

The Urban Climate Change Footprint of Greater Cairo

Eman Abdelazem, PhD
General Organization for Physical Planning (GOPP)
City of Cairo, Egypt
emanclimate@gmail.com

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Keywords	LCZ, climate footprint, urban climate, vulnerability, green spaces
City Population (Metropolitan)	22,183,000
City Area (Metropolitan)	3,084 km ²
City GDP	190 billion USD
Climate Zone	Bwh (hot desert)
ARC3.3 Linkage	Urban Climate Science Element

Introduction. According to Figure 1, boundaries were determined for Greater Cairo that did not take climate change into account, nor new urban development areas. This major metropolitan area includes the old capital complex, the new administrative capital, and Is characterized by a population size that, according to 2020 Estimates, reached 179,129. The population density in Cairo is estimated at 50,259 per km², and the number of people arriving to Greater Cairo daily is about 5 million.

The primary data-driven issues in Greater Cairo relate to the differences in the locations of meteorological stations, particularly regarding the monitoring of microclimatic conditions. According to the Global Monitoring Guide, the height of these stations should not exceed 2 meters within microzones. Additionally, there is a discrepancy in climate data across various sources, including fixed stations, mobile stations, remote sensing, and urban climate models, which complicates our understanding of urban climate change.

Brief History. Every place has a “climate story” embedded in its cultural and urban heritage, records of how humans have dealt with climate variability in that place and adapted sustainable ways of life and utilized natural resources. This urban cultural record complements available scientific data and constitutes the missing link in effective management of climate change risks in urban areas. Greater Cairo appears to be a place of new urban development with good

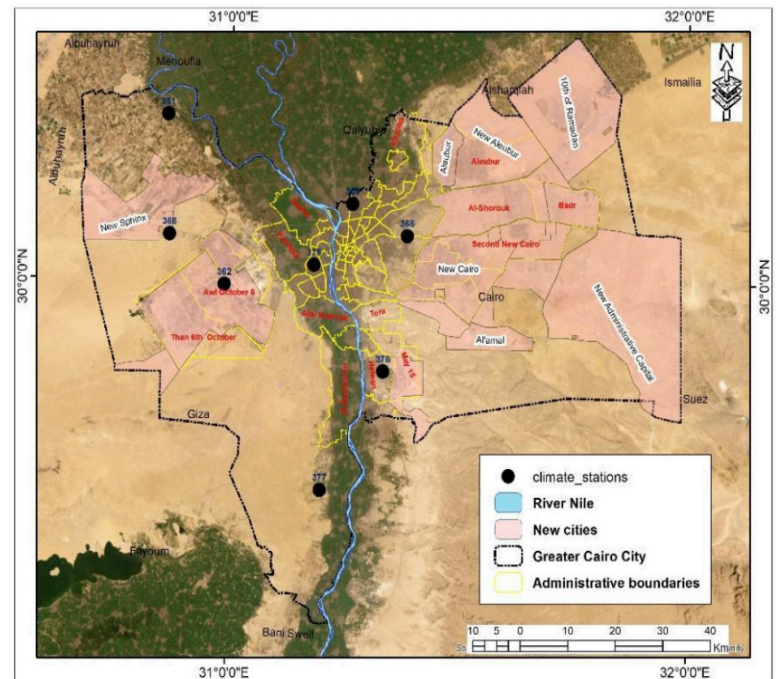


Figure 1. Greater Cairo City

planning, green spaces, and a large percentage of trees, in addition to urban forests, with lower temperatures on the outskirts of the city. The metropolitan area starts from the Nile River with low to moderate temperatures, then heads south toward the desert, where temperatures begin to rise.

The General Organization for Physical Planning, representing the Ministry of Housing, Utilities, and Urban Communities in the National Council for Climate Change, plays a key role in advancing urban climate initiatives. This leadership will be highlighted through the National Adaptation Plan, which focuses on the impact of climate change on the urban sector.

Analysis, Evaluation, and Implementation. Temperature is one of the most significant factors influencing climate change in urban areas. It is evident that new urban development can have a positive effect on urban climate change, as the climate in cities differs from global climate change. Urban climate is largely a result of human activity.

