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A proposed Model for Measuring the Performance of Smart Public Parks

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ABSTRACT

Public parks are one of the most important uses of land in cities, because they are green spaces that contribute to purifying the urban environment from carbon emissions and air pollution ratios. They also contribute greatly, including their recreational activities, to the psychological and physical satisfaction of their visitors.

Technologies development: a new concept has emerged called smart parks that depend on providing energy, and smart parks are one of the most important components of smart cities in the modern era. The research aim is to produce a model for measuring the performance of smart parks or measure the performance of traditional parks to turn them into smart public parks. The research methodology is based on, inductive approach, by identifying the difference between traditional parks and smart parks, the theoretical foundations for designing smart public parks and the different criteria and foundations that would govern smart parks. Through the research, a deductive approach was followed through an analysis of global and regional models of smart parks, with the aim of extracting and defining performance measurement criteria to integrate them with the consistent design principles of smart parks.

The study set up a proposed model that can be applied to measure the performance of smart parks and the performance of existing traditional parks to support their transformation into smart parks. The model included (8) main criteria, (25) sub criteria, (84) key performance measurement indicators (KPIs). The researcher applied this model to "Al-Azhar Park" and identified indicators that need to be assessed to turn it to a smart park.

Keywords: *smart park; smart governance; key performance measurement indicators (KPIs); smart environment; landscape elements.*

1. Introduction

Parks are an essential part of urban life. Technology is constantly changing and developing with tremendous speed in every aspect of our lives, however it is barely used in designing these green areas that provide humanity with great services.

Public parks are considered the lungs of cities and the barrier that protects them from the factors which are affecting human life. Parks present alot of supports to our life such as cleaning the air, reducing the risks of air pollution, tempering the atmosphere, and mitigating from the sun's heat and providing an atmosphere of moisture, psychological satisfaction of the population hence providing a higher quality of living which helps human to increase the productive capacity of workers .

Public parks differ in terms of area, design principles, and landscape elements according to the different function performed by the park, such as zoos, botanical gardens, picnic parks ... As well as the principles for designing public parks differ according to the environmental aspect of each city, as well as differing from country to another. While we find that Egypt allocates 1 acre / 1000 people in public parks we find that, in return, the United States of America allocate 5 acres / 1000 people in [1]. So, Luskin Innovation Center (UCLA) which seeks to solve environmental challenges launched a new concept for the park called "SMART PARKS". This definition is a new addition to parks that use technology with all its types including; environmental, digital, and materials to obtain values such as; high level of accessibility, community fit, improved standard of health, safety, water, resilience and efficiency in, and operations with high effectiveness and maintenance [2] .

Recently, the concept of smart cities has emerged as one of the modern and promising directions in the planning of urban societies and is governed by many dimensions such as smart governance, smart economy, smart mobility, smart environment, smart living, and most importantly smart people in spite of cultural and civilizational identities that are the basic pillars that are indispensable for any society, so they distinguish it from others.

Problem

The problem is:

- Defining the basic criteria for smart parks and this has resulted in the inability to measure their performance, even though smart parks are one of the most important components of smart cities in the modern era.
- The inability to measure the performance of traditional public parks previously established to turn them into smart parks.

Objectives

The research aims are:

- produce a model for measuring the performance of smart parks based on a set of ruling criteria that include a set of standard indicators, based on the criteria of smart cities .
- evaluate current smart parks and measure the performance of traditional parks to turn them into smart public parks. The research methodology is based on:
  - Inductive approach: By identifying the difference between traditional parks and smart parks, the determinants of public parks, the theoretical foundations for the design of public parks and smart public parks and the different criteria and foundations that would govern smart parks.
  - Deductive approach: by analyzing some of the global and regional experiences of smart parks to extract the criteria and indicators on which the proposed model would be based on.

2. Theoretical Studies

2.1 The difference between traditional public parks and smart parks

The parks are green areas that are included in lands that are designated for recreational functions; that do not contain buildings, have different uses, contain greenery, water and vast lands. On the other hand, the parks can be considered to be an area that include various facilities to spend leisure time, and used as separate shelters such as mobile campsites or simple accommodations to spend hiking time, or amusement areas equipped with various playgrounds or activities. There are regional parks that have areas that are between the urban green areas and national parks, and include rural areas or a forest so that their areas are subject to freedom of organization and aim to preserve natural parks [1].

