DESIGNED TO FAIL?
HEAT GOVERNANCE IN URBAN SOUTH ASIA:
THE CASE OF KARACHI
A SCOPING STUDY

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EXECUTIVE SUMMARY

According to the Global Climate Risk Index (2021), Pakistan is the eighth most vulnerable country in the world, and its southern province of Sindh is one of South Asia's 'hotspots' for climate change (Mani, 2018). The 2015 heatwave in Karachi – Pakistan's largest city – was a trigger for local action, with heatwaves becoming an object of climate governance for planners, policy makers and a large number of NGOs engaged in on-ground relief work. The resulting actions on overheating undertaken by urban governors and policy makers, remain top-down and challenged by unexamined assumptions about the vulnerabilities of poor groups. Such one-dimensional approaches to discrete climatic events led us to question whether current heat management strategies in cities like Karachi are, in fact, designed to fail in the protection of life.

This scoping study draws on a review of key policy documents, plans, grey, academic, and scientific literature to outline the role of state and non-state actors in Karachi's heat governance. It emphasizes the need to understand heat, microclimates, urban planning, infrastructural inequities, and vulnerability in a relational context. It also presents original climate data analysis for the last 60 years in Karachi, to quantify the rapid temperature change in the city: findings that underscore why it is important now, more than ever, to talk about heat in the context of an unequal city. This is even more pertinent in the context of a city like Karachi that lies in the 'ultraviole(n)t' zone of solar exposure (Kripa and Mueller, 2020).

Fundamentally, this scoping study underscores that the experiences of heat must be understood as a slow onset disaster, particularly in terms of the effects of chronic heat exposure on daily life, worker productivity, health, and wellbeing, amongst other indicators (Opperman, *et. al.* 2019). In doing so, this Scoping Study proposes a way forward to think about Karachi's changing weather and the onset of chronic heat exposure in terms of 'zones of vulnerability'. Such zones are crucial to consider not only due to their higher vulnerability to detrimental effects of heat exposure, but also because risks associated with rising temperatures are likely to make them into nodes that reveal, deepen and sediment pre-existing socio-spatial inequalities within cities like Karachi. Finally, this scoping study serves as a resource base for those who are interested in studying the relationship between rising temperatures, chronic heat exposure, urban planning and vulnerability in other parts of the urban Global South.

1. INTRODUCTION

Human activity has raised global temperatures by approximately 1.1°C since preindustrial times, and studies (Bazaz *et al.,* 2018; Carrington, 2021) show nearly 70 percent of cities worldwide are impacted. Heat has recently gained traction globally given the spike in climate change induced events across the Global North (Cecco, 2021; Cappucci and Samenow, 2021). The 6th Annual IPCC report on Climate Change (2021) has also given somber warnings of global temperatures experiencing up to a 2°C increase by as early as 2040, resulting in irreversible impacts of anthropogenic climate change. In regions such as South Asia, temperatures have already reached levels that are higher than what is considered biologically liveable (Lewis, 2021; ADB, 2010; Mearnes and Norton 2009). According to the Global Climate Risk Index 2021, Pakistan is the eighth most vulnerable country in the world (Eckstein *et al.*, 2021): within the last two decades, Pakistan has experienced over 152 adverse climatic events comprising floods, storms, heatwaves, and droughts (UNDP, 2020). Certain studies (Chaudhry, 2017; Anwar, 2012) based on the Global Circulation Models (GCMs), project that in Pakistan, average temperatures will increase 2.5–2.8 °C by the 2050s, and 3.9–4.4 °C by the 2080s. From a historical perspective, the overall temperature in Pakistan has already risen by an average of 0.6°C (TFCC, 2010). A significant change is the increased frequency of days with intense heat: a five-fold increase in heatwave days per annum (TFCC, 2010). Pakistan's southern province of Sindh is understood as one of South Asia's hotspots for climate change (Mani, 2018:10), and its largest city – Karachi – has become a focal point for planners, policy makers and NGOs in matters of heat governance.

With an official population of 16 million, Karachi is located at 24 degrees north of the equator, within the zone of 'ultraviolent' radiation (Kripa and Mueller, 2020). This is the zone between 30 degrees North and 30 degrees South that is increasingly exposed to intense ultraviolet radiation. The 2015 heatwave – considered the fifth deadliest recorded in global history across parts of South Asia (Escape, 2016) – was a trigger for local action in Karachi. The heatwave precipitated an official 1181 deaths (Chaudhry, 2017; Chaudry *et al.,* 2015; Imtiaz and Rehman, 2015), although senior municipal officers estimate a higher figure of 3000 deaths. Heatwaves are now an object of governance in Karachi and in other cities in Pakistan, and the impacts are understood as taking different forms: impairing health, well-being and productivity, and triggering migration (Mueller *et al.,* 2014; Umar and Saeed, 2018; ILO, 2019; HANDS, 2020). However, the policies and plans – Task Force on Climate Change 2010, National Climate Change Policy (NCCP) 2012, and Sindh Climate Change Policy (draft) – amongst several others, have largely omitted heat and thermal stresses from the broader discussion on climate change risk mitigation and adaptation. Thus far, the only government intervention for managing heat is the Karachi Heatwave Management Plan 2017 (KHMP), which treats heat as a discrete event and ignores the fact that extreme heat also occurs as prolonged exposure, particularly as a result of climate change where it is increasingly considered as a slow onset event, resulting in loss of productivity, impacts on health and wellbeing, and even the incidence of chronic disease (Oppermann *et al.,* 2021). In Karachi, the actions on overheating by city planners, urban governors and policy makers, remain top-down and challenged by unexamined assumptions about the vulnerabilities of poor groups. Hence, there is limited evidence about whether current heat management strategies in cities like Karachi are a good fit for the context in which they are deployed.

Poor populations in relatively high-risk areas (Willbanks *et al.,* 2007: 359) have always been considered more vulnerable to adverse climate events. The Intergovernmental Panel on Climate Change (IPCC) defines vulnerability as "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes" (IPCC, 2001: 995). This definition was updated in 2018 to reflect the "propensity or predisposition to be adversely affected...encompass[ing] a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt" (IPCC, 2018: 560). However, vulnerability is a complex and multidimensional concept encompassing individual biophysical as well as socio-spatial, economic, and environmental characteristics. Fundamentally, vulnerability is embedded in everyday life and not necessarily linked with episodic extreme events. In this scoping study, vulnerability is understood as being driven by social power relations and inequalities that arise from shifting regimes of urban resource accessibility (Adger, 2006). The relative inability to recover from the harm wrought on by material and socio-spatial inequalities, is understood to be a function of a person and group's social positionality by virtue of ethnicity, gender, age and class and the wider political economy; the issue of political economy being particularly pertinent as it draws attention to the planning and governance process that produces resource inequality at different spatial scales, for instance the city, the neighbourhood and the household. Moreover, attention to class, age, gender and ethnicity enables a deeper conceptualization of vulnerability in terms of consequences for daily life for men, women, children, the elderly and migrants who are at risk of heat exposure. Hence, a key challenge is to understand how social vulnerability intersects with access to water, electricity, adequate/safe housing and how this might exacerbate heat exposure. In highlighting this approach, we caution against homogenising vulnerability, and the subsequent capacities to cope with it. Such a view complicates the idea of discrete climate events as mere catalysts, rather suggesting that these events compound existing vulnerabilities and impact populations in a multitude of social, economic, and physiological ways.

In Pakistan, generally, people living in rural and small towns are considered the most vulnerable in terms of absolute poverty and access to infrastructures. However, a mega-city region like Karachi brings with it its own dynamic of vulnerability. Unstable governance structures, anti-poor urban planning (Hasan, 2016) and political violence

(Verkaaik, 2004; Khan 2010; Gayer, 2014) have been both a cause and effect of differential and contested access to land, livelihoods, and infrastructures. In 2018-2019, 52 percent of Pakistan's population (216 million) was considered vulnerable to poverty, with nearly 78 million Pakistanis designated poor, and the province of Sindh showing one of the highest headcounts at 44 percent (Jamal, 2021). In urban Pakistan, vulnerability to poverty often intersects with limited or poor access to critical infrastructures such as adequate and secure housing, land, clean water, and uninterrupted electricity (UNDP, 2020). In Karachi, well over 62 percent of the population resides in informal settlements with unequal access to infrastructures. Further, an unknown number of people live in makeshift housing such as *jhuggies* and many are homeless (Ahmed, 2020). Moreover, in Pakistan, 72 percent of the country's total population, and 68 percent of its urban population, is involved in informal[1] employment (Pakistan Employment Trends Report, 2018; ILO 2021), with a substantial number of low-wage workers in Karachi[2] implicated in informal employment: daily wage jobs, or in precarious contractual arrangements devoid of labour welfare policies and services through the state or through their employers. This leaves them out of not just tax nets, but also of broader social security arrangements. The larger part of their incomes is spent on necessities such as food and utilities (Hasan *et al.,* 2017). Under such uncertain arrangements of employment, housing tenure, and social safety, particular urban populations become further vulnerable to sudden shocks such as climatic events, or unprecedented urban regulations such as containment during the pandemic. Changing climate and the variations in microclimates across the city, not least tied to varying urban ecologies and built morphologies, add a further layer of complexity to this vulnerability.

This scoping study features original data analysis on climate data for the last 60 years for Karachi, as well as a review of key policy documents, plans, grey literature, and academic and scientific literature concerning Karachi's emergent heat governance space. We draw on these to outline the role state and non-state actors are playing in Karachi's heat governance, and the importance of understanding heat, vulnerability, and inequality in a relational context. Non-state actors such as civil society organisations have become particularly active in Karachi's heat space, albeit in indirect ways. The review is placed within the broader context of rising temperatures, rapid urbanisation, ecological degradation, and extensive infrastructural inequities, as well as the historical socio-spatial marginalisation of working class, poor, and lower-income populations, who are most at risk of heat impacts.

Karachi is a highly unequal city where land, housing, and inequitable infrastructures – in addition to different rates of temperature change in the city's core and peripheral areas – have become significant drivers of people's

1 Based on ILO standards, the Pakistan Employment Trends 2018 Report describes 'informal' employment in three categories: household enterprises (own-account workers); enterprises with less than 10 persons; and excluding agricultural and non-market production.

2 Breakdown by city not available in Pakistan Employment Trends Report 2018.

vulnerabilities: for vulnerable populations, living with heat means living with the risk of death. We underscore that in the present context, heat governance in Karachi is designed to fail in the protection of life. In the absence of credible long-term empirical data and analysis, coupled with a limited understanding of the unequal city at the policy level, the failure to plan for heat governance pivots not only on planners' and policymakers' fixed/rigid understandings of heat but also in terms of the limited administrative capacities and resources available at the local scale for mitigating heat risks. We conclude by discussing the prevailing lacunae in the local context of discussions on heat and vulnerability in relation to home and workspaces, and the possibilities of overcoming these to enhance the tools, discourses, and methodologies through which policymakers and planners can better understand and manage heat.

2. CHANGING CLIMATE, RAPID URBANISATION

Karachi is Pakistan's largest city and a strong driver of the country's industrialization and development: it contributes approximately 25 percent to Pakistan's GDP, and 54 percent of its tax revenue. Karachi comprises 7 districts that are administered by the Karachi Municipal Corporation (KMC), and 6 cantonment areas that fall under the purview of the Pakistan military (Figures 1a & 1b). Karachi's variegated topography, geographical location, and heterogenous land cover contribute to a complex climatic profile. Moreover, high-density high-rise buildings interspersed with abundant use of asphalt for roads and limited green vegetation typify Karachi's central business district and wealthy neighbourhoods, while large neighbourhoods of low-income and informal settlements or *katchi abadis* are characterised by dense housing, little or no vegetation, and limited access to water and electricity. Thus, Karachi hosts a variety of micro-climates across its many settlements.

