"Athens, you're a kiln":

A thermal justice approach to urban heat and social vulnerability in Athens municipality

Panagiotis Polyzos

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

LUCSUS
Lund University Centre for Sustainability Studies

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Abstract:

Extreme heat is not neutral. In Athens, the dense urban environment and harsh summer climate disproportionately impact the socio-economically marginalized. This research bridges the gap between climate data and human experience by uniting geospatial and qualitative survey data regarding heatwaves in Athens Municipality, with urban heat island research, vulnerability theory and climate justice. Satellite data show that during 20-27/07/2025, temperatures averaged between 34.62°C and 38.23°C. During heatwaves, residents experience physical and mental symptoms, due to high temperatures, lacking residential and public infrastructure, high adaptation costs, and obligations requiring exposure during peak-heat. Vulnerability status mildly affects the experience. The results call for inclusive climate adaptation, based on upgrades of public assets, subsidized cooling technologies, urban planning regulations and legal protection against extreme heat.

Keywords: Thermal Inequality, Urban Heat Island, Heat Vulnerability, Climate Justice, Heatwave Adaptation, Athens Municipality

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So, inspired by the additional geology courses I took, I dedicate this work to these wonderful people, my community, with whom, across the span of geological time, we found each other. If life is to be repeated, I would be lucky to meet you all again in the next lifetime, and all the ones that follow, because to live you only once would not be enough.

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On that note, I want to urge the reader to always bear in mind and soul all the individuals that are currently suffering due to the ingrained injustice of our society. All the humans undergoing war, torture, genocide, displacement, sexual, physical, and mental violence. All the children who don't have a chance at a childhood, all those living in poverty, hunger and unsanitary conditions. All the non-humans living in horrid conditions in factories and farms, brutally murdered and commodified by the caprices of humanity. And all those who suffer due to climate change and human greed, decimating oceans and forests old as time.

"I come with empty hands and the desire to unbuild walls."

— Ursula K. Le Guin, The Dispossessed: An Ambiguous Utopia

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1. Introduction

Climate change is identified to be one of the most complex and urgent challenges that humanity will be forced to tackle in the 21st century (Maragno et al., 2020), with extreme high-temperature events now becoming the leading cause of weather-related mortality on a global scale (Ellena et al., 2020). Specifically, over the last half-century, the probability of extreme heat has magnified significantly with such events now being up to a hundred times more frequent than they were a hundred years ago.

Within this increasingly warming context, cities function as critical hotspots. Their dense urban structure, characterized by heat-trapping materials like asphalt, concrete, stone, metal, tar and gravel, as well as limited vegetation and anthropogenically produced heat, creating heat domes and exacerbating the Urban Heat Island (UHI) effect (Arnfield, 2003; Ellena et al., 2020; Keith et al., 2023). The UHI effect is a phenomenon that causes urban areas to be significantly warmer than their rural surroundings, aggravating the duration, frequency and intensity of heatwaves. Considering current levels of urbanization and that more than 50% of the global population currently reside in cities, the UHI is a serious matter (Leal Filho et al., 2018; Voelkel et al., 2018).

It is, although, worth discerning that the environmental and structural aspects are just one facet of the heat experience. the social groups that bear the greatest burden of extreme heat are senior citizens, children, low-income residents especially outdoor workers, immigrants, the mentally or physically ill, the homeless and substance users (Amorim-Maia et al., 2023; Cheng et al., 2021; Conlon et al., 2020; Ellena et al., 2020; Hamstead, 2023). Seniors and young children have a reduced biological ability to thermally regulate their body temperature, making them physically vulnerable. Children usually require caretakers that are also indirectly affected (Cheng et al., 2021; Ellena et al., 2020). The elderly have a reduced chance of receiving help or being alerted during a heat emergency, due to higher likelihood of social isolation (Cheng et al., 2021; Mitchell & Chakraborty, 2014; Romero-Lankao et al., 2012). Individuals with cardiovascular and respiratory diseases, diabetes or other chronic health impairments are more susceptible to adverse outcomes (Cheng et al., 2021; Romero-Lankao et al., 2012). Lastly, mental illnesses, especially when accompanied by using certain substances (psychotropic medication, alcohol, illicit drugs, etc.) can impede both the body's regulation capacity and the mind's perception of heat risk (Cheng et al., 2021; Meerow & Keith, 2021). Income is a primary driver of vulnerability, as it limits the ability to afford electricity bills (i.e. energy poverty), obtain or maintain air conditioning systems or even relocate to cooler areas (Amorim-Maia et al., 2023; Guardaro et al., 2020; Romero-Lankao et al., 2012). Vulnerability is significantly higher in inadequate, poorly insulated housing, such as older buildings lacking air-conditioning, and high-floor apartments in multi-story buildings are also more prone to overheating (Ellena et al., 2020; Leal Filho et al., 2018; Romero-Lankao et al., 2012). Other factors include low education level and limited knowledge of the local language, as these can result in insufficient access to emergency weather warnings and public health information (Ellena et al., 2020; Marcińczak et al., 2025; Voelkel et al., 2018).

Despite the documented physical intensity of heat in general, justice perspectives are rarily considered in literature and urban policy. Current heat-related research is heavily focused on modeling and mapping, (reaching up to 68% in some meta-analyses (e.g. Meerow & Keith, 2021), reducing the matter of heat to a series of abstract, numeric weather values like degrees Celsius and land surface temperature (LST) (Hamstead, 2023; Turner et al., 2022). While the numerical values are necessary and effective in identifying thermal patterns and how these change over time, they often overlook the socio-political factors of vulnerability and eventually invisibilize the human experience of heat (Hamstead, 2023). While most scholars see mere statistical patterns of heat imbalances, in reality these translate into disrupted everyday practices, shattered social networks and ultimately a whole different perception of life for people experiencing extreme heat (Hamstead, 2023; Meerow & Keith, 2021). The need to pivot from understanding heat simply as a "meteorological event", to a holistic view of it as "thermal insecurity" is crucial for uncovering matters of individual agency and relations to the urban environment (Hamstead, 2023).

Considering the absence of qualitative interpretation of extreme heat, this thesis seeks to integrate meteorological information with the human experience by moving beyond a positivist, technocratic approach to urban heat. By using satellite data to examine the prevalence of a specific extreme heat event and applying the lens of vulnerability and climate justice theories on quantitative survey data, my research investigates how populations in the central neighborhoods of Athens experience and adapt to extreme heat. To be effective, urban climate adaptation must be equity-driven, recognizing that residents need more than just cooler outdoor temperatures. It should include appropriate interventions that address the underlying structural problems in the city, as well as the social, political, and economic barriers people face (Amorim-Maia et al., 2023; Hamstead, 2023; Kotsila et al., 2025). The aim is not just to approach temperature as a measurement but to turn it into a pursuit of climate justice.

In Athens, there has been no solid, holistically approached study regarding the perceptions of its residents on extreme heat. This thesis aims to explore and explain the trends in resident's experience of heat and their deemed needs, by integrating climate data from a past extreme heat event and the residents' responses in a survey. I will do so by answering:

- How were LST spatially distributed in Athens municipality during the week 20-27/07/2025, when the most intense heatwave of last summer peaked?
- What are the experiences of residents in the municipality during heatwaves, what factors contribute to their exposure, and what needs do they have for effective relief?
- How can the experiences of the residents and the lens of climate (thermal) justice theory inform adaptation mechanisms?

2. Setting the scene

The Mediterranean region is particularly vulnerable to shifts in temperatures and extreme heat events, and big cities like Athens stand as emblematic "heat spots" (Arnfield, 2003). As the largest city in Greece, the Athens Larger Urban Zone is the 7th most populous in the European Union, housing about four million residents. Due to its unique combination of geography, climate and intense urbanization it has become a prime area of overheating (Giannaros et al., 2013; Kourtidis et al., 2015; Marcińczak et al., 2025). The city, located within the Attica Basin, is bounded by mountains on the north, west and east, and the Saronic Gulf on the south, which creates a complex local environment where topography and urban morphology interact to trap heat (Giannaros et al., 2013; Kourtidis et al., 2015). Historical records highlight the urgency to address extreme heat, as the city has faced multiple severe heat events, soaring as high as 46.0°C (Zoulia et al., 2009). These are largely driven by the lack of green spaces, the heat storage of building materials and intense air condition usage (Zoulia et al., 2009). With climate change intensifying the hot air masses from the south and southwest of the Mediterranean, such acute heat events are projected to become the "new normal" (Kourtidis et al., 2015).

