The Urban Island Heat Effect in Islamabad: Climate Change Impacts on the Informal Economy and Workforce

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Islamabad, 2025

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Acknowledgement

This study was accomplished through the assistance of certain, significant people who guided and motivated me throughout the progression of this study. My utmost gratitude is given to them and the time they provided to help me broaden my intellect and perceptions as I went over my write down process. My parents and sisters who always support me may it be financially, morally, or in spirit from the time I started conducting the study until I completed it. That support helped me remain steadfast as much as my abilities allowed me to. I would also like to commend them for the endless patience and insight they provide regardless of the time or setting. My professor as well as my supervisor, Dr. Majid Hussain, through his guidance and constant encouragement drawing out my ideas and skills and helping me shape them. My panel of examiners; Dr. Zartashia Anwar and Dr. Abdul Rasheed who offered me insights as well as taught me across my semesters added on to the help I required whilst learning how to write my ideas. My childhood friends who have always kept me determined and offering distractions when needed to help me maintain my mental composure when encountering multiple challenges at once. I would also like to thank Mr. Qadeer Ahmed, who took out time from his work as an uber driver to help me navigate the sector, which would've been harder if I was doing it on my own. And foremost, to the All-hearing and All-knowing; the Almighty God, who keeps me steadfast and resolute. Who bestowed me with the strength to accomplish this research.

Abstract

Urban heat is an increasingly critical but unevenly experienced consequence of rapid urbanization and climate change, particularly in cities of the Global South. This study examines how the Urban Heat Island (UHI) effect shapes livelihood vulnerability among informal workers in Islamabad, Pakistan. Despite being a planned city, Islamabad has experienced intensified thermal stress due to land-use change, expansion of impervious surfaces, and growing climatic variability. The research investigates how these environmental conditions intersect with socioeconomic precarity to affect work, health, and adaptive capacity within the informal economy.

The study adopts a qualitative research design, drawing on in-depth semi-structured interviews, participant observation, and field notes collected from informal workers in the G-9 sector, including street vendors, daily wage laborers, construction workers, and service providers. To contextualize lived experiences, remotely sensed climate data from Google Earth Engine; MODIS, and Copernicus datasets were used to characterize land surface temperature, air temperature, humidity, wind speed, and cloud cover during the period of fieldwork. This environmental data was used for contextualization and triangulation rather than as a standalone analytical method.

Findings show that UHI-related heat and weather variability compound existing vulnerabilities by disrupting income generation, reducing productivity, damaging perishable assets, and intensifying health risks. Limited access to healthcare, absence of formal labor protections, and regulatory harassment further constrains adaptive capacity of these workers. Coping strategies are predominantly informal and short-term, relying on social networks, borrowing, improvised heat mitigation, and spiritual resilience. Integrating Urban Metabolism and Vulnerability theories, the study demonstrates how urban environmental processes translate into unequal social and economic outcomes. The findings highlight the need for climate-responsive urban planning and inclusive adaptation policies that address the specific risks faced by informal workers in rapidly urbanizing cities.

Keywords: Urban Heat Island; Informal Economy; Climate Vulnerability; Urban Metabolism; Pakistan

Chapter No 1.

Introduction

1.1 Background

Across the period of civilization climate change has led to numerous ecological transformations and mass extinctions. The most notorious one heuristically identified by scientific research as the ‘Great Dying’. It caused a multitude of species to die as a result of greenhouse gas emissions from global warming on the surface level (Wallace-Wells, 2019). This was the first recorded catastrophic event attributable to climate change. While these events occurred long before the prevalence of human civilization, the current era of anthropogenic climate change poses more complex and unprecedented dilemmas to the ecosystem and human societies, concurrently. Some of them include ‘Urban Heat Islands’ (UHI), unregulated resource consumption, housing insecurities, lack of access to adequate social services and basic necessities.

Unlike past climate events, the technological advancements of the 21st century have significantly accelerated climate change and it's primarily driven by the mass consumption of fossil fuels (Sati, 2015), production of non-biodegradable goods (Datta et al., 2024), and the depletion of natural resources (Choudhary et al., 2024), all of which contribute to a rapid rise in global temperatures; and despite the additional carbon dioxide adding to the atmosphere; irreversible processes are already in motion due to the cumulative impact of previous greenhouse gas emissions. The main purpose of this study is to assess the impact these environmental processes have on the urban centres, and how these the respective changes cause challenges regarding productivity levels, change in working conditions and aggravation of health issues of the daily wage workers.

1.1.1 Rapid Urbanization and Urban City Centres

Human deprecation of the ecosystem stems from inherent biological traits and unabating need for expansion and exploration, or "madness gene" (Kolbert, 2014). And this tendency has sufficiently led to the development of a planned metropolis like Islamabad. However, the unregulated population growth of the city has started to surpass the capacity of its available resources and places a significant strain on it. In addition to this, the lack of nuanced research on the spatial arrangement and designing of infrastructure correlation with the rate of carbon emissions is insufficient (Stokes & Seto, 2016).This is the reason why mitigation strategies lack; due to the limited discussion on initial prevention.

Several informal settlements gradually form when a city experiences urban growth. This is a result of rural urban migration when the rural region starts to have less sufficient resources comparatively to urban centres. However, these settlements are far from a satisfactory living environment due to lack of access to basic services such as water supply, sanitation and infrastructure as well as electricity (While & Whitehead, 2013). These marginalized communities are more susceptible to climate variability such as flood, heat waves and poor air quality. In the case of Islamabad only the latter two.

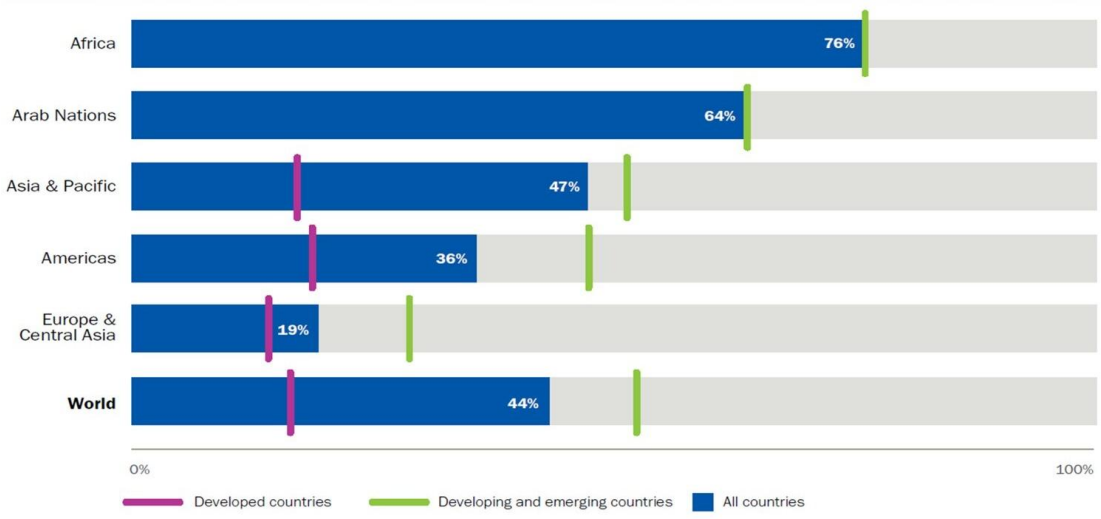
When there is such fast paced economic growth, it leads to increase in the income gap and urbanization plays a key role in shaping these social imbalances. It is also notable that the population of urban centres are too large to be able to meet the quota of the available resources provided by the city. Which inevitably leads to these imbalances. However, sustainable development is always there to prevent such a cul-de-sac (dead end). It can be achieved through large investments, integration of green based technologies, and strict implementation of efficient policy reforms. This will help promote low carbon emissions and climate resilient infrastructures (Auwalu & Bello, 2023).

This section primarily discusses the negative impacts of urbanization and its trickle-down effect on the inhabitants, particularly focusing on informal labourers of the city. The detrimental effects include job insecurity, minimal and inconsistent wages,

including the lack of access to social protections and benefits (Auwalu & Bello, 2023). Informal workers often face exploitation, poor working conditions, and limited opportunities due to their vulnerabilities. The increasing cost of living in urban areas exacerbates their vulnerabilities further. This section also explores certain measures that can help mitigate these consequences, fostering a more equitable urban environment.

1.1.2 Rapid Urbanization and Climate Change

Rapid urbanization has created an arena for economic growth, technological innovations and has turned society into a cultural melting pot. It has created urban centres that promote innovation and attract investment and growth. It still has its repercussions such as increased energy consumption, increasing transportation demands and industrial activities (Ali et al., 2024). More and more land is being replaced with roads built with concrete and asphalt (Imam,2025); these heat absorbing materials are causing a rise in temperature on the ground contributing to UHI and causing urban centres to have a higher index in comparison to rural areas around the cities.



Notes: South Asia has a higher rate of informal employment than Africa: 78 percent. Because South Asia is grouped with more developed countries in Asia and the Pacific Islands in the chart, this fact is not visible.
Source: ILO, 2018.

Figure 1.1 Informality and the climate change-poverty nexus

Urbanization presents a complex trade off; it causes economic growth but at the expense of the environment's degradation. Additionally, it accounts to 70% of the carbon emissions on a global scale (James, 2024). Newly built roads increase accessibility of transportation concurrently increasing the onset of a big number of vehicles leading to increased traffic, industrial activities, and construction. These have been recorded as the leading cause of air pollutants in urban centres (Transportation Research Board, 2002). Air pollution is also commonly found in bustling cities as compared to rural regions. Urban growth also puts a strain on local water supplies due to increased demand for drinking water, water for sanitation processes, and water for agricultural processes. This also leads to contamination of water from pollutants collected through urban surfaces, and mismanagement of waste from industrial activities (Smith et al., 2023). Noise pollution, stemming from industrial activities, vehicles, and technology, has compelled native wildlife to migrate to less active regions. This exodus poses a threat to the urban ecosystem and endangers species that are native to the area (Ware et al., 2015). This section of the literature examines the effects of rapid urbanization on cities, particularly focusing on its implications for informal and daily wage labourers. Furthermore, it intends to explore how urbanization influences climate patterns through the depletion of natural resources and the impact on various consumers, with a specific emphasis on the vulnerabilities of the workforce most affected by these changes.

1.1.3 Climate Change and Informal Economies

According to a global survey, Pakistan is identified as a developing economy (World Bank,2025). It has the 5th largest population in the world; approximately 256 million citizens (Worldometer, 2025). The economy is situated in crippling inflation (around 38%), large informal economy (above 80%) and increasing youth unemployment (approx. 30%) (Fairwork, 2023)

The capital city of Pakistan is Islamabad; it is also known as Islamabad Capital Territory (ICT), a city known for its planned infrastructure, green spaces, and geographical location. The city covers a total surface area of 906.5 km² (World Population Review, 2025). The population is now estimated to be more than 2.3 million according to census (CP, 2023). Established in the 1960s (O'Donnell, 2025), ICT was

specifically chosen to be the capital due to its strategic location and relative security compared to other major cities. This means that it is a pre-planned city. In spite of this, with the changing climate and increasing population it is also found to fall short on certain pre-emptive measures crucial for the increasing vulnerabilities of the citizens. The city is characterized by its dense green areas and is surrounded by the Margalla Hills, contributing to a relatively mild climate compared to other regions of the state.

Despite it, like many urban areas, the capital territory also faces challenges related to climate change, including rising temperatures, erratic rainfall patterns, and increased incidence of extreme weather events (Khan & Fee, 2014). These changes are placing pressure on the urban infrastructure and the natural environment, leading to water scarcity and elevated air pollution levels such as smog occurrences. The informal economy is a significant part of Pakistan's economy, estimated to be around 59% of GDP (Pakistan Economic Survey, 2025). However, there is limited data available when it comes informal workers; more than half of the GDP's source is unestablished due to the dismissal of this segment of the population.

On a broader scale, Pakistan is highly vulnerable to climate change due to its geographical diversity and reliance on agriculture, which is susceptible to shifts in climate patterns. Additionally, it being situated near the equator and one of the highly susceptible climate zones leads to often experiences of severe floods, droughts, and heatwaves, impacting food security and livelihoods. This has caused the struggle of irregular work patterns, delays in projects, inadequate policy reforms, and has increased the number of people falling below the poverty line (World Bank Group, 2022).

The informal economy is a significant aspect of Pakistan's overall economic landscape, particularly in urban areas like Islamabad. Many residents, especially those migrating from rural areas, engage in informal work due to a lack of access to formal employment opportunities and basic services (Naz & Khan, 2021). Informal workers often lack job security, social protections, and access to essential services such as healthcare, which exacerbates their vulnerability to climate-related risks further. This section focuses on the current situation of the city which has made it more susceptible to climate impact and natural disasters, which is observed to be potentially detrimental to the workforce operating in the city.

1.1.4 UHI Effect and Its Widespread Impact

UHI effect is widely recognized as a heat accumulation phenomenon, which is the most noticeable characteristic of urban climate caused by urban construction and human activities (Oke, 1973). It is caused mainly by the retention of solar heat in the fabric of buildings and ground surfaces, and the obstruction and re-absorption of night-time outgoing longwave radiation by buildings which obstruct the sky view (Parker, 2010). It is also due to reduced evapotranspiration from less vegetation, the urban geometry trapping heat, waste heat from human activities, and altered wind patterns.

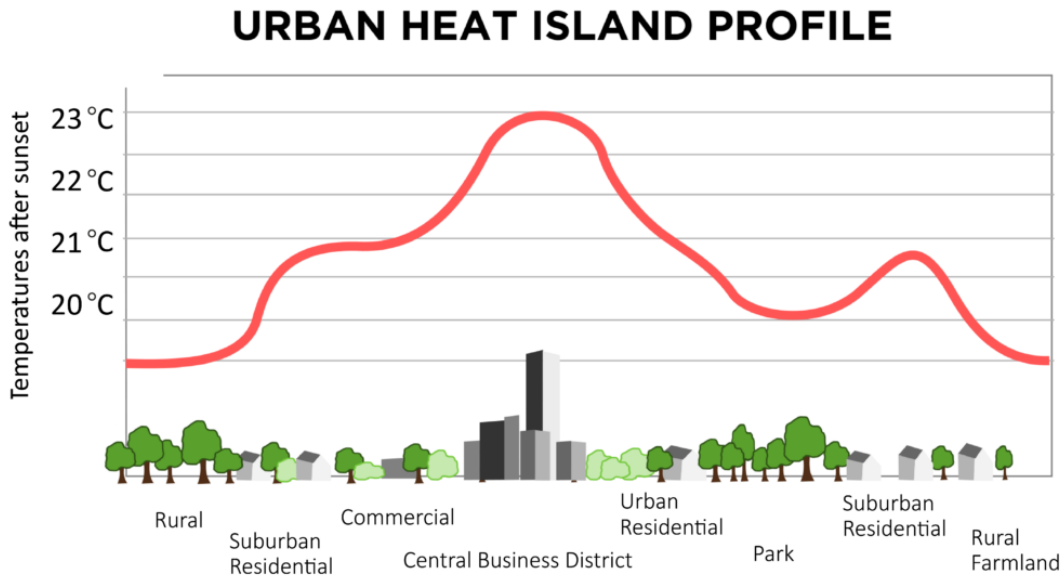


Figure 1.2 UHI Effect relative to districts

The increase of land surface temperature caused by UHI effect influences material flow and energy flow in urban ecological systems, as well as alter their structure and functions, exerting a series of ecological and environmental effects on urban climates, reduce water quality, depletion of soil properties, atmospheric environment, biological habits, material cycles, energy metabolism and citizens' health (L. Yang et al., 2016).