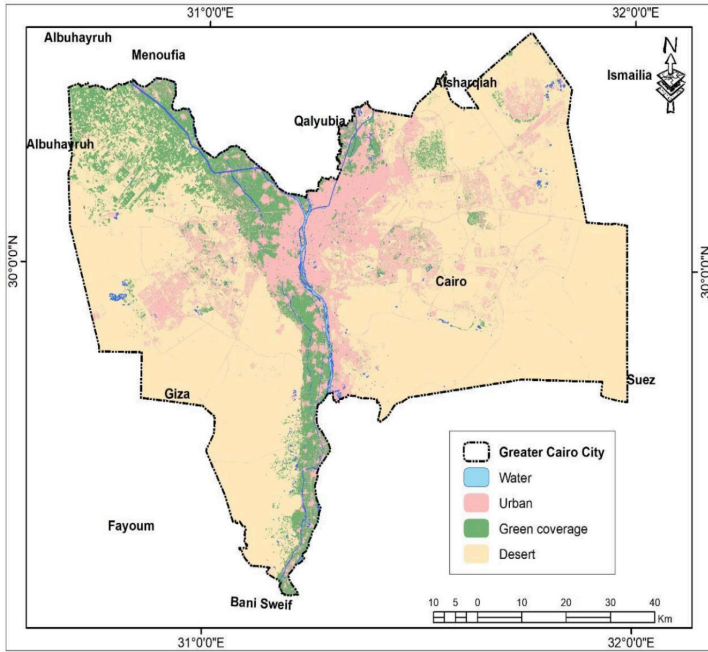


Figure 2. Land cover classification for Greater Cairo has a significant impact on temperature differences, as Greater Cairo is characterized by extreme weather events.

Unlike global climate change, which is assessed using climate models, supercomputers, time series data spanning at least 100 years, and historical evidence, the climate of a city can be observed within a much shorter timeframe—often in as little as five years. Urban climate is closely linked to human activities and urban development, significantly impacting the physiological climate experienced by people

It is evident that the heat experienced in certain neighborhoods of Cairo is closely linked to the city’s urban planning, human activities, transportation patterns, and population size. This is particularly noticeable to the residents of Greater Cairo, especially during daylight hours, when human activity and emissions from transportation increase. In contrast, the outskirts of the city experience a significantly different climate, with lower heat levels compared to the urban core. As a result, the climate in some areas of the city can be considered a temporary, human-made phenomenon. Urban development has, however, had a positive impact in certain parts of Cairo.

Table 1 shows the percentage increase in green spaces in new cities; however, it does not distinguish between tree types and green areas that contribute to shading or those that help reduce temperatures. While this increase is a valuable addition for beautification and landscaping purposes, it is not aligned with climatic or environmental standards.

The study area is located in Giza, one of the three components of the Greater Cairo Urban Complex (Cairo-Giza-Qalyubia). It includes the Dokki area (Dokki and Harat ‘Uwlaa’) and is administratively bordered by the Nile River to the east, Agouza Neighborhood to the west, Bulaq Al-Dakroul District to the north, and Harat Thany neighborhood to the south and southwest.

City	Green Space
Al-Shorouk	1.8 km of green spaces.
15 of May (new urban community)	The percentage of cultivated area represents 2% of the urban mass of the city, with a total of 1 km of green areas, with the per capita share of green areas as 7 m3.
Aleubur	The area of the city’s green belt is 21.4 km, and the area allocated for agriculture in the Orabi area outside the Kurdoon area is 4.1 km acres, which includes planting flats and planting roads, 2.9 million square meters.
Sheikh Zayed	Green areas and roadside plants include 1.5 km.
Badr	Green areas: 16 km. It includes green areas and roadside plants. The total amount planted is 0.4 km and 2 road islands of 50 km. The total green areas being implemented is 0.1 km in the residential neighborhoods and the industrial area. 45,000 trees were planted in the urban forest with an area of 0.9 km. The nursery was moved to the heart of the industrial zone in an area of 0.03 km.
New Cairo	Total green areas are 4.2 km.
6th of October	Total green areas are 275 km.