Karachi's physical terrain is marked by the Khasa and Mulri hills to the north and northwest and rolling plains leading down to the Arabian Sea coast in the south (Pithawala *et al.*,1946). In terms of vegetative cover, the brackish waters around the Karachi harbour and the mouth of the Indus Delta host dense mangrove forests, with rangeland forests towards the north and north-east of the city.[3] The city's hydrology is based around the Malir River to the East, the Lyari River passing through the centre, and the Hub River to the west. The Malir and Lyari rivers support not only the city's drainage system, but also agricultural activities. In the context of these locational, ecological, and physiographic features, Karachi's climate is classified as BWh (low altitude, hot arid and subtropical climate) under the Koppen-Gieger system (Beck *et al.*, 2018). Although the city's annual ambient temperature averages 25.9 degree Celsius, data from 2020 shows a summer (June)

3 https://earth.esa.int/web/earth-watching/historical-views/content/-/article/karachi-pakistan

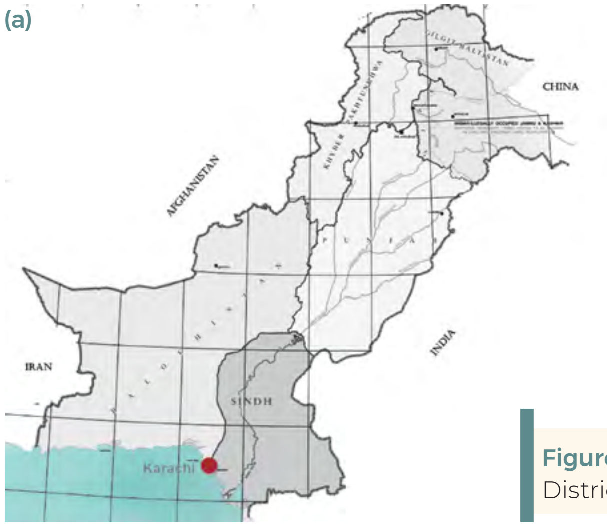


Figure 1 (a) Karachi's location on Pakistan map (b) Karachi District map. Prepared by Karachi Urban Lab, 2021.

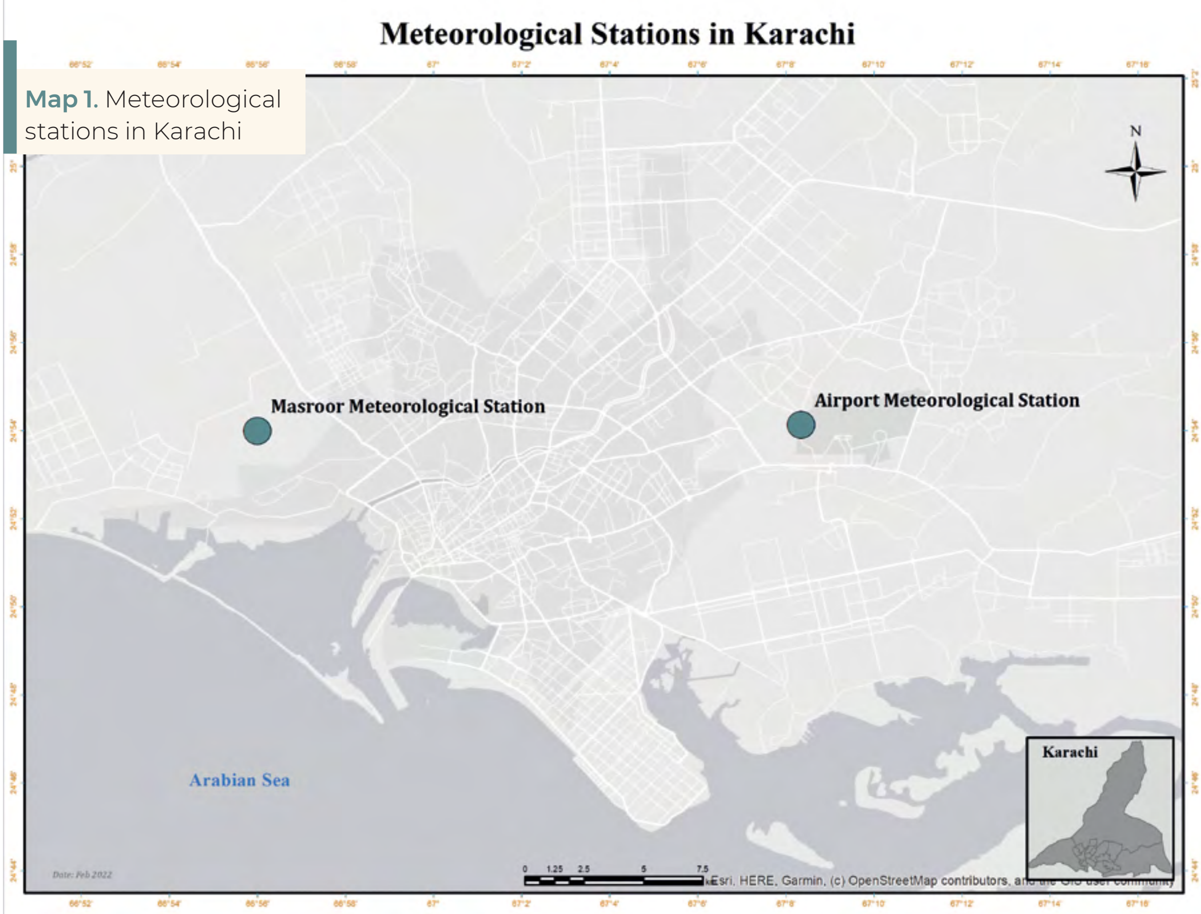
high of 42 degrees and a winter (December) low of 10 degrees (Climate-Data, 2020)[4].

Karachi experiences relatively high humidity due to its location on the Arabian Sea, with values ranging from 58 percent in December to as high as 85 percent in August (Hasan and Mohib, 2003). This humid condition generates an experience of 'moist heat waves' that are characterised by ".... very warm, oppressive, humid conditions throughout the day and night, often with nocturnal cloud cover, a feature that prevents loss of heat accumulated throughout the day and thus less night-time relief." (McGregor *et al.*, 2015:1) Wind patterns around the year are largely dependent on the moisture laden coastal breeze blowing in from the Southwest, and a brief spell of drier winter winds from the North. Rainfall in Karachi is highly variable, and typically lasts from June to September with an average annual rainfall of about 170 mm (Zafar and Zaidi, 2019). The years 1987, 1991, 1993, 1999, and 2014 were the driest years during which Karachi received less than 50 mm annual rainfall. However, in 2020, the monsoon rainfall was unprecedented with 345 mm recorded within a span of two days. Different parts of the city were submerged for weeks in water; power outages lasted for days, and more than a 100 people died (Bhutto, 2020). Even though the 2020 rainfall was unprecedented, the city's degraded infrastructures exacerbated the floods and the extent of damage to people's lives and possessions.

2.1 Changing climate

A clearer understanding of climate trends in Karachi is imperative to inform policy making for climate adaptation. Despite the recent increase in the body of literature on impacts of climate change, there is still a lack of clarity on the specific changes in climate Karachi has already undergone and is projected to experience in the future. This can partly be attributed to the lack of climate data gathering points: Karachi has only three state-operated weather stations, out of which two are at military bases with restricted data sharing. The data from only one, the Jinnah Airport

4 https://en.climate-data.org/asia/pakistan/sindh/karachi-992367/



Map 1. Meteorological stations in Karachi

weather station, is relatively easy to access. In the absence of easily accessible climate data, existing studies are unable to employ rigorous statistical analyses to credibly quantify changes in Karachi's climate.

For this study, we have acquired daily climate data[5] for the duration of 1960-2020 at Jinnah Airport weather station, situated near the centre of the city. We also acquired daily climate data from 1975-2020 from the weather station located at the Pakistan Air Force (PAF) Masroor air base, located at the Western periphery of the city closer to the coast, in a sparsely developed area. (Map 1) To our knowledge, the climate data for Masroor has not been used previously in a published study. This also raises important questions regarding the limited access to important climate data that prevents informed heat governance. In this section, we present results that demonstrate the rapid warming being experienced in Karachi. For the first time, we highlight the spatial, seasonal, and diurnal variations in the rate of warming being experienced across the city's uneven morphological and climatic terrain and assert the need for multiple monitoring sites across the city to build a higher resolution understanding of the city's microclimates.

Figure 2 shows annual average maximum (left panel) and minimum (right panel) temperatures (T_{max} and T_{min}) at both Airport and Masroor. Across all four time-series, a clear increasing trend is

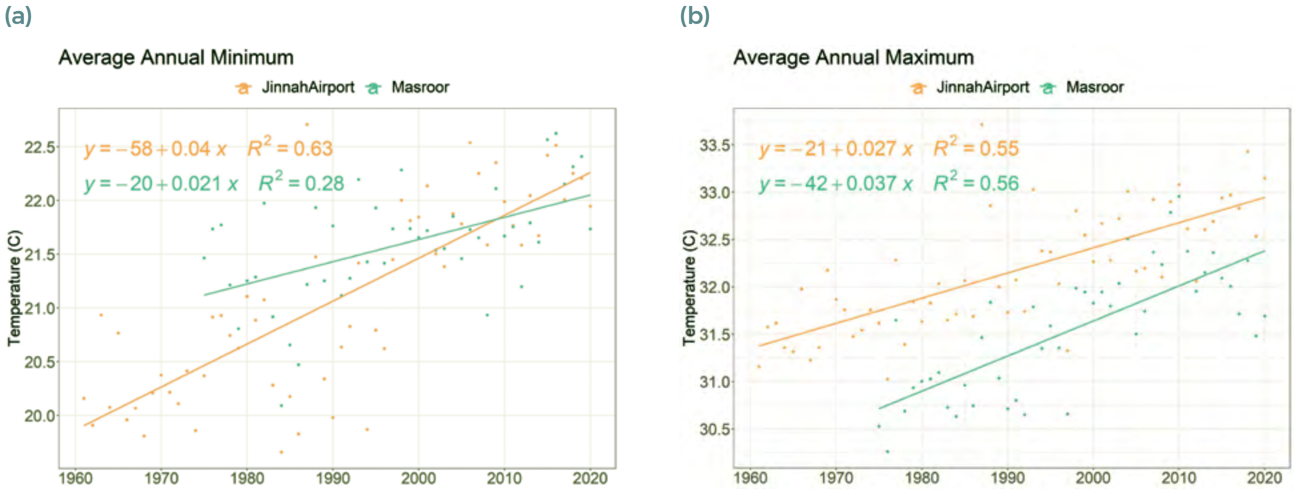
5 For 4 meteorological parameters: T_{max}, T_{min}, precipitation and humidity

observed illustrating the rapidly warming climate in the city. Since 1960, Karachi's night-time temperature has increased by approximately 2.4 °C, while daytime temperatures are up by 1.6 °C. Relative to the global average increase in temperature of 1.1 °C since 1900 (IPCC 2021), the rate of warming in Karachi is especially high. The left panel shows that T_{max} (signifying daytime temperature) is higher at Airport than at Masroor. However, the difference in T_{max} between the two stations is narrowing, with the rate of increase at Masroor (0.37 °C/decade) slightly greater than that at Airport (0.27 C /decade). For T_{min}, shown in the right panel, the relationship is inverted. At the beginning of the time-series, night-time temperatures were higher at Masroor. However, with the rate of increase at Airport (0.4 °C/decade) almost twice as large as that at Masroor, that is no longer the case. Based on the current trends, the difference in night-time temperatures between the two stations is getting larger. The Airport station, closer to the city centre, has both higher daytime and night-time temperatures.

These results display a clear difference in the rate of warming between the two stations, which are about 18 km apart. This difference can be partly attributed to the Urban Heat Island (UHI) effect since the Airport station is more inland and surrounded by dense urban settlements relative to Masroor, which is located closer to the coast and surrounded by comparatively fewer, lower density settlements, consisting mostly of large tracts of rocky, undeveloped land. In their analysis on differences between UHI for Karachi and surrounding rural towns, Rizvi *et al.*, (2019) demonstrate that the UHI effect is greatest between 0100-0400 hours (approximately corresponding to the T_{min}), which is borne out in our results too.

