



USING URBAN GREEN SPACES IN MITIGATING CLIMATE CHANGE CASE STUDY: NEW ADMINISTRATIVE CAPITAL, EGYPT

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ABSTRACT

Due to global urbanization expansion, temperatures in cities are rising continuously resulting from climate change, causing an impending risk of urban heat islands and heating. Urban green spaces are considered an effective way to mitigate climate change in urban environments; they have enormous potential to reduce vulnerability to heat waves, improve cities' urban resilience, offer numerous environmental benefits, and encourage overall well-being. This study focuses on the role of urban green spaces in mitigating climate change by exploring the benefits and abilities of urban green spaces in mitigating climate change. The urban green spaces in the New Administrative Capital will be analyzed showing their sustainable benefits in mitigating climate change. The main objective of this research is to conduct a guideline showing how green urban space can help in climate change mitigation. The findings revealed that urban green spaces have a high potential for contributing to climate change mitigation efforts.

KEYWORDS: Urban green spaces, Climate change, mitigation, resilience, sustainability.

استخدام المساحات الخضراء الحضرية في التخفيف من تغير المناخ دراسة حالة: العاصمة الإدارية الجديدة، مصر نهي حسين حفناوي*

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الملخص

ترتفع درجات الحرارة في المدن باستمرار نتيجة لتغير المناخ العالمي نظراً للتوسع العالمي لل عمران، مما تسبب في خطر محتمل للجزر الحرارية الحضرية. تعتبر المساحات الخضراء الحضرية هي وسيلة فعالة للتخفيف من تغير المناخ في البيئات الحضرية؛ حيث انها تقلل التعرض للموجات الحرارية، وتحسين المرونة الحضرية في المدن، وتوفر العديد من الفوائد البيئية، وتشجع الرفاه العام. تركز هذه الدراسة على دور المساحات الخضراء الحضرية في التخفيف من تغير المناخ من خلال استكشاف فوائد وقدرات المساحات الخضراء الحضرية واستخدامها في التخفيف من حدة تغير المناخ. تم ستحلل الورقة البحثية المساحات الخضراء الحضرية في العاصمة الإدارية الجديدة التي تظهر فوائدها المستدامة في التخفيف من تغير المناخ. ومن هذا المنظور، يتمثل الهدف الرئيسي لهذه الورقة في وضع مبادئ توجيهية تبين كيف يمكن للمساحات الحضرية الخضراء أن تؤدي دوراً هاماً في التخفيف من آثار تغير المناخ حيث ان النتائج أظهرت أن المساحات الخضراء الحضرية لديها إمكانات عالية للمساهمة في جهود التخفيف من تغير المناخ.

الكلمات المفتاحية: المساحات الخضراء الحضرية، تغير المناخ، التخفيف، المرونة، الاستدامة.

1. INTRODUCTION

Climate change is a result of increasing population and expansion in urbanization placing a strain on the environmental resources. Nonetheless, population expansion and urbanization are the fundamental aspects of society, which must be supported by a resilient system to ensure sustainable livelihoods. In addition to open public spaces along with common amenities, urban green spaces (UGS) are essential in creating a healthy urban environment [1].

Climate change is a phenomenon that globally has a great effect on urban life. Sea levels rise because of rising global temperatures, which also increase the frequency of severe weather events including storms, droughts, and floods as well as increasing tropical illnesses. These all have severe effects on housing, infrastructure, human livelihoods, essential services, and health in cities. However, as urban activities are among the biggest producers of greenhouse gas emissions, cities act as the key contributors to climate change [2].

As a result of the urbanization process, many urban areas have suffered from climate risks, thus it is important to make risk mitigation and adaptation a crucial element of urban planning. Therefore, the mitigation and adaptation of climate risks in urban areas and cities is crucial to reducing their vulnerability.

Green spaces themselves can be greatly significant as they can provide local services to urban residents. Despite making up less than 3% of the earth's surface, urban areas have more than 50% of the global population and it is estimated to increase to 68% by 2050 [3].

Greenspaces have a significant role in the planning consideration in developing as well as developed world through promoting the quality of the urban environment. The need for new UGS and developing the existing ones arises with the expansion of the population. Climate change is an essential consideration that planners of public spaces must consider. Many cities are currently focusing on maintaining and expanding their green spaces as a part of their sustainable development plans [4].

This research aims to investigate climate change causes and hazards, principles to maintain climate quality within cities, as well as climate change mitigation strategies, to avoid a significant human effect on the Earth's climate. Furthermore, the benefits and capabilities of green urban spaces in mitigating climate change will be reviewed then three different examples of urban green spaces will be analyzed to evaluate their effect and efficacy in mitigating climate change.

New Administrative Capital's Central Park and Green River will be analyzed as a case study to demonstrate how UGS can help in mitigate climate change in cities. Finally, a guideline will be developed showing how urban green spaces are capable of mitigating climate change.

2. METHODOLOGY

Fig. 1 displays the research methodology, which can be categorized into three main phases.

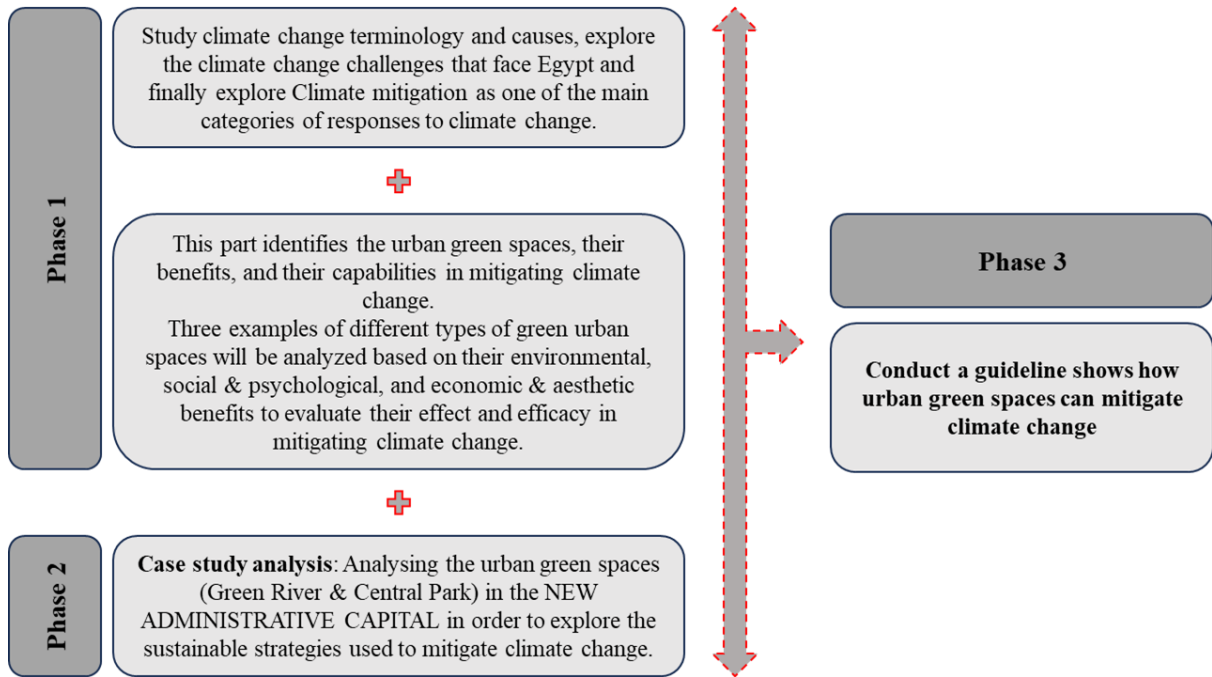


Fig. 1. Research methodology

3. CLIMATE CHANGE

The greatest challenge facing our time is climate change. The earth's natural systems and civilizations are expected to be severely impacted by rising global temperatures, which are mostly the result of human activity. These effects could be disastrous. The predicted effects of ongoing global warming comprise sea level rise, significant shifts in weather patterns, an acceleration of economic system disruption, coastal community and port facility relocation, food and water shortages, an increase in disease, increased risks to the safety and health of citizens from natural disasters, and large-scale migration of people. Potential consequences could include civil turmoil and war [5].

Climate change is an expression used to refer to long-term variations in weather and temperature patterns. Massive volcanic eruptions or fluctuations in the sun's activity could be the cause of these shifts. But throughout the 1800s, human civilization has been the main contributor to climate change, primarily as a result of fossil fuel combustion [6].

It is expected that climate change will make these catastrophes worse and put urbanites' lives at more risk. Furthermore, 70–80% of all greenhouse gas (GHG) emissions, including CO₂ emissions, are emitted into the atmosphere by cities worldwide; as shown in Fig. 2. Urbanization's bare surfaces combined with carbon dioxide generate "heat islands" and significant air pollution, which can be dangerous or very uncomfortable for anyone living there. Even though more urbanization in developing nations complicates these climate-related issues, it also offers chances to establish creative liveable, environmentally friendly, and carbon-neutral communities [7].

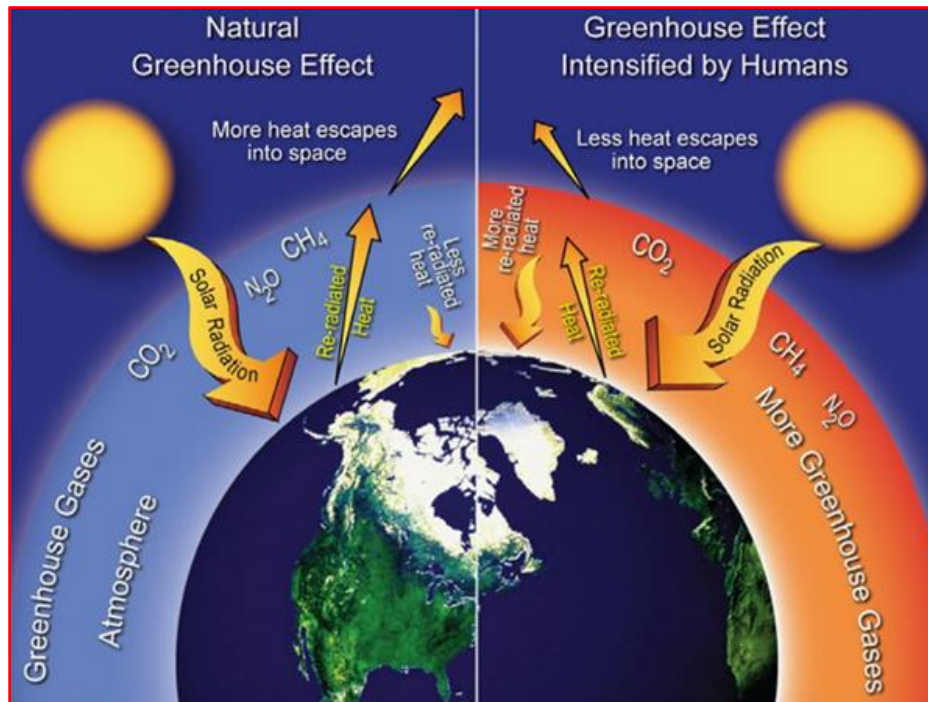


Fig. 2. Greenhouse Effect [8].

Over 50% of the global population is located in cities and other urbanized areas, which emit most of the greenhouse gas emissions. To develop effective strategies for climate change mitigation, a deeper comprehension of the relationships between urban form and greenhouse gas emissions is necessary [5].

Many believe that the primary effect of climate change is increased temperatures. However, the temperature rise is just the start since everything on Earth is linked together, changes in a particular location can have an impact on changes in all other areas since the Earth is a system. Rising sea levels, flooding, melting polar ice, catastrophic fires, severe droughts, severe storms, and decreasing biodiversity are among the many of the climate change impacts now [6].

Over the following decades, unprecedented human activity will be demanded to either mitigate climate change impacts and prevent its worst possible outcomes or adapt to the repercussions that cannot be avoided [5].

3.1. Climate Change in Egypt

Given the probable rise in dust storms, heat waves, storms across the coastline of the Mediterranean, and severe weather incidences, Egypt is extremely subject to climate change. There has been evidence of significant warming over the past three decades, with annual average temperatures rising by 0.53 degrees Celsius each decade. The country's climatic problems have impacts on and are still going to affect today's younger generations [9].

Additionally, Egypt's understanding of the significance of taking national and international climate change action is rapidly expanding. The country's commitment and actions to deal with the impacts of climate change are at a turning point. Egypt has committed to progressively greening its budget across all sectors and integrating climate change into national development strategies in the 2030 Vision and Sustainable Development Strategy [9].

3.2. Basic principles for maintaining climate quality within cities

One of the government's major objectives is to build resiliency and adaptability to climate change, as well as to mitigate its negative consequences. This objective would be fulfilled by maintaining the public's health from the adverse consequences of climate change, reducing potential losses and damages to the state's resources and ecosystems, building infrastructure resistant to the effects of climate change, applying disaster risk reduction strategies into practice, and expanding and maintaining green spaces [10]

Climate change responses can be divided into two categories: mitigation and adaptation, both of which help to build resilience. Both techniques are essential to establishing the resilience of cities' climate and can be linked with efforts to improve value, enhance liveability, and increase sustainability [11].

The key principles of preserving urban climatic quality encompass a range of approaches aimed at reducing the adverse effects of urbanization on the environment. Among these principles are [12]:

1. Reducing Greenhouse Gas Emissions: Municipalities must make a concerted effort to minimize greenhouse gas emissions. This entails putting sustainable practices into action, supporting clean energy sources, improving efficient transit, and enhancing urban forests and urban green spaces.

2. Adopt Low-Emission Development Trajectories (mitigation): They can support global efforts to mitigate climate change by depending on low-emission development pathways.

3. Climate Resilience and Adaptation: Cities must adapt to meet the challenges posed by climate change. This includes strengthening local climate resilience by planning for severe weather circumstances, increasing sea levels, and other climate-related concerns.

4. Seamless Integration of Climate Action with Urban Planning: Urban planning procedures ought to incorporate climate action, this guarantees that strategies for municipal development take sustainability and resilience into account.

5. Enhancing government support and capacity: dealing with climate change is a complicated issue that calls for cooperation from several departments or agencies within the city government. Building political support for action is also necessary, as in the conventional silos that make up city governments, neither adaptation nor mitigation quite fits in. Planning for climate change needs to be comprehensive, integrated, and cross-sectoral, with actors working across administrative borders, to be effective.

