

Re-definition(s) of the role of Central Business Districts under the effect of extreme heat conditions and Climate Change: Evidence from the Mediterranean context.

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Abstract

Central Business Districts have always been the loci of major transformation, redevelopment and constant re-definition(s) regarding their role within large urban territories. Climate Change combined with Urban Heat Island, could render CBDs particularly vulnerable to extreme heat conditions and persistent heatwaves, affecting their key functions and quality of life. This work investigates the above issue through a case study in Athens, a densely populated Mediterranean urban agglomeration. Methodology involves identification of key aspects of the CBD structure that increase its vulnerability to extreme heat waves and related hazards and pressures. Our conclusions state that Climate Change could eventually lead to changes in urban structure, affecting existing CBDs and possibly favoring relocation of activities towards other city zones, where climatic conditions will be more favourable.

Keywords: Central Business District, Climate Change, Heatwaves, Urban Structure, Urban Planning, Athens

1. Introduction

In the summer of 2023 an extreme heatwave stretching from Miami and Texas to Arizona and California has led to unprecedented record-breaking temperatures, most notably in Phoenix with a 31-straight-days with over 43.3 °C record. During the same period, in the Mediterranean air temperatures hit 46°C in Rome and Madrid, with major cities suspending certain functions, temporarily banning outdoor working and outdoor events, and taking precautionary measures to protect human population from extreme heat conditions and consecutive heatwaves. Generally, the persistent heatwaves of July 2023 have largely affected several Mediterranean capital cities including Madrid, Rome, Athens and Lefkosia (Figure 1). More cases worldwide have been reported where extreme heatwaves due of unprecedented nature are linked to partial lockdowns in urban metropolitan areas, putting urban life on pause¹.

The common driver and accelerator behind such conditions is Climate Change. Since the last quarter of the 20th Century, Planet Earth has entered an accelerating global warming phase, with the mean surface air temperature on land reaching about 15°C (14.98°C in 2023), i.e. a +1.09 in 2011–2020 period in respect to the pre-industrial levels and the 1850–1900 average (IPCC, 2022). This increase practically means that winters are expected to be less cold, while summers will be warmer and with more heat extremes. Globally, the last ten years have been the warmest on record, while the summer of 2023 has official been declared as the hottest summer on record (<https://climate.copernicus.eu/summer-2023-hottest-record>).

¹ <https://www.bloomberg.com/news/articles/2023-08-02/heat-lockdowns-are-the-new-covid-lockdowns>,

<https://www.telegraph.co.uk/global-health/climate-and-people/sudans-heatwave-school-closures-children-lockdown-africa/>

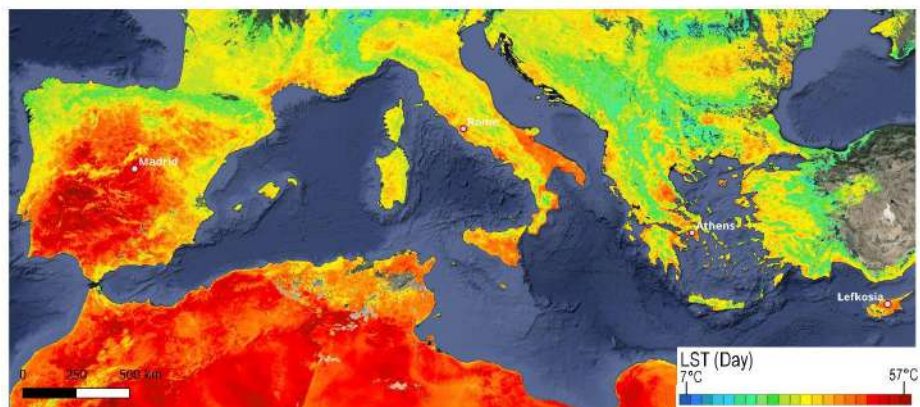


Figure 1. Land surface temperature (day time) across South Europe and parts of northern Africa during the heatwave of 10 July 2023 (source: [Google Earth Engine](#), 'MODIS/061/MOD11A1').

While significant uncertainty remains regarding the exact future climatic conditions and related hydrological phenomena at the regional level, one thing is certain: Global warming will result into longer and more frequent extreme heatwaves in many regions, directly affecting current standards of living, and causing an increase of human thermal discomfort. This can be translated into significant problems predominantly in urban areas of high exposure to such climatic conditions, where the concentration of people and infrastructure is maximized. According to the Intergovernmental Panel on Climate change (IPCC, 2022), in urban areas climate change has caused adverse impacts on human health, livelihoods and key infrastructure including transportation, water, sanitation and energy systems, with resulting economic losses, disruptions of services and negative impacts to well-being. Moreover, compound hazards are expected to occur more often as heatwaves could possibly be accompanied by droughts, wildfires, flash-floods and other weather extremes, that could expose the fragility of urban infrastructures and resources.

A major parameter of climate change in urban areas is that heatwave impacts are multiplied by the Urban Heat Island (UHI) effect. UHI is a phenomenon where urban centers experience higher ambient air temperatures than surrounding suburban and rural areas, that are less urbanized (Sánchez-Guevara et al., 2017). UHI is often quantified through air temperature differences or surface temperature differences (Peng et al., 2012). UHI is most notable during the evening and night hours, as impervious surfaces and buildings release the heat absorbed by solar radiation during the daytime. The relationship between Urban Heat Island and urban form is a complex one, with street canyon effects, wind speed, blue and green urban infrastructure, along with traffic conditions, and energy functioning of buildings playing a crucial role (Xu et al., 2019; Luo et al., 2020). Generally, the spatial distribution of heatwaves within urban areas is influenced by building density and impervious surfaces (do Nascimento, 2022), land use structure, and intra-urban microclimatic variation (e.g. due to the effect of a coastal zone) (Luo et al., 2020). Researchers are also exploring the linkage between urban heat island and urban pollution island, as heatwaves are associated with higher concentrations of pollutants (Ulpiani, 2021). Heatwaves in urban areas result into positive heat loops at a local scale: a heatwave is followed by a rise in energy use for cooling, and the associated discharge of anthropogenic waste heat from the buildings to the environment increases (Luo et al, 2020).

The above remarks are particularly relevant when considering the South European/Mediterranean context. At a general level, Europe is considered to be a Climate Change hotspot, warming more rapidly than the rest of the planet (EEA, 2023). Heatwaves in Europe are responsible for more deaths than other natural hazards and disasters, including floods, hurricanes and earthquakes, with the highest heat-related mortality rates reported in Italy, Greece, Spain and Portugal (Ballester, et al., 2023). While in Central and North EU cities like London, Paris, and Warsaw, heatwaves last for just a few days and are mostly perceived as “Climate Change evidence”, in EU-South capitals like Madrid, Athens, and Rome, record-breaking temperatures and heatwaves are largely undermining the citizens’ quality of life lasting for several weeks or even months. Mediterranean ranks among the top five regions globally demonstrating significant increasing trends in the intensity, maximum duration, frequency, and cumulative heat of heatwaves (Perkins-Kirkpatrick & Lewis, 2020). In such cases, heatwaves could pose particular stress on energy systems, have drastic consequences on food production, discourage tourism traffic, while everyday functioning is also severely affected.

In this research I focus on how central city areas widely known as the Central Business District (CBD) are affected by extreme heat conditions and persistent heatwaves as Climate Change unfolds. CBD areas have long been the nuclei of economic and social life within metropolitan areas, while being particularly dynamic, undergoing major changes through different urbanization cycles, including suburbanization, de-urbanization and re-urbanization processes. Climate Change could impose a new process of urban restructuring, particularly affecting CBD areas in certain metropolitan regions where extreme heat risk is maximized. Our main hypothesis is that the “vibrant” character of such central districts could be largely undermined for considerable periods of time, possibly resulting into a redefinition of their role and imposing changes in the city form and structure in the long term.

To examine this hypothesis, I first delve deeper into the historical role of CBDs, also examining recent transformations taking place in terms of urban form and structure. At a next section I present the major challenges posed by extreme heat conditions on CBD areas, through a case study in Athens, i.e. a typical large metropolis of the Mediterranean region. Methodology is based on the identification and examination of the key dimensions of the urban spatial structure of the city center, and the assessment of their vulnerability to the increased exposure on heatwaves. The conclusions provide links to urban planning and spatial adaptation issues, while considering the possibility of new climatic conditions favoring more decentralized spatial arrangements.

2. Central Business Districts: Conceptualizations and dynamics

Cities are usually conceived as the spatial outcome of economic processes, with contemporary city growth being driven by agglomeration economies. Since the early scientific conceptualizations of city-structure by scholars of the Chicago School of Anthropology, the crucial role of Central Business District has been underlined. Ernest Burgess in his concentric rings model identifies CBD as the focus of commercial, social, civic life district, and also the headquarters of economic, social civic and political life. According to Murphy and Vance (1954), CBD is the heart of the city where the greatest concentration of offices and retail stores is found, reflected in the cities highest land values and tallest buildings, while it is also the focus of pedestrian and automobile traffic. According to Drozd & Appert (2010) a CBD is a “unique area of massive concentration of activities and focus for the polarisation of capital, economic and financial activities in cities”. Key geographical attributes of CBD are: a) prime

accessibility/centrality in transportation terms (Murphy, 1979) and b) concentration/density of key urban activities and land uses (McCull, 2005).

Based on a concentric rings' approach (Park & Burgess, 1925), CBD zones are usually coinciding with the oldest and more central city parts with large-scale redevelopments and high-rise office and administrative buildings pushing housing further out. CBD monofunctionality in US cities can be explained by economic land rent processes: As a city grew in size, competition for land at the center resulted in land values so high that only business could afford. It is certain though that CBDs also present considerable internal variation, even within the same city. According to Murphy (2007), there is a tendency toward regionalization of specific functions (financial areas, hotels sections, theater grouping, night clubs and other specialized localities).