While the UHI impacts both daytime and night-time temperatures, factors driving the heat islands during the day are different than those at night (Arnfield 2003). In addition, existing literature for major urban centres globally shows temperature increases do not necessarily occur uniformly across the entire year (Imhoff *et. al.* 2010). To investigate whether there are seasonal and

Figure 2: Annual average maximum (a) and minimum (b) temperatures for two weather stations in Karachi. Jinnah Airport is located closer to the centre of the city, while Masroor is situated near the coast



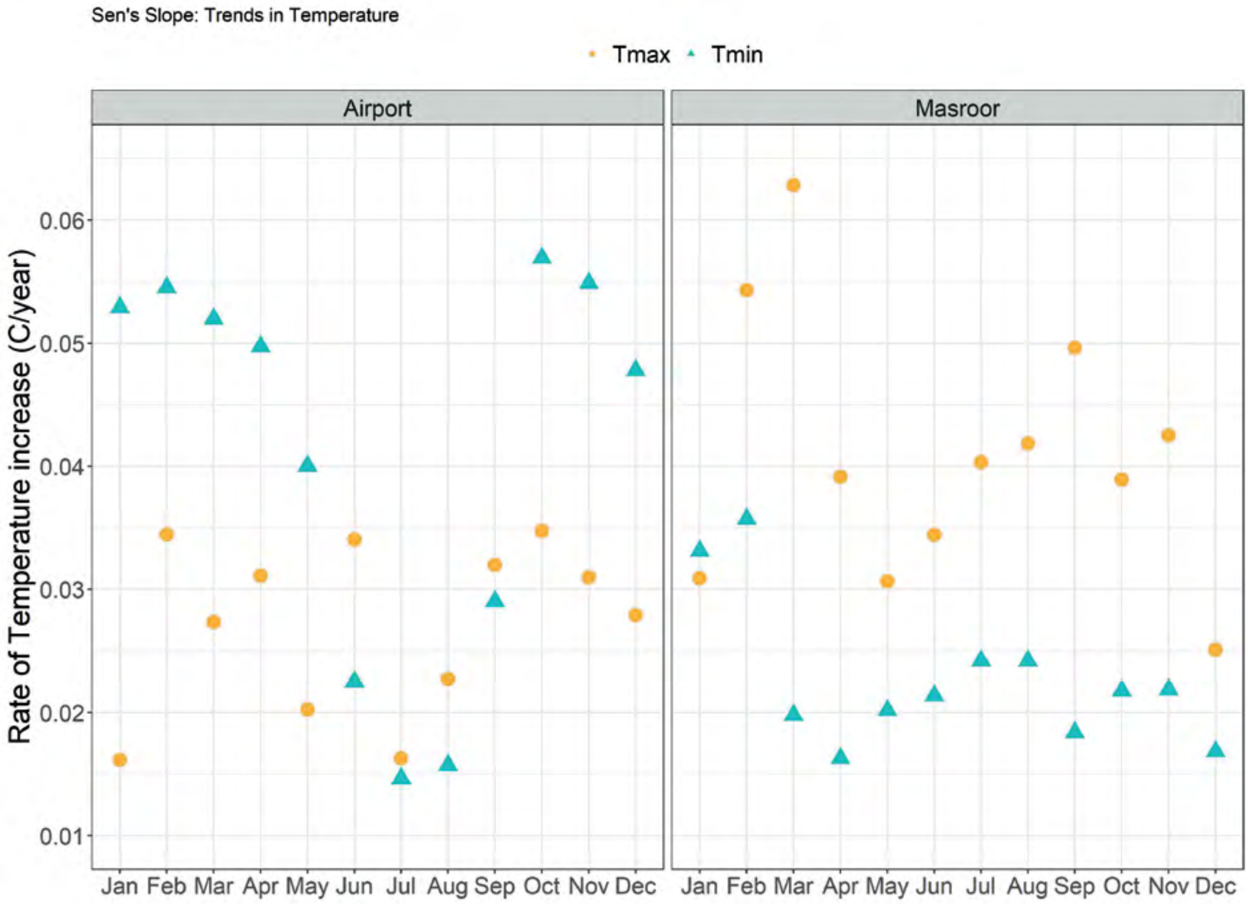


Figure 3: Rate of annual temperature increase in each month for each station using the Sen's slope method

diurnal differences in rate of temperature increase at each station, we calculate trends for each calendar month for both T_{max} and T_{min}. using the Mann-Kendall (MK) test. The MK test is a non-parametric test that is widely used in climate analyses to detect statistically robust trends (Modarres and de Paulo Rodrigues da Silva 2007; Tabari and Talaee 2011). Results from the MK test for Karachi reveal that 47 of the 48 monthly trends (2 variables × 2 stations × 12 months) are statistically significant, further emphasising the intensity of warming being experienced in Karachi.

Next, we calculate the magnitude of the monthly trends using the non-parametric Sen's slope method. Our results shown in Figure 3 provide a comparison of the diurnal, seasonal, and spatial variations in the rate of warming experienced by Karachi. Near the city centre (Airport weather station), the highest rate of increase is for night-time temperatures (T_{min}) from October to May where the rate exceeds 0.4 °C/decade. This finding is supported by existing analyses for South Asian cities that show the UHI effect to be greater during the night (Peng *et al.*, 2012). The rate of increase for T_{min} at the Airport from June-September is noticeably lower highlighting the seasonal variation in warming. It is only in these four months that the rate of increase for T_{min} is lower than that for T_{max}. A plausible reason for this reduced UHI effect could be precipitation since most of the annual rainfall in Karachi occurs between June-September (Rizvi *et al.*, 2019).

At the Masroor station closer to the coast, like the results shown in Figure 2, the rate of increase of day-time temperatures (T_{max}) is almost always higher than night-time temperatures (T_{min}). For nearly all months, T_{max} increases at Masroor are higher than those observed at the Airport. This implies that the less urbanised area is warming up faster than the urbanised area (i.e., the UHI index is negative). While most large cities globally experience a positive UHI, previous studies have found some cities (often surrounded by deserts) experience lower daytime temperatures than surrounding areas. A possible reason for this is the presence of vegetation in the city that provides an evaporative cooling effect during the day (Stabler *et al.,* 2005). However, this evaporative cooling from vegetation is not present during the night and does not appear to affect night-time temperatures.

Unlike at Jinnah Airport, monthly T_{min} trends for Masroor show a lower rate of increase. One reason for this might be the modulating effect of the coastal breeze that prevents night-time temperatures from soaring near the coast. This modulating effect has been found previously by Acero *et al.,* (2013) and Giannaros and Melas (2012) where proximity to the coast reduced the UHI effect. The seasonality in rate of temperature increase observed in the Airport time-series is not as obvious at the Masroor station, where rates of increases are generally comparable throughout the year for both T_{min} and T_{max}, except for the Jan-Mar where the rate of increase in T_{max} spikes.

Figure 4 shows how daytime and night-time temperatures vary at the Airport station and provides a comparison for how the temperature profile has changed over the past 50 years. For the two periods shown here (1960-1970 and 2010-2020), average maximum (T_{max}) and minimum (T_{min}) temperatures were calculated for each month. During the 1960s, average T_{max} exceeded 35 °C only in May. The figure reveals that based on average T_{max}, the 'summer' season in Karachi now has shifted earlier with daytime ambient temperatures averaging over 35 °C in April; a finding supported by other recent studies (Ullah *et al.,* 2019). Not only has the summer season shifted earlier, but it also lasts longer now, with T_{max} in June also averaging well above 35 °C. Karachi's climate profile in the 1960s shows the presence of two 'warm' seasons; the first one follows the end of winter (April onwards) while the second one occurs right before the onset of winter (in October). While the second warm phase tended to be slightly cooler than the first warm phase during the 1960s, the data suggests that the second warm phase now shows T_{max} that are almost as high as those observed in the first warm season.

The monthly pattern of night-time temperatures differs from that of day-time temperatures; the two phases of warm season are not observed with night-time temperatures peaking in June and then decreasing through January. Over the course of a year, average night-time temperatures show a greater range of variation than day-time temperatures. The increase in May night-time temperatures is among the more notable earlier shifts in climate; average T_{min} in May are now as high as T_{min} was in June in the 1960s. Considering both temperature variables, the difference in climate between May and June has reduced significantly over the past 50 years.

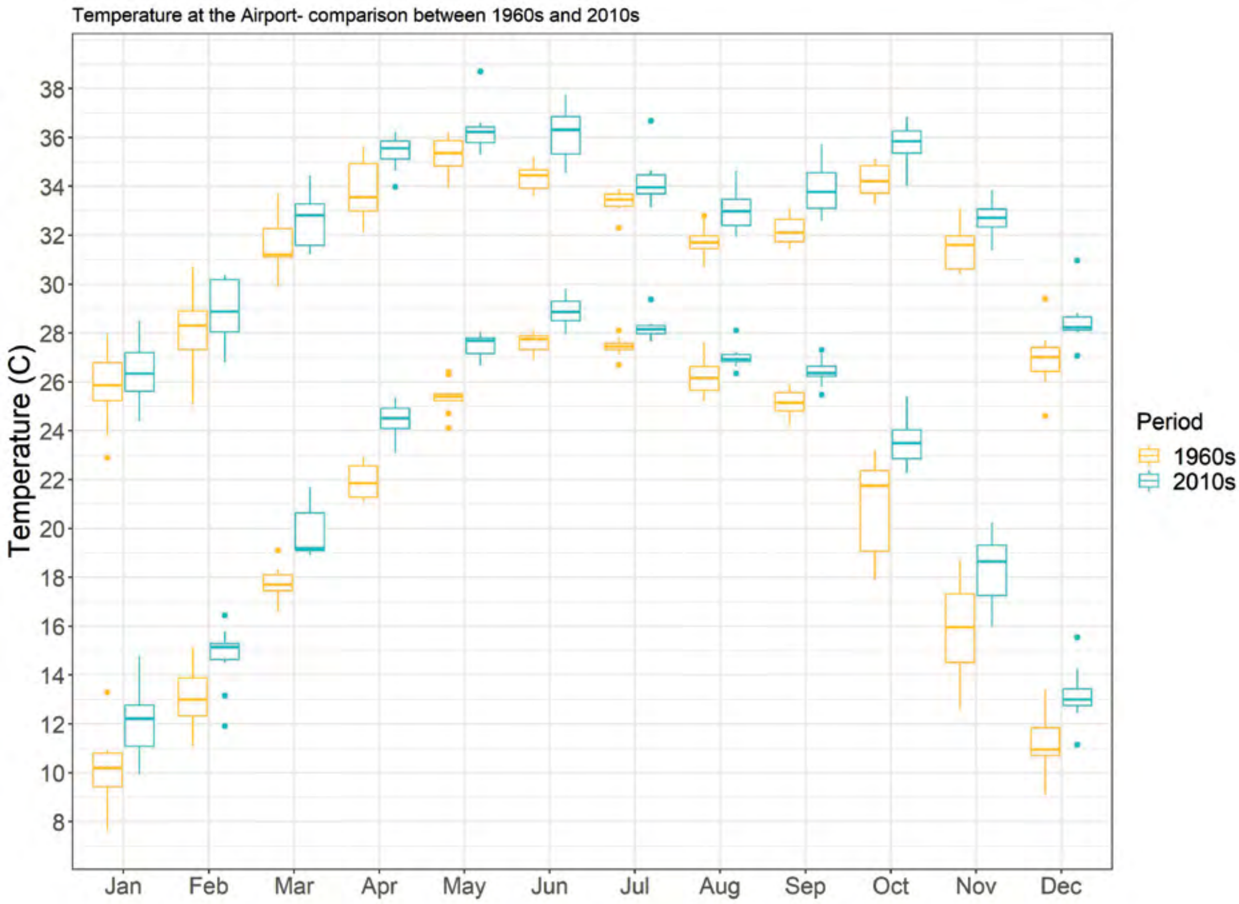


Figure 4: Average maximum and minimum temperatures during 1960-1970 (1960s) and 2010-2020 (2020s) at the Jinnah Airport

The findings mentioned above agree with studies that have predicted changing climatic trends in the coastal hubs of South Asia (Syed, 2014), as well as the onset of temperature extremes in Pakistan (Zahid and Rasul, 2011; 2012; Klein Tank *et al.*, 2006). Despite such noticeable shifts in the climate patterns of Karachi, there is a clear gap in consolidating temperature data and integrating it with urban indicators to build a more nuanced understanding of the implications of climate change for urban environments. Some reasons for this gap include: a lack of advanced weather monitoring systems at current weather stations; an insufficient number of localised weather stations to monitor microclimates across the variegated morphologies of an unequal city; data records not accounting for standardised measures such as Wet-Bulb Globe Temperatures (WBGT); a lack of climate studies on Karachi incorporating appropriate heat indices that account for external factors such as humidity. Additionally, other cities within Sindh, such as Jacobabad and Larkana, routinely experience prolonged periods of higher temperatures in comparison to Karachi. For instance, during the 2015 heatwave, the highest temperature recorded in Karachi was 44.8 °C but in the comparatively smaller cities of Larkana and Jacobabad, the temperature highs were between 49°C to 50°C (Hanif, 2017). However, the compounded effects of urbanisation, temperature, humidity, and coastal proximity differ across these cities. The use of appropriate heat measures is crucial to analyse such differences, particularly in terms of problematizing how we understand heat on a spatio-temporal scale and in relation to vulnerability.

