“Come hail or heatwave, work goes on”: Assessing heat stress vulnerability among female construction workers in Hyderabad, India.

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Author's declaration

No portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or another institute of learning.

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Abstract of the thesis

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The wide-ranging effects of climate change-induced extremities are already being witnessed across the world. One of the consequences this is the effects of the rising temperatures on workers engaged in professions with long outdoor work activity, such as the construction sector. Particularly in countries such as India, the informality of construction sector and the lack of workplace benefits can exacerbate occupation heat stress among workers. Further, women engaged in the construction sector can be more vulnerable to the effects of heat stress due to additional stressors such as domestic responsibilities, childcare, and gender wage gap. Through qualitative methods, this research explores and documents how women working as unskilled labour in the construction sector in Hyderabad, India cope with heatwaves and the factors that make them vulnerable to it. The research also explores the institutional awareness and mitigation responses to the threat that climate change poses to the construction sector in the country. It is found that the coping capacity among female construction workers is limited due to the lack of institutional awareness and mitigation strategies. Further, the informality of construction sector and the absence any adaptation responses to climate change also effect the adaptive capacity. This can have potential long-term implications, as it will weaken the resilience, eventually leading to a negative critical threshold. After documenting the experiences of the women, the researcher suggests recommendations that can build adaptive capacity of the workers and the industry to rising incidents of heatwaves.

Keywords: Occupational heat stress, heat stress construction sector, female construction workers, heat stress coping, Hyderabad construction sector, heat waves India.

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Table of Contents

List of figures

List of tables

List of abbreviations

BOCW: Building and Other Construction Workers

OHS: Occupational Heat Stress

OHS: Occupational Health and Safety

SES: Socio-ecological Systems

WBGT: Wet Bulb Global Temperature

PHS: Physical Heat Strain

IMD: Indian Meteorological Department

1. Introduction

A typical workday for Sujata starts at 9 am when she starts work at a construction site in the city, where she will be expected to lift heavy bags of sand, cement, bricks, and debris weighing up to 15 kgs from 9 am-6 pm every day, with only one day off per week. For a whole day's work, she gets paid 350 rupees (4 EUR). While working, she must also take care of her 10-month-old child, since there is no one back home to look after her kid and there are no childcare facilities at work. So, she lays a hammock inside the construction site and puts her child to sleep. If she gets hurt or falls ill, she will need to bear the medical expenses herself or will be sent away at a moment's notice. A similar story emerges among many women engaged in what is called unskilled labour in the construction sector across India. These women work without any guarantee of fixed pay or healthcare, housing, and maternity benefits. Now, climate change-induced temperature rise is acting as an additional stressor, making these women vulnerable to occupational heat stress.

Workers across the world engaged in outdoor work such as agriculture, construction, mining, factory work and others face vulnerability due to climate-induced temperature rise (Nunfam et al. 2019). Labour trends suggest South Asia and Western Africa are the regions that will most likely be affected by occupational heat stress, resulting in productivity losses of 5.3 per cent and 4.8 per cent respectively by 2030 (ILO 2019).

The AR6 fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC) working group I states that the world is already experiencing the anthropogenic effects of climate change. The global surface temperature has been rising at a much faster pace since 1970 than it has in the last 2000 years. Under Shared Socioeconomic Pathways scenarios, temperature increases of 1.6-3.0 degrees Celsius are most likely to occur by the end of the century (IPCC 2021).

Particularly in urban settings, climate-induced impacts have already caused disruptions to human health, livelihoods, and key infrastructure. The occurrence of heatwaves has intensified in cities, and these impacts are stated to be concentrated in socially and economically marginalised neighbourhoods such as informal settlements (IPCC 2022)

These trends have wide-ranging consequences for both natural and socio-ecological systems across the world and will lead to increased heat exposure for those working outdoors (Dash and Kjellstrom 2011). This will exacerbate heat stress among the working population, resulting in economic and social vulnerability at different scales, in addition to direct physical effects on health and wellbeing (ILO 2019).

Heat stress can lead to short-term physiological problems like heat cramps, exhaustion, heat stroke and long-term damage to vital organs (Dutta et al, 2015). Workers in low and middle-income countries such as India are more vulnerable to heat stress due to vulnerability across a wider range of individual and institutional scales. Factors such as low income, lack of workplace safety and benefits, and the informality of the construction sector can potentially exacerbate heat stress conditions among workers (Kjellstrom et al. 2016).

For women engaged in manual labour in the construction sector, lack of sanitation and childcare facilities and familial responsibilities may also exacerbate the conditions of heat stress, making them more vulnerable (Venugopal et al. 2016).

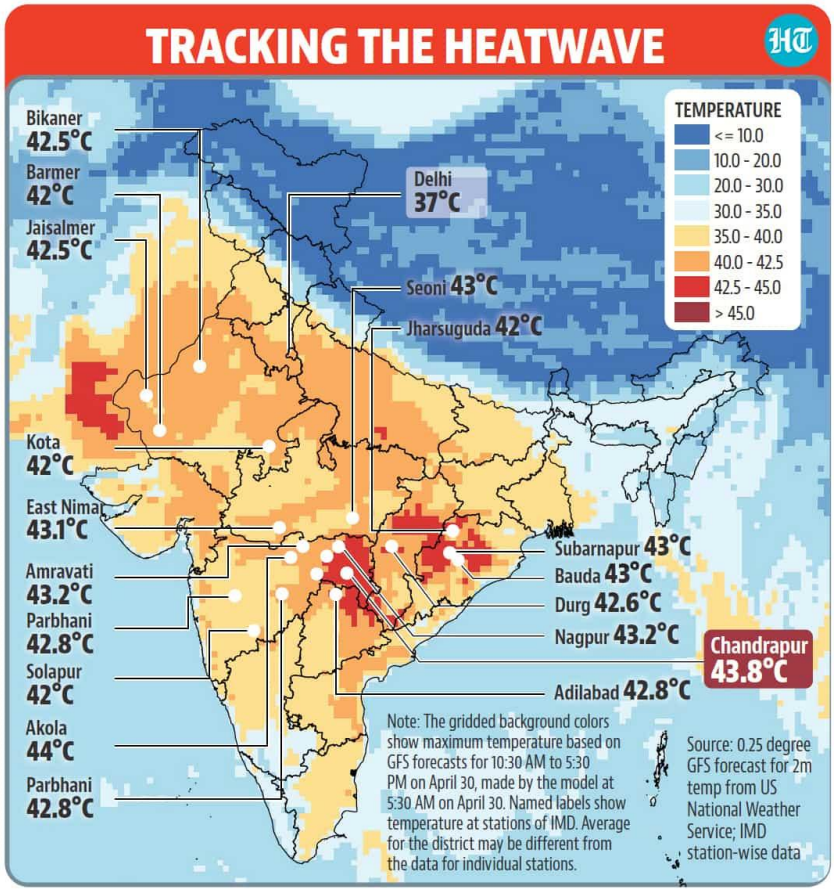
1.1 Heat stress in the Indian context

The effects of climate change are already being witnessed in India. The 15 years between 2003 and 2017 saw the 11 warmest years on record, with an anomaly of 0.54 degrees Celsius above average (Golechha et al. 2021). Further, there has been an increase in surface area temperature all over the country in the last century (Srivastava et al. 2017).

With the rise in average temperatures, India has already been experiencing considerable incidences of heatwaves and severe heat waves. According to the Indian Meteorological Department, a heatwave is declared when the temperature reaches 4.5-6.0 degrees above normal, and a severe heat wave is declared when the temperature departure is more than 6 degrees Celsius. Data from 103 weather stations across the country shows that the number of heat wave days per year rose from 510 to 680 in the last decade. Even the number of severe heat wave days have risen from 80 to 100 (Pai et al. 2017).

In 2022, the country experienced its warmest March in 122 years, with temperatures soaring above 30 degrees Celsius in parts of northwest India (The News Minute 2022). In April and May, many parts of north and central India like Rajasthan, Madhya Pradesh, Gujarat, and Maharashtra experienced intense heat waves, with temperatures crossing 40 degrees Celsius (The Indian Express, 2022).

Figure 1: Heatwave map of India



Source: Hindustan Times, 2022

This can put working populations at risk of death due to heat stress. Especially in the construction sector in India, with few provisions for worker's safety such as accident coverage, health insurance, safety regulations, and high informality, the temperature rise is expected to affect the hardest (Dehury and Dehury 2017). Although the scale of the problem is huge, studies on occupational heat stress have been limited to a public health framework and less attention has been paid to exploring the coping capacities and the stressors that limit it. Hence, this study aims to fill the knowledge gap by exploring the coping capacity of women and the factors that hinder it.

1.2 Research aims and objectives

This research aims to explore how different institutions such as family and work can either strengthen or weaken the human, financial and social capitals of women engaged in the construction sector and how it contributes to their coping capacity. Further, the research will integrate this with a critical thresholds framework to explore how limited coping capacity can push individuals to a negative tipping point. The research aims to answer the following questions:

1. How do different forms of institutional vulnerability, such as lower wages, the informality of the construction sector, lack of safety benefits, and domestic responsibilities limit the coping capacity of the women?
2. What institutional responses are available to mitigate heat stress among these women?

The objective of the research is to document the experiences of the women and explore how their coping capacity may lead to a critical threshold.

1.3 Research outline

The research is divided into five chapters as follows.

Chapter one introduces the area of research by linking climate change to occupational heat stress. Then, it describes climate trends in India, the rising incidence of heat waves in the country, and how it affects outdoor work activity.

Chapter two includes a literature review. This chapter would review the literature on occupational heat stress in four subsections. First, it starts by defining the broader concepts of vulnerability, coping capacity, and adaptability. Then, the review explores the link between climate change and outdoor work activity and occupational heat stress. Then, it discusses the literature on the construction sector in India and explores how those working in the sector

suffer from occupational heat stress. Later, it discusses the role of women in the Indian construction sector and how occupational heat stress affects women disproportionately. Later, it discusses institutional adaptation strategies such as heatwave action plan and how this can reduce vulnerability of workers to heat stress. The review also discusses the conceptual framework that guides the study and the site where it is being conducted.

The methods used to approach this study are discussed in chapter three, along with a discussion about why these methods were chosen and their limitations.

The fourth chapter sets the context of the study and discusses the findings by analysing the interviews.

The fifth chapter will contain a discussion of the findings. The sixth chapter will include conclusion and recommendations.

2. Literature review

This review aims to place the research problem within relevant literature and highlight the contribution of this study to the current research. To begin with, the review defines key concepts used in this study, which are vulnerability, coping capacity, adaptation, and critical thresholds. Then, it explores the literature for the research problem by linking climate change and outdoor activity. It then contextualises the research problem within the Indian construction sector and discusses the research done so far on occupational heat stress among workers in the sector. Then, it discusses the role of women in the sector and explores heat stress among female workers in the sector in India. Then, the review looks at institutional mitigation responses such as policies, regulations, and workplace benefits for workers in the sector. Additionally, it also explores heat stress mitigation plans like the heatwave action plan in Indian cities and the provisions for construction workers in it. The next section discusses the conceptual framework guiding this study.

Lastly, the review describes the study site and the climate trends of the site and concludes the review by identifying the research gap.

The database for literature was compiled using Central European University's online library and Google Scholar. Research papers were identified in Springer (https://www.springer.com/gp) , PubMed (https://pubmed.ncbi.nlm.nih.gov/), Science Direct (https://www.sciencedirect.com/), ResearchGate (https://www.researchgate.net), and JSTOR (https://www.jstor.org/) were selected. Non-academic sources that have been included consist of Indian government portals and news websites.

The keywords used for the search are: vulnerability, climate change coping capacity, occupational heat stress, heat stress construction workers India, heat stress women India,

occupational heat stress women India, coping heat stress, and heat stress vulnerability and resilience.

