

# BENGALURU BURNING

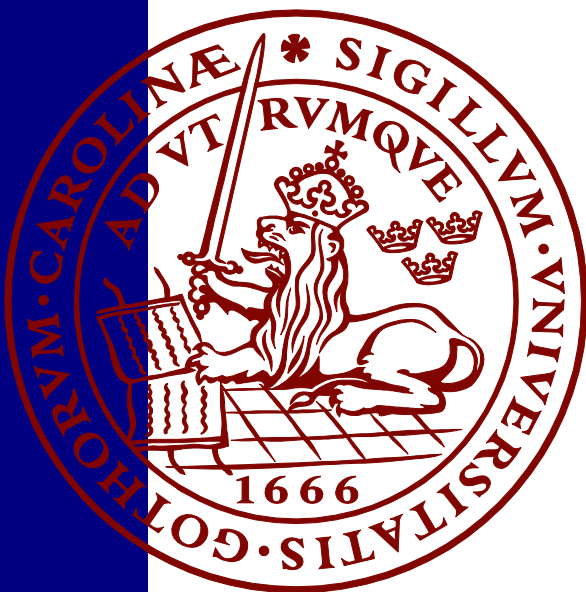
*A critical analysis of the impacts of and adaptation to heatwaves*

*Mahima Moolbharati*

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A thesis submitted in partial fulfillment of the requirements of Lund University  
International Master's Programme in Environmental Studies and Sustainability Science  
(30hp/credits)



## LUCSUS

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Sustainability Studies



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Mahima Moolbharati

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Master's Programme in Environmental Studies and Sustainability Science

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Supervisor: Maryam Nastar, LUCSUS, Lund University

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## **Abstract**

Climate-changed induced extreme events like heatwaves have become increasingly critical issues in urban India. Rapidly growing cities are vulnerable to adverse effects of heatwaves exacerbated by inequalities embedded in urbanisation. This study uses the case of Bengaluru, India to explore how residents of different socio-economic backgrounds experience heatwaves. Further explored are adaptation strategies implemented at individual and city level. This study identifies gaps in climate change adaptation and their challenges. Critical urban theory is applied to discuss why these challenges persist.

Mixed methods of literature review and interviews are used to gather data for the study. The findings reveal differences in exposure to heatwaves are rooted in inequalities of access to formal housing and essential civic infrastructure. There is a risk of maladaptation to heatwaves at individual level, and inadequacy of holistic adaptation strategies at city level. Neoliberalism, gentrification and postcolonialism perpetuate inequalities in urban areas, thus hindering effective adaptation.

**Keywords:** heatwave vulnerability, climate change adaptation, critical urban theory, neoliberalism, gentrification, postcolonialism

**Word count:** 11983 words

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## List of Abbreviations

IPCC- Intergovernmental Panel on Climate Change

BBMP- Bruhat Bengaluru Mahanagara Palike

IT- Information technology

LULC- Land And Use And Land Cover

UHIE-Urban Heat Island Effect

KSAPCC- Karnataka State Action Plan on Climate Change

LST- Land Surface Temperature

IMD- India Meteorological Department



CUT- Critical Urban Theory

MNC-Multinational Corporation

EMPRI-Environmental Management Policy & Research Institute

NDC-Nationally Determined Contributions

INR-Indian Rupee

CAP -Common Alerting Protocol

KSHAP- Karnataka State Heatwave Action Plan

ECBC-Energy Conservation Building Code

HAP-Heat Action Plan

BESCOM-Bangalore Electricity Supply Company Limited

BEE-Bureau of Energy Efficiency

KREDL-Karnataka Renewable Energy Development Limited

BDA-Bangalore Development Authority

EIA-Environmental Impact Assessment

KRDCL- Karnataka Road Development Corporation

UN-United Nations

SEDAC-Socioeconomic Data and Applications Center

IIHS-Indian Institute for Human Settlements

NAFCC- National Adaptation Fund On Climate Change

ABIDe- Agenda for Bengaluru Infrastructure Development

## 1. INTRODUCTION

Climate change is one of the most pressing issues of our time. One of the most concerning aspects of climate change is its unequal impacts (IPCC, 2022a). Those who are most vulnerable to extreme weather events are often the ones who have contributed the least to causing the problem (IPCC, 2022a). This includes low-income communities in developing countries like India, where a large section of the population lives on minimal consumption of resources (Revi, 2008). To ensure a life of dignity and prosperity for all, urban development must consider the compounding effects of climate change on the existing socio-economic vulnerabilities of disadvantaged groups. The UN Sustainable Development Goals Target 11.3 'Inclusive and Sustainable Urbanisation' aims to "enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries." by 2030 (*Goal 11*, n.d.). Target 11.5 'Reduce the Adverse Effects of Natural Disasters' sets the goal to "significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations" by 2030 (*Goal 11*, n.d.).

India is vulnerable to the dangers of climate change induced extreme events (Revi, 2008). The country is home to over 1.4 billion people, and its population is expected to continue growing rapidly in the coming years (United Nations Population Fund, n.d.). Urbanisation is an emerging trend in the country, with millions of people moving to cities in search of better opportunities (Kundu, 2020). Although India is not predominantly urban in its landscape, there are emerging urban hotspots in the country that consist of concentrated population, economy, natural and human resources (Revi, 2008).

The nexus of urbanisation and extreme events poses a significant danger to the future of cities. Bengaluru, a major city in southern India, is one of the fastest-growing urban areas in the country with a population of over 9.6 million people (Government of Karnataka, n.d.-a). In 2019, the city experienced its hottest day on record over the last five years, with temperatures reaching 39.9°C (Government of Karnataka, 2023). A combination of increased surface temperature and densely packed built environment can lead to the emergence of wicked problems such as the urban heat island effect; the risk to cities from heatwaves is determined by not only hazard exposure, but also by the deepening of existing vulnerabilities (Prashad, 2014; Revi, 2008).

Notably, the impact of heatwaves is not evenly distributed across the city's population. Those who are most vulnerable to the effects of extreme heat include the elderly, people with pre-existing health conditions, and low-income communities. These groups are more likely to live in areas with less

greenery and more concrete cover, which exacerbates the effects of the urban heat island effect. Additionally, they may not have access to adequate means of cooling, formally structured housing or sufficient water, which puts them at a greater risk. (Dubey et al., 2021)

India has committed to ambitious targets in its 'First Nationally Determined Contribution Under Paris Agreement' to reduce emissions, adopt climate-friendly development pathways and to adapt to climate change by enhancing investments in key sectors (Government of India, 2022). However, progress in adaptation is distributed unevenly, and the gaps are mostly borne by low-income population groups (IPCC, 2022b). Urban cities in India require holistic planning, a vision that has not yet been realised in the country. India's apex public policy think tank 'NITI Aayog' reported that "urban planning, which is the foundation for the integrated development of cities, citizens, and the environment, has not received adequate attention" over the last few years (NITI Aayog, 2021). Further, a study of 37 Heat Action Plans (HAPs) of the country finds only 2 HAPs with explicit assessment of existing vulnerabilities; most HAPs are insufficiently funded, lack transparency and oversimplify the risks of heatwaves in urban areas (Pillai & Dalal, 2023). My study is an exploration into the difference in experiences among resident of different socio-economic groups, heatwave adaptation strategies and gaps in implementation of adaptive strategies in Bengaluru city.

### **1.1 Research Questions**

The following are the guiding research questions of the study: -

- 1) How do residents of neighbourhoods in Bengaluru with different socio-economic backgrounds experience heatwaves?
- 2) What are the adaptation strategies to heatwaves at individual level and city level in Bengaluru?
- 3) What are the gaps in the implementation of climate change adaptation? What elements make adaptation to the extreme urban heat challenging?
- 4) Why are these challenges persistent?

In order to address these questions, I will use Critical Urban Theory (CUT) (Brenner, 2009) to explore the different dimensions of climate change impacts, and the inequalities that persist in climate change adaptation strategies (Revi et al., 2014). The theory presents opportunities to understand the deeper drivers of inequality in urban areas (Brenner et al., 2009) that compound climate change risks in

vulnerable groups. It is suited to explore the case of Bengaluru, as the city has emerged as a hub for global corporations, promoting rapid and unprecedented economic growth (Sudhira., 2008).

## **1.2 Thesis Structure**

The thesis is divided into the following sections:

- I. Background- information of the case for geographical context, urbanisation trends, heatwave vulnerability, nexus of urbanisation and climate change
- II. Theory- understanding critical urban theory and fundamental drivers of inequality in urban cities
- III. Methods- research design and methods used to address the four main questions of the study
- IV. Results- presenting findings from research conducted through literature review and field interviews
- V. Discussion- applying the guiding theory to the local context of the case
- VI. Conclusion- summary of the research and potential for future study

## **2. BACKGROUND**

### **2.1 Geographical Context**

Bengaluru is a land-locked city in the southern state of Karnataka, India; it bears a latitude of 12.9°N and is spread across an area of 2196 square kilometres (Government of Karnataka, n.d.-a). The city's population is a little over 9.6 million residents, with a decadal population growth rate of 47.18% (Government of Karnataka, n.d.-a). Bengaluru has a rich history of scientific and technological advancements and is now home to leading multi-national corporations giving it the tag of India's Silicon Valley (Govind & Ramesh, 2019).



Figure 1: Location of Bengaluru City

Source: <http://travelsmaps.com/map-of-bangalore.html>

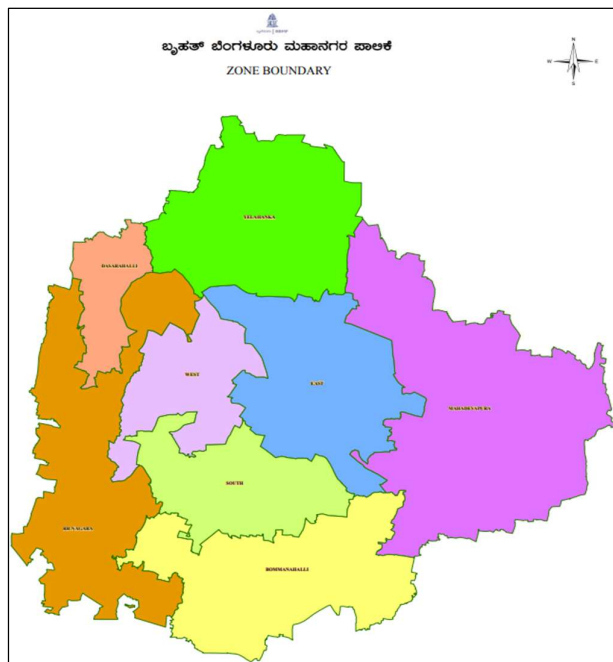


Figure 2: Bengaluru BBMP Zones

Source: (BBMP, n.d.)

The city is divided into 8 zones of the local municipality called Bruhat Bengaluru Mahanagar Palike (BBMP), as illustrated in figure 2. These zones are further divided into 198 wards that facilitate the jurisdiction of BBMP in the city. Bengaluru has seen significant growth in population over the last two decades, and saw an increase from 5.7 million residents in 2001 to 8.4 million in 2011. (Verma et al., 2017). It has the highest average annual growth rate of population among all the megacities in the

country between 2001 and 2011 and is expected to be one of the fastest growing cities in India in the following decade (Verma et al., 2017). Thus, it is an important case in the study of growth in urban India.

## 2.2 Urbanisation in Bengaluru

Bengaluru was once considered a small town and often a place for old-aged residents; it is often referred to as ‘Garden City of India’ owing to its history of extensive green and blue cover (Nagendra, 2016). However, it has witnessed significant change in land use over the last three decades.

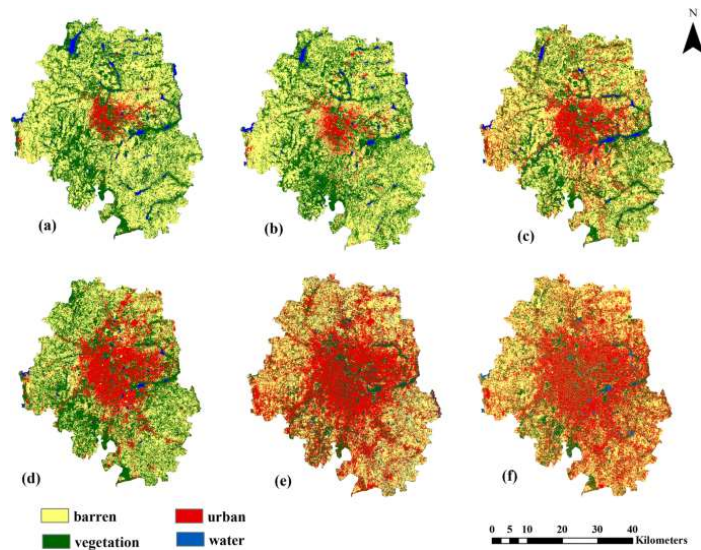


Figure 3: Land Use & Land Cover map of Bengaluru (Urban) for the years (a) 1989, (b) 1994, (c) 2001, (d) 2005, (e) 2014, and (f) 2017

Source: (Govind & Ramesh, 2019)

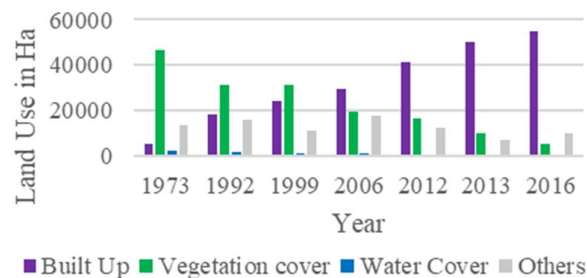


Figure 4: Land Use & Land Cover in Bengaluru (urban) between 1973 and 2016

Source: illustrated with data presented in (Ramachandra & Aithal, 2016)

Figure 3 visualises the change in the land use and land cover (LULC) of the city between 1989 and 2017. Built up environment has encroached upon vast areas of green and blue cover, causing drastic changes in the landscape of the city. As illustrated in Figure 4, the built area has changed from 5448 hectares in 1973 to 54807 hectares in 2016 (Ramachandra & Aithal, 2016), thus registering a ten-fold increase in built area of the city. Bengaluru has lost more than 79% of its green cover in the last four decades due to rapid urbanisation; lakes and small water bodies in the city have also been encroached upon, leading to a decline in water availability and quality (EMPRI, 2021). Municipal bodies in the city have not been able to cope with the rapid urban growth, thus leading to large gaps in the provision of basic amenities such as running water, sanitation, regular waste collection and other such key services (Sidhwani, 2015).

The influx of Information Technology (IT) firms and multinational corporations (MNCs) in the city has triggered an incoming migration of young professionals with high-income employment and rapid wealth building in some individuals owing to a flourishing start-up culture.

Figure 3 visualises the closely packed urban areas in the city. High-density built-up areas contribute to the formation of urban heat islands, and the phenomena is called Urban Heat Island Effect (UHIE) (Siddiqui et al., 2021). Urban Heat Island Effect (UHIE) can be defined as the creation of a pocket of urban space that experiences a higher temperature than surrounding areas due to high absorption of heat by concrete structures, roads, pavements and other built environment elements (Gago et al., 2013; Mohajerani et al., 2017; Siddiqui et al., 2021). Dark concrete surfaces on roads, pavements and rooftops absorb more heat from the sun's radiation than natural surfaces of soil, vegetation and water bodies (Mohajerani et al., 2017). Further, densely packed urban structures have lower heat circulation and dissipation mechanisms, leading to ambient heat being trapped in the surroundings and forming a bubble of urban space with higher temperature than rural or sparsely packed areas (Deilami et al., 2018). Rapid and haphazard urbanisation has exposed the city of Bengaluru to UHIE; a study by the Indian Institute of Science found that urban areas in Bengaluru were 2-3°C hotter than the surrounding rural areas due to UHIE (Raju et al., 2018; Siddiqui et al., 2021).

## **2.3 Impact of Climate Change in Urban Areas**

### **2.3.1 *Temperature Rise and Heatwaves***

Bengaluru has experienced a steady rise in its average annual temperature in recent years. According to the Karnataka State Action Plan on Climate Change (KSAPCC), the average temperature of Bengaluru has increased by 1.4°C from 1970 to 2019, which is higher than the average temperature increase of 0.8°C observed globally during the same period (EMPRI, 2021). Occurrence such as

heatwaves, flooding due to excess precipitation, and erratic weather patterns have become common news in the city (Bhasthi, 2017). According to the Indian Meteorological Department, the frequency of heatwaves in Bengaluru has increased in recent years. In 2020, the city experienced its longest heatwave on record, which lasted for 13 days, with temperatures reaching up to 38°C (Government of Karnataka, 2023; Times of India, 2022).

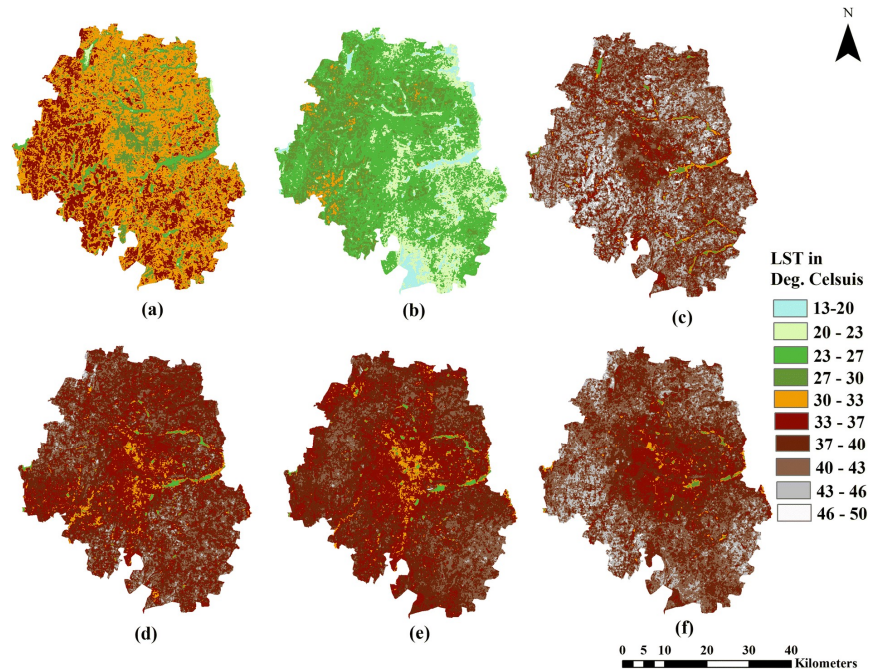


Figure 5: Land Surface Temperature Map of Bengaluru Urban district for the years (a) 1989, (b) 1994, (c) 2001, (d) 2005, (e) 2014, and (f) 2017

Source: (Govind & Ramesh, 2019)

Over the last three decades, Bengaluru has continuously observed warmer Land Surface Temperatures (LST) with some parts crossing 40°C (Govind & Ramesh, 2019). The significant change in LST in the early years of the twenty first century is a concerning event, and the same for 2017 presents a possibility of warmer years (Govind & Ramesh, 2019).

Heatwaves are defined as periods of abnormal hot days (IPCC, n.d.); and they are considered as extreme weather events, which is defined as “an event that is rare at a particular place and time of year. Definitions of rare vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile of a probability density function estimated from observations” (IPCC, n.d.). The Indian Meteorological Department (IMD) considers a deviation of 4-5°C above the mean daily maximum temperature to identify heatwaves in the country (Nandi & Swain, 2022).



### **2.3.2 Nexus of Urbanisation and Climate Change**

Rapid and haphazard urbanisation has exposed the city of Bengaluru to vulnerabilities of climate change induced extreme events (Dubey et al., 2021). This is further exacerbated by the disappearing blue and green cover in the city, trees, lakes, and other green spaces that play a vital role in regulating the microclimate of an urban area by providing shade and cooling through evapotranspiration (Jamei et al., 2020; Prashad, 2014). Although other parts of India experience heatwaves that reach higher absolute temperatures, Bengaluru is a case study of rapid change in urban landscape against the backdrop of a rapidly changing climate (Siddiqui et al., 2021). The compounding of multiple contributing factors has led to the emergence of wicked problems in the city that need immediate action that is holistic and is considerate of the city's human-nature interactions (Prashad, 2014). The concentration of population in certain areas of the city is a significant factor in overloading the city's ecological capacity to sustain its residents.. The city's population density is increasing at an unprecedented rate, with over 9.6 million people residing in the city (Government of Karnataka, n.d.-b). It may lead to a lack of access to affordable housing, forcing many residents to live in informal settlements and slums. Karnataka government has identified 2804 sums in the state of which 597 are located in Bengaluru (Karnataka Slum Development Board, 2011).

Bengaluru Urban district is considered to be at critical risk to heatwaves owing to combined factors of high population density, marginal workers, outdoor workers and low-income residents (Dubey et al., 2021).

### **3. THEORY**

The application of CUT (Brenner, 2009; Brenner et al., 2009) is relevant to explore the underlying drivers of inequalities in the city. This section will discuss some seminal works in the sphere of CUT and concepts that have facilitated the discussion of the case.

#### **3.1 Critical Urban Theory**

Critical urban theory (CUT) could best be defined as an antithesis to urban theory and is characterised by its rejection of market-oriented and technocratic approach to urbanisation (Brenner, 2009). CUT is a field of study that focuses on analysing the social, political, economic, and cultural dimensions of urban life, with a particular emphasis on issues of power, inequality, and social justice (Brenner et al., 2009). It critiques dominant urban development models and argues for alternative approaches that prioritize the needs and voices of marginalized groups (Brenner et al., 2009). Although it can be abstract by nature, one way to define CUT is that “rather than affirming the current condition of cities as the expression of transhistorical laws of social organization, bureaucratic rationality or economic efficiency, CUT emphasizes the politically and ideologically mediated, socially contested and therefore malleable character of urban space—that is, its continual (re)construction as a site, medium and outcome of historically specific relations of social power.” (Brenner, 2009, p. 1)

CUT expands on concepts such as neoliberalism, gentrification, and colonialism, among others to critique normative urban development (Brenner, 2009; Brenner et al., 2009). Although this thesis does not have the capacity to explore all the concepts outlined in seminal works on the subject, I will use the lens of neoliberalism, gentrification and postcolonialism to explore the case.

#### **3.2 Neoliberalism**

Neoliberalism is characterised by a commitment to free markets, privatisation, individualism, and profit-facing pathways of development (Brenner, 2009; Harvey, 2019). It is not just an economic doctrine or a set of policies, but rather a mode of regulation that seeks to restructure the relationship between the state, the market, and society (Brenner et al., 2009). Oftentimes the rewards of these regulations are reaped by groups with pre-existing privileges, suppressing opportunities of meaningful growth in disadvantaged groups (Cossa, 2020). A main component of neoliberalism is the relationship between the state and corporations, where governance tools are used to favour private entities for profit-generation; consequentially the state abandons provision of welfare services for social good (Brenner & Theodore, 2002).

Brenner et al., 2009 argue that many cities around the world have become neoliberal urban laboratories, where private interests are prioritized over public needs. They further posit that neoliberal urbanism has resulted in the financialization of urban development, with real estate becoming a key driver of economic growth and profit-making. This has led to a focus on high-end real estate development, at the expense of affordable housing and social infrastructure.

Neoliberalism, “has in recent years been extended to cities around the world competing for global capital investment, through a set of measures which range from the formation of public–private partnerships, the promotion of urban megaprojects, to the segregation and displacement of poor sectors of the urban population.” (Cossa, 2020, p. 365)

### **3.3 Gentrification**

Gentrification is a social phenomenon in which “the poor, minorities, the elderly and the moderate-income working class may gradually be squeezed out of their neighbourhoods.” (Crosby, 2020, p. 185). Brenner et al., 2009 discuss how real estate developers, financial institutions, and other powerful actors are able to shape the built environment to their advantage, often at the expense of ordinary people. Neighbourhoods in the city can be observed to have an existing division based on factors such as rent, religion, socio-economic status, cultural background etc. (Kumar et al., 2016). One of the contributing factors of gentrification is the rise of state-led urban housing reforms influenced by vested interests of private firms (Chava et al., 2019; van Gent, 2013). This process often results in the displacement of lower-income residents and the loss of affordable housing options (Chava et al., 2019). A common trend in India is the gentrification of the outskirts of the city through the development of large-scale housing projects on vacant land mostly targeted at middle and upper-middle class households (Chava et al., 2019). This may lead to a change in the social composition of the area and attract more investment in what were historically small settlements, thus changing the landscape and the socio-economic status of the area (Chava et al., 2019).

### **3.4 Postcolonialism**

The developing world is still reeling with the aftermath of its colonial past (Ranganathan, 2018; UN News, 2022). Colonisers are attributed to the privatisation of land, enclosure of commons, installation of infrastructure for mobility, ‘othering’ of traditional knowledge, and erasure of local culture and for alienating the native population (Basu, 2020). This school of thought has been deeply entrenched in the colonies and it still wields influence in the way the colonies view improvement (Ranganathan, 2018).

Postcolonial development has challenged the “geopolitical logics of imperialist controlled territorial projects, spatialities of mobility, and exile, and by interrogating the continual persistence of the hegemonic and hierarchical international order” (Basu, 2020, p. 238). Roy, 2016 argues for CUT to be more nuanced in its understanding of urban development in a post-colonial government’s endeavours of urban land reforms.

Postcolonial countries also inherited hierarchical structures that dictate the classification of the population along social and economic lines (Ranjith & Pius, n.d.). The differences between rich and poor is carried into the liberated nation where the power of making decisions still lies with groups that were historically privileged (Sundaresan & John, 2020). Consequentially, urban cites of social or economic value in postcolonial nations have retained the archaic lines of division that continue to perpetuate inequalities (Ranganathan, 2018).

## 4. METHODS

Bengaluru has been selected as a case study as I believe it is at a point of inflection where it is set to grow beyond its ecological and social threshold (Ramachandra & Aithal, 2016; Sudhira., 2008). A fast-growing megacity in a developing country needs to address many pre-existing challenges before it can tackle climate change (Revi, 2008). Bengaluru has been used as a selective case study to explore impact of climate change and the persistence of these challenges.

The complexity of wicked problems arise from the interlinkage of various persistent problems (Jerneck et al., 2011). These problems manifest themselves differently in different contexts, a case study is helpful to contextualise some aspects of the inter-dependencies.

Selective case studies also have their limitations that influence the research. One of the most significant limitations is that the results of research from one particular case may not be generalizable to a broader context (Kanazawa, 2017). Especially when using a selective case study, one must be aware of the local conditions that influence the research that may differ from place to place. Another limitation of selective case studies is the influence of the researcher's predisposition on the reliability of the findings (Kanazawa, 2017).

My research is designed to address the research questions by studying academic literature, reviewing public information, and stakeholder interviews. By approaching the subject from different dimensions of experience, action, and knowledge I hope to understand the key issues surrounding the inequality in the impact of climate change in urban areas.

The first research question, exploring unequal impacts of heatwaves, required a combination of information derived from academic literature about the inequalities in Indian cities, grey literature from local news outlets and documented residents' accounts. This was supplemented by interviews of residents about their experiences, which also revealed information on coping strategies at the individual level (RQ2)

Another part of the second question, exploring coping strategies at the city level, was addressed by a combination of academic literature study and public service documents. Interviews with a local academic was helpful to understand the state of affairs in the city.

The third question that explores the gaps and challenges of climate change adaptation using documents in the public domain, secondary field data, literature review and inputs from my discussions with the interviewees.

The fourth question of why inequalities are persistent in the city is discussed through the lens of CUT. The insights for understanding why the challenges of climate change adaptation and inequalities in urban areas persist are derived from seminal works on the topic and supporting academic literature review.

The different methods of research are described below:

#### **4.1 Literature Review**

We rely on the work of our predecessors to understand the complexities of the world around us and to ask better questions. By knowing what has been done so far, we get a sense of what needs to be done going forward. (Kanazawa, 2017)

The literature review for this study derives from a wide spectrum of subjects related directly or indirectly to the research questions. Some of the topics of study were climate change, adaptation to extreme-events, sustainable development, urbanisation, urban planning and development, CUT, international, national and sub-national policymaking, among other relevant topics. While preference for deep study is given to literature published in the last decade, some older seminal works are referred for theoretical concepts and historical information. The primary portal for sourcing published literature is 'Scopus' and Lund University's digital library catalogue service 'LubSearch'. Scopus is used to identify relevant articles and book titles. Search strings are designed using salient keywords and the results are filtered through temporal and relevant subject matter filters. Some examples of the search strings used to source relevant literature are as follows:

("bengaluru" OR "bangalore") AND "heatwave" – 48 results

("bengaluru" OR "bangalore") AND "heatwave" AND "adaptation" – 26 results

"critical urban theory" AND ("india" OR "indian city" OR "urban india" OR "bangalore" OR "bengaluru")  
– 13 results

#### **4.2 Grey Literature and Public Documents**

Climate change adaptation and sustainable development is a field of work that is constantly evolving. In order to understand the extent of work done on the subject in Bengaluru, I relied on information issued by the governments of national, state and city level. Supporting data such as Karnataka's State Action Plan, Karnataka Heatwave Action Plan, India's Nationally Determined Contribution (NDC) commitments and National Communication, meteorological or statistical has been sourced from

government websites, and official communication memorandums. Grey literature has been used for civil society testimonials, and reporting of heatwave events in the region by referring to dominant local sources such as 'The Hindu', 'The Times of India', 'Deccan Herald' etc. While it is difficult to avoid inherent biases in reporting, explicitly political or one-sided opinions are avoided for the study. A wide range of informal citizens' forums and non-governmental platforms like 'Bengaluru Sustainability Forum', 'Fridays for Future Karnataka' are visited for gathering an overview of citizens' grievances, and essays by local academics.

### **4.3 Interviews**

Interviews are an incredibly useful method for gathering data in academic research to bring forward information about people's experiences and perspectives about lived realities (Adams et al., 2007). I have attempted to bring into focus some realities of the residents and people involved in climate change adaptation. The interviewees were approached directly through existing networks, social media, or recommendations by the respondents. The interview questions were usually open-ended and flexible, allowing for follow-up questions and extension of responses. Ethical considerations related to informed consent and confidentiality were taken into account when conducting interviews. The questions asked during the interviews were related to residents' experiences of heatwaves, adaptive strategies at individual level and possible knowledge of state action for climate change adaptation. Interview questions to other stakeholders attempted to understand the process of policymaking in Bengaluru. All inputs from the interviews have been used anonymously.

The audience for interaction ranged from residents of neighbourhoods considered to be relatively wealthy, such as Sahakarnagar, Whitefield, Judicial Layout and from informal settlements around Yelahanka. The type of employment for the different respondents is taken note, to assess the flexibility the individual has for remote-working or flexible hours of work. The socio-economic class of residents is influenced by many factors such as income, family size, religion, caste etc., and it is complicated to categorise the respondents as "elite" or "poor" on all the nuances. A generalisation of the economic status of the respondents is made based on the average cost of property of the neighbourhood of residence, with the data collected from popular property information websites like [www.99acres.com](http://www.99acres.com), [www.nobroker.com](http://www.nobroker.com), [www.rentomojo.com](http://www.rentomojo.com). These prices cannot be considered exactly accurate when compared to the final prices but act just as an indication of the general cost of property in the neighbourhood.

A few of the planned interviews with local policymakers and academics could not be conducted either due their reluctance to participate or due cancellations for personal reasons. Four interviews were

conducted, and the language of communication was either English or Kannada based on the preference of the interviewee. No translators were used as I am a native Kannada speaker. Following is the list of respondents:

Table 1: List of interview respondents

Category	Reference name	Type of Employment	Neighbourhood/ Organisation	Average cost of property (INR/sqm)
Resident	Respondent 1	Remote work	Sahakarnagar	6550
Resident	Respondent 2	Office work	Dasarahalli	5200
Resident	Respondent 3	Homemaker	Informal settlement near Yelahanka	Varied, approximated around INR 2000
Academic Researcher	Respondent 4	Office work	Indian Institute of Human Settlements	

References to the field interviews will follow the format of (Interview, respondent [number]).

#### 4.4 Research Limitations

There are many challenges and limitations in conducting research about India. One of the most significant limitations is the lack of updated population data in the country; the latest census data is from 2011 and the next upcoming census is planned to be conducted in October 2023. This presents a gap in understanding the magnitude of the problem and limits researchers from making sound arguments. Further, there is a lack of a holistic government repository for knowledge on climate change measurement, updated environmental statistics and related topics; some historical information from the Indian Meteorological Department can only be accessed by paying a fee, posing a hurdle for public-interest research.

I acknowledge limitations in my research owing to my pre-disposed biases and anglicised way of thinking. The interviewees approached were directly or indirectly connected to pre-existing networks in the city, but there are many other stakeholders that play an important role in the process. My research is only a starting point in the extensive network of climate change adaptation work in the



city. The sample of interviews conducted are not fully representative of the nuances in the city's residents. Further, there are some influential factors of religion, caste, gender, age etc. that determine the experience of residing in Bengaluru that contribute to the adaptation to heatwaves. The stakeholder engagement in my research did not consider these factors, as it would entail a much deeper study over a longer period of research.

## 5. RESULTS

Heatwaves are a multi-level issue in urban areas as they pose different problems at individual and city level. The multi-dimensional impact of heatwaves contributes to their classification as high-risk events (Revi et al., 2014). Increased annual temperatures and frequency of heatwaves have led to an increase in heat-related illnesses, particularly among vulnerable populations such as the elderly, children, and those with pre-existing health conditions (Dubey et al., 2021; Government of Karnataka, 2023). Over the years there have been reported deaths due to heat strokes in many regions of the country (Indian Meteorological Department, 2022). Heatwaves pose a significant threat to the lives and well-being of people living in tropical countries and are predicted to be further heightened as global temperatures continue to rise (Venugopal et al., 2020). Rising demands due to urbanisation could pose an acute shortage of drinking water in India in the upcoming years exacerbating the impact of heatwaves on residents with existing vulnerabilities (Kookana et al., 2020; Nastar, 2020).

### 5.1 Difference in Experience of Heatwaves

As the occurrences of extreme events like heatwaves increase, many vulnerable groups will be pushed to the brink of survival (Revi et al., 2014). This section explores how residents of different socio-economic neighbourhoods experience heatwaves differently.

Outdoor workers, such as construction workers, delivery persons, street vendors, and traffic police, are among the most vulnerable to heat stress during a heatwave in India (Dubey et al., 2021; Nastar, 2020). Workers face a range of challenges, ranging from exposure to direct sunlight during peak heat hours, and limited access to cooling measures, such as shade and water. On the other hand, white collar jobs and employees with the flexibility to work from home are able to afford the option to stay indoors during peak heat hours. They have access to hydration cooling mechanisms (Dubey et al., 2021; Heyes & Saberian, 2022). When asked how they cope with their work on peak heat hours, respondent 1 replied as follows-

*“we usually have some or the other alternative to cope with the heat. But not the poor people, they don’t have the amenities”* (interview, respondent 1)

On the other hand, residents of lower income households that do not have access to direct mechanisms for cooling said they would just bear with the heat as needed:

*“yes, it’s hot but what can you do...even heat must be experienced. I don’t think we will install any cooler or anything for the rest of the summer”* (interview, respondent 2)

*“it was very very sunny a few days ago...today it rained a little so it’s fine...but it’s very stuffy now, it feels like someone just splashed water onto a very hot pan now the steam is rising”*  
(interview, respondent 3)

Further, tech-savvy residents with access to on-demand services like Swiggy, Dunzo or Zomato are able to avoid outdoor exposure by using the delivery services for daily essentials. Respondent 1 while discussing the use of delivery services revealed-

*“if it is too hot I just decide to not go out, that’s most of the time. I use whatever facilities I have”* (interview, respondent 1)

Early warning messages and forecasts of heatwaves in the country are useful to a digitally adept and literate audience (Nastar, 2020). The Karnataka State Heatwave Action Plan 2023 has implemented the national ‘Common Alerting Protocol’ (CAP) to send alerts in case of severe heatwaves (Government of Karnataka, 2023). However, some vulnerable communities face barriers of literacy and digital literacy that hinder the efficient use of early warning systems using digital tools for dissemination (Khan et al., 2018).

Housing conditions, particularly the type and area of housing, also play a critical role in the experience of heat stress during a heatwave. Residents in formal housing with access to basic civic infrastructure are able to cope with extreme heat (Kumar et al., 2016). India is home to a large informal housing sector, which lacks proper ventilation and access to green spaces, making the residents of such dwellings more vulnerable to heat stress (Krishna et al., 2014; Kumar et al., 2016). As respondent 1 notes:

*“it’s manageable for people that live in a normal house but people who come from the lower side of it, who don’t have proper amenities find it very difficult. We have some or the other means to cope with it but not for people like them”* (interview, respondent 1)

Similarly, residents of densely packed neighbourhoods with narrow streets and no access to green spaces such as Chikpete, or Chamarajpete are at a higher risk of heat stress compared to those living in well-planned neighbourhoods with well-spaced housing units (Kumar et al., 2016). Another determinant of the type of housing available to families is the religion and caste; although discrimination on the basis of religion and caste is not as prominent in urban areas as in rural areas, it is still an important factor in the accessibility of housing (Pillai & Dalal, 2023; Sidhwani, 2015). Historically, upper-caste families have been able afford to build houses that are spacious, and vernacularly climate-conscious to provide optimal indoor conditions; this can be seen in vernacular

architecture techniques of using central courtyards and atriums, high quality building material and planning for adequate daylight and ventilation (Sidhwani, 2015). Independent houses in well-planned, older neighbourhoods of Bommanahalli, Jayanagar Malleshwaram or Sahakarnagar are noted to have these characteristics (Ranganathan, 2015). On the other hand, housing conditions of lower-caste families do not fare well in terms of access to basic services such as water and sanitation, sufficient space or quality building materials (Sidhwani, 2015). This inequality has spilled over in big cities where segregation in residential areas is driven by caste to a large extent (Sidhwani, 2015).

Occupant density within housing units is another critical factor affecting the experience of heat stress during a heatwave in India. While the National Building Code of India provides guidelines for the design of buildings to ensure adequate space and ventilation to promote thermal comfort for occupants (Bhatia et al., 2016), individuals living in overcrowded housing units, particularly in urban slums, are at a higher risk of heat stress during a heatwave (Government of Karnataka, 2023; Nandi & Swain, 2022).

The economic status of the household largely influences the access to resources such as stable electricity and water supply (Dubey et al., 2021). Essential services like water, sanitation, electricity etc determine the vulnerability to heatwaves (Dubey et al., 2021; Nastar, 2020). The availability of cooling devices, such as air conditioners and fans, is limited in many areas of the country, making it difficult for individuals to reduce heat stress during a heatwave (Heyes & Saberian, 2022). As shared by Respondent 3 regarding the lack of electricity in the home of their close relative:

*“they are one of the few houses that do not have electricity at home, I don’t know how they will cope with the heat...they were unable to clear their previous electricity bill so they will just have to live with their situation”* (interview, respondent 3)

## **5.2 Heatwave Adaptation Strategies**

### **5.2.1 Adaptive Strategies at Individual Level**

Adaptation to heatwaves at individual level is influenced by the capacity to afford coping strategies to extreme heat (Heyes & Saberian, 2022). Households with formal building structures and access to stable electricity choose to upgrade and retrofit their homes with air conditioning, coolers, fans, refrigerators etc (Heyes & Saberian, 2022). However, residents of low-income households or informal settlements are unable to afford these measures, and even piped water is scarce (Dubey et al., 2021).

A common strategy to deal with heatwaves is to avoid direct exposure to sunlight and outdoor heat, a luxury that can only be afforded by a small section of the country’s population (Pillai & Dalal, 2023).

Some people do not spend prolonged periods of time exposed to outdoor elements to experience outdoor heat significantly in a way that would change their lifestyle. Reflecting on reduced exposure to outdoor environment, Respondent 1 had this to say-

*“when it’s too hot, I usually don’t go out unless I absolutely need to step out. I think that’s the case with many people these days...even my friends”* (interview, respondent 1)

The option to stay indoors is not afforded to everyone. When asked if they step out during the heat since they are a homemaker, Respondent 3 revealed that their husband was the one that usually goes out:

*“where will I go...it’s him (the husband) that usually goes out. Even yesterday and today he went out because someone called for him...I don’t know how he returned back, you either have to take the bus and walk from the bus stop or an autorickshaw”* (interview, respondent 3)

A rather new, but popular trend to adapt to rising temperatures in the city is to travel to cooler tourist areas and resorts on the outskirts of the city. Bengaluru is well connected to nearby hill-stations like Chikkamagaluru, Ooty, Kodaikanal and other popular tourist destinations in the hilly regions of the Indian peninsula. Individuals with a disposable income and the flexibility to work remotely are lately choosing to stay on extended vacations to avoid peak heatwave days. (Saxena, 2021)

### **5.2.2 Adaptive Strategies at City Level and Their Challenges**

Strategies at the city level juggle between adaptation to climate change and to the negative impacts of urbanisation. Karnataka State Heatwave Action Plan (KSHAP) attempts to tackle the increasing threat of heatwaves in the state by deploying short, medium and long-term actions. These are described in the following table:

Table 2: Action plans of KSHAP

Vision	Actions
Short-term action plan	<ul style="list-style-type: none"> <li>i. creating awareness on heat-related issues, temporary kiosks for shelter and water distribution</li> <li>ii. change the timings of services like schools, offices and outdoor markets to adapt to peak heat hours</li> </ul>
Medium-term action plan	<ul style="list-style-type: none"> <li>i. install LED display boards to disseminate weather data</li> </ul>

	<ul style="list-style-type: none"> <li>ii. development of the state Energy Conservation Building Code (ECBC) and green buildings</li> <li>iii. accurate measurement of temperatures and identification of heat hotspots</li> <li>iv. develop zonal Heatwave Action Plans (HAP) for the different cities in Karnataka to ensure effective implementation of the strategies (</li> </ul>
Long-term action plan	<ul style="list-style-type: none"> <li>i. capacity building and sensitising children and local communities on heatwave management</li> <li>ii. Investments in forecast systems and equipment are planned</li> <li>iii. with annual improvisation of HAP based on data collection and feedback</li> <li>iv. collaborative input from academia, centres of excellence and dedicated research centres</li> </ul>

Source: (Government of Karnataka, 2023).

City-wide employment of strategies for heatwave adaptation can also include establishing directives for building construction with green building principles like increased green cover, adequate spacing between buildings, building insulation, adequate ventilation, energy efficiency measures etc. (He, 2019; Kleerekoper et al., 2012). Further, cities can implement urban heat island mitigation strategies such as reducing concrete pavements by using open-grid design or pavement with natural materials (Gago et al., 2013; Mohajerani et al., 2017). Urban development strategies also promote the planning of neighbourhoods by preserving natural green cover, well-spaced buildings to prevent heat trapping (Corburn, 2009; Kleerekoper et al., 2012).

There is an acknowledgement of the need for collaborative action against heatwaves in the KSHAP. Bengaluru has a wide network of civic bodies, some of which have overlapping functions : (Government of Karnataka, n.d.-a; Idiculla, 2020). Appendix I provides a list of the local civic bodies and their functions. The need for improved collaboration between state and non-state stakeholders is resonated by members of think tanks and NGOs in the city, but there is a need for robust engagement mechanisms that can be sustained over a long period of time (Bengaluru Sustainability Forum, n.d.). This sentiment was resonated by Respondent 4, when they spoke of present state of affairs in the city-

*“There is not a lot of collaboration between the government bodies and academia or think tanks...organisations like Bengaluru Sustainability Forum are a really nice initiative that can bridge some of the gaps in collaboration between governance and academia”* (interview, respondent 4)

In order to ensure effective implementation, adaptation policies need to be tuned to address the needs of the region at a local level (IPCC, 2022c). The needs of the city may not always align with the needs of the state (Pillai & Dalal, 2023). Karnataka is home to cities of drastically different sizes, at different levels of economic growth (Government of Karnataka, 2022). Bengaluru is unique in its composition as an international hub for technology (Govind & Ramesh, 2019; Verma et al., 2017). The state’s HAP does not fully represent the vulnerabilities of wage gap, exposure to risk, population density, outdoor labour, overburdened infrastructure, and other key deficiencies in the city. A simple example of this can be found in the language barriers in the city- Kannada is the official language of the state and many policies and memorandums are circulated in Kannada. The state HAP explicitly mentions that heatwave knowledge and awareness campaigns through TV, newspapers etc. will be disseminated in Kannada (Government of Karnataka, 2023, pp. 32, 38). However, the city is home to many formal and informal migrant workers from different parts of the country (and the world) who speak a multitude of languages (Summa Linguae, 2021). Migrants in the city do not always pick up the native language of Kannada, and informal migrant workers especially face challenges due to language barriers (Marchang, 2021). Thus, the state HAP is rendered insufficient to tackle the effects of heatwaves in a city as complicated as Bengaluru. Megacities like Bengaluru require a more detailed and nuanced approach for effective use of HAPs (Pillai & Dalal, 2023).

Adapting to extreme heat in densely packed cities requires innovative building design and sound urban planning to mitigate urban heat island effect. Comfort in buildings can be improved by active cooling through mechanical ventilation, air conditioning or standalone coolers. These measures are energy-intensive and account for 45%-55% of the building’s energy use (Bureau of Energy Efficiency, n.d.; Kimemia et al., 2020).

Increased use of energy for cooling poses a danger of maladaptation, adding another layer of complexity to the issue of adaptation (Revi et al., 2014). An urgent matter in Indian cities is the optimal use and sufficiency of fundamental resources in order to ensure equitable distribution among all residents. One of the most insecure resources is energy consumption through electricity in buildings. Since building air conditioning removes heat from the interiors and emits it to the atmosphere via the outdoor units, extensive use of this system feeds into the rising outdoor air temperature, thus

requiring higher demand for cooling. This positive reinforcing loop causes an uncontrollable demand for energy, especially in densely packed urban areas (Revi et al., 2014). Many parts of Bengaluru are unable to keep up with increased electricity demand in the summer and therefore Bengaluru Electricity Supply Company Ltd. (BESCOM) often resorts to decreasing energy load through power cuts, colloquially known as 'load-shedding'. Load shedding is a rather reactive response to energy demand that cannot be sustained over a long period of time.

The need for a sustainable solution to meeting the rising energy demand in the country has engendered the inception of nation-wide initiatives such as the Energy Conservation Building Code (ECBC) by the Bureau of Energy Efficiency (BEE), under the Ministry of Power. ECBC is envisioned as an energy code that can complement the existing state building codes (Bureau of Energy Efficiency, n.d.; KREDL, 2022). By promoting active and passive energy savings, the code aims to provide adequate comfort to building users while promoting efficient use of energy.