Athens has the typical Mediterranean climate, featuring warm, dry summers where July and August appear to be the hottest months (Kourtidis et al., 2015). During this period of peak heat, the average daytime maximum temperature is approximately 33.5°C, with the denser part of the city being prone to more extreme temperatures (Kourtidis et al., 2015). According to long term (1987-2001) data from the National Observatory of Athens, annual maximum temperatures have ranged between 34.7°C and 44.1°C, with higher temperatures becoming increasingly common in the later years of the time series (Kourtidis et al., 2015). Over the past 25 years, this trend has intensified, with higher annual maximum temperatures, as Kotharkar & Gosh (2022) show that Mediterranean heatwaves since the 1980s have become more frequent and intense. Before the adoption of air-conditioning infrastructure on a house-hold level, there were devastating extreme heat events in 1987 and 2007 (Kourtidis et al., 2015). The prolonged temperatures of over 40°C led to extreme strain of the state apparatus and multiple casualties (Katsouyanni et al., 1988; Kourtidis et al., 2015).

In the recent decades, accelerated industrialization and urbanization have intensified the phenomenon, driving up temperatures during periods of extreme heat (Kourtidis et al., 2015). Multiyear assessments of the UHI effect demonstrate that the temperature difference between the city and its rural surroundings can be as high as 10°C (Zoulia et al., 2009). During the night, the UHI effect remains dominant, with temperatures often being up to 4°C higher in the metropolitan area compared to non-urbanized surroundings (Giannaros et al., 2013).

Urban expansion has historically been a primary driver of the UHI effect and subsequently how modern-day thermal inequality manifests in Athens. The city's rapid population growth, combined with the lack of meticulous urban planning has resulted in great proneness to extreme heat (Kourtidis et al., 2015; Louis & Sapountzaki, 2010). The type of buildings also changed, for example in the 1970s urban commercial-use buildings represented only 14% of such constructions; however, this figure surged to 55% during the 1980s on the expense of shorter residential buildings and open plots (Santamouris et al., 2001).

Today's urban design is characterized by various architectural features that reinforce heat retention. Athens is dominated by a seemingly unending network of high aspect ratio (height-to-width) streets, creating "urban canyons" that trap heat and restrict air flow by up to 10 times compared to undisturbed wind conditions (Santamouris et al., 2001; Zoulia et al., 2009). The construction materials possess high heat storage capacity and low reflectivity (albedo), heating up excessively during the day and releasing waves of heat during the night (Kourtidis et al., 2015; Santamouris et al., 2001). Lastly, urban expansion has been performed at the cost of green areas and water surfaces, particularly around the central part of the city, eliminating the cooling effects of evapotranspiration and evaporation (Santamouris et al., 2001; Zoulia et al., 2009). The chronic lack of sufficient urban planning has forced Athenians to rely on personal adaptation strategies. To cope with the disrupted thermal reality, there has been a massive adoption of air-conditioning technologies, which further aggravates the UHI effect due to waste heat from the air condition units. (Louis & Sapountzaki, 2010; Santamouris et al., 2001).

All these chronic dysfunctions have accumulated to shape the current state of extreme heat in the city. July 2025 was marked by an exceptionally severe and prolonged heatwave across Greece. According to data from the weather service operated by the National Observatory of Athens (2025), the heatwave consisted of two phases. The beginning was between 14-17 July, its peak was between

20-27 while the days 18-19 July marked normal-for-the-season temperatures. The second phase of the heatwave was particularly grueling for urban centers like Athens. During these nine days, some areas in Attica (the region where Athens is located) experienced temperatures of 30°C or higher for up to 80% of the total hours, indicating that the heat rarely subsided even during the nighttime. Nationally, the heatwave peaked on July 25th, when nearly the entire population was exposed to temperatures exceeding 40°C, underscoring the extreme nature of this meteorological event within the context of the country's recent climate history.

3. Theory

3.1 UHI research and its importance

The UHI effect is broadly defined as the phenomenon where temperature levels within urbanized areas appear higher than those in their surrounding rural or non-built environments (Leal Filho et al., 2018; Sidiqui et al., 2022). Studying the UHI effect is complex. The primary method for identifying a heat island is to measure the thermal radiation emitted from the Earth's surface on a specific location, during a specific period in time, through remote sensing (Arnfield, 2003). Several satellites such as Landsat, MODIS and ASTER, are equipped with infrared sensors, measuring atmospheric radiances at surface levels (Giannaros et al., 2013; Marcińczak et al., 2025). This energy is not the heat of the ground, but a mixture of emitted radiance from the Earth's surface, upwelling radiance emitted by the atmosphere, and downwelling radiance from the sky that is reflected off the surface (Weng et al., 2004). The measurements are then converted into LST, through a complex-mathematical procedure that involves conversion of radiance to temperature and corrections based on the atmospheric and ground compositions (Weng et al., 2004).

The core criterion to identify a UHI are measurements that consistently show high temperatures in a location, especially in comparison to vegetated or rural surroundings (Sidiqui et al., 2022; Weng et al., 2004). Correlating temperature data with biophysical indices, such as the composition of the city is a crucial part of the identification process. The Normalized Difference Vegetation Index, used to measure greenness, along with the Normalized Difference Built-up Index, used to measure concrete or asphalt surfaces, provides the necessary empirical basis to prove that urbanization is the driver of said observed heat (Guo et al., 2015; Voelkel et al., 2018). Lastly, whereas day temperature variability is important, in UHIs the temperature emitted from the ground usually peaks at night (Giannaros et al., 2013; Mitchell & Chakraborty, 2014).

Satellite data offer a clear image that takes the form of numerical weather and urban climate models (Giannaros et al., 2013; Kourtidis et al., 2015). Without this data, scientists would not be able to improve climate models and their ability to examine future scenarios for urban environments (Guo et al., 2015). Additionally, with UHI research, city planners are able to move from reactive management to proactive urban design (Keith et al., 2023). Specifically, UHI research has shown the cooling benefits of nature-based solutions (e.g. expanding tree canopies, and guided resource allocation), to inform about where cooled spaces should be built and where reflective materials have the biggest impact in an overheated city (Amorim-Maia et al., 2023; Guardaro et al., 2020). For public health governance, mapping UHIs in cities can inform warning systems and activate emergency responses, potentially saving lives (Meerow & Keith, 2021). Ultimately, having tangible evidence of visualized heat and its distribution in space is a powerful tool for advancing environmental justice by identifying the patterns behind thermal inequity and ensuring equitable climate adaptation (Mitchell & Chakraborty, 2014; Shi et al., 2016).

3.2 Climate vulnerability and the vulnerability scoping diagram

Vulnerability in the context of climate can be defined as the capacity to tolerate damage caused by exposure to a hazard (Cheng et al., 2021). It signifies the susceptibility of a system or population to be adversely affected by climate stressors and rather than being described as a static value, climate vulnerability is dynamic and generated by the intricate interplay of environmental, social, and economic factors (Leal Filho et al., 2018; Maragno et al., 2020). Ciplet et al. (2015) highlight that vulnerability is not just an outcome of physical exposure; but also socially produced through historical and structural inequalities. In their study of heat, Amorim-Maia et al. (2023) apply an intersectional lens to climate vulnerability and examine how disadvantaged social classifications, such as non-dominant gender, low socio-economic and migrant status, converge to produce amplified experiences of climate risk. In their study of Barcelona, they concluded that low-income residents or immigrants from the Global South are more vulnerable to adverse extreme heat effects, due to housing precariousness, energy poverty (inability to afford bills for cooling activities) and limited access to “public refuge”. Similarly, Mitchell & Chakraborty (2014) in their study of Pinellas County in Florida attribute disproportionate vulnerability to heat to historical developments leading to segregation, zoning based on race, and neighborhood disinvestment. These marginalized groups, as they found, are often amassed to highly dense neighborhoods that lack adequate vegetation.