A relatively different context regarding CBD structure is observed in the EU-Mediterranean model of urbanization, where central city areas have traditionally been the place of residence of the upper class, while the labor class has settled in the periphery. This is what Leontidou (1990) has defined as an inverse-Burgess model. CBD areas in the Mediterranean, usually coincide with historical city centers and have been characterized by high population densities. Urban layout can be more organic, especially in the oldest parts of the city where streets are narrow and built-up coverage is very high. Land uses are highly mixed and differentiated vertically, with commercial shops occupying the ground-floor and apartments occupying the rest floors. Unlike American-style cities where a sudden collapse of built-up density and building heights is observed as one moves out from the CBD, in Mediterranean cities density gradients are "smoother", following a pyramid-like structure of building heights from the core to the outer rings. Particularities of urban form and structure of the Mediterranean core-city zones are important parameters related to the distribution of public spaces and green urban areas, also affecting microclimatic conditions and energy behavior at the urban scale (Tsirigoti & Bikas, 2017).

It is important to note that CBDs are not static but rather dynamic elements within the city structure, usually undergoing major changes. Conceptualized in functional terms and not as spatially fixed high-rise structures around central metro stations, CBD zones could expand their boundaries, spread into new areas or withdraw from others. Deteriorating housing conditions and social deprivation has been a well-documented process of urban decay of city-core areas (Broadway, 1989; Hall & Barrett, 2012). Dynamics are also particularly important at the metropolitan/regional scale. According to Soja (2000), in the postmodern metropolis the periphery is gaining more importance with the emergence of a polycentric or even totally dispersed urban form. Under such de-urbanization processes, downtown areas can lose their significance. Recently, however, processes of re-urbanization are being observed at least in the European territory (Salvati et al., 2019). Large-scale urban regeneration projects, real-estate driven gentrification of central city areas, and expansion of the tourism sector, are key factors currently affecting CBDs in Europe. In the Mediterranean context such processes are particularly intense with gentrification of inner-city areas affecting major cities like Madrid (Sequera & Janoschka, 2015), Barcelona (Arbaci & Tapada-Berteli, 2012) and Athens (Balampanidis et al., 2021).

Based on this understanding of CBDs as dynamic city element, it becomes particularly important to delve deeper into the effects of Climate Change. The ongoing climate crisis has already heavily impacted urban areas, that become particularly vulnerable to compound risks including extreme heatwaves, sea level rise and floods, wildfires. In the following case study, I intend to sketch such vulnerabilities by identifying key urban functions and how they can be

affected by extreme heat conditions in the Mediterranean context. Adopting an urban planning perspective when addressing such problems is crucial and it could lead into new insights on how cities could adapt or be transformed by unfolding environmental challenges.

3. Athens case study

3.1 Heatwave impacts and compound risks in Athens metropolitan area.

Athens is located at 37°58' N (Latitude), 23°42' E (Longitude) with a population of 3,81 million at the level of urban agglomeration (Attika Region, census of 2021). The metropolitan area is located in the Attika peninsula. The compactly built-up part of the city (Lekanopedio of Athens) is bounded by large mountains to the North, West and East, while towards the south the city is stretching along the coastal zone. Along this coastal metropolitan axis between Piraeus Port and municipality of Vouliagmeni, the new development project of the Ellinikon is currently taking place (Figure 2). An extended periurban zone surrounds the city from the east (Mesogeia Plain) where the international airport is located, from the west (Triasio Plain) where industrial activities mostly concentrate and from the north where residential suburbs and commercial activities surround the national highway connecting Athens to Central and Northern Greece.

The climate is characterized as subtropical Mediterranean with mild winters and warm summers (Georgakis & Santamouris, 2017). Athens, like other big cities of the eastern Mediterranean, belongs to the top-ranked European capitals with respect to heatwave severity and urban thermal risk (Smid et al., 2019). According to a recent study by Kartalis (Kartalis, 2024), heatwaves have significantly increased in the period 2001-2020 in respect to 1971-1990, both in terms of frequency and duration. According to climate scenarios adopted by the Regional Climate Change Adaptation Plan of Attika Region (<https://www.patt.gov.gr/category/koinonia/perivallon/pepka/>), the increase of mean annual days of very high temperatures (>35 °C) in the near future (2030-2060 period) will reach 15-19 days (RCP 4.5 and RCP 8.5, respectively), and 22-55 days (RCP 4.5 and RCP 8.5, respectively) up to 2100. Tropical nights (>20 °C) will also increase by 27-33 (RCP 4.5, RCP 8.5 respectively) per year. Table 1 summarizes expected changes in Heat Extremes, Humidex index, Mean Moisture and air pollution (PMs) under RCP8.5 scenario in central Athens zone, based on the Greek Ministry of Environment & Energy data.



Figure 2. Case study area, with demarcation of CBD area, Piraeus Port, International Airport and the new Ellinikon Project site on the coastal zone.

Table 1. Projections for period 2031-2060 in central Athens (change in comparison to baseline time period 1971-2000, under RCP8.5 (source: <https://mapsportal.ypen.gr/maps>, own elaboration).

Very Hot days (>35) baseline	Change in Very Hot days (>35 °C)	Days with Humidex (>40 °C) baseline	Change in days with Humidex (>40 °C)	Mean Moisture (RH) change
14.4	19.9	15.1	30.6	-2.1
PM2.5 (Mean annual) baseline	PM10 (Mean annual) baseline	Change in Mean Annual Highest temp (°C)	Tropical nights (>20 °C) baseline	Change in Tropical nights (>20 °C)
43.6	47.1	2.1	44.8	39.0

Due to the rapid and largely unplanned urbanization process mostly occurring through the 20th century, the city of Athens is characterized by a considerable lack of green and blue areas that could possibly improve microclimatic conditions. The unsustainable paradigm adopted during Athens urbanization process can be clearly demonstrated by the artificialization of the main river (Kifisos) spanning west of the central zone, where most part of the river's route has been transformed into a major highway, and also to the considerable absence of parks and public spaces within the urban fabric.