Smart Parks are defined as parks that use technology to learn and adapt into their socio-physical surroundings as well as being high in accessibility, immune to climate change. They are energy and water efficient, making them more eco-friendly, low maintenance, and aid in promoting the health and safety of communities. Also, technological innovations can increase the park's performance and cut down long-term costs [2].

2.2 The determinants of public parks

2.2.1 Natural determinants

Climatic factors (temperature, wind, amount of rain), the topography of the land on which the park is located, soil quality and availability of water as follows [3]:

- *Climatic factors:* It is one of the most important factors in the success of parks. The lack of suitable climate and environment leads to the unsuccessful cultivation of many plants, that would often succeed in other regions with a suitable climate.
- *Topography:* It affects the design of parks. This effect appears in the style of designing parks and how a human will feel towards the space. The topography can be used to improve the climate of different spaces. However, in this particular environment, surface water drainage remains a problem facing the site's geography.
- *Soil fertility:* It is an important factor for establishing parks, as good fertile soil can cause diversity in cultivating various plants, while the lack of good agricultural soil causes the need to resort to fertilizers of all kinds to improve the properties of the soil in order to become suitable for cultivation, which henceforth will increase construction costs.

2.2.2 Unnatural determinants

It includes all human factors, including social factors, construction costs, periodic maintenance, and the expertise and creativity of the urban designer.

2.3 Governing standards for smart park design

2.3.1 Value criteria for smart parks

There are eight value criteria by which the performance of smart parks can be measured or achieved. These standards can be used to measure the performance of public parks and see their ability to be converted into smart parks or used to measure the performance of smart parks [2]. These criteria have a set of key indicators that dictate the standards. Many of the benefits of the criteria affect and overlap with one another, as shown:

Community fit: A smart park innovatively uses and reverberates its surroundings aspects' of which include; cultural, social, ecological and physical. Parks that are related and integrated into their respective communities can improve and encourage more social interactions and social bonding [4].

Access: Ideally a smart park should be centrally located, well accessible and attractive psychologically to community members. People can only benefit from the presence of parks if they can reach them physically with ease, as access might be constrained because of natural geographic barriers, highways and other man-made infrastructure that can interfere with the easy passage of members to a park [5].

Resilience: A smart park must be able to withstand changes that could result from city development, environmental changes, change in demographic, or other external affecting forces. Parks must be flexible and responsive to any new potential environmental challenges that can vary from increasing temperatures because of global warming to unpredictable rain. Urban parks play an effective role in aiding cities to improve and adapt to climate change.

Water: A smart park uses schemes to sustain and recycle water resources. Parks can also utilize modern infrastructure to treat city wastewater and filter rainwater. The cost of water used in parks; which include irrigation and aquatic features like fountains or splash pads, are one of the most expensive operating costs for many smart parks; hence, water conservation is a vitally important strategy for parks with limited resources [6].

Health: A smart Park increases the ease of performing healthy activities, exercise and encourages the overall wellbeing of a community. Parks play a role in increasing community health by dedicating areas that promote physical activity and improve mental health. Parks are thought of to be therapeutic and result in overall improved wellbeing of community members.

Energy: A smart park uses methods to sustain energy resources and encourages the generation of clean energy. Parks posses the ability to produce their own energy by using conservation technologies such as solar panels. An alternative method that smart parks use clean energy is diminishing the need of air conditioning as parks contain a lot of green and planted areas. This therefore results in the improvement of the quality of air and in the overall environmental conditions.

Operations & Maintenance: Technology is commonly used in Smart Parks to increase the efficiency and ease of operations and maintenance.

Safety: A smart park provides a secure, safe and comfortable environment for members. We can increase the safety of our parks by increasing the use of technology, such as; using security systems that use motion detectors, cameras and employing the use of biometric passwords, improving visibility, and implementing park safety measures including high walls and wired fencing. The Safety criterion is related to the Operations and Maintenance criteria, as it is known that poorly maintained facilities are often perceived as less safe.

