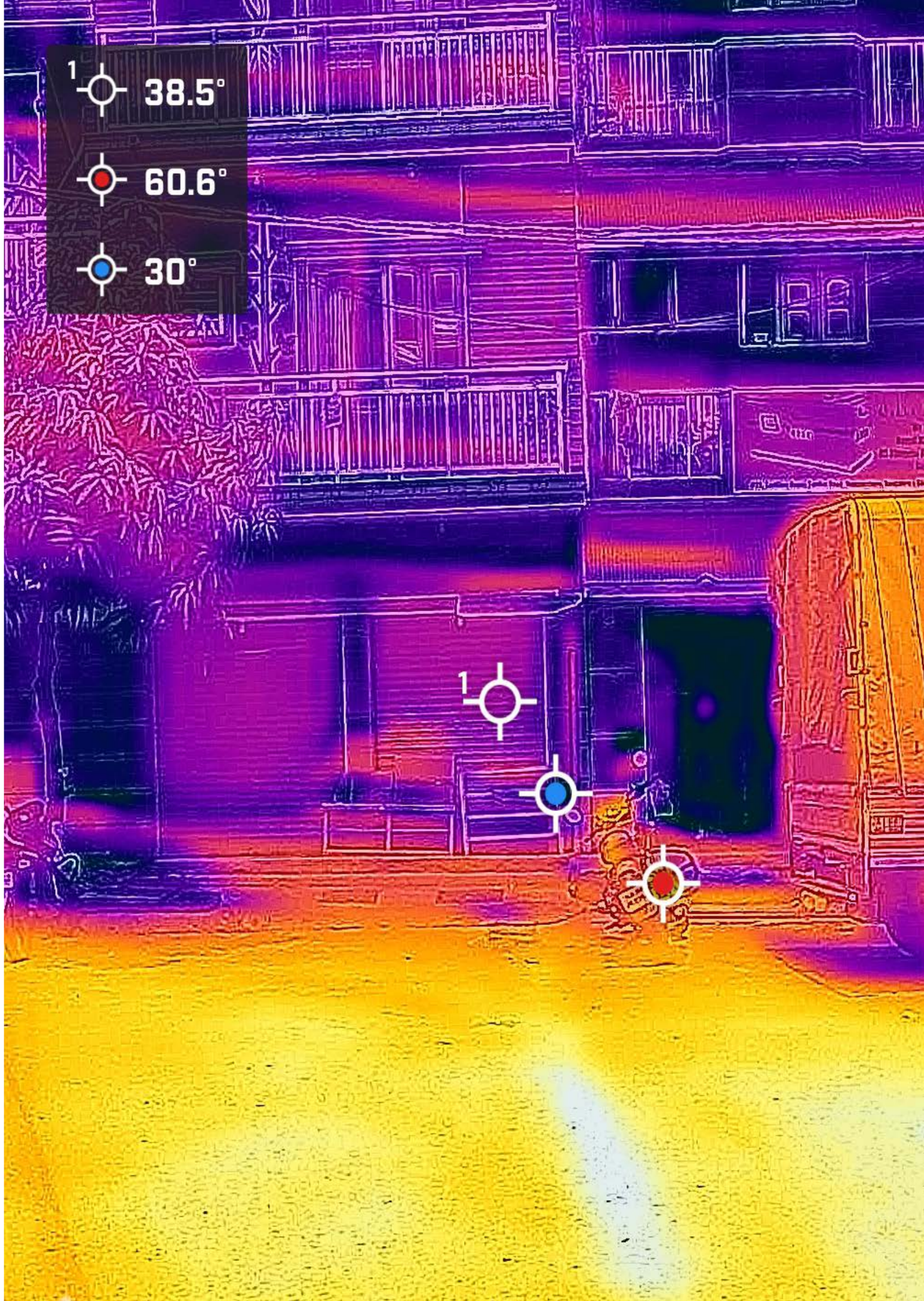


Fig 49: Using Thermal Imaging to understand the heat gain properties of various materials.
Source: Project Team

Annexure 1

Heat Justice and the Politics of Recognition

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“Please water and save our dying plants, Abhay”. This is what a colleague recently said when I asked him how I could be useful during one of my visits to the usually verdant but now scorched campus (of the inter cultural and environmental organisation that we work with) on the outskirts of Bengaluru city.

The heat, the groundwater and surface water scarcity, the pollution, the missing and delayed rainfall, the greed and rapacious capture of elemental water resources by criminal mafias and commodified capitalist rhythms, the apathy of both government and fellow citizen, and the million other urgent priorities for modernity’s afflicted children meant that some plants (and trees and birds and insects and animals and people and lakes and entire neighbourhoods) in Bengaluru were thirsty and hot. And dying. Silently. Unrecognised.

What politics of justice allow for a genuine reckoning of climate change? What narratives of suffering, survivance, and resistance convey the full measure of what was lost and what could be gained in and through climate impacts? What subjects and subjectivities are entangled in the causal drama of gain, loss and damage in an urban and systemic bounding? How might we excavate the historical and spatio-temporal silences through an emergent embodied ethicality that is neither dystopian nor reductionist? It was a glimpse of some of these questions that excited me about the possibilities for (and from) the Bangalore Heatwave Guide project.