High density of development and high levels of impervious surfaces in Athens, are parameters linked to a considerable UHI effect (Papamanolis, 2015), with UHI intensity estimated at 5–6 °C between central urban parts and the surrounding periurban areas (Roukounakis et al, 2023). According to a study by Giannopoulou et al. (2011) mean air temperature is maximized in the area north-west of the CBD. Difference can reach 2-3 °C in comparison to the south coast zone and as one moves to the east-west-north suburbs. Generally, the center of Athens and the western part are found to present a similar temperature regime due to the lack of green, the densely built areas and the increased traffic (Giannopoulou et al., 2011). In a similar way

Roukounakis et al. (2023) state that under heatwave conditions and in the absence of strong air circulation, areas of intense daytime UHI effect are observed in central as well as western parts of the urban complex. This is partly confirmed by examination of Land Surface Temperature (LST) distribution during the most recent heatwave (Fig.3). Based on the corresponding maps, it becomes evident that the heat island effect is more intense in the central and west zone, while the southern coastal metropolitan zone benefits from relatively lower temperatures. It is also notable that LST is maximized during the daytime in agricultural and bare ground areas of the periurban zone.

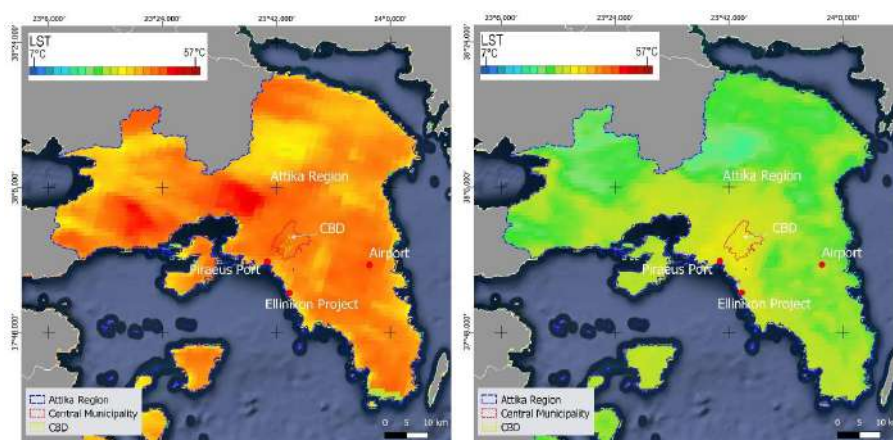


Figure 3. Land Surface Temperature for daytime (left) and nighttime (right) during the heatwave of 15 July 2023 (source: Google Earth Engine, 'MODIS/061/MOD11A1')

Recent evidence shows that Climate Change is already affecting key functions of the city. On 15 July 2023 during the heatwave 'Kleon', the archaeological space of Acropolis suspended its functioning for several hours, while the same happened a few day later. During the same heatwave, the Train Administration (TrainOSE) had to adjust several train schedules and speed limits for security reasons. Also, precautionary measures have been taken by public administration, with several municipality services and tax offices switching to remote work, flexible working schedule and special work permits. Private sector was also affected, as there have been orders to stop open-ground work at least during the afternoon hours (12:00 -17:00). Partial lockdowns of schools have also been reported during similar heatwave conditions during the past years, this issue being related to insufficient air-conditioning systems.

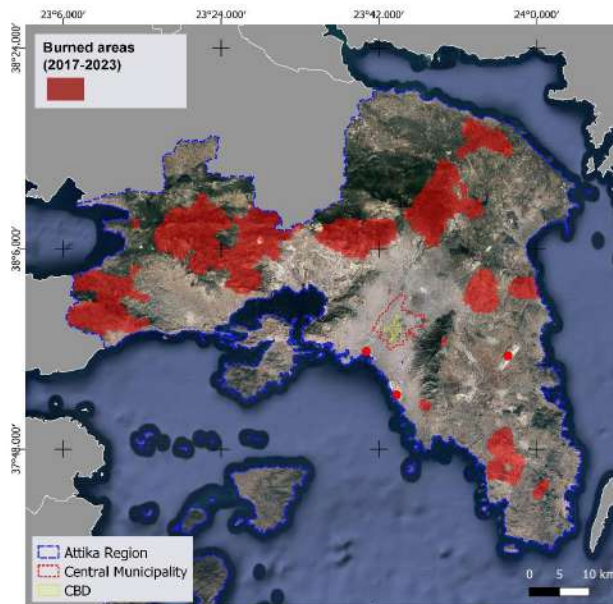


Figure 4. Burned areas during the period 2017-2023 in Athens Metropolitan area (source: Google Earth Engine, MCD64A1.061 MODIS Burned Area Monthly Global 500m).

Compound risks of heatwaves in Athens are related to air pollution and wildfires. Heatwaves in central Athens are usually combined by high levels of particulate matter (PM) concentrations, that are also maximized in the city core (Moustris, 2017). Vulnerability of Athens metropolitan area to fire risk is also a major problem, with most recent fires resulting into significant loss of periurban vegetation and forest land. Extreme fire risk is highly dependent on a combination of windy conditions and extreme heat. Forest fires in the Attika area are increasing during the past years, as shown in figure 4 where burned areas are mapped per time period; this being partly attributed to climate change. During the heatwave of 2021 with temperatures reaching up to 46 °C, a wildfire in the area of Varypompi near Parnitha Mountain, resulted into smoke covering the Athenian sky and rendering respiration very difficult for millions of people. As part of the emergency measures taken, access to major city parks has been occasionally suspended (including the central park of Pedion Areos and all big metropolitan parks) due to anticipated extreme fire risk. Closing down of parks is usually combined by cancellation of cultural activities that have been programmed within their infrastructures. The reasoning, as explained by the Prefectural Administration of Attika during heatwave 'Kleon', was one of "precautionary reasons, reducing heath risk and malicious actions". Closing down of public parks for several days has raised protests from citizen groups defending their right to public access into green urban spaces.

3.2 Central Business District in Athens: Key dimensions and vulnerability

The central municipality of Athens counts 643,4 thousand with a population density of 17.102,9 people/km², recorded as one of the highest urban densities in Europe. Building blocks are compactly built, with narrow streets at the neighborhood level and considerable lack of green infrastructure and lack of public spaces. Notable open space in the central part is related to the

presence of large archaeological spaces, and there are several areas with significant tree coverage around Acropolis, in Lykabetous hill, in the National Garden and in the large park of Pedion Areos (Fig.5). Microclimatic conditions around such green areas are considerably improved, however their influence is mostly local, limited to the surrounding building blocks. A considerable increase in tree coverage is notified in the eastern and northeast axis, just outside of the central municipality and towards the high-class municipalities of Papagou, Psychiko and Neo Psychiko, and Imyttos mountain (Fig.5).

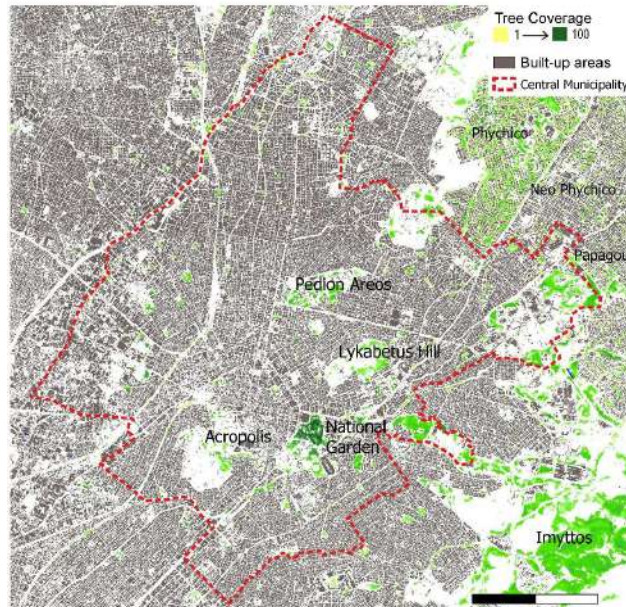


Figure 5. Built-up areas and Tree Coverage in the central zone of Athens (source: own elaboration on data obtained from Copernicus Land Monitoring Service).

To identify the Central Business District within the central municipality of Athens, the combined concentration of several activities has been examined. More specifically, libraries, banks, bars/pubs, cinemas, courthouses, restaurants, malls, museums, clubs, theaters, hotels, department stores and public buildings, have been considered, and to identify the distribution of those activities within the urban fabric, data were obtained from Open Street Map (<https://download.geofabrik.de/>). A Kernel Density estimation was applied resulting into the spatial pattern of Figure 6. Results show that the highest concentration is identified in the triangle between Acropolis, Lykabetus Hill and Pedion Areos, also expanding towards Piraeus Str. (south-west), Sygrou highway (south) and Patision Str. (north). This area can be perceived as the CBD of Athens, coinciding with the highest concentration of business and recreation activities.

To further support this delineation, I have also consulted the Google maps 'commercial corridors' data, where zones with high concentration of people are identified and marked as 'busy areas' during the daytime and nighttime. Such data are reported in the graphs of Figure 7 for characteristic central locations mapped by numbers (C1-C7) in Figure 6. Based on data retrieved from Google maps on a normal-temperature day of April, peak hour is observed at

noon (12:00-15:00), though the temporal patterns can vary between the different central-city spots.