Table 1. Green space in new urban communities

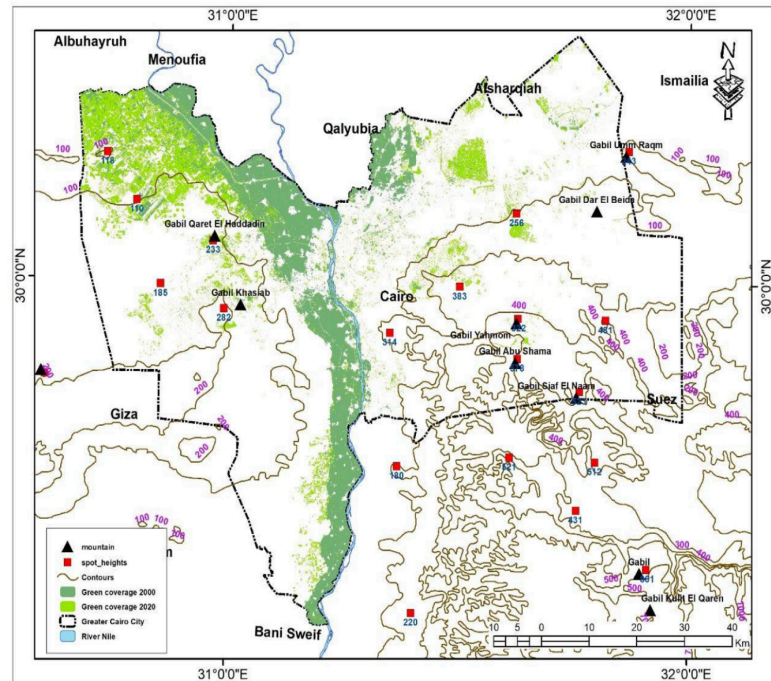


Figure 3. Change in Green Space Extent between 2000 and 2020

This area represents approximately 4% of the total area of Giza City (about 6 km²). According to the 1/5000 survey maps of the study area, there are two agricultural meteorological stations: Giza Agricultural and Dokki, as shown in Figure 4.

Methods. The Local Climate Zone (LCZ) is considered an effective criterion for studying urban climate change, aiming to provide open access to urban datasets for researchers worldwide. Data from various cities can be accessed through the WUDAPT (World Urban Database and Access Portal Tools) project, which is available via multiple smart applications. The spatial accuracy of this data ranges from 300 meters to 10 kilometers. The WUDAPT project is a globally organized initiative that addresses data gaps to tackle global challenges related to sustainable cities and communities. It facilitates the following three key components:

1. Collecting basic city data in a consistent manner (Bechtel et al., 2015).
2. Storing this data in an easily accessible format (Ching et al., 2015).
3. Extracting relevant data for modeling, experimentation, and producing results (Feddemma et al., 2015).

Roofing materials, building construction types, engineering designs, occupations, and activities that contribute to increased energy and water consumption, as well as the generation of solid waste, gases, and particles, are all illustrated in Figure X depicting the area's occupational structure. The value of this data lies in its ability to facilitate several key objectives: the collection of information on the form and function of cities for climate studies; the storage of this data in a searchable, widely accessible geographic database; the development of tools for extracting features and analyzing urban characteristics for comparison; the creation of models; and the verification of the accuracy of the collected data. Figure 3 clearly illustrates the methodology best suited for climatological studies of localized regions.

Results. The Dokki area was divided based on climatic criteria specific to the Local Climate Zone, including factors such as sky visibility, aspect ratio, average building height, terrain roughness, the ratio of building cover to land surface, the proportion of impervious surfaces (paved areas, rocks), the proportion of earth surface cover (bare soil, vegetation, water), surface heat absorption or release capacity, albedo, and heat sources. These factors allow for the determination of the urban climate footprint of the Dokki area and its impact on global climate from 1934 to 2018.