Passive cooling can be achieved through traditional ecological knowledge or green building techniques such as solar reflecting roofs, green roofs, well-ventilated atriums, insulation of building shell, nature-based materials or integrated building design (Kimemia et al., 2020). Methods for UHIE mitigation include installing rooftop vegetation or coating of special paints with high solar reflective capacity (Kleerekoper et al., 2012). Rooftop UHIE mitigation techniques have been proven to reduce the indoor temperatures by 2-3°C (Kleerekoper et al., 2012). However, installation of these passive cooling techniques in has not been achieved in all parts of the city, and informal settlements particularly lack pre-existing conditions to accept these measures (Government of Karnataka, 2023; Sidhwani, 2015).

### **5.3 Gaps And Challenges Of Climate Change Adaptation**

#### ***5.3.1 Gaps in Implementing Climate Change Adaptation in Bengaluru***

Deficiencies in implementation of urban development are a challenge for effective implementation of climate change adaptation policies (Revi, 2008). Bengaluru has a few instances where these gaps have come to the forefront, discussed below.

Bengaluru was indicted as one of India's 100 Smart Cities after its Smart City Proposal was approved in 2017 by the Ministry of Housing and Urban Affairs (MoHUA) (Government of Karnataka, 2018). The vision for the city includes Citizen & Stakeholder Focus and Environmental Responsibility; however, the Smart Cities dashboard maintained by the MoHUA shows that no tenders have been issued for any project so far and no funds have been mobilised for the city (Ministry of Housing and Urban Affairs, n.d.).



The haphazard growth and business-first mindset has resulted the city to grow beyond its municipal capacity (Sudhira., 2008). Bengaluru Development Authority (BDA) is tasked with creating the city's master plan for the city under the Karnataka Town and Country Planning Act 1961 (BDA, 2017). The Draft Master Plan for Bengaluru 2031 was published in 2017, with the guiding principles of streamlined governance, mobility, inclusive growth and ecological sustainability (BDA, 2017). However, this draft was subject to criticism from multiple stakeholders and citizens' forums which led to the plan being withdrawn in 2020 (Deccan Herald, 2020, 2021; The Hindu, 2020; The New Indian Express, 2021)

Sundaresan & John, 2020 conducted interviews with the members of the Revised Master Plan for Bengaluru 2031 (Draft) (BDA, 2017). The findings revealed major gaps in the current infrastructure that must be addressed before the plans for new development can be realised. One interviewee commented "We talk all these big things, but we don't even have proper footpath to walk on in Bengaluru. The current master plan can't make any difference to people's lives. These scenarios [proposed in the draft] are useless" (Sundaresan & John, 2020, p. 150).

Although the planning commission invited participation from residents and civil society organisations, the grievances are not considered seriously. The account of an advisor to the committee talks about their surprise that the clause for participation was even accepted in the final draft. An excerpt from the interview reveals "...That is when I realised that the participation clause suggested in the draft guidelines we submitted to government has gone through—I never expected it would. It is a miracle—either the officer who finally approved it overlooked or didn't take it serious [sic]. (Interview with planning advisor, December 2019)" (Sundaresan & John, 2020, p. 147).

The representative of a prominent slum residents' collective shared their reluctance to attending the participatory meetings by saying "What is the point of going- no response will be there- we won't get any respect, they won't allow us to speak. The master plan is in English—everyone speaks English. They will call all but will only listen to certain people and will only listen to what they want to hear. This is just box ticking ... namesake consultation ... [to] make a report. That is all. (Interview with activist collective, September 2019)" (Sundaresan & John, 2020, p. 149).

Attention to climate change in India has been slow; urban cities in India have been primarily focused on issues of poverty alleviation, economic and social development challenges (Revi, 2008). Environmental Impact Assessments (EIA) reports in India are criticised for their lack of transparency, verifiability, low participation, and neutrality, among many other objections (Jha-Thakur & Khosravi, 2021). In Bengaluru, a major road widening project spanning over 152km by Karnataka Road

Development Corporation Limited (KRDCL) was proposed without an EIA (Mundoli et al., 2020; Nagendra, 2020). An extensive field survey conducted by Mundoli et al., 2020 found systematic irregularities with the number of trees proposed to be cut for project. The field survey estimated a much higher number of trees that would need to be cut for the proposed route than what was communicated by KRDCL.

The draft Bengaluru Master Plan 2031 was rejected by one of the consultants for its lack of serious consideration of the environmental aspects of the plan. The interviewee revealed their disinterest by remarking: “We kept green belt [land use zone in the master plan] because there is ‘Green Bengaluru’ activist bunch ... as if green belt [in the plan] will ensure we have fresh air ... there is in reality no green belt. Activists associate green in the map with [actual] green in real [on ground]. If we changed it, they would say [that it will cause] ‘sprawl’, ‘air pollution’ etc. The authorities love keeping green belt because if we changed the green belt regulation, then they can’t do the conversion of land use (legal procedure involving heavy bribes; Interview with planning team member, September 2019)” (Sundaresan & John, 2020, p. 150).

This limited understanding of the importance of the environment, especially mature green cover was resonated by respondent 4. When asked if environmental concern and the ecological values are represented in urban development in the city they replied:

*“not that much. Because everything gets swept under green spaces...it’s more in terms of aesthetic. The point of view that large trees are irreplaceable in terms of carbon stock, cooling, shade and so on, is not yet well articulated”* (interview, respondent 4)

In view of these gaps, the implementation of climate change adaptation in urban cities lack targeted work at municipal government level (Singh et al., 2021). A review of existing actions on climate change adaptation in India notes that “many highly vulnerable megacities, notably, coastal Mumbai and Kolkata, and semi-arid Delhi and Bangalore, report negligible planned adaptation, which is far removed from the evidence of these cities being highly vulnerable to climate change” (Singh et al., 2021, p. 16)

### **5.3.2 Challenges of Implementing Climate Change Adaptation**

Implementation of climate change adaptation is layered with complexities and nuances of socio-economic vulnerabilities in India (Kundu, 2020; Revi, 2008). Indian policymaking operates at the levels of national, state and city-level governments; the national Five-Year Plans serve as guiding policies

that are extended by the state and city entities (Kundu, 2020). However these policies are not fully realised for a multitude of reasons or pre-existing developmental gaps that need to be addressed before effective implementation of climate change adaptation (Khan et al., 2018; NITI Aayog, 2021). Some of these challenges are explored in this section with the caveat that many more layers exist, requiring a future detailed study.

### ***Knowledge gaps***

India is an ancient culture but a relatively young republic nation. It possesses deep traditional ecological knowledge on many subjects, including weather-based lifestyles and ecologically-conscious vernacular architecture that has passed on building construction techniques from generation to generation (Chandel et al., 2016; Gupta, 2017). However, modern and urban architecture has not retained much of this knowledge in a bid to follow “modern architecture” techniques that are often mismatched with the climatic conditions of the region (Gupta, 2017; Zhai & Previtali, 2010). The emerging need for building guides that are in tune with the climatic conditions of the region and provide optimal indoor comfort is a gap that is only partly addressed by national and Karnataka state building codes (Gupta, 2017).

Another barrier to effective adaptation strategies exists in the realm of reliable and updated data on key decision-making parameters like population, land use, extreme events, spatial and temporal data of the country (Banerjee & Chattopadhyay, 2020; Natar, 2020). Census data is collected every ten years, and the latest census data available in the country is from the year 2011. The next planned census is set to take place in October 2023, due to delays caused by Covid-19 (Census by Government of India, 2011; Census Commissioner, India, n.d.). This has hindered many researchers and policymakers in making accurate recommendations, causing them to either rely on outdated data, extrapolated data or data provided by third-party organisations and international organisations like UN, SEDAC etc. (Dubey et al., 2021). The term “urban” itself needs to be well defined to suit the Indian context and large population. As per NITI Aayog, 2021, there are around 8000 towns that are counted as ‘urban’ and possess urban characteristics but are still governed administratively as rural areas because they have not been awarded the urban status yet. Thus, there is also “an emerging need to assess whether these parameters are able to reflect the extent of urbanisation in the country realistically for appropriate policy making and interventions” (NITI Aayog, 2021, p. 79). Further, there is a lack of reliable and updated information on climate measurements, socio-economic indicators of development and statistical data on urbanisation in the public domain. As expressed by Respondent 4-

*“there is no repository of essential spatial and temporal data that can be accessed easily by the public...at IIHS we are attempting to create useful data sets and maps through our own fieldwork. There is a lot that needs to be done but we hope our work is useful for other researchers and decision-makers”* (interview, respondent 4)

### ***Availability of Resources and Capacity***

There is a need for widespread capacity building for sustainable urban planning. As noted by NITI Aayog, 2021, there is a glaring inadequacy in state level town-planning professionals. There is a requirement of over 12000 town planners across the country, and it is reported that only 4000 positions have been sanctioned (NITI Aayog, 2021). Further, knowledge gaps are deepened by the absence of subject experts and there is a need for capacity building for effective policymaking (Revi, 2008; Upadhyaya et al., 2021).

Adaptation has received lesser attention than mitigation even though early actions adaptation are considered prudent measures that would reduce the climate burden (Sathaye et al., 2006). India faces an additional challenge of lack of adequate resources and funding for climate change adaptation (Prasad & Sud, 2019). Although the National Adaptation Fund on Climate Change (NAFCC) has mobilised some resources for adaptation, the implementation faced the hurdle of relevant financial, technical and capacity support from states (Prasad & Sud, 2019).