A standard way to conceptualize climate vulnerability is by disaggregating it into three main pillars; exposure, sensitivity and adaptive capacity (IPCC, 2001). In academic and policy research, exposure refers to the external environmental effects that a population faces (Voelkel et al., 2018). This can take the form of excessive rain that leads to flooding, prolonged cold temperatures, a drought, or in the case of urban heat the intensity and spatial distribution of environmental heat (Ellena et al., 2020; IPCC, 2001). Sensitivity refers to the extent that the population is affected, as well as the case-specific characteristics that raise susceptibility (e.g. demographics) (Cheng et al., 2021; IPCC, 2001). Finally, adaptive capacity represents the ability of the population to cope and adapt, for example in extreme heat, factors that favor adaptive capacity are income, AC, access to green spaces and social support networks (Cheng et al., 2021; IPCC, 2001; Voelkel et al., 2018).

Putting this segmentation of the phenomenon into a structured framework, Shandas et al. (2017), present the Vulnerability scoping diagram (VSD) (figure 1).

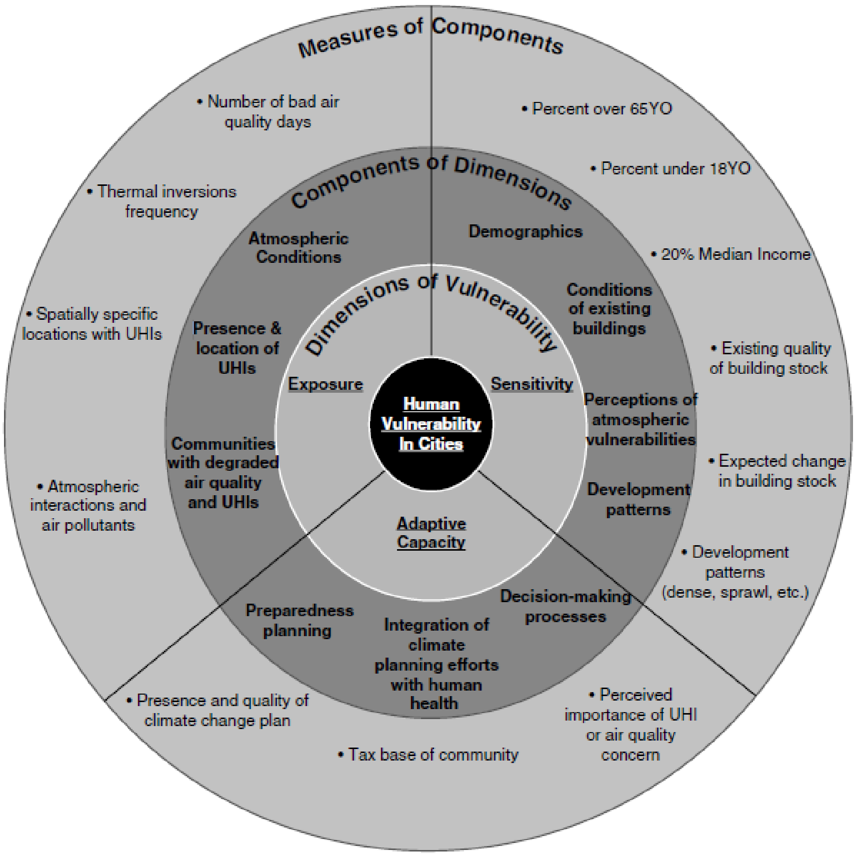

Figure 1. Vulnerability scoping diagram, by Shandas et al. (2017)

The VSD is a hierarchical conceptual tool that synthesizes the three dimensions of climate vulnerability into a guide for analysis. It mainly serves heuristically for discussion, but also as a roadmap for specific points in data collection that are needed to assess how environmental hazards, namely extreme heat and pollution, impact urban communities. The diagram is structured on the three main pillars (exposure, sensitivity & adaptive capacity), however these are broken down into broader categories of factors. The first layer of depth is the “Components of Dimensions”. Here the pillars are translated into focal points that the researcher should take into consideration. For example, exposure components include atmospheric conditions and the locations of UHIs, sensitivity components include factors like demographics or the condition of existing buildings and adaptive capacity consist of parts such as urban development patterns and the integration of health into climate planning. Lastly, the most granular level is the measures of components, representing the actual raw data indicators used for the measurement of vulnerability.

One last remark on vulnerability that stems from Shandas et al.'s (2017) application of the VSD is that vulnerability can also be viewed as a feedback loop. A population may become more vulnerable when impacted by a climate event due to negative effects on their health and welfare, at least in the short term. Missing out on work, unexpected healthcare costs, infrastructure damage or general inability to complete necessary daily tasks may lead to diminished resources, which can put a population in a disadvantageous position, where they are unprepared for the next extreme event, thus compounding their vulnerability over time.

3.3 Climate justice and its application on extreme heat (thermal justice)

In the core of Climate Justice lies a "great injustice"; the populations most vulnerable to the impacts of climate change are usually those who contribute less to it (Ciplet et al., 2015). Climate justice is fundamentally connected to heightened and disproportionate vulnerability to climate-related hazards (Ciplet et al., 2015). It connects to intersectionality, with interrelated types of socioenvironmental injustices fueling vulnerability in urban environments (Amorim-Maia et al., 2023) Similarly, vulnerability is not merely a reaction to natural phenomena, but a result of social mechanisms (Ellena et al., 2020).

To address different types of inequalities related to climate justice, researchers often utilize a trivalent framework consisting of "distributive", "procedural" and "recognitional" justices. Distributive justice examines the fair allocation of social and material advantages, procedural justice talks about the fair inclusion of socially diverse voices in decision-making, and recognitional justice deals with the legitimization of varying social and cultural identities, while acknowledging historical patterns of disadvantage (Amorim-Maia et al., 2023; Ellena et al., 2020; Shi et al., 2016). When this framework, and any related concepts, are applied specifically to extreme heat events, it is often referred to as “thermal justice” (Amorim-Maia et al., 2023; Hamstead, 2023). Consequently, thermal justice investigates the differences in the lived experience of heat and cold, attributing the emerging disparities to intersecting social and structural vulnerabilities (Amorim-Maia et al., 2023; Hamstead, 2023).

3.3.1 Recognitional justice

Recognitional justice is a critical starting point due to the acknowledgment of pre-existing patterns of advantage and disadvantage and the legitimization of diverse social and cultural identities (Bulkeley et al., 2014). In the context of extreme heat, recognitional justice forces planners to perceive heat not as a neutral meteorological event but as a socially produced phenomenon. This includes recognizing how historical land-use practices have created "urban heat riskscapes" (Hamstead, 2023; Marcińczak et al., 2025). Another recognitional justice framing is the embodied knowledge. Hamstead (2023), drawing from feminist literature, proposes the epistemology of “weathering”, seeking to reorient weather studies towards the human perception of temperature. The disembodied meteorology is reframed into state sanctioned violence where the lived experiences of thermal (dis)comfort translate awareness of climate change into situated political claims.

3.3.2 Distributive justice

In the case of thermal justice, distributive justice refers to the spatial and social distribution of heat exposure and access to cooling resources (Amorim-Maia et al., 2023; Bulkeley et al., 2014). Mitchell & Chakraborty (2014) identify “landscapes of thermal inequality” where elevated LST are significantly higher in census provinces with higher poverty and ethnic minority rates. Overheated poor and densely built neighborhoods have minimal access to both residential central air conditioning and public cooling centers (Mitchell & Chakraborty, 2014; Voelkel et al., 2018). A major distributive barrier is energy poverty. Low-income residents may not own cooling systems or cannot afford to maintain adequate indoor temperatures due to high utility bills (Amorim-Maia et al., 2023; Guardaro et al., 2020).

3.3.3 Procedural justice

When it comes to thermal adaptation, procedural justice refers to the equitable integration of many views, values, and needs in decision-making (Shi et al., 2016). Effective procedural justice moves beyond consultation towards co-production by allowing urban planners and residents to interact to shape neighborhood heat action plans (Guardaro et al., 2020). Many socially disadvantaged groups have historically been excluded from official planning procedures or are unaware of the ways in which they can participate, leading to miscalculated efforts that may not even benefit the residents they intended to protect (Guardaro et al., 2020; Hamstead, 2023).