3.3. Climate Change Mitigation

There is a direct relationship between average worldwide temperatures and greenhouse gas concentrations in the atmosphere, the key to solving the climate change problem is to minimize the amount of emissions released into the atmosphere while also decreasing the current concentration of carbon dioxide (CO₂) by increasing sinks (for example, increasing forest area). Attempts to minimize emissions and improve sinks are called "mitigation" [13].

Mitigation is reducing the flow of greenhouse gases which retain heat in the atmosphere. This can be done in two approaches: either by minimizing these gas sources or by boosting the "sinks" that absorb and retain these gases (including the soil, oceans, and forests). Avoiding severe human impact on Earth's climate is the objective of mitigation [14].

The Convention demands all Parties to establish and carry out climate change mitigation programs, considering their obligations and abilities. These initiatives focus on economic activity to incentivize greener acts and discourage those that emit significant amounts of GHGs. Mitigation strategies include, for example, increasing the use of renewable energy, the implementation of new

technology such as electric vehicles, or changes in attitudes or behaviors, such as driving less or changing one's diet. Furthermore, they include growing trees and other sinks to take more CO₂ from the atmosphere, as well as improving cookstove design [13].

The urban design offers cities the opportunity to reclaim some of the characteristics that are now primarily associated with rural living, such as localized food production that minimizes the need for shipping, storage, and packaging, and green infrastructure, such as natural systems that manage stormwater and lower heating loads. To enhance the estimates now supplied in the transport sector, a more thorough assessment of the potential benefits is required. These and other methods that take advantage of the non-transportation features of the urban form may considerably contribute to overall GHG mitigation [5].

Local governments can influence climate change mitigation in several ways. They can affect the conversion of energy to noncarbon sources because they are purchasers (and sometimes producers) of power. Tax and fee policies, education, and other economic incentives or disincentives can also affect the behavior of local businesses and residents. Nonetheless, decisions made by local governments mainly in the areas of land use control and urban planning have the greatest impact on the shape of cities [5].

4. URBAN GREEN SPACES

Urban Green Spaces (UGS), as well as open public spaces and shared amenities, have a significant effect on the metropolitan area in creating healthier environments. UGS's multiple functions (commonly referred to as ecosystem services), range from carbon sequestration to microclimatic regulation, and demonstrate its significance for sustaining environmental equilibrium [1].

Sustainable metropolitan areas are upstanding on a foundation of healthy environments, which predominate and influence social prosperity and economic activity. Urban Green Spaces are an important part of these environments since they comprise a metro's public open spaces and shared amenities, can support the development of healthier environments for inhabitants of an urban region, and serve as a critical factor in microclimatic urban regulations. It also provides ecological services for metropolitan run-off regulation. Furthermore, the mental and physical well-being of metropolitan residents is significantly impacted by UGS [1].

There are several advantages that urban green spaces provide to cities and their citizens. They provide a natural environment for leisure, exercise, and socialization. In addition, urban green spaces also enhance air quality, lessen noise pollution, and decrease the urban heat island effect. They also boost biodiversity, and protect wildlife habitats, while improving the physical well-being and mental health of city residents.

In the context of the city, urban green areas play a vital role in creating more environmentally friendly and sustainable cities. The Sustainable Development Goals (SDGs) are an international initiative spearheaded by the United Nations (UN) that aims to Poverty eradication, environment protection, and enhance the lives and opportunities of people. The Sustainable Development Goals (SDGs) were agreed by all member states in 2015, and it was emphasized that the goal years of 2030 and 2050 should be used to achieve the SDGs. The UN sustainability goal 11, "Sustainable cities and communities," highlights the significance of urban sustainability. This goal includes the emphasis on "establishing green public spaces", which is impossible to accomplish without fundamentally altering how we build, develop, and maintain urban spaces [15].

4.1. Benefits of Urban Green Spaces

Urban green spaces can be successful tools for addressing some of the difficulties caused by urbanization and related to climate change, like pollution and heat island effects in cities. UGSs could enhance the sociability and psychological behavior of persons using them by expanding their access to nature, which is otherwise constrained because of the rising of urban life complexity [16].

UGS are defined as publicly accessible open spaces in urban and peri-urban areas that are partly or completely encircled in vegetation. They offer several major interests, some of which have an impact on the ecosystem level that boosts and improves the dwellers' quality of life. These benefits are particularly important regards urbanization and population expansion of urban areas, having an important effect on environmental sustainability, biodiversity, human health, and the well-being of urban areas' inhabitants. Given the advantages of urban green spaces particularly for human health, it is critical to figure out how individuals regard these spaces and their interests [16].

Urban green spaces are essential to cities' sustainable development. Green space interventions enable outdoor enjoyment and active lifestyles, enhance environmental conditions, preserve biodiversity by establishing wildlife habitats, and enhance the city's existing identity. They also lessen surface runoff and heat island effects on a bigger scale. The roles they have played in decreasing carbon emissions and enhancing public health have gotten more attention in recent years. UGS offer numerous advantages that fall into three main categories: those related to environmental benefits, economic and aesthetic benefits, and social and psychological benefits [15, 17].

The well-being advantages of being in contact with nature have been widely researched. For this, urban parks and green areas are highly valued for their capability to restore connections between people with nature. Urban green spaces offer critical ecological functions such as maintaining biodiversity, preventing soil erosion, purifying air and water, and stabilizing microclimates [18].

Parks are widely regarded in urban environments for their ability to enhance physical exercise. Residents frequently regard urban parks as valuable community assets, providing unique chances for physical activity, social contact, escape, and enjoying nature [18].

4.2. Urban Green Spaces in Mitigating Climate Change

UGS are essential for mitigating climate change. These spaces like parks, urban forests, and gardens, offer significant advantages for the environment. Through photosynthesis, they take up carbon dioxide, a significant greenhouse gas, which helps lower its atmospheric concentration. Additionally, green areas purify the air by eliminating pollutants acting as natural air filters and improving air quality. They also contribute to temperature regulation by providing shade and mitigating the urban heat island effect. All things considered, investing in, and maintaining urban green spaces is critical to mitigating climate change and developing more sustainable cities.

UGS are becoming a popular technique for improving the resilience of climate change, which refers to the ability of a socio-ecological system to endure, modify, and/ or adapt to preserve stability and functionality in response to disturbances. They offer plenty of ecosystem services resulting in a wide range of socioeconomic and environmental advantages, from reducing urban heat islands to addressing health inequities, urban green spaces are becoming highly recognized as fundamental "green infrastructure" [19].

Multifunctionality is a key feature of urban green infrastructure. Besides services mentioned previously, various types of UGS such as green roofs, food gardens, urban forests, parks, and pocket prairies offer many other amenities essential to preserving the quality of life in the face

of climatic change, involving the production of food, storage of carbon, and cultural services (involving community cohesion, recreational opportunities, and aesthetics) [19].

Urban green areas can mitigate heat and air pollution, regulate stormwater, and protect against climatic change impacts while also improving life, recreation, and public health in cities [20].

Furthermore, urban green spaces offer further environmental advantages that can help in mitigating the climatic change impacts, such as the heat-reducing effects of urban parks. Urban green spaces can produce a Park Cool Island (PCI), which can extend their cooling impact up to 4.7°C colder than their urban surroundings and extend this cooling impact 100-1000 meters into the city. This is especially relevant in areas of the world where residents live in slums and unplanned settlements, which are more likely to experience rising temperatures due to their geographical location, poor building materials, and dense populations, which raises morbidity and mortality rates [18].

Urban green spaces offer further economic and aesthetic benefits that include cost savings resulting from the energy cost reduction of cooling buildings by increasing green urban space and tree planting, serving as a location for the production and supply of fruits, a source of wood for green business centers, a place to create new jobs, and an increase in the Property Value due to the integration of environmentally friendly practices and the attraction of tourists who are given a convenient atmosphere, security, and amenities [17].

Finally, urban green spaces have a vital role in mitigating climate change, as they contribute to mitigating strategies of climatic changes involving the improvement of the quality of air, local climatic regulations, urban heat island and temperature control, and heat stress reduction [21]. **Fig. 3.** shows the different urban green spaces' benefits.

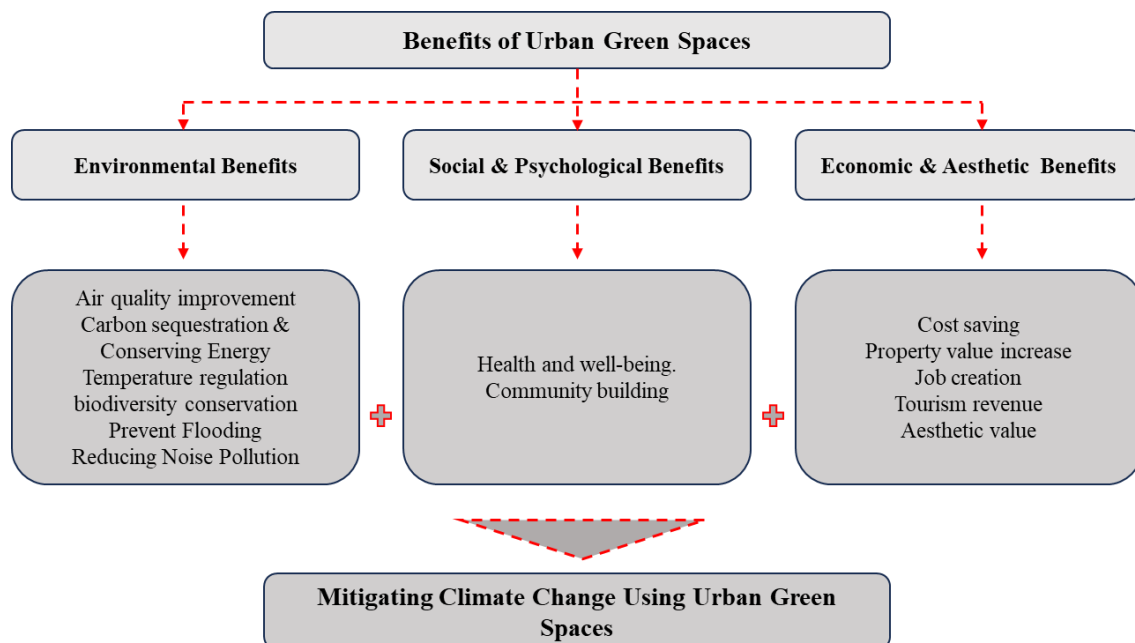


Fig. 3. Benefits of urban green spaces [Author based on 17, 21].

4.3. Examples of urban green spaces

Urban green spaces encompass all green places, including parks, gardens, recreational areas, open spaces, residential gardens, tree-lined roadways, green roofs, and vertical greenery systems, among others [22].

The primary purpose of these examples is to evaluate the effect and efficacy of different types of urban green areas in climate change mitigation efforts by analyzing them based on the environmental benefits, social and psychological benefits, and economic and aesthetic benefits.

A. Al-Azhar Park

Al-Azhar Park is located in the Old Cairo area. It is surrounded by various historical sites and is regarded as one of Cairo's great parks. The designers of Al-Azhar Park wanted to create a park that would revitalize the city's history and tradition while fostering the development of both the economy and society [23].

Al-Azhar Park has had a great impact on Cairo by changing an enormous area that was formerly utilized as an open landfill. It has been designed with a variety of activities in mind, including a conceptualized hilltop lookout kiosk, a play zone for kids, an amphitheater and stage, recreational fields, a viewing plaza, and a historical wall promenade; as shown in **Fig. 4.** [24].



Fig. 4. The development of Al-Azhar Park [25].

The Environmental Benefits

The creation of a massive park in the center of polluted Cairo is already beneficial to the environment, in particular, because it is close to the Salah Salem Highway, a major thoroughfare that connects north and south of greater Cairo and regards heavy traffic every day. As a result, the park functions as a large air purification facility in which plants absorb all pollutants in the air and transform them into oxygen for the enjoyment of visitors [26].

Using water from subsurface water reservoirs as a low-cost near-water provider eliminates the need for long pipes and the loss of expensive water resources [26].

Attaining a certain level of environmental sustainability for the park by using an innovative irrigation system that uses the least amount of water possible to irrigate the vast expanse of open spaces, while taking into account Cairo's hot, dry weather and the water shortage situation. [26].

Cultivating various kinds of plants and planning the park layout to address all of the site constraints, beginning with the three water tanks and the large slopes on the eastern side of the park [27].

Improving biodiversity through various types of medicinal and culinary herb plants, and a variety of local trees [26].

Offering panoramic views to visitors to show them landmarks, as well as a variety of trees to provide shading in the summer in seating areas to avoid high temperatures. Defining the boundaries and guiding the path of visitors by varying the colour of the plants and providing a variety of flowers at the entry to create visual stimulation [27].

Social And Psychological Benefits

This project concentrates on empowering residents by offering them training in various fields to ensure that they can be beneficial to the program. While residents were given priority to work in the park today, some of them now rely on their businesses based on what they learned from the survival training. Furthermore, various community services such as education and healthcare

were offered to make this neighborhood more sustainable, effective, and safe for both visitors and residents [26].

Social programs and healthcare services are provided for the impoverished and overcrowded neighborhoods; the park's main features and pathways are distributed to integrate with the surrounding area, particularly the old historic zone; historical heritage is preserved and restored through the renovation of the Ayyubid wall and the Darb Al Ahmar district [27].

Being an approach to enhance the neighborhood's aesthetics and overall safety/comfort, visitors can enjoy recreational space; and a variety of activities, including a play zone for kids' area, a theatre, and playing fields, are planned [27].

Economic And Aesthetic Benefits

Al-Ahzar Park development project features a microcredit program for neighboring inhabitants to renovate dwellings along with enhancing existing/found new businesses [24].

Enhancing the neighborhoods' safety and aesthetics, developing job opportunities and crafts for residents living nearby the park, raising money through entry, parking, and restaurant fees, and offering microcredit programs to these residents to help them renovate their dwellings and expand their new businesses [27].

In addition to providing green space for pleasure, the construction of parks boosts the value of real estate and draws in businesses and tourists. Ancient crafts were also restored, encouraging a link to ancient skills and craftsmanship [26].

As a result of all the above, Al-Azhar Park is considered an important part of the city's cultural heritage, as these public spaces preserve layers of its history. While Al-Azhar Park has made significant progress towards implementing many sustainability strategies, many remain unfulfilled. For example, in the environmental domain, energy conservation measures, the use of renewable energy sources, and wastewater recycling are all lacking. In terms of the social component, the signs' lettering is too small, and they are not uniformly distributed. In terms of economics, the park uses fertilizers, which reduces its ecological performance [27].