### ***Housing Conditions***

India has one of the highest numbers of slum dwellers in the world, with an estimated 65 million people in 2011; over 18.78 million households face a shortage of dwelling caused by poverty or congestion in urban areas (Government of India, 2012). Informal housing units often lack adequate ventilation or capacity for retrofitting of cooling equipment, exposing the residents to extremely uncomfortable indoor environment during peak heatwave days (Banerjee & Chattopadhyay, 2020). Even in the formal housing sector, low-income housing units are constrained in their ability to provide passive cooling or active cooling that would be sufficient to provide comfortable indoor conditions (Banerjee & Chattopadhyay, 2020).

### ***Energy Sufficiency and Efficiency***

India has developed by leaps and bounds over the last three decades in the sphere of technology and digitalisation. Cooling technology in the urban built environment primarily relies on air-conditioning units that are either centralised for commercial spaces or individual units in the residential sector

(Rawal et al., 2022). In the last decade, many more households mostly belonging to the middle-class have invested in air-conditioning which has increased the energy demand significantly (Rawal et al., 2022). This is a concerning trend, as increased energy demands lead to issues of higher greenhouse gas emissions, overburdening of the energy production system and inequal distribution, among other interlinked issues (Revi et al., 2014). In poorer households the lack of access to stable, uninterrupted electricity and water supply is a significant challenge to maintain household and individual cooling (Krishna et al., 2014).

When considering pathways for sustainable development, the fundamental argument that must be revisited is an overall reduction in consumption of resources. Efforts of delivering stable electricity to vulnerable groups must be complemented by conscious use of energy and resources. At COP27 in November 2022, the delegation of the Indian Ministry of Environment, Forest and Climate Change made a statement that presented India's vision of "Lifestyle for Environment, LiFE"; it emphasises the need for "paradigm shift from mindless and destructive consumption to mindful and deliberate utilization" (PIB, 2022). The government has launched programmes such as the Bureau of Energy Efficiency's Energy Conservation Building Code (ECBC) (BUREAU OF ENERGY EFFICIENCY, 2017), the Indo-Swiss Building Energy Efficiency Programme (Ministry of Power, n.d.), Bijli Bachao Campaign (literally translated to mean "Save Electricity") (PMO India, 2014) and others. However, these campaigns and programmes operate at the national level, and they lack the granularity that is needed for the diverse states in the country. The ECBC code is aimed to be incorporated in the building code of several state governments in the country, but since its kick-off, the code has only been formally applied in Karnataka for commercial buildings (KREDL, n.d.). The gap for energy efficiency in residential buildings needs to be addressed to pre-empt maladaptation due to high energy demand for cooling in residential buildings (Revi et al., 2014).

### ***Lack of Collaboration and Coordination***

Karnataka state government is divided into 42 departments, overseeing different functions. Some of which are relevant to this study are the Department Of Forest Environment And Ecology, Department Of Health And Family Welfare, Department Of Housing, Department Of Urban Development etc. (Government of Karnataka, n.d.-a). These departments often work in silos as there are no established platforms for collaboration on overlapping matters (Benjamin, 2010; Unnikrishnan & Nagendra, 2020).

Local civic bodies in the city perform functions stipulated by the 12th Schedule to the Constitution and are primarily accountable to the state government (Government of Karnataka, n.d.-a). However, they do not have locally elected representatives from the city, which means that these organisations are

not directly accountable to the residents of Bengaluru (Idiculla, 2020). Additionally, the Agenda for Bengaluru Infrastructure Development (ABIDe) Task Force, while not a statutory authority, has directive influence on many infrastructure matters in the city (Idiculla, 2020; NewsDesk, 2020).

The complex jurisdictional overlaps and the absence of clear accountability is a challenge to identify which civic agency is responsible for which task. This adds to the complexity of effective implementation of policy in the city and causes acute delays in the realisation of climate change adaptation. (R. D'Souza & Nagendra, 2011)

## **6. DISCUSSION : Why are these challenges persistent?**

This section deals with the fourth research question of why some challenges of implementing climate change adaptation persist in Bengaluru. This question is primarily explored through the lens of CUT to unpack the existing and compounded inequalities in urban areas. As mentioned earlier, CUT provides a multitude of tools for study; the three main themes of discussion are neoliberal urban policies, gentrification, and postcolonialism.

### **6.1 Neoliberal Urban Policies**

Profit-based urbanisation has emphasised neoliberal models of development in the recent years (Brenner, 2009); Neoliberalism, “has in recent years been extended to cities around the world competing for global capital investment, through a set of measures which range from the formation of public–private partnerships, the promotion of urban megaprojects, to the segregation and displacement of poor sectors of the urban population.” (Crossa, 2020, p. 365). Joy & Vogel, 2021 provide a critical understanding of the failures of the neoliberal agenda in urban cities. They highlight issues of inequality, unaffordable housing, climate disasters etc. that are omnipresent because of the way neoliberal planning promotes municipal governments to prioritise the needs of private sector entities. This is resonated in a study of the process of urban planning in Bengaluru where the authors posit that “urban planning in India has been characterised by modes of selective participation that only accommodate elite and middle-class interests” (Sundaresan & John, 2020, p. 143).

Karnataka is set to attract investors from across the world for projects across various sectors with its platforms like ‘Global Investors Meet- Invest Karnataka’ with a focus on ‘Brand Bengaluru’ for talent and technology (Business Standard, 2022; PMO Govt. of India, 2022). Bengaluru is an interesting case study where economic development has taken precedence over social development or environmental protection (Ramachandra & Aithal, 2016).

Owing to the influx of technological talent and industrial entrepreneurship, Bengaluru has emerged as a technological hub in the recent years; this has attracted capital investment from multinational corporations that have had a strong influence in the urban development of the city (Sudhira., 2008). For example, the neighbourhoods with large-scale technology parks like Whitefield, Electronic City etc. have been developed almost entirely around the incoming MNCs (Sudhira., 2008).

Citizen accounts and local newspapers provide the juxtaposition of what Whitefield used to be versus what it is currently. V. D’Souza, n.d.; Rajangam, n.d. share their experiences of growing up in the area in the late 1990s when Whitefield was considered a fringe settlement on the outskirts of Bengaluru

city. They now lament the drastic changes in the neighbourhood owing to the establishment of IT parks, high-rise buildings and large shopping malls. The development of IT-friendly areas by private enterprises has emphasised neoliberal characteristics of wealth accumulation, relaxation of regulations, and disinvestment in social infrastructure for the benefit of the public good (Kavilkar, 2018). An example of this in Bengaluru is the development of a special flyover that exclusively benefits the employees of Embassy Technology Park and Manyata Technology Park in Nagawara (Asianet News, n.d.; Deccan Herald, 2022; India Today, n.d.)

## **6.2 Gentrification in Bengaluru**

Bengaluru was once reputed as a quaint and sleepy retirement town for pensioners (Bangalore Mirror, n.d.; Dutta, 2006). Interestingly, the neighbouring town of Mysuru (colloquially called Mysore) was the state's capital city and a historical seat of power for the Wadayar dynasty and Bengaluru was considered a secondary city (Nagendra, 2016). The beginning of the IT revolution propelled the city towards a radical change, as it gained traction as a global hub and world city (Sudhira., 2008).

One of the impacts of gentrification is the increased rent or cost of property in a neighbourhood (Brenner, 2009). This has been the case in Bengaluru as well, which can be noted in the neighbourhoods of the city (Chava et al., 2019; Mishra, 2022). The cost of property has increased manifold over the years with the incoming of elite residents, upcoming luxury apartments and MNC offices in the city (Chava et al., 2019). The effect of gentrification in one neighbourhood can also be an influential factor on the surrounding neighbourhoods (Crosby, 2020). With rising property costs, the risk of generational residents being displaced into lower-quality neighbourhoods or informal settlements rises, (Brenner, 2009; Harvey, 2019) making them vulnerable to heatwaves.

The study by Chava et al., 2019 in Bengaluru to identify impacts of gentrification in the city compare the rent, rent burden, vehicle ownership, and related parameters. The study tracks the transformation of the neighbourhood of Yeshwanthpur, which was historically a working-class neighbourhood that is now home to many high-rise condominiums. The results of the study compares the differences in socio-economic characteristics between old-build and new-build housing residents; the mean rent differs between INR 3307 for old-build and INR 29,153 for the new build; further, the rent burden between the two groups differs at 16% and 28% respectively.

The arrival of multi-national corporations invited skilled migrants to the city, sharply increasing the average income and consequentially, the standard of living among the residents (Benjamin, 2010; Chava et al., 2019). Gentrification also impacts the cost of living in cities, where newly redeveloped



neighbourhoods tend to have a higher cost of living (Crosby, 2020). Bengaluru is comprised of well-paid young professionals in the IT sector (Sudhira., 2008; Thomas & Thomas, 2020). A study conducted to assess the spending habits of IT professionals in the city showed that on average the respondents spent 43% of their monthly income on lifestyle choices influenced by the society around them (Thomas & Thomas, 2020). Increased living costs arising from lifestyle choices leaves families with a smaller budget for large investments, in this case, room coolers or air conditioners. As resonated by Respondent 2-

*“I already have a lot of expenses and I have been spending a lot of money lately...I will have to wait for a while before buying anything.”* (interview, respondent 2)

Gentrification leads to the displacement of poor residents, often without any option for secure or comfortable housing elsewhere (Chava et al., 2019; Harvey, 2019). Decent housing is of importance for vulnerable groups to adapt to climate change, and displacement lowers their capacity to cope with extreme events such as heatwaves (Revi et al., 2014). Gentrification traps groups that are already economically disadvantaged into cycles of further deficiencies by engendering increased rent and influencing lifestyle choices of residents (Harvey, 2019).

### **6.3 Postcolonialism**

Bengaluru has a deep colonial history as it was considered to be a quaint and mild-weathered town suitable for British inhabitants (Nagendra, 2016; Ramachandra & Aithal, 2016). The British era development of the city saw investments in rejuvenating lakes, increasing the green cover, and expansion of the tree-lined road network in the city which influenced its identity as a ‘garden city’ (Nagendra, 2016). But this development was reserved for the British officials, and was made inaccessible to the native population (Ranganathan, 2018). Accounts of the city from colonial researchers reveal the way the city was segregated spatially as “civil and military station” and “native *bazaar* [market] or *pettah* [locality]” (Ranganathan, 2018, p. 1391). *Pettahs* received little or no government funding for development, and were described as unsanitary localities with narrow streets that were littered with filth (Ranganathan, 2018).

The city has inherited some good and some problematic characteristics from its colonial period (Nagendra, 2016; Ranganathan, 2015). Like the rest of the country, Bengaluru is still unlearning lessons from its colonial past but unfortunately some of the legislation is still influenced by the British era laws (Unnikrishnan et al., 2021). Through the apparatus of legislation and infrastructure, post-colonial development in urban areas has retained the privileges and vulnerabilities among many groups of

population (Ranganathan, 2018). This is resonated in the continued discrimination and systemic disadvantages faced by minorities and socio-economically weaker sections even throughout the years of urban “improvement” (Ranganathan, 2015). The caste system was formalised into a bureaucratic tool of division by the British and the effects of this are persistent even in the 21<sup>st</sup> century (Desai & Dubey, 2012). Historically, the caste system was a deciding factor on the type of employment a person could carry out; upper-caste Hindus like Brahmins and landlords were allowed to stay indoors while lower-caste workers were bonded by labour and were expected to carry out tasks outdoors (Desai & Dubey, 2012; Ranganathan, 2018). These discriminations have been intrinsically embedded in Indian society even in this century, executive-level jobs are held by the elite upper-caste while outdoor workers like construction labour, delivery services, street hawkers, city cleaners etc. typically belong to lower castes (Desai & Dubey, 2012).

The current landscape of the city is a mix between its colonial remnants and the phase of profit-facing development at the turn of the century (Ranganathan, 2018). This difference can be experienced if one visits the relatively older neighbourhoods of Richmond town, where most houses are built in the style of the colonial bungalow; on the other hand, newer areas like Whitefield, Electronic City or Marathahalli are dotted with high-rise buildings and office spaces for IT corporations (Housing News, n.d.; Mohan, n.d.). At the same time, much of the *pettah* area still stands on narrow streets, closely packed buildings and overpopulated households which lack basic municipal services (Ranganathan, 2018).

Another problematic aspect of colonial influence in India is the focus modern architectural design techniques and ignorance of vernacular knowledge of construction . High-rise concrete structures with glass façades and reduced porosity of pavements dot the skyline of Bengaluru. Unfortunately, many of these buildings are unsuited for tropical climates and do not account for natural ventilation to provide optimal indoor environments. (Gupta, 2017; Ranganathan, 2018; Zhai & Previtali, 2010)

A combination of these drivers has created vast inequalities in the city that must be addressed before climate change adaptation can be implemented in a manner that leaves no one behind.

## 7. Conclusion

My thesis is an attempt to explore the way residents in Bengaluru experience and adapt to heatwaves. Further, I have discussed a few of the persistent challenges that hinder effective implementation of climate change adaptation policies in the city. I have used critical urban theory to explore the drivers of inequality in the city and their omnipresence in climate change adaptation. This section presents some key takeaways from the study, how it situates in the larger picture of sustainability science, and the possibilities for future research on the topic.

There is a noticeable difference in the way residents with different socio-economic backgrounds experience heatwaves. The city is diverse in its type of employment; some skilled professionals have the option to work remotely and avoid exposure to direct heat by relying on on-demand delivery services for daily necessities. Further, the type of housing and economic capacity influences the ability to cope with extreme heat. Where on one hand residents from wealthy, well-planned neighbourhoods tend to have limited exposure to direct heat and have access to basic necessities of electricity and water to cope with extreme heat. In contrast, some households in poorer neighbourhoods or informal settlements bear the extreme heat with few or no options for alleviation of heat stress. Direct heat is further compounded in these neighbourhoods by urban heat island effect, poor ventilation, or poorly planned housing layouts. Lack of basic infrastructure like electricity and water further inhibits adaptive capacity to heatwaves.

I also explore some adaptive strategies at city level and the challenges of their equitable implementation. Karnataka's State Heatwave Action Plan (KSHAP) intends to assess the vulnerability of the state's population to heatwaves but does not outline targeted actions for different socio-economic groups. Bengaluru does not have a specialised heat action plan for the city to address the compounding of heatwaves and negative impacts of urbanisation. The probability of maladaptation to heatwaves by energy-intensive cooling mechanisms is high, as most households resort to using air-conditioners or space coolers to cope with the heat. The state-owned entity responsible for electricity distribution in the city is unable to meet the energy demand, resulting in widespread power outages. In order to improve indoor thermal comfort, passive cooling techniques and lessons from vernacular architecture are promoted to some extent. However, their applicability and benefits for low-income and informal settlements are not fully realised due to gaps in existing infrastructure.

The challenge of implementing climate change adaptation in India is layered with socio-economic vulnerabilities, pre-existing developmental gaps, lack of capacity and effective administrative tools for effective collaboration. There is also a lack of reliable and updated data on key decision-making

parameters like population, land use, statistics on extreme events, spatial and temporal data of the city. India needs widespread capacity building for sustainable urban planning. Adaptation has received less attention than mitigation, and there is a lack of adequate resources and funding for climate change adaptation.

Some of the challenges for effective implementation of climate change are rooted in persistent developmental issues. The topics of neoliberalism, gentrification and postcolonialism are explored in the study through the lens of critical urban theory. The influx of multinational corporations (MNCs) and information technology (IT) firms in the city has encouraged neoliberal urban policies. Privatisation of land use for housing and technology parks has rendered much of the urban development to prioritise economic profit over social improvement and environmental protection. MNCs in the city have attracted highly skilled migrants with significantly higher income than native residents which has led to trends of gentrification of neighbourhoods across the city. Postcolonial development in the city has retained many of the power structures and hierarchies established during the British occupancy of the country. This has alienated residents from key decision-making portals and perpetuated the disadvantages faced by communities along the lines of religion, caste, socio-economic class, and key markers of identity.

This thesis is an attempt to add to the understanding of experiences, knowledge, and challenges of climate change of the global south in sustainability science. By applying well established theories that question the pathways of urban development, I hope to highlight the critical deficiencies in Bengaluru. There are deep challenges that must be addressed while also coping with increased frequency of extreme events to ensure adaptation to climate change in way that is meaningful and equitable for all. This thesis is only the beginning in the journey of studying the wide range of challenges and inequalities in urban Indian cities. There is scope for future research to bring detailed accounts and experiences from a wider audience to represent the diversities of urban population in the city. Nuances of gender, religion, caste, generational privileges, and other important factors must be studied in depth to provide a holistic understanding of how the urban Indian citizen copes with extreme events.

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## Appendix I: Civic Bodies in Bengaluru and their functions

Organisation	Functions	Functional Overlap
Bangalore Development Authority (BDA)	Responsible for land use zoning, regulation and planning of land, providing sites, creating urban infrastructure and improving urban environment	A function of BBMP under the Constitution which is also partly carried out by BMRDA and Agenda for Bengaluru Infrastructure Development (ABIDe)
Bangalore Metropolitan Region Development Authority (BMRDA)	Responsible for planning, coordinating, and supervising the orderly development of land in the larger Bangalore Metropolitan Region	A Municipal Corporation function mainly carried by BDA in city limits
Lake Development Authority (LDA)	responsible for protection, conservation, reclamation, restoration, regeneration, and integrated development of lakes in the BMRDA jurisdiction	
Karnataka Urban Infrastructure Development and Finance Corporation (KUIDFC)	Provides assistance for urban agencies in planning, financing, and providing expertise to develop urban infrastructure	A Municipal Corporation function: similar tasks also carried out by ABIDe
Karnataka Slum Clearance Board (KSCB)	Performs rehabilitation of all declared slum areas in the city	A Municipal Corporation function also performed by BDA and BBMP
Public Works Department (PWD)	construction and maintenance of buildings for most of the Karnataka government departments and Public	Builds housing for economically weaker sections, similar tasks to KSCB

	undertakings and maintenance of road works	
Bangalore Water Supply and Sewerage Board (BWSSB)	Responsible for the pumping and distribution of drinking water, sewerage collection, water and wastewater treatment and disposal	A Municipal Corporation function: some aspects like wastewater disposal also carried out by BBMP
Bangalore Electricity Supply Company Limited (BESCOM)	the agency responsible for power distribution in the city.	
Bangalore Metro Rail Corporation Limited (BMRCL)	responsible for the metro rail based public transport system.	
Bangalore International Airport Area Planning Authority (BIAAPA)	vested with the sanctioning of land-use of the area around the new Bengaluru International Airport.	

Source: (Government of Karnataka, n.d.-a; Idiculla, 2020)