To achieve the general criteria for smart parks, digital technologies must be used in each landscape element and inside public spaces designed for activities. Here are some digital technologies and possible applications that can be used as an efficient way to govern and achieve all the value criteria of smart parks.

2.3.2 Digital technologies and application

Capitalizing the park access, safety, programming, operations, and interactions can be achieved by employing the use of digital modern technologies and applications that can obtain, register, and filter data can be used as key information between park managers and visitors.

There are four digital technologies, as shown:

- Wi-Fi allows electronics to connect to the Park's wireless Internet Service. Park visitors utilize it to help plan activities or use it to create and capture digital content such as photos and videos. Visitors can also use it to make calls when cellular networks are not available. This aids in maintaining and ensuring their safety. Park managers can use it to access any park utilities to download, alter or upload data and information.
- Geographic information systems (GIS) employs software to collect, analyze, manipulate, and represent geographical data [7]. It can aid in determining the parking and road availability, and it can also be utilized to observe changes in crime rates at the areas surrounding the park, guaranteeing the safety of all visitors. Managers can also use GIS to oversee weather and topographic information, which makes it easier to choose the most adequate landscaping to combat and reduce climate change. This can be paired with soil fertility measures and atmospheric requirements to manage the optimal use of water efficiently in parks[8].
- Applications softwares (apps) are softwares that can run on electronic devices; most commonly phones, laptops, and tablets. Most of which may not require Internet, however, those that do store user content and preferences as well as retrieving real-time data. This is increasingly useful and meets all smart parks criteria.
- Digital sensors can gather, maintain and transmit information remotely about many factors such as quality of water and air, moisture, light intensity, resource usage, temperature, and motion.

2.3.3 Landscape elements

There are many digital technologies used in landscape elements within smart parks that help to achieve all the value criteria of smart parks., as follows:[2]

Automatic lawn mowers: It is an electric machine, that runs on electricity instead of fuel, does not emit air pollutants. By reducing carbon dioxide emission, it can reduce the need of human maintenance Fig. (1).

Fig. 1 - Automatic lawn mowers

Near-infrared photography: The photos are taken by altering a traditional digital camera using a kit or with a near-infrared camera. Post-processing software is used on photographs to gain insight on the plant's health. This can be used to alert mangers to existing or potential problems in the health of trees, permitting staff to take the necessary measure to prevent trees from falling Fig. (2).

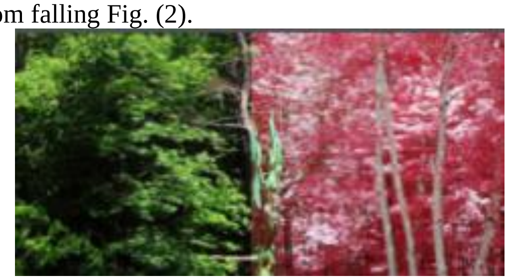

Fig. 2 - Typical photo, left, compared with near-infrared version, right, which can help determine health of trees

Green roofs & walls: It is one of the techniques of modern landscape in smart parks, it is the lightest type and requires the least amount of maintenance and no permanent irrigation system. Green walls may be called substrate-based, as it uses containers of low mass containing soil or other substrates that are still growing joined to the wall and use irrigation and water drainage systems [9] Fig. (3).

Fig. 3 - Green wall

Air-pruning plant containers: Air-pruning plant containers are non-permanent plant holders established to promote the growth of healthy roots, especially during stressful weather or drought events.

Vibrating pollinators: There are battery-operated gadgets that oscillate near in the proximity of the frequency as the wings of pollinators' to encourage plants to produce pollen, so they can be pollinated by human hand Fig. (4).

Fig. 4 - Vibrating pollinators used as a method to develop crop yield for parks with edible gardens

Smart irrigation (Smart water controllers): They are commonly known as timers. They manage patterns for watering digitally and control water usage as irrigation handles about 70% of the freshwater use worldwide.

Smart irrigation (Low-pressure and rotating sprinklers): Moving sprinkler heads ensures 360° coverage for the areas surrounding the sprinkler, while utilizing low-pressure to permit water to penetrate the Earth rather than being carried away by wind [10] Fig. (5).

