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The Role of Smart Infrastructure in Strengthening Cities' Resilience to Climate Change

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Abstract: This research aims to help residents, planners, designers, and officials reconsider the functions and opportunities available through redesigning streets and surrounding public spaces. It also aims to create a healthier environment for residents by examining the current status of these areas and discussing their current conditions. Furthermore, the research highlights how thoughtful redesign can contribute to improving the quality of urban life, enhancing public spaces, and meeting community needs.

Keywords: *Smart cities, Street scape, Smart Infrastructure, Parklets, Promenade.*

1. Introduction

Public parks and Promenades are a cornerstone of modern city planning, serving as integral gathering spots for the public to undertake outdoor activities, experience nature, or simply kneel for some relaxation. These Promenades are thoughtfully designed with all possibilities in mind and constructed to provide walking areas, children's playgrounds, resting places, as well as other emergent activities entertainment. With their amenities and facilities, parks and Promenades take care of coping with the problems of people living in cities and metropolitan areas and even villages regarding commensurate places for exercises, interaction, and nature.

Cities often face significant challenges in servicing the constituents because of a combination of underfunded government agencies and financial backers, convoluted procedures, unreasonably long planned and drawn timelines, and practically ever green construction periods. This might lead to failing to meet the requirements and expectations in the set timelines and in trying to solve the most urgent problems of the city for the residents.

Through a comparative study by Analysing and studying modern urban space components, such as parklets and promenades, benchmarking before and after them under go such as transform, shifts give an idea of the possibilities to sustain environmental and social added value multifunctionality.

1.1. Research Questions

The research will also try to answer simple questions, based on Development of Green Infrastructure in Egypt (2015-2023) **[1]**. (Figure 1) This graph illustrates the gradual increase in solar and wind energy capacity, along with the increasing number of green infrastructure projects in Egypt during the period from 2015 to 2023. The data highlights the significant growth in both renewable energy capacity and the implementation of green initiatives, reflecting Egypt's commitment to sustainable development and its transition to renewable energy sources, which can be summarized as follows:

Q1: Does the absence of smart and sustainable cities impact the quality of life in new cities?

Q2: How can the concepts of sustainability be applied in urban planning?

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Q3: Are there clear standards for sustainable design and planning in new cities?

Q4: Does pollution impact the health of residents in new cities?

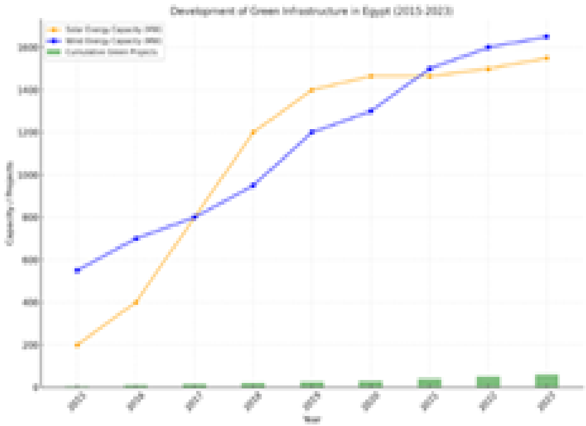


Figure 1. Development of Green Infrastructure in Egypt (2015-2023)

1.2. Research Objective

The aims of this paper to explore the relationship between smart and sustainable cities, their applications, urban plans, and the elements of new streetscape design and layout. It also aims to identify the basic criteria for sustainability, examine its comprehensive concept, strategies, and measurement indicators, and evaluate the extent of its application in the detailed urban plans of 6th of October City. It also contributes to organizing and reusing urban spaces to serve different functions, taking into account different user categories, both individuals and groups. It aims to evaluate existing elements, studing their impact on the surrounding urban environment, and explore the possibility of enhancing their efficiency. The paper also aims to improve the efficiency of urban spaces, raise public awareness of their importance from different perspectives, and encourage thinkers, researchers, and stakeholders to reconsider development and improvement plans for these areas to maximize their benefits.

1.3. Research Methodology

The research methodology is qualitative and relies on two axes: theoretical and analytical analysis. The research methodology aims to understand the interrelationship between public spaces and modern site design elements, and to propose a framework for addressing the environmental, social, and cultural aspects of creating these elements. This is achieved through two main approaches:

The First Approach: Explore the details and visions of countries in creating these elements under different climatic conditions, along with global strategies for planning and designing detailed urban plans. This includes a comparative analysis of successful international models.

The Second Approach: Compare selected case studies based on their environmental and social aspects, and evaluate their impact on the surrounding urban environment.

1.4 Case study Selection

Six of October city Based on its founding date, the city was designated as a first-generation city by the New Urban Communities Authority, which is why it was chosen for this case study. The city's population is still increasing at a rapid rate, making it imperative to increase housing, services, and infrastructure to meet the rising demand. This dynamic setting offers a variety of options for urban expansion, alteration, and enhancement, making it the perfect place for study and experimentation. The city is a great place to improve the functionality and efficiency of its streets and adjacent public and service areas because of its multifunctional spaces, different user demographics, and the application of research findings. By addressing these areas, the study aims to support the city's social and environmental growth and enhance its suitability for daily life.

2. Cities and Climate Change

Climate change and environmental challenges are receiving more attention in recent years due to their profound effects on a number of the economic and social spheres. Numerous crises have resulted from this, underscoring the pressing need for ecologically sound solutions. The move toward creating sustainable and intelligent cities is one of the most well-known of these options. Because of this, several cities worldwide are trying to adopt these technologies and incorporate them into their urban architecture and planning. **[2]**

2.1. The Impact of Climate Change on Urban Areas

One of the biggest health risks is air pollution. The government has implemented a number of measures to enhance air quality in the last ten years, including limiting industrial emissions, enhancing solid waste management, creating public transportation, and, most recently, launching electric buses. Additionally, a system for collecting rice straw has been put in place, which stops agricultural waste from being burned and contributing to harmful pollutants like black smoke. A crucial next step is creating an integrated air pollution reduction plan that include more stringent regulations on major air contaminants as well as precise, time-bound goals. (Figure 2)

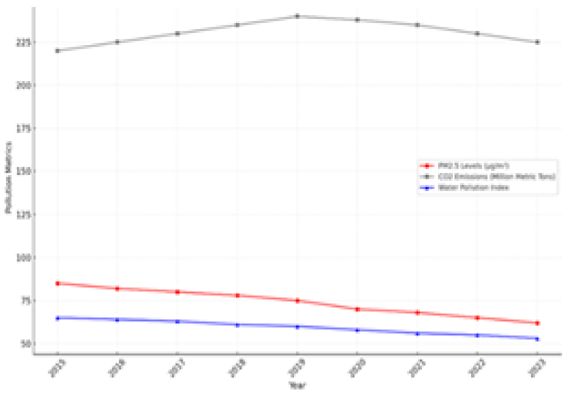


Figure 2. Pollution Levels in Egypt (2015-2023) [3]

This graph shows Egypt's pollution trends from 2015 to 2023, including the water pollution index, carbon dioxide emissions, and fine particulate matter (PM2.5) levels. The data demonstrates a steady increase in the quality of the air and water, along with a notable drop in pollution levels, demonstrating the beneficial effects of the environmental actions implemented during this time.