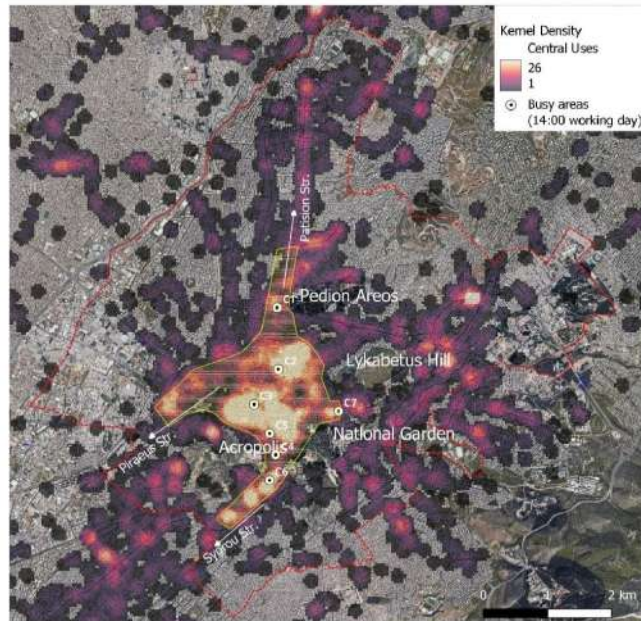


Figure 6. Kernel Density maps (50m pixel, 150 radius, method: quartic) with concentration of land uses and activities linked to CBD functioning.

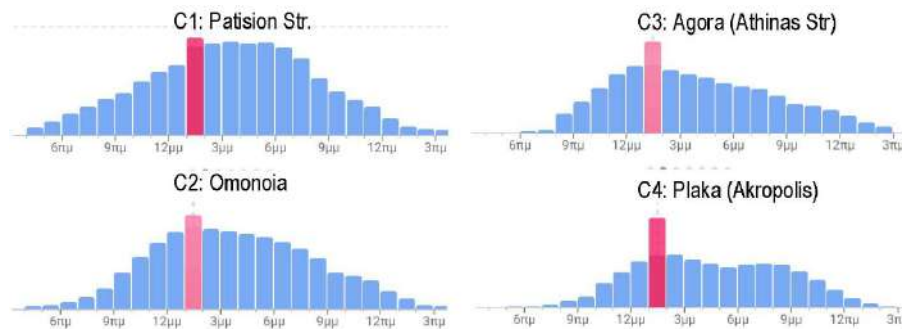


Figure 7. People concentration in characteristic central-city spots on a normal-temperature day of April. Blue bars represent average values, while purple bars represent actual concentration of people at 14:00 on a working day of April (source: Google maps/Busy areas).

Tourism activity is another important dimension of the central zone in Athens. To analyze tourism patterns within this zone I have applied Airbnb data as obtained from InsideAirbnb platform (<https://insideairbnb.com/>). Airbnb is an activity free to locate anywhere in Athens, overruling existing land use regulations. Generally, it tends to concentrate in areas with high accessibility to tourism-related activities especially museums, archaeological spaces and recreation. As shown in Figure 8, Airbnb concentration is largely spotted inside the CBD zone,

with a major focus on a semicircle around Acropolis (Psyri-Plaka-Koukaki neighborhoods) and an expansion towards Kolonaki and Exarcheia neighborhoods on the northeast, and Metaxourgeio and Thiseio on the west.

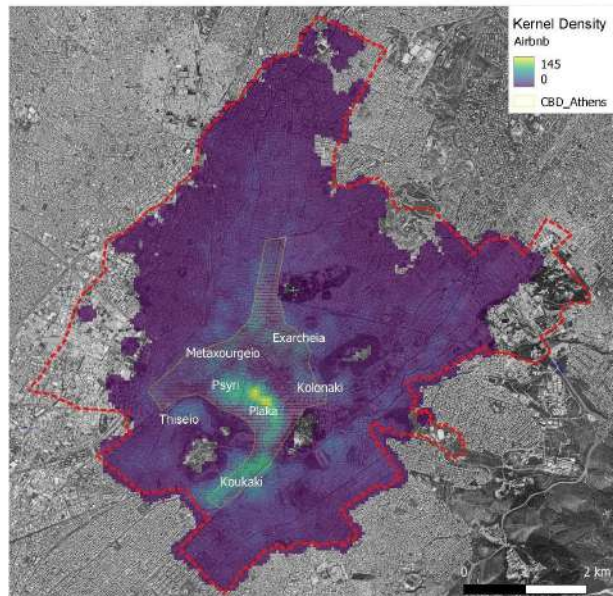


Figure 8. Tourism activity concentration (kernel density, 50m pixel, 150 radius, method: quartic).

Both of the above key dimensions of CBD functioning in Athens (i.e. business/recreation and tourism), are highly dependent on outdoor activities and pedestrian mobility, including street shopping, archaeological space exploration and sightseeing, visiting cafeterias and restaurants etc. These activities can be rendered particularly vulnerable in the case of heatwaves as people become unwilling to move, or even the authorities might decide to pose restrictions to protect public health (see Section 3.1).

A third dimension of CBD Athens is what I define as “housing/population”. Generally, housing within a CBD zone remains a key parameter in order to preserve a sustainable mixed-use zone. Historically, the center of Athens has been a densely populated area, with a major concentration of people within the boundaries of the current CBD and its surrounding neighborhoods. However, since the 90’s, an important suburbanization process has resulted into a loss of 22.5 percent (186,000 people) of the central municipality’s population. The suburbanization process was largely driven by the deterioration of quality of life in the center due to traffic congestion, air pollution, lack of public spaces and overbuilding. As middle-class and high-class residents were moving out, immigrants and refugees were moving in, based on the well-known invasion-succession processes (Lee, 2015). Loss of population combined with the economic crisis of 2009-2019 period, left the central area in a degraded condition, with thousands of empty shops and apartments, further deteriorating the conditions of the housing stock and public spaces especially in the north central sector where social deprivation, unemployment and poverty are more intense (Arapoglou et al., 2021). Such processes have largely affected CBD functioning as many office buildings were practically abandoned (Cheirchanteri, 2023), and economic activity was considerably reduced.