Islamabad, the capital territory, faces similar challenges as any other urban city centre. Studies conducted by (ESCAP, 2025) indicated that the rapid urbanization and land-use changes in the city over the past few decades have contributed to the intensification of the UHI effect. The conversion of agricultural land, forests, and barren land into built-up areas with impervious surfaces has led to increased heat absorption and

retention. The loss of green spaces and the increase in impervious surfaces are identified as key factors contributing to the rising land surface temperatures in Islamabad. Lack of management and logistics as well as economic challenges have further exasperated the climate crises. The capital is a beneficiary of these systemic discrepancies. This section sheds light on the UHI effect in the capital, examining its impact on various aspects of the city. It emphasizes how the UHI effect significantly influences daily employment opportunities for vulnerable populations.

1.1.5 Informal Workforce and Its Challenges

Informal labour workforce includes individuals that are not registered or regulated under existing regulatory frameworks. They are most commonly part of developing economies. Due to their involvement with informal firms, they suffer from unstable wages, unpredictable work days, more vulnerability to inflation and other economic fluctuations in a country's economic conditions, due to their lack of existence in government databases they are also not able to access social safety nets. Against a global average of 11.2%, Pakistan spends just under 2% of its GDP on social protection (ESCAP, 2025). Unfortunately, Pakistan still faces pending issues with human development. The country currently ranks 141 out of 174 countries on the Human Capital Index (HCI), with a score of 41 out of 100 (World Bank Group, 2022).

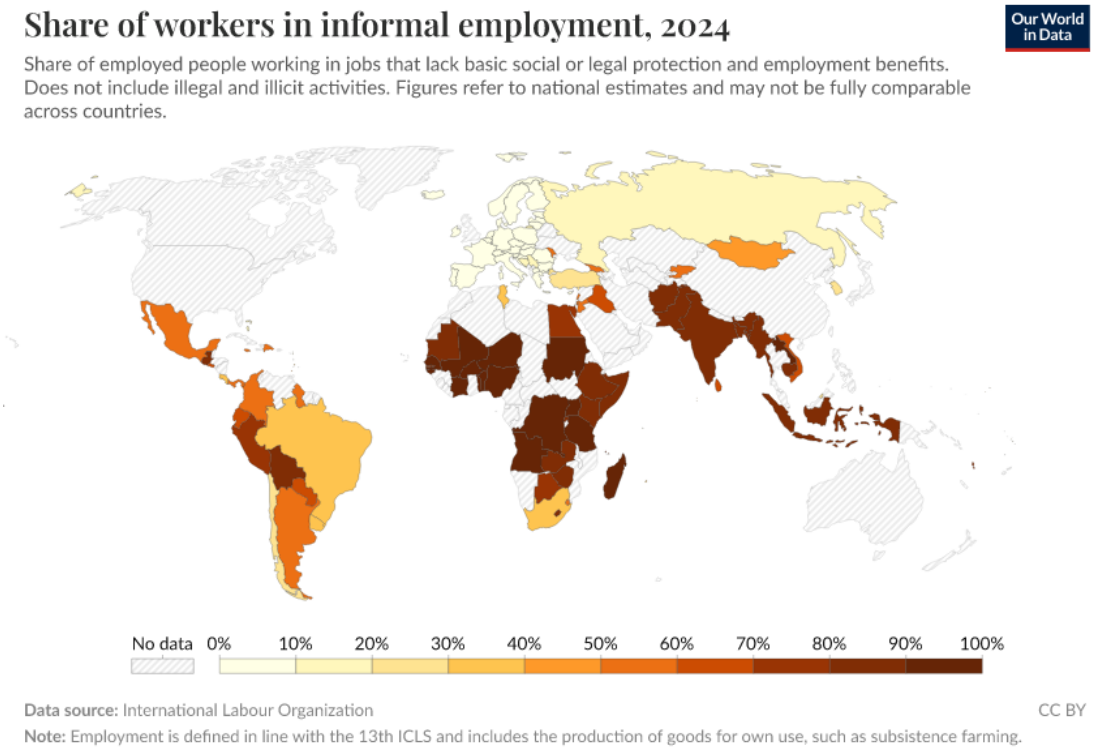


Figure 1.3. Informal Employment as of 2024

Informal sector workers that function on a daily wage structure such as construction workers, are directly exposed to the materials and conditions that contribute to climate change. To mitigate this issue, it is essential to equip them with the skills needed for responsible resource management and reuse. Despite advancements in technology, these grassroots workers who handle critical tasks will remain indispensable.

Sustainable development hinges on supporting them through social safety nets that protect their rights and well-being. Given their high vulnerability and direct encounters with climate change, empowering these workers is crucial for building resilience against environmental challenges.

1.1.6 Impact of UHI on the informal Workforce

It is observed that the drastic changes in the climate patterns are increasing in the Federal Capital Territory more rapidly than before. These include alarming frequent earthquakes in progressively smaller time gaps from the previous one, unpredictable

temperature changes, and natural disasters such as the recently recorded lightning strikes and hailstorms. These events have caused significant damage to property, agriculture, infrastructure including loss of life. This has also led to a large portion of the state's capital being invested in restoration of its after-effects and compensation for the property damaged. According to a survey, Pakistan has been a victim of 13 earthquakes in the past 365 days (Earthquake Track, 2025).

However, the biggest stakeholders of the setbacks from these events are the most vulnerable communities of the city. These include all individuals that live in informally established communities; delivery boys, passengers of daily public transport such as metro bus and vans, street vendors, construction workers that sit in several sectors and beggars. Thes are all the people that stay outside for majority of their day. Most of them do not have access to a stable and well protected, as well as, insulated safe space for that period. This leaves them completely exposed to the incoming calamities.

This encourages a discussion of lack of safety centres in the city such as minimum number of bus stalls; the lack of sitting areas that are required for individuals to take a break from the heat, intense sunlight, rainfalls or in extreme conditions; protection from hail that can cause life-threatening injuries. Furthermore, the increasing number of highways, motorways and flyovers completely isolate the individuals that cannot afford vehicles or even public transport. Even the practice of crossing a road for these pedestrians has turned into a strenuous activity. This is robbing certain citizens from access to different public areas as they won’t be able to reach it; it is not acquirable through walking or cycling which is the preferred and only option for these individuals in most cases.

This is a violation of their fundamental rights to exist within the society and what it offers. In addition to all that, the biggest setback is their inability to earn a significant income to run their households as a big portion of it is being used for the daily travel expenses. This further exacerbates their chances of overcoming financial hardship and achieving a higher standard of living. These interrelated risks could also set the stage for major societal disruptions, including the displacement of people and greater pressure on the city that will be unprepared for the influx of displaced migrants on top of the ones they currently host (Mueller et al., 2014). This section discusses the

overlapping and interconnected issues that cause hindrances for the informal workers to earn income and live a safe and adequate standard of life within the city premises.

1.2 Problem Statement

The Urban Heat Island (UHI) effect in Islamabad poses significant risks to the city's informal economy and workforce, particularly affecting the livelihoods of informal workers who often lack access to resources and social protections. With fluctuations in weather patterns attributed to urban heating and lack of social safety measures available; these workers, who play a crucial role in maintaining urban functionality, face depletion in productivity levels, increased health risks and reduced economic opportunities and income generation. This study aims to examine the intersection of UHI effects with the assistance of a structure of causality (cause and effect) through recorded weather patterns and changes in heating (cause); whilst simultaneously observing the varying vulnerabilities of informal workers (effect) for a focused, time-bound examination of Islamabad's informal workforce.

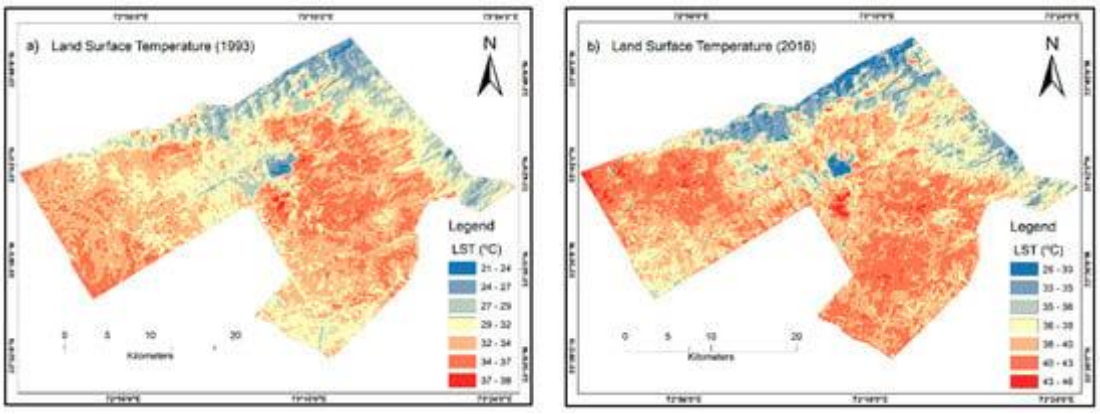


Figure 1.4 Land surface temperature (LST) for Islamabad in (a) 1993 and (b) 2018.

1.3 Research Objectives

1. To assess the economic consequences of UHI regarding the productivity of informal workers.

2. To explore the coping mechanisms and adaptive strategies employed by informal workers in response to the fluctuations in weather and heating.

1.4 Research Questions

1. How does the UHI effect influence the productivity, health and working conditions of informal workers in Islamabad?

2. What coping mechanisms do informal workers use to manage the challenges posed by UHI, particularly in relation to the weather and heat patterns?

Chapter No 2.

Theoretical Framework

To examine the formation of the Urban Heat Island (UHI) effect through urbanization and resource consumption, this study integrates ***Urban Metabolism theory***. This analysis will then explore the disproportionate impact of UHI-related environmental stressors on Islamabad's informal workforce. To achieve a comprehensive understanding of this disparity, the study will apply ***Vulnerability theory***, leveraging its principles for clarity.

2.1 Urban Metabolism Theory

Urban metabolism refers to the processes of material resource transformation in cities, often analysed through flows within urban systems (Saguin, 2019). According to Saguin's work, this concept has been central in addressing the environmental changes in relation to urban subtexts. It utilizes mathematical models to understand 'resources consumed and trace material' energy flows' in a closed urban system. Most of these findings originate from industrial ecology, which views urban metabolism through a biological standpoint as it sees material and energy flows of urban systems like living organisms. Urban consumption is more than exchange of good and services as it goes further and helps bring insight on the symbolic use of space and experiences of its inhabitants that defines an urban lifestyle (Güllü & Çakir Kiasif, 2025).

The Vienna school, a subfield, connects socioeconomic changes with urban material flows. Common methodologies include mass-balance accounting, while newer tools like *life cycle analysis* and *ecological footprint* assessments are emerging. Urban ecology offers a similar perspective but critiques the industrial ecology framework for being overly simplistic. Some defined urban ecology as "the study of the relationship between people and their urban environment" – which is essentially human ecology of the city (Park,1926). Cities are no longer perceived and presented as wasteland and deserts of biodiversity, or, as nature *deficit* space (Casanelles-Abella & Egerer, 2025).

Hence, it is crucial to study the urban spaces as a modern ecosystem of its own making; or man-made to be precise. To conclude, integrating various approaches to urban metabolism is essential for addressing urban sustainability challenges effectively, it cannot be an isolated concept.

Urban Metabolism consists of several schools, of which, a key one is *Industrial Ecology* which employs the use of UM as an analytical tool. It seeks to quantify consumption and production in the form of material and energy flows in an urban system. According to the National Society for Industrial Ecology ; "The idea is first to understand how the industrial system works, how it is regulated, and its interaction with the biosphere; then, on the basis of what we know about ecosystems, to determine how it could be restructured to make it compatible with the way natural ecosystems function"(Newell & Cousins, 2015). Furthermore, the term *Planetary urbanization* refers to the idea that urbanization has expanded beyond cities in itself and deeply transforms the entire planet due to the shared climate changes, hence, it helps to follow up on understanding political ecologies of urban spaces and the global implications of urban expansion in real time (Brenner & Ghosh, 2022).

The combination of theories helps put emphasis on the complex interplay between urban environments and climate change particularly using urban spaces and what it offers as an urban metabolism. In Islamabad, these dynamics significantly impact the informal workforce, which constitutes a highly vulnerable population. As climate patterns shift, the intensified heat exacerbates the working conditions for informal labourers, who often operate outdoors without adequate protection or resources as they are the direct recipients of the city's spaces and environment. This heightened exposure not only threatens their health but also jeopardizes their livelihoods, as extreme weather can disrupt daily employment opportunities. Furthermore, the concept of urban metabolism highlights how resource flows and socioeconomic factors intersect in urban settings, revealing that the informal workforce often lacks access to the same adaptive resources available to more formal sector employees. Addressing these climate-related challenges through integrated urban sustainability strategies is crucial, ensuring that Islamabad's informal workers are supported and empowered in the face of changing climate patterns. This approach aligns with the need for interdisciplinary solutions that

consider both environmental and social dimensions not just material produced items, fostering resilience for one of the city's most at-risk populations.

2.2 Vulnerability Theory

Vulnerability theory understands human beings as embodied creatures who are inevitably embedded in social relationships and institutions (Grear & Fineman, 2014). According to legal scholar Martha Fineman who helped pioneer the ideology since 2008 in both social sciences and as a macro- legal political theory, the acknowledgment of the lived complexity of the 'vulnerable legal subject' that is a political vision of how the human condition is profoundly shaped by an inherent and constant state of vulnerability across the life-course from birth until death..