Fig. 5 – Rotating, Low pressure sprinklers

Smart irrigation (Subsurface drip irrigation- SDI): Despite being used for several decades, newly developed irrigation innovations, such as graywater recycling technology and smart water controllers, have increased their practicality in parks Fig. (6).

Fig. 6 - Subsurface drip irrigation (SDI)

Smart irrigation (Smart water metering): Smart water meters locates areas of high-water consumption, permitting the manager to pinpoint chances to preserve water and prevent water flooding.

Smart irrigation (Graywater recycling): It is the process of recycling wastewater that was used in showers or sinks. The recycled water can contain moderate amounts of nitrogen, phosphorous, and potassium that are necessary minerals for plant health and act as natural fertilizers, hence reducing the need of use artificial fertilizers [11].

Urban furniture and amenities: include structures and furniture's that visitors use in smart parks, such as pedestrian counters, smart benches, automatic bicycle, solar shade structures, digital signs, solar-powered trash compactors, smart water fountains and restroom occupancy sensors Fig. (7).

Fig. 7 - Urban furniture and amenities

Smart lighting: Choice of lighting plays an important role in reducing light pollution, which is the use of excessive artificial lighting that can result in irreversible consequences for wildlife, the climate, and humans. There are five technologies that are used to develop lighting equipment in smart parks.

Smart lighting (Motion-activated sensors), It can be utilized in all areas of the parks to illuminate places in use. Motion sensors can also aid in reducing light pollution by switching the lights off when they are no longer used.

Smart lighting (LEDs and fiber optics as art), LEDs (light emitting diodes) are semi-conductors that produce light when a current run through them. Fiber optics are flexible fibers made of glass or other transparent solids that allow them to transmit light. They are a technological advancement and result in there being safer and more reliable data transmission. This technology can be digitalized and variably warped to create unique visual displays Fig. (8).

Fig. 8 - LEDs and fiber optics as art

Smart lighting (Off-grid light fixtures): They are dependent on the local power grids. They also depend on renewable and green energy generating devices, including solar panels or wind turbines as energy resources. Fig.(9).

Fig. 9 - Digital additions to LED fixtures and off-grid light fixtures

Smart lighting (Digital additions to LED fixtures): These digital technologies can detect and store information about; vehicle traffic, pedestrian, weather, air quality, noise, and light. It helps to improve the internet connectivity. Using digital additions, they can be added to LED fixtures.

Lighting shields: They can be added onto fixtures that already exist in all regions of the park, by placing covers around light sources. This can be an impactful part of a plan to control and decrease light pollution.

2.3.4 Activity spaces

Modelling spaces to utilize technology to meet all the value criteria of smart parks, and establish a designated space for dancing, music, and community interaction that attracts members and may increasingly appeal teenagers. Technologies create activity spaces that are easily accessible, include new materials, design spaces differently, innovative maintenance techniques, equipment designs, and Wi-Fi capabilities. There are six technologies that park managers and designers can utilize to enhance activity spaces, as shown[2] :

Interactive play structures: They are close in structure to orthodox play structures, as they employ digital games system that visitors can interact with virtually. The structures can also gather collect visitor data and are connected to Wi-Fi to allow for wireless management.

High-performance track surfaces: They are rubber running tracks that are resilient to harsh weather composed of two layers to ensure efficient traction and absorption of shocks. These tracks are considered high performance hence they can increase athlete's performance, are easier on critical joints, and attracts more park visitors and encourage physical activity.

Pool ozonation: It is a technique for water filtration with two processes: ozone generation and ozone management. Ozone generation builds ozone particles in water that eradicates organic and inorganic substances and sanitizes water in a method that acts like chlorine, however, without the negative health effects of eye and skin irritation that come from using Chlorine[12].

Energy-generating exercise equipment: The equipment, used similar to machines generally found in gyms, these machines are present both indoors and outdoors. Outdoor exercise equipment are intentionally designed for their low maintenance and durability. Also, these machines have benefits that make them superior to normal gym equipment, which is that they are capable of turning the person’s kinetic energy to chemical energy and potential energy that can be later on used as a clean source of energy.

Outdoor DJ booths: Outdoor DJ booths are stands that are used to manipulate and amplify music and randomized beats from laptops and phones. These booths could be energized by clean resources.

Hard-surface testing equipment: Hard-surface testing equipment is a practical way to evaluate the measure of safety on hard surfaces under playgrounds instead of using “eyeball tests” to assess surfaces as we do normally. Hard-surface testing equipment uses digital sensors to replicate the force that would be exerted by a child’s head to provide quickly accessible and realistic data on the velocity, impact, and likelihood for head injury. This can used to diminish the chance of child injuries while playing and improving the overall safety.

3. ANALYTICAL STUDIES

Through the comparative analytical study, an analysis is conducted on some of the most innovative smart parks in the world both globally and regionally to extract suitable criteria for measuring the performance of smart parks based on what was reviewed in the theoretical study, and what was actually applied in the implementation of these smart parks. These gardens are “Gardens by the Bay” Singapore, “Haidian park” China, “Sky garden” London, “AL Mamzar Park” The United Arab Emirates, “AL Janbiyah Eco-Environmental Garden” Bahrain and “ Dubai Miracle Garden” The United Arab Emirates.

3.1 Global parks

3.1.1 “Gardens by the Bay” Singapore

It is a nature reserve extending over 100 hectares (250 acres) of reclaimed land in downtown Singapore. It consists of three waterfront gardens: Southern Gulf Park, East Gulf Park and Central Gulf Park. The largest of these parks is the Southern Gulf Park, which occupies an area of 54 hectares. The Gulf Gardens are part of the Singapore government's strategy to transform Singapore from a garden city into a city in a park. The innovative services that the park includes:

Save energy: It includes specially selected glass panels that minimize solar heat gain, and a cooling process that dehumidifies the air using a liquid desiccant system to save the energy used. This method of energy conservation is an efficient technology that results in up to 30 percent of electricity savings .

Sustainable energy: The garden's dependency on the power grid is also reduced through the great usage of solar panels installed on some of its tower-like super tree structures. The gardens themselves generate up to 8 percent of its electricity need [13] .

Fig. 10 - flower dome

Smart environment: Gardens by the Bay use the base principles of environmental sustainability. A Lot of effort was put into planning and designing for sustainable cycles in water and energy.

Smart water: The lake involves key ecological processes and functions such as a living system. It also acts as natural filtration for the extra water from the Gardens and supplies aquatic habitats that encourage biodiversity such as fishes and dragonflies.

Smart irrigation: The excess water from within the Gardens is collected by the inner lake system and filtered by using aquatic plants before being discharged into the reservoir. Naturally, the treated water from the lake system is also utilized in the built-in irrigation system.

Smart planting / Save energy: The air in Flower Dome is de-humidified by liquid desiccant (drying agent) before it is cooled. This is done to reduce the amount of energy required in the cooling process [14]. Also, this desiccant is recycled using the waste heat from the burning of the biomass Fig. (10)

Smart Maintenance an aquatic ecosystem: Habitats for aquatic animals are created within the lake's system by maintaining the diversity of aquatic plants, proper water circulation, and aeration. This ensures that current and possible problems are on the park's radar such as mosquito breeding Fig. (11).

Fig. 11 - garden's lake

Conclusions: The value criteria applied in "Gardens by the Bay" Singapore and its indicators include

- *Smart environment:* considered an example of sustainable environment projects. And it works to generate vital energy and produce clean energy.
- *Smart governance:* by generating electricity from special solar panel, as well as the fact that all maintenance is immediately uploaded to the park's database.
- *Smart agriculture:* Equipped with an integrated system that allows it to reuse rainwater after storing it, and using treated water.

3.1.2 "Haidian park" China

Haidian Park has become one of the country's foremost technologically advanced communities. The parks history traces to its close proximity to China's most prestigious technology universities and research institutions [15]. The innovative services that the park includes:

Smart mobility: The park has autonomous shuttle buses, smart walkways tracking people's steps using facial recognition. The park has a digital leaderboard of sorts. It is part of an 'intelligent' jogging track that runs along the park. Stand in front of the board, get your picture taken, sync with your phone, and run on the track. Cameras will scan the run and record details of your run at the end of a lap that will be displayed .

Smart lighting/Smart facilities: Smart lamp posts that can record data, and intelligent pavilions equipped with a conversational assistant between visitors.

Smart environment: The park has virtual reality gear, a walking, talking robot which looks a Star Wars character, and more screens to entertain the visitors or be used as a mean of amusement.

Part of smart city/ Smart technology: The park came after the government's decision to build a "smart city", which welcomed about 1.2 million tourists during the previous year. After running the pilot program, the park is trying to upgrade in order to make life easier and more luxurious through applications of artificial intelligence.

Digital technologies and application: Geographic information systems (GIS) uses digital software to gather, store, analyze, manipulate and present geographical data by assessing roads and parking availability. The park uses its electronic sensors to capture, collect, and remotely transmit information.

Smart sounds: When a visitor inquiries about anything, artificial intelligence devices will answer, which helps promote the visitors to inquire about information, service life, travel conditions, and the acquisition of information and other functions Fig. (12).

Fig. 12 - digital technologies and application

Conclusions: The Value criteria applied in "Haidian park" China and its indicators include

- *Smart mobility:* By using autonomous shuttle buses and smart walkways tracking people's steps using facial recognition.
- *Smart environment:* It is designed to be part of a smart city. It is also using different applications of artificial intelligence to help aid the visitors and answer all their inquiries, as well as being a somewhat form of entertainment for them.
- *Smart Governance:* Take full control of the audio and video surveillance of the park and help visitors to gain information about various roads to hike using its internet database.

3.1.3 "Sky garden" London

Sky Garden is London's most elevated public garden, a social space with 360-degree views of the city's iconic skyline. A park inside a skyscraper in the British capital, London. Although it is a biomass of green trees on the 34th to 37th floors of the building, these floors are equipped to be a smart garden by using noise control systems Fig. (13). Many of its innovative features include:

Smart planting: It controls the air quality of the atmosphere of the crops, to ensure the ideal conditions for the plant to grow and produce the greatest yield. It is also home to drought-resistant flowering plants .

Smart energy and smart governance: The park uses several renewable energy technologies that produce energy that doesn't produce carbon emissions and focuses on producing clean energy that doesn't pollute the environment .

Smart maintenance: By maintaining a good indoor garden all year-round using plant sensors and their vital functions, to monitor for any existing or potential diseases that could affect the plants health.

Fig. 13 - Sky garden "London"

3.2 Regional parks

3.2.1"AL Mamzar Park" The United Arab Emirates

Al Mamzar Park is located on the banks of the Gulf on the western side of the beaches of Dubai and the beaches of the park adjacent to the shores of the Emirate of Sharjah. It covers an area of 99 hectares. The park includes many innovative services such as:

Smart Bands: Waterproof smart watch with GPS are provided to help families track their children inside the park[16]. Fig. (14)

Fig. 14 - Smart band

Smart Oasis: It has two smart oasis hubs by the beach to provide shade and a system to harvest humid air and convert it into drinking water by using solar power. The Smart Oasis can produce 90 m^3 of drinking water every day. It also provides a charging area for phones and using tracking technology caretakers can track the phones to ensure their safety Fig. (15).

Fig. 15 - Smart Oasis

Smart Scanning: Used to monitor trees and plants. Classification of plants and detection of potential and underlying diseases and illness using thermal maps, aerial imagery analysis, and ratios of carbon emission. Fig. (16).

Fig. 16 - Smart drones

Smart Containers: Send out alerts when the container is full, so that someone can clear it .

Smart Rescue: The municipality has lately instituted a smart rescue system that uses drones that deploy lifebuoy rings to protect swimmers from drowning in the Gulf.

Smart Bands, Benches: More than 10 solar-powered smart benches give out free Wi-Fi as well as remote charging services for phones. The way to use this piece of modern technology is to simply place it on the bench.

Smart Palms: They provide free Wi-Fi and charging stations are also already available in the park which are considered part of the advancement of digital technology .

Telephone app.: Park members can utilize the app to go on a virtual tour of the park facilities, and rent their favorite chalet, grill area, and sports areas before physically going there. There is also a new virtual learning center in the park that provides both fun and a good learning experience simultaneously.

Virtual reality experience: The experience of planting vegetables and fruit trees for children is provided, while teaching them about the environment as well.

Smart paints: The amphitheater area has been coated with smart paint that decrease air pollution by intaking carbon dioxide.

Conclusions: The value criteria applied in AL Mamzar Park and its indicators include

- *Smart individuals:* Using the smart bracelet service, it is a way that allows parents to track the movements of their children.
- *Smart rescue:* which works to save the visitors from drowning with a drone.
- *Smart facilities:* to allow visitors to charge their devices electronically from smart seats inside the park. And including solar powered seats and lighting poles.
- *Smart Environment:* By serving the smart board, it transforms the humidity of the atmosphere into fresh water.
- *Smart Governance:* Through the smart scanning service that you it uses to create a database and detect diseases, classify plants, and carbon emission ratios.

3.2.2 “AL Janbiyah Eco-Environmental Garden”

AL Janbiyah Eco-Environmental Garden is the first park in the Kingdom of Bahrain to be completely powered by renewable energy; using solely solar and wind energy. It is considered a turning point for the development of the rest of the parks in the Kingdom. The park includes many innovative features including:

Clean energy: By using solar panels and energy generating fans to operate the park in order to reduce pressure on the government grid system hence reducing the amount of non-renewable energy used. The garden contains 23 panels for solar energy at a rate of 250 watts and contains two fans to generate electricity from wind at a rate of 150 watts from each fan, this produces sufficient energy to run the parks [17] .

Smart lighting: Reduces lighting consumption of electricity by replacing traditional high-energy lighting with low efficiency with low-consumption lamps (LEDs) that have a much higher efficiency and longevity and achieving significant electricity savings by up to 64 % and reduces the costs .

Smart planting& smart environment: It uses waste recycling, which includes the usage of organic garden waste resulting from cutting and pruning crops, in addition to food waste from visitors and turns them into organic agricultural fertilizers, which contributes to the disposal of waste and the provision of fertilizers while maintaining a low cost.

Smart Maintenance: It sends all its waste to recycling factories, to renew the usage of the waste resources.

Cultural identity: As this element includes the recycling and the usage of large agricultural wastes and is used in the execution different forms of garden furniture or shaded places inspired by the Bahraini heritage (wooden artwork) Fig. (17).

Smart facilities: By adding specified seats and pedestrian path for visitors with special needs. It also has smart seats that allow for the wireless charging of the visitors phones, so long as they are seated on them.

Smart spaces: The park contains free Wi-Fi for visitors inside all the different areas of the garden.

Fig. 17 - AL Janbiyah Eco-Environmental Garden

Conclusions: The value criteria applied in AL Janbiyah Eco-Environmental Garden and its indicators include

- *Smart facilities:* To allow visitors to charge their devices electronically from smart seats inside the park.
- *Smart environment:* By providing an environment with suitable technology that works with clean renewable energy.
- *Smart Governance & maintenance:* By sending all kinds of waste to recycling factories, and the entire facility is controlled and monitored through the Internet.
- *Smart agriculture:* By recycling agricultural residues and wastes to form organic agricultural fertilizers.

3.2.3 "Dubai Miracle Garden"The United Arab Emirates

The garden was launched on Valentine's Day in 2013. The garden occupies over 72,000 square meters [18], making it the world's largest natural flower garden featuring over 50 million flowers. Dubai Miracle Garden was then carried out and completed by Akar Landscaping and Agriculture Company at a cost of around $11 million (AED 40 million) Fig.(18) .

Fig. 18 - Flower clock "15 meters high"

The innovative services that the park include :

Smart irrigation (Graywater recycling): Dubai has no sewer system. The water is then cleaned and processed. Dubai municipality retreats the grey water of the city and sends it directly to the garden. The garden again re-filters the water and converts it to a very high-quality water for its usage at the garden .

Smart irrigation (Smart water metering): Smart water meters identify areas of high-water consumption, and evenly regulates the usage of the water , as the plants are only watered after the closing hours at night.

Smart environment: It is the first in the region to open an indoor butterfly garden and sanctuary that houses over 15,000 butterflies, therefore making it the world's largest butterfly garden.

Green roofs & walls: It is one of the techniques of modern landscape in smart parks. As part of a licensing deal between the Dubai Miracle Garden and The Walt Disney Company, a topiary of Mickey Mouse was unveiled in 2018 [19]. The Dubai Miracle garden was also declared as the world's largest vertical garden, leading the green walls development notion. Currently, an Airbus A380 flower structure in the garden is listed by Guinness World Records as the biggest flower structure in the world Fig. (19,20).

Fig. 19 - Mickey Mouse anthropomorphic

Fig. 20 - The model of the Emirates Airbus A380

Conclusions: The value criteria applied in Dubai Miracle Garden and its indicators include

- *Smart irrigation:* using gray water to irrigate the garden completely after it closes its doors in the evening.
- *Smart planting:* Through the work of vertical Agriculture work models of Disney and Airbus aircraft have been made.
- *Smart environment:* Has the world's largest indoor butterfly garden and sanctuary.

3.3 The criteria and indicators that were derived from the analysis of smart gardens both globally and regionally

Through the analysis of several gardens both regionally and regionally, we have acquired a criteria that is considered to be the foundation for evaluating smart parks, also detecting several characteristics that are present and used as the indicators for that criteria, Table (1).

Table 1- The criteria and indicators that were derived from the analysis of smart gardens

Criteria	Indicators
Smart planting	Automatic irrigation, smart devices, automatic lawn tractors, interaction with rainwater, follow up the needs of plant growth and Weather prediction.
Smart governance	Using smart devices (free Wi-Fi - using the Internet), geographical Information System (GIS), Carbon emission ratios and intelligent scanning techniques by classifying plants, detecting diseases, trees and extracting vital indicators.
Smart environment	Clean energy production, interaction with rainwater, dependency on clean energy to run the park and reduce material consumption, weather forecast, control the internal and external environment and Carbon emissions control.
Smart people	Convert the movement to energy, free use of Wi-Fi and securing individuals with a smart bracelet.
Smart maintenance	Intelligent maintenance control units, confronting risks, crises, and disasters, improved operating efficiencies, fire alarm systems and intelligent scanning techniques.
Intelligent mobility	Services for people with special needs, traffic and walking paths and smart parking.
Smart control and living	Smart robots and artificial intelligence used for aiding and helping visitors. As well as the usage of internet-based databases and uploading data to manage the park and smart spaces for activities.
We can add another criteria according to the culture and heritage identity of communities	
Cultural, Civilizational and heritage identity	Historical, Heritage, Functional reference, Social- economic Significance and mental image (paths, districts, nodes, landmarks, edges).

4. Dissections and Results

Using smart park criteria and indicators, we will propose a model for measuring the performance of smart public parks and measuring the performance of traditional parks and their potential to be turned into smart public parks .

The calculation of the relative weight of each component of the Key Performance Indicators (KPIs) is done by calculating the indicator achievements in each of the applied study parks and awarding (0) which represents [non-verification< 50%], and (1) which represents [verification > 50%], for each KPI the repetition was calculated by adding the score achieved in all parks. The weighing % was then estimated by dividing the total score of each KPI on the total repetition for all KPIs, Table (2).

Applying the proposed model with its main criteria and performance indicators on Al-Azhar Park in Cairo. By monitoring and summing the relative weights of all KPIs, the performance of Al-Azhar Park as a traditional public park was evaluated. On the other hand, identifying indicators that need to be assessed to turn it into a smart park was concluded, Table (3).

5. Conclusions

- Through the theoretical and analytical study of the research, the researcher prepared a proposed model for measuring or evaluating the performance of smart parks, the model included (8) main criteria, (25) sub criteria, (84) key performance indicators (KPIs).

- The relative weight of each indicator was determined through the analytical studies carried out on six global and regional parks, which totaled to a 100%.

- The proposed model was also applied to Al-Azhar Park, Cairo, to measure its performance as a public park and it was found that it achieves only about 50% of the criteria and indicators of smart parks. The deficiencies could be identified through indicators in which the park scored 0, and therefore these indicators are evaluated and improved using the smart governance to improve the performance of this park and turn it into a smart park.

-The criteria of smart Government, Smart Environment, Smart Maintenance and Smart living are the least relative weights in all criteria because of decