Journal of Environmental Toxicology Research

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Cooling Indoor Climate, Greater Cairo

Abstract

Egypt in general, especially Greater Cairo, faces extreme weather events—heat waves—and a range of energy challenges against the visible effects of climate change due to rapidly growing urbanization and heavily strained energy infrastructure. In the region, cooling constitutes a major source of energy consumption, and it is expected to grow further. Accelerated technological change in cooling demand reduction, and early implementation of the Kigali Amendment and Paris Agreement in Egypt. Our approach is based on four pillars: reducing cooling demand and using climatic treatments in construction; supporting the phase-down of hydrofluorocarbons (HFCs); replacing and safely disposing of inefficient cooling appliances and refrigerants; and improving cooling appliance operation, training, and awareness.

Keywords

Urban • Cooling • Resilience • Vulnerability • Climate

Research Article

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Received: 27 April 2024; **Processed:** 19 June 2024; **Accepted:** 05 July 2024

Introduction

According to Figure 1, boundaries were determined for Greater Cairo that did not conform to the climate perspective and its goal of creating new urban development areas. This major urban city, which includes the old capital complex and the new administrative capital, is characterized by a population size that, according to 2020 estimates, reached 179,129. Population density in Cairo is estimated at 50,259 per km2, and the number of people arriving in Greater Cairo daily is about 5 million.Residents of Greater Cairo suffer from high temperatures in buildings in general, especially residential buildings, which requires many climate treatments to protect these residents, especially in new cities where there are desert extensions and a clear rise in temperature. In addition, Greater Cairo needs:

- **Political:** Support implementation of Paris Agreement (through NDCs) and Kigali Amendment objectives
- **Financial:** Develop financial models to boost sustainable cooling
- **Technical:** Enable natural refrigerants and energy efficient solutions to mitigate the rising cooling demand reducing cooling demand and using climatic treatments in construction

Materials and Methods

Reducing cooling demand and using climatic treatments in construction

Perhaps what draws attention is that one of the most important features of the climate map of Greater Cairo is the built mass, as human factors contribute to influencing the city's climate, which changes: 1.Its environmental features; 2. population size; 3. urban sprawl; and 4. the distribution density of each of them. 5: the use of the land

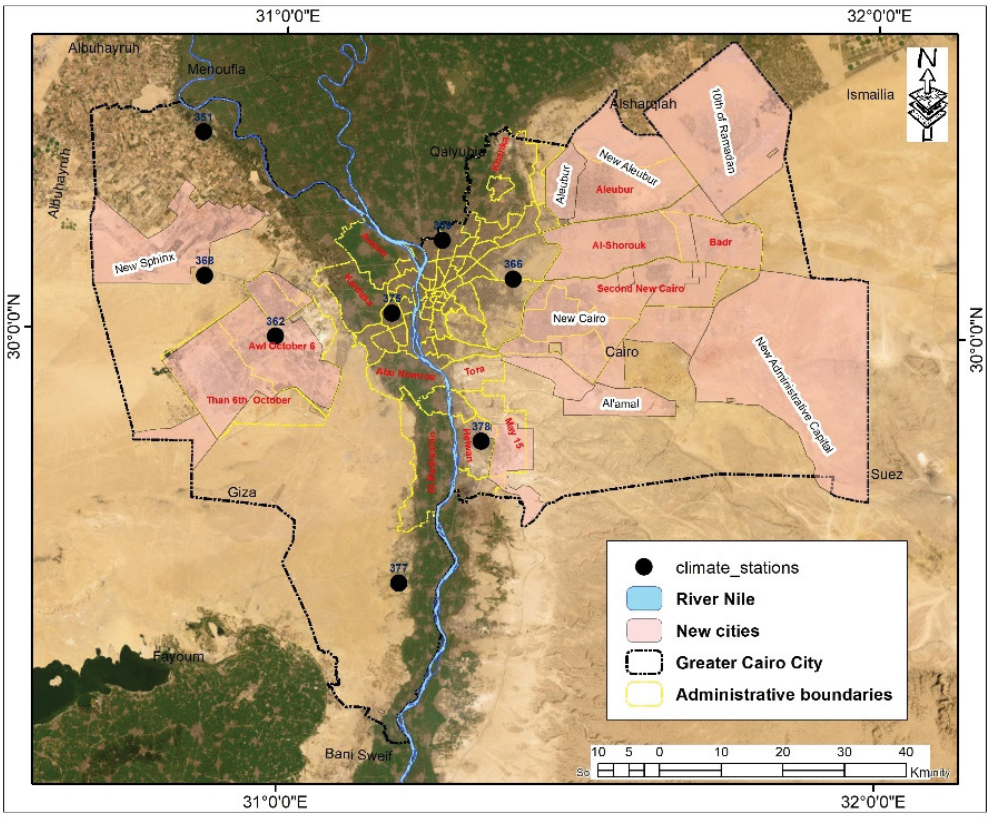

Figure 1. Greater Cairo

in it; 6: the heat that is reflected and radiated from buildings and asphalt surfaces; and 7: the heat and gases that are emitted from means of transportation, power generation stations, and all factories. The climate conditions within the city change as a clear reflection of the change in the use of the land according to urban expansion, the increase in population, etc. This results in human activities, and in light of the heat accumulation in the city, people and their human activities are affected, and spending on energy consumption increases in order to modify and condition the air inside buildings. The building can respond to the surrounding environmental factors to achieve the greatest benefit from their positive effects and reduce the impact of negative factors.

This is done by controlling each of the elements: 1: Shape; 2: Orientation; 3: Building Materials; 4: Size; 5: Methods of Assembling Buildings Just as building adaptation includes its response to climatic elements to improve the internal environment, adaptation also includes creating comfortable conditions for the outdoor spaces between and around buildings. This is what we find in traditional designs, especially in historic Cairo. Glass buildings, which were once considered unsuitable for housing anywhere, have now become residential places everywhere by adding air conditioning devices to them without regard to the amounts of energy and resources consumed, and half of the energy used in the operation and construction of any building, we make use of the production of an artificial indoor climate in this building. Below, we discuss a group of elements that have an impact on the internal climate of buildings. (Figure 2 and 3)

Supporting the phase-down of Hydrofluorocarbons (HFCs)

The design style of many modern buildings requires us to take a decisive pause to evaluate their effects and influence on the internal climate of the residence in terms of supporting the gradual reduction of hydrofluorocarbons (HFCs), as there is a reciprocal relationship between the building and the nature of the environment of the site in which it resides, both climatically and architecturally, and this relationship is a success. With a reason, meaning that both are the cause of the success of the other. A successful building is an integral part of the site surrounding it and is in harmony with its elements. A successful site is

Figure 2. Load-bearing guard walls and structural buildings in New Cairo

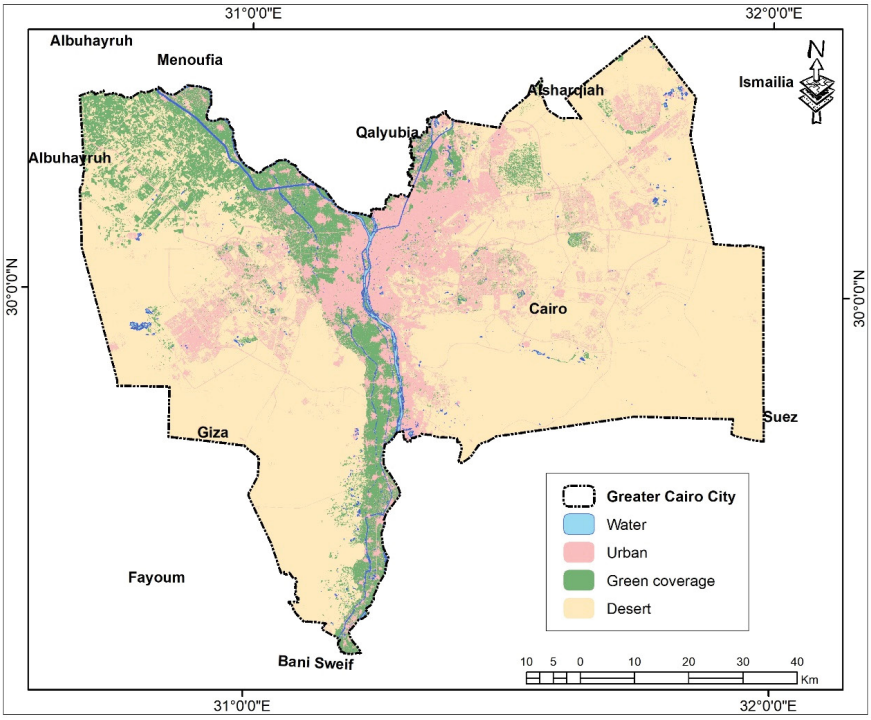

Figure 3. Land cover

one that contains successful architectural works that are in harmony with each other. All plans must respect the carrying capacity of the environmental environment so that it accepts the necessities of urbanization and the requirements of the population without disrupting environmental and climatic balances, and this is the essence of sustainable development, which brings us to the meaning of environmentally and climatically balanced cities.