In the most recent period (2011-2021) population loss is practically stabilized, with a marginal 3.1 percent decrease. Figure 9 shows a dot density distribution of population in the central municipality, with respect the current CBD boundary. Data are obtained at the level of Urban Analysis Units (EKKE-ELSTAT, 2015), using Hellenic Statistical Authority (ELSTAT) population census data for 2011. The map shows that significant population still resides within the CBD boundary, especially in the neighborhoods of Koukaki, Exarcheia, Kolonaki, and Metaxourgeio, where large scale gentrification processes are currently taking place. Conversion of apartments to Airbnb accommodation along with a major trend of replacing neighborhood-level shops with tourism-oriented stores and recreation facilities, are pushing land values up, this ultimately resulting into a major relocation of permanent residents out of the CBD nuclei.

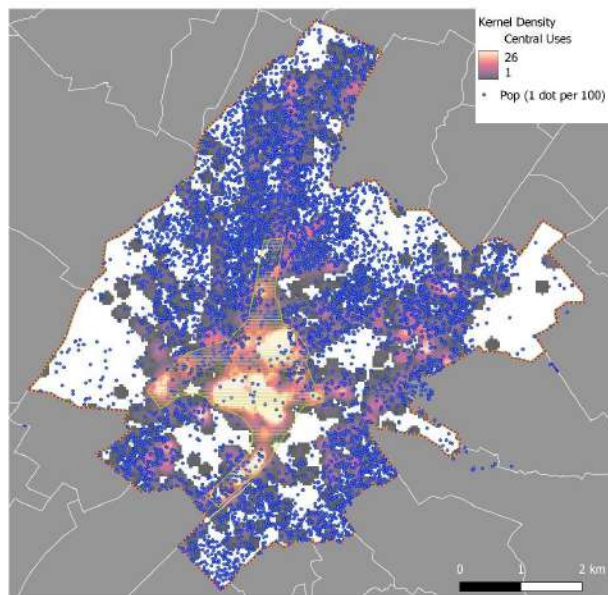


Figure 9. Population distribution (2011) in comparison to CBD boundaries and commercial/recreation activities concentration (Population data obtained from EKKE-ELSTAT, 2015)

Overall, it can be stated that despite considerable population relocation towards the suburbs during the 1991-2011 period, Athens CBD still acts as a key market area for over half a million residents mostly located in the adjacent neighborhoods. However, poor environmental conditions and Climate Change are imposing stress to this population, while considerable vulnerabilities in respect to the housing/population dimension are identified. Data show that the majority of population (75,8%) resides in old apartments constructed before the '80s, usually with very low energy standards and without thermal insulation. At the same time, population is considerably aging. About 19 percent (19%) of the population in several central municipality is above 65 years old, this fact rendering a significant proportion of residents particularly vulnerable to the impacts of persistent heatwaves. Based on the spatial distribution presented in the corresponding map (Figure 10) these two major vulnerabilities in respect to heatwaves (old housing stock and aged population) are maximized within the CBD, this fact raising important concerns regarding quality of life conditions and public health, and also regarding future energy demands for cooling. Another important social issue to be considered is the high poverty rate in Athens municipality, estimated to be around 24 percent (Petraiki, 2013), and

geographically concentrated in poverty pockets close to the center (Kypseli, Kato Patisia), or even within the CBD (Omonoia square, Victoria square, Metaxourgeio etc).

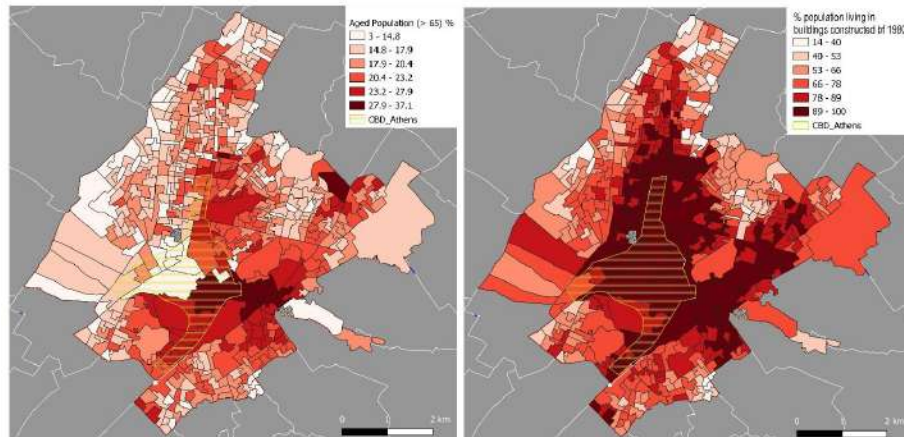


Figure 10. Aged population and old housing stock in Central Municipality of Athens (source: own elaboration on EKKE-ELSTAT 2015 data).