2.2. Egypt's Role in the Field of Climate Change

Although Egypt has stepped up its efforts to tackle climate change, it still needs to improve its institutional capabilities. The nation's overall greenhouse gas emissions have risen at a rate far faster than the world average and are predicted to continue rising over the next few decades, despite the fact that per capita emissions are still modest by international standards.

Subject to further foreign financial support, the government has established sector-by-sector emission reduction objectives by 2030, aiming to reduce emissions from the transportation, oil, and gas sectors by 7%, 37%, and 65%, respectively, compared to business-as-usual scenarios. Egypt has already started putting its 2050 National Climate Change Agenda into action. [4] (Figure 3).

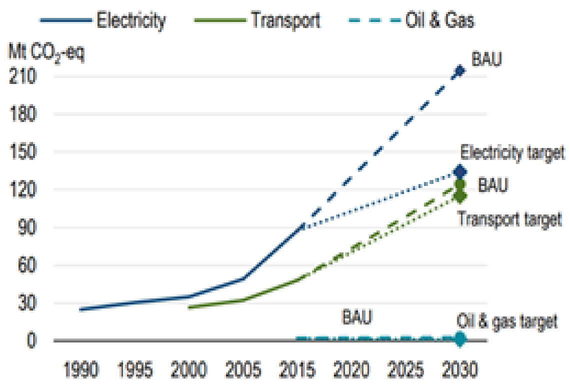


Figure 3. GHG emission trends,1990-2015, Sectoral targets for 2030

However, there are implementation issues facing the city, especially when it comes to obtaining the funding required to increase capacity at all levels. Data on greenhouse gas emissions must be updated often in order to evaluate the effects of mitigation and adaptation techniques more accurately. Every area of the economy is progressively being negatively impacted by climate change. By 2025, the government hopes to have its National Adaptation Plan finished.

3. Urban Heat Island Phenomenon

The urban heat island (UHI) phenomenon is widely known as a phenomenon in which urban areas experience higher temperatures due to factors such as urban development and human activities. **[5]**

The urban heat island (UHI) effect occurs when warm air concentrates over urban areas, gradually lowering temperatures in surrounding suburban and rural areas. (Figure 4) This results in daytime temperatures in cities rising by 1-3°C, with nighttime temperatures rising by up to 12°C. **[6]**

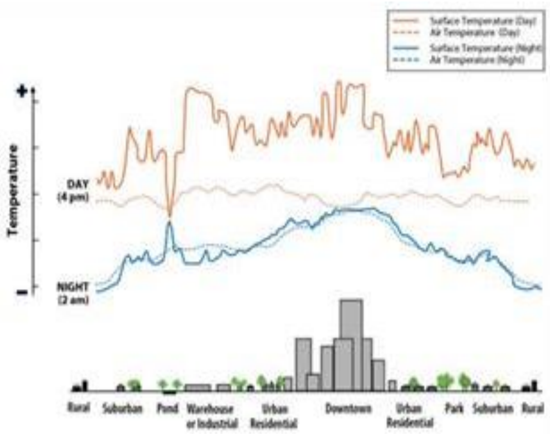


Figure 4. The temperature profile in different areas, with the formation of the UHI [7]

A region in an urban setting that experiences noticeably warmer temperatures than the surrounding rural regions is known as an urban heat island (UHIs). The two primary categories of these heat islands are atmospheric and surface-based urban heat islands. The content, identification and measuring techniques, and related effects of each kind vary. [8] (Table 1).

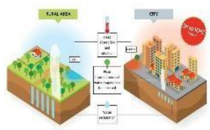
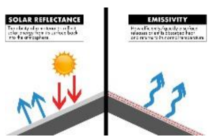
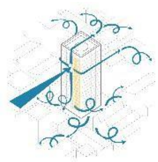
Table 1. Basic Characteristics of Surface and Atmospheric Urban Heat Island.

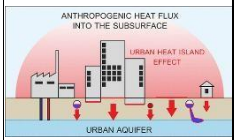
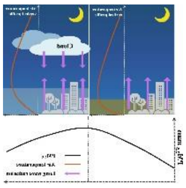
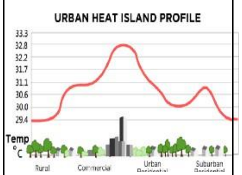
Feature	**Atmospheric UHI**	**Surface UHI**
Definition	Refers to the warmer air found in urban areas compared to the cooler air in surrounding rural or suburban regions.	Refers to the temperatures of the surface itself.
Temporal Development	It may be minimal or absent during the day, but it is most pronounced at night, just before dawn, and in the winter.	It occurs throughout the day and night, reaching its peak intensity during the day and in the summer.
Peak Intensity (Most intense UHI conditions)	Less variation: - Day: -1 to 3°C - Night: 7 to 12°C	More spatial and temporal variation: - Day: 10 to 15°C - Night: 5 to 10°C
Typical Identification Method	Direct measurement methods include: Stationary weather stations Mobile tracking or surveys	Indirect measurement: Remote sensing
Typical Depiction	Isotherm map Temperature graph	Thermal image

3.1. Factors Affected Urban Heat Island (UHI)

Urban heat islands arise from a variety of factors, and their severity varies in urban areas based on factors such as design, climate, and land use. **[9]** (Table 2)

Table 2. Factors Affected Urban Heat Island Process [10]

Factors	**Description**	**Image**
1.Impervious surface	Vegetation helps lower both surface and air temperatures, while urban surfaces tend to increase surface temperatures.	
2. Properties of Urban Materials	This refers to the ability of a material's surface to reflect sunlight.	
3.Urban Geometry	Building height and street width influence wind flow and the amount of radiation	

	both received and emitted by the environment.	
4.Anthro-pogenic Heat	The heat generated by human activities, including waste heat emissions from industry, air conditioning, motor vehicles, and other sources. Top of Form Bottom of Form	
5.Pollutants	This reduces air transparency, trapping heat and hindering cooling by preventing nighttime re-radiation. Top of FormBottom of Form	
6.Weather Conditions	Clear skies maximize the amount of solar energy reaching urban surfaces, while strong winds and cloud cover help mitigate the urban heat island effect.	
7.Geographic Location	Climate, topography, and local terrain have a significant impact on the formation of heat islands.	

3.2. Causes of Variation in Urban Heat Island Intensity

Urban heat islands (UHIs) vary in severity across different locations around the world and are influenced by a range of factors (Table 3) **[11]**.

Table 3. Causes of Variation in UHI Intensity.

Causes	**Description**
Diurnal Changes	Urban Heat Island (UHI) effect is more pronounced at night because cities release stored heat, leading to reduced cooling in rural areas.
Seasonal Variation	The peak intensity of the Urban Heat Island (UHI) effect typically occurs in winter, while summer sees the most active UHI conditions. Spring and fall experience more moderate UHI effects.
Urban City Size	Cities with higher population densities tend to be warmer than less

	populated areas due to increased human activity and energy consumption.
Urban City Form	Affect the exposure of urban surfaces to solar radiation.
Lack of Green Spaces	Tree planting and increased vegetation cover help reduce air temperatures.
River Effects	Large water bodies influence land temperatures by generating land and sea breezes and promoting evaporation.
Intra-urban Variability	UHI intensity has a strong positive correlation with the proportion of building and impervious surfaces, but a negative correlation with the proportion of green spaces

3.3. Urban Heat Islands Mitigation Strategies

City planners are implementing sustainable solutions to mitigate the extreme heat stress caused by the urban heat island. These strategies primarily focus on changing the surface energy balance.

a. Vegetation and Green Spaces

Trees and plants, including shrubs, vines, grasses, and ground cover (Figure 5), help lower surface air temperatures through shading and evaporation. In doing so, they reduce the "urban heat island" effect by reducing energy consumption, air pollution, and greenhouse gas emissions. **[12]**

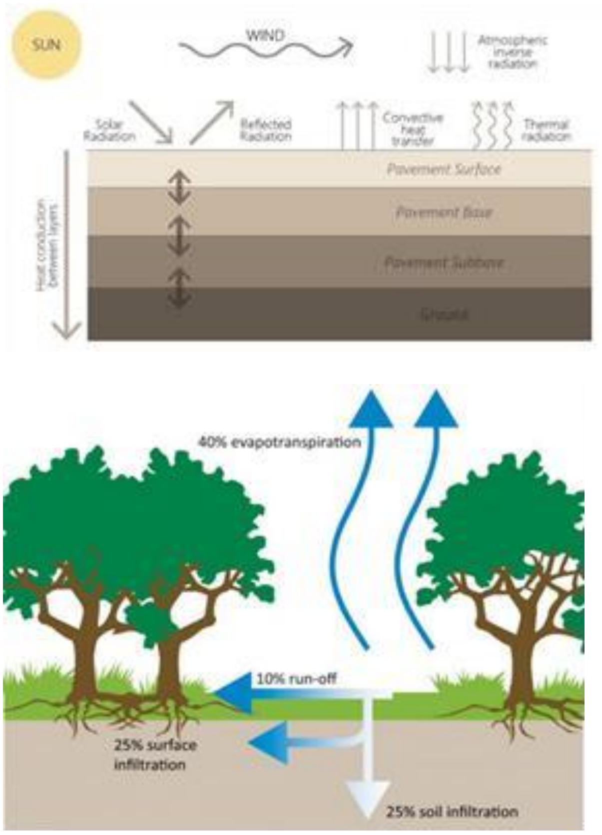


Figure 5. Vegetation and Green Spaces effect [13]

b. Green Roof:

Green roofs, which involve planting vegetation on rooftops, help mitigate the urban heat island phenomenon by providing shade and cooling through evaporation and transpiration. These roofs can be installed on various buildings and contribute to reducing urban heat islands by reducing energy consumption, air pollution, and greenhouse gas emissions. (Figure 6)

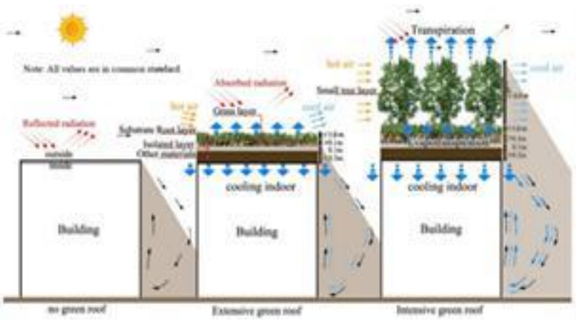


Figure 6. A schematic structure of an extensive green roof and an intensive green roof, and the cooling mechanism in the daytime. [13]

c. Cool Roof:

Cool roofing materials, made of reflective and emissive materials, help reduce the heat island effect in cities and suburbs by keeping buildings cooler during peak summer temperatures. These roofs contribute to mitigating the effects of the urban heat island (UHI) by reducing energy consumption, air pollution, and greenhouse gas emissions. **[14]**

d. Cool Pavement:

Cool pavements are paving materials designed to reflect solar energy and enhance water evaporation, helping to lower surface temperatures and mitigate the urban heat island phenomenon. They can lower surface temperatures by up to 17°C. (Figure 7), leading to reduced energy consumption, improved air quality, and lower greenhouse gas emissions. **[15]**

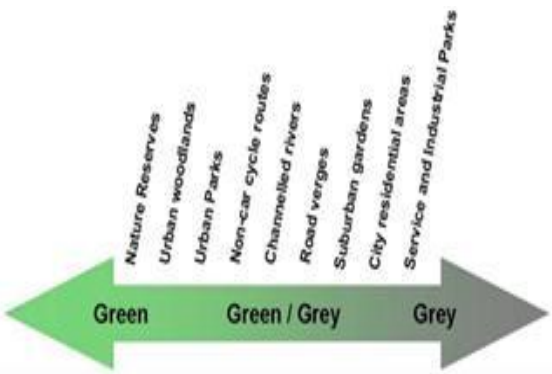


Figure 7. Heat exchange processes in a typical urban pavement. [16]

4. Urban Heat Island Phenomenon

Green infrastructure (GI) is a network of interconnected natural areas that preserves the environment's ecological qualities and functions while offering human populations a number of advantages. A strategic approach to urban development, urban green infrastructure (UGI) planning aims to improve ecosystem services, **[17]** create green areas, and solve urban problems. It may be divided into geographical categories. (Table 4)

Table 4. Green Infrastructure Elements and Practices.

Position	Element
Street green	- Bioswale. - Tree alleys. - Green verge - Riverbank green.
Building	- Atrium. - Private Garden. - Green playground. - Green wall - Green roof
Parking lot green	- Pocket Park. - Bioswale. - Green verge. - Tree allays
Public and Recreational area	- Parklets - Promenade - Parks. - Gardens. - Camping areas. - Community spaces.

	- Neighborhoods and Institutional green space. - Cemetery and churchyard. - Green sports facilities.
Natural and Agricultural areas	
Blue spaces	

4.1. Green Infrastructure Principals

Green infrastructure principles provide a strategic framework for sustainable land use that benefits people, wildlife, and the economy. These principles are essential to the success of green infrastructure initiatives.

a. Integration of green and grey infrastructure:

Urban green infrastructure planning combines green spaces with transportation networks and utilities, delivering environmental, social, and economic benefits while addressing essential infrastructure needs. (Figure 8)

Figure 8. The Grey-Green Continuum. [18]

b. Connectivity:

Create and restore green space networks to enhance and maintain the operations, functions, and benefits of green spaces, with an emphasis on connecting landscapes to encourage or restrict movement and flow. **[20]**

c. Multifunctionality:

Enhance the environmental, social, cultural and economic benefits of urban green spaces by recognizing their interconnectedness and addressing social issues related to demand and accessibility.

d. social inclusion:

UGI planning promotes socially inclusive and collaborative processes, prioritizing vulnerable stakeholders and balancing diverse interests to ensure fair and equitable access to green space services.