In Karachi, such climatic shifts are likely to exacerbate people's vulnerabilities that have been conditioned by long standing socio-spatial and infrastructural inequalities. The inequalities have arisen in the context of colonial and post-Partition legacies of urban development, migration, inadequate housing, and inequitable land distribution. In the following section, we provide a brief overview of these dynamics.

2.2 An Unequal City

Karachi is a port city that expanded under British colonial rule in the 19th century. With the Partition of British India in 1947, Karachi became the federal capital of the new nation-state of Pakistan. Partition triggered the arrival of 600,000 Muslim migrants from the Indian states of East Punjab, Northern India, and the former United Provinces into Karachi (Figure 5a & 5b); a historical moment that marked an unprecedented demographic shift. Since 1947, Karachi has grown exponentially both in terms of urban sprawl and population. In 1972, approximately 63 percent of the population of the metropolitan area lived within 10 km of the city centre. Today, over half of Karachi's population resides more than 20 km from the city centre (Shehri, 2014).

Karachi's expansion has unfolded on agricultural land and along a long coastline overlooking the Arabian Sea. But this sensitive ecological land is gradually eroding due to land reclamation for real estate development and infrastructural projects. In the districts of the north and

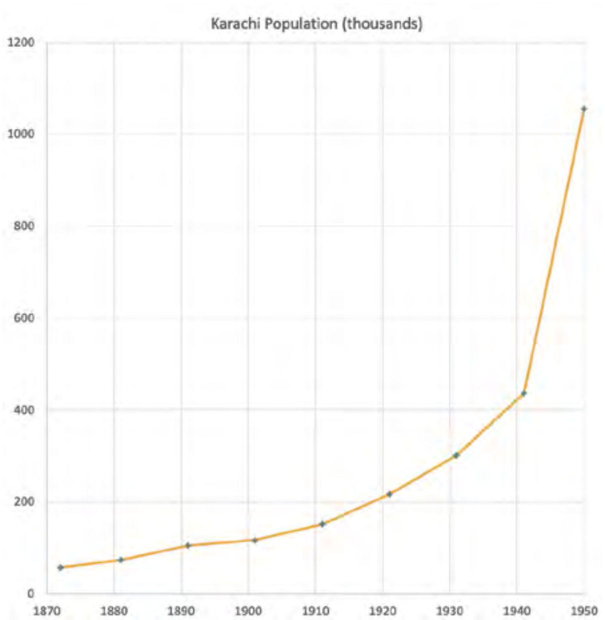


Figure 5a: Growth in Karachi's population, in thousands, from 1872-1951. Source: 1921 Census of Bombay Presidency; www.macrotrends.net. Prepared by: Karachi Urban Lab, 2021.

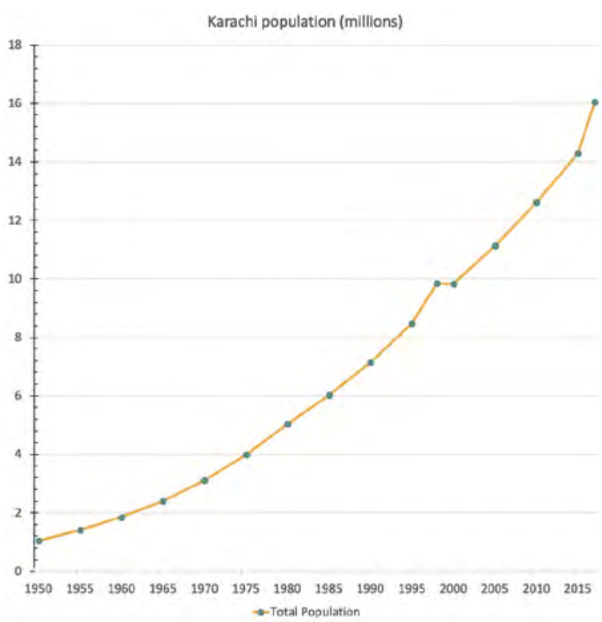
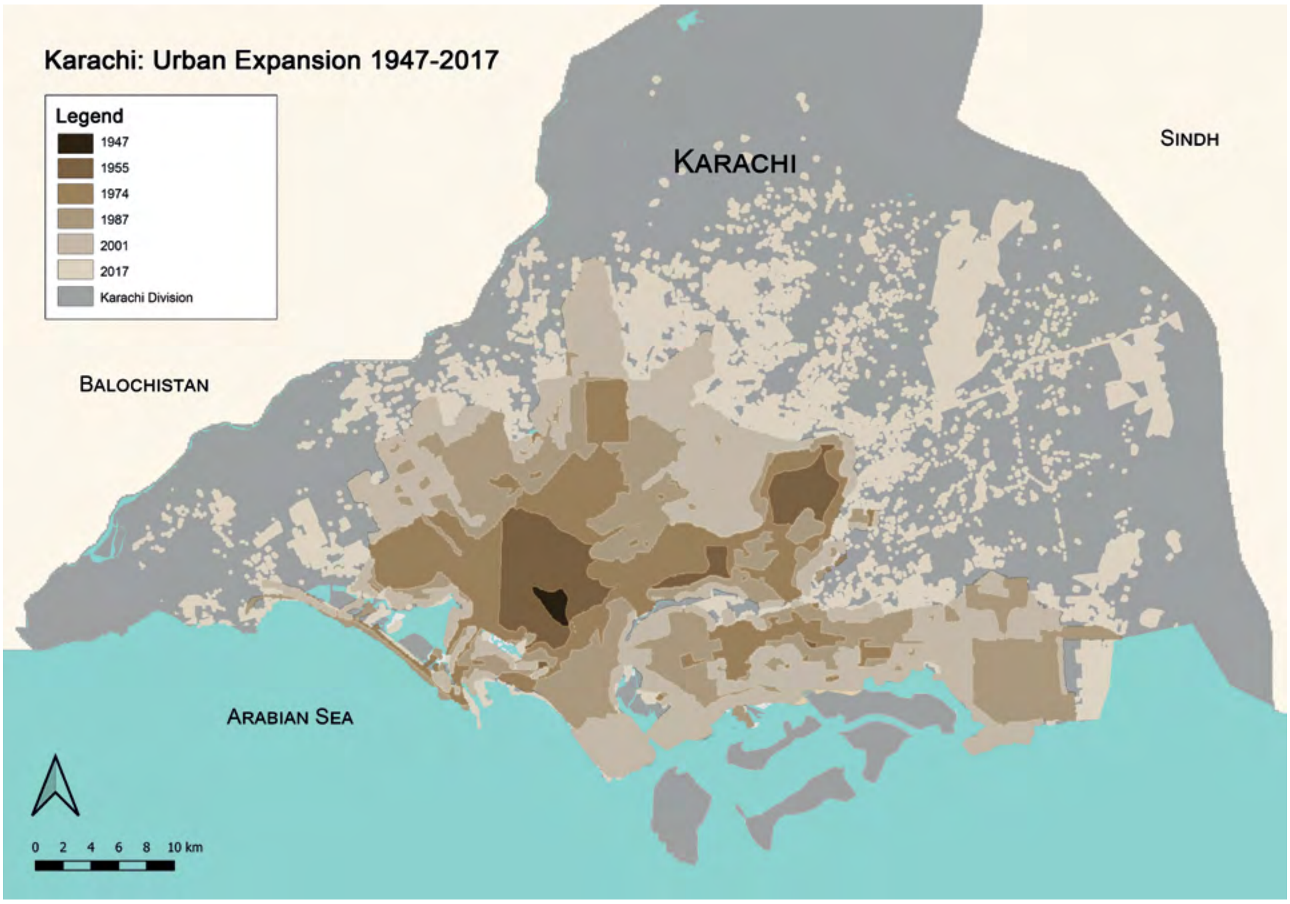


Figure 5b: Growth in Karachi's population, in millions, from 1951-2017. Source: Pakistan Population Censuses 1998, 2017; www.macrotrends.net. Prepared by: Karachi Urban Lab, 2021

west, urban expansion triggered by new informal settlements and gated housing schemes, has taken place in either the undulating plains that are largely devoid of vegetation and have dry riverbeds and water channels, or on agricultural land (Figure 6). The Malir Basin was a rich agricultural zone at the time of Partition. Beginning in the 1980s, a long spell of drought and unsustainable sand/gravel mining practices lowered the indigenous water wells. Sand/gravel mining in Gadap relates to the city's expansion, being the key constituent of concrete: the material predominantly used in the construction of buildings for rich and poor alike. The riverbed in Malir has been excavated to a depth of 20 feet or more and extraction continues in sensitive areas, for instance near water pipelines. Consequently, as built-up land has increased, cultivable land has declined: cultivable land in Gadap and Malir has decreased from 61 percent in 1960 to 19 percent in 2000 (Shehri, 2014).

The Malir and Lyari Rivers are polluted due to the dumping of industrial and untreated effluent discharge (Siddique *et al.*, 2009). Over the past decades, the city's natural drainage system, consisting of nullahs that allow rainwater to flow across the city into the Arabian sea, has turned into a dumping ground for all kinds of waste. In the summer monsoon, the *nullahs* often overflow, and water stagnates in the city's streets for days. Working class, poor settlements that inhabit the *nullahs*' banks, are regularly submerged in this combination of water and sludge. Rapid

Figure 6: Karachi's urban expansion post-Partition. Data sources: KSDP 2020, World Bank online database. Processed and prepared by Karachi Urban Lab, 2021.



urbanisation in Karachi has also produced differentiated spaces with stratification along classes and consumer lifestyles; an emergent urban middle-class[6] aspires to invest in and live within exclusive housing schemes on the city's new peripheries against the backdrop of an acute housing crisis for the poor, low-income and working-class populations. Estimates reveal a housing shortage of roughly 10 million units in the country, and the deficit continues to grow in Karachi (World Bank, 2017). Rapid and variegated urbanisation has also led to rising energy demands for lighting and cooling the city's private spaces, and certain authors (Mahmood *et al.*, 2013) contend this rise will become more pronounced in response to climate change. Unsustainable levels of electricity consumption relate to the demand for cooling technologies such as air conditioners and changing middle-class lifestyles (Khalid and Sunikka-Blank, 2018).

Alongside these developments, Karachi's inner-city neighbourhoods have continued to densify by occupying available open green spaces, initiating (largely illicit) vertical construction by colluding with multiple tiers of state and non-state actors, and converting and subdividing large amenity plots, public land, parks, and cemeteries into smaller residential plots. Karachi's peripheral areas are dotted with informal settlements or new *katchi abadis* (Anwar, 2013), and many are not connected to the electricity grid and have limited or no access to public water supply. The story of Karachi's informal settlements can be traced to the planning edicts and the rationalisation of urban space after 1947, notably the State's reliance upon large populations of working-class labourers/migrants, whom it had no plans to house in the ambitious strategy for industrialization in the 1960s (Daechsel, 2015). Fundamentally, Karachi's five master plans have failed to address the extensive challenge of affordable and adequate housing, and equitable land distribution. The first such attempt was made in the late 1950s, when the state planned the resettlement for the post-Partition working class, poor migrants under the 1958 Greater Karachi Resettlement Plan. Conceived by Constantine Doxiadis, the plan proposed satellite towns in Landhi and Korangi for rehabilitating the migrants (Daechsel, 2011). But the plan failed to account for people's proximity to workplaces in the city centre, and this greatly impacted their abilities to maintain livelihoods. This also forced a substantial number of the working class back into the city's core, where they distributed themselves amongst various kinds of cheap accommodation: informal shacks, informally increasing verticality, and plot subdivisions. As occupations, such as retail, labour, and industrial activities, remained focused around the city centre, formally planned housing schemes located on the periphery, proposed as part of the Karachi Development Plan 1975-1984 and later the Karachi Strategic Development Plan 2020, never materialised, and most state housing schemes remain vacant (CDGK, 2020:68).

Despite being clearly marginalised within the state's vision of its new orderly city, informal settlements have continued to emerge and expand. Karachi contains

6 During the first decade of the 21st century, the middle-class in Pakistan grew from 32 percent to 55 percent of the total population and accounted for 90 percent increase in national consumption (Ghani, 2014).