2.1 Definitions and distinctions

2.1.1 Vulnerability

The concept of vulnerability has been explored in literature across many domains such as anthropology, social sciences, and technology. But the study of the vulnerability of natural systems has been the most consistent (Adger 2006). In the early stages of its research, the vulnerability of natural and socio-economic systems was studied in isolation (Berkes 2007). But there is an increasing consensus that climate change poses a significant danger to both natural systems and ecological systems and that anthropogenic and natural vulnerability are interdependent (IPCC 2022). Under this framework, there has been an increasing emphasis to integrate these two systems and the subsystems that exist in them (Adger 2006).

Over the years, many definitions of vulnerability have come up in the context of climate change and human interaction with it. In natural hazard studies, vulnerability is defined as a tendency to suffer losses from hazardous events (Etkin et al. 2004). While climate scientists often refer to vulnerability in terms of the likelihood of weather-related impacts that will affect a socio-ecological system, social scientists define vulnerability as a representation of a set of socio-economic parameters which determine people's capacity to cope with this external disturbance (Allen 2003). Further, the IPCC Third Assessment Report (TAR) defines vulnerability as

> "The extent to which a natural or social system is susceptible to sustaining damage from climate change. Vulnerability is a function of the sensitivity of a system to changes in climate (the degree to which a system will respond to a given change in climate, including benefits and harmful effects." (IPCC 2001, p. 95)

In a framework similar to IPCCs', Turner et al. (2003) define vulnerability as a degree to which a system or a specific component of a system is likely to experience harm due to permutations or a stressor. Further, it has been argued that vulnerability also resides in the resilience of a system experiencing hazard (Berkes 2007). Adger (2006) also points out that vulnerability in a socio-ecological system is influenced by the built-up erosion of elements within the system.

2.1.2 Social vulnerability

Among the many aspects of the concept, social vulnerability within socio-ecological systems has been gaining ground. This has been studied by human ecologists, as there is an understanding that environmental vulnerability does not exist in isolation to greater polities of resource access and use (Adger 2006; S.L. Cutter et al. 2003).

The framework of social vulnerability argues that the risk of environmental disasters depends on factors such as political power and representation, access to resources, including technology and education, and social status (Comfort et al. 1999; S. Cutter, Mitchell, and Scott 2000; S. L. Cutter et al. 2003). Poorer households living in urban settlements tend to be more vulnerable to environmental risks such as flooding and heatwaves. Women are further at risk of environmental disaster, due to the double burden of familial and professional responsibilities (Fordham 2003). In the south Asian context, many stressors such as low rates of literacy, lack of property rights, and low social status have been highlighted as factors of vulnerability (Ariyabandhu 2000).

For this study, the definition of social vulnerability is accepted in the context of coping capacity and applied to the framework.

2.1.3 Coping, adaptability, and social vulnerability

Although coping and adaptation are often discussed in relation with each other, this section discusses their definitions and differences. Coping is defined as the responses people employ within the existing structures in the face of environmental stressors (Eriksen, Brown, and Kelly 2005). Further, under the framework of social vulnerability, coping is described as a short term strategy employed by households and individuals when facing an external shock (Adger 2006).

Adaptability is defined as the ability of actors in the system to influence and manage resilience. In the system, adaptability is a social component, where sub-systems like individuals, community, and institutions act in tandem to prevent the system from crossing a critical threshold (Walker et al. 2004).

Coping and adaptation are separated by many factors, but most importantly by timescales. Although both processes are intrinsically linked, coping is defined as the process that takes place within the current system (Eriksen, Brown, and Kelly 2005). Adaptability refers to making changes in the behaviour of the system where coping takes place. This process may necessarily be done to increasing the capacity to cope in the current system (Brooks 2003).

Further, coping is also influenced by the societal processes and vulnerability. The presence of social capital and networks of formal and informal trust and safety tend to increase the coping capacity of communities (Devereux and Næraa 1996).

However, adaptation to climate-induced shocks occurs on a larger timeline and multiple scales. Due to its temporal complexity, it is argued that adaptation does not occur instantly. The current system requires time to realise its adaptive capacity. Hence, the adaptive capacity of a system represents potential, rather than adaptation itself (Brooks 2003).

2.1.4 Importance of institutions in building adaptation

In the context of the complexities of coping and adaptation, it can be said that coping is a short-term strategy employed by individuals to avert the immediate effects of climate change. Whereas, adaptation requires long term strategic actions that may require institutional change (Pelling 2010).

As discussed previously, coping capacity is influenced by societal process, which may be tied to institutional processes at a higher level. Informal, social, cultural, and political institutions influence the coping patterns of individuals and households. In this context, it is also important to explore the role of institutions in building adaptive capacity.

In vulnerability research, the presence of capitals such as human, societal, financial, natural, and physical capitals have been highlighted as factors that lead to greater coping capacity. These capitals have are also influenced by social and political processes at a larger scale, which have a greater role in building adaptation (Berman et al. 2012).

On the other hand, the resilience approach identifies the complex linkages across different systems in an SES and acknowledges how the collapse of one system can lead to less adaptation across different sub-systems (Berman et al. 2012).

2.1.5 Tipping points in socio-ecological systems

Tipping points in a system are defined as thresholds of localised effects, including socio-cultural, economic, and ecological. These tipping points occur when small pressures in the system cause large scale, abrupt changes in the properties of the system, leading to regime shift (van Nes et al. 2016).

The term tipping point was popularised by social scientists in the context of racial segregation (Lauerburg et al. 2020). But over the last two decades, tipping points has been discussed in relation to earth systems and climate change.

In socio-ecological systems, tipping points are discussed with two common terms, regime shift and transformations. Regime shifts are defined as large changes in the structure and functioning of a socio-ecological systems (Folke et al. 2004), whereas transformation is defined as a reorganisation of the elements in the system and involves rapid, non-linear change (Olsson et al. 2014).

In the current discourse, regime shifts are discussed as undesirable states that need to be prevented, while transformations are framed as guided actions for a positive tipping point (Milkoreit et al. 2018).

In the context of climate change and societies, transformative social tipping points have been referred to those that increase the societal resilience and reduce the damages caused by climate change through mitigation and adaptation strategies. Whereas, harmful social tipping points occur in the absence of strategies to prevent the effects of climate change (David Tàbara et al. 2018).

In SES, although a tipping point might be present in only one of the sub-systems, it might lead to knock-on or cascading affects in other systems (Lauerburg et al., 2020). These affects that flow through subsystems are also representative of the system's resilience and the coping and adaptation capacities of the subsystems.

2.2 Occupational Heat Stress (OHS) and climate change

Sectors with prolonged outdoor work such as agriculture and construction employ a significant workforce worldwide. Agriculture and the construction sector employ 32% and

12% of the global population, respectively (Ioannou et al., 2021). Due to the rising incidence of heat waves, the labour loss due to heat induced casualties is predicted to be nearly 2200 billion USD by 2035 (ILO 2019).

Over the last few decades, there has been increasing emphasis on integrating climate change and its effects into considerations of outdoor work activities. Beyond the human core temperature of 37 degrees Celsius, there are is a danger of being exposed to heat stroke, eventually leading to death (Jay and Kenny 2010). Other symptoms of heat stress range from dehydration, injuries, heat fatigue, respiratory and cardiovascular diseases (Lundgren et al. 2013). As a result, heat stress has emerged as an important indicator. The Wet Bulb Global Temperature (WBGT) has emerged as an important assessment method, which is adopted in many studies across the world (Gao et al. 2018).

This method, which was developed in the 1950's by the United States army (Yaglou and Minard 1956). The WBGT incorporates physical conditions like air quality, humidity, radiant temperature and wind speed in a single index to assess heat exposure in individuals (Rowlinson et al. 2014). Although it was developed to measure and mitigate heat stress among the marine corps, it has been adopted in many physiological and medical studies to document effects of rising temperature on outdoor work activities like agriculture, mining, and construction sector and has been used in many studies to assess occupational heat stress (OHS) among workers (Dutta et al. 2015; Lundgren et al. 2013; Sett and Sahu 2014). The WBGT formula used for indoor and outdoor assessment, without the presence of solar radiation is:

$$WBGT = 0.7T_{nw}+0.3T_g$$

This variable has also been modified to measure solar radiation outside the buildings using:

$$WBGT = 0.7T_w+ 0.2T_g+0.1T_a$$

Where, T_{nw} is the natural wet bulb temperature, which is measured with a wet wick thermometer, T_g is the temperature in the middle of a 150mm diameter, T_a is the air temperature shielded from radiation. The upper threshold considered for WBGT is 30 degrees Celsius.

Despite the adoption of WBGT across many physiological studies for nearly 60 years, it has been argued that the approach has failed to keep up with the changing conditions. Particularly, it is noted that the measurement does not appropriately reflect the severity of climatic effects and ignores components like metabolic rate and wind speed (d'Ambrosio Alfano et al. 2014; Acharya et al. 2018). Alternatively, newer assessments like Discomfort Index, Predicted heat strain (PHS), and universal thermal climate index have evolved (Gao et al. 2018).

2.2.1 OHS in Indian context

Combinations of factors such as geographical position and high dependence on outdoor professions as agriculture and construction makes certain regions of the world such as South Asia vulnerable to severe OHS (ILO, 2019). Drawing an important distinction between occupational and general heat stress, Gao et al. (2018) state that workplace settings may have special features such as higher metabolic rate, which can potentially increase heat stress among workers. Additionally, insufficient social protection and inadequate adaptation measures may further limit coping capacity among workers and exacerbate heat stress (Nunfam et al. 2019).

In the Indian context, the discourse on occupational heat stress has been gaining emphasis. Studies have explored the link between outdoor occupations and rising temperatures (Dutta et al. 2015; Krishnamurthy et al. 2017; Venugopal et al. 2016) using an epidemiological framework by measuring WBGT in construction sites.

It has been noted that nearly 85% of workers engaged in agriculture, construction, salt pans, garment and steel industries are vulnerable to heat stress and are beyond WBGT (Venugopal et al. 2020).

In another instance, a study conducted in a steel factory in southern India revealed that nearly 96% of workers experienced the heat stress-induced health effects such as dizziness, excessive sweating, headache, excessive thirst, and muscle cramps often and 61% reported heat stress as a major problem during the summer season (Krishnamurthy et al. 2017). Further, workers also reported an impact on their personal and social lives as they spent more time and resources coping with heat stress.

2.2.2 Vulnerability of Indian construction workers to OHS

The construction sector in India is the second largest employer in India, after agriculture employing nearly 55 million people (Nihas et al. 2013). The sector has been witnessing rapid growth in Indian metropolitan cities, drawing labour from rural areas to cites (Srivastava and Sutradhar 2016). This growth of the sector can be reflected in the fact that the sector contributed to 9% of the Gross Domestic Product (GDP) of the country and nearly 55 million people are employed in the sector (Construction Industry in India | Construction Sector Investments' n.d.)

Despite the high employment rate, the construction sector has remined highly informal, devoid of any workplace benefits and safety mechanisms in place. As of 2015, there were nearly 44 million unorganised workers in the sector (Samanta and Gochhayat 2021). While the Indian workforce makes up for 7.5% of the global construction sector, it accounts for 16.4% of the workplace accidents globally (Kanchana et al. 2015).

The rise in urbanisation can also be attributed to the fact that nearly 34% of the unorganised workforce in the sector can be found in Indian cities (Saha et al. 2021). The sector in urban

India mainly consists of workforce who migrate from rural areas to cities in search of jobs (Srivastava and Sutradhar 2016; Nihas et al. 2013). Many of the workers are found to be going back to their native residence during the agriculture season to assist with farm activities (Dutta et al. 2015).

This adds another layer of informality to the sector, as workers in the construction sector are engaged on a daily wage basis as unregistered workers. In this context, climate-induced extremities such as the rising incidence of heat waves can exacerbate the existing vulnerabilities for the workers in the construction sector, as they lack legal protections, health benefits and are from the economically and socially vulnerable sections of the society (Dutta, Rajiva, Andhare, Azhar, Tiwari, Sheffield, et al. 2015).

2.3 Women in the Indian construction sector

Women in the sector are particularly vulnerable due to lower wages and more work, lack of social protection mechanisms, and domestic responsibilities (Panneer 2019). Unlike most countries, where the sector is dominated by men, the Indian construction sector employs a significant proportion of women, nearly 30% (Patel and Pitroda 2016). While a only few of them hold technical and managerial positions, most women are integrated into the lower end of the workforce.

Most women working in the sector are unskilled and employed to do heavy manual labour such as carrying sandbags, bricks, cement, stones, clearing rubble (Moir 2016). Further, there are hardly any opportunities for women to move up the workplace hierarchy, as they are seldom given training to improve their skills and usually end up assisting their male counterparts at work (Devi and Kiran 2013).

Women are also paid lower than their male counterparts and are required to work more hours than those specified by the government (Panneer 2019). A survey conducted in the western

state of Gujarat found that women in the construction sector earn only half of what their male colleagues are paid. The study also found a high level of occupational risks due to workplace accidents, resulting in temporary and permanent disabilities (SEWA 2000)

Further, it has been found that women also face gender discrimination and sexual harassment from their workplace construction managers/site supervisors in addition to not having work benefits like health insurance and childcare (ScD and Mori, 2016.; Tiwary et al. 2012; Raval, Vankar, and SEWA 2000).

2.3.1 Women and OHS: Layers of vulnerabilities

As discussed above, women in the construction sector face multiple stressors at different scales. It is necessary to place these stressors in the context of climate change and OHS and explore how heat stress related impacts add to layers of vulnerability and limits the coping capacity of women engaged in construction activity.

Only few studies have established the link between gender and climate-induced heat stress in workplaces (Venugopal et al. 2016; Sett and Sahu 2014).

Venugopal et al. (2016) conducted the first study to assess how the lack of sanitation facilities in workplace hinders women's ability to cope with heat stress, further causing illnesses. Further, Sett and Sahu (2014) study the effects of heat stress on women working in brick kilns and briefly highlight how heat stress can be a risk multiplier in the presence of familial arrangements such as gender roles, child rearing and domestic chores.

A study of workers in the north Indian state of Punjab reveals a range of heat stress induced illnesses among women such as dehydration fever, fatigue, and Urinary Tract Infection (UTI) due to lack of hygienic toilets. It also reveals long-term health effects such as miscarriage and cervical pain (Bharara et al. 2012).

Although research points out to coping mechanism among workers such as drinking excess water to avoid heat stress (Dutta et al. 2015), studies focused on OHS in women have highlighted how the lack of sanitation facilities such as gender segregated toilets deter them from drinking more water so as to avoid taking bathroom breaks (Venugopal et al. 2020; Krishnamurthy et al. 2017; Sett and Sahu 2014).

2.3.2 Workplace policies for construction workers

To tackle with the problems arising from, along with the informality of the sector, the Government of India introduced the Building and Other Construction Workers (BoCW) (Regulation of Employment and Condition of Services) act in 1996. Under the regulation, the state governments and union territories are required to set up Construction Workers Welfare Board (CWWB) to implement the provisions of this act. These boards would be responsible for registering workers and making them aware of workplace benefits such as maternity leave, accident cover, health insurance, pension, childcare facilities, and education the children (Government of India 1996). The act also mandates that construction sites meet minimum safety requirements laid out by the respective state governments (Roy and Naik 2017).

The Occupational Health and Safety code (2020) of the Government of India mandates that in industries such as mining and construction, which potentially involve workplace hazards, there should be facilities such as ambulance to minimise workplace accidents (Government of India 2020). Although no direct link between heatwaves and outdoor activity has been established as a part of the code, provisions under the act such as providing clean water and sanitation facilities, providing adequate ventilation and breaks to employees may possibly build adaptability among the workers.

Similarly, the Building and Other Construction Workers (BOCW) act 1996 too has welfare measures for workers registered under it. Under the act, the respective state and union territories across the country are responsible to set up a Construction Workers Welfare Board (CCWB), to make sure that the workers in the state are registered under the act. Although even BOCW does not link climate change-induced heat waves and workers safety, provisions as a part of the act may potentially build adaptive capacity among workers. Under the act, registered workers receive benefits such as fixed working hours, health insurance, accident coverage, maternity benefits, housing, and childcare facilities (Government of India 1996).

Even though these welfare measures exist on paper, their implementation has been slow. Although the act was introduced in 1996, many states across the country did not implement it until after the supreme court of India's intervention in 2006 (Roy and Naik 2017). Even after that, studies have found that not many workers know about the BOWC act, which further prevents workers from claiming their entitled benefits (Naraparaju 2014; Srivastava and Sutradhar 2016).

2.4 Coping and adaptation to heat stress

While studies have established the link between occupational heat stress and climate change through epidemiological measurements such as Discomfort Index and Wet Bulb Global Temperature (WBGT), it is important to link OSH with concepts such as coping, adaptive capacity, and adaptation to explore how outdoor working populations deal with rising temperatures.

In a study conducted in Ahmedabad, in the Western state of Gujarat, it was found that some of the most common coping strategies in low-income households was avoiding outdoor work activity, drinking plenty of fluids and wearing head covering while stepping out in the sun.

Although the study explores self-reported heat illnesses among low-income groups, it does not account for outdoor workers and their social vulnerability (Tran et al. 2013).

Exploring social vulnerability in the Indian context and how it further limits coping capacity of households and individuals, Rathi et al. (2022) developed a heat-vulnerability index among selected neighbourhoods across four different cities. It was found that in these areas, there is a high vulnerability across the neighbourhoods. The study concludes that vulnerability and adaptive capacity are not mutually exclusive. High vulnerability to heat waves exists due to lack of coping capacity, and that vulnerability and coping capacity are inversely proportional.

Further, factors such as access to electricity and water, are important factors to consider as ways to build resilience in a system to heat waves (Hatvani-Kovacs et al. 2016). Excess electricity consumption to tackle heat stress has been acknowledged as one of the ways to adapt to changing climate (Patz et al. 2014).

The magnitude of vulnerability of individual workers to occupational heat stress also depends on coping capacity, the social protection strategies in place, and adaptation at higher scales (Davies et al. 2009; Nunfam et al. 2019). It is necessary to explore localised social welfare measures to build adaptation and resilience in the system. These strategies entail provision of fluids and cooling system, education and outreach, moving work indoors, heat breaks and shifting work timings have been suggested (Dehury and Dehury 2017; Gao et al. 2018; Lundgren et al. 2013).

At the institutional level, strengthening workplace safety regulations and workers' rights through unions have the potential to increase the adaptive capacity of the workers. Communication, awareness and outreach and training to build capacity among institutions to draw the link between climate change and outdoor work activity also has potential implications for adaptation at a larger scale (Nunfam et al. 2019). Further, it is also advocated

that workers should be compensated for the direct effects of heat stress such as workplace accidents and illnesses, which lead to income losses (Kjellstrom et al. 2016).

As discussed earlier, few studies have accounted for the link between vulnerability of sub-groups such to occupational heat stress (Venugopal et al. 2016; Sett and Sahu 2014; Panneer 2019). While institutional adaptation in the form of workplace regulations such as BoCW (Building and other Construction Workers) act OSH (Occupational Health and Safety) have the protentional to build resilience in the system, it is yet to be explored.

2.4.1 Heatwave action plans as adaptation measures: Indian cities

As a response to the rising incidence and longevity of heatwaves, Indian cities have started adopting heat action plans to build greater adaptive capacity in the urban system to heat waves (Golechha et al. 2021).

One of the first cities to implement an action plan was Ahmedabad, in the western state of Gujarat. Built through a multi-stakeholder approach, the plan recognised four important strategies to tackle heat waves entail: community outreach and awareness campaigns to disseminate information on heatwaves; early warning system; building capacity among health practitioners; and promoting adaptive measures to reduce heat exposure (AMC 2019). The plan also included expanding cool roofs to build resilience in low-income neighbourhoods. Under this measure, rooftops in these neighbourhoods would be painted with reflective paint to ensure lower indoor temperatures.

Under the heat action plan, the labour department is also responsible to identify construction sites across the city and ensure there is adequate water facilities for workers on site and move work hours to cooler part of the day (AMC 2019).

As a result of the heat action plan, the city of Ahmedabad was able to reduce heat-related mortality up to 25%. This was a result early warning system, community outreach, and capacity building for disaster mitigation among institutions such as municipal corporation and medical officials (Hess et al. 2018).

This initiative has been scaled up in many different cities such as Surat, Nagpur, and Chandrapur. Similarly, many states such as Telangana, Maharashtra, and Rajasthan have taken up similar heat action plans (Golechha et al. 2021). There needs to be more studies done on the effectiveness of these action plan in reducing heat stress among outdoor workers.

2.5 Conceptual Framework

The conceptual framework integrates the capitals framework developed for the CLIMSAVE project (Tinch et al. 2015) with the positive tipping points framework (Tàbara et al. 2018) to explore how limited coping and adaptive capacity may drive a subsystem in the socio-ecological systems to and beyond critical thresholds.

Tinch et al. (2015) argue that while the factors contributing to coping and adaptive capacity are difficult to quantify, capital stocks can act as an indicator of coping capacity. The presence of these stocks can further one's coping capacity. According to the framework, the capital stocks are:

- Natural capital: Stock or flow of energy that yield valuable goods and services.
- Produced/manufactured capital: Material goods and infrastructure that contribute to the production processes
- Human capital: Education, health, skills, and motivational factors.
- Social capital: Presence of structures. institutions, networks and relationships that enable to the functioning of individuals and societies.
- Financial capital: The ability to enable and procure other forms of capital.

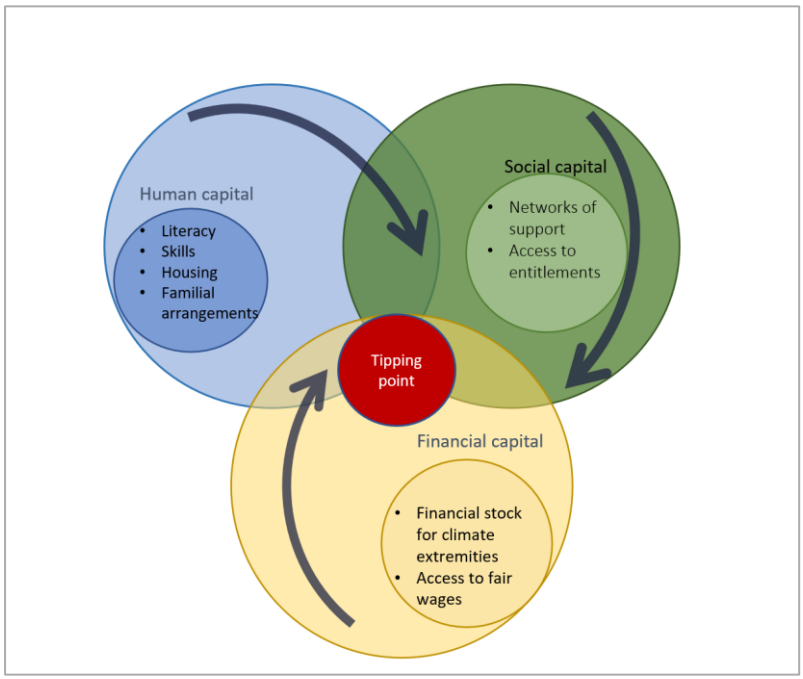
For this study, human, social, and financial capital have been adopted, as these stocks are the most relevant. The questionnaire for the research has been developed by customising these capital stocks according to my guiding research questions. The table explains the role of capital stocks in this thesis.

Table 1: Capital stocks

Human capital	• Literacy level • Skills • Housing • Family
Social capital	• Formal and informal networks of support • Governmental support during heat waves. • Access to healthcare and social security • Land entitlements • Presence of social power in urban and native settings.
Financial capital	• Financial power to respond to climate-induced crises • Capital to quit or take days off of work when sick • Access to financial resources when sick • Access to pension and paid days off. • Ability to pay for medical bills in the face of increasing heat waves.

After examining these capitals, the framework integrates it with tipping points to examine the critical threshold of the workers studied. The possible stressors to the tipping point could be the absence of these capitals. This is described in the illustration below:

Figure 2: Conceptual framework with capitals relevant for the case study



2.6 Study Site

The city of Hyderabad is in Deccan plateau in southern-central region of India and is the capital of the 29th state of India, Telangana. Spanning an area of 650 sq. kms, the population of the city was 10.5 million as of 2021. In terms of global ranking, Hyderabad ranks 31st in terms of population growth (Wakode et al. 2013). By 2035, the population of the city is expected to rise to 14.1 million people (UN DESA 2019).

Figure 3: Map of Hyderabad

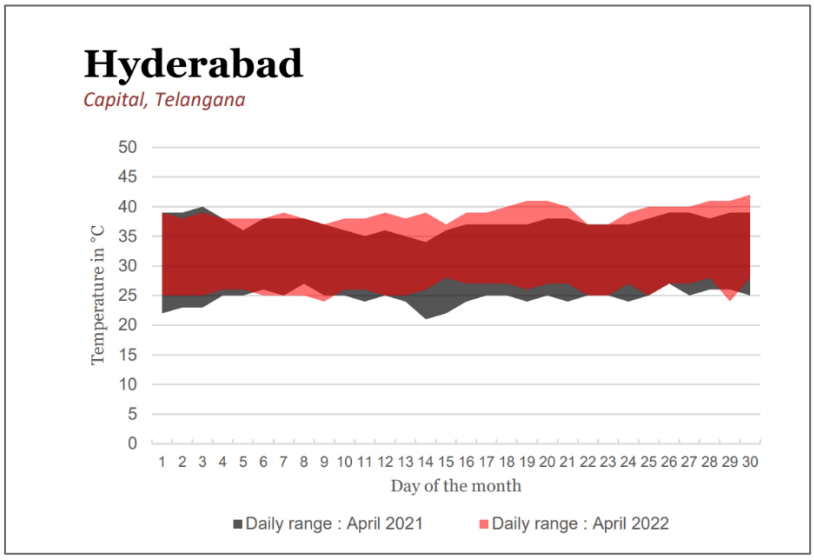
Source: Google Maps.

The city has a dry and semi-arid climate, with an average temperature of 26 degrees Celsius. Summers, between April-June, have temperatures hovering about 30 degrees. In May, the maximum temperature crosses 40 degrees and is the hottest month in Hyderabad (Suresh K. Rathi and Sodani 2021).

The incidence of heatwaves in the Telangana region have been steadily rising, and the region is termed as one of the heatwave vulnerable regions in south-central India (Satyanarayana and Rao 2020). Nearly 96% of those effected by heat stress in the region belong to below poverty line, and the rest of the 4% were pink card holders, who are just above poverty line (Nadarajan et al. 2021).

Between 2006 and 2015, Hyderabad experienced 390 days with temperatures above 40 degrees (Suresh et al. 2021). In April 2022, Hyderabad experienced 10 heat wave days, as opposed to one heat wave day in 2021 (Chanchal and Chanchal 2022).

Figure 4: Heatwaves in Hyderabad



Credits: (Chanchal and Chanchal 2022)

As the city is one of the rapidly growing Information Technology hubs in India, it has been experiencing rapid urbanisation, resulting in large-scale labour migration to the city (Bala et al. 2016). As a result of this, there is an increased risk of heat stress exposure among populations due to Urban Heat Island effect too (Suresh et al. 2021).

2.7 Conclusion

There has been increasing research on the physiological and social effects of heat stress among working population. Study on OHS in the construction sector has also gained prominence. Through measurements such WBGT and Discomfort Index, studies have explored the physiological effects of rising temperatures on construction workers. However, many factors such as social-economic vulnerability, institutional support or the lack of it, education and gender also have the potential to limit coping to external stressors. Women are much more vulnerable to occupational heat stress due to existing social vulnerabilities which limit their coping capacity.

In the India context, patriarchal norms, informality of construction sector, gender wage gap, and heavy workload coupled with lack of basic facilities for women like sanitation, childcare and maternity benefits can potentially drive the workers to a critical threshold in terms of heat stress.

Only few studies have focused on OHS in women in India. There is also a lack of studies on OSH through a systems framework. This enables research to explore the linkages across institutions and individuals, to look at formal and informal institutions of support to cope with heat stress. The systems approach also draws a broader picture of the how social vulnerability at an individual level effects the adaptation and resilience of the system. This research aims to take the coping and tipping points approach and address the existing gaps in current literature.

3. Methodology

This chapter discusses the methods employed for data collection and how this helped answer the research questions. Additionally, the limitations of this research will also be discussed.

Qualitative research involves collecting textual, non-numeric data in the form of texts, audio, and video. This method is used to understand people's beliefs, perceptions, experiences, attitudes, and behaviours (Pathak et al, 2013). As the guiding research question explores coping capacities, I chose this approach to document workers experiences.

3.1 Data collection

3.1.1 Review of literature

To understand the research context, current discourse in the field, and identify knowledge gaps, I first undertook archival research. This method involved critically analysing the key debates and concepts in the core area of research, which is, coping, adaptability, vulnerability and tipping points in SES. This method was also applied to understand key arguments in the research on occupational heat stress in Indian context and analysing public documents regarding the construction sector to understand the broader threat of climate change to outdoor activity in the country.

3.1.2 Questionnaire

Based on archival research, I decided to have two sets of interviews: primary interviews with the women working in construction sector, and secondary interviews with stakeholders responsible for heat stress mitigation at institutional level.

Since the interview approach was kept semi-structured, open-ended questions were drafted for primary interviews. The archival research gave an overview of the research problem and

helped me formulate my research questions. These research questions have guided the formulation of the questionnaire.

Table 2: Themes for primary interview questionnaire

Themes	Description
General Demographics	Information about the participants entail age, family size, native, and how long they've been living in Hyderabad
Workplace details	Questions relating to wage rate, work hours, workers registration, and workplace facilities to cope with heat.
Personal coping mechanisms	Mechanisms for coping with heat stress at a personal scale, informal networks of support, and previous experiences with heat stress.

3.1.3 Sampling

The snowball sampling technique is employed for finding research subjects, where one participant gives the name of another participant, who in turn nominates the third and so on. Hence, the participants are selected like a rolling snowball (Cohen and Arieli 2011).

This sampling technique was employed as the research participants would have otherwise been inaccessible. Such hard-to-reach populations are generally not open to researchers who do not have access to their social network (Dusek et al. 2015). For instance, during the initial days of fieldwork, the members of the community were reluctant to speak, as they feared possible repercussions of going on record. Hence, snowball sampling was chosen as mutual

contacts would already have some form of established trust, which I could build up on. Through this sampling technique, 12 participants were selected.

3.2 Study site

The region under study is Hyderabad, a city in the south-central part of India. I chose Hyderabad for this research as I have contacts in the city who helped me narrow in on people I can reach out to. Additionally, as a native of Hyderabad who speaks both Telugu and Hindi, interacting with workers was expected to be easier.

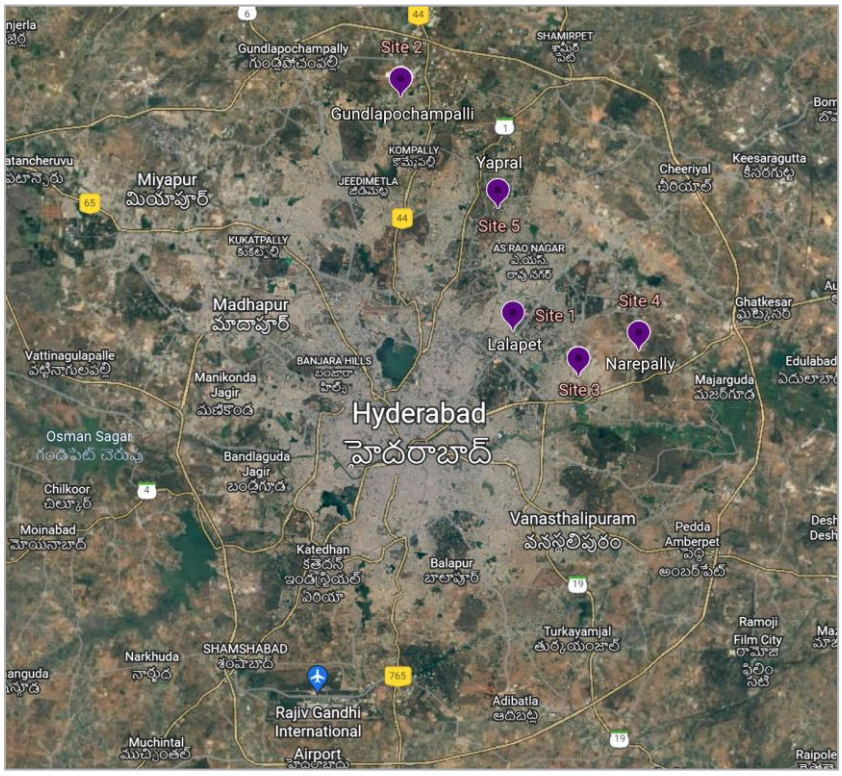
3.3 Interviews

The semi-structured approach is a mix of structure and unstructured interviewing methods, where the researcher prepares prior questionnaire, but lets the participant guide the interview and elaborate on particular issues through open-ended questions (Alsaawi 2014). This approach was adopted as to let the participants elaborate on their coping strategies, which had the potential of answering the research question. The interviews were divided into two parts based on the participants. Primary interviews were conducted with women engaged in manual construction labour. Secondary interviews were conducted with stakeholders of the different institutions related to the study subject.

3.3.1 Primary interviews

Primary interviews were conducted from May 3-20 across five different sites in Hyderabad municipality area. The identity of the participants has been kept anonymous, as assured in the consent agreement. Instead, codes have been used to denote participants' identity. For example, participant 1 refers to the first interviewee, participant 2 refers to the second and so on.

Figure 5: Interview sites



Source: Google maps

Table 3: Participants and interview location

Participant code	Description	Site code and name
Participant 1	Worker registered under the BOCW act.	Site 1, Lalapet
Participants 2 and 3	Unregistered workers employed by a private construction firm.	Site 2, Gundlapochampally suburban area in the norther part of Hyderbad
Participants 4 and 5	Unregistered workers employed to work at a small site	Site 3, Boduppal, located at the eastern end of Hyderabad
Participants 6, 7, and 8	Unregistered workers employed to work at a small construction site at the suburbs of the city	Site 4, Narapally suburban area located north-east of Hyderabad

Participants 9-12	Migrant workers belonging to Jharkhand hired by a private firm	Site 5, Yapral, a suburb in the north-east of the city

All the interviews were conducted in person. While only one interview was conducted at the neighbourhood where the participant lives, the rest of them were conducted at the sites where they work. Interviews lasted anywhere between 5-15 minutes and seeking more time with the participants was not possible as I interviewed them during their work hours.

3.3.2 Secondary interviews

Secondary interviews were conducted with institutional stakeholders from Indian Meteorological Department (IMD), Department of Labour Welfare, a site supervisor at a private construction organisation, and Gandhi Hospital, a public hospital in Hyderabad.

I set out to do these interviews to gather data on measures that may have been implemented to reduce heat exposure among workers. Further, secondary interviews were also a means to explore the level of awareness about heat stress among these stakeholders. For these interviews, a mix of purposeful and snowball sampling was employed.

3.4 Data Analysis

The data analysis stage includes transcribing the information from spoken to written. This stage also includes thematic analysis, which is one of the most heavily relied upon analytical tool in social sciences. Thematic coding approach consist of five stages. They are: getting familiar with data, generating initial codes, identifying themes, constructing thematic networks, and interpretation (Alsaawi 2014).

As the interviews were recorded in Telugu and Hindi, they were manually translated and transcribed to English. These transcripts were thematically coded in the NVivo software.