Vulnerability theory takes seriously the political and legal implications of the fact that human beings live within a fragile materiality (Fineman, 2025). We are, all of us, inarguably vulnerable. Sometimes, this vulnerability is realized in the form of dependency on others for care, cooperation, or assistance and sometimes in our dependency on social arrangements, such as the family or the market or economy not as an individual defect or limitation. Vulnerability can be assessed reasonably precisely for a specific group of people living and working at a specific time and place, and the 'unsafe conditions' that contribute to it (Blaikie et al., 2014). Human beings are not considered vulnerable because they have certain characteristics or are at various stages in their lives but because they experience the world with differing levels of '*resilience'*. The inequality of resilience is at the heart of vulnerability theory because it turns our attention to society and social institutions. No one is born resilient. Rather, resilience is produced within and through institutions and relationships that confer privilege and power. Those institutions and relationships, whether deemed public or private, are at least partially defined and reinforced by law.

Vulnerability Theory highlights that all individuals exist within social relationships that shape their resilience. For informal workers in Islamabad, this means their inherent vulnerability is exacerbated by systemic inequalities and environmental challenges, such as the UHI effect.

By integrating these theories, we can better understand how social structures influence resilience and understand how it effects equitable resource access and capabilities as well as decision-making power of the most vulnerable group of people in urban centres which in this study is Islamabad's informal workforce.

2.1.1 Operationalization of Theories

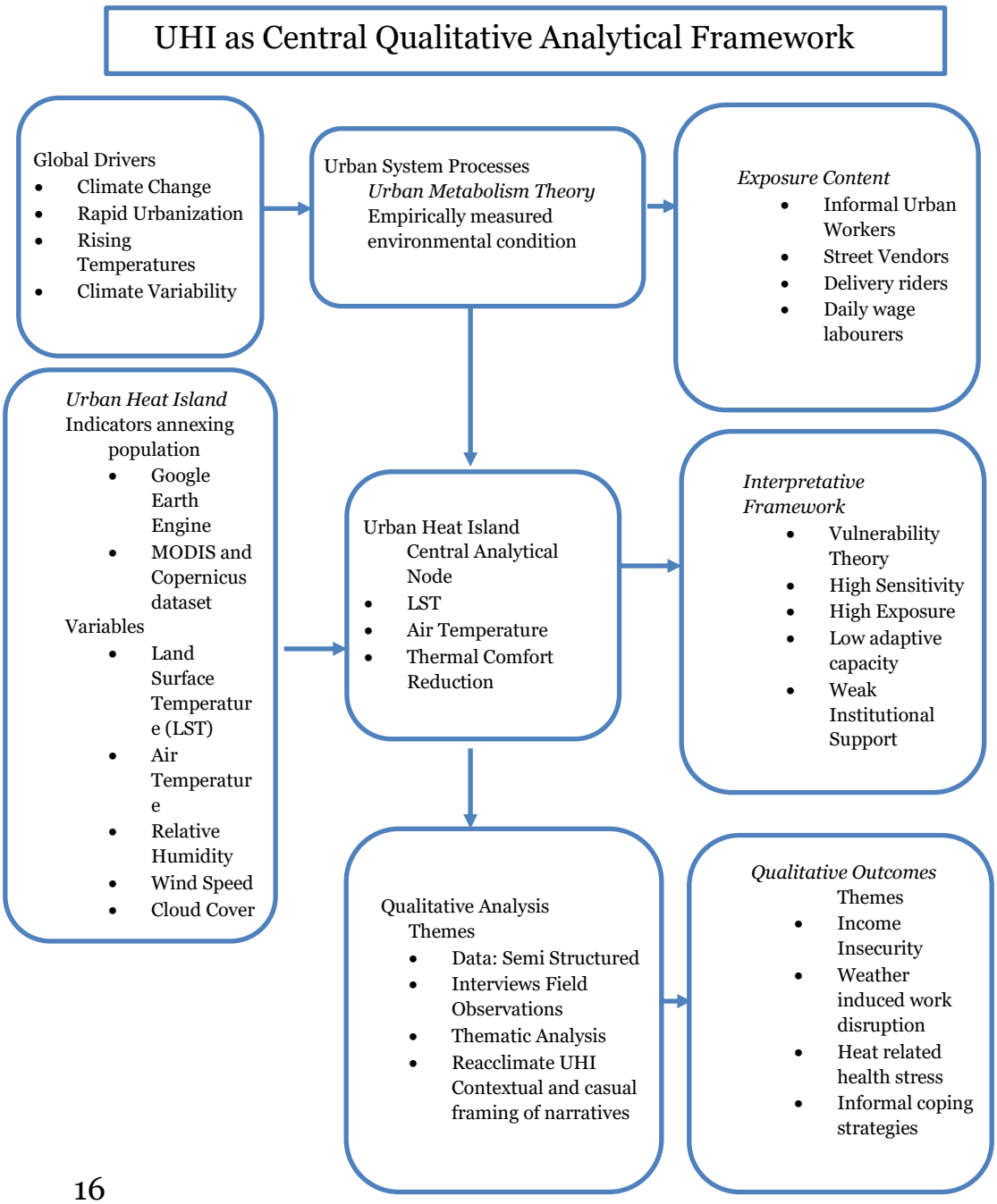
This theoretical framework was put to use in investigating how the processes and flows within the urban system impacts the informal workforce and tests their resilience that is perceived to be due to the cause of unstable income generation, unpredictable weather changes; health concerns as a result of these changes and lack of shelter and refuge available from all these visible and invisible causes of their daily vulnerabilities.

The research began with interviews and observations whilst simultaneously collecting numerical data on the respective weather and heat fluctuations. This helped analyse the impact of environmental, social and institutional factors on the livelihood, health and income security of the informal workers in the G-9 sector. Additionally, it also helped discern the influence of environmental conditions on the day-to-day decisions of the workforce regarding their availability for on-site work (which is the usual predicament for them regardless of their struggles).

Chapter No. 3

Methodology and Area Profile

This methodology section describes the research design, sampling techniques, data collection methods and the data analysis that will help to investigate the impact of fluctuating weather and heating patterns on the city and how this inevitably causes challenges for the informal workforce. Since the study is qualitative, it seeks to provide a subjective perception on the prevalent issue and goes in depth to target the research objectives.



3.1 Study area

As this study focuses exclusively on the capital territory, the data was collected from sectoral sections of the city, primarily areas that are within the sector of G-9 and its segments. These locations were chosen to accommodate the researchers' financial, cultural and physical constraints. Additionally, they represent distinct regions within the city that has an influx of daily wage workers of all genders, and age groups from all places across Pakistan due to the access to a bus station and commercial market area nearby. This ensured diversity in the data and enhancing the accuracy of the findings. This approach provides a comprehensive understanding of the dynamics at play within the capital's sector-based neighbourhoods.

3.1.1 Sampling Technique and Size

The data collection method employed purposive and convenience sampling. This approach was necessary due to the researcher being a full-time student with limited time and resources. The chosen location aligned with the researcher's financial capacity for travel and current understanding of cultural barriers and safety concerns such as the inability of females to visit the locale after a certain time of the day.

The number and categories of respondents were chosen in alliance to purposive sampling relative to the thematic context of the locale within the range of 20 individuals who are informal labourer, daily wage workers, street vendors, construction workers, etc. This was one due to the vast onset of all forms of informal workers that earn their livelihoods on hand to mouth basis daily; the G-9 sector is infamous for such workforce due to it being a commercial area majorly (its residential qualities are overlooked in comparison to its economic appeal). The participants were divided into 3 categories that consist of:

1. Construction workers found on the green beds of the sector (majorly male dominated),

2. Street vendors that travel along the sector with their carts or the one's settles in a significant location such as 'Peshawar Mor',

3. Female vendors (all forms).

3.2 Data collection

The study employed qualitative methods to gather comprehensive data. In-depth interviews were conducted using semi-structured interview questions to explore participants' perspectives in detail. Semi-structured interviews allow flexibility to probe deeper into emerging themes. Additionally, observational methods were used to record behavioural patterns and contextual details in natural, everyday conditions and settings of the individuals. Together, these methods ensured a robust and nuanced data collection process, enhancing the validity and reliability of the findings.

3.2.1 Key Informant

The researcher used purposive sampling to choose the key informant which was the designated driver of researcher. The respective informant was selected due to his familiarity with the city and its designated populations of interest to the researcher. He was also accustomed to the cultural norms of the area due to him being a senior citizen and was of significant help in rapport building with participants due to them being majorly male dominant. However, his work-life balance was respected which led him to be unavailable at times for this task. The researcher reached out to an Indrive service driver who fortunately as a retired policeman and helped with reaching the respective population and offered his own perceptions on the respondents due to his employment period majorly being spent on the roads patrolling the sector.

3.2.2 Participant Observation

Participants were observed in their locale and daily environment in order to record their behavioural patterns and collect key contextual details in their subjective conditions. It also helped build rapport and understand ways to approach and pursue them appropriately. Apart from the informal workers' testimonies, input was also welcomed by their peers and passersby.

This occurred without any significant effort from the researcher apart from urging on the peers to interject the respective participants if needed. This also led the suspicious workers to be more comfortable with the researcher due to the lack of urgency demonstrated in trying to collect all perceptions.

3.2.3 In-depth Interviews

Interviews were conducted with the assistance of semi-structured questions to explore the conditions of the participants and to understand each respondent sufficiently with follow up questions**.** This helped collect first hand experiences of participants who work without a contract and stable income (sometimes none) and experience the continuous, unpredictable weather and temperature changes. Informed consent forms were translated and explained in layman terms to the participants, ensuring they understood what they signed up for.

3.2.3.1 Interview Guide

Questions were separately written and taken in hardcopy to all the interviews in order to recall the sequence of questions and to avoid missing out on any relevant information. Open-ended interviews tend to stray off topic at certain times so a guiding paper in hand keeps the researcher attentive. Relying on printed text helped the researcher keep track of all the objectives to be achieved and have a certain flow to the ongoing conversations with the informal workers and keep them from losing interest in the conversation too. The questions were also kept simple and to the point to minimize chances of potential ambiguities and misinterpretation by the respondent compromising the objective behind the study.

3.2.4 Jotting

Handwritten and scribbled informal notes were recorded in real time to keep track of the interviews in procession and to avoid misplacing or losing crucial details. The main aim is to avoid overlooking relevant material which isn't recorded through audio memos and pictures. If such information is inscribed as underlined key words or small statements, it becomes easier recalling events with accuracy.

3.2.5 Field Notes

Notes of the observations and daily events occurred (if any) were recorded to monitor the on-going process of data collection and sort the data gained. They were developed in the form of daily observations made regarding the objectives, informal discussions and miscellaneous information offered by respondents and their respective peers.

3.2.6 Daily Diary

The research integrates daily journal writing to record a personal take of the events occurred and to have a perspective from the source of the individual responsible for collecting data. This will also help understand any underlying biasness demonstrated by whom the research was collected by.

3.2.7 Audiovisual Methods

In respect with the consent of the respondents, the investigator recorded audio memos of the participants and clicked a picture when applicable. This was strictly done with regards to the comfort level of the participants as they were already on edge due to political instability and fear of their own security and livelihood, especially female participants due to difference in cultural norms and values with the investigator. This made it an extensive and time-consuming exercise, which can be a challenge when it is a matter of work-life balance. In order to ease the process, the audio memos were recorded on the researcher's mobile phone, this helped prevent misplacement of information. Later on, tools such as ATLAS.ti and add-in extensions on MS Word were employed to transcribe and translate and to further ease the configuration of all collected information.

This process is essential to collected first hand experience of individuals who work without a contract basis and experience the continuous, unpredictable weather and temperature changes. Informed consent forms were translated and explained in layman terms to the participants, ensuring they understood what they signed up for. Audio enables more conversational and more expansive onset of information. Furthermore, it builds trust in the researcher and their perception regarding the findings.

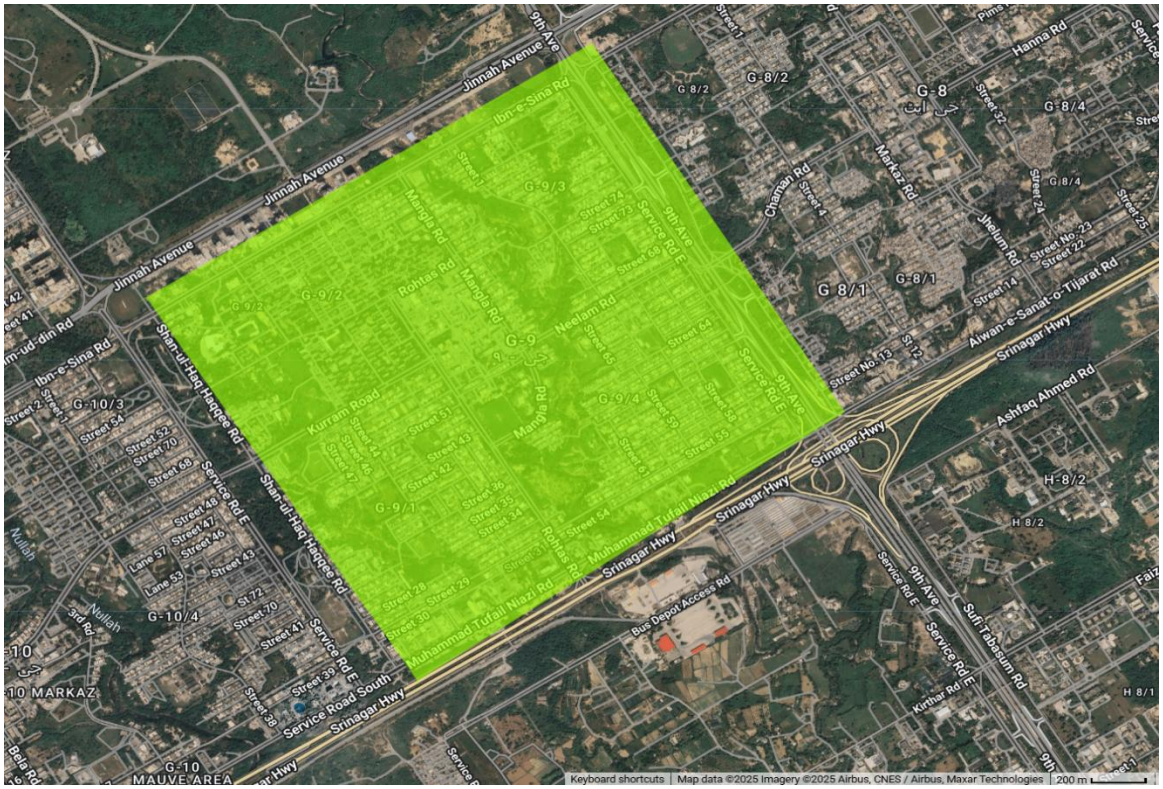
3.2.8 Analytical Walkthrough

Analysis of data included transcribing interviews and organizing field notes, followed by a rigorous coding process where segments of the data were assigned descriptive labels to form a thematic outlook. These initial codes were then grouped into broader categories based on shared concepts and relativity of the participants, eventually leading to the identification of over-arching themes that captured the essence of the participants' experiences under the peak-time heat and exasperation from the lack of stable work opportunities. This process helped form a nuanced understanding of the interplay of financial, cultural and social norms in respect to the UHI effect on these workers as expressed in the data in the latter analysis section.