Heatwaves and heat stress – complex climate phenomena mediated by complex social, scientific and material infrastructures – have appeared a few times in my climate educator/learner/consultant journey. I remember wondering what the fuss was all about when a young law student from a climate justice course a few years back insisted on bemoaning the fact that heatwaves were not officially recognised as disasters in Indian law and policy. I remember being surprised when I learned about the deadly heatwave in France in 2003 that led to a large number of deaths, especially among the elderly – my initial thought then was that surely a rich and scientifically advanced country such as France must have had the financial and technological resources to avoid excessive and widespread damages from heat. I remember grimacing as I thought about the billions (yes, billions!) of animals that had burned to death in the Australian wildfires of 2019-20. I remember tearing up as I read about approximately one billion slower-moving and fixed oceanic lifeforms, particularly mussels affixed to rocks and the shore, that literally boiled to death off the coast of Canada as the water got hot in 2021. I remember being amazed as I learned more about the epidemiology of heat-related illness and how our official statistics in India (and prevalent practices in hospitals and health care centres) massively under-reported heat-related illnesses and deaths. I remember being excited (and then, paradoxically, partly repelled) as I dived deeper into the consultancy world’s estimates of the massive innovation opportunity presented by the cooling challenge facing India and many parts of Africa. I remember being drawn into the technical minutiae of heatwave action plans for Bhuj and cool roof technologies in Gujarat. I remember being inspired by creative projects put together by my students that highlighted possibilities for heat-related resilience in informal urban settlements, in gated communities and elite urban neighbourhoods, and in university campuses across India. I remember advising a friend and former client on the pragmatic possibilities of heatwave-related strategic litigation in India.

And then, in 2023, the Bangalore Heatwave Guide project and the wonderful team involved with it offered another lovely opportunity to bring together the many lines of departure and inquiry relating to heat in India. The project design emphasis on locally-led adaptation, participatory processes for vulnerability and resilience mapping/planning, and meaningful artefacts for resilience that imbued vernacular configurations of hyperlocal places particularly excited me. I continue to dwell on the possibilities for a theorisation of heat justice in India that might draw upon the findings of the project.

While my involvement with the project has been rather limited following the initial conceptualisation stage, I did particularly enjoy participating in one of the project-promoted walks in late December 2023 to understand climate vulnerability in Marappanapalya Ward. I remember, as our group made its way through one of the narrow lanes of a low-income settlement adjacent to Bangalore Creative Circus, a small group of women questioning me and a colleague (we were the last stragglers in the group) on what all of us were doing there that afternoon. When we told them about our project and its emphasis on heat, a couple of the women nodded, and then playfully laughed, and pointing to another woman in their group, said: “Ask her to teach you about this, she is a leader, she knows everything!”. The rest of the group burst out into loud peals of laughter even as the woman who had been pointed out as the leader smiled and blushed at the same time.

We promised to return to them for their guidance as the project evolved. We indeed have much to learn from frontline communities even as we (re)calibrate our politics of recognition for the claimants and dispensers of heat justice in India.

Annexure 2

Climate Vulnerability Walks undertaken during Project Period

a. One Health Bengaluru City OHBC Dengue Workshop
August 2023

Fig 50: Workshop Participants at the presentation and project briefing session before the walk
Source: Project Team

b. SAGE Ambassadors Workshop
September 2023

Fig 51: SAGE Ambassador programme students and participants at the presentation and project briefing session before and during the walk
Source: Project Team

c. Climate Vulnerability Walk
December 2023

Fig 52: Participants during the Climate Walk and the debriefing session after the walk
Source: Project Team

d. Climate Vulnerability Walk
March 2024

Fig 53: Participants during the Climate Walk at one of the checkpoints
Source: Project Team

e. Climate Vulnerability Walk
June 2024

Fig 54: Participants at one of the checkpoints discussing Heat and its effects on livelihoods and work
Source: Project Team

Heat in Bangalore

Ashoka Trust for Research in Ecology and the Environment (ATREE) is a globally recognised non-profit organisation focused on environmental conservation and sustainable, socially just development. ATREE engages in the generation and dissemination of rigorous interdisciplinary knowledge that informs and is informed by the needs of grassroots communities, policymakers, and the wider public.

Initiative for Climate Action (ICA) is a non-profit company that has a vision to catalyse, enable and accelerate low-carbon and zero-carbon futures of justice and sustainability. Currently a growing community of 50+ members from across India (from diverse disciplinary backgrounds and experiences), ICA is a community of collaborators, orchestrators, enablers, dreamers, doers, and everything else it takes to build a better world for all. We are attempting to realise exciting new paradigms of what people-centric and nature-inspired organisations can be like.

The **Bengaluru Sustainability Forum (BSF)** is a multi-institutional initiative focusing on issues of urban and peri-urban sustainability in Bengaluru. With an aim to foster a holistic understanding of sustainability issues and innovative solutions in the city, BSF curates interdisciplinary conversations and collaborations involving various stakeholders - from academics, researchers and practitioners to social advocates and citizens. The wide range of engagements facilitated include retreats, workshops, panel discussions, webinars, film festivals, exhibitions, podcasts and a Small Grants Programme to enable and support local, innovative, cross-disciplinary, collaborative projects to start off and grow into a sustainable future.

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