4. Methodology

For the present research I have employed a mixed-methods approach, synthesizing spatial-climatological mapping with survey data to investigate the uneven landscape of thermal vulnerability in the Athens Municipality. By combining LST data derived from satellite imagery with the lived experiences of residents, this thesis bridges the gap between the "technical" science of urban climatology and the "nuanced" insights of urban geography and critical heat studies.

4.1 Spatial distribution of LST

Consulting the VSD diagram, I explored the exposure to heat by conducting a spatial analysis of the heat prevalence during a specific heatwave event in Athens. Specifically, on 20-27th of July 2025, when temperatures soared both during the day and night. The objective is to produce maps that depict the spatial distribution of LST within the dense urban fabric of the municipality. Data were retrieved from NASA’s Moderate Resolution Imaging Spectroradiometer (MODIS) and were free upon request with a signed-in account.

I evaluated both MODIS and Landsat remote sensing systems before opting for the most efficient data. While Landsat offers a higher spatial resolution (100m) for thermal data as opposed to MODIS (1km), the latter is far superior in temporal resolution. MODIS covers the globe daily, providing data for every 1-2 days, while Landsat’s frequency of measurements is 8 days. A high frequency of data is essential for capturing the peak intensity of heatwaves and the nocturnal UHI effect, which often reaches its maximum long after sunset. For analysis, I obtained 15 measurements for the dates of interest. One satellite measurement per day (performed around 15.00), and one per night (performed around 22.30). The time series had only one missing data entry, the daytime of 23rd of July.

I conducted the processing of the temperature data using ArcGIS Pro and followed a multi-step raster analysis. First, the administrative boundaries, as defined by the European Union (Eurostat/GISCO geographical data), of the municipality were laid onto the world map layer of ArcGIS. After I isolated the Athens Municipality local administrative unit (LAU), I converted it into a shape file which I later used to request the spatially relevant thermal data of MODIS. The data provided was in TIF files, meaning spatially referenced data grids. Each grid was applied on the map, containing the temperature metadata per 1km. With the raster calculator tool, I converted the LST values of the data from Kelvin to Celsius and by resampling the grid as bilinear I achieved a smoother transition between the 1km-wide pixels. Lastly, I applied a color gradient for clearer visualizations.

4.2 Human Dimensions

To explore the sensitivity and adaptive capacity of residents in Athens, I developed a qualitative-quantitative survey.

4.2.1 Design, Structure, Dissemination and Analysis

The questionnaire, consisting of 30 inquiries, was designed to capture three distinct dimensions of extreme heat: the thermal lived experience, infrastructure and social factors, and adaptation pathways. In the survey, 8 questions referred to the sensitivity aspect of vulnerability and questions related to adaptive capacity were 17. Question types used included yes/no, open-ended, and tiered questions (e.g Likert scale) with scores 1-5, and 1-4 for a single question.

The first part includes questions regarding the perceived experience of the heatwave and the frequency of heat-related somatic and mental health symptoms (e.g., dizziness, exhaustion, mood change, impact on daily labor etc.). The second part consists of questions regarding housing cooling capacity throughout the day, insulation, use of cooling devices, the reliance on cooled spaces, the reasons for which residents are forced to exit their house during the heat peak hours (11.00-18.00) and what factors exaggerate their overheating while away from home. In the final part, respondents were presented with adaptation measures and asked to classify them as potentially efficient, and suggest their own solutions to make their areas more resilient to extreme heat. Finally, they were asked to potentially identify with selected vulnerable social groups, namely disabled, regularly medicated for a somatic or mental condition, 65 years old or older, immigrant or asylum seeker and average annual income per household member is less than €10.000.

To establish a more personal connection to the experience of extreme heat, I urged the respondents to recall past heatwaves, specifically the heatwave that occurred during the week of July 20–27 of last summer. Similarly, later in the questionnaire, I asked whether they considered protection from heat to be a human right, assuming that the emotional and political connection to the phenomenon and their experiences had already been established.

I disseminated the survey through the social media platforms of Instagram and Reddit, with a targeted focus on the r/Athens_Greece Reddit community. This platform was chosen for its high engagement levels and its characteristic culture of hosting nuanced discussions regarding municipal issues. By posting in a localized "subreddit", I was able to approach respondents who are actively engaged with the city's current issues. On Instagram, I approached people I know that live in the municipality and also posted it on my profile's "story". I urged respondents to share the survey as well, verifying that this "digital snowballing" approach allowed for the rapid collection of the necessary data. In total, I collected 108 viable responses, with 50% (54 respondents) of the sample identifying as belonging to one or more vulnerable groups. For analysis and visualization, I used RStudio to perform t-tests for selected questions between the "vulnerable" and "non-vulnerable" groups. For the rest of the questions, I created pie-charts and bar-plots, where applicable.

4.3 Ethical Considerations

The ethical framework of my study is grounded in the principles of complete privacy, autonomy and the protection of marginalized voices. A central ethical principle of my research is that certain sensitive information should never be a prerequisite for scientific participation. As a consequence, respondents were not required to disclose their specific neighborhood, with the only prerequisite for participation being that the respondent is a resident of Athens municipality. Instead, geographic information was requested on a purely voluntary basis (e.g., "In what area of Athens municipality do you reside?"). Furthermore, questions regarding whether a respondent identifies as belonging to a disadvantaged or vulnerable group (socio-economically, physically or otherwise) were entirely optional. As a researcher, I hold the firm position that the burden of proof regarding marginalization should not be forced upon the participant, but rather that the researcher is obliged to create a safe space where such identities can be shared only if the participant feels it adds to the recognition of their thermal struggle.

Regarding data safety, the questionnaire was hosted on Cryptpad, an end-to-end encrypted, open-source platform. This ensured that no third-party providers had access to the raw data and all responses were stored in an encrypted environment. Participation was entirely anonymous, meaning no IP addresses, names or contact details were collected.

4.4 Limitations

Due to the strict deadlines of the thesis and limited computational resources, the spatial analysis provides a "snapshot" of a specific heatwave rather than a multi-decadal study, such as those utilized in the bibliography. While this captures the intensity of this specific extreme event, it does not account for the subtle shifting of UHI patterns over time and space, across the whole of Athens.

Lastly, the use of an online questionnaire and its distribution on digital platforms may skew the demographic towards a younger, more tech-savvy or politically active population, potentially under-representing the elderly, who are often among the most physically sensitive to extreme heat. Similarly, Cryptpad's inability to accommodate a multilingual version led me to choose Standard Modern Greek as the sole language of the questionnaire, potentially invisiblizing migrants or other social groups who may be excluded due to limited Standard Modern Greek proficiency.

4.5 The researcher vs afflicted individual

In keeping with the traditions of critical social research, it is necessary to state my positionality. I do not in any way approach this topic as a detached, "objective" observer. As a resident of Athens for my whole life, during the heatwave analyzed in this study and many more before it, I have experienced the physical and mental toll of the "concrete jungle" firsthand. All the sleepless nights in an uninsulated apartment, with the extensive use of AC being a luxury, especially during the harsh years following the economic collapse of the country, and all the insufferable commuting under a relentless sun, cultivated the simple realization that extreme heat is, indeed, violence. What for some is the “ideal vacation weather”, for others is a decimation of functionality, of socialization and even a matter of survival. Thus, the traumatizing personal experiences from my childhood, adolescence and now adult life are serving as the primary catalyst for choosing this topic and carrying out this work.

This dual role as both a researcher and an afflicted individual creates a unique sense of duty. I am motivated by a desire to translate individual discomfort and structural betrayal into academic evidence that can advocate for those who lack the resources to escape the heat. While I struggle for high standards in data processing and analysis, my "insider" status allows for deeper empathizing with the survey respondents and a more critical eye toward the planning failures that have led to my city’s current thermal state.

In the place where great minds philosophized and debated the concept of justice millennia ago, I, now, commit to pursue it.

5. Results

To answer the first question posed in my research, I made figures that employ satellite data to examine temperature prevalence during the heatwave of July 20-27, 2025. The figures show the excessive temperatures that are sustained even during the night. While the UHI effect in central Athens is confirmed by literature, I also observed a thermal pattern between the western and eastern parts of the municipality, with the west experiencing 2.5-4.0°C of higher temperature during daytime.