3.2.9 Use of Geospatial Data for Triangulation and Contextualization relative to In-depth interviews

The following data was collected from the Area of interest (AOI); sector G-9 in Islamabad using remote sensing. The figure shows the location of the sector and the boundaries within which the fluctuation of the following plot graphs was collected using Satellite Imagery with the help of Google Earth Engine and Copernicus Programme; it uses MODIS which is a low earth orbit (LEO) satellite employed for measurement of the radiative energy of the surface or the "skin" temperature of the ground (Yang et al., 2017). The timespan for which it was collected ranges from the 1st of August 2025 till the 30th of September 2025.The range of this two-month period was specifically chosen due to its interlinkage with the duration of the in-depth interviews conducted. This will help align the accuracy of the experiences of the participants in real-time with the help of quantified weather patterns. The time at which data was observed for each day is 2:00 p.m. in the evening as it is the peak time of heating as well as the availability of all the informal workers in the area (GEE, 2025).

Figure 3.1 Satellite view of G-9 Sector

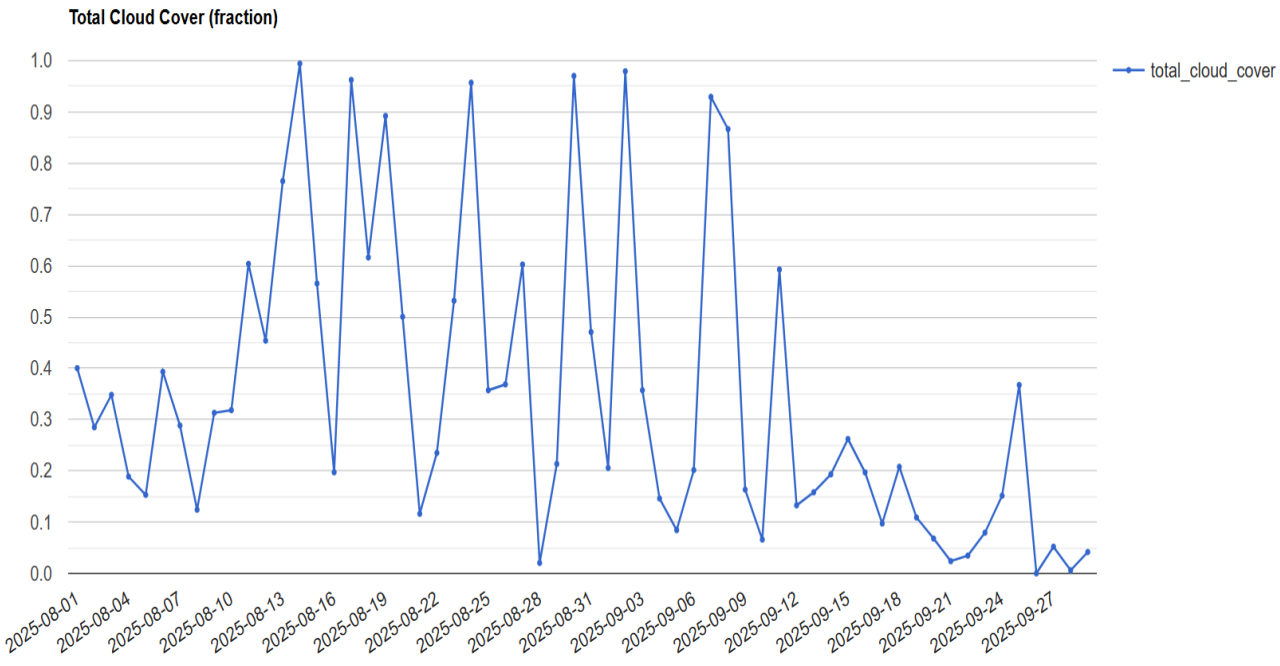


Point (73.02613, 33.68556) at 10m/px, *Longitude: 73.02612601204032,* ***Latitude: 33.68555991209895,*** *Zoom Level: 14,* ***Scale (approx. m/px):9.55462853564703***

3.2.9.1 Total Cloud Cover

The cloud cover fraction line chart is used to show the changes of cloud covering the sky. This helps better understand the environment in which the informal workers sit and look for work on open roads without any shelter or covering.

Figure 3.2



The chart shows numerous days with nearly 100% cloud cover. These occurred prominently around August 15th, August 23rd, August 30th, and September 4th.These days would be overcast, dim, and likely cooler, potentially signalling periods of heavy rain or poor light for work. The worker may need rain protection or alternative lighting. There are also many days where the cloud cover drops near **0.0 or 0.1**. These include days around August 12th, August 25th, September 6th, and September 21st.These days would be bright, sunny, and potentially very hot, especially if the day is dry. The worker would need to protect themselves from intense direct sunlight and heat. The chart exhibits extreme day-to-day changes. For instance, cloud cover often jumps from near 0.1 to 1.0 (clear to completely overcast) in just one or two days (e.g., between September 2nd and September 4th).

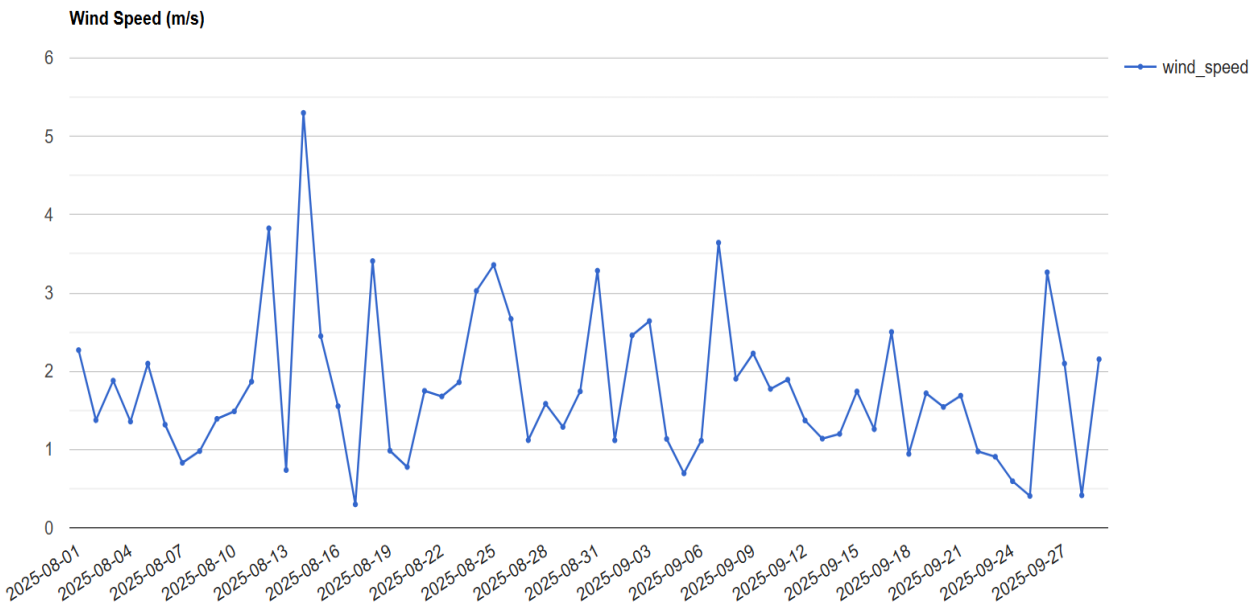
The weather is highly unpredictable without access to forecasts. An informal worker must be prepared for a wide range of conditions *daily*, making planning difficult. While August shows frequent, sharp peaks reaching 1.0, the latter half of September (after the 15th) shows a general trend toward **lower cloud cover and fewer peaks** above 0.6, suggesting a transition to potentially drier or clearer weather, although the low cover on September 25th is followed by a slight increase again.

To conclude this the chart depicts a period of highly **unstable weather** with constant shifts between full cloud cover and clear skies, which translates to a challenging environment for an informal worker dependent on predictable conditions.

3.2.9.2 Total Wind Speed

The graph is a line chart that plots the **wind speed** data point for each recorded day, allowing for a clear visualization of how the wind speed fluctuated over the two-month period.

Figure 3.3



The **x**-axis is labelled with specific dates, showing the progression from early August to late September. The **y**- axis represents the measured **Wind Speed** in **m/s**. The scale ranges from 0 to 6 m/s, indicating the intensity of the wind on any given day.

The blue line connects the daily data points, highlighting the **variability** of the wind speed. The data shows that the wind speed is highly **unpredictable** and changes significantly from one day to the next, with no clear long-term upward or downward

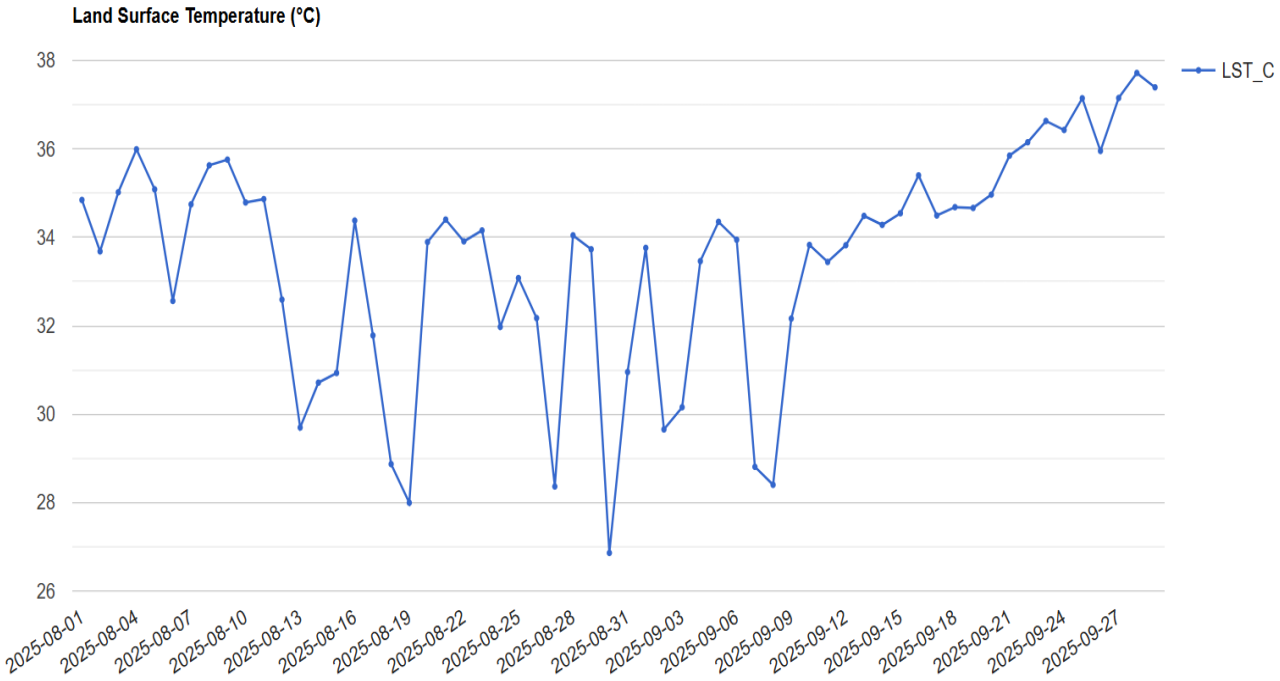
trend across the entire period specially for an informal worker who does not have access to the forecasts of these weather changes.

The key observations here include he maximum recorded wind speed, which is the **peak** of the chart, occurred around **August 15th-16th, 2025**, reaching a value slightly above **5 m/s**. There are multiple instances where the wind speed dropped very close to **0 m/s**, indicating periods of near-still air. The most prominent dips are seen around **August 19th** and **September 25th**.The first half of the data, primarily **August**, shows very **high volatility** (large, rapid changes) with several sharp peaks and valleys, including the overall maximum. Generally, the wind speeds in **September** appear to be **less intense** than in August, with most peaks remaining below **3.5 m/s**. The fluctuations are still present but the overall range of speeds seems narrower after the start of September.

3.2.9.3 Land Surface Temperature

This chart displays the daily **Land Surface Temperature (LST)** measured in **degrees Celsius** over the same period as the previous charts, running from August 1, 2025, to September 28, 2025. This data is critically important for an informal worker, as high temperatures directly affect working capacity, safety, and the preservation of health, while low temperatures might necessitate different preparation as most of their working hours are spent under the direct sun without any shelters.

Figure 3.4



The graph is a continuous line chart plotting the daily LST, allowing for a clear visual assessment of the temperature dynamics over the two-month span. The horizontal X-axis clearly shows the progression of dates, starting in early August and concluding in late September. The vertical Y-axis represents the Land Surface Temperature, with a scale ranging from 26C to 38C covering a significant range of warm to hot conditions. The blue line, labelled 'LST_C', connects the recorded daily temperature points, highlighting the extreme variability and key temperature events throughout the period.