575 informal settlements as declared by the Sindh Katchi Abadi Authority (SKAA), the provincial agency for regulating informal settlements. However, some researchers suggest a substantially higher number of 700 informal settlements (Hasan and Mohib, 2003). Within these informal settlements, tenure security is uneven, and densities are much higher than in the formally planned areas of the city. For instance, Mujahid Colony, an informal settlement in Karachi's District Central, has a density of approximately 228,600 people/sq km (Anwar *et al.*, 2021), compared to 43,063 people/sq km overall in District Central (PBS, 2021), and 14,600 people/sq km within Karachi's overall built-up area.[7] While Karachi's total residential area is 36 percent of its total district area, 74 percent has been planned and developed for 38 percent of the population. In contrast, the 22 percent that is 'informally' developed caters to over 62 percent of the population, which constitutes the urban poor, working class, low-to-lower middle income, and marginalised residents (Hasan, 2015).[8] Approximately, 88 percent of the total housing comprises smaller plots of land, typically 120 sq yds or less; while housing on plots varying from 400-2000 sq. yds constitute only 2 percent of the total housing stock that caters to middle and upper-middle income households. Thus, housing and land are a major driver of inequality in Karachi. Moreover, people residing in informal settlements often live in the most ecologically unstable, and hazardous areas where they are most exposed to the vagaries of climate events (Hasan *et al.*, 2017). Hence, the state's consistent failure to address the increasingly sombre housing crisis, infrastructural inequities, and arbitrary urban planning, have contributed to the widening of the inequality gap while also increasing the burden on infrastructure and utilities provision (Anwar *et al.*, 2020; Anwar *et al.*, 2016).

The close interdependencies between heat (mis)management and various infrastructure services – particularly water and energy – are essential factors in managing extreme events as well as unprecedented circumstances such as containment measures during the Covid-19 pandemic (Oppermann *et al.*, forthcoming). Even though in the more populated districts of Karachi, electricity and public water provision is heavily burdened and under severe need of repair and maintenance, in much of the peripheral areas of the city, infrastructural services are either completely absent or entirely basic. These are largely on 'off-grid' sources of electricity supply, despite Karachi Electric's claim that 99.99 percent of Karachi is

7 Calculated by KUL, 2021. Population: 16.05 million (PBS, 2021); Built-up area: approximately 1100 sq km (calculated from polygons). Although the Census 2017 cites the population density of Karachi as 4,551 people/sq km, this value is based on the combined area of the 6 districts comprising Karachi Division: a total of 3527 sq km, as cited by the Census 2017. However, for urban research, it is more practical to consider the population density as the total population distributed across the total built-up/inhabited area, which we calculate to be around 1100 sq km. Hence, our value for Karachi's population density is 14,600 people/sq km rather than 4,551 people/sq km.

8 As based on Hasan (2015) derived from the KSDP 2020. The KSDP 2020 cites total residential area as 36.7% of urbanised area. Informal settlements occupy around 22% of the total residential area. Additionally - without necessarily conflating katchi abadis (KAs) with informal settlements - KUL's calculation considers SKAA's total area for katchi abadis (64.3 sq. km). Adjusting for various researchers' estimates that KAs occupy more land than is officially documented, we calculate this figure to approximately 100 sq. km. Comparing this with a total built-up area of Karachi (1100 sq. km, derived from shapefile data), we calculate the area occupied by informal settlements to be around 9% of the urbanised land in 2020. This drives our point that vulnerable populations are housed within higher density residential zones. These are initial estimates that require deeper empirical investigation.

electrified, and 73 percent is load-shed free.[9] Considering this, the extent to which the urban poor have actually been extended secure rights is certainly contentious, but the state nonetheless has been forced during particular development projects to at least 'tolerate' and even extend amenities such as piped water to the urban poor and growing informal settlements to facilitate the building of its planned architecture. Even though residents across social groups face regular problems in procuring water, especially safe water, it is the urban poor who have particularly vulnerable water access (Anwar *et al.,* 2016; Anwar *et al.,* 2020). The vulnerability that inheres in uneven waterscapes – both in terms of water surplus/floods and water scarcity – pivots on the nexus of the planned and unplanned city. Moreover, this dynamic articulates Karachi's highly unequal water experiences within broader processes of historical change, development, and the expanding ecological footprint of urbanisation.

2.3 Ecological vulnerabilities

In addition to the political-structural dimensions of unequal infrastructural, land and housing provision, there are multiple dimensions of ecological degradation that have contributed to poor people's vulnerability in Karachi. The first layer of ecological vulnerability springs from the way urban development and mega-infrastructure projects have affected Karachi's coastal landscape and its mangrove forests. This is pertinent because Karachi's extended coastline houses almost all of Pakistan's mangrove forests. Over the past several decades, the clearance of mangroves coupled with land reclamation for urban development, both for elite housing schemes as well as expansion of low-income coastal communities such as Machar Colony in District West, has not only destabilised interconnected ecosystems, but also made Karachi vulnerable to flooding and global warming. Mangrove forests have an indirect relationship with heat: scientists (Dinilhuda *et al.,* 2020) posit that tracts of mangroves act as storehouses for greenhouse gases including carbon dioxide and may indirectly contribute to lower temperatures across biomes as well as urban settlements in their immediate surroundings. The loss of mangroves forests is linked not only to greater coastal erosion and loss of biodiversity as is conventionally understood, but also to global warming (Ornizal *et al.,* 2018), which inevitably drives up temperatures in coastal cities. Certain authors (Salik *et al.,* 2015; Muzaffar, 2018) have also emphasised the socioeconomic consequences of such ecological degradation, and the impacts this has on livelihoods, particularly on women employed in Karachi's fishing industry. In addition, aerosol effects due to high degrees of ambient air pollution result in the formation of atmospheric brown clouds that not only mask effects of greenhouse gases, but also increase global solar heating and change the thermal structure of the atmosphere (Ramanathan, 2007). According to the World Air Quality Report (2020), South Asia is at the epicentre of an air-pollution crisis, with such pollution presenting the third highest risk

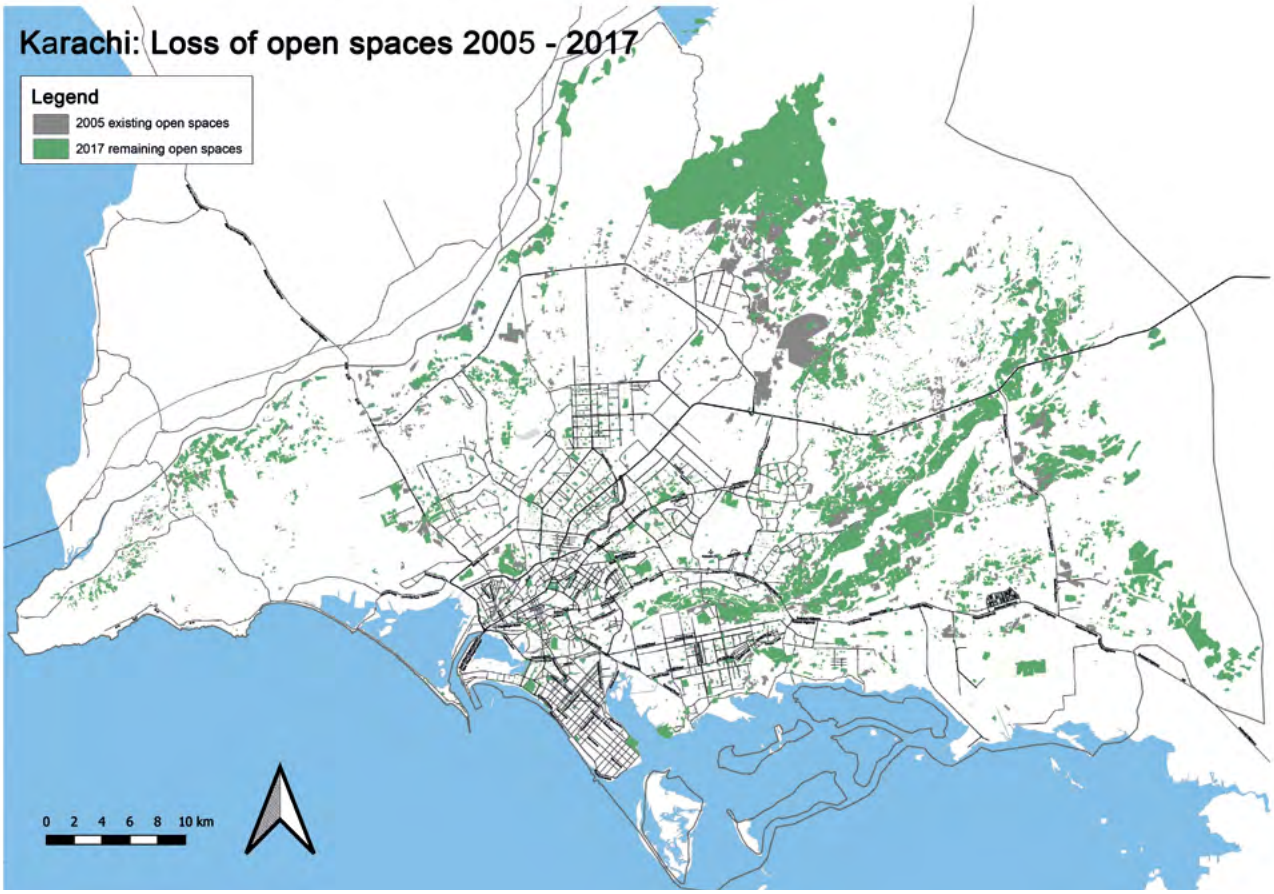
9 Personal correspondence, 2021.

for premature deaths. Not only is pollution a key aspect to understanding ecological vulnerabilities within the region, but it is also an essential consideration for future heat mitigating strategies.

The second layer of ecological vulnerability relates to the conversion of large tracts of agricultural-pastoral communal lands into informal urban housing (Anwar, 2018; Abdullah and Anwar, forthcoming) and private housing schemes (Mazhar *et al.*, 2020) in the city's periphery, as well as declining green spaces in inner city areas (Qureshi *et al.*, 2010). Interestingly, the *Karachi 2020 Strategic Development Plan* (2007) had earmarked PKR 10 billion for increasing the number of green areas in the city. The initiative was based on several motivations that included aesthetics for building a 'world-class city' and alleviating air pollution. However, the plan for urban greening overlapped with an era of intense infrastructural developments such as road construction and expansion, which targeted roadside and median trees. Studies (Schetke *et al.*, 2016) suggest that between 1992 and 1999, there was a 23 percent decline of green space in Karachi, with a further 18 percent decline between 1999 and 2009 (Qureshi *et al.*, 2007).

Figure 7 shows the destruction of vegetation in Karachi from 2005 to 2017. Certain authors (Arshad *et al.*, 2020) emphasise the links between

Figure 7: Loss of open green spaces in Karachi 2005-2017. Data source: World Bank online repository. Processed and prepared by Karachi Urban Lab, 2021.



diminishing green spaces and the impact on Karachi's UHIs, as well as the related health consequences (Huang *et al.*, 2017). These patterns of change also signal the potential impact on people who work outdoors such as street vendors, hawkers, construction workers, and security guards, who have difficulty escaping the heat or navigating the city in search of shade. Even though the local government has championed greening initiatives for the city's health, such initiatives have led mostly to the construction of privatised landscaped parks, planting date palms that are unsuited to the city's climate, and cultivating water hungry, and fast-growing exotic species, such as the conocarpus that exacerbates asthma and causes respiratory problems (Ginn, 2018). From a historical perspective, Karachi's green spaces have always been oriented toward the wealthier parts of the city where land prices are high. In the military cantonments of Defence and Clifton, private gardens display an unsustainable 'Dubai aesthetic' where exotic plants and rolling green lawns are supported by cheap labour, chemicals and vast quantities of water in an already water-stressed city (Ginn, 2018). Thus, Karachi's 'greening' is locked in an unequal geography of class power and infrastructural inequities. Expanding sustainable greening initiatives to less privileged parts of the city will not change structural conditions, but they might bring some respite to poorer residents in search of cooling/shade in an increasingly hot city.

In this section, we have outlined some of the important socio-spatial, infrastructural, and ecological inequalities that condition ordinary people's vulnerability. Karachi is Pakistan's largest urban centre with increasingly consumption-oriented middle and upper classes; it is a city of vast disparities in income and distribution of urban resources. Over 62 percent of Karachi's population lives on little more than 9 percent of its total built-up area. These are also the populations most vulnerable to extreme heat events, with precarious incomes and serious shortages of water and uneven access to electricity. In the next section, we turn to a deeper discussion of heat in the context of Karachi's 2015 heatwave, and the ensuing discourses, policies and plans that frame thermal governance in an unequal city.