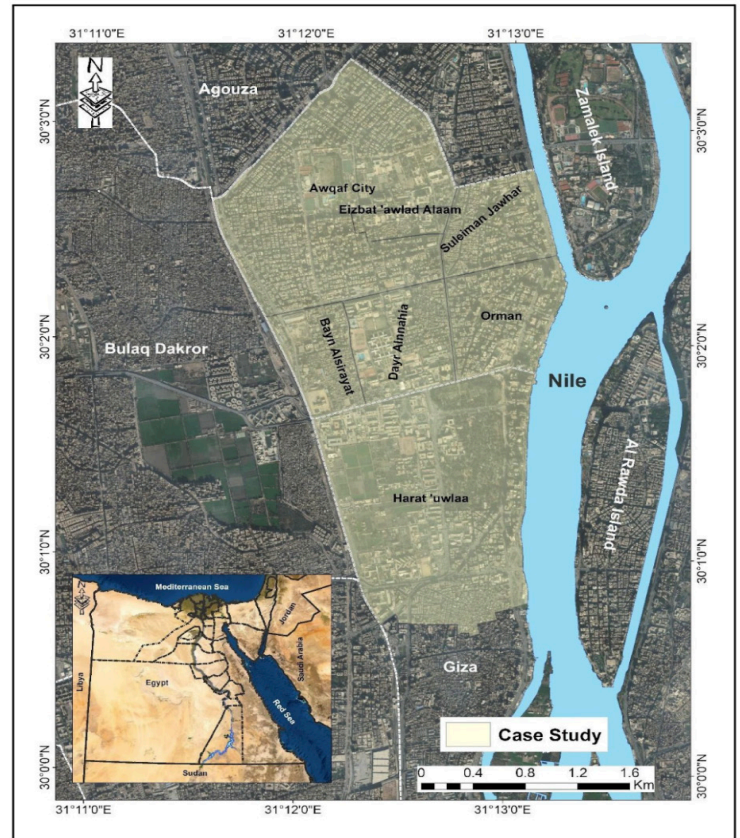


Figure 4. Dokki Section of Giza

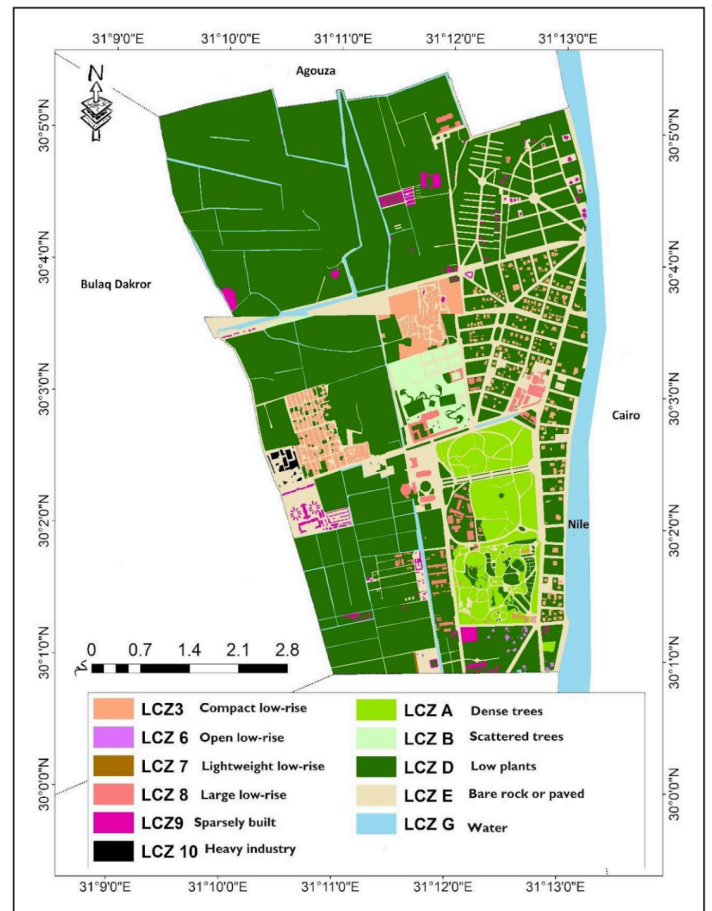


Figure 5. Local climate Zone of Dokki 1934

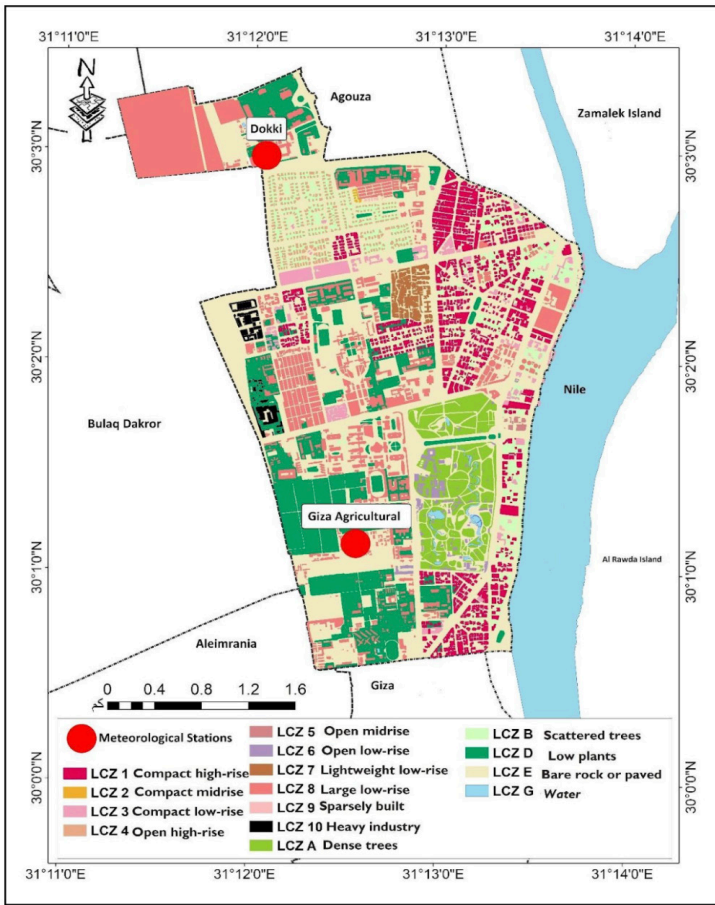


Figure 6. Local climate Zone of Dokki 2018

Figures 3 and 4, which depict the local climate zone map of the Dokki area, clearly show that from a climatological perspective, it is essential to collect data on the city's land cover, including vegetation, soil, water, roads, and more detailed data on materials like concrete, steel, bricks, glass, asphalt, and other construction elements.

The transition from an agricultural to an urban environment has a distinct impact on the urban climate of the Dokki area, a change that has not been adequately captured by the two meteorological stations located there, lacking the necessary accuracy to document such a shift. To address various needs effectively, it is advisable to collect and analyze data on land use patterns and urban functions from multiple sources and at different times.

LCZ	1934	2018
LCZ 1	×	✓
LCZ 2	×	✓
LCZ 3	✓	✓
LCZ 4	×	✓
LCZ 5	×	✓
LCZ 6	✓	✓
LCZ 7	✓	✓
LCZ 8	✓	✓
LCZ 9	✓	✓
LCZ 10	✓	✓
LCZ A	✓	✓
LCZ B	✓	✓
LCZ D	✓	✓
LCZ E	✓	✓
LCZ G	✓	✓

Table 2. Comparative analysis of change results between year 1934 and 2018

Table 2 highlights the emergence of new layers in the local climate zone by 2018 that were absent in 1934, including LCZ 1 (Compact High-rise), LCZ 2 (Compact Mid-rise), LCZ 4 (Open High-rise), and LCZ 5 (Open Mid-rise). The area underwent significant urbanization, losing its rural character and transforming into a densely developed region with a high concentration of apartment buildings, resulting in a substantial increase in its urban carbon footprint.

Concluding Thoughts and Future Implementation. The Egyptian government is making significant efforts within Greater Cairo and its surrounding areas to achieve the 2030 Sustainable Development Goals, particularly Goal 13 on Climate Action. The following measures have been implemented to align with urban development:

- A high-speed electric train network, spanning approximately 1,000 km with a design speed of 250 km/h. The first line runs from Sokhna to New Alamein. The second line connects Sokhna Port, Alexandria Port, and Jarboub (west of Matrouh), passing through the Suez Canal, the Administrative Capital, New Cairo, Helwan, Badrashin, 6th of October, Sadat, Burj Al Arab, and Alexandria.

- The third line links Hurghada and Safaga to Qena and Luxor, while the fourth line connects 6th of October City with Luxor and Aswan.
- Establishing forests irrigated by treated wastewater, primarily located on the outskirts of Greater Cairo and within new urban communities.
- Reducing energy consumption by creating low-emission zones and expanding the use of electric and gas-powered vehicles.
- Investing in communications and information technology infrastructure.
- Banning construction in certain neighborhoods of Greater Cairo, expanding the development of new cities, and issuing a new building law.
- Planting trees along roads to reduce greenhouse gas emissions from vehicles.

Currently, efforts are underway to issue a climate law, alongside new research and the development of a national adaptation plan for urban climate. This will help assess the impact of urban climate on global climate change and inform the development of future policies.

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Additional Data

- **Gross National Income (GNI):** 3,900 USD (Lower-Middle Income)
 - **Population Density:** 22,183,000 people/km²
 - **Gini Coefficient:** 31.5
 - **Human Development Index (HDI):** 0.728 (High)
 - **Type of Climate Intervention:** Hybrid (both mitigation and adaptation)
-