Four codes were created, and the responses were codes under this. The coded results were used to build themes on coping capacity and heat stress. These themes are further discussed in the results section.

3.5 Limitations

The fieldwork for this thesis was done in a limited timeframe, due to which trust building with the participants was not feasible. Gaining the community's trust posed a major challenge during the initial couple of weeks of field work. Many women refused to be interviewed, as they feared they said would be reported to their supervisors or government representatives. Hence, I had to scale back the number of participants from 20 to 10. This lack of trust was also seen among construction firms. Thus, only the sites where I had previously established contacts were approached for interviews.

The interplay of Indian caste system and climate vulnerability was also something that this research could achieve due to time and framework constraints. Although nearly 80% of the 'unskilled' labourers in the sector belong to the Scheduled Caste (SC) community, a marginalised and formerly untouchable community in India, there remains a vast gap in research between caste discrimination and climate vulnerability.

Although some of the participants mentioned that they belong to the *Lambada* community, a Scheduled Tribe (ST) community in Telangana, the timeline of the fieldwork and thesis was too short to follow-up on the caste dynamics.

4. Results

This chapter discusses the findings of the primary and secondary interviews in line with the theoretical framework. The first section of the chapter sets context to the construction sector in Hyderabad and discusses the dynamics of the sector. The second section then discusses the findings of the primary interviews. This discussion is guided by the thematic codes generated as a part of data analysis. The next section sets the context for secondary interviews and discusses the findings from each interview.

4.1 Dynamics of construction sector

The construction sector is said to be one of the largest sectors in Hyderabad, employing more than 2 million people from different parts of the country. Owing to the rapid urbanisation in the last three decades, the sector has been catering to the growing demand for flyovers, ring roads, IT offices etc. Due to this, workers from different parts of the country such as rural Telangana, Jharkhand, Bihar, and Odisha have been migrating to the city in search of work (ActionAid India, 2017).

During the field work, I took observational notes. It was noted that workers either live in labour settlements in the low-income areas of the city or live close to construction sites in huts and temporary houses made of corrugated iron sheets. It is observed that those living on their own in these neighbourhoods belong to Telangana and Andhra Pradesh, the Telugu speaking states and hence, they are considered locals.

In the low-income neighbourhoods where they live, every day from 8 am, workers assemble at the labour *adda* in hopes of finding work for the day. An *adda* (or *naaka*, as called in other states) can be a meeting point, usually close to the main road, where most construction workers meet in hopes of finding work.

Figure 6: Workers waiting at an *adda*

Photo credits: Praveen Bushipaka.

As observed in Lalapet, men and women carrying crowbars, shovels, and tiffin boxes show up at the *adda*, waiting to be picked up by prospective contractors or *mestris* (mason) for the day's work.

While waiting at the *adda* with the women, in attempts to gain trust, I struck up a conversation with some of them. During this time, they told me that some days they find work and some days they do not find work. The standard strategy acknowledged by most workers in the *adda* is that they wait to be picked up by potential supervisors from 9 am-12 pm. If they do not get picked up during this time, they go back home and hope to find work the next day.

These workers at the *adda* find new a site nearly every day and are paid for the number of hours they put in. Hence, if they skip work one day, they lose wages for that day.

Unlike the workers living in *adda,* the out-of-state migrants working in private construction sites are brought to the city by a *tekadar* (middleman) and are housed in huts and makeshift houses close to the site. They live here until the project is completed and find a new site.

As there were heatwave warnings in most parts of April and May, temperature recordings were taken on the days when field work was underway. On most days, the temperature was above 36 degrees Celsius.

Based on the themes identified for primary interviews, the next section will be divided into three parts, general demographic, work conditions, and personal coping. Below is a detailed list of the primary interviewees to understand the context for the next section.

4.2 General demographic

4.2.1 Place of origin

Of the 12 participants, seven belonged to the Telangana region and spoke Telugu. The others were from different states such as Jharkhand and Bihar and migrated to Hyderabad in search of work. The workers at the Yapral site mentioned that a *tekedar* (middleman) brought them to the city and pointed them to the work opportunity at the site.

These women were also the ones living close to construction sites. Even amongst the local workers, some of them were living in huts close to where they work and moved to another place after the building was complete.

4.2.2 Age

I included the age factor as I wanted to know the age trends of women working in the sector. I also wanted to explore if older women (those above 50 years) worked in the sector, to explore their experiences of heat stress and how the climate has changed over the years. But most participants were under between 18-40 years old.

It was interesting to see that many participants did not know what their exact age was. When asked for age, respondents guessed their age and said:

> "I might be around 30 years old" - Participant 2
>
> "I would be around 40 years old" - Participant 8
>
> "I don't really know my age. I maybe 20-25 years old" - Participant 10

While some participants knew how old they were, many only had a rough idea of their age.

4.2.3 Family size

Only one participant said that she had migrated to Hyderabad alone. The other 11 participants had families living and even working with them. Those interviewed at the Yapral construction site, which was owned by a private firm, mentioned that many of them came with their husbands and children. In the absence of anyone to look after the kids, women either left their kids closer to the site to play or would lay a hammock inside the building and put them to sleep.

In the initial interview, participant 1 mentioned that women with younger kids usually do not come to the city to work and that unless there was a childcare support at home (in-laws or other familial support), young mothers would not work in the construction industry.

Contrary to that, in Yapral and Narepally, where the out-of-state migrants were working, many women were mothers with small children, who were working on site while simultaneously taking care of their young ones.

4.2.4 Literacy

Only participant 8 mentioned that she studied up until grade 9 before she left education to work in construction. The rest of the respondents said they had no formal education. This became obvious when the consent form was explained to the interviewees. Although it was drafted in both Telugu and English, the women could not read it, hence they were wary of signing the document. Some even mentioned that the lack of education is the reason they chose to work in construction, since the nature of work did not require any prior skills.

4.2.5 Previous work

This part of the questionnaire was included for either young women who were just started working or those who transitioned into the construction sector less than 10 years ago. Seven participants mentioned that they recently moved to the construction sector. Before that, they were either working as agricultural labourer or just stayed at home.

Participant 10 pointed out that back in her village in Jharkhand, she stayed at home and looked after the children while her husband worked as a construction worker. Since she does not own land back in the village, she had to migrate to Hyderabad for extra earnings.

The rest of the respondents pointed out that they worked on agricultural fields as daily labourers since they did not own any land themselves. Participant 9 pointed out:

> "Back in the village, I used to work in agriculture. I used to grow potatoes and tomatoes. But there is a water shortage and rainfall has reduced as well so had to shift to construction work."

As none of the participants called Hyderabad their hometown, it was interesting to see how long they have been living there and how their experience of working in the city has been. Only 3 participants from Telangana, have been living in the city for the last 15 years. The rest migrated to the city in search for alternate livelihood as agriculture failed or were in the need of extra income.

4.3 Work conditions

Under this theme, questions related to their work such as wage rate, hours of work, rest hours, and nature of work were asked. As the construction industry is highly informal in India, there are many unregistered workers who receive wages lower than those stipulated by the government. To test this hypothesis, participants were asked questions about their work such as awareness of registration and unionisation and if they were registered or knew anything about how to get registered. The findings from this section would be useful to understand the financial capital of the workers.

4.3.1 Nature of work

In terms of the nature of work, a pattern can be drawn from the responses of the participants. The nature of work is highly volatile but generally switched between lifting bricks, sand, transporting heavy material from one place to another, and lifting whatever construction debris was left over. Some of the respondents further stated they are supposed to follow the supervisors' instructions. For instance, participant 8 pointed out

> "I do all sorts of odd jobs here. I throw away (construction) debris, do curing work, lift bricks, and do whatever the supervisor tells me. It's a lot of physical work and sometimes I must carry heavy material up to 3-4 floors. Additionally, I work as domestic help in the houses that have already been occupied."

Participant 9 mentioned that her work on site entailed lifting bricks, clearing debris and do as the supervisor instructors her. Hence, it can be said that women are assigned tasks like lifting heavy materials and transporting it to those working in the site.

4.3.2 Work and break time

Even under this theme, similar responses were received, and it is noted that the work usually starts at 9 am and ends at 6 pm, with a one-hour lunch break at 1 pm. Some interviewees mentioned that this is the time when they get to take rest and cope with the heat. But apart from the one hour, the workers do not get any additional break time. Participant 5 said:

> "Usually, that one hour break gives me a lot of rest. But if I'm tired after that too, I just go home and get paid only for the hours that I put in."

Participant 6 points out that extreme weather such as heat waves do not change their work and break timings. She states:

> "No matter the weather, these are our work timings and they do not change."

Interestingly, participant 12 that sometimes they are made to work on Sundays as well. She noted:

> "They (supervisors) won't even let me rest in shade for some more time. The supervisor yells at us if we take a break. If I don't work, they reprimand a lot. One day I did not work, they yelled at me quite a bit. Sometimes we even end up working on Sundays."

4.3.3 Wage rate

As the rate of wage contributes financial capital, I wanted to explore how this affects their capacity to cope. This was also an attempt to explore if the women were being paid according to the wage rate laid down by the BOCW act.

The discourse around wage rate was interesting to explore, as interviewees had different responses to this. From the responses, it was clear only participant 1 was being paid 700 rupees (8.61 EUR) a day, which falls in line with the rates stipulated for unskilled workers by the BOCW act 1996. The others were unregistered and were being paid less than the stipulated minimum wage. Hence, the wage rates for the rest hovered around 300-400 (up to 5 EUR) rupees a day.

Another noteworthy aspect was two of the out-of-state migrant workers did not really know how much they were being paid. For instance, participant 12, who hailed from Jharkhand and only migrated to the city two weeks ago mentioned:

> "I do not really know how much I earn. The *takedar* gives me 1000 rupees a week."

Similarly, another worker from the same site, participant 10, speculated that the wage rate maybe around 300 rupees a day and that she does not exactly know how much she is paid every day.

4.3.4 Access to sanitation and drinking water

As workplace facilities have the potential to reducing heat stress, I wanted to explore the accessibility and availability these facilities. These facilities could entail access to water and toilets, shaded areas for rest, maternity care benefits, childcare facilities, and others.

A general trend that can be observed is that there are drinking water facilities at each site. The respondents working at the large construction sites (for instance, the Yapral and Gundlapochampally sites) said that the employers provide access to drinking water, which helps them cope while working in the heat. But two workers belonging to the smaller construction site in Uppal area mentioned that the site managers/supervisors do not provide

them with water and that the *mestri* (head workman/mason) brings a can of water before the work starts.

Similar responses were heard from participant 1, who mentioned that before the start of workday, the *mestri* gets water which is accessed on site by all workers.

Even in terms of access to sanitation facilities like toilets, the workers at bigger construction site seemed to be better off, as they had access to toilet. In the site in Narepally, participant 8 described:

> "No one gives us any water here. I must spend out of my pocket and buy. There are no toilet facilities here either. We relieve ourselves out in the bushes."

Across the interviews, the feasible and affordable coping strategy that was highlighted was drinking water and staying hydrated to avoid heat stroke. Hence, the availability of access to safe drinking water on site is recognised as important in the context of rising heatwaves.

4.3.5 Childcare

Another important aspect of workplace facilities is child support and maternity care for female workers.

Of the 12, four participants were new mothers with children younger than one year. Before starting the fieldwork, based on archival research, I developed a hypothesis that most construction sites in India do not have childcare facilities or maternity benefits, which may affect women's ability to cope with heat stress. During interviews, this hypothesis was confirmed.

While approaching participants, it was observed that there were women breastfeeding or looking after their children while taking up curing work on site. Participant 10 said that she gave birth to a baby only a month ago and had resumed work. She said:

> "There's no one to look after the child. My husband and I work here so I'll have to look after the baby. So, wherever we go, we take him there."

Participant 9 too echoed similar sentiments. She mentioned that as there was no one to look after her child, she had to take him to the construction site. She also mentioned that she would generally lay a hammock inside the building that is under construction and lay the baby to sleep there.

A similar strategy was adopted by participant 7 in the absence of access to day-care facilities, either at workplace or through informal networks of support such as family. She said that since the walls of the building are constantly cured, it would be cooler inside, hence ideal to put the child to sleep there.

Although participant 8 had slightly older children, she too highlighted that since there was no one to look after them, she would leave the children to play out in the sun. She also added that if the kids got ill due to being exposed to sun all day, she would have to get them treated at her own expense.

This absence of day-care facilitiees not only restricted the women's capacity to cope, but also exposed the children to heat-related illnesses and the potential accidents on the construction site. Although construction sites are mandated to provide day-care facilities under the BOCW act, this was not implemented in any of the interview locations. Hence, the participants were left on their own to take care of their children while working.

4.3.6 Social benefits

Looking at the pattern of responses, it can be said that there is no provision for sick leaves or compensation for health care expenses incurred. The interviewed women mentioned that if they fell ill, they would take the day off but would not be paid for the days they could not work. They also mentioned that the employer does not pay for medical expenses. Even for unionised workers, as mentioned by participant 1, compensation is only given in case of serious accidents or deaths and heat stress and heat related illnesses are not covered.

4.3.7 Accommodation

An interesting part of the field work was delving into the accommodation provided for migrant workers and how it could increase their coping capacity.

Of the four sites, two were large private construction sites where out of state migrant workers were employed. The company provided makeshift accommodation next to the sites for the workers to live in. Once the site is complete, these workers would move to the next site would be provided with accommodation there.

Five of the respondents claimed that the accommodation provided was not adequate to cope with hot days and nights. Participant 8 pointed out that all the supervisors provided was a small piece of land and *tadika* (roof made of coconut and palm leaves) and that they had to make their own huts from scratch.

> "They give us some open land and some *tadika* and we must make our own huts. Now, if this site is finished, we have to look for another place. And we have to set up a hut and transport all our belonging there all over again. And these huts are so unbearably hot even in the night, but what else can I do?"

Participant 12 also emphasised that housing provided by the company was a makeshift one made of metal sheets that got unbearably hot in summer, making it difficult to cope with heat even in the evenings. She said:

> "It gets so hot in those houses at night. So, I sometimes take my baby and sleep outside because we do not have any air conditioning."

Although one construction company claims that these facilities are provided with electricity, limited financial capital for workers meant that they could not afford any conditioning, which induced severe heat stress among the women.

4.3.8 Worker's registration

As many of the issues faced by the workers in regard to access to welfare policies and housing were related to being unregistered, I investigated how many workers were registered or to what extent they were aware about it.

As discussed earlier, only one of the research participants was a registered worker and has been getting wages as stipulated by the BOCW act. While some of the women were not aware of any worker registration or worker cards, many of them were not registered, were making lower wages, and are devoid of any workplace benefits.

Participant 7 described that even back in her village, she did not have any citizen identity cards such as *Aadhar* card (social identity card), ration card, or voter ID to claim benefits such as ration and pension. Similarly, participant 6, who is from the Telangana state, mentioned that she has been working as a construction worker for as long as she can remember but has never been officially registered.

A similar pattern can be seen with out-of-state workers. As most of them came to the city only two weeks ago, they were counting on the *tekedar* (middleman) to provide them with registration cards. As participant described

> "I don't have any labour card right now. The *tekedar* who brought us said he would provide us with the card."

4.3.9 Prior occupational heat stress exposure

While taking up literature review, it was noted that many of the workers in the construction industry are agriculture workers who would migrate to the city when there is no agricultural activity. Hence, I wanted to understand if this applied to these women as well and how they were exposed to heat stress in their previous occupation.

Looking at the pattern of responses, the participants can be divided into two groups: one without any prior work experience, and other who were previously agriculture labourers back in their village. There, as participant 4 describes, the workers were not given any heat breaks or provided water.

> "I used to work in agriculture fields, laying seeds and picking the produce when it is ready to be harvested. There, even when I work in summers, there was no rest or heat breaks. They would not give any breaks. After lunch, we would get about 10 minutes of rest. There I used to get heatstroke. When that happened, I'd just get myself treated at the local clinic and get on with work."

Even though this participant mentioned that working in the construction sector is better than the work in field, owing to more pay and extended rest during lunch, the coping capacity and responses to heat stress remained the same.

Further, participant 3 also mentioned that she worked in agriculture fields back in West Bengal, where her village is. Even there, she felt tired working under the hot sun all day.

4.3.10 Coping with OHS

In the light of many vulnerabilities such as lower wage rate and lack of job security or benefits, it was necessary to investigate how women cope with rising temperatures and working outdoors for long hours, to answer the central research question.

I got different responses to how the participants work in extreme heat. A common pattern of responses was a feeling of helplessness and not being able to have much say in the situation. For instance, participant 11 mentioned,

> "What to do, we are poor so just have to work wherever. I don't have any land back in the village, so we need to work wherever there's any kind of work."

A similar response was recorded from participant 10. She mentioned:

> "What do we do when there's too much sun? Whatever the sir (supervisor) tells us, we need to do. We don't get any rest. These people (construction company) don't get me treated if I get sick. I must bear the expenses myself. If I'm too sick maybe I will take rest in the accommodation they've given us for about two days."

Some participants also mentioned that they never felt tired or had symptoms of heat stress while working in the heat. But access to drinking water and lunch break were considered some of the important aspects to cope with heat stress. Participants 5 and 6 mentioned that they would rest inside the building under construction during lunch time, as the walls inside the building were constantly cured, hence it would be cooler inside.

Apart from this, other coping strategies such as wrapping a cotton towel on the heat to prevent heat, constantly drinking water, and taking the day off were mentioned.

This section discussed how the work conditions of the participants limited or further their coping capacity. In this case, occupational heat stress was linked to the informality of the

construction sector, which restricted the financial and, in some cases, human capital of the interviewees. Many of the issues faced by the participants were directly linked to being unregistered, especially in terms of social benefits such as childcare, housing, and wage rate. This further made them vulnerable to occupational heat stress.

Hence, to build coping capacity among workers, it is first important to recognise this informality and address it. Further, it is of priority to understand the link between heat waves and outdoor work activity. This would enable institutions to better implement heat stress mitigation plans to build adaptive capacity among workers.

4.4 Personal coping

In the absence of both institutional and informal support systems to cope with heat stress, I wanted to explore the personal coping strategies these women engage in. It was found that personal coping depended on limited financial and social capital. Some of the workplace provisions such as housing and wages closely affected their personal lives, and hence even coping strategies.

Some of the common responses that have been reported across interviews were related to drinking water, visiting the doctor, and taking break from work for a few days. Out of these, the latter two came at their personal expense, as the workers are not covered for medical expenses and are paid daily. Hence, if they missed work for a day, they would lose out on their daily wage.

Participant 4 perfectly describes the most common response to heat stress. She said:

> "I take rest at home for about 10 days and don't go out for work. It costs about 2-3000 rupees (25-35 EUR) if I go to the doctor. The doctor prescribes tablets or injection to deal with heat stroke."

Similar responses were recorded from other participants, who mentioned that they would go to the hospital at their own expense.

Apart from this, other responses like drinking *sharbat* (solution made of water, sugar, and lemon), *kobbaribonda* (coconut water), and cold beverages were also mentioned as some of the coping strategies.

Another important point that was highlighted through the responses was the importance of housing and how it contributed to discomfort level even during the evenings. Some participants, such as 5, 7, and 9 mentioned that they have ceiling fan at home, which they described made their homes cooler and liveable. In contrast to this, some participants mentioned that they could not afford to have ceiling fans at home, which made coping with high night-time temperatures very difficult. This was also attributed to the fact that the accommodation provided to the workers was inadequate to protect them from extreme heat. Participant 12 raised this issue and said:

> "Even if I get sick, what will I do? There is so much heat and they've given us houses made of tin sheets. It is so hot inside that room. At night too, it's so hot sometimes I don't sleep inside. I just go out in the open and sit or put a damp cloth over myself to cool down. What else to do?"

A similar experience was shared by another worker on the same site, who had a one-month-old baby. The participant said that on the nights when it is too hot, she just takes her baby outside for more breeze and sleeps outdoors.

Participant 8, who was interviewed on another site too shared a similar experience regarding housing. As the construction company did not give them adequate housing, she had to end up making the thatched huts with her family and states that her family is exposed to different stressors in different seasons. She said:

> "We are exposed to different stressors in different seasons. In summer, I get heat stroke. Once monsoon arrives, there's cold, fever, a lot of dust. During summers, it's so hot inside the hut but if we step out, there are so many mosquitoes that it is difficult to stay put. Once monsoon arrives, there ae scorpions and snakes coming into the hut."

Overall, the main strategies for coping included staying hydrated, taking day off from work, wrapping a cotton towel on the head, and sleeping outdoor due to the lack of air conditioning. Apart from these, which were possible within the limited capitals they had, the women did not know any alternative coping strategies.

4.4.1 Familial support

As women share the double burden of workplace and domestic duties, it was important to investigate how familial institutions limit or further the workers' capacity to cope. For this, women were also asked about their responsibilities once the workday ends.

While some participants noted that they have support from their husband and children in domestic chores such as cooking and cleaning, the rest of the women noted that they were solely responsible for these. For these respondents, having sole responsibility over domestic chores was linked to the fact that there was no other female support at home. For instance, participant 2 noted:

> "Right after work, I need to look after household chores. I don't really have a choice since I have two sons. They don't know how to cook so even if I'm tired or sick, I have to do it. I don't have any daughters so I'm the only one who can do housework. If I ever get sick, my sons take me to the doctor. If they give me tablets, I take them and continue working at home."

Even participant 1 noted similar coping strategies. She said that although her family takes care of her when she's sick, she is responsible for cooking, since her sons and husband do not know how to cook. Participant 7 echoed similar sentiments and said that since she is

widowed and has a daughter to look after, she is responsible for all the domestic chores. Participant 10 said:

> "The men in the family don't really look after me when I'm sick. So, I have to look after myself and also the domestic chores."

Unlike these responses, participant 5 and 7 mentioned that they have some form of support for domestic responsibilities from children and husband respectively. While participant 5 mentioned that her husband and children cook and clean if she fell sick, 7 mentioned that since she and her husband are both orphans and have no familial support, they help each other through all the chores.

4.5 Awareness of climate change

To tie all this together, it was crucial to explore the level of awareness on climate change in the context of rising temperatures and if they have found the temperature to be rising each passing year. It is also worth exploring if education level had any correlation to the level of awareness about climate change.

Although the participants were not aware of the term climate change, some of them noticed the change in temperature and rainfall over the years. Those who worked as agriculture workers had higher awareness of the change in temperature over the last few years. For instance, participant 3 earlier mentioned that she noticed the gradual reduction of rainfall and increase in summer temperatures. As some of them left agriculture work due to lack of rainfall, they identified or understood the change in climate. Even though the other participants did not have agriculture background, they agreed that it was way too hot to work and has been like this for a few years now. Participant 7 described that flood were the reason she had to leave her hometown

> "Last year, back in the village, our house got drowned in the rain. My elder son was just a year old, and I was pregnant with my second. Since we don't have any other place in the village, my husband and I had to move to the city. Even before the flood, I was still staying at that place when it rained heavily. We would flush the water out and stay on the bed. Then, my second son was born. Because of the rains and floods, my son was severely affected. He had infection in his blood, so we had to rush him to the hospital. We moved right after that."

Hence, it appeared that in one way or another, most participants felt that the temperature was changing and that it was getting too hot to continue business as usual.

To conclude, the primary participants are exposed to different form of vulnerabilities due to the lack of human, financial, and social capital. It was found that some of the capitals were overlapping and directly linked to each other. For instance, it can be noticed that low financial capital was related to low levels of skill set and literacy. Hence, in the absence of any institutional support, the women have very low-levels of coping capacity and were employing simple mechanisms that may not protect them from heat-induced illnesses for too long.

4.6 Secondary Interviews

A second set of interviews were conducted to answer the second question of the research, which was to find out about mitigation and adaptation strategies at the institutional level to prevent heat stress among workers and to explore cross-scale linkages among institutions to build resilience in the system. For this, four stakeholders, a site supervisor, the director of the Indian Meteorological Department (IMD) in Hyderabad, an officer at the department of Labour Welfare, Telangana, and a doctor working at a public hospital in Hyderabad were interviewed. The findings from each interview will be discussed below.

4.6.1 Construction site supervisor

I wanted to explore site safety policies, regulations, and workers benefits, particularly for female workers. Hence, the site supervisor from the Yapral site was interviewed.

It was found that there are about 200 people working on the site. In terms of site safety, workers at the height of 1.5 meters and above, safety belts are provided, and safety nets are attached to the buildings for worker safety and helmets were mandatory for all the workers. However, there are no regulations in place for medical coverage or insurance for major accidents. There is only a first aid kit on site. The participant emphasized that generally no major accidents take place in the construction sector.

There are no childcare facilities on site. The workers had to rely on informal networks of support from extended family or other women on site to take care of the children. The supervisor mentioned that they would let the women breastfeed their children during work hours and lay hammock in the finished building to put the children to sleep.

In terms of heat stress among workers, there is no action plan in place. The participant mentioned that although so far there have been no heat stroke cases on site, they procured cotton towels for all the workers to protect themselves from heat. It was also mentioned that there were water facilities on site which everyone could access.

Apart from these, there were no other facilities or regulations in place for the workers to cope with heat stress. Even for female workers, there were no maternity or childcare regulations. In terms of workers' registration, the participant mentioned that policies such as labour laws and Employee Provident Fund (EPF) were not yet implemented on the site. This means that the workers were not entitled to any benefits covered by the BOCW act.

4.6.2 Indian Meteorological Department (IMD)

As IMD is one of the primary institutions along with the state disaster response department to implement the heat wave action plan in Telangana, I wanted to explore the early warning systems in place, the future implications for the state of Telangana and particularly Hyderabad in terms of heat waves, and heatwave action plans and what this means for outdoor work activity. For this, I contacted the director of IMD in Hyderabad.

Over the last 15-20 years, rapid urbanisation in Hyderabad has led rise in land surface temperature and urban heat island effect. Due to this, there has been a noticeable increase in the surface area temperature in Hyderabad. The city displays a mean surface temperature of 39-41 degrees Celsius and has witnessed the highest rate of urbanisation in comparison to other cities like Delhi, Mumbai and Kolkata (Aithal et al, 2019), As the interviewee pointed out:

> "So, a major thing that can be noticed is that temperatures are steadily rising and there is a sudden downpour of rains urban areas, as opposed to steady monsoon."

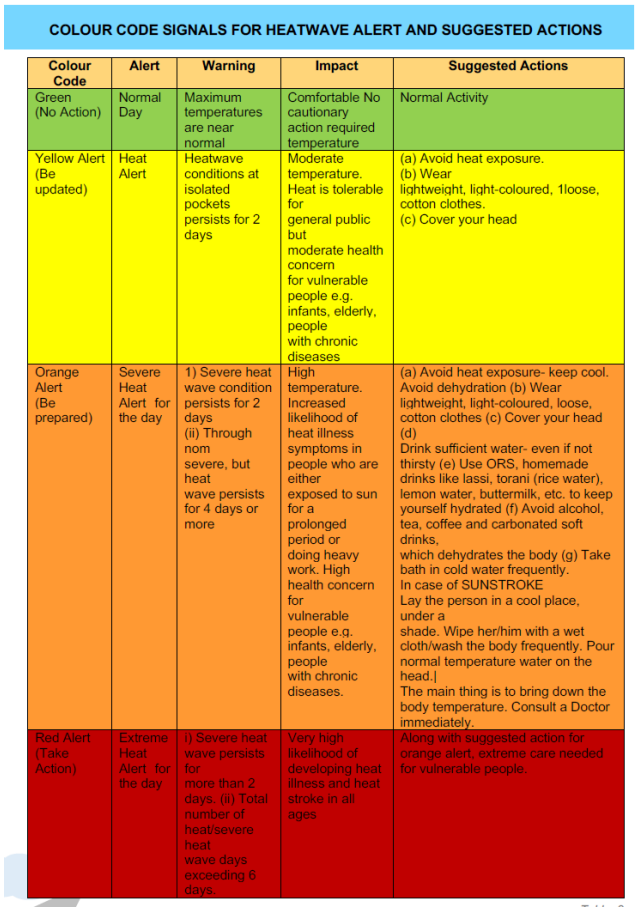
In terms of heat stress mitigation among outdoor workers, the scientist highlighted the need to shift timings for outdoor work activity such as construction and agriculture. As the peak temperature time is between 12-3 pm in the afternoon, the work timings needed to be shifted to early mornings and resume in the evenings.

Highlighting the indoor discomfort level for those living in informal settlements, cool roofing using white reflective paint was recommended as one of the important strategies to protect vulnerable populations from heat stress.

As IMD is one of the primary stakeholders of the heatwave action plan, the participant explained that the action plan is revised every year in collaboration with the state disaster management department, the health department, and the labour department.

In this plan, colour codes are given to the intensity of heatwave in the state. For instance, red alert is issued when there is a prolonged heatwave exceeding 47 degrees Celsius for more than three days. Under this scenario, all outdoor work is mandated to stop, and the health and disaster management departments are on high alert for any casualties. The orange alert is issued when the heatwave lasts for two days with maximum temperature exceeding 40 degrees Celsius.

Figure 7: Colour codes for heatwave responses



COLOUR CODE SIGNALS FOR HEATWAVE ALERT AND SUGGESTED ACTIONS

Colour Code	Alert	Warning	Impact	Suggested Actions
Green (No Action)	Normal Day	Maximum temperatures are near normal	Comfortable No cautionary action required temperature	Normal Activity
Yellow Alert (Be updated)	Heat Alert	Heatwave conditions at isolated pockets persists for 2 days	Moderate temperature. Heat is tolerable for general public but moderate health concern for vulnerable people e.g. infants, elderly, people with chronic diseases	(a) Avoid heat exposure. (b) Wear lightweight, light-coloured, 1loose, cotton clothes. (c) Cover your head
Orange Alert (Be prepared)	Severe Heat Alert for the day	1) Severe heat wave condition persists for 2 days (ii) Through nom severe, but heat wave persists for 4 days or more	High temperature. Increased likelihood of heat illness symptoms in people who are either exposed to sun for a prolonged period or doing heavy work. High health concern for vulnerable people e.g. infants, elderly, people with chronic diseases.	(a) Avoid heat exposure- keep cool. Avoid dehydration (b) Wear lightweight, light-coloured, loose, cotton clothes (c) Cover your head (d) Drink sufficient water- even if not thirsty (e) Use ORS, homemade drinks like lassi, torani (rice water), lemon water, buttermilk, etc. to keep yourself hydrated (f) Avoid alcohol, tea, coffee and carbonated soft drinks, which dehydrates the body (g) Take bath in cold water frequently. In case of SUNSTROKE Lay the person in a cool place, under a shade. Wipe her/him with a wet cloth/wash the body frequently. Pour normal temperature water on the head.| The main thing is to bring down the body temperature. Consult a Doctor immediately.
Red Alert (Take Action)	Extreme Heat Alert for the day	i) Severe heat wave persists for more than 2 days. (ii) Total number of heat/severe heat wave days exceeding 6 days.	Very high likelihood of developing heat illness and heat stroke in all ages	Along with suggested action for orange alert, extreme care needed for vulnerable people.

Source: Telangana heatwave action plan, 2021

Under the set of responses, apart from giving heat breaks, the labour department is also mandated to organise awareness camps in construction sites and regular health check-ups in coordination with the health department (Government of Telangana 2021).

4.6.3 Labour department

An officer working at the Department of Labour Welfare was approached to know about the implementation of BOCW act, the benefits for unregistered workers, site safety inspection, and implementation of heatwave warning for the benefit of construction workers.

While the chief labour officer was not available for an interview, I had an informal conversation with this officer, who did not consent to go on record.

During the conversations, two important things were discussed. The first was regarding lack of site safety regulations, as observed during the field visit. The second was regarding the implementation of heat breaks for workers when there is a heatwave warning in the state.

For the first aspect, the officer mentioned that no site safety inspections have been taken up of late to track safety standards. The officer did not mention if the department plans on resuming any of these inspection drives.

Regarding the second aspect, the labour department can only issue suggestions to construction sites and the department has little power to enforce these breaks as a mandate. The officer also mentioned that although the department is aware of the heatwave action plan and participates in the action plan meetings, there has been no real mandate or regulation regarding it.

4.6.4 Public health practitioner

As the health department is also an important stakeholder in the heatwave action plan, a doctor working Gandhi General Hospital, Hyderabad was interviewed on the precautionary measures and ways to build adaptation among outdoor workers.

The doctor touched upon many aspects of heat stress and early, preventable symptoms of heat stroke that would be highly relevant to the construction sector.

1. Identifying early signs

As there are a spectrum of heat-associated illnesses, it is important to identify issues such as heat cramps, heat syncope, and heat exhaustion cause heat stroke when left untreated.

The symptoms of heat exhaustion are sweating profusely, high body temperature, leading up to 40 degrees Celsius of core body temperature, and unable to perform any physical activity. At this point of heat exhaustion, it is important to treat the workers and take measures to bring down body temperature. Without these measures, a person maybe exposed to heat stroke, which is highly likely to cause to death.

The doctor emphasised the need for increased awareness among workers and supervisors to identify these early signs and treat the workers before they are exposed to heat stroke.

Even in terms of heat stroke, the doctor highlighted that the first hour of heat stroke is the golden hour, when the body temperature needs must be brough down by spraying cool water on the affected person and resting them in a cool area. For this too, there needs to be awareness on immediate response and damage mitigation among workers on site.

2. Prevention and long-term mitigation

As prolonged exposure to heat leads to varied illnesses like heart attack, brain stroke and organ damage in the long run, having prevention and mitigation strategies in place at construction sites is key.

Apart from awareness, the provision of fluids, preferably with electrolytes is a good adaptation strategy. Additionally, providing frequent heat breaks and providing adequate shaded areas for rest was also highlighted as an adaptation strategy.

Further, workers in the industry tend to be overworked at sites with poor safety regulations, which may exacerbate the issue of heat exhaustion and increase accidents on site. Therefore, the doctor highlighted the need for stronger regulations for safety and workers welfare.

3. Gender and heat stress

Addressing the gender gap in coping strategies, the doctor mentioned that women have lesser access to education and awareness about heat-associated illnesses and how to cope with them. As women have primary responsibility of childcare and other family responsibilities, in addition to professional work, they tend to be more vulnerable to heat exhaustion.

4.7 Concluding remarks

All the primary participants interviewed during research are integrated into the lower end of the construction industry. These women work in a highly informal fashion, without any guarantee to either work, fixed pay, or benefits. Further, many of these women lack informal networks of support and are expected to look after domestic responsibilities such as cooking, cleaning, and childcare. These aspects have severely restricted the human, financial, and social capital of these women. As a result, their coping capacity is limited only to short-term responses, which may not be a viable solution in the long run.

This highlights the needs for institutional intervention to build adaptive capacity among workers. As observed from the secondary interviews, there is little being done at the higher level to understand the risk of heat stress exposure among workers. This can be witnessed in the lack of heat stress acknowledgement in the BOCW act and the response of the department of labour welfare. There is a need for these institutions to understand the risk of climate change on outdoor workers and implement mitigation strategies to prevent casualties in the long run.

5. Discussion

This chapter discusses the findings of the study based on the guiding framework and research questions. This research set out to explore how women engaged in manual labour cope with heat stress in the presence of institutional vulnerability and how their capitals contribute to it. The secondary aim of the research was to explore what institutional responses are available to mitigate OHS among workers in the construction industry.

Based on the results, I analyse the three capitals, human, social, and financial and link it to the coping capacity and critical thresholds. These capitals will first be discussed as individual cases below.