For the second question, I needed to analyze the quantitative and qualitative data provided by the residents themselves. During heatwaves, residents have trouble coping with extreme heat and this manifests in a plethora of symptoms. Factors contributing to their exposure include lack of crucial infrastructure upgrades to their homes (e.g. thermal insulation), or economic barriers in the use of AC, which they try to compensate by designating "cool zones" at home, sometimes even with other people. Work is the main responsibility that drives outdoors exposure during peak heat, with cancelling or postponing it being a limited option. The quality of public transport and publicly accessible cooled spaces is bad, further exaggerating their exposure. The favored measures needed for effective relief include subsidies, upgrades in public infrastructure, as well as legislative support regarding labor.

5.1 Exposure

The analysis of Land Surface Temperature (LST) for the Municipality of Athens during the study period confirmed the presence of a major thermal event. For the daytime measurements temperatures ranged between 32.27°C and 43.88°C, with six out of the seven measurements being close to or above 40°C. The data indicates a sudden increase in thermal intensity on the 21st with an increase of almost 7°C (see figure 2) with its peak day being July 27th (43.88°C). Regarding nighttime temperatures, the data form a smoother curve, slightly increasing towards the 25th and slightly decreasing afterwards. The lowest temperature was recorded on the night July 20th (29.32°C) and the highest on the night of July 25th (33.75°C). All nighttime measurements exhibit temperatures of almost 30°C or above.

The combined daily mean temperatures tell a similar story with six out of seven measurements being close to or above 35°C, the lowest being July 20th (30.8°C) and the highest July 25th (38.23°C). This verifies that, in the examined period, July 25th was indeed the hottest day when I averaged the measurements of the daytime and nighttime averages, as claimed by the National Observatory of Athens (2025).

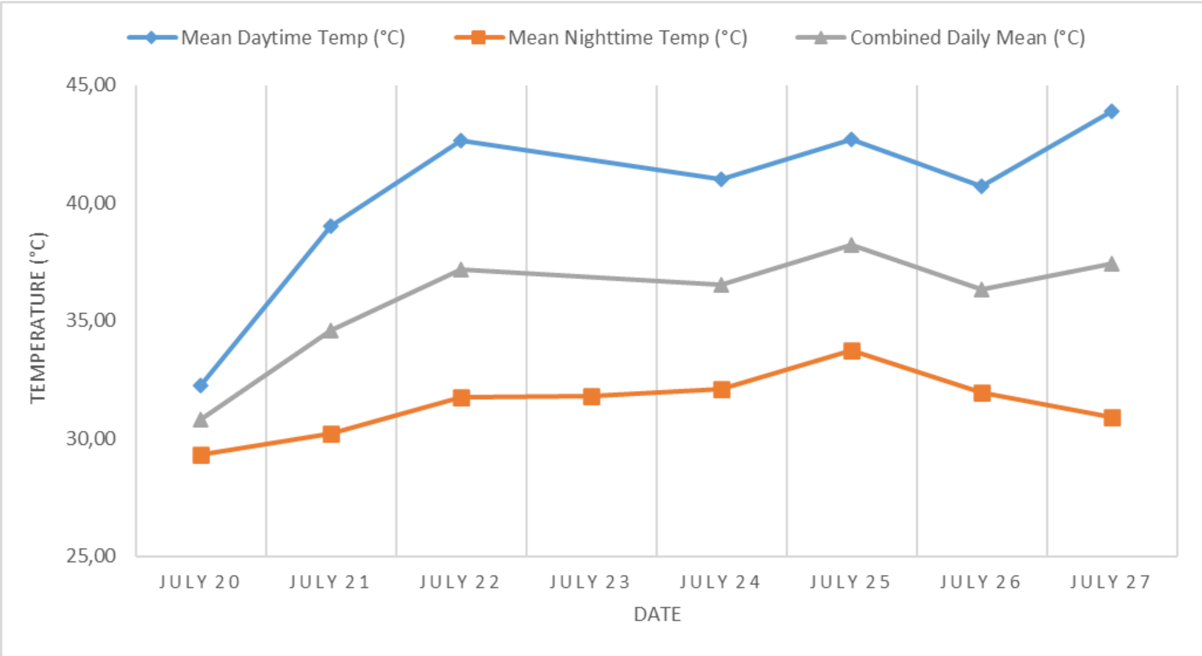

Figure 2. Mean LST Values for Athens Municipality (July 20–27, 2025)

Spatially, the daytime temperatures reveal a specific pattern of thermal distribution. An apparent difference that emerges pertains to the temperature between the western and eastern areas of the municipality. In the western part temperatures appear to be between 2.5-4.0°C higher. This heat distribution pattern is not as distinct during the nighttime. The temperatures remained roughly the same, with a slight difference of less than 0.5°C. Still, while temperatures decreased overall from the daytime measurements, the urban fabric retained significant heat during the night.

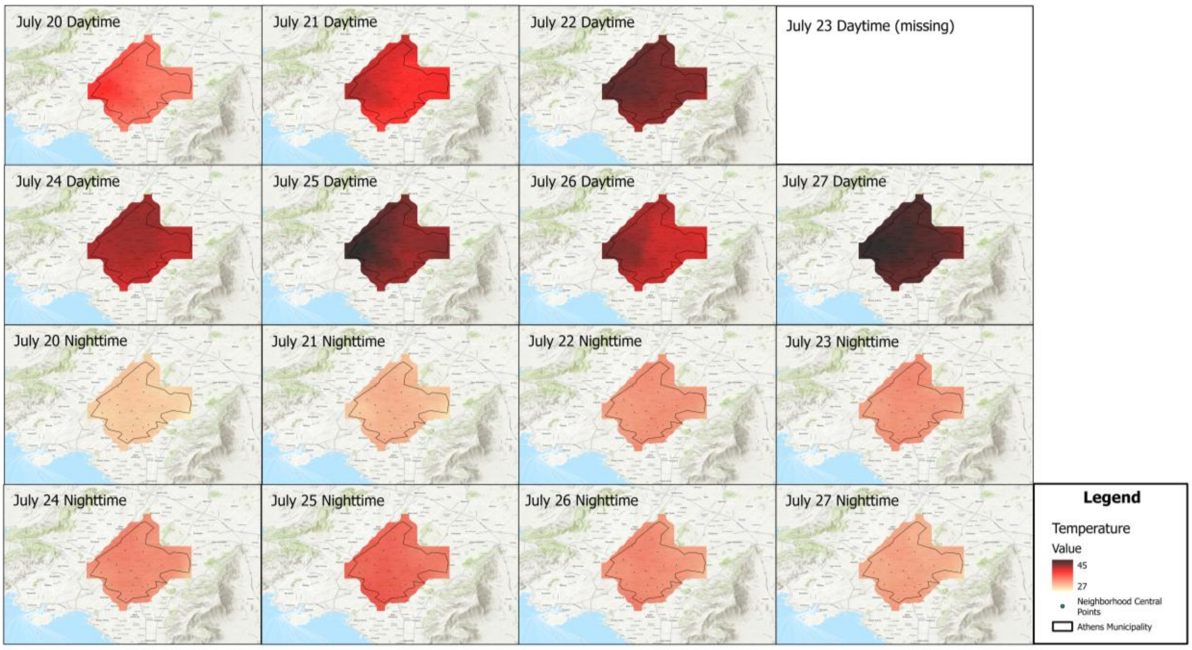

Figure 3. LST Map of Athens Municipality – July 20-27, 2025

5.2 Sensitivity

The fundamental categorization that I followed regarding the respondents, was between two groups, the vulnerable and the non-vulnerable. Half of the respondents (54) identified with the given vulnerability status or identified as belonging to a different group that is disproportionally affected by extreme heat. The additional groups included mental health disorders, womanhood, and social isolation.

The physical or mental sensitivity of the residents is high, with many of them experiencing symptoms such as sleep disturbance, fatigue and a loss of productivity. The statistical difference between the two groups in regards to their experience is insignificant ($p>0.05$). Similarly, for built environment sensitivity, the majority rated the ability of their homes to stay cool during the day and night as medium or bad, with more negative responses regarding the nighttime. No statistical significance was found between the two groups ($p>0.05$).

Table 1. Scores of physical and mental impacts of heatwaves, and residential cooling capacity per group.