3.3 Overall assessment and discussion

To assess the overall vulnerability of the CBD of Athens to heatwaves, the three key dimensions and related functions (i.e: Business & recreation, tourism, housing/population), and their respective vulnerabilities are combined to a single graph (Figure 11). Exposure to hazard and compound risks are also included; while increase of adaptation capacity remains to be investigated, with the role of urban planning being particularly crucial in order for the CBD to retain its attractiveness & functioning during future heatwaves. The major risks identified are related to the loss of vibrancy and decreased quality of life, followed by population moving out. Such processes might be accompanied by a possible decrease in tourist flows, especially during the summer period.

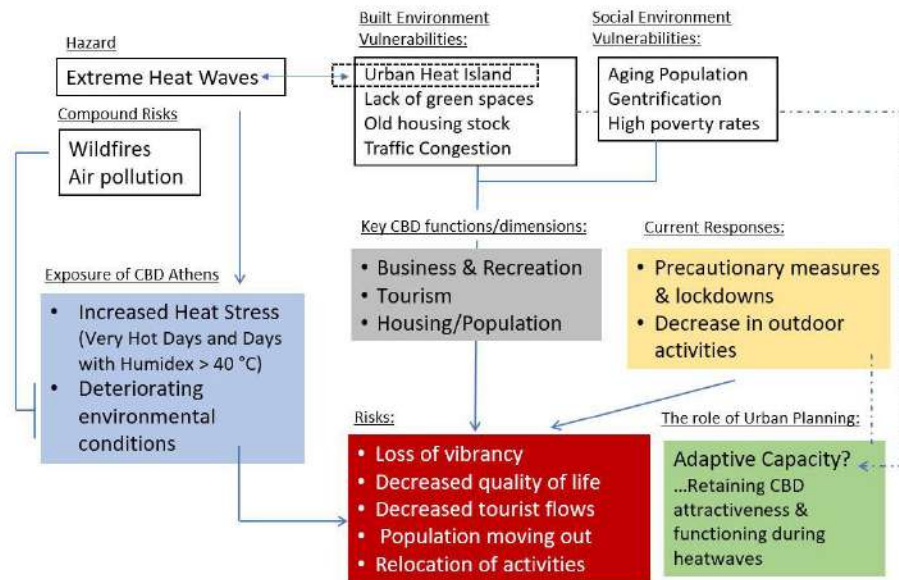


Figure 11. Connections between hazard, vulnerabilities and risks regarding extreme heatwaves in CBD of Athens.

From the preliminary research and data analysis presented, it becomes evident that the future role of the CBD of Athens will be largely dependent on urban planning strategies applied, with respect to land use policies, handling of the gentrification processes, and embracing a climate-resilient and sustainable agenda. As the CBD of Athens in its current state is particularly vulnerable to heatwaves, it is probable that it could face the consequences of certain activities relocating towards more favorable locations. A key example is the new mixed-use hub currently created on ex-brownfield land (the Ellinikon project, <https://theellinikon.com.gr/>), where large investments are taking place within a large coastal zone accompanied by skyrocketing land values. Consequently, favorable climatic conditions due to less intense Urban Heat island effect could render the coastal zone of Athens most attractive in the future -especially during the expanding summer period- possibly challenging the traditional role of the CBD.

4. Conclusions

Dependencies between Climate Change and urban structure should be at the core of current urban planning discourse and practice, opening up new fields of research exploration. CBD areas are persistent structural elements of a city with their historical role mainly based on a very high concentration of people and business facilities that are particularly dependent on face-to-face interactions, vibrant streets and outdoor activities. Regardless of the varying socio-spatial context in different geographical regions and the fact that they are going under considerable changes through time, CBDs are steadily perceived as key elements of the city structure, functioning as economic “hearts” of cities. Current evidence shows that as the Climate Crisis unfolds, such areas might be heavily affected, while climate-related risks could challenge existing urban structures and hierarchies. Evidence from this work sets the ground for more elaborated studies on this crucial topic, opening up the question of possible re-definition(s) of the role of Central Business Districts under the effect of Climate Change.

Results from the case study in Athens reveal three key dimensions supporting the current CBD role: Business & recreation, tourism, and housing/population. All three dimensions are particularly vulnerable to increasing heatwaves and compound risks like increasing air pollution, mainly due to parameters related to urban planning, including lack of green infrastructure and poor housing conditions, while social inequality and aging population add another important dimension to be considered. The cumulative impact of increased heatwaves could greatly affect CBD functioning and quality of life of citizens during the summer period, and have a direct impact on economic activity, tourism flows, and productivity levels. Moreover, it could pose important stress on critical infrastructure, including the health system, while outdoor activities and outdoor work would be largely discouraged.

In the long term, such conditions could possibly result into a relocation of activities towards other city zones where climatic conditions will be more favorable. Based on current evidence, Athens is undergoing large-scale gentrification processes in the central zone, and also impacted by large-scale investments along the coastal zone. In this scenario, the center of Athens will be facing major challenges in the future and an integrated spatial adaptation plan would be needed in order to ensure quality of life and reduce the adverse impacts of Climate Change.

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