5.1 Human capital

In terms of human capital, the participants have very low levels of literacy and awareness of coping methods. As witnessed in the pattern of responses, the women did not know how else to cope but employ simple mechanisms like wrapping a cotton towel over the head, staying hydrated, and taking days off work.

There is also a correlation between low levels of literacy and the nature of work the participants are employed in. As they are employed as unskilled labour with little scope for skill development, some of the participants pointed out this is a consequence of having no formal education.

It can also be noticed that some of the participants lack another important human capital, housing. For out-of-state migrant workers, the housing provided was close to the construction site and made of corrugated metal sheets, which made indoor temperatures very high. This was inadequate to deal with the rising day and night-time temperatures. Importantly, many of

these migrant women were new mothers who found it hard to cope with heat stress in these houses while taking care of a new-born child.

5.2 Social capital

As most of them are unregistered workers, they did not have any access to workplace benefits such as healthcare, maternity benefits, accidental coverage, and paid leaves. Further, there was low awareness among the participants regarding workers registration.

In terms of support systems, both formal and informal, most participants lack any form of support system. Although there is some form of familial support in the event of illness, the participants were still solely responsible for domestic and childcare duties due to social norms.

Even in terms of land entitlements, the participants were vulnerable both in rural and urban settings. Some of them did not own any land back in their villages and hence looked towards city for work. This could point to lack of land holdings as social security in times of disaster.

Further, social vulnerability could also be manifested in the form of the lack of social security cards, which limits one from accessing governmental benefits. Hence, the lack of social capital restricts the coping capacity.

5.3 Financial capital

Many of the participants were being paid less than the minimum wage. This is also coupled with the lack of any benefits or medical coverage in case of illnesses, which means the women were left on their own to take care of any illnesses or heat stresses arising due to strenuous work.

The participants have limited financial capital and any heat-related illness would put further strain on their limited financial resources.

The lack of land entitlements also ties to financial capital, as one would have limited coping capacity in the face of climate-induced disasters.

As research points out, larger societal processes influence the coping of individuals (Devereux and Næraa 1996). Particularly in the South Asian context, the lack of these capitals among women has been highlighted as factors intensifying vulnerability (Ariyabandhu 2000).

In conclusion, the lack of these capitals makes women more vulnerable to heat stress. Hence, the participants showcase limited coping mechanisms in the presence of these stressors.

5.4 Coping and tipping points

The low level of coping capacity and limited capitals have the potential to lead these women to a critical threshold, after which there could be a new domain with lesser responses to heat stress. This scenario in the long run could lead to a total collapse, which in this context could mean rising fatalities among workers in the construction industry.

Although individual tipping points maybe highly subjective, this case study highlights that the participants are either past a tipping point into a new domain or are fast approaching it. This is illustrated in the figure below.

Figure 8: Tipping point

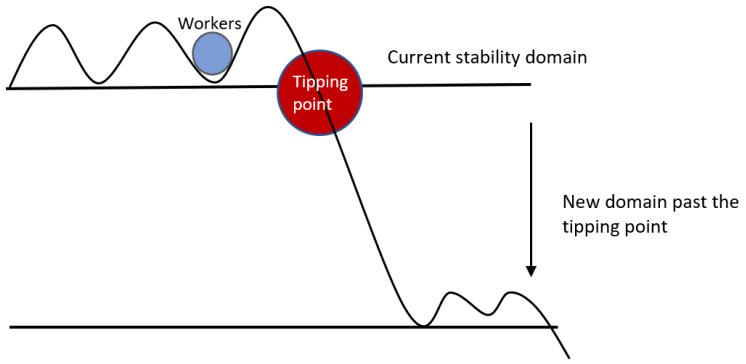


Figure 8 illustrates how limited coping capacity can push individuals beyond a tipping point. The height of the waves describes the coping and adaptive capacity of the workers in the system. In the current stability domain, they are able to engage in coping mechanisms with the limited capitals they have. But in the long term, these limited responses can push them to a tipping point. In the new domain, there may be even lesser coping capacity due to weakening capitals to engage with. This process in the long term could lead to a total collapse of a subsystem.

As witnessed in this case study, a new domain could mean more days off work to cope with heat stress, increased spending towards medical bills, or switching to a different profession, as witnessed in some cases.

While this tipping point may not show immediate effects in the system, in the long run, this may have cascading affects in different institutions, weakening the resilience of a larger system.

Hence, institutions play a critical role in not only building adaptive capacity among workers, but also preventing these cascading effects.

6. Conclusion and recommendations

This research was taken up a crucial time when many parts of South Asia, including the study site, were experiencing intense heatwaves that commenced earlier than the usual. The case of female construction workers highlights layers of vulnerability and how little has been done at the institutional level to understand the seriousness of this problem.

Women integrated at the bottom end of the industry possess very little capitals to cope with climate extremities. With heatwaves becoming more intense, it is of high priority to protect these informal workers, on whom the construction industry in India relies upon heavily. Further, as some of these workers are already past a critical threshold, this can show cascading effects across different institutions such as family, workplace, and society. This can eventually weaken the overall resilience of the system.

From this case study, it can be said that much needs to be done to make the sector and the workers in it resilient to heat stress. Primarily, it is of high priority to link climate induced extremities to the construction sector and explore how the informality of the sector affects the workers capacity to cope. The welfare of female workers also need to be prioritised, to increase their resilience.

Primarily, the existing policies such as BOCW act and OHS code 2020 need to consider occupational heat stress while accounting for occupational injuries. For women, it is much more important to implement the existing maternity and childcare benefits that the BOCW act guarantees.

6.1 Recommendations

Following the discussion, the following recommendations have been suggested:

6.1.1 Heat breaks

The adaptive capacity of the workers could be increased through mandated heat breaks. Although this has already been suggested by earlier researchers (Acharya, Boggess, and Zhang 2018; Venugopal et al. 2020), it has not been implemented. Further, although the Telangana heatwave action plan mentions shifting work away from the peak heat hours of the day (1 pm-5 pm) (Government of Telangana, 2021), as witnessed on field, this has been limited to only a suggestion. Hence, there needs to be a stronger push to include this in the BOCW act. To track the implementation of this on construction sites, more site visits need to be conducted by the labour department.

6.1.2 Workers registration

The construction sector in India depends greatly upon informal migrant labour from different parts of the country. It is necessary to draw the links between this informality and how it leads to lowering resilience of the sector against heatwaves.

As observed in the case study, most participants were unregistered workers who were earning wages below the minimum mandated under the BOCW act. This severely restricted their financial capital to cope with heat stress. Hence, it is important to make workers aware of the BOCW act and the benefits guaranteed under it.

6.1.3 Heat stress mitigation awareness

As one of the secondary interview participants pointed out, there even needs to be greater awareness of heat waves and its effects on construction workers among different levels of workers in the sector. As witnessed in these sites, there is very little awareness or mitigation strategies such as first aid kits in place. Hence, those in charge of decision making such as

site supervisors and managers need to be better equipped to deal with symptoms of heat exhaustion and stroke among workers.

6.1.4 Workplace provisions

In this context, these entail facilities such as childcare, provision for water, cool air, and shaded areas for heat breaks, and sanitation facilities. As observed, the lack of these facilities severely restricted the women's capacity to cope with heat stress. Hence, it is important to provide these facilities to build adaptive capacity to heatwaves. The lack of social and financial capital mean women bring their children to work, further exposing them to heat stress and other potential accidents on site. Hence, the presence of childcare facilities at work will greatly increase the women's capitals to cope with heat stress.

Further, even housing is a facility that could significantly further the worker's coping capacity. For migrant workers hired by private companies, this is an important mechanism that can improve their adaptability. The current housing option provided is highly informal and prone to heating in summers. Hence, there needs to be better regulations for monitoring the materials used to make houses for migrants.

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Appendix

Consent to take part in research

పరిశోధనలో పాల్గొనడానికి సమ్మతి

Assessing heat stress among female construction workers in Hyderabad, India

Name of the researcher: Ambika Sairam

హైదరాబాద్‌లో మహిళా నిర్మాణ కార్మికులలో వేడి ఒత్తిడిని అంచనా వేయడం

పరిశోధకురాలి పేరు: అంబికా సాయిరాం

I [name of interviewee] agree to participate in this research study.

నేను [ఇంటర్వ్యూ చేసిన వ్యక్తి పేరు] ఈ పరిశోధన అధ్యయనంలో పాల్గొనడానికి అంగీకరిస్తున్నాను.

I understand that even if I agree to participate now, I can withdraw at any time or refuse to answer any question without any consequences of any kind.

నేను ఇప్పుడు పాల్గొనడానికి అంగీకరించినప్పటికీ, నేను ఎప్పుడైనా ఉపసంహరించుకోవచ్చని లేదా ఎలాంటి పరిణామాలు లేకుండా ఏ ప్రశ్నకు సమాధానం ఇవ్వడానికి నిరాకరించవచ్చని నేను అర్థం చేసుకున్నాను.

I have had the purpose and nature of the study explained to me and I have had the opportunity to ask questions about the study.

నేను అధ్యయనం యొక్క ఉద్దేశ్యం మరియు స్వభావాన్ని నాకు వివరించాను మరియు అధ్యయనం గురించి ప్రశ్నలు అడిగే అవకాశం నాకు లభించింది.

I understand that participation involves being interviewed

పార్టిసిపేషన్ అంటే ఇంటర్వ్యూ చేయడం మరియు అవసరమైతే డాక్యుమెంట్‌లకు యాక్సెస్ అందించడం అని నేను అర్థం చేసుకున్నాను.

I agree to my interview being audio-recorded.

నా ఇంటర్వ్యూ ఆడియో-రికార్డ్ చేయబడిందని నేను అంగీకరిస్తున్నాను.

I understand that all information I provide for this study will be treated confidentially.

ఈ అధ్యయనం కోసం నేను అందించే మొత్తం సమాచారం గోప్యంగా పరిగణించబడుతుందని నేను అర్థం చేసుకున్నాను.

I understand that in any report on the results of this research my identity will remain anonymous. This will be done by changing my name, the name of my organization, and disguising any details of my interview which may reveal my identity or the identity of people I speak about.

ఈ పరిశోధన ఫలితాలపై ఏదైనా నివేదికలో నా గుర్తింపు అజ్ఞాతంగా ఉంటుందని నేను అర్థం చేసుకున్నాను. ఇది నా పేరు, నా సంస్థ పేరు మార్చడం మరియు నా గుర్తింపు లేదా నేను మాట్లాడే వ్యక్తుల గుర్తింపును బహిర్గతం చేసే నా ఇంటర్వ్యూ యొక్క ఏవైనా వివరాలను దాచిపెట్టడం ద్వారా చేయబడుతుంది.

I understand that signed consent forms and original audio recordings will be retained in Ambika Sairam's possession, until 31 July 2022.

సంతకం చేసిన సమ్మతి ఫారమ్‌లు మరియు ఒరిజినల్ ఆడియో రికార్డింగ్‌లు 31 జూలై 2022 వరకు అంబికా సాయిరామ్ ఆధీనంలో ఉంచబడతాయని నేను అర్థం చేసుకున్నాను.

I understand that a transcript of my interview in which all identifying information has been removed will be retained for one year after the submission of the thesis 31 July 2023.

31 జూలై 2023న థీసిస్‌ను సమర్పించిన తర్వాత నా ఇంటర్వ్యూ యొక్క ట్రాన్స్క్రిప్ట్ మొత్తం గుర్తించదగిన సమాచారం తీసివేయబడిందని నేను అర్థం చేసుకున్నాను.

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Signature of research participant and date

పరిశోధనలో పాల్గొనేవారి సంతకం

I believe the participant is giving informed consent to participate in this study

ఈ అధ్యయనంలో పాల్గొనడానికి పాల్గొనేవారు సమాచార సమ్మతిని ఇస్తున్నారని నేను నమ్ముతున్నాను

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Signature of researcher and date

పరిశోధకుడి సంతకం