The temperature data exhibits several distinct features and trends that would be highly impactful for an informal worker. The maximum recorded LST approaches 38^ C, occurring toward the end of the data period around September 25th-27th. These days would represent dangerously hot conditions, requiring maximum precautions against heat stroke, especially for those working outdoors. Conversely, the minimum temperature recorded is significantly lower, dropping to approximately 27^C on August 29th-30th, with other notable low points around August 17th (near 28^ C and

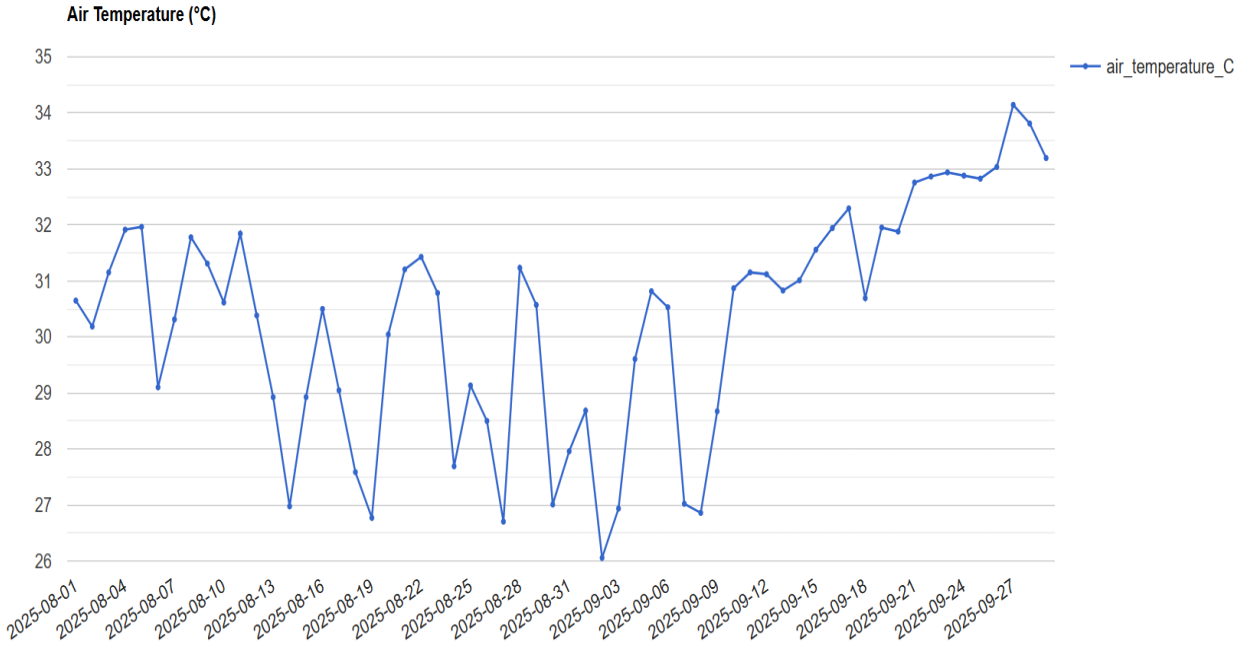
September 8th-9th (near 28^ C). These drastic dips indicate abrupt cooling periods, possibly due to weather events like strong winds or heavy cloud cover and rain, creating a highly variable and unpredictable thermal environment.

A key pattern observed is the difference in temperature stability between the two months. August shows numerous sharp peaks and valleys, particularly the severe drops around August 17th and August 30th, indicating high daily thermal volatility. In contrast, the second half of the data, primarily September (after the 10th), shows a sustained upward trend, with the temperature generally staying above 34^C and reaching the peak high points. This suggests that the second half of September transitioned into a period of more consistently high, intense heat compared to the erratic but often cooler periods seen in August. For an informal worker, this means that while August required readiness for rapid temperature swings, late September demanded continuous adaptation to extreme heat.

3.2.9.4 Air Temperature

This chart displays the daily Air Temperature measured in degrees Celsius from August 1, 2025, to September 28, 2025. This metric is the most direct measure of the thermal environment and is essential for an informal worker to gauge daily comfort, hydration needs, and physical stress levels.

Figure 3.5



The chart is a line graph illustrating the progression of air temperature over the two-month period The X-axis tracks the dates, while the Y-axis provides the temperature scale, ranging approximately from 26 degrees Celsius to 34 degrees Celsius. The blue line shows the highly dynamic nature of the daily air temperature.

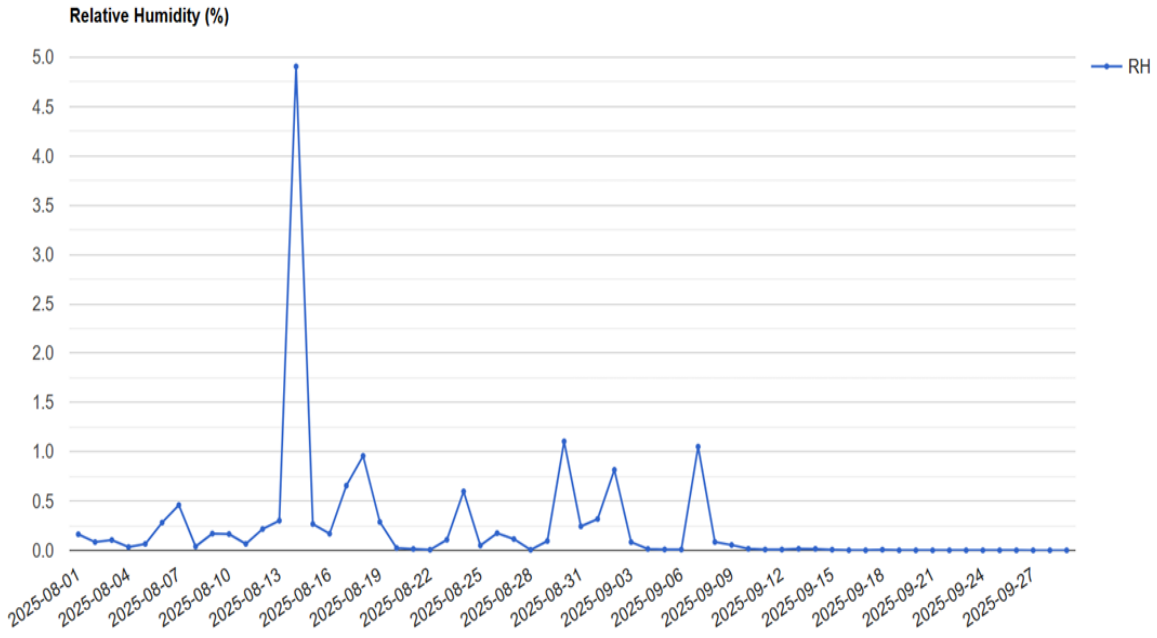
The chart demonstrates significant day-to-day fluctuations, making weather planning highly challenging for someone without access to forecasts. The most dramatic dips occur around August 17th and September 3rd, with the air temperature dropping to the lowest recorded value of approximately 26.5^ C. Other significant cool periods include late August, around the 27th, and August 30th. These sudden drops would provide brief but significant relief from the heat. The maximum air temperature, the highest point on the chart, is recorded toward the end of the period, around September 25th-26th, reaching just over 34^C. These days represent the most strenuous working conditions due to heat. The temperature in August is characterized by extreme instability. It features rapid, deep swings, jumping from high peaks (near 32^ C) to the lowest valleys (near 27^ C) multiple times. This requires constant adaptation from the informal worker, needing both strategies for heat and provision for sudden, cooler changes. While the first week of September shows volatility, the period from September 10th

onward exhibits a distinct and sustained warming trend. The temperature remains generally above 30^ C, with the final two weeks of the month showing the highest and most consistent temperatures, mostly staying between 32 C and 34^C .
This indicates a transition to more persistently hot conditions, demanding continuous, heightened measures for heat safety. In essence, the air temperature data confirms a period where an informal worker would be subject to erratic thermal stress in August, followed by a more sustained and intense heat stress in the latter half of September.

3.2.9.5 Relative Humidity

This chart displays the daily Relative Humidity (RH) measured as a percentage (%) over the same period, from August 1, 2025, to September 28, 2025. Relative Humidity is a key indicator of moisture content in the air and is vital for an informal worker, as it directly impacts how effective perspiration is (affecting heat stress) and is crucial for storing moisture-sensitive materials or goods.

Figure 3.6



The chart is a line graph illustrating the progression of Relative Humidity throughout the two-month period. The X-axis represents the dates, and the Y-axis provides the

Relative Humidity scale, which spans from 0.0% to 5.0\%. The blue line, labelled 'RH', plots the recorded daily humidity values. However, an immediate observation is that the recorded values are extremely low, generally staying well below 1.0% for the majority of the period, with a single, massive spike. This suggests the data might be showing a specific, non-standard metric of humidity or perhaps an anomaly, given that typical.

Relative Humidity levels rarely drop below 20% or 30% outside of extremely arid environments. Assuming the units and labelling are correct as provided, we proceed with the analysis of the observed values.

The dominant feature of this chart is the extreme, isolated peak that occurs sharply around August 15th-16th. On this day, the Relative Humidity jumps from near 0.0% to almost 5.0 %, representing a sudden and dramatic influx of moisture. This singular event stands in stark contrast to the rest of the data, which shows nearly negligible humidity. Other minor, smaller peaks reaching up to $1.0% occur around August 19th and September 8th-9th, showing brief moments where the atmospheric moisture content increased marginally.

For the informal worker, the overall low humidity environment suggests that the air is generally very dry. This would mean that while perspiration would be effective for cooling, there is a high risk of dehydration and potential issues with dust or dry materials. The critical observation is the dramatic change that occurs after September 9th-10th. From this point until the end of the data period on September 28th, the Relative Humidity drops and remains consistently near 0.0%, indicating a period of extreme, sustained dryness. This sustained zero-level humidity coincides precisely with the period of highest and most stable Land Surface and Air Temperatures observed in the previous charts (late September), confirming a transition to a consistently hot, dry environment.

This single significant humidity spike on August 15th-16th is an event that should be cross-referenced with the previous charts. It precisely matches the day of the highest Wind Speed and the day of highest Total Cloud Cover on the charts, indicating that a major, short-lived weather system—likely a thunderstorm or a brief, very humid

front—passed through. This event brought both high wind and high moisture, a crucial correlation for an informal worker to note for managing sudden heavy rain or localized flood risks during otherwise dry periods.

3.2.10 Research Ethics

This segment is the most sensitive aspect of the study. Since the group of participants are from culturally motivated regions and strictly practice gender specific norms and traditions, priority was given to obtaining culturally sensitive and continuous mentions of informed consent that respected power dynamics, dignity and ensured voluntary participation. Emphasis was given to contextual confidentiality and anonymity, recognizing the limitations of close-knit communities, and meticulously securing all data while being transparent about its use. In addition to being mindful of biases and ensuring reciprocity. If the participants indicated unwillingness of any form to disclose their personal details (specially in case of women due to the fear of their communities back in their villages); coding was used to replace the actual names and demographic information to maintain anonymity. It was also brough to light that the participation was purely optional and they had all rights to discontinue any moment without any further repercussions.

Chapter No 4.

Findings and Analysis

This chapter presents the study's findings and analysis by integrating participant narratives with environmental context to explain how urban heat and weather variability shape daily life for informal workers in Islamabad's G-9 sector. Using thematic analysis, it identifies recurring patterns across interviews, income insecurity, weather dependent earnings, health strain and neglected care, coping through informal networks and faith, and systemic vulnerability driven by regulatory disruption. These themes show that climatic exposure is not experienced as a standalone hazard but as a compounding force that intensifies existing economic precarity, limits work capacity, and deepens reliance on borrowing, charity, and short-term adaptations. The chapter then situates these lived experiences within geospatial and climate data to contextualize reported heat stress and work disruption, strengthening interpretation through triangulation while keeping participant accounts at the centre of the analysis.

4.1 Thematic Analysis

Following are the thematic analysis of interview data, presenting the core themes and sub-themes that emerged from participants' accounts of work and survival in G-9. The analysis organizes verbatim testimonies to show how economic insecurity, weather exposure, and structural pressures intersect in shaping day-to-day decision-making. Rather than treating each issue in isolation, the themes are presented as connected dimensions of vulnerability, where fluctuations in temperature and rainfall directly influence earnings, health, mobility, and access to basic needs. The section that follows discusses each theme in detail, linking participant quotations to the study's research questions and situating individual experiences within broader patterns of informal urban livelihood.

Sr.	Theme and Sub-Theme	Verbatim	Respondent
1	**Income Insecurity and Subsistence Living**	*I need at least 5000 Rs minimum to get by each day in ideal cases but I get paid 2500. I used to be the only income person in my family but now my sons and my daughter also work but we still can't make up for our bills and needs.* *It's easier to sit and work here then go back to our villages because there is barely any work there even if life is better at home where we come from. I have to pay for my kids' fees. By now it's been 5 days and i haven't made enough to take home.*	Muhammed Salim Muhammed Salim
2	**Insufficient and Unstable Earnings**	*We earn enough every day to fill our stomachs and we never calculate much, however much Allah gives us.'*	Gulzar khan
3	**Overwhelming Financial Burdens**	*I eat rice from the market once a day due to the high prices. I have a lot of bills to pay. My utility bill is 33000 a month which I have to send back. I make 700 to 800 rupees a day.* *I make 30000 a month but our house rent is 15000 and electricity bill is 20000, where do we bring it from? We live on day-to-day wages; we burn fire for cooking we don't use gas because it's very expensive its 50*	Haq Nawaz Shahnaz Bibi and Sobia Bibi

		rupees per kg. We don't focus on health; we focus on work.	
4	**Income Dependency on Weather Patterns**	*We paint so our work is best in warm weather so we barely get any work in cold and wet weather, we have to take and give loans and get by through peers, friends and relatives around us.* *In winters I sell 'maqai ke danay' because of demand. In hot weather i make more money because people want cold kulfi so i get 1000 rupees profit sometimes.* *In moderate weather, I get to sell a lot due to my ability to travel to a lot of places and in heat I don't even want to do it. Wet Chaddar on my head helps cool down but I still sweat and feel fatigue.* *My business is only good in cold weather not warm temperatures, the customers preferred sugarcane in warm seasons that I used to make.*	Muhammed Salim Mohammed Mujahid Kashif Ali Mohammed Nadeem
5	**Loss of Assets and Productivity due to Extreme Weather**	*When it rains i make no money because fruits go rotten under that weather, so i put plastic sheet on it and just go home. My wife makes 5000-6000 rupees which still isn't enough if we combine both our earnings.* *It's hard to earn money for example i put in 30,000 in buying these fruits but i might not even earn 12000 for them by the afternoon because of weather changes, maybe it might take me 3 days to make that money i put in, back.*	Manzur Sabir Hussain Gulzar khan

		If it rains or hails we have this tin covering behind us. We just go and hide under it till the storm stops and then we try to get back to our work. *I have to sell my corn before it goes bad. I have to throw them away if that happens.*	Marvez Khan
6	**Physical Health Burden and Neglected Care**	*The changes in heating affects our health too such as a lot of sweating and headaches and dizziness. I sit on this road till 2 p.m. but if I start getting work, I sit longer no matter what.*	Muhammed Salim
7	**Heat and Labor-Related Illness**	*I walk so much that I have got sores on my feet and I have to keep applying turmeric because it's too expensive to go to a doctor. It still hasn't. healed as you can see.* *I have high blood pressure and I sometimes fall from dizziness too. I get so many bruises and I have to keep going to the doctor to get it checked but what can I do? I still have to keep working.*	Manzur Haleema bibi
8	**Barriers to Affordable Healthcare**	*I do get fever often but i dont go to doctor because they charge me 1000 rupees , there are so many mosquitoes here because of the plants that u have to just apply a mosquito repellent and keep working* *I just drink chai 2 times to work through the pain. I just keep a wet chaddar on my head if it gets too hot. I don't go to doctors because I can't afford it. I just have to tolerate it. I walk to my house too after getting off the bus stop.*	Anwar Khan Pathani

9	**Immediate Coping and Informal Support Networks**	*Wet Chaddar on my head helps cool down but I still sweat and feel fatigue.* *i walk a lot everyday for work but on days the weather is tolerable, i work a lot ,but if its not i sit under a tree or take shelter under a bench.* *If i feel sick from the heat i drink water or juice. I sit under a tree given by Allah and spend my days doing this work on the road.*	KAshif Ali, Haq Nawaz Sabir Hussain
10	**Spiritual Resilience and Reliance on *Rizq* (Divine Provision)**	*We earn enough everyday to fill our stomachs and we never calculate much , however much Allah gives us.* *We come on motorbikes everyday to G-9. It costs us 200 to 400 rupees in petrol but what can we do even if it's a loss in daily income.But it's fine because Allah fulfils our everyday needs.* *These things come and go events happen , seasons pass , i tolerate it all but i trust my Allah (God) that he wont leave me empty handed and has my rizq for me.* *I even wanted to study but I chose to help my family out i had to, but i still say Alhamdulillah God provides for us.* *I will not lie my God is witness i do not have enough to go by everyday. Sometimes a man passing by or customer pays a bit more but*	Gulzar Khan Mohammed Najib Mohammmed Mujahid Haq Nawaz

		its still not enough maybe i can buy tea from it. *I am praying that I get enough money 'Inshallah' to start something else*	
11	**Reliance on Borrowing and Charity**	*In cold weather the days are smaller and it's hard to work outside so I just go back home.* *I take some loans such as 500 rupees for a day from a cousin to get by for that day.* *We have to take and give loans and get by through peers, friends and relatives around us. We ask for time like 1 or 2 months to pay it back when we are in an emergency and something happens. Our 'nizam' (system) is disrupted.* *I just eat food from a langar (charity place) nearby where people come and offer food.* *My younger son who lives in Saudi Arabia does provide a little money which helps a lot but alone i wont be able to afford it*	Haq Nawaz Muhammed Salim Muqeeb Sabir Hussain
12	**Systemic Vulnerability and Regulatory Harassment**	*CDA pay a lot of visits, they come and take all our stuff we use to earn income but what can we do apart from worrying. We are just left with stress of how they can pick up our things whenever they like.*	Muhammed Bashir Anwar Khan

		The CDA staff come and break my things and take it away and make videos of my things.	
13	**Lack of Formal Protection and Dignity** **CDA Disruption and Economic Loss**	*i sit here on road till CDA comes and takes away my things i have to hide them, sometimes they let me sit sometimes they dont.* *CDA disrupts our business when they dont wanna make us sit , they do it without a proper reason most times, we don't sit on this road everyday, i had to run on Friday when I went for Jummah Prayer in my dirty clothes because i didnt have enough time after dealing with the authorities ,it gets so hard.*	Sabir Hussain
14	**Lack of Formal Protection and Dignity**	*Sometimes the police take me away because I sit and rest in between my work under this building and they think I'm sitting here begging. They do not like it.* *Previously I had a sugarcane machine in Kazafi chowk adda (bus station) because CDA authorities closed it down. They didn't let me work, they also don't let me work here but I do it when I can. They did it because they said you are creating a lot of crowd.They also emptied Raja Bazaar. They said its causing a lot of trash*	Haleema Bibi Mohammed Nadeem

4.1.1 Income Insecurity and Subsistence Living

This theme was chosen to highlight the economic vulnerability of the informal workforce in the most basic day to day needs that a person requires to live with dignity.

This is crucial for understanding how the additional stress of changing weather patterns becomes a devastating factor rather than a mere inconvenience for the daily wage workers of G-9.

4.1.1.1 Insufficient and Unstable Earnings

This sub-theme puts emphasis on the fact that workers exist below or near the poverty line, often experiencing days that go by with zero income generation. This extreme highlights how weather fluctuations can immediately threaten their ability to feed their family. The testimonies of the informal workers helped understand how there was a big gap between their perceived needs and their actual earnings.

Muhammed Salim who works as a Misri (painter) remark*; "I at least need 5000 Rs minimum to get by each day in ideal cases but i get paid 2500. I used to be the only income person in my family but now my sons and my daughter also work but we still can't make up for our bills and needs ".* This informs about the daily baseline income he requires to fulfil his needs but his typical earning falls short of it, demonstrating a very big income deficit in his case. *"By now it's been 5 days and I haven't made enough to take home".* He faces a lot of unpredictability and irregularity in his daily work, his prolonged periods that go on without his required income pushes him further into poverty and makes him vulnerable.

Figure 4.7 Muhammed Salim and his painting Equipment

Gulzar Khan who collects all forms of cardboard and paper waste explained; *'We earn enough every day to fill our stomachs we never calculate much, however much Allah gives us"*. He showed a certain acceptance in a resigned and wise manner of his income instability and suggested the perspective that calculating earnings is not necessary and its in the hand of God.

Figure 4.8 Gulzar Khan at his waste collecting site alongside fellow workers

4.1.1.2 Overwhelming Financial Burdens

This section addresses the high costs such as of rent and utility bills that workers have to pay without a choice. These fixed costs mean that even a slight discrepancy in daily income generation (which is often) due to their work environment issues for e.g. taking a day off or losing productivity due to the intense heat; immediately creates debt and financial crisis for them.

Haq Nawaz, who works as a Pirri (knits baskets) excludes: " *I eat rice from the market once a day due to the high prices. I have a lot of bills to pay. My utility bill is 33000 a month which I have to send back home. I make 700 to 800 rupees a day.*". This

emphasizes the large bill for a month that he has to send back every month in whatever case adding on to his financial stress; it shows the high living expenses compared to his income that he majorly sends over to his family.

Shahnaz Bibi and her younger sister Sobia Bibi who provide collectively for their total of 7 sisters and 3 brothers and Shahnaz's daughter explain:" *I make 30000 Rs a month but our house rent is 15000 Rs and electricity bill is 20000 Rs, where do we bring it from? We live on day-to-day wages; we burn fire for cooking we don't use gas because it's very expensive its 50 rupees per kg. We don't focus on health; we focus on work."* This is a very elaborate explanation of the crisis they face daily due to their total expenses exceeding their total collective income. They also further explain why they focus on work instead of worrying about their health as it just isn't a priority for them. Their father works in a nursery and also provides his income but it still isn't enough for their large family.

4.1.2 Weather-Induced Economic Disruption

This theme directly addresses the weather patterns caused by the UHI effect as a "cause" of economic discrepancies "effect," examining how temperature and precipitation changes dictate earning potential of the daily wage labourers.

4.1.2.1 Income Dependency on Weather Patterns

This sub-theme details how UHI induced weather fluctuations affect the demand and feasibility for specific types of informal work in G-9. The responses from the workers helped highlight that for some, warmer weather is essential (painting, fruit sales), while for others, heat, cold or rain is a major constraint; leading to unstable seasonal income patterns.

Muhammed Salim quotes: " *We paint so our work is best in warm weather that is why we barely get any work in cold and wet weather, we have to take and give loans and get by through peers, friends and relatives around us*". This shows a very apparent dependency on community; it also shows how weather plays a part in their daily work

not just as a cause of their issues but as a stable indicator of their potential opportunities in their field of work.

Mohammed Mujahid sells Kulfi in a cart which he purchases from a company in G-11 sector and walks all the way to G-9 to sell it, he also sells other things according to season:" *In winters I sell 'maqai ke danay' because of demand. In hot weather I make more money because people want cold kulfi so I get 1000 Rs profit sometimes."* This also shows another example of how a business benefits from extreme temperatures contrasting with the actual worker who suffers in that environment.

Kashif Ali from Laki Marwat who sells Chabbay (straw plates and baskets) on his bike on the road everyday exclaims: " *In moderate weather, I get to sell a lot due to my ability to travel to a lot of places and in heat I don't even want to do it. Wet Chaddar on my head helps cool down but I still sweat and feel fatigue."* This highlights the negative dependency of how much physical excursion he requires to sell a lot of his goods and how he feels how it gets unbearable and causes a significant slowdown for him due to intense heat.

A juice-stall owner near the green bed in G-9, Mohammed Nadeem says; " *My business is only good in cold weather not warm temperatures, the customers preferred sugarcane in warm seasons that I used to make.*" He elaborates on how cooler temperatures is best for business showing a counterargument to the Kulfi Vendor and demonstrating different forms of climate dependencies.

4.1.2.2 Loss of Assets and Productivity due to Extreme Weather

This sub-section focuses on the direct financial losses that result from extreme weather events such as rain, hail or heating. For the informal workers dealing with perishable goods or jobs requiring continuous presence, weather directly correlates with lost inventory or depletion in wages, often causing immediate loss of any accumulated capital.

Manzur, a 50-year-old man from Nira Wali who owns a fruit cart for around 30 years emphasizes: "When it rains, I make no money because fruits go rotten under that

weather". This is a very good example of immediate asset loss, where the acquired goods are destroyed just because of temperature changes. This shows a direct correlation between weather and destruction of capital.

Sabir Hussain from Mundi Khel,Narwaal; with a great amount of heart problems further exacerbated by the heat is another fruit vendor near Manzur. He says :" *It's hard to earn money for example I put in 30,000 in buying these fruits but I might not even earn 12000 for them by the afternoon because of weather changes, maybe it might take me 3 days to make that money I put in, back*." This calculates the risk helping to see that rapid fluctuations in temperature can cause big financial loss that can possibly never dimmish the gap from that day's earnings.

Figure 4.9 Sabir Hussain and his Fruit Stall in G-9

Gulzar the paper waste collector says: " *If it rains or hails we have this tin covering behind us. We just go and hide under it till the storm stops and then we try to get back to our work."* He shows a coping strategy by having a makeshift covering of tin over his shed but he still loses time and observes his slowed down productivity causing hurdles in making his daily earnings.

This section shows how even if the workers are not experiencing any personal or financial problems in acquiring assets and earning for the day, the change in weather pulls them back from generating their income at full potential. This also inevitably will lead them into poverty.

4.1.3 Physical Health Burden and Neglected Care

This theme addresses the "health" component of the study's questions and put emphasis on the physical toll of working outdoors in UHI induced weather conditions and the resultant lack of access to care.

4.1.3.1 Heat and Labor-Related Illness

This sub- section focuses on the direct physiological consequences of working long hours in intense heat and demanding physical roles from the labourers every single day without a day off. These conditions, exacerbated by the UHI, lead to acute symptoms that reduce productivity and require forced rest, often resulting in lost wages and prolongs period of healing.

Muhammad Salim, who sits for long periods of time next to his painting equipment on the side of the road seeking jobs provides symptoms he experiences under the heat : "*The changes in heating affects our health too such as a lot of sweating and headaches and dizziness. I sit on this road till 2 p.m. but if I start getting work, I sit longer no matter what.*" This confirms the causal relations of UHI induced weather fluctuations and its direct effect on health.

Manzur, who struggles to pay even his most recent electricity bill, shares a personal struggle he faces everyday he leaves to earn with his fruit cart: "*I walk so much that I*

have got sores on my feet and I have to keep applying turmeric because it's too expensive to go to a doctor. It still hasn't healed." This shows how his severe physical exertion materializes in the form of sores, providing a testimony of the long roads he has covered to find his customers. This is a simple example of chronic physical injury resulting from continuous labour in addition to lack of finances to seek proper treatment.

Haleema Bibi, a 60-year-old elder who travels everyday from Mehr Abadi near the outskirts of Islamabad to G-9 offers; "*I have high blood pressure and I sometimes fall from dizziness too. I get so many bruises and I have to keep going to the doctor to get it checked but what can I do? I still have to keep working.*". Her existing chronic condition was worsened by the heat and physical stress, raising the risk of other health related incidents as well as the hospital expenses she potentially has to pay.

4.1.3.2 Barriers to Affordable Healthcare

This sub section explains why the health issues caused by UHI and labour are often neglected because the sheer cost of healthcare in addition to the low-income acts as a major barrier; forcing workers to rely on cheap, self-administered fixes or simply "tolerate" their pain.

Anwar Khan, a barber on the roadside, who barely gets any customers altogether says: "*I get fever often but I don't go to doctor because they charge me 1000 rupees, there are so many mosquitoes here because of the plants that u has to just apply a mosquito repellent and keep working* ". This provides a specific amount which Anwar cannot afford, showing how he tried to properly seek healthcare but his financial limitations cause him to find alternatives.

Pathani also focuses on forgetting about her physical ailments by drinking tea as a source of comfort and much needed distraction from her everyday struggles; "*I just drink chai 2 times to work through the pain. I just keep a wet chaddar on my head if it gets too hot. I don't go to doctors because I can't afford it. I just have to tolerate it. I walk to my house too after getting off the bus stop*". She highlights how she choses to make a conscious decision of not to stress about her physical health and focuses on earning money prioritizing it over her personal feelings as a coping strategy.

"We used to have Sehat card till Imran khans time but not anymore". This shows how the loss of former social protections places all the burden back on the vulnerable workers like Pathani.

4.1.4 Immediate Coping and Informal Support Networks

This theme addresses coping mechanism and adaption strategies employed by the workers focusing on the practical, short-term solutions they use to survive the physical heat and the financial shortfalls. This also demonstrates how spiritual perspectives help the workers cope from the issues at hand ny looking forward to tomorrow.

4.1.4.1 Physical Heat Mitigation Strategies

This sub-theme captures the immediate, self-learned techniques workers use daily to combat the high temperatures and direct sunlight (UHI symptoms), as they cannot afford structured relief like air conditioning or formal breaks or holidays.

Kashif Ali shows a general example of a low-cost, fast and effective coping mechanism against the intense heat he is exposed to on daily basis: *"I just keep a wet chaddar on my head if it gets too hot but I still sweat and feel fatigue."*.

Figure 4.10 Kashif Ali with his head covering resting on his shoulders while he sells corn to a lady.

Haq Nawaz travels on his bike to sell his baskets across the sector =he wishes he had a stable shop but he makes do of his bike and goods: " *I walk a lot everyday for work but on days the weather is tolerable, I work a lot, but if its not I sit under a tree or take shelter under a bench. There are some places for sitting but I don't make any money if I go and sit there so I am out here on the road."*

This shows a reliance on natural shade of the trees and public infrastructure in some places of the sector but a reluctance to use them for long periods as it distracts him from his customers or costs him money.

Figure 4.10 Haq Nawaz ‘s Chabba makeshift bike stall

Sabir Hussain who owns a fruit van employs a coping strategy by using his own purchased good as a way to battle heat for momentary relief: " *If i feel sick from the heat i drink water or juice. I sit under a tree given by Allah and spend my days doing this work on the road.”*

These examples show how critical thinking skills and quick fixes employed by these workers help them earn just a little more each day battling the intense weather.

4.1.4.1 Reliance on Borrowing and Charity

This sub-section incorporates the financial coping mechanisms necessary when unpredictable earnings are not enough to make up for the many expenses, it also a reliance on informal, fragile social networks within the community.

Haq Nawaz explains his perspective of how it is hard for him to keep earning on a cold day so he prefers to borrow and take that day off instead; *" In cold weather the days are smaller and it's hard to work outside so I just go back home. I take some loans such as 500 rupees for a day from a cousin to get by for that day."* He prioritizes his health on a cold day of work and chooses to not earn and stress about it later, he instead leans on his extended family for support in these times. This highlights the small-scale system of borrowing and lending and shows how survival finances work for Haq on the days he doesn't feel like he can give his all to his work.

Muhammed Salim mentions on how he borrows money and provides a promise of paying it back by establishing a timeline for his lender: " *We have to take and give loans and get by through peers, friends and relatives around us. We ask for time like 1 or 2 months to pay it back when we are in an emergency and something happens when our 'nizam' (system) is disrupted."* This puts emphasis on the critical role social capital and peer relations play in overcoming financial discrepancies when the main livelihood fails to keep up with the fluctuations in weather.

"*I just eat food from a langar (charity place) nearby where people come and offer food."* Muqeeb, a man who sits on the road on the yellow line at the side of the pavement and looks for any work he can get due to his old age and physical shortcomings such as strength and hard labour a young man can do, which he acknowledges. This shows his reliance on charity for his basis sustenance when he has zero income showing the highest level of vulnerability.

Sabir Hussain, the fruit vendor, deals with his stress of finances by keeping hope on his son and helping him shoulder the big family which consists of 2 families; 2 daughters, his son's son and daughter , his brother in laws son and his wife:"*My younger son who lives in Saudi Arabia does provide a little money which helps a lot but alone I won't be*

able to afford it." This demonstrates how people seek help from extended relations which is vital for survival of the daily wage earners but not a guaranteed source of income.

4.1.4.3 Spiritual Resilience and Reliance on *Rizq* (Divine Provision)

This sub-theme addresses the non-material coping mechanism prevalent among the workers who prefer turning to faith in helping them manage chronic uncertainty, economic shortfall, and health related stress. For these workers, accepting their situation as *rizq* (God-given sustenance) or saying *Inshallah* (God willing) as a reflex at the end of any sentence provides emotional stability and reduces anxiety regarding income volatility and health threats, which are exacerbated by UHI effects. This mindset gives a false sense of comfort temporarily and helps them get back to work despite profound risks and financial loss, acting as a crucial component of their adaption strategies and helps them rationalise their daily attendance to work.

Gulzar Khan incorporates his faith with his hard work to not have unnecessary regrets or feelings of insecurity*; "We earn enough every day to fill our stomachs and we never calculate much, however much Allah gives us. We come on motorbikes every day to G-9. It costs us 200 to 400Rs in petrol but what can we do even if it's a loss in daily income. But it's fine because Allah fulfils our everyday needs."* This illustrates how he does not rely on human plans but instead turns to a Higher Being for his sustenance, His faith acting as a stress reliever. He chooses to directly associate his means of survival as a promise from God that He won't let him return empty-handed.

Mohammed Najib has a wise perspective when it comes to his hardships in daily income generation and sees God's provision as a potential coping strategy for himself: *"These things come and go events happen, seasons pass, I tolerate it all but I trust my Allah (God) that he won't leave me empty handed and has my rizq for me."* He puts his trust in Allah and believes that his persistent effort and dealing with hardships will be met with blessings from Allah.

Mohammed Mujahid wanted to pursue studies but due to his family's financial crisis he had to start earning for their survival; he says *"I even wanted to study but I chose to*

help my family out I had to, but i still say Alhamdulillah God provides for us". Saying Praise be to God is used in everyday terms in Pakistan as a way to show gratitude and contentment no matter the situation, redirecting their poverty crisis as a divine hardship.

Anwar Khan who is going through generational poverty believes his finances are dealt with by Allah's help and His provisions through people who provide him with payment of his bills; " *I will not lie my God is witness I do not have enough to go by every day. Sometimes a man passing by or customer pays a bit more but it's still not enough maybe i can buy tea from it."* This shows an awareness of the crisis when he believes its not enough but his immediate assertion of divine hope shows a constat struggle to manage varying interests.

Haq Nawaz hopes of starting anew in future when he believes that Allah will create a path for him different from the current one and he demonstrates his hope by saying Inshallah commonly used by Muslims as a silent promise of good to come. He says: *"I am praying that I get enough money **'Inshallah'** to start something else".* He relies on God's will for his future like majority of the other informal workers.

4.1.5 Systemic Vulnerability and Regulatory Harassment

This theme shifts focus to the external, non-climatic factors that make the informal workers so vulnerable to UHI induced weather effects. Constant regulatory harassment disrupts their stability, making adaptation to climate change nearly impossible.

4.1.5.1 CDA Disruption and Economic Loss

The actions of the Capital Development Authority (CDA) or police create constant instability, directly leading to confiscation of inventory, lost income, and fines. This external regulatory pressure is presented as an economic threat equal to, or greater than, the weather itself.

Sabir Hussain has to transfer and put up a new stall everyday due to the authorities meddling with his things without his permission. Sometimes the fine him or sometimes they let him go because of his age: " *I sit here on road till CDA comes and takes away*

my things i have to hide them, sometimes they let me sit sometimes they don't." He talks about his loss of his inventory and earning sources due to regulatory enforcement.

Manzur expresses his stress over the situation he faces: *"I have to change spots of my cart because CDA takes it away and fines me about 2000-3000 rupees and I have to pay so that I can get my cart back".* This makes the loss of income worse by paying a fine on top of that, showing how these fines represent a large portion of their already small income. This shows the lack of awareness and systemic discrepancies in the government-based authorities.

Anwar Khan expresses how his barber equipment is targeted when he sets up shop on roadside: *"The CDA authorities come and break my things and take it away and make videos of my things".* This shows the governments illegal forms of enforcement of laws and use of pressure on vulnerable and poor workers. It also highlights the form of public shaming these workers face.

4.1.5.2 Lack of Formal Protection and Dignity

This sub-theme focuses on the lack of formal recognition or designated space for informal workers. They are treated as liabilities (trash, crowding) rather than functional elements of the city, leading to psychological stress and continuous displacement.

Sabir Hussain complains about the pressure authorities create on his work: "*The government also causes many problems in our business, its like duty for us but CDA disrupts our business when they don't want to make us sit , they do it without a proper reason most times*". This shows the nature in which the authorities cause hurdles for the fruit vendor and that his work is victim to the authorities' changing mood.

Haleema Bibi , the elder lady who works in 5 houses daily and takes a small break near the buildings' footsteps expresses: *"Sometimes the police take me away because I sit and rest in between my work under this building and they think I'm sitting here begging".* This shows the level of dehumanization and lack of dignity offered to her and a simple request of rest for some time is misunderstood and used as a completely different narrative to take her with them.

Mohammed Nadeem, the fruit juice stall owner expresses his concerns for his earning: *Previously I had a sugarcane machine in Kazafi chowk adda (bus station) before CDA authorities closed it down. They didn't let me work; they also don't let me work here but I do it when I can. They did it because they said you are creating a lot of crowds. They also emptied Raja Bazaar. They said it causing a lot of trash."* This shows how the authorities use official forms of justifications to displace a worker and disrupt his work only because they are seen a public nuisance showing a great example of what it mean to be a vulnerable individual in society.

4.1.6 Economic Motivation: Familial Obligations and Intergenerational Sacrifices

This section emphasizes the strong influence and often non-negotiable duties that come with families and personal need to fulfil them too. The need to provide makes them endure often very harsh working conditions. Pursuit for income is often sought by them not for personal needs but as a response to their immediate and unrelentless family problems that arise and the silent obligation demanded from them to support the dependants of the family or the very least to secure a survivable future for their loved ones.

The small unstable earnings are often adjusted across large joint families; however, it still causes them hurdles in paying for the bills. For instance, Shahnaz and Sobia earn for their entire family consisting of many siblings which became an essential call for them to step up after Shahnaz's husband passed away leaving her to look out for their child as well. They said: "*We have never studied, from the start we have been working, our brothers are young, we are 7 sisters and 3 brothers. Us both earn for the whole family; Shahnaz husband has passed away so we live together now and afford the expenses together."* The lack of education put the sisters into more vulnerability but they try to overcome it by taking radical decisions such as combining families and working as household providers together for their big family.

4.1.6.1 Necessity to Work Due to Dependency and Kinship Duties

This sub-section focuses on the specific and person- specific family crises such as onset of illnesses and new responsibilities that are unavoidable by these vulnerable workers.

One of them, in particular, is Kausar who travels everyday with her cart to sell vegetables and travel the sector regardless of how she's feeling health wise. She quotes: "*The weather does affect me a lot I have high fever and I do nothing just take a pill and carry on walking my cart, my feet also hurt from constantly doing this."*

She had to join the informal work due to it becoming a necessity after her father broke his leg and became dependant on others and her mother also became ill around the same time period. Furthermore, she also had to make money to marry her daughters off in accordance to tradition whilst also paying the bills for healthcare of her mentally disabled husband; i.e.; *"I had to leave my village because my husband was mentally disabled and I had to marry my 2 daughters off as well and needed the money. Every month I pay 40000 Rupees in total which includes medicine for my husband's treatment and house bills combined. I pay 10000 Rupees for my daughter who studies the Quran which also includes her 2000 Rupees in school fee."*

The financial obligations; paying her husband's bills as well as saving for her daughter's wedding and education, and the added household bills and travel costs of the vegetables leaves Kausar with little to wish for with. Her family situation compelled her to seek a job which she still hides from her village community due to the cultural barriers faced by women in her community.

Similarly, Mohammed Nadeem who sells fruit juice on the road side, had to abandon his wish for education and join his father as a household head and providing for his family members. He had to leave his 8th class due to poverty and his family conditions dictating his future career path. He offers: *"I studied till 8 class but I have 7 people in my family and my father also works so I started helping. We just have to do this, somehow, we get by everyday Alhamdulillah (by God's will)."*

Mohammed Nadeem's will to help his family over rid his wish for seeking further studies. His awareness of his alleged responsibilities led him to change his career and potential future causing him another hurdle in breaking out of the generational poverty cycle.

4.1.7 The High Overhead Costs of Travel to Workplace

This theme highlights the heavy and often unavoidable logistical costs faced by mobile vendors, particularly expenses related to transportation, fuel, and sourcing supplies. Unlike fixed-shop owners, mobile vendors must pay these costs on a daily basis before they earn anything at all. As a result, a significant portion of their gross income is immediately consumed by business operations, leaving very little room for profit, savings, or financial security.

Transportation functions as a fixed daily cost for most vendors. Muhammed Bashir, a fruit seller, spends between 400 and 500 rupees each day on petrol to travel to the G-9 sector, amounting to nearly 15,000 rupees per month. Similarly, Gulzar Khan, who collects and sells paper waste (raddi), spends approximately 200 to 400 rupees daily on fuel simply to reach his work area. These costs are unavoidable and must be paid regardless of whether the vendor earns anything that day.

For others, overhead costs are even more burdensome relative to their income. Kausar, who operates a vegetable cart, spends around 700 rupees daily just to travel to the mandi, purchase vegetables, and move her cart to the street. Mohammed Nadeem reports spending 500 to 600 rupees per trip to source goods from the mandi. Even workers outside traditional vending face similar pressures. Shahnaz and Sobia, who work as houseworkers, explained that travelling to their workplace in Mehr Abadi costs them between 1,000 and 2,000 rupees. These recurring expenses significantly reduce their take-home earnings and contribute to their chronic inability to save, invest in better working conditions, or afford necessities beyond basic subsistence.

4.1.7.1 Excessive Expenditure and Loss due to Fuel, Transportation, and Supply Sourcing

Whilst the former headings covered the financial burdens faced by the informal workers, this sub-section primarily puts emphasis on the disproportionality of the cots that they cover for operationalizing their work for the day. This includes examples such as the cart loaded by street vendors. This significantly compromises their already low daily income generation.

Muhammed Bashir, who has been in the fruit selling business for approximately 30 years and more spends a significant amount daily on the transport of his fruits from the Mandi (Bazaar) to the selling location which is the roadside near G-9 Markaz. He said:

"*I bring all my fruits and veggies from the Mandi. I bring it on car so my petrol costs of 400-500 Rupees is also there which makes it about 15000 Rupees every month just in petrol costs."* Given that he makes 1000 to 1200 rupees daily of which 400 to 500 Rupees end up as travel expenditure shows the little amount of profit he gains after all the excursion is takes to just provide the fruit from the bazaar to the customer. This leaves him with little options on what he can do with his income and inevitably ends up spent in household expenses.

Kausar faces similar logistical discrepancies as she provides 700 Rupees to the taxi for picking her vegetables and cart from the Mandi and unload them on the road which she chooses to sell them on, not to mention the further walking she has to do after that point as well, leaving her with little to no incentives in doing this work. She offers: "*The city has gotten very expensive; it costs me 700 rupees just to come to the mandi and get my veggies and take my cart till the road."* This shows she is aware of the rising expenses but she can only do so much about it.

Gulzar Khan who collects recyclable waste also faces similar challenges as he lives very far from his worksite and has to offer a significant sum each day as he comes to work and as he goes back. He said: "*We come on motorbikes every day to G-9. It costs us 200 to 400 rupees in petrol but what can we do even if it's a loss in daily income."* He understands that he has limited options in saving his money. He is left with the option of just earning his daily expenses even if it only helps him meet his day-to-day expenses only.

4.1.8 Adaptation and Constraint on Work Sites

This theme explores how the instability of working spaces—shaped by regulatory harassment, exposure to weather, and the absence of permanent infrastructure—forces informal workers into constrained and often unprofitable locations. These conditions affect not only their income but also their safety, dignity, and ability to sustain their livelihoods.

Regulatory displacement by CDA authorities emerged as a persistent challenge. Vendors described constant fear of eviction, confiscation of goods, and financial penalties. Mohammed Bashir explained that CDA officials frequently seize their belongings, creating "further tension" and uncertainty. Manzur reported paying fines of

2,000 to 3,000 rupees to retrieve his cart after it was taken away. Mohammed Nadeem shared that his earlier sugarcane business was shut down by authorities on the grounds of crowding and waste generation. Currently, he works in areas where vending is not permitted and hides his stock behind a tree whenever officials approach.