Question	Average scale score (vulnerable)	Average scale score (non-vulnerable)	Significance
Somatic effect	4.1	3.9	0.4238
Mental and emotional effect	3.6	3.2	0.1308
Ability of home to remain cool during the day	3.7	3.3	0.1285
Ability of home to remain cool during the night	3.6	3.4	0.3553

5.3 Adaptive capacity

Regarding technological capacity, the vast majority of the respondents have not thermally isolated their house, nor have they ever received funding to do so (see table 4). The high cost of such upgrades stands out among the reasons for not performing the upgrade, while lack of ownership stands out as a general barrier both for upgrading and applying for funding. When asked about AC, the responses weighed towards frequent use during heatwaves. Between the two groups there was a statistically significant difference, with vulnerable individuals using it less than their non-vulnerable counterparts ($p<0.05$). The main reason discouraging the use of AC among the respondents was overwhelmingly the high energy costs, while environmental concerns were mentioned as a second reason. Similarly, the likelihood of the vulnerable group using other, less effective cooling devices (e.g. fans) was also statistically significant ($p<0.05$, see table 2).

Regarding the behavioral capacity of the respondents, a fairly common experience proved to be the consolidation of life into a single “cool” zone in the house. A less common, yet still prevalent experience was gathering with other people in a room or a house to overcome the barriers of using the AC or other cooling devices. Visiting naturally or artificially cooled spaces that are open to the public is also something the majority of respondents opt for (see table 4), however main barriers include lack of such spaces, the distance, crowdedness and not adequate cooling capacity. In the “other” section, some respondents clarified that in a heatwave even a small distance can be impossible to bear. The social capacity of the respondents also appears to be very low, with the vast majority of them relying on themselves, rather than their family and friends, community, or local authorities and the state.

When it comes to peak heat hours (11.00-18.00), respondents tend to avoid going out for more than 4h and there was no statistical difference between the two groups ($p>0.05$). The main barriers preventing them from staying at home are having to go to work or another place of obligatory presence, and availability of certain services only during these hours. While outside, factors that led to overheating were mainly related to public transport (lack of shade while going to or waiting at the stops, long waiting hours and unreliable arrivals, and lack of AC or other cooling mechanisms). Other highlighted factors were the lack of green infrastructure and densely built streets that prevent natural ventilation. Cancelling or postponing responsibilities during peak heat hours is also not an option for the majority of respondents, with the difference between the two groups being statistically insignificant ($p>0.05$, see table 2). Among the barriers cited by the respondents, the majority pertain to their job, either the nature of it or that a heatwave is not enough of an excuse for remote work. A few cited working “under the table” (not officially hired) and not being able to lose daily wages.

Table 2. Scores of use of cooling devices, time spent outdoors and ease of cancelling or postponing responsibilities during peak heat hours (11.00-18.00) per group.
*Statistically significant ($p<0.05$) difference between the groups.
** Scored 1-4.

Question	Average scale score (vulnerable)	Average scale score (non-vulnerable)	Significance
Use of AC	3.4	4.1	0.0008*
Use of other, less effective cooling devices	3.9	3.2	0.0011*
Time spent outdoors during peak heat hours (11.00-18.00)**	2.1	1.9	0.3447
Ease of canceling or postponing responsibilities	3.3	2.9	0.218

Lastly, on the topic of institutional capacity, the overwhelming majority views protection from extreme heat as a basic human right, similar to water or healthcare (see table 4). Among the adaptation measures presented, all of them gather a similar level of support. Subsidies for AC, energy prices and heat insulation, expansion of accessible, cooled spaces and infrastructure that provides shade, upgrades of public transportation, and obligation by law for workspaces to offer remote work, a cooled working environment or frequent breaks and day-offs, depending on the nature of the job, are regarded as effective.

Finally, the respondents presented their own measures that would make their area or the municipality more resistant against heatwaves (see table 3).

Table 3. Adaptation measure categories proposed by respondents sorted by times mentioned.

Proposed Measure Category	Times mentioned
Green Infrastructure (parks, trees, gardens, green roofs etc.)	16
Reduced urban congestion (cars, tourists, construction works)	5
Repurposing of abandoned spaces (into parks, gardens, shaded areas etc.)	5
Construction regulations (price caps for new, uninsulated buildings, ban on glass buildings, minimum tree coverage etc.)	4
Municipal cooled spaces (air-conditioned, municipal pools etc.)	3
Public transport upgrades (route restructuring)	2
Blue infrastructure (stream restoration)	1

Table 4. Responses to yes/no questions per group.

Question	Yes (vulnerable)	Yes (non-vulnerable)	No (vulnerable)	No (non-vulnerable)
Residential thermal insulation upgrades	7	5	47	49
Received funding for thermal insulation	1	1	53	53
Consolidation into a single "cool zone" at home	48	42	6	12
Consolidation with other people in room/house to use cooling devices	29	22	25	32
Visiting artificially/naturally cooled publicly accessible spaces	32	29	22	25
Protection from heatwaves as a human right	53	53	1	1

6. Discussion

6.1 Heat as a shared urban burden

The results portray extreme heat as not a mere meteorological phenomenon, but as a pervasive and violent disruption to the daily lives of Athens residents. Both vulnerable and non-vulnerable respondents report an above average rate of somatic, psychological and emotional harm, highlighting that central Athens is an urban heat riskscape (Silva et al., 2026). Their experience is complemented by the residential failure of uninsulated homes, unable to keep heat out. The majority of residents rated their housing's ability to stay cool as medium or bad, with conditions worsening at night, meaning that residents are used to “compound heatwaves”, where temperatures stay high around the clock (Gao et al., 2026). Their embodied experience, the “weathering”, serves as a testament of the structural disadvantages most of them face (Hamstead, 2023).

For many Athenians, the use of AC is a costly standard utility, leading to the designation of temporary "cool zones" within homes to cope with high electricity bills. Their economic struggle is a clear manifestation of "energy poverty", with non-vulnerable residents opting more for cheaper, less effective alternatives (Amorim-Maia et al., 2023; Guardaro et al., 2020). Simultaneously, subsidies for thermal insulation are almost nonexistent, putting the burden of the costly upgrades on the individual rather than a comprehensive adaptive strategy. This housing and financial precarity directly correlates with the ability of the individual to seal themselves from extreme heat (Amorim-Maia et al., 2023; Sessa et al., 2025). The lack of adequate income is transformed into a direct physical and psychological punishment due to institutional neglect, reinforced by the lack of subsidies (Hamstead, 2023; Kotsila et al., 2025). The attempt to create affordable refuge at home is exaggerated by the inadequate cooled and publicly accessible spaces scattered throughout the municipality. Formal municipal “shelters” are scarce and not cool enough, while de facto shelters (e.g. shops) provide only artificial cooling and require a service fee, adding another layer of economic injustice (Amorim-Maia et al., 2023; Guardaro et al., 2020; Kotsila et al., 2025)

Work is the primary driver of outdoor exposure during peak heat hours (11:00–18:00), yet most residents cannot cancel or postpone these responsibilities. When compelled by labor conditions, heat distress can only be described as a form of violence (Hamstead, 2023). This exposure is aggravated by unreliable public transport that lacks shade at ground-level stops and often operates without functioning AC. Streets and public transport are the main unit of public space that residents occupy outside, making it a focal point of exposure (Fu et al., 2026).

6.2 Climate justice implications

6.2.1 Recognitional justice

Recognitional justice is a necessary precondition for both distributive and procedural justice. Without it, the experiences of residents remain invisible to the policy frameworks intended to protect them (Bulkeley et al., 2014). The results have profound implications for recognitional justice, legitimizing the lived struggle of residents. A first step was acknowledging vulnerable social categories and complementing them through additional input from the residents (e.g. mental health conditions etc.). Intersectionally identifying individuals who might be more prone to adverse outcomes of extreme heat, and confirming that they are affected disproportionately by “energy poverty”, can lead to more targeted protection (Bulkeley et al., 2014; Hamstead, 2023).

A second implication revolves around the embodied experience of the totality of residents (Hamstead, 2023). Sleep disturbance, fatigue, loss of productivity and the many more somatic and mental symptoms of the residents directly counter the dominant meteorological narrative that counts temperatures rather than affected people (Hamstead, 2023). Climatic data do not exist in a vacuum, and these physiological thresholds serve as crucial data for emergency interventions and long-term planning (Hamstead, 2023; Psiloglou et al., 2025). A functional system based on heat-health approaches would prove extremely insightful to the state or the local authorities (Ellena et al., 2020). Such a system, for example, will use meteorological forecasts to trigger emergency protocols, determined through assessments of the temperature-mortality relationship, and based on relevant thermal thresholds (Kotharkar & Ghosh, 2022).

Lastly, there is a need for recognition of the power imbalance burdening several respondents. Power is conceptualized not merely as a matter of individual agency or financial resources, but as the production of effects directly through social relations (Ciplet et al., 2015). In the residential sector, the primary barrier to thermal insulation was the lack of home ownership. This tenure-based barrier represents a profound asymmetry of power regarding the built environment. Protective resources are often connected to property ownership, so renters are legally unable to access the benefits of energy-retrofit programs (Amorim-Maia et al., 2023). In the case where renters can intervene, they are often unwilling to take on the added expense for a property they do not own (Guardaro et al., 2020). Without proper incentive to maintain or provide cooling features, landlords directly affect the exposure and adaptive capacity of their tenants (Ciplet et al., 2015; Kotsila et al., 2025). Similarly, another power dichotomy is that of the labor sector. For many, work is the main driver of outdoor heat exposure, yet the power to cancel, postpone, or modify work hours rests with the employer. The very naturalized answers "not enough of an excuse (for remote work to be allowed)" and “the nature of the job”, prove that employer inflexibility is directly affecting exposure (Kotsila et al., 2025). Those who work “under the table” lack employee benefits and regulatory protections, and their wage is connected to their work-hours, putting them on the forefront of this injustice (Ciplet et al., 2015; Kotsila et al., 2025).

6.2.2 Distributive justice

The results also demonstrate how benefits, costs, and risks associated with extreme heat and adaptation measures may be unequally distributed to the residents, the distributive justice of the matter. Geographically, the western part of the municipality heats up more, meaning there is a thermal imbalance affecting the population that resides in these neighborhoods. This can be attributed historically to a more intense industrialization of the whole western part of the city, higher traffic levels, less points of high elevation, and high building density (Giannaros et al., 2013; Kourtidis et al., 2015; Santamouris et al., 2001). For distributive justice to be realized, adaptation measures should take the form of localized interventions that prioritize these high-heat zones (Turner et al., 2022).

The “cooling gap” vulnerable residents face is also apparent as a distributive issue of heat (Amorim-Maia et al., 2023). The difference in AC use between vulnerable and non-vulnerable groups, with the former using AC significantly less paired with the high energy costs that were identified as the primary barrier, verify the "cooling gap". The financial cost of staying safe is prohibitive for the more vulnerable, forcing them to rely on less effective devices like fans. The implication is that distributive solutions must be restorative, prioritizing the disproportionally affected (Amorim-Maia et al., 2023; Ciplet et al., 2015)

A last field of unequal distribution of heat exposure is public transport. Residents highlighted public transport as a main contributor to their exposure in three distinct ways. Waiting without shade, delayed arrival and lack of AC inside the transportation vehicle, are all points of additional exposure to heat, which creates a clear divide between those who commute by car and those who use public transport. In fact, some modes of transportation are more prone to thermal discomfort such as underground railways, which also serve more people (Meerow & Keith, 2021). Without proper planning, structural failures accumulate as infrastructure is damaged and strain is put on the energy grid by extreme heat (Meerow & Keith, 2021; Turner et al., 2022). The implications for distributive justice are plenty as planning needs to take into account the ignored data of exposure during transit, focus on public transport passengers, who are more prone to classify as generally vulnerable, and aim for decongestion potentially through labor policies (Ellena et al., 2020; Guardaro et al., 2020; Keith et al., 2023).

6.2.3 Procedural justice

Procedural justice requires a shift in whose knowledge is prioritized, away from a purely technocratic reliance on meteorological instruments towards the lived experience of the residents (Amorim-Maia et al., 2023; Hamstead, 2023). A recurring theme in the results is the demand for legal protection against extreme heat. The overwhelming majority of Athens respondents view protection from heat as a basic human right. This shows a procedural demand to shift to a rights-based governance model (Ciplet et al., 2015). In this model, residents are "rights holders", opening a seat at the table for them to co-create heat action plans, ensuring that infrastructure upgrades in public transport or cooled spaces actually reflect their everyday realities (Ciplet et al., 2015; Guardaro et al., 2020). This demand is extended towards employers, whose excessive power over employees needs to be readjusted by obligations to provide cooled working conditions, frequent breaks and day-offs. Labor unions and vulnerable workers can play an important part in achieving legislative protection against extreme heat (Shi et al., 2016).

Procedural justice is often impeded by "siloed" governance, where different departments act independently (Meerow & Keith, 2021). The results pinpointed public infrastructure and labor as primary drivers of exposure to heat, however cross-departamental cooperation of the respective public departments is absent (Louis & Sapountzaki, 2010). Procedural justice requires breaking down these governance siloes to integrate labor departments and urban planning into the central agenda of municipal heat action plans (Ciplet et al., 2015; Kotharkar & Ghosh, 2022). This will allow residents to advocate for changes across all systems that contribute to their thermal insecurity, through integrated response mechanisms (Shi et al., 2016).

6.3 Pathways to adaptation

My third question revolved around pathways to adaptation, informed by the residents and read through the lens of climate justice. Residents support and proclaim a variety of adaptation measures that alternate between long-term physical mitigation and immediate socio-institutional management, and these are heavily supported by theoretical frameworks in heat studies, climate justice, and urban planning. The pathways encompass the urban environment, infrastructure, and legislation. Nature-based solutions are the most broadly demanded intervention, with priority given to the hotter western neighborhoods (Leal Filho et al., 2018; Sidiqui et al., 2022). Since staying cool is effectively a commodity, subsidies are essential, ideally targeting heat-vulnerable buildings rather than just individuals, so that older and poorly insulated housing is prioritized (Amorim-Maia et al., 2023). Investment in public infrastructure is urgently needed, especially in public transportation and a network of affordable, multipurpose, cooled public spaces (Guardaro et al., 2020; Kotsila et al., 2025). Legislatively, decongestion, a climate-resilient building code, and the legal recognition of heat protection as a human right would unlock tenant rights to thermal retrofits, mandatory employer obligations during heatwaves, and extended protections for undeclared workers. This would turn adaptation from an individual burden into a collective, enforceable commitment (Bulkeley et al., 2014; Hamstead, 2023; Kotsila et al., 2025)

6.3.1 Urban environment

The most proposed measure revolves around nature-based solutions. Residents are in favor of expanding green infrastructure in the form of planting street trees and creating parks and gardens. Trees and vegetation provide cooling through shading and evapotranspiration, while also raising the perceived comfort of the residents in the landscape (Fu et al., 2026; Gao et al., 2026; Leal Filho et al., 2018). Stream restoration was also proposed, which may provide evaporative cooling, and higher thermal capacity, which is particularly effective for daytime UHI mitigation (Leal Filho et al., 2018; Sidiqui et al., 2022). Considering the implications of distributive justice, each area may have different capacity to nature-based solutions, and a geography-specific plan should be considered for the most heat-prone places (e.g. the western part of the municipality).

Another prominent claim of the residents is direct financial support, specifically subsidies for AC, energy prices, and residential thermal insulation. Staying cool during heatwaves is a commodity tied to economic status and in the case of AC, the situation is dire for the vulnerable. A just approach to this “energy inequality” is to provide technological subsidies and tiered electricity pricing for heat-vulnerable residents (Amorim-Maia et al., 2023). To not end up with an unjust strategy that excludes the experiences of non-vulnerable residents, instead of the heat-vulnerability of the individual, we could be measuring the heat-vulnerability of the residence as well. Older and uninsulated buildings or buildings with a greater sensitivity to heat due to their geographical location can rank higher in the priority listing of who gets the support first.

Serious interventions in public infrastructure are necessary. Commuting is a major point of exposure for residents, who advocate for installation of AC in all public vehicles, the transformation of bus stops into “shaded stops”, adherence to scheduled arrivals or even a smarter restructuring of the route network. All these measures are confirmed to make public transport more accessible and the passengers more resilient to overheating (Guardaro et al., 2020). Similarly, the municipality needs to upgrade its cooled spaces, to give the opportunity to residents to enjoy a pleasant environment. These spaces need to have a multi-purposed character, meaning that it should include libraries, civic centers, schools etc., so residents can use them for a variety of reasons alongside heat protection, at minimal cost. The aim is to create a “cooling network”, where residents are protected from overheating throughout their transit to their destination (Amorim-Maia et al., 2023; Kotsila et al., 2025).

6.3.2 Legislative pathways

Decongestion has great potential to alleviate the UHI effect in Athens (Zoulia et al., 2009), as vehicles are major sources of waste heat in the urban environment (Hamstead, 2023; Keith et al., 2023). Alleviating traffic decongestion by pedestrianizing the city center and other busy avenues can have several benefits. Pedestrian and bike lanes significantly reduce waste heat and can facilitate the realization of an extensive “cooling network”, alongside green and cooled spaces (Kotsila et al., 2025; Meerow & Keith, 2021). Additionally, higher walkability and bike use are associated with improved public health, which promotes lower vulnerability to heat (Meerow & Keith, 2021). However, an urban factor that regularly works synergistically with traffic congestion is population density (Almashhour et al., 2024). Residents in Athens report that tourism leads to crowded streets, overburdened public services, and packed buses and metros transforming systems that long-term residents rely on (e.g. public transport), into sites of intense thermal stress (Yaprak et al., 2025). The municipality ought to implement caps on visitors and prioritize thermal safety over tourism-based revenue (Kotsila et al., 2025). Similarly, smarter visitor dispersal in crowded central streets and monuments could reduce both overheating and overcrowdedness (Yaprak et al., 2025). All the excessive short-term housing could be used for long-term residents instead, making the implementation of all adaptation strategies more effective and meaningful.

Another intervention proposed by residents was construction regulations. Some basic propositions included price caps for inadequate buildings, bans on glass buildings, minimum tree coverage and better building height to street ratio. The aim of such a measure category is to prioritize thermal resilience and operational performance under extreme heat conditions (He, 2024). Bans should not be limited to glass, but a wide range of heat trapping materials and structures. A climate-resilient building code can mandate strict standards for durable and temperature-resistant materials, paired with resilient structure models that withstand heatwaves (Almashhour et al., 2024). Such materials may include hollow-bricks, concrete alternatives that allow aeration, high-albedo materials and paints for rooftops or instead vegetated parts, like green roofs (He, 2024; Joshi et al., 2024). Even if these can lead to increased construction costs, their long-term efficiency counters it (Almashhour et al., 2024). Inspired by the “minimum tree coverage” proposed in the survey, I dare to propose the 3-30-300 rule, which advocates that every resident to be able to see at least 3 trees from their home, have 30% tree canopy cover in their neighborhood, and live within 300 meters of the nearest high-quality public green space (Silva et al., 2026).

Lastly, a very important step in the legislative approach, is the recognition of certain rights. Residents overwhelmingly supported the recognition of protection from extreme heat as a human right. This would open the way to legal recognition of heatwaves as "emergencies" comparable to hurricanes or floods, which would trigger immediate institutional resource allocation and legal protocols (Meerow & Keith, 2021). Residential rights also require an update, namely the legal right of tenants to demand thermal installations and participate in applications for funding (Bulkeley et al., 2014). Ultimately, several steps can be taken in the direction of labor rights. Residents ask for laws that obligate workspaces to offer remote work or a cooled indoor environment when temperatures exceed certain thresholds, and depending on the nature of the job, workers that are prone to exposure should benefit from frequent breaks and day-offs. These of course should be extended to under-the-table and subcontracted workers as they usually lack legislative protection (Kotsila et al., 2025). It is also necessary to strengthen regulations against the agents responsible for the implementation of such rights, namely employers, corporations and owners (Hamstead, 2023).

6.4 Opportunities for future research

There are also approaches I did not fully pursue, and they deserve attention. Green gentrification is the most pressing one. Nature-based solutions are broadly supported here and in the literature, yet planting trees and creating parks in low-income, heat-vulnerable neighborhoods can raise property values and push out the very residents they were meant to benefit (Almashhour et al., 2024; Leal Filho et al., 2018; Meerow & Keith, 2021). Without accompanying tenant protections and rent controls, green-blue infrastructure can become a tool of displacement disguised as resilience (Hamstead, 2023; Silva et al., 2026). Future research should also examine the gendered dimensions of heat vulnerability more closely. While womanhood was identified by respondents as an additional vulnerability category, it was not in my scope to explore how domestic labor, caregiving responsibilities, and patriarchy shape women's thermal experience in particular. The psychological toll of extreme heat also requires further study. I captured some mental and emotional symptoms through survey responses, but a deeper clinical or ethnographic approach would better illuminate how repeated heatwave exposure accumulates into chronic stress, and how that burden is distributed across social groups. Lastly, including elderly and migrant residents (who I failed to represent adequately) in a more meaningful way, perhaps through participatory research designs, would bring the field closer to the procedural justice it advocates for (Bulkeley et al., 2014).

7. Conclusions

My thesis makes a deliberate intervention in a field that has long privileged the thermometer over people. By integrating LST data with the lived experiences of 108 Athenians, I contribute to sustainability science not merely as a technical exercise but as a normative endeavor. The dominant paradigm in urban heat research remains heavily oriented toward modeling and mapping and while these methods are important, they consistently fall short of capturing the social layering of thermal suffering. I demonstrate that bridging spatial climatology with survey data is not only methodologically viable but an ethical necessity. It produces a fuller, more honest account of what extreme heat does to a city and its people, one that sustainability science must embrace if it is to remain relevant to those most at risk.

Athens is not simply a hot city, but an unjust one. The heatwave of July 20–27, 2025 was not experienced, by any means, equally. Satellite data exposed a persistent east-west thermal gradient of 2.5–4.0°C, inscribed into the urban fabric by decades of unregulated industrialization, high building density, and planning neglect. The survey data, in turn, revealed that residents share a common experience of thermal insecurity, caused by uninsulated homes that fail to cool at night, costly and unreliable public transport, and workplaces that offer no legal protection against dangerous temperatures. Vulnerability status does matter, most critically in the statistically significant "cooling gap", where economically marginalized residents rely on fans while their counterparts run air conditioning. This is a blatant case of energy poverty, and no amount of satellite imagery can adequately capture it without the voices of those who live it.

Through the lens of thermal justice, these patterns cease to be unfortunate coincidences and become the outcomes of structural failure. Recognitional justice demands that planners stop treating heat as a meteorological abstraction, but rather as socially produced violence rooted in inequalities of ownership and labor. Distributive justice demands restorative, geography-specific interventions (e.g. subsidies, cooled public infrastructure, public transport upgrades) that prioritize those affected the most. Procedural justice demands that residents who know their neighborhoods most intimately are not consulted as an afterthought, but positioned as co-producers of the heat action plans that will govern their lives. The overwhelming consensus among respondents that protection from extreme heat constitutes a basic human right is not just sentiment, it is a procedural demand that sustainability governance must take seriously.

The title of this thesis is borrowed from a lyric by the band “Τα Ξύλινα Σπαθιά” (“Wooden Swords”), from their 1993 song "Αδρεναλίνη" (“Adrenaline”). The whole lyric goes like this:

“Η μέρα σβήνει (The day goes away),

Αθήνα είσαι καμίνι (Athens, you are a kiln).

Ώσπου να φέξει (Until dawn breaks),

να δούμε ποιος θ' αντέξει (let us see who will endure)”.

Written over thirty years ago, this line was never intended as climate research. It was a raw expression of what it feels like to inhabit this city at night, trapped in heat that refuses to relent. And yet, it describes with more accuracy and urgency than most academic research what the residents surveyed in this thesis experience every summer. The fact that extreme heat has been embedded in Athenian popular culture for decades, that ordinary people sang about thermal insecurity long before policymakers acknowledged it, is itself a form of embodied knowledge that sustainability science is only beginning to take seriously. It is a testament to how normalized, and therefore how violently ignored, this suffering has become. When a city's heat is so total, so relentless, and so unevenly distributed that it becomes the subject of song, it is no longer a meteorological event, it is a condition of life, and that is precisely what I sought to make clear.

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