4.2. Functions of Green Infrastructure

Urban green spaces play a pivotal role in promoting human health, protecting biodiversity, and addressing climate change, making them a key solution to urban challenges. These spaces perform a variety of functions, including environmental, natural, biological, and vital roles, in addition to their economic, social, and humanitarian benefits. **[21]** (Table 5)

Table 5.: Functions of Green Infrastructure

Field	**Function**
Environmental and natural functions	Temperature regulation. Carbon sequestration. Air pollution mitigation. Urban heat island effect mitigation. Enhance the thermal performance of the buildings. Noise absorption. Soil stabilization. Water quality. Stormwater management
Biological and vital functions	Enhance species resilience. Wood and food production. Biofuel production.
Economic functions	Increases property values. Investing in green infrastructure.

Social and humanitarian functions	Investing in green infrastructure. Health effects. Enhancing aesthetic vision and achieving psychological comfort. Enhancing the working and learning environments.

5. Analytical Study

The urban heat island (UHI) effect affects cities across all climate zones, with larger cities experiencing more pronounced effects, particularly in hot and dry regions. This study examines the role of green infrastructure planning in mitigating the UHI effect in cities that share similar climatic conditions, such as desert or arid climates.

5.1. Description of the study area

Green Park promenade the study area is located in the 6th of October Governorate, which is part of Giza Governorate. It has a rectangular shape with a total area of 27,010 square meters. It lies between the latitude coordinates 29°53'24.3"N and 30°01'14.3"N, and the longitude coordinates 30°50'167"E and 31°00'52"E, approximately 32 km southwest of Cairo. This area was chosen for its variety of urban elements, including a range of residential buildings with heights varying between 4 and 12 meters. The area also features diverse vegetation, including trees and grass, both within the site and along the side streets, which vary in width from 3 to 35 meters. The area forms different types of urban valleys and has varied orientations with respect to prevailing wind directions. (Figure 9)

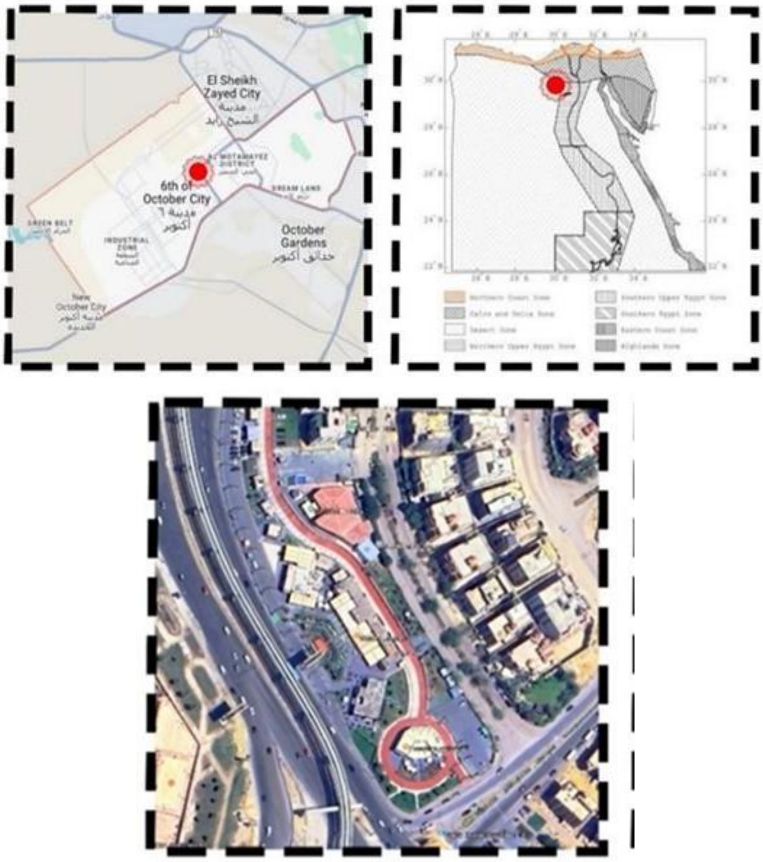


Figure 9. The location of the Green Park project in relation to the Arab Republic of Egypt and Giza Governorate.

5.2. Study Area Features

Table 6: Functions of Green Infrastructure

<table>
<tr><th></th><th>Green Park promenade</th></tr>
<tr><td>Location</td><td>The study area is situated in the 6th of October Governorate, which falls under the Giza Governorate. It is rectangular in shape, with a total area of 27,010 square meters.</td></tr>
<tr><td>Climate</td><td>The climate is hot and dry, with limited rainfall. The region experiences a semi-arid season, marked by high temperatures and dryness. The average annual temperature is 25°C during the day, with temperatures reaching as high as 35°C in July and August.</td></tr>
<tr><td>Land use</td><td>The project includes a range of service buildings such as cafés, restaurants, and specialized stores, including a car showroom and an electronic gaming center. The site is equipped with

pedestrian walkways, bike lanes, green

spaces, paved areas, and various water features.</td></tr>
<tr><td colspan="2">Project Features</td></tr>
<tr><td>Buildings</td><td>The buildings occupy 7% of the project's total area. Concrete has been used for the façades and roofs, with uninsulated aluminum cladding applied to all the exterior walls.</td></tr>
<tr><td>Cycling Path</td><td>A pathway, covering 8% of the project area, has been constructed using concrete. It is utilized for activities such as cycling, roller skating, and hosting various events and activities.</td></tr>
<tr><td>Pedestrian Walkways</td><td>Pedestrian walkways have been constructed using interlocking tiles, covering 6% of the project area. These walkways are not shaded and lack seating areas or any built or planted shading elements, making them difficult to use during the daytime.</td></tr>
<tr><td>Seating Areas</td><td>Some fixed benches have been placed along the walkway, but in small numbers. As a result, the reliance has shifted entirely to the seating areas and tables provided by the cafés and restaurants within the project.</td></tr>
<tr><td>Shading</td><td>Shading primarily relies on manually operated umbrellas in certain seating areas owned by some cafés and restaurants. However, they do not function as intended during all times of the day.</td></tr>
<tr><td>Greenery</td><td>The vegetation extends along the project, covering 21% of the total area. However, it is distributed in small, fragmented patches containing shrubs and small trees. This vegetation is not primarily used for shading. A tree fence, approximately 1 meter high, is also present in some areas along the project's boundaries, but it is not continuous.</td></tr>
<tr><td>Parking Spaces</td><td>Car parking areas are located along the eastern boundary of the project, covering approximately 21% of the total area, with space for 63 vehicles. These areas are paved with asphalt and lack shading, either through built elements like canopies or vegetation. Security gates are present at each parking area.</td></tr>
</table>

Facilities	The project includes a mosque building located at the center, a restroom facility for walkway users, an electronic gaming building, a children's play area, and a vehicle for electronic mail services.
Lighting	There is a variety of lighting elements used in the project, including streetlight poles, wall-mounted lighting, and pathway illumination. However, it has been observed that the lighting distribution is poorly planned, often weak, or not functioning at times. Additionally, maintenance is needed, with a reliance on floodlights mounted on top of the buildings.
Design Elements	There are some artistic elements distributed along the walkway, which are primarily associated with specific holidays, events, or celebrations, such as New Year's celebrations, Ramadan festivities, or other holidays.

Figure 9. Green Park promenade Project Features

Source: Researcher.

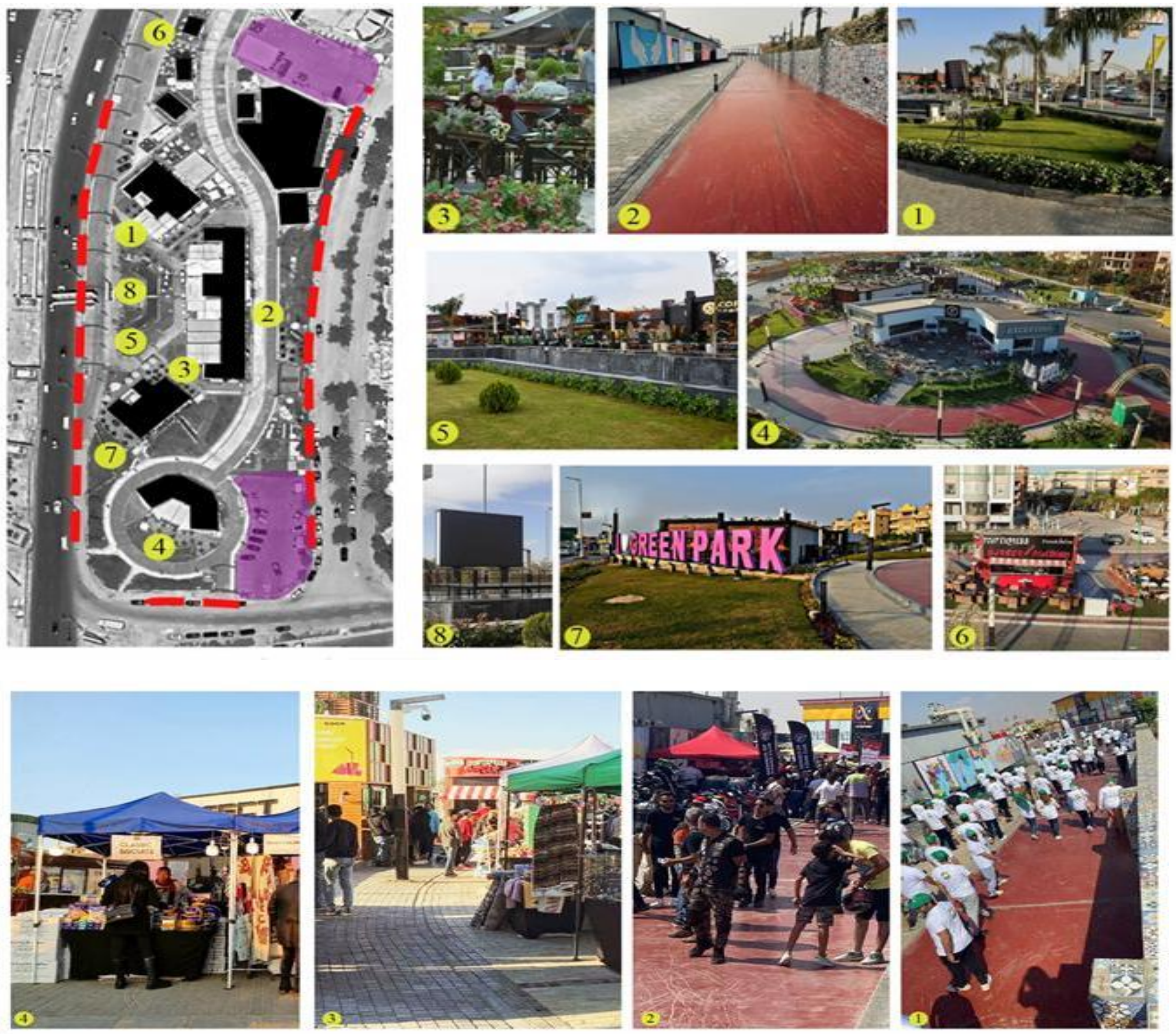


Figure 10. Green Park promenade Project different activates locations.

Source: Researcher.

5.3. Site Analysis for the Study Area

a. Street Network:

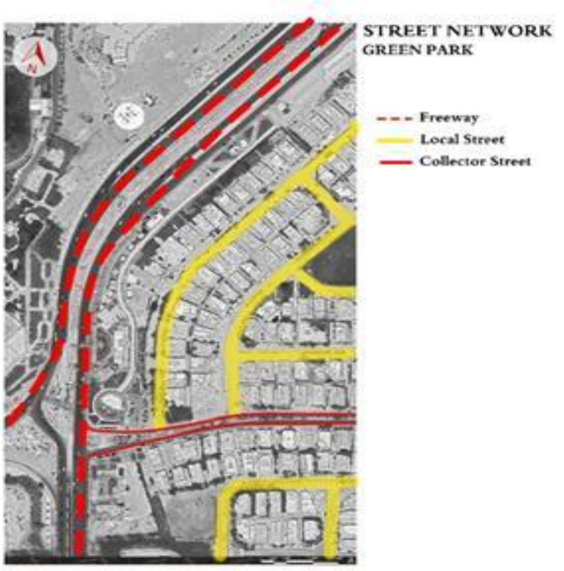


Figure 11: Street Network Analysis of Green Park Promenade

Source: Researcher

b. Average Daily Traffic volume

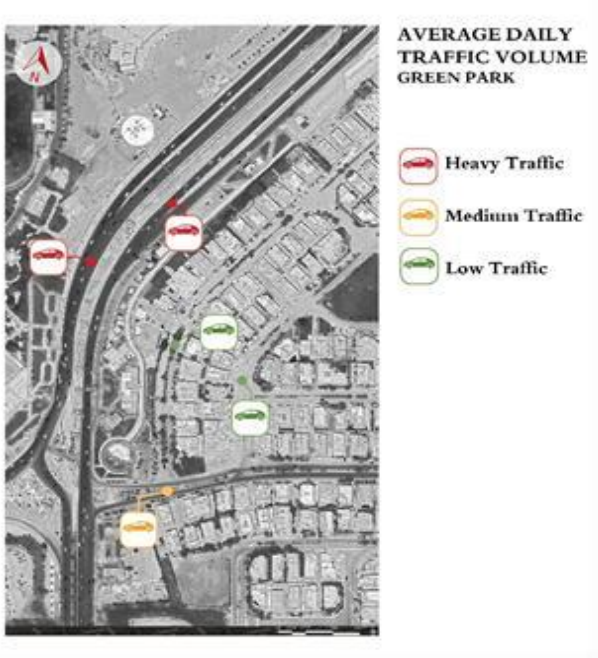


Figure 12: Average Daily Traffic Volume around Green Park Promenade

Source: Researcher

c. Public Transportation:

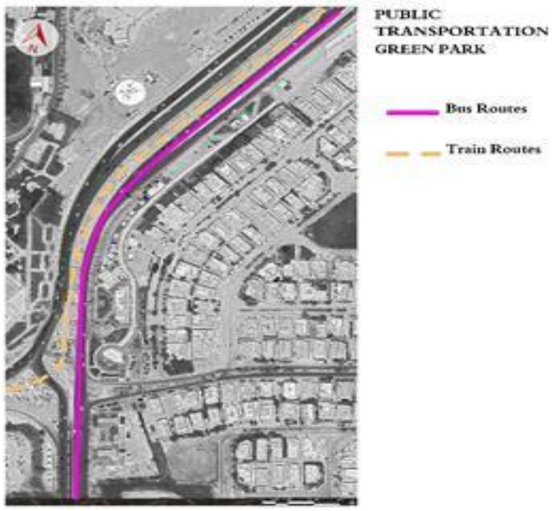


Figure 13: Average Daily Traffic Volume around Green Park Promenade

Source: Researcher

d. Walking Radius

Figure 14: Average Daily Traffic Volume around Green Park Promenade

Source: Researcher

6. Applied Study

The study area is situated in the Giza Governorate's Six of October City. The research area plot has a total size of 27,010 square meters and is rectangular in form. About 32 kilometres southwest of Cairo, it is located between latitudes 29°53'24.3"N and 30°01'14.3"N and longitudes 30°50'167"E and 31°00'52"E. This neighbourhood was chosen because of its varied urban features, which include a collection of residences with heights varying from 4 to 12 meters. Additionally, the region has a variety of vegetation, such as grass and trees, alongside roadways that vary in width from 3 to 35 meters as well as within the property itself. The region has different orientations with regard to the directions of the predominant winds and generates different kinds of urban valleys.

6.1. Simulation Study Zone Description

- Building Area: 280 m² (Table 7)
- Green Space: Comprising about 30% of the study area, it contains a small number of trees.
- Total Area of the Study Area: 12,500 m², which will be modelled using the ENVI-MET software.
- Building Orientation: South
- Building Height: The building has a single floor with a height of 4 meters.
- Materials Used in the Study Area:
- Building: Walls and flat roofs constructed from uninsulated concrete.
- External Surroundings: Sidewalks and pavements made of concrete.

Table 7: Functions of Green Infrastructure

	Base Case Description
Position of the Building in the Project.	
Building Mass	
Floors	One floor Building
Area	280 m²

6.2. Simulation Description

The computer simulation software ENVI-met, which is intended to replicate the local climate, will be used in this simulation investigation. ENVI-met has been shown to be useful in simulating local urban climatic conditions in several investigations in the same field.

ENVI-met 5.7.1 software will be used to run the simulation, which will primarily focus on the study area's physical layout under local weather variables, such as air temperature, relative humidity, wind direction, and speed. The software enables for modifications depending on regional requirements inside ENVI-met and has extensive data on building measures, material, soil, vegetation, and water qualities. The LE-ONARDO model, an application of ENVI-met Headquarter, can produce all outputs.

6.3. Study Zone SWOT Analysis

Table 8: Study Zone SWOT Analysis

points of strength	• **Strategic Location:** The project is situated in a prime, attractive location on the edge of a quiet residential neighbourhood with a moderate population density. • **Accessibility:** Easily accessible for both pedestrians and vehicles. • **Design:** Features a modern, aesthetic, and visually appealing architectural style, complemented by diverse green spaces and comfortable seating areas. • **Variety of Economic Activities:** Includes a mix of cafes, restaurants, and retail shops, catering to various customer needs. • **Diverse Building Spaces:** Offers a range of unit sizes, including buildings, kiosks, and food trucks, to accommodate different business models. • **Parking Facilities:** Ample parking spaces are available for visitors. • **Landscaping:** Rich variety of vegetation, along with decorative water features such as fountains, enhancing the overall ambiance. • **Mixed Land Use:** The site includes dedicated pedestrian walkways, cycling lanes, fitness zones, and leisure seating areas. • **Security**: Equipped with surveillance cameras and staffed by security personnel to ensure visitor safety. • **Events & Activities:** A wide array of events and activities are hosted, attracting a diverse range of visitors and enhancing the project's vibrancy.
points of weakness	• **Environmental Standards Compliance:** The building designs do not fully align with environmental sustainability standards. • **Shading and Sun Path Analysis:** Sun movement and shading elements have not been adequately considered, impacting key areas such as pedestrian walkways, seating zones, and indoor spaces. • **Green Space Distribution:** The layout of green areas is not optimized for both aesthetics and usability. • **Insufficient Tree Planting:** There is a lack of adequate tree coverage, especially shade-providing trees, which affects comfort in outdoor areas. • **Maintenance Issues:** The walkway suffers from poor maintenance, which negatively impacts its appearance and the safety of its facilities. • **Overcrowding During Peak Hours:** The area experiences significant congestion during peak times, reducing the overall enjoyment of the space. • **Limited Parking Availability:** There is an insufficient number of parking spaces to meet visitor demand. • **Impact on Nearby Residential Area:** The proximity to a residential neighbourhood has affected the privacy and tranquillity of local residents. • **Condition of Surrounding Pedestrian Paths:**

	The pedestrian walkways surrounding the project are in poor condition and require upgrading. • **Accessibility for People with Special Needs:** The design does not adequately follow accessibility codes for people with disabilities. • **Lighting Design:** Lighting distribution and diversity need improvement to enhance functionality, safety, and ambiance during nighttime.
opportunities	• **Integration of Renewable Energy:** Incorporating renewable energy solutions, such as solar panels, can help generate clean energy for the project. • **Pollution Reduction:** Implementing sustainable practices can significantly reduce environmental pollution. • **Mitigation of Environmental Effects:** Strategic planning can help minimize the impact of environmental phenomena such as rising temperatures and heavy rainfall. • **Hosting Diverse Events:** The walkway can be activated through various events like music concerts, exhibitions, and street markets to attract more visitors. • **Tourism Promotion:** The project can be marketed as both a local and international tourist destination. • **Redevelopment for New Amenities:** Certain areas within the walkway can be reallocated or redesigned to introduce new facilities and services that better meet visitor needs. • **Smart Technology Integration:** Enhancing the visitor experience by incorporating technology, such as mobile applications and free public Wi-Fi, can create a more interactive and user-friendly environment.
Threats	• **Competition:** The presence of other nearby entertainment and leisure destinations creates competitive pressure on the project. • **Economic Conditions:** Economic challenges may limit people's ability to visit the walkway regularly, especially since most services offered are paid rather than free. • **Weather Conditions:** Extreme weather such as high temperatures or heavy rainfall can negatively impact visitor comfort and reduce foot traffic. • **Security and Safety Perception:** Visitors' sense of safety within the walkway is a critical factor that can influence their willingness to return. • **Pollution and Air Quality:** Environmental factors like air pollution can affect the overall visitor experience and public health. • **Lack of Privacy for Adjacent Residential Areas:** The walkway's proximity to residential neighbourhoods may compromise the privacy of nearby residents, leading to potential conflicts or dissatisfaction.

6.4. Simulation Scenarios Description

Two scenarios are proposed to evaluate the effectiveness of the proposed Urban Green Infrastructure (UGI) principles in determining air temperature and the predicted mean value (PMV) of the simulation model. All scenarios are modeled using ENVI-met 5.7.1, with each scenario using the analytical model for the same climate zone.

a. Case 1: Base Case:

Refers to the base case of the study area. All related features, whether planted or built, are added as they are in the real world.

b. Case 2: The New Scenario Greenery (Green roofs, Walls, Parks Vegetation and Tree Planting):

Involves tree planting on existing surfaces. This scenario includes the following measures: (Table 9)

Table 9: Types of used Vegetation

Used trees	Height (m)	Crown Width (m)
Cassia Leptophylla	6	7
Koelreuteria Paniculata	10	13
Palm Washingtonia	18	3

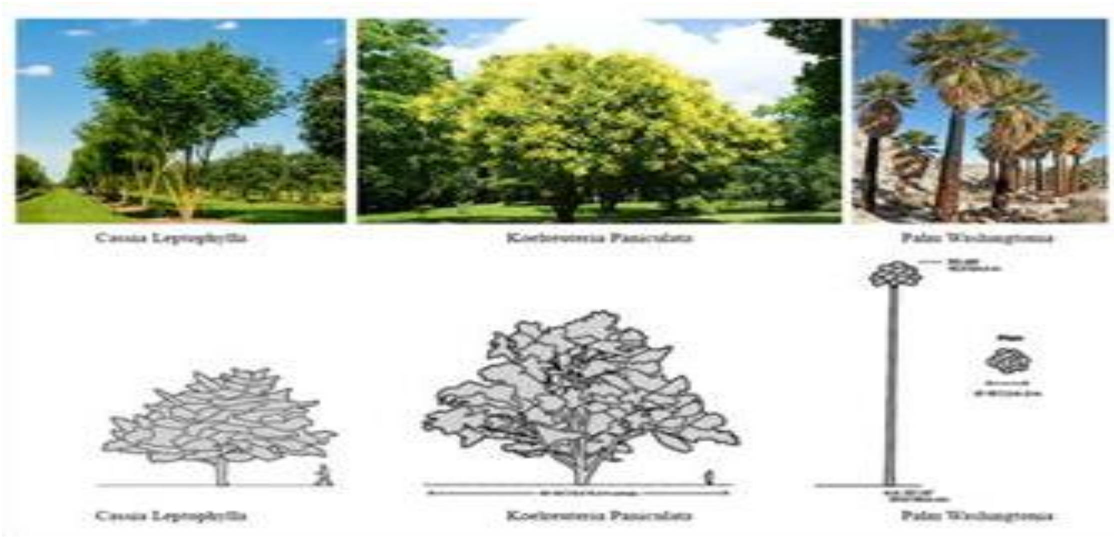


Figure 15 Types of used Vegetation

Source: Researcher

6.5. Input Simulation Data

The model area is approximately 0.0025 square kilometres, with dimensions of 50 × 50 square meters. The average building height ranges from 4 to 5 meters, and the simulation grid dimensions for the main model domain are 50 (x) × 50 (y) × 40 (w) meters. The number of cells on each axis is 150 × 150 × 80 meters, while the cell size is 3 × 3 × 2 meters, respectively. The air temperature ranges from 22 to 35°C, the relative humidity ranges from 40 to 60%, the wind speed at the internal flow boundary is 3 meters per second, and the wind direction (constant wind direction at the internal flow) is 320 degrees. The trees used in the ENVI-met program are represented below.

6.5.1. Case (1) Model (1) Base Case

This represents the current conditions of the study area, with all planted and built features as they would be in the real world. (figure 16)

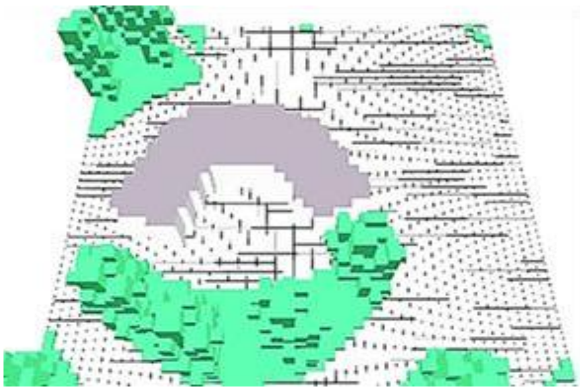


Figure 16: Case 1 Base Case of the ENVI-met simulation model.

Source: Researcher

6.5.2. Case (2) Model (2) The New Scenario Greenery

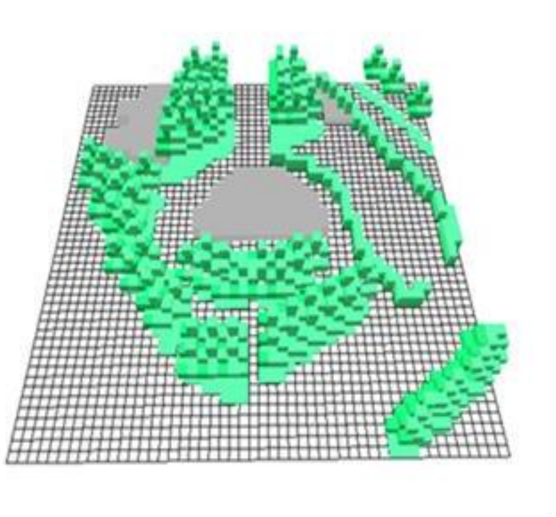
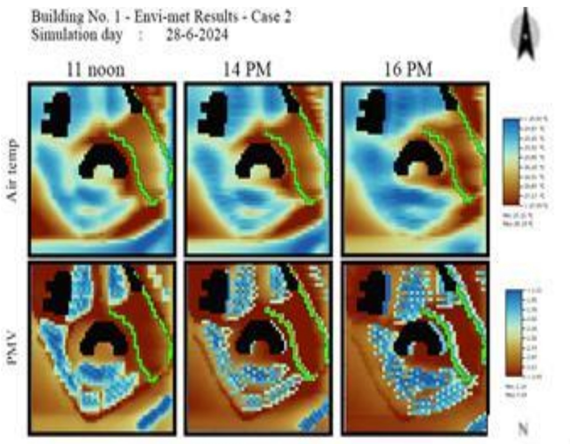


Figure 17: Case 2The New Scenario Greenery of the ENVI-met simulation model.

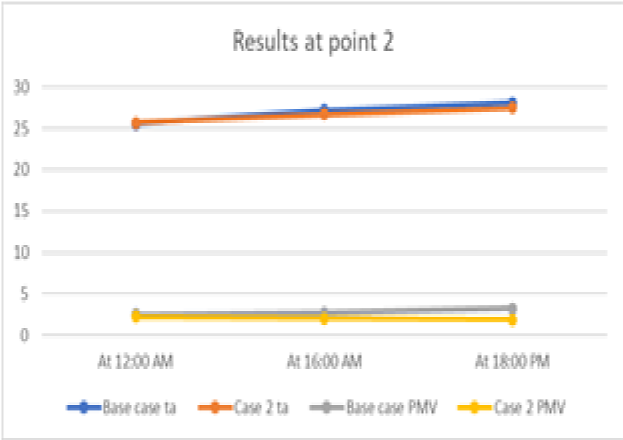
Source: Researcher

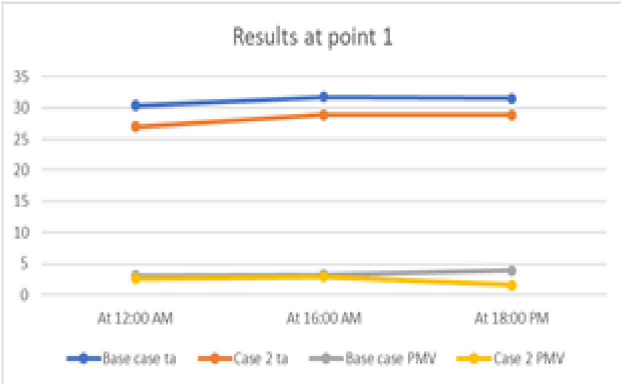
7. Results

By simulation the two cases from 11:00 am to 16:00 pm on Summer, 28 July 2024, the following Figure show; the air temperature (Ta),) and predicted mean vote (PMV) to identify the thermal comfort. (figure 18)



Source: Researcher





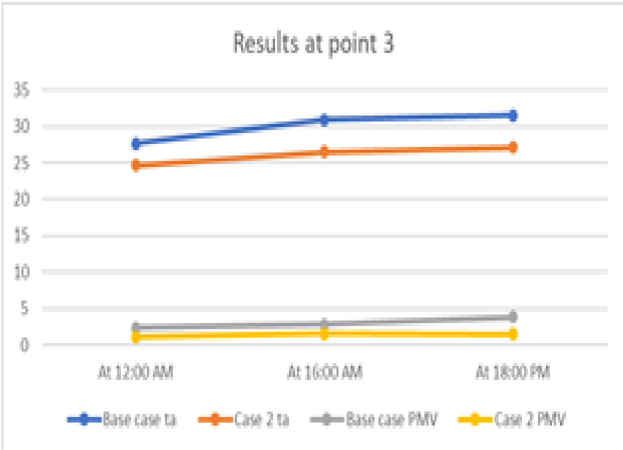


Figure 18: Comparison between air temperature and pmv results of Base case and case2

Table 10: Comparison between air temperature and pmv results of Base case and case2

	Base case			**Case 2**		
	Point 1	**Point 2**	**Point 3**	**Point 1**	**Point 2**	**Point 3**

Ta	**At 11:00**	**30.4**	**25.6**	**27.7**	**27**	**25.7**	**24.7**
	At 14:00	**31.8**	**27.2**	**30.9**	**28.9**	**26.7**	**26.5**
	At 16:00	**31.5**	**28.1**	**31.5**	**28.9**	**27.5**	**27.15**
PMV	**At 11:00**	**3.03**	**2.49**	**2.4**	**2.58**	**2.26**	**1.14**
	At 14:00	**3.2**	**2.7**	**2.8**	**2.9**	**2.01**	**1.6**
	At 16:00	**3.9**	**3.2**	**3.8**	**1.6**	**1.9**	**1.5**

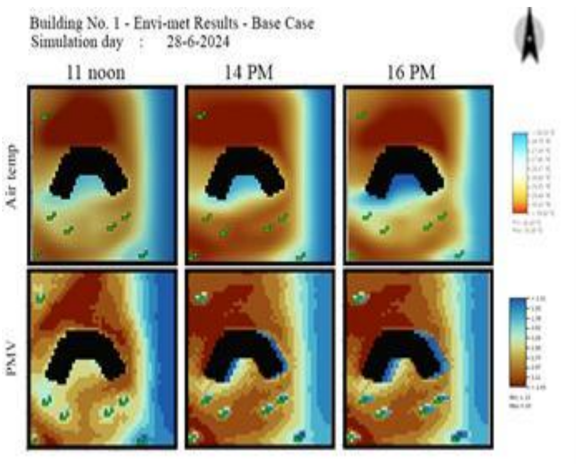


Figure 19: Comparison between 3 points selected for measurements for the 3 hours in the base case and base 2.

Source: Researcher

8. Discussion

Air Temperature Result Discussion:

By analyzing the air temperature from 11:00 am to 16:00 pm, the following was found:

The air temperature has decreased in Case 2 in the parks while in the surrounding areas and streets is an unnoticeable change compared to Base Case in the current situation.

At 11:00 am, Ta was decreased in Case 2 by 1.1°C. compared to the Base Case at setting area and the surrounding area of the building.

At 14:00 pm, Ta in for Case 2 decreased by 1-1.5°C compared to Base Case.

At 16:00 pm, Ta in Case 2 the Ta decreased by 1.5-2°C compared to Base Case.

Predicted Mean Vote (PMV) Result Discussion:

By analyzing the predicted mean vote (PMV) to identify the thermal comfort from 11:00 am to 16:00 pm, the following was found:

The PMV decreased significantly in the study area in Case 2 compared to the Base Case PMV value in The Park

At 11:00 am in Case 2 the value was 1-1.5 lower compared to The Base Case.

At 14:00 pm the PMV value in Case 2 it decreased by 0.5-1 compared to The Base Case.

At 16:00 pm the PMV value in Case 2 was about 0.5 lower than The Base Case. This confirms the effectiveness of UGI principles on urban thermal performance and thermal comfort, resulting in a reduction in the UHI effect.

9. Conclusion:

By analyzing the result of the three point it was concluded that:

At Point 1: located behind the building in an area of pedestrian pathways which considered open paved areas, the maximum rate of decrease in air temperature was at case 2 with using Greenery methods, green walls and Roofs, Trees and vegetation, the amount of decrease wasn't too much because the material and shade considerations.

At point 2: located near of the building and it is considered as a partially shaded during sunny hours due to its proximity to the building and its exposure to the building shadow it is also an open paved area with small amount of fabric canopies that used for shading without any tree elements in area the maximum rate of decrease in air temperature was at case 2 also with a slight change in air temperature.

At point 3: located in front of the building in an area of pedestrian pathway near to the vegetarian area and planted canopy trees with shaded area across the daylight hours at case 2, the maximum rate of decrease in air temperature was at case 2 because of using the UGI Scenario with Greenery methods the ratio of decrease reached a 4 °C at case 2 to the Base case scenario.

The study explores the feasibility of greening strategies to mitigate heat islands in the Giza area, particularly 6th of October City. In this specific case, simulation results using ENVI-met showed that greening facades and roofs has very limited mitigation effects at the pedestrian level. Conversely, dense tree planting has proven to have good potential during the hottest times of the day. For a country with a hot and dry climate like Egypt, there are still many research gaps to be filled, and a paradigm shift is needed to transfer the topic shifts from its current position in the field of urban planning and architecture to a more appropriate position within the heart of urban ecology. Despite some limitations, the study's findings could help improve the planning of urban green spaces to maximize their cooling potential.

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