3. CONTEXTUALISING KARACHI'S HEAT GOVERNANCE

In June 2015, Karachi experienced a week-long heatwave, the deadliest to hit Pakistan in over 50 years. Between 19th and 23rd June, an officially recorded 1181 people died as temperatures rose to 45°C with a corresponding heat index value of 66°C. Although these were not record-breaking temperatures in the city's history: the maximum recorded temperatures in the month of May and June stood at 47.8°C in 1938 and 47°C in 1979 (Hanif, 2017). Still, the 2015 heatwave gained extensive attention in the media due to the high casualties officially recorded. Research (Chaudhry *et al.*, 2015) shows most deaths occurred in low-income areas and included labourers and homeless people (Imtiaz and Rehman, 2015; Guriro, 2015). Although, the official records offer limited scope for understanding the material and environmental contexts in which people died. Certain factors regarding the natural and built environment may have exacerbated the effects of high temperature during the days of the heatwave, for instance neighbourhood densities, house construction materials, infrastructure access, and workplace conditions.

Until recently, the dominant discourse on disaster management in Karachi focused largely on urban flooding. Heat was never engaged; even in the Multi Hazard Contingency Plan (PDMA, 2013), there is no mention of heat as a threat in the Sindh context. The 2015 heatwave changed that and in doing so, triggered extensive talk around rising temperatures as a disaster and its subsequent management by the state. The event led to the drafting of the Karachi Heatwave Management Plan (KHMP) (Commissioner Karachi, 2017) in collaboration with the Karachi Commissioner Office, Government of Sindh and Leadership for Environment and Development (LEAD) Pakistan, through its Climate & Development Knowledge Network (CDKN) Program. The KHMP follows the template originally developed for the Indian city of Ahmedabad, which also experiences high temperatures (AMC, 2016). Although the KHMP lists broad normative strategies for coping with a heatwave, it does not provide specific definitions of a heatwave or contextually relevant coping mechanisms compatible with Karachi's varying microclimates. Notably, the KHMP is the only heatwave action plan ever drafted for any city in Pakistan; its counterpart at the national level is a significant piece of legislation: the National Adaptation Plan for Climate Change.

3.1. The 2015 Heatwave: a new discourse

The technical report on the 2015 heatwave released by the Commissioner of Karachi borrows the definition 'heatwave' from the World Meteorological Organization (WMO), which states "a heat-wave occurs when the daily maximum temperature of more than five consecutive days exceeds the average maximum temperature by 5°C." (Chaudhry *et al.*, 2015). Heatwaves are determined based on relative climatic conditions of local contexts and there is no universal definition. The report addresses this important point but does not draw on a definition of heatwave that accounts for the Karachi context, which is complicated by high levels of humidity. In the report, Karachi's heatwaves are described as "moist heatwaves" but there are no specific indicators for categorising them. Further, the report does not engage with key factors such as the number of days with consecutively high temperatures, heat index values, wet bulb globe temperatures and humidity. The KHMP is a direct output of the technical report and aims to identify and plan for the management of heatwaves. We can glean from Figure 8 that the KHMP relies on criteria for different kinds of heatwave management alerts, which are based on forecasted temperatures as opposed to the heat index for determining the severity of heatwaves.

The KHMP's heat action strategy relies on ambient temperature readings that provide a narrow understanding of how heat events occur. It also assumes heat-related disasters are discrete, short-term events. The plan begins by specifically stating "...as climate change intensifies, so too will the severity, frequency and/or duration of heat events" (Karachi Commissioner, 2017: 14). This approach overlooks the extended periods of extremely hot summers that have become a recurring phenomenon, and the long term, chronic effects of heat that are better understood as a slow onset of disaster and death (Cross *et al.*, 2021; Oppermann *et al.*, 2021). This is a critical oversight because the variegated experiences of heat on the individual and the communal scales are often a result of underlying vulnerabilities such as a lack of access to cooling infrastructures (water, electricity, green spaces); prolonged exposure due to outdoor working spaces; and lack of ventilation within homes. Even though the KHMP deploys key words such as 'heat-stress', 'gender' and 'vulnerability', it does not elaborate on their significance in the heat mitigation landscape. While it identifies certain groups that are at higher risk, including "...street vendors, beggars, traffic police, hawkers, and homeless people" (Karachi Commissioner, 2017: 69), there are no recommendations tailored to their needs. The KHMP highlights 'insufficient data' as a key reason for the exclusion of vulnerable populations in planning agendas. However, in subsequent years, the government has not followed up on surmounting the data deficiency challenge.

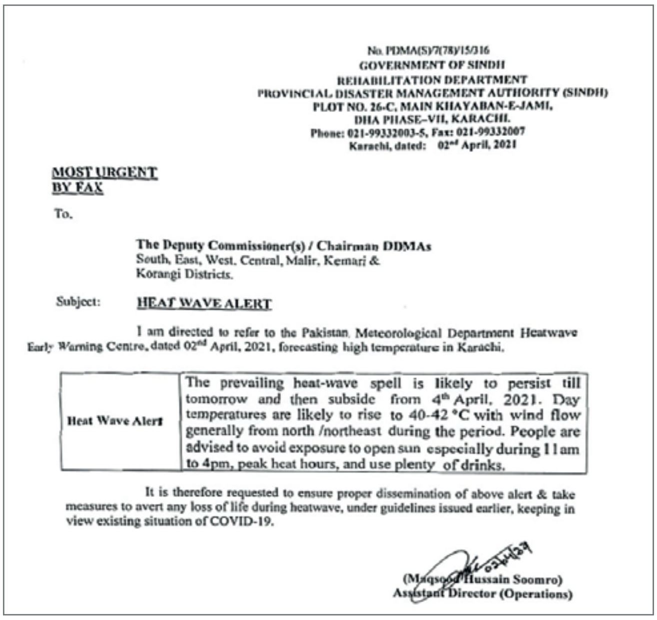
How do planners' and policymakers' interpretations of heatwaves and heat in general, reflect the kinds of responses that were coordinated to manage the 2015 and subsequent heatwaves in Karachi? The KHMP emphasises anthropogenic climate change, atmospheric conditions, and UHIs as drivers of extreme heat events. Even though such environmental factors are important to consider in managing heatwave impacts, there are additional

Figure 8: Criteria for different kinds of alerts specified in the heatwave management plan and suggested responses. Source: Chaudhry et al. (2015)

Type of alert	Criteria	Response
Hot day advisory	Forecast 40°C-41,9°C	Increased communication in media on heat issues
Hot day warning	Forecast ≥ 42°C	High level of public awareness increased, focus and preparedness of government agencies
Heatwave emergency	≥ 42°C forecast AND **minimum** temperature ≥ 30°C for more than 2 or more days When there are significant levels of heat related illness and even mortality there must be the declaration of a Heatwave Emergency and a rapid response regardless of specific wether criteria	Declaration of a Heatwave Emergency

critical dynamics such as socio-spatial and infrastructural inequalities that drive risk of heat exposure and death. Vulnerability to heat-stress is highly driven by biologically adaptive, socio-economic, and physiological factors (McGregor *et al.,* 2015). Researchers have linked increased risk of heat-related illnesses to factors such as low socioeconomic status (Basu and Samet, 2002), lower levels of education (Michelozzi *et al.,* 2005), age (Kenney and Munce, 2003), and gender (Havenith, 2005; D'Ippoliti *et al.,* 2010). In Pakistan, studies have been conducted on the worsening impacts of open field jobs, longer working hours, and limited access to medical care on heat-stress among labourers (Bakhsh *et al.,* 2016). The KHMP does not consider the interactions between these variables and heat, resulting in short-term interventions –primarily heat stroke relief camps and public information dissemination –that are mostly geared towards managing acute-heat, and not its long-term consequences. Moreover, the KHMP emphasises the state will "[empower] implementation agencies to supply the required levels of service and support in a way that is coordinated and efficient" (Commissioner Karachi, 2017: x). This aspect of the KHMP is certainly evident whereby the onus of responsibility for on-ground relief work, service and support provision, has been shifted to "implementational partners", which comprise non-governmental organisations (NGOs), social welfare agencies and philanthropic groups.

Thus, the state's principal responsibility is communicating information to civil society organisations that are seen as implementation partners. At the onset of a heatwave, advisories and circulars are issued



No. PDMA(S)/7(78)/15/316
GOVERNMENT OF SINDH
REHABILITATION DEPARTMENT
PROVINCIAL DISASTER MANAGEMENT AUTHORITY (SINDH)
PLOT NO. 26-C, MAIN KHAYABAN-E-JAMI,
DHA PHASE-VII, KARACHI.
Phone: 021-99332003-5, Fax: 021-99332007
Karachi, dated: 02nd April, 2021

MOST URGENT
BY FAX

To,

The Deputy Commissioner(s) / Chairman DDMAs
South, East, West, Central, Malir, Kemari &
Korangi Districts.

Subject: HEAT WAVE ALERT

I am directed to refer to the Pakistan Meteorological Department Heatwave Early Warning Centre, dated 02nd April, 2021, forecasting high temperature in Karachi.

Heat Wave Alert	The prevailing heat-wave spell is likely to persist till tomorrow and then subside from 4th April, 2021. Day temperatures are likely to rise to 40-42 °C with wind flow generally from north /northeast during the period. People are advised to avoid exposure to open sun especially during 11am to 4pm, peak heat hours, and use plenty of drinks.

It is therefore requested to ensure proper dissemination of above alert & take measures to avert any loss of life during heatwave, under guidelines issued earlier, keeping in view existing situation of COVID-19.

(Maqsood Hussain Soomro)
Assistant Director (Operations)

Figure 9: Portion of a circular issued by the PDMA as a Heat Wave Alert to all concerned departments in Karachi.

by the Meteorological Department, the key department responsible for communicating weather forecasts to the Commissioner Office Karachi. Figure 9 shows a copy of an alert issued by the Provincial Disaster Management Authority (PDMA), based on information provided by the Meteorological Department as a Heat Wave Alert for 4th April 2021 and the directives issued.

The Karachi Commissioner's office acts as the central node for information sharing and coordination with all other departments, including Health Departments, Traffic Police, Utility Providers, Education, Labour and Information Departments amongst other Social Welfare and Ambulance Services (Commissioner Karachi, 2017). These advisories are further circulated through media channels, instructing people against outdoor movement during peak hours. Apart from these communications for raising awareness, there are no other mandated regulations for provincial government and municipal departments. This is more significant in the context of Karachi's shrinking municipal budgets (Maher, 2019) since 2008, and the bleak impact on the local government's capacity for future heat risk mitigation.

3.1.1 *Limited local government resource capacity*

The 2021-22 Sindh provincial budget allocated PKR 1150 million to the PDMA for 'rehabilitation' activities (GOS, 2021:8), and out of this, PKR 1000 million is earmarked for relief work.[10] However, a review of the PDMA's relief efforts shows that relief provision has been directed mostly toward urban floods, COVID lockdowns, and droughts in Sindh.[11] In the provincial budget as well as within the kinds of engagements listed on the PDMA's website, there is no mention of funds or activities directed toward heat risk mitigation. Specifically, there are no provisions for pre-empting heatwaves and anticipatory planning for the impacts of heat. Further, the PDMA plays no role in the primal chain of communication in the event of a heatwave warning: such information is communicated directly as an advisory from the Pakistan Meteorological Department to the Commissioner's office, and the Commissioner subsequently informs the PDMA. During an interview with the Deputy Commissioner of District South, which houses some of Karachi's oldest residential and commercial areas and has a population of 1,769,230 (PBS, 2021), it became apparent that the PDMA's role in heat risk mitigation is arbitrary:

> *"There is no defined role of the PDMA; everything falls on my shoulders; I am the PDMA and the DDMA (District Disaster Management Authority). Just today, there was an advisory for a heatwave, so I had my department ensure that all shopkeepers keep a water cooler outside their shops. I am doing what I can within my limited resources"*[12].

There are multiple non-state actors operating in Karachi's heat governance space, from NGOs, philanthropic and international organisations to medical universities and corporate actors. Some prominent stakeholders include NGOs such as Shehri, the Urban Resource Center, HANDS, Caritas, Edhi Foundation, Alamgir Trust, Faizan Global Relief Foundation (FGRF), Al Khidmat Karachi as well as international organisations such as the Red Cross, Red Crescent. The Edhi Foundation and Chhipa Welfare Association operate on a stand-by basis to provide ambulance services and medical assistance during heatwave alert days (Latif, 2015). NGOs such as the Pakistan Relief Foundation (PRF), the FGRF, Saylani Trust, and Al-Khidmat Karachi are particularly active with on-ground relief work for heat risk mitigation; they set up heatwave relief camps throughout the city when an alert is issued (Azam, 2015; Khan, 2021). Several NGOs also provide research-based resources on climate protective strategies (HANDS, 2020; Anwar, 2012; 2017). Figure 10 provides an overview of the major

10 The total budget for 'rehabilitation' is divided into two headers in the provincial budget: out of 1150M, 150M is for office work (desk activities, other non-field expenses), and 1000M for relief work (procuring and distributing aid equipment, travel, accommodation, ration bags, and such).