The lack of a fixed workplace also forces vendors to choose between physical comfort and income generation. Without permanent stalls or shelters, workers remain fully exposed to heat and weather. One fruit juice vendor explained that while sitting under a tree or bench provides temporary relief from the heat, it also means losing customers and earnings. Muhammed Salim similarly expressed that having access to even basic shade or a shed would make working conditions significantly more bearable.

Physical exposure further heightens risk. Vendors like Muhammed Bashir, who work directly on the roadside, experience intensified heat and face constant danger from traffic. The absence of a secure location also places tools and inventory at risk. Anwar Khan, who works under a tree, shared that he must leave his equipment with someone overnight, relying solely on trust and sympathy, stating that his "Muslim brother will keep it for me." Vulnerability is not limited to vendors alone; Haleema Bibi recounted being detained by police simply for sitting and resting under a building, as she was mistaken for a beggar.

Together, these accounts illustrate how unstable and contested workspaces severely constrain informal workers' ability to adapt, earn safely, and maintain dignity within the urban environment.

4.1.8.1 Instability of Working Space and Dictation of Sales Generation

This sub-theme explores the perception of how the necessity of selling anything on the road may it be fruits or services, severely impacts the worker's income, workflow, safety and longevity of services.

Mohammed Bashir, for instance, noticed how working directly on the road increased the rise in temperatures he experienced. He said *"Working on the road adds on to the heating for me as compared to sitting in shade but that slows down my work."* He was stuck in the dilemma between choosing to make more money by staying in direct sunlight and sun's heat or go rest in the shade and lose potential customers.

The need for a stable site to go on with the daily work was also mentioned by Mohammed Nadeem who sold fruit juice with his small makeshift shop on the pavement. His previous location of work near the bus stalls with his sugarcane machine was shut down by the Capital Development Authorities (CDA) because of onset of trash and crowding. He said*: "Previously I had a sugarcane machine in Kazafi chowk adda (bus station) before CDA authorities closed it down. They didn't let me work regularly; they also don't let me work here but I do it when I can."* He makes do of the unpredictable days of hurdles he faces in earning his income and works when he is permitted to often hiding his stock from the authorities if needed. This also compromises his customers locating him as he is not available in only one place.

Another testimony given by the Basket maker, 'Haq Nawaz' also showed how he indirectly phrased his wishes for a stable location he can work from and his customers can find too. He said: "If the sunlight and heat get too much it's hard to travel and work around the city on my bike, it might be easier and better for me if I had a shop."

This constant change in work dynamic of having to run or hide products or just simply travelling to seek customers undermines the stability of the products sold which distinguishes it from the physical damage which was covered in former section 4.1.2.2 and general harassment in section 4.1.5.1.

4.2 Geospatial Data: Supporting and Contextualizing Interview Findings

To situate the qualitative inquiry within its physical and climatic setting, environmental conditions within the study area were examined using geospatial and climate data. This step was undertaken not as a separate analytical exercise but as contextual grounding, allowing participant narratives to be interpreted in relation to the urban thermal environment in which every day work was occurring. 'Urban Heat' is therefore treated as a structuring condition of lived experience rather than as an independent outcome of investigation.

Remotely sensed datasets accessed through Google Earth Engine, including MODIS and Copernicus products, were used to characterize thermal and atmospheric conditions within the G-9 sector of Islamabad. Variables examined included land surface temperature, air temperature, relative humidity, wind speed, and cloud cover. Data were

focused on peak daytime hours, particularly around 2:00 p.m., when heat exposure is highest and informal workers are most actively engaged in outdoor labor. The temporal scope of the data corresponded with the period during which interviews and field observations were conducted, ensuring alignment between environmental conditions and participant accounts.

This environmental contextualization served two primary purposes. First, it provided an objective baseline for understanding the intensity and persistence of urban heat within the study area, independent of individual perception. Second, it enabled triangulation of qualitative findings by allowing reported experiences of fatigue, disrupted work routines, health strain, and income instability to be read against empirically observed thermal conditions. Participants were not informed of specific temperature values or climatic measurements, reducing the risk that interview responses were shaped by awareness of the environmental data.

By incorporating geospatial information in this manner, the study strengthens the interpretive depth of the qualitative analysis without shifting its epistemological orientation. Urban heat is embedded within the methodological design as contextual evidence that supports, rather than substitutes for, lived experience. This approach ensures that subsequent analysis remains grounded in participant narratives while acknowledging the material urban conditions that shape vulnerability, constant exposure, and coping strategies within the informal economy.

Chapter No 5.

Summary and Conclusions

The Urban Heat Island (UHI) effect in Islamabad is a significant socioeconomic risk, disproportionately impacting the city's informal workforce. As temperatures fluctuate due to urban heating, these workers who operate without any social safety nets or resources, face a cycle of declining productivity, escalating health crises, and significant income loss. To analyse this critical issue, this study employed a causal structure that links observed heating and climate data (the cause) directly to the varying levels of vulnerability and hardship experienced by informal workers (the effect) over a specified duration in Islamabad.

The study integrates two main theories: *Urban Metabolism Theory* and *Vulnerability Theory.* Urban Metabolism was used to understand how urbanization and resource flows create the UHI effect, while Vulnerability Theory was applied to analyse how inherent human fragility is exacerbated by systemic inequalities, which limit the resilience of informal workers. Together they were operationalized to answer and validate the oncoming data from the interviews conducted.

The methodology employed a qualitative design focusing on subjective perceptions, combining Geospatial Data Analysis with in-depth interviews. Geospatial data was collected for Land Surface Temperature (LST), Air Temperature, Wind Speed, Total Cloud Cover, and Relative Humidity between August 1 and September 30, 2025, during the peak heating time of 2:00 p.m. due to it being a rush hour. This quantified data was used to provide factual resonance and validation to the daily challenges reported by the workers. Data collection involved in-depth interviews using semi-structured questions, participant observation, field notes, and audio-visual recordings, ensuring culturally sensitive and continuous informed consent was maintained.

The Geospatial Data confirmed a period of highly unstable and unpredictable weather during the study period. Key findings included significant temperature volatility; land Surface Temperature (LST) and Air Temperature data showed extreme thermal volatility in August, characterized by rapid, deep slopes in graphs. This transitioned

into a period of sustained, intense heat in late September, where temperatures consistently remained high, with LST approaching and air temperature exceeding. This also showed the unpredictability of the weather patterns; Cloud cover showed constant shifts between clear skies (near 0.0 fraction) and completely overcast days (near 1.0 fraction).

Furthermore, a major, short-lived weather system occurred around August 15th-16th, marked by high wind speed and humidity, demonstrating the need for informal workers to be prepared for rapid and dangerous weather shifts daily.

The thematic analysis yielded five critical themes detailing the experience of informal workers under UHI conditions. Workers face chronic economic deficits, with earnings being insufficient and unstable. Fixed costs, particularly high rent (up to 15,000 PKR) and utility bills (up to 33,000 PKR), often exceed their collective income, forcing them to compromise on necessities like gas usage or healthcare. Productivity is highly dependent on climate, with certain jobs thriving in warm weather (like kulfi selling) while others are severely inhibited by heat, cold, or rain. Extreme weather causes direct asset loss, with rain spoiling perishable goods (like fruits) and halting work, leading to immediate financial losses that can take days to recover. Workers suffer from direct heat and labour-related illnesses (dizziness, headaches, excessive sweating, and chronic sores on feet). They face severe barriers to affordable healthcare, relying on cheap, over-the-counter medication (e.g., Paracetamol) or home remedies (turmeric), as doctor fees (around 1,000 PKR) are unaffordable. The loss of formal support, such as the *Sehat card*, further exacerbates their vulnerability. Workers employ physical heat mitigation strategies (drinking water/juice, using a wet *chaddar*, seeking natural shade under trees or benches). Financially, they rely heavily on borrowing and charity (taking small loans of 500 PKR from relatives, eating at *langar*). Crucially, they exhibit spiritual resilience and reliance on *Rizq*, turning to faith (trusting Allah/God) to manage chronic uncertainty and rationalize persistent effort despite hardship. External forces compound their struggles. Workers face constant CDA disruption, which includes confiscation of goods, asset breakage, and heavy fines (2,000–3,000 PKR). This harassment, often based on accusations of creating crowding or trash, demonstrates a lack of formal protection and dignity, leaving them constantly exposed and displacing them without proper reason.

Conclusion

The findings validate the study's core hypothesis, establishing a clear structure of causality: the fluctuating and intensifying heating patterns associated with the UHI effect significantly exacerbate the existing economic, physical, and systemic vulnerabilities of Islamabad's informal workforce.

The study revealed that the unpredictable thermal environment confirmed by the Geospatial data directly translates into tangible socioeconomic consequences for workers whose livelihoods are dependent on the stability of the weather and outdoor conditions. The intersection of *Urban Metabolism Theory* highlights how the city's growth processes create the UHI (the environmental cause), while *Vulnerability Theory* explains that the failure of social institutions (e.g., lack of social protection, healthcare access, and formal working spaces) critically restricts the workers' resilience. Demonstrating that these workers are a perfect example of what vulnerability looks like. The consequence is a fragile population forced to rely on fragile informal networks and spiritual coping mechanisms rather than institutional support to survive climate-related economic shocks.

In conclusion, the UHI effect does not merely make work uncomfortable; it acts as a stress multiplier on an already highly marginalized and economically precarious population. For Islamabad's informal workforce, continuous exposure to erratic, intense heat directly impacts productivity, leads to escalating health issues, and, when combined with systemic regulatory hostility, creates a cycle of persistent poverty and vulnerability, making their daily survival an increasingly difficult "duty". Addressing this crisis requires integrated strategies that link climate mitigation and urban planning with robust social safety nets and regulatory reforms to grant informal workers dignity and security.

Chapter No 6.

Recommendations

These recommendations are structured to address the core vulnerabilities identified in the thematic analysis, focusing on mitigating the environmental stressors of the Urban Heat Island (UHI) effect while building the social and institutional resilience of the informal workforce, as informed by Vulnerability Theory.

The study revealed that workers face chronic income insecurity, severe health risks exacerbated by UHI, reliance on fragile informal coping mechanisms, and systematic regulatory harassment. Therefore, recommendations are categorized into four key areas: Urban Planning and Climate Mitigation, Social Protection and Health, Economic Stability and Livelihood Support, and Regulatory Reform and Dignity.

- Implement green and cool infrastructure, such as shaded public resting areas and covered market stalls with heat-reflective roofing, in high-density informal work zones (like G-9). This directly mitigates the physical impact of the high Land Surface Temperature (LST) (and Air Temperature confirmed by the geospatial data
- Reintroduce comprehensive health coverage (e.g., the *Sehat card* mentioned by respondents) and establish accessible, low-cost clinics near work areas. This addresses the severe financial barrier where workers cannot afford high fees (e.g., 1,000 PKR doctor fee) and must instead "tolerate" pain or rely on cheap fixes for labour-related and heat-induced illnesses.
- Provide targeted financial subsidies for essential utilities (electricity and gas) to informal worker families. This is critical because fixed monthly costs, such as electricity bills up to 33,000 PKR and rent up to 15,000 PKR, often exceed the workers' total collective income, forcing them to use expensive or dangerous alternatives (like burning fire for cooking).
- Introduce state-backed micro-insurance policies specifically covering income loss and asset destruction resulting from extreme weather (rain, hail, heat). This addresses the rapid depletion of capital, such as fruits spoiling in the rain or a vendor losing 18,000 PKR in potential earnings in a single afternoon due to weather changes

- The Capital Development Authority (CDA) and police must immediately cease arbitrary actions, including confiscation of goods, asset breakage, and the imposition of heavy fines (2,000–3,000 PKR). This external harassment acts as a severe disruption and economic threat that destabilizes livelihoods and compounds climate vulnerability
- Designate official, legal working zones for vendors and daily wage labourers within commercial sectors like G-9 to end the practice of continuous displacement. This grants the workforce formal protection and dignity, recognizing them as functional city components rather than public nuisances creating "trash" or "crowds".
- Given that the peak time for heat and worker availability is 2:00 p.m., city planning must ensure the provision of easily accessible, clean public drinking water stations. Policy reforms should also mandate guaranteed hydration breaks for physically demanding jobs, reinforcing the low-cost coping strategy of drinking water and seeking temporary relief from intense heat.

Interview Guide

1. What is your primary occupation? (Construction worker, street vendor, housemaid, etc)
2. How many hours do you typically work in a day?
3. What is your average daily income?
4. Do you have access to any healthcare services? (mention of Sehat card as example)
5. Have you experienced any health issues related to working conditions in the past year?
6. Do you believe the change in weather patterns has affected your income? If yes How?
7. How often do you face job insecurity?
8. Do you receive any form of financial support or social protection?
9. How would you describe your overall job satisfaction? (feelings on it and expression changes maybe)
10. Have you adopted any coping strategies to deal with climate-related challenges?
11. Can you describe your daily work routine? What challenges do you face?
12. How do climate conditions affect your work performance and productivity?
13. In what ways have frequent changes in weather impacted your health and well-being? Does it change work schedule or stop work?
14. What specific financial challenges do you encounter as an informal worker?
15. How do you manage your expenses with your current income?
16. Can you explain any experiences of job insecurity you have faced recently?
17. What types of support or resources do you think would help improve your situation?
18. How do you cope with the financial pressures and lack of job availability related to your work?
19. What strategies do you use to maintain your health while working in challenging conditions?
20. Can you share any experiences related to access to healthcare services? Has your job provider ever offered healthcare safety etc?

21. How do you perceive the impact of urbanization on your work and living conditions? (mention of increase in rent, food and travel price)
22. What role do you think your specific community support plays in your ability to cope with challenges? (mention peers, family, friends, etc)
23. In your opinion, what are the biggest threats posed by drastic weather changes to your livelihood?
24. How do you feel about the government's role in supporting informal workers like yourself? (if any)
25. What recommendations would you make to improve the working conditions for informal workers in your area?

Participant Consent Form

I voluntarily agree to participate in this research study.
I understand I will not benefit directly from participating in this research.
I agree that my interview will be recorded in the form of audio memo (and picture if allowed).
I understand my name will not be used, instead, it will be replaced with a coding name (participant, respondent, fake name).
I understand my personal details will be safe and hidden in the study.
I understand I can stop anytime and refuse to answer any question I am not comfortable with.
I understand this study is free of any mental or physical harm to me.
I understand this research is purely for educational and explorative purposes.

Questions:
I acknowledge that I am free to contact the researcher to seek any other forms of clarification and information regarding the study.
If you have any questions, you can contact me at _____

_____ _____

Signature of Participant Date

_____

Signature of Research

Annexure

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