Climate is considered the key to sustainable design, as climate change affects the dwelling, thermal comfort, health, and energy use within the dwelling.The built environment, including the electrical equipment it includes, is a major consumer of energy, in addition to the external envelope of buildings, one of the basic elements that affects energy consumption inside buildings. This has called on most countries in the world to develop specialized programs to save the energy consumed through it. Buildings consume energy mainly in the process of climate control and the balance between the inside and outside of buildings. There is also a relationship between the shape of the building and energy consumption, which causes an increase in the electricity bill and is closely related to the phenomenon

of buildings that are environmentally and climatically unbalanced, which arises from greater reliance on air conditioning devices.

Neglecting natural ventilation, Cairo derives its electrical energy needs through a unified electrical network with a voltage of 220 MV through 14 transformer stations. The percentage of energy consumption in lighting represents about 59% of Cairo's total consumption, while this percentage does not exceed 35% nationwide. The average per capita share of electricity consumed for lighting in Cairo is about 735.33 kWh per year, but it is higher than the average in the neighborhoods of Al-Waili, Al-Khalifa, Mokattam, Abdeen, Al-Darb Al-Ahmar, Al-Gamaleya, Al-Marg, Rod Al-Farag, Old Misr, and Heliopolis. Maadi-SSayyidaZeinab, recording about 820 kW per capita, while it is less than the average in the neighborhoods of Qasr al-Nil, Zamalek, Shubra, Al-Sahel, Al-Sharabiya, Al-Zaytoun, Al-Tebin, Helwan, Ain Shams, Al-Basateen, and Dar Al-Salam, reaching 600 kWh per capita. As for the rest of the neighborhoods around the general average of Cairo, Figure 4.

Replacing and safely disposing of inefficient cooling appliances and refrigerants

The lack of homogeneity of the buildings erected with their designs, finishes, and colors—the dissonance of the colors used in the facades of the buildings—with the character of the general surrounding framework, which in turn led to the presence of spots of architectural visual pollution that cannot be hidden—and the installation of air conditioning devices in a random manner on the facades in various housing areas and segments. In addition to changing the original shape of the facades, whether by expanding openings, deleting some of them, adding new ones, especially on the ground floor, or closing balconies in discordant shapes that are different from each other, This is done without coordination with the responsible agency, which results in a distortion of the building's shape, especially in the Third Settlement.

Figure 4. Lack of climate treatments for buildings and the use of artificial ventilation in Cairo

The deterioration of the city's coordination environment helped shape the facades. The city mass must allow the northern air to penetrate its mass and not impede its movement during the period of excessive heat from April to October, so that it reaches the greatest depth. And to repel and protect the built mass from unsuitable air directions, whether during periods of deficient or excessive heat, which comes mainly from the west. The general shape of the city and its urban fabric confirmed the theory of preserving the essence of environmental balance. The fine dust suspended in the air comes from the surrounding desert areas and the roads. The city's unpaved dirt, which is carried by winds across the region, causes harm to human health as a result of carrying toxic substances on its surface and transporting them to human lungs.

Therefore, the harmful effects of air pollution on humans in the city of New Cairo cannot be ignored. Air pollution is a result of the prevailing winds throughout the months of December and January. In February, it blows from the south, southeast, and southwest directions, carrying factory pollutants and dumping them on the city, as the industrial area is located at a higher level than the city areas. There are complaints submitted by residents regarding this matter, and this matter has been verified by the Environmental Affairs Agency. Central Administration for Inspection and ComplianceThe design of a climate-balanced building is a basic response to comfort standards.