11 http://www.pdma.gos.pk/new/response/Relief.php

12 Interview conducted in April 2021, office of the District Commissioner South.

Figure 10: An overview of 100 State and Non-State Actors working on heat related issues at the national (Pakistan), Provincial (Sindh) and local (Karachi) scales; both directly and indirectly. Prepared by Karachi Urban Lab 2021

state and non-state actors involved directly and indirectly in heat-related action on various scales. It also includes state institutions such as Federal, Provincial and District level government departments, ministries, and courts. However, we emphasise that interventions by such institutions have largely been limited in scope, top-down, and uncoordinated.

Within the broader landscape of disaster risk management, NGOs such as the FGRF and Al Khidmat are leading first responders and they operate at multiple scales: FGRF has the most extensive outreach that stretches from the local to the global. These NGOs are not only emergency relief providers but also longer-duration capacity builders in specific lacunae in the formal policy making process. Within their scope of work, some organisations also scale up and down their operations depending on sudden events: such as an earthquake in the north of the country, flooding along the country's many alluvial banks, or unexpected bus/train crashes. Following such sudden events, secondary teams within the organisations are dispatched to the areas, or regional teams are mobilised to quickly teleport themselves and their equipment to the affected sites falling in their respective jurisdictions. Hence, NGOs like FGRF and Al Khidmat operate at two temporal scales: firstly, through categorical stock inventories and archiving, they specialise in contingency based responses and just-in-time dispatches to the sites of disaster, creating consistent flows of materials, technologies, people, and discourses in real-time, creating an impression of being always at the ready. Secondly, these NGOs have carved out their own space in the discursive imaginaries of Karachi's residents and governors and assert their presence through prolonged and consistent activities that solidify their impact on the city, such as annual tree plantation drives. It is increasingly evident that disaster management and mitigation, like other essential urban public services such as health, education, and housing, have been outsourced entirely to private parties, philanthropic organisations, and NGOs. This is a deliberate delegation of responsibility from the tiers of a constitutionally ‘Islamic welfarist’ state to a multitude of non-state actors who are implicated in the process through multiple motivations, ranging all the way from religiosity to the sensibilities of late philanthro-capitalism. The organisations and individuals share a discursive commitment to ‘service’, combining themes of piety, civic duty, morality, and ethical self-formation, as well as the right to the city – all in their own colloquial media of linguistic and visual representation. Nevertheless, representatives of these NGOs are aware of their limited capacities and outreach. This was reflected in an important statement by a senior representative of Al Khidmat Foundation at a first responders workshop organised by the Karachi Urban Lab on 5th July 2021. The senior representative noted:

> *“NGOs are a tiny point; the state’s role is diminishing, and the non-state’s is rising. But we can’t compete with the kind of work the state can do.”*

These organisations’ relationships with the state in heat governance and more broadly, climate action, varies: some NGOs collaborate with the state through MoUs, and others act independently. For instance, HANDS and Edhi Foundation have technical affiliations and MoUs with national agencies such as the Federal Ministry of Climate Change (MOCC), the Provincial Ministry of Health, and the PDMA. Many NGOs, academic institutes, and individual activists operate independently in advocacy, information dissemination and on-ground relief.

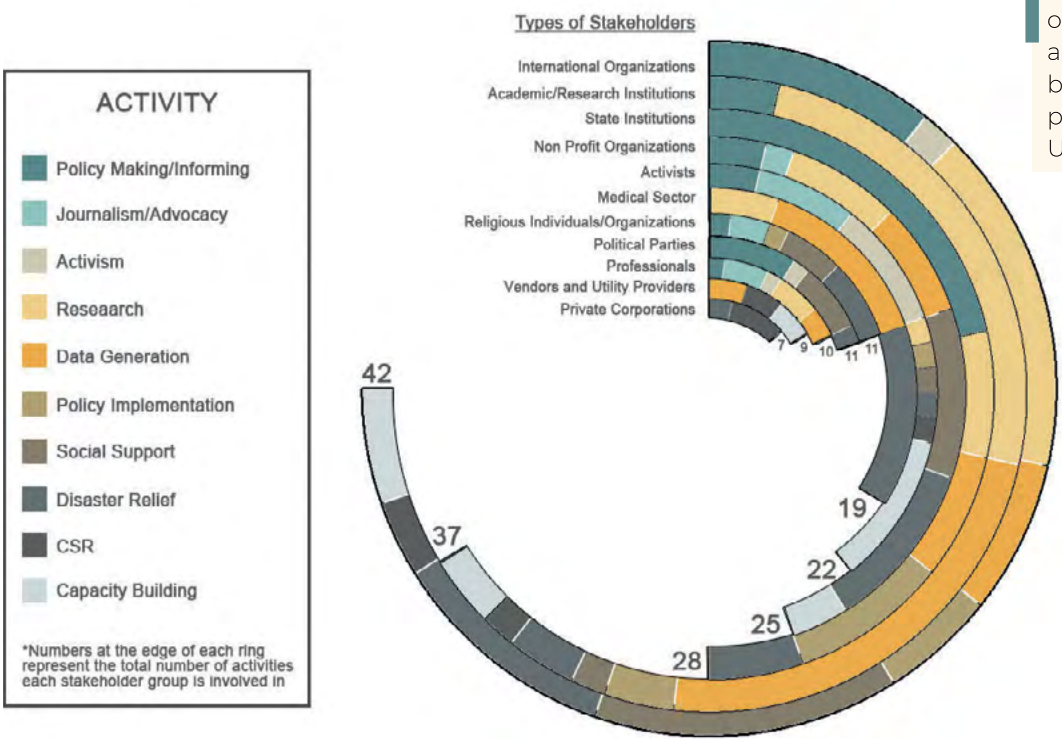


Figure 11: Domains of heat-related actions undertaken by stakeholders, prepared by Karachi Urban Lab 2021

However, the NGOs initiatives do not engage with long term planning because the assumption is that the state should have the capacity to act in the long term. Figure 11 illustrates the different kinds of activities undertaken by the major stakeholders in Karachi's heat governance space. The stakeholders include state and non-state actors involved in research, data generation and informing policy action.

Fundamentally, most of the non-state actors are not engaged directly with heat. The exception is the FGRF that has started experimenting with cooling interventions on ground, but these are small-scale. Notably, most NGOs are involved in heat governance through tree plantation drives that dovetail with the national government's 'Billion Tree Tsunami' initiative (Gul, 2020), part of the former ruling party's – Pakistan Tehreek-e-Insaf's – Green Growth Initiative (GGI) that was started in 2014. The GGI is aimed at an environmentally sustainable and climate change resilient economic growth model. Islamic NGOs such as the FGRF and Al Khidmat Karachi, have become champions of plantation drives, seeing it as a crucial urban greening initiative for heat risk mitigation at the local scale: as a senior representative of the Al-Khidmat Foundation emphasised in the first responders' workshop in July 2021: "The only way to break the heatwave is through plantation."

The representatives of these NGOs see tree plantation as a religious duty. In a conference held in Karachi by the Red Cross, Red Crescent in January 2021, key Islamic NGOs such as FGRF and Al Khidmat Karachi emphasised that protecting the environment was synonymous with upholding religious obligations. Mufti Muhammad Zubair, a religious scholar presenting at the conference, explained:

> *"It is vital to plant trees since it is written in one of the hadees that if a person is planting date trees and during the process azan is being recited, you should continue the plantation."*

Such claims form the basis of environmental ideologies of most Islamic NGOs engaged indirectly in Karachi's heat space. The significance of plantation and the protection of the environment is bound up with Islamic principles that translate into greening strategies as a primary form of heat management. The FGRF's initiatives have led to the planting of 350,000 plants/trees across various cities in Pakistan, and specifically 70,000 trees in Karachi. This has happened in collaboration with the Karachi Municipal Corporation. The visibility of such campaigns is an important factor in generating MoUs and attracting funds. The FGRF has signed a MoU with World Wildlife Fund (WWF) for spreading awareness, exchanging technical expertise, and providing human resources for the Green World Campaign. Even though such initiatives should be applauded as part of a broader environmental sustainability agenda in Pakistan, certain authors (Ashraf, 2019) have shown that the GGI's policy implementation for forestation has worsened inequalities at the local scale.

In the context of an unequal city like Karachi, it is vital to ask which communities' benefit from the plantation drives, and what areas are targeted. Notably, most of the NGO-led and state-supported plantation drives are oriented towards Karachi's affluent areas; the initiatives are also connected with city beautification schemes, as highlighted in Section 2.3. This partly reflects the actions of a growing coalition of middle and upper middle-class citizens who are working with municipal institutions in new 'urban greening' initiatives. A statement given by the director of a prominent NGO that is active in climate change advocacy, alluded to the ways in which specific areas of the city are selected for plantation drives in Karachi:

> *"....80% of the trees are being planted in areas of Karachi where water is easily available and where people understand the value of plantation. The efforts on tree plantation are not focused on those parts of the city, such as poor areas, where water supply is a big challenge and people may not see the value of tree plantation." (First Responders Workshop on Heatwave and Rain Emergency, July 2021)*

Despite a unified approach that sees tree plantation as the primary strategy for heat mitigation, there is a glaring lack of consensus regarding the causes of the heatwave, and who to hold accountable for deaths. In the next section, we explore how different stakeholders comprehend their own roles, and those of other actors involved in heat-specific interventions.

3.2.1 Who was responsible for the 1181 deaths in the 2015 heatwave?

During the 2015 heatwave, media reports actively highlighted the conflicts over who was responsible for the high casualties in Karachi:

> *"...everyone's tripping over themselves to point the finger somewhere: at K-Electric, at the Sindh government, the federal government, on fasting, or climate change. We have seen a political spectacle in Karachi and Islamabad despite all the misery in Sindh: shouting matches between the PML-N and the PPP in parliament; Qaim Ali Shah and other PPP leaders bizarrely protesting power outages outside their own Sindh Assembly." (Afzal, 2015)*

Government agencies and media outlets, and even banned military groups such as the Tehrik-e-Taliban Pakistan (TTP) (Khan, 2015) blamed the main utilities - the Karachi Electric (KE) and the Karachi Water and Sewerage Board (KWSB) – for electricity and water shortages that were understood as key drivers of the heatwave impacts and deaths (Ali, 2015; Chaudhry, 2017: 8). While government agencies blamed the utility companies, the media criticised the state for abrogating its responsibility in heat risk mitigation. The Prime Minister and Federal Government had assigned heat mitigation responsibility to the NDMA and the Karachi Corps Commander, and in this process the Provincial and Local Governments had taken a back seat (Javaid, 2015). But the heatwave had also coincided with the month of Ramazan, and NGOs such as the Edhi Foundation underscore this contributed to the high death count. In an interview, the Chairman of the Edhi Foundation, explained thus:

> *"Despite the heat and cases of extreme dehydration, people continued to fast. Statements from government authorities around religious obligations to fast further compelled individuals to continue fasting."* [13]

13 Interview conducted at Edhi Centre, February 2021.

Moreover, laws such as the Ramazan Ordinance 1981 contributed to the intensified impacts: the ordinance imposes penalties on persons consuming food and drinks in public. Despite warnings about extreme temperatures and statements from religious authorities exempting the vulnerable from fasting, people remained discouraged from following media alerts for preventive measures (Chaudhry, 2015; Campbell, 2015). The narrative that the primary cause of deaths was fasting during Ramazan, exemplifies the perception that the state lacked a sense of urgency in responding to contingencies during the heatwave. This perception persists in the present context where hope lies in the agency of the individual who is supported by NGOs and other non-state actors in managing heat impacts. Other non-state actors' interventions through information dissemination projects that are focused on warnings and recommendations, also place responsibility of heat management on the individual. This is evident in the work of organisations such as the START Network, Aga Khan University, and others (HANDS, 2020).

In a context where there has been limited consensus regarding the multidimensional factors and dynamics that exacerbate the effects of heat in Karachi, and the state's critical role in heat governance, in the following section we conclude by probing the relational and multidimensional context of heat, space and vulnerability, and underscore the importance of a socially just urban planning and policy framework that is cognizant of the profound changes taking place to human and natural systems in cities like Karachi.

4. CONCLUSION: URBAN PLANNING, CHRONIC HEAT & VULNERABILITY

This scoping study has foregrounded the social, economic, and environmental inequalities and multiscalar vulnerabilities that exacerbate ongoing and predicted impacts of rising temperatures in Karachi. In Section 2.1, we have shown that Karachi is rapidly warming with statistically significant increase in temperature observed in every month for every season at both weather stations. Using time series data, we underscore that not only is Karachi experiencing both higher daytime and night-time temperatures, but that the rate of warming varies seasonally and spatially across the city. Different parts of the city are warming at different rates with the centre warming faster than the coast during the night, and the coast warming faster than the centre during the day. In the centre of the city, the rate of warming is much higher in the winter than during the summer, especially for night-time temperatures. This warming also overlaps with the varying morphologies and structural inequities within the city, but additional layers of data are required to draw out credible correlations between local microclimates and political-infrastructural factors. Additional data on humidity and heat indices, for example, would help identify pockets of thermally inadequate housing stocks, and this could be studied for overlaps with informal/nondurable housing stocks across the city's informal settlements.

Further, we have contextualised the shift to warming temperatures by reviewing key discourses, policies, and plans on Karachi's heat governance, and discussed the role of multiple non-state actors who are directly and indirectly involved in heat risk mitigation. A key point we make is that state policies and plans have implicitly and explicitly shifted the onus of responsibility for dealing with the effects of heat onto the individual, as opposed to addressing the longstanding socio-spatial and infrastructural inequalities and economic disparities that have conditioned people's vulnerability and undermined their capacity to cope with sudden and extreme climate events. Karachi's urbanisation process, its variegated ecology, topography, and socio-spatial inequalities generate highly varied experiences of heat. Thus, we underscore heat must be understood as a dynamic that interacts with differentiated urban spaces and unequal geographies and ecologies, and these complex interactions generate differentiated forms of heat exposure, especially for vulnerable populations.

Moreover, we underscore that the experiences of heat must be understood as a slow onset disaster, particularly in terms of the effects of chronic exposure on daily life, worker productivity, health, and wellbeing, amongst other indicators (Opperman *et al.,* 2021). This is particularly pertinent to Karachi, which lies in the 'ultraviole(n)t' zone of solar exposure (Kripa and Mueller, 2020), whereby 'exposure' must be differentiated from vulnerability, as the latter "...refers to the propensity of exposed people or activities to experience detrimental effects" (McGregor *et al.,* 2015). These, in addition to physical attributes of built spaces such as materiality and density are important considerations when talking about ongoing planning exercises and their inclusion in future practices of heat risk mitigation strategies. Not only have recent master plans (KSDP, 2020) disregarded such factors, but their conceptualizations for maintaining or enhancing residential densities rarely move beyond its material aspect. Since the 2015 heatwave, planning and policymaking agendas have failed to consider the vital intersections of densities, materialities and socio-economic factors with heat and the importance of thermal comfort. The city's building codes do not refer to thermal properties of suggested materials, specifications regarding ventilation, or suggestions on orientations for the hottest portions of the house, such as the kitchen.[14] A building's physical attributes are essential considerations in protection against rising temperatures, and feed into exacerbating detrimental effects of heat, particularly for vulnerable populations.

Although some literature exists on heat-related vulnerabilities in Pakistan (Arshad *et al.,* 2020; Malik *et al.,* 2012; Zahid and Rasul, 2012), these are either focused on projection models, or fail to consider complexities within the urban environment that complicate the narrative of climatic vulnerability. Most research is also concentrated in Punjab and is focused on rural to urban climate

14 Based on guidelines provided in the Karachi Building and Town Planning Regulations 2002 as published in the Sindh Government Gazette. http://www.sbca.gos.pk/pdf/KB_TPR.pdf

migrations (Mueller, 2014; Umer and Saeed, 2018). These studies suggest that among other factors such as economic opportunity, many migrant workers move to cities to avoid heat-stress impacts on labour productivity. Although there is some anecdotal evidence for such occurrences in Sindh, it has largely remained unexplored within the literature. On urban heat vulnerabilities, certain authors (Zuhra *et al.*, 2019), have developed a heat vulnerability index for inner city neighbourhoods in Lahore using indicators such as pre-existing illness, population density, housing density and housing material in tandem with socioeconomic variables of class and education to identify 'hot spots of vulnerability'. While such studies provide comprehensive assessments of compounding factors involved in the experience of heat, the findings are based on ambient temperature thresholds that are the sole measure of heat and heat-stress and exclude important variables such as heat index, humidity, and solar exposure. There is also no consideration for understanding heat in terms of its temporal and spatial shifts, for instance how "...heterogeneous, polyrhythmic interactions play out in space and time as energetic-thermal flows are variously exchanged, accumulated and dispersed within and around human bodies". (Opperman *et. al.* 2020: 275)

In this concluding section, we draw from Opperman, *et. al.* (2019) to think about Karachi's changing weather and the onset of chronic heat exposure in terms of 'zones of vulnerability'. Such zones are crucial to consider not only due to their higher vulnerability to detrimental effects of heat exposure, but also because risks associated with rising temperatures are likely to make them into nodes that reveal, deepen and sediment pre-existing inequalities within the city.

We define 'heat zones of vulnerability' as unequal geographies distinguished in terms of their heat emissions, exposure, and subsequent thermal experiences. We suggest this can be used to spatially and temporally analyse spaces in the city through the lens of those who are most vulnerable and assess their encounters with heat on multiple scales such as climatic conditioning, materiality, densification, and access to infrastructures, among others. We underscore that the term "zones" does not limit our understanding of dynamic vulnerabilities to its spatial implications, rather, we extend this definition into material and non-material relationships and interdependencies that intersect with such zones. The compounding impacts of such factors determine the liveability of a space and inform the mechanisms through which people occupy them. This is particularly pertinent because individuals' ability to cool through biological processes such as sweating, and material capacities such as access to water, ice, and temperature regulating appliances are highly dependent on the kinds of spaces they occupy. These 'heat zones of vulnerability' thus necessitate a nuanced understanding of how variegated experiences of heat are determined by a range of economical, socio-political, as well as infrastructural factors unevenly distributed across the city. In Figure 12, we visually conceptualise work and home spaces, and their interconnections with commute systems, urban green spaces, and infrastructures of cooling.

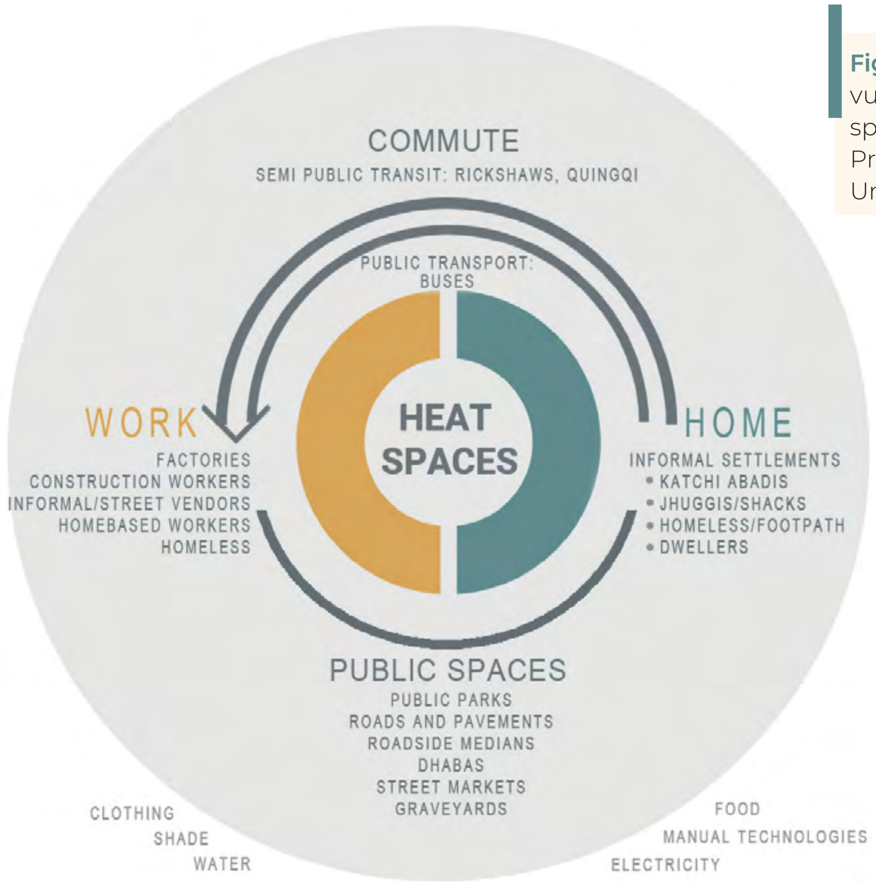


Figure 12: Types of vulnerable heat spaces in the city. Prepared by Karachi Urban Lab 2021

Despite substantial literature (Hasan, 2015; Lodi *et al.,* 2013) on concrete as the predominant construction material in Karachi, the variegated experiences within interior spaces and building envelopes constructed using concrete has been largely ignored. Within concrete construction, some of the most vulnerable housing stock lies in informal settlements or *katchi abadis* that have developed incrementally and comprise a patchwork of various different materials on small plots of land (mostly 80 sq.yds). This results in different zones of heat created within the same dwelling, with interiors comparatively hotter than the outdoors and trapping heat within the house; something that is not considered by standards for indoor climates (Nicol, 2004; Hashemi *et al.,* 2015). *Jhuggis* or shacks that are made of temporary materials comprising fabric, wood, mud, bamboo amongst other easily deconstructed material, comprise the most vulnerable segment of the city's housing stock and at risk from anti-encroachment drives, floods, fires, in addition to limited protection from heat. For outdoor workers, especially those on construction sites and in factories, the exposure to heat is much higher. This was reinforced by certain statistics from the 2015 heatwave – Edhi Foundation reported most of the dead being brought to the morgue were working class factory workers who came from the low-income Landhi and Korangi areas of Karachi.[15]

Since 2015, heatwaves in Karachi have been a recurring phenomenon but they appear to have resulted in fewer

15 https://www.reuters.com/article/us-pakistan-heatwave-idUSKCN1IM2AU

casualties. This could be due to the increased preparedness by state and non-state actors, especially interventions at the level of raising awareness. However, vigilance on reporting cases/casualties has evidently decreased despite the increased frequency of extreme heat events. This was observed in 2018 when a heatwave once again coincided with Ramazan, and in 2019 when heat stroke wards and camps were set up pre-emptively in anticipation of a heatwave. Yet, data on the number of cases, the areas in the city most affected, and the populations most at risk, were neither collected nor reported. Data such as what localities report higher frequencies of serious heat illness and cases of mortality is critical in identifying zones of vulnerability and can assist in pre-emptive measures to curb impacts of future heatwaves, especially to mitigate the risk of chronic exposure. Such a framework is also necessary to consolidate heatwave experiences over a continuous timeline. Heat spaces also challenge the assumption that heat poses the greatest threat in outdoor spaces, laying emphasis on indoor spatial vulnerabilities such as poor ventilation and erratic water and electricity provision. Importantly, this also addresses how responsibilities regarding the management of heatwaves are perceived, and where the onus of blame lies, particularly in terms of how coping strategies are conceived and maintained. As outlined previously, the necessity to redefine heat as a slow-onset disaster is crucial for effective, long-term planning against rising temperatures. However, doing so requires the consolidation of long-term, intersectional data.

Even though there are recommendations in the Karachi Heatwave Management Plan to install district-specific weather monitoring systems and to record and analyse data from health centres across Karachi, these are yet to materialise. However, it is pertinent to note that heat is a complex phenomenon resulting from the interaction of temperature (sensible heat), humidity and direct or diffuse radiation load (McGregor *et al.,* 2015). Despite this, assessments for heat-stress and heat management plans are usually taken from data coming out of weather stations that do not necessarily correlate with local environmental conditions, or the additional heat stress resulting from high levels of physical labour or exertion. These are necessary for a nuanced analysis of chronic heat exposure and heat stress. We suggest the inclusion of ‘heat zones of vulnerability’ as a possible framework to better understand and respond to changing climatic conditions, both in terms of data collection based on the temporal and spatial variability of thermal experiences, and future analysis of the intersectionality between the built environment and rising temperatures that may continue to exacerbate chronic heat exposure.

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