B. High Line Park, New York City, USA

The High Line is a linear elevated urban park and greenway on Manhattan's west side that was constructed on an old New York Central Railroad spur. The structure of the park consists primarily of steel frames with reinforced concrete roof decking [28].

The Environmental Benefits

The landscape design of The High Line contributes many of the environmental advantages of green roofs, including the ability to reduce storm-water runoff by up to 80%, mitigate the "heat island" effect caused by hard, reflective city surfaces, and provide shading, oxygen, and ecosystems for insects and birds [29].

The Park successfully mimicked nature by converting the old structure into a green destination with diverse plant varieties, delivering fresh air and relaxation. Through its features and characteristics, the park improves urban air quality by reducing pollution and purifying the atmosphere [28].

Created a green roof-style drainage system that addresses the challenges of excess rainfall and drought while also creating a better environment for the High Line's plants [29].

The High Line's concrete route system was created with the dual goals of minimizing stormwater runoff and lowering plant watering requirements. Pre-cast concrete planks with open joints allowing rainwater to pass between boards and into nearby planting beds make up the paths. Rainwater may drain into the planting beds through perforated metal panels placed between them

and the space underneath the sidewalks. Water can be absorbed into the planting beds as needed, or drained out if the soil becomes too saturated, thanks to the planting beds' strategic positioning of drains at low points [29].

utilizing recycled green trash in gardening and on-site composting of all garden waste to cut down on material entering the waste stream and do away with the energy-intensive need to transfer garbage to an independent compost facility. As an alternative to commercial fertilizer, utilizing recycles vital nutrients back into the garden soil [30].

The High Line's planting strategy reduces the resources used in the landscape by selecting native, drought-tolerant, and low-maintenance plants. As local growers are better suited to create plants that thrive in the climate, nearly half of the plants on the High Line are native species, which minimizes the amount of plant failure and replacement expenses [30].

Reconnecting with nature is not the only benefit of the High Line in New York City's urban landscape; it has also enhanced the presence of a wilder and more biodiverse ecosystem within the densely populated metropolitan system [28]. Wildlife species, especially natural pollinators, can also find food and refuge in the ecosystem of the High Line [30].

Social And Psychological Benefits

The High Line Park is a remarkable public space where residents and visitors may assemble, relax, exercise, and appreciate nature. It encourages a sense of belonging and connection. Even in urban settings, The park has been successful in drawing people to spend time relaxing and strolling to satisfy their innate need for a connection with nature [28].

Economic And Aesthetic Benefits

The High Line Project is an impressive example of green roofs that connect people to nature. The park received a total of 7 million visitors in 2018, up from 4 million in 2011. As a result, the project has become one of New York City's most popular attractions, as well as one of the city's most notable landmarks [28].

The park's paths now have energy-efficient LED lighting fixtures that blend in seamlessly with the surrounding city sky's ambient light at night [31].

The High Line focuses on plant species that are native, drought-tolerant, and require minimal maintenance. Using these plants minimizes the park's landscaping resource requirements and minimizes plant failure and replacement costs [30].

As possible, materials are bought around a 100-mile radius. This strategy reduces transportation expenses while also ensuring that plants are more adaptable to the local climate [30].

The success of the park has not only improved the area's aesthetics but also generated new employment opportunities and raised property values. Property values along the High Line frequently rise as a result of the park's popularity. Real estate development near the park has also resulted in economic growth.

Additionally, it has given local businesses growth opportunities and revitalized in neighborhoods surrounding it. Employment Opportunities are generated due to the High Line's management, programming, and maintenance.

C. SuperTree Grove, Singapore

They are giant Structures, that reach heights of up to 50 meters above the ground, offer shade during the day, and come to life at night with an incredible light and music display. The Supertrees are more than just futuristic-looking structures; they represent an innovative new approach to growing and exhibiting plants. Featuring a broad variety of flora complemented by wonderful bromeliads, ferns, orchids, and tropical climbers, the Supertrees will satisfy any plant lover [32].

Eleven of the SuperTree have integrated ecologically friendly characteristics. Some contain photovoltaic cells on their canopies that capture solar energy to power the Supertrees, while others are integrated into the Conservatories and function as air exhaust receptacles; as shown in **Fig. 5**. [33].

The SuperTrees are considered as advanced structures that integrate horticulture and ecological technologies. They provide an outstanding blend of nature and technology, leading to numerous benefits as follows:

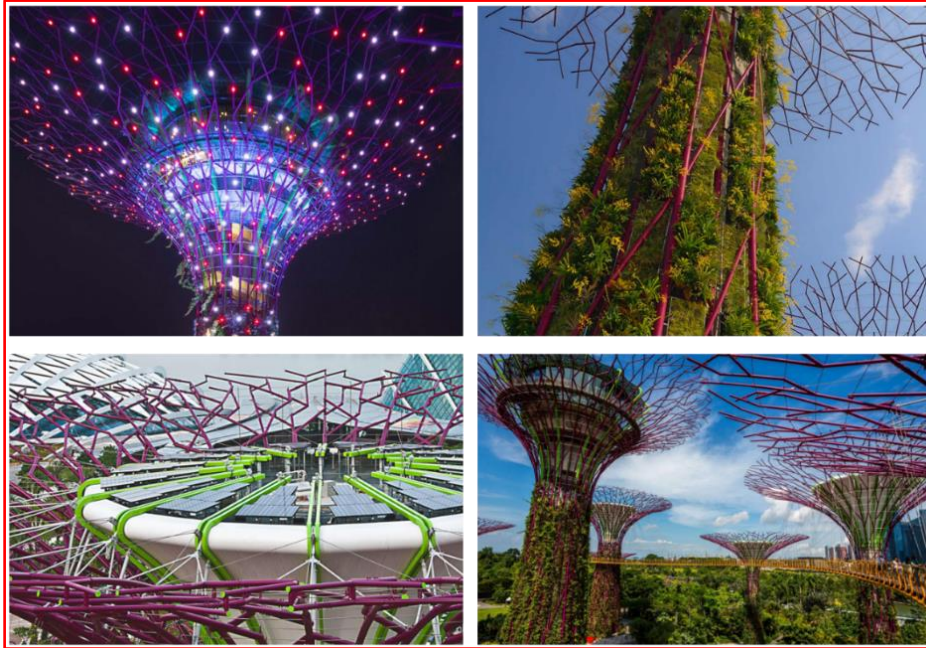


Fig. 5. Supertree Grove, Singapore [33].

The Environmental Benefits

Over 162,900 plants of over 200 different kinds are hosted in these sustainable vertical gardens, which improve air quality, lessen the impact of the urban heat island, keep the surrounding area cooler, and increase biodiversity [32].

The SuperTrees represent man's attempts to recreate nature's balance. They, like prominent rainforest trees, sustain a living skin of epiphytes, ferns, and floral climbers, resulting in vertical gardens in tropical Eden. They are outfitted with advanced environmental technologies that mimic the ecological functions of trees—photovoltaic cells harness solar energy for the SuperTrees' operation, similar to how trees undergo photosynthesis; rainwater harvests gather rain, just as trees help form clouds to deliver rain. The Conservatories' cooling systems incorporate several of these environmental technologies [34].

They are intended to emulate the ecological functions of real trees. Each structure is furnished with photovoltaic cells that gather and store solar energy during the day, which is then utilized to illuminate the garden at night. Their distinctive design functions as a rainwater collector, directing water to fountain displays and irrigation systems [33].

The Social and Psychological Benefits

The SuperTrees are created at a scale that would be immediately recognized anywhere on the site, and they provide the chance to build vertical gardens in tropical climates. Their heights vary between 30 to 50 meters, placing them well above the tree canopy that will surround the Lion

Grove region. An elevated path connecting the SuperTrees would provide a spectacular view of all the Gardens while also enabling an exceptional experience of exploring the SuperTree canopies. Additionally, a treetop cafe will be located within the 50-meter tree and accessible by a spiral staircase and elevator. The SuperTrees are illuminated and have media projected onto them at night [34].

The Economic and Aesthetic Benefits

In an attempt to reduce energy use, they turn off accent and decorative lighting that isn't necessary at night. At times when there are few visitors, there is also less lighting in parking lots and pathways [33].

Using iconic elements, the project aims to create a "city in a garden." The Supertree Grove are vertical garden designed to resemble trees. These gardens have large canopies that offer shade during the day and transform into an incredible show of light and sound at night. Supertree Grove has not only improved the area's aesthetics but is also considered a very important tourist destination in Singapore which generated new employment opportunities and raised property values [35].

5. CASE STUDY ANALYSIS: NEW ADMINISTRATIVE CAPITAL

The New Administrative Capital (NACC) project was created to be a city that is responsive locally and globally integrated as well. The goal of the city's urban design is to merge districts (known as 'valleys') into a megacity linked by the 35-kilometer Green River and enormous infrastructural networks. Additionally, one of the primary goals of the NACC project is to build a vibrant, sustainable, and locally responsive city which connected to its close surroundings; in which people's daily lives will be enjoyed [36].

Egypt's NACC aspires to alleviate population expansion and create a new growth hub for the next generations; through a comprehensive plan founded on the ideas of sustainable, green, walkable, liveable, linked, smart, and business districts; all the while boosting political, social, and economic efficiency [36].

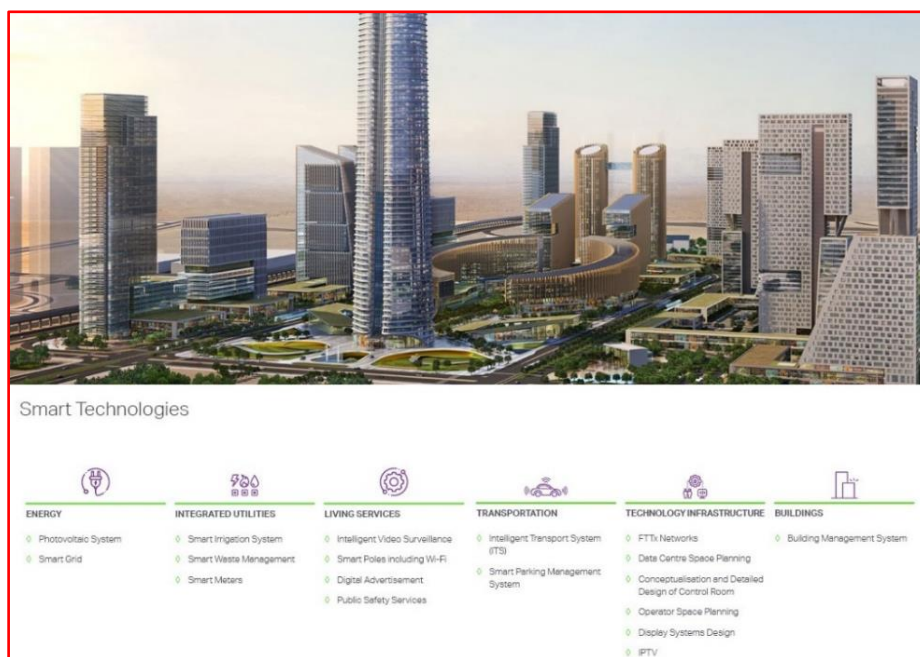


Fig. 6. Smart city features of NACC [37].

The NACC is a creative project that aims at addressing urban challenges while incorporating sustainable practices that mitigate climate change by implementing smart and sustainable city strategies; as shown in **Fig. 6**. It attempts to preserve the city's climate in the following ways: High-Tech Infrastructure, Green Spaces, and Effective Water Management; climate-responsive design comprises building orientation, shading, and materials that adapt to the desert climate; and an intelligent transportation system. It is also meant to be resilient to extreme weather events, including floods, proper drainage systems, and flood-resistant infrastructure [36, 37, 38].

5.1. Reasons For Selection

NACC was chosen as a case study for the following reasons:

The city aims to decrease its environmental footprint by digitalizing energy infrastructure and paving the way for sustainable practice through using sources of renewable energy [39].

The NACC intends to create an integrated urban environment with green areas and magnificent natural landscapes, enabling residents to enjoy nature while preserving the environment as well.

5.2. Basic Information of Case Study

Egypt's New Administrative Capital is an innovative city that aims to establish itself as the country's new financial and administrative hub. The city will locate on an uninhabited strategic desert 60 km from great Cairo's centre and 60 km from the Suez Canal as well [40]. Upon completion, NACC will have a land area of 715 km², 6.5 million residents, and provide two million work opportunities. Egypt's government has decided to relocate governmental ministries, civic institutions, and parliament to the NACC [41]. **Fig. 7**. shows some iconic buildings in Egypt's New Administrative Capital.



Fig. 7. Buildings in NACC [41].

5.3. Green River

The concept of the Green River is to create an artificial lake and plenty of green space in addition to providing a variety of amenities and services for residents as well as visitors. It is located at the center of the city acting as a river-like chain of urban parks offering an abundance of amenities and services, including eateries, cafés, bike lanes, green spaces, events, and activities.

The Green River is 35 kilometers long and its master plan is connected through seven central parks comprising recreational, economic, and socio-cultural opportunities and services [36], [42]; as shown in **Fig. 8**.

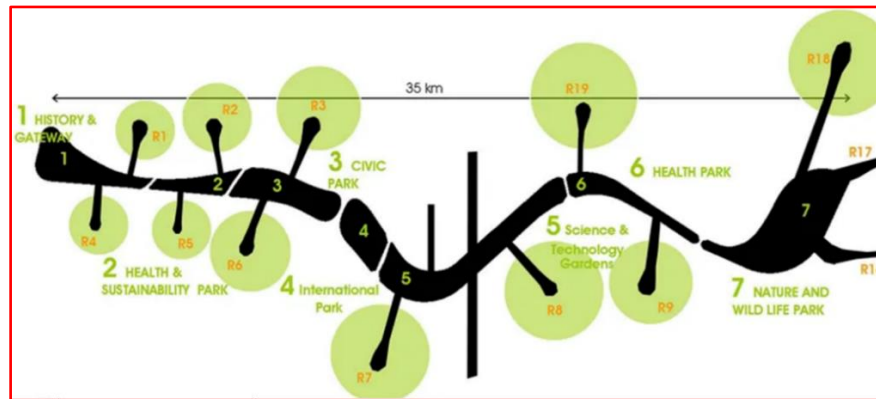


Fig. 8. The Green River & oasis [42].

The Green River forms an integrated system of water bodies and attractive surrounding landscapes as it runs along the city. It includes a network of lakes, canals, and waterways that pass through the city's business, residential, and recreational areas. The New Administrative Capital's social and recreational life concentrates around the Green River, providing a range of amenities and water-based activities. establishing particular areas for bicycling and walking as well as large green spaces for leisure [36, 42].

The Green River acts as a vital part of enhancing the air quality and purifying the environment. It filters the air, as well as cleaning and improving the quality of water. Furthermore, the Green River helps sustain biodiversity and protect the surrounding ecosystem. The Green River's creative design demonstrates the city's commitment to sustainable growth and environmental protection. It acts as an evolving model of water infrastructure integration in the urban environment, creating a standard for modern cities to follow [36, 42].

5.4. New Administrative Capital's Central Park

It is one of the biggest new parks in the world the first one of its kind in Egypt and Africa, extending along the spine of NACC. The Park is double the size of New York City's Central Park and acts as the heart of the environmental, cultural, and social of the city [43].

A 10-kilometer length of the new park offers various activities. The park features gardens that represent three periods of Egyptian history: Pharaonic, Classical, and Islamic. These include spaces for events, locations for sports and culture, and family-friendly zones suitable for all ages [43].

It is a huge 10-kilometer-long urban oasis spanning 440 hectares and serves as Egypt's New Administrative Capital's primary city park and dynamic green lung. This park is designed with an extensive variety of services and locations to provide a wide range of experiences [43].

Central Park is separated into three distinct zones (as shown in **Fig. 9**), each with a distinct ambiance: CP1 for natural setting, CP2 for cultural identity, and CP3 for civic environment. They

are linked by a network of routes, which includes primary entrances and pathways hierarchy. The park's main 15-meter avenue and secondary 8-meter path run the full length, with similar hardscape materials and furniture styles. Trees are placed strategically along pedestrian paths to add shading and improve the character of the pathways [43].

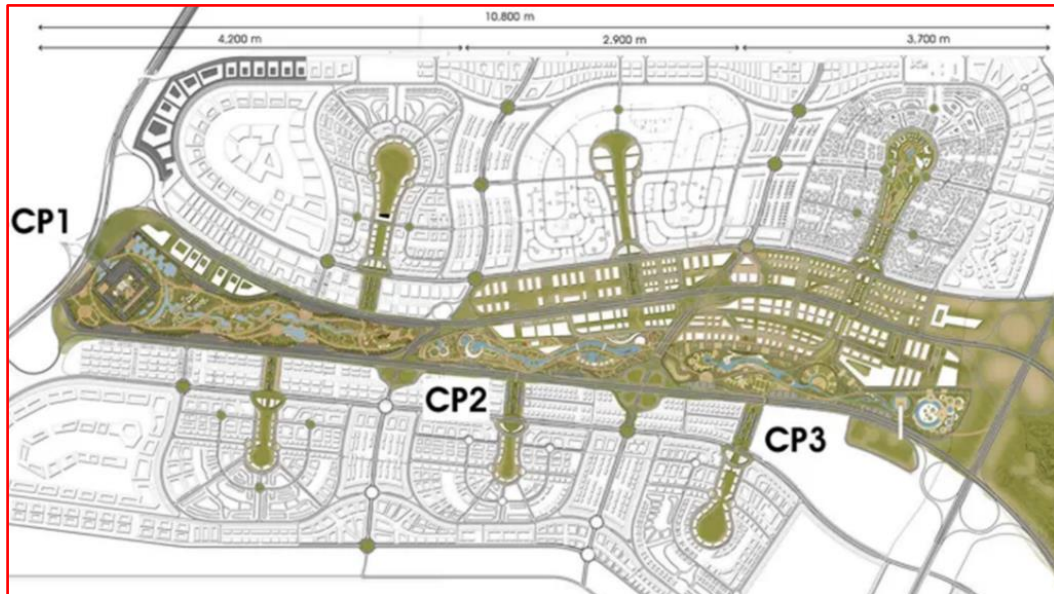


Fig. 9. Zones of NACC's Central Park [42].

The park smoothly integrates natural and man-made components and provides soothing natural environments for a peaceful retreat. It provides a variety of diverse gathering places where individuals can socialize, engage in civic activities, enjoy recreation, and feel a sense of belonging [43]; as shown in **Fig. 10**.



Fig. 10. Central Park in NACC [44].

The design of the park is intended to be accessible to people of various abilities. The park can be accessed easily on foot, and transit stops are positioned conveniently nearby, while also avoiding the risks of speeding traffic. Efficiency and comfort are prioritized, with a focus on reducing exhaustion and risks by offering sufficient space in terms of line of sight, usefulness, approach, and size [43].

Benefits of the Urban Green Spaces in New Administrative Capital

The masterplan of the park incorporates sustainability concepts as follows:

Environmental Benefits

The design of urban green spaces in NACC emphasizes resilience to the impacts of climate change. The NACC ensures long-term sustainability by creating infrastructures capable of withstanding adverse weather events [37].

By employing renewable energy sources and digitalizing its energy infrastructure, the city is seeking to reduce the environmental impact and pave the way for sustainable practices [37].

The urban ecological systems were conserved on-site while designing the park's Softscape by establishing supporting environments for wildlife and native flora and employing xeriscape landscaping to decrease and/or eliminate the need for irrigation [43].

Comprehensive management of stormwater networks (like culverts and pipes) defends local flooding [43].

There are very few grassed regions, decreasing the irrigation needs, whatever the source while encouraging efficiency and water security [43].

Buildings and plantings are placed to take advantage of beneficial wind and airflow, reduce airborne dust, and enhance thermal comfort in the outdoors [43].

Social and Psychological Benefits

The park effectively integrates natural and man-made elements. It provides soothing natural places such as gardens, lakes, and open lawns, while on the other hand offering man-made spaces such as open-air eateries, plazas, play areas, sports fields, and culturally themed spots provide vitality to the park. It also has a play facility, children's learning gardens, an outdoor theatre, and an event lawn. Spaces for celebrating knowledge and enhancing culture are offered by the library and reading gardens [43].

Efficiency and comfort are prioritized, with a focus on reducing tiredness and risks through offering sufficient space concerning size, functionality, line of sight, and approach [43].

To avoid risks to health off-site or on-site at disposal facilities, effective and safe recycling, and composting techniques involve segregated waste containers in all visitor-frequented areas [43].

Drinking water, shading places, regular spots for rest, and proper pedestrian paths throughout motivate active mobility through walking, cycling, and other activities, all of which have health, social, and economic advantages [43].

Economic and Aesthetic Benefits

Effective outdoor lighting minimizes the overall energy demand in the park [43].

In addition, many entertainment services will happen in the urban green spaces in NACC that will let visitors enjoy their time, resulting in increasing numbers of visitors and improving the business's growth opportunities [43].

From the above, the urban green spaces will have a significant impact on Egypt's real estate market in general, as well as the New Administrative Capital specifically. Since they overlook many areas of the New Administrative Capital, like the Central Business District (CBD) and downtown, they will encourage many foreigners to rent properties there. UGS will also attract Egyptians to live in the park's nearby areas and investors to buy real estate in those areas to enjoy the stunning nature of the Green River, which will support Egypt's real estate industry. With its large green spaces, recreational, cultural, and sports areas, it will provide a sustainable and eco-friendly environment, improve air quality, and lower the temperature of the New Administrative Capital.

A diverse range of species indicates a healthy ecosystem that is more capable of dealing with problems like climatic change. The Park provides the ecological value of the surrounding landscape, as well as the Strategic Goals and Targets of Egypt's Biodiversity Strategy and Action Plan (2015-2030), through conservation, rehabilitation, sustainable management programs, and the implementation of environmental education and awareness campaigns about desert conservation, ecotourism, and support.

While the New Administrative Capital is still being constructed, the city's commitment to sustainability and climate resilience is remarkable. It intends to be a model for future Egyptian and global cities by combining climate-conscious design, technology, and urban green spaces.

Finally, urban green spaces in the New Administrative Capital contribute significantly to Egypt's ecological systems, provide a wide variety of well-being alternatives for all, reflect the country's rich cultural heritage, and encourage physical activity and economic opportunities. They highlight Egyptian art and adaptability, act as a year-round climate-adaptive space, promote education and smart city technology, and, most importantly, serve as the New Administrative Capital's vibrating social heart that integrates communities.

6. RESULTS AND DISCUSSIONS

Urban green spaces are critical in addressing climate change. They have many advantages, including decreasing the urban heat island effect, enhancing air quality, and sequestering carbon dioxide. These green places also boost biodiversity, improve mental health, and promote physical activity. More urban green spaces can help establish sustainable and resilient environments that support climate change mitigation efforts.

UGS protect various ecosystem processes. Offering entertainment and cultural activities, controlling erosion, disposing of solid waste and sewage, supplying fuel and food, supplying groundwater, performing as windbreaks, providing psychological and other health benefits, acting as food sources, and direct mitigation of the urban heat island impact by cooling through evapotranspiration and shading are some from these processes. UGS's ability to deliver ecosystem services is enhanced by its urban area, structure, and biodiversity, as well as their management efficiency [7].

Cities may become more resilient and sustainable in the face of climate change by incorporating more green space. UGS have considerable potential to contribute to future climatic change mitigation, as illustrated in the following guidelines in **Table 1**.

Table 1. UGS guidelines for mitigating climate change [Author based on 7, 17, 18, 19, 45, 46].

Benefits	Indicators	Criteria
Environmental Benefits	Air quality improvement	UGS can mitigate the impact of climatic change as they can directly reduce air pollution when vegetation traps dust and smoke particles and decrease the emissions of greenhouse gases.
	Carbon Sequestration & Conserving Energy	UGS assist in mitigating the consequences of climatic change through carbon sequestration.
		Green spaces can reduce the urban heat island effect, lowering energy consumption and enhancing air quality in surrounding areas.
		Vegetation can be used to minimize the energy costs of cooling the buildings which is increasingly accepted as a cost-effective justification to encourage UGS and tree planting in cities. They enhance air circulation, offer shading, and evapotranspiration. This creates a cooling impact that causes air temperature reduction.
	UGS reduces the need for fossil fuels, lowers the carbon footprint, and minimizes energy usage for cooling and heating.	
	Temperature regulation	Green spaces contribute to regulating temperature resulting in decreasing the urban heat island effect.
	biodiversity conservation	Urban green spaces promote biodiversity and environmental wellness by supporting a diverse range of plant and animal species.
Urban green spaces connect the urban and rural areas. They offer aesthetic relief, seasonal change, a link to the natural world, and act as centers for species reproduction and the conservation of plants, soil, and water quality.		
Prevent Flooding	UGS provide the absorption of water and purification, soil stabilization, and pollution filtering, with influences varying according to species composition.	
	Urban green areas can assist with adapting to climate change by offering natural flood control and lowering the risk of soil erosion. They help avoid flooding by absorbing rainwater and slowing runoff.	
Reducing Noise Pollution	Urban green spaces in densely populated cities are capable of significantly lowering the levels of noise, based on their amount, quality, and position relative to the source of noise pollution.	
	Green spaces can decrease noise pollution by acting as a buffer between residential areas and busy roadways or industrial zones.	
Social and Psychological Benefits	Health and well-being	Urban green spaces offer a convenient source of relaxation and psychological relief. Having access to green spaces may enhance mental health and well-being while decreasing stress and anxiety
		They also encourage physical activity, lowering the stress levels and reducing the risk of obesity and other diseases. People who had been exposed to natural surroundings noticed a quick decrease in stress, whereas those exposed to the urban environment experienced a high level of stress.
Community building	Urban green spaces offer the space required for children to engage in active play and for adults to be energetic in their spare time.	
	Urban green areas increase social interaction; they can serve as community gathering places, encouraging social cohesiveness and a sense of belonging among individuals, resulting in reduced crime rates and improved self-esteem.	

Benefits	Indicators	Criteria
Economic and Aesthetic Benefits	Cost saving	Developing urban green spaces is a cost-effective strategy for mitigating climatic change impacts.
		UGS can minimize the costs of city maintenance.
		Trees and other plants offer shading and cooling, which reduces the demand for air conditioning and lowers the cost of energy for individuals as well as businesses.
		Green urban landscapes can absorb and filter rainwater, which reduces the demand for costly stormwater management equipment.
	Property value increase	Green infrastructure could raise property values while additionally attracting businesses and tourists, leading to economic growth.
		Green urban spaces, including parks, gardens, and green roofs, can boost property values in the neighbouring areas, resulting in economic benefits for both homeowners and businesses.
		Land developers benefit financially from UGS as they raise property values.
	Job creation	The creation and maintenance of UGS in cities can increase job opportunities in landscaping, maintenance, and environmental education.
	Tourism revenue	Well-designed and maintained green urban spaces can attract tourists, creating revenue for local businesses, and improving the local economy.
	Aesthetic value	Urban green spaces can improve a city's aesthetic appeal, contributing to it being a better place to live, work, and visit.

7. Conclusions

Urban green areas, such as parks, offer significant advantages to communities and should be a priority in urban policy, as they serve numerous purposes in urban settings that improve the quality of life and mitigate climate change.

There are various strategies in which UGS can help in climatic change mitigation. They contribute a significant role in minimizing emissions that contribute to global climate change. Greenings can filter airborne particulate matter (PM), provide oxygen, and contribute to reducing extreme weather conditions that cause the Urban Heat Island Effect, resulting in energy savings and enhancing the urban climatic quality.

Green spaces in cities can help to reduce urban heat island effects. Regarding climatic change, with the predicted increase in temperature, dryness, and intensity of heat waves, UGS have even greater significance, as they may provide a cooling impact extending to the surroundings.

In summary, the Green River is a masterwork that elevates the New Administrative Capital as an outstanding destination for life, business, and recreation. It represents the sense of beauty, peace, and pleasure of green places in urban settings. The Green River's innovative and unique design attracts a variety of marine life and aquatic plants, increasing its environmental and investment importance, giving possibilities for relaxation and leisure activities, as well as locations for residents to socialize and engage. It is a vital asset to the city and its residents, representing the desire for a life balanced between the metropolis and nature that nature, environmental sustainability, and biodiversity.

Finally, the New Administrative Capital's Central Park contributes significantly to ecosystems, providing a variety of alternatives for the well-being of all, reflecting the rich cultural heritage of Egypt, and encouraging physical activities and economic prospects. It highlights the country's art and adaptability, promotes smart city technology, and, most importantly, serves as the New Administrative Capital's vibrating social heart leading to communities' engagement.

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Not Available

CONFLICT OF INTEREST

There is no conflict of interest.

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