Islamic architecture used the possibilities offered by the climate to produce a design that adapted to it and used huge, high walls, a multiple courtyard system, and also the use of green spaces and water in the design. Which was created by Islamic architecture, and it is as follows:

1. Solar collectors to provide hot water.
2. Open terraces for use on hot nights.

3. Upper openings “under the ceilings” and thick tiles keep the ceilings cool.
4. Placing windows overlooking shaded courtyards reduces heat gain and the intensity of illumination.
5. High ceilings allow the movement of cool air.
6. Air catchers capture air currents.
7. Water bodies to cool the air entering the water tanks.
8. Mashrabiyas to provide shade and privacy.
9. Water and greenery in private courtyards and public gardens help cool the air and filter it from dust.
10. The underground floors (basements) benefit from the temperatures.
11. The external walls are thick and have limited openings to reduce heat gain.

Many recent studies have been conducted on Islamic architecture buildings, and it was found that in the summer the temperature is 5 degrees lower in Islamic buildings than in the case of modern buildings, and in the winter it increases at the same rate in Islamic buildings. Salah Zaki, 2009. The climatic design of the urban site is as follows:

1. Providing comfortable climatic conditions for people inside the urban space.
2. Contributing to providing comfortable climatic conditions inside the buildings that are connected to this urban space.
3. Achieving comfort in the urban site. At any point in the urban space that has human use, conditions of thermal comfort are available.

Improving cooling appliance operation, training, and awareness

There is no doubt that the continuity and stability of the compact urban formation achieve the concept of sustainable development related to the environmental and climatic aspects of residential buildings. This pattern, in its simplest form, is the closeness of the rows of adjacent buildings, the narrowness of the movement paths, and their frequent windings to protect the facades from the sun’s rays and from the movement of hot winds through the spaces. Environmental compatibility occurs through the extent of the building’s success in achieving the needs of its users related to thermal comfort through the climatic and environmental architectural design of all elements of the facility, in addition to the building’s harmony with the surrounding site. In the new urban complexes, it is noted that the majority of them did not adequately take into account environmental and climatic standards while preparing their urban plans. We can see this through the similarity of the styles and models of buildings in these clusters, despite the differences in their spatial characteristics. Most studies have indicated a decline in the thermal efficiency of urban styles in new cities when compared to styles of Islamic architecture in the city of Cairo (Figure 4).

Result

- The results that we conclude from this are that the elements influencing the creation of an internal climate for the building in terms of being climatic or urban and influencing the process of cooling the building all have a mutual influence on each other to create that artificial internal climate. And then relying on artificial adaptation and ignoring dependence on nature. And also ignoring the most important foundations and planning standards that must be taken into account to adapt the urban fabric to climatic conditions, which are:

1. Clustering of buildings.
2. Distribution with internal spaces.
3. Urban guidance.
4. Street planning.
5. Road networks.
6. Coordination of sites in the city.

- The comprehensive orientation of the urban fabric plays a major role in reducing the severity of the hot climate. The aim of the orientation must be to receive desirable winds and direct the movement of air within the urban mass to provide ventilation inside residential units and in urban spaces. It is known that the prevailing direction of the desired winds in Cairo is north. And

in the northwest, the largest dimension of buildings and spaces must be directed in this direction in order to benefit from the greatest amount of air, taking into account that this orientation receives a relatively large amount of direct solar radiation. From this standpoint, urban formations must be chosen that achieve the best direction of air movement without conflicting with solar radiation, whether benefiting from it or reducing its bad effects. Therefore, the best orientation for construction is for its longitudinal axis to be east-west, so that the most northern facades are far from solar radiation, or the southern facades can be treated against solar radiation.

- Energy can be rationalized through building facades through the following:

A. Dividing the treatment of facades into:

1. Facades that do not have any thermal treatments are therefore more equipped to absorb heat and transmit it to the surrounding environment.

2. Facades with heat treatments.

3. Shaded facades, which is the optimal thermal condition.

B. Determine the corresponding interface type:

1. Traditional facades.

2. Facades with flat glass that reflect sunlight.

3. The facades are glass.

X. The methods corresponding to the facade and the type of architectural and urban treatment:

1. Asphalt roads, which are the general condition, the most common in Cairo, and the worst thermally.

2. Treatment methods for landscaping sites with the aim of reducing their heat emissions to the surrounding environment.

3. Green spaces.

Completely shaded roads, which are the ideal roads for the environment that aims for thermal comfort.

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Citation: Ahmad Eman A. A. “Cooling Indoor Climate, Greater Cairo.” *J Environ Toxicol Res* (2024): 107. DOI: 10.59462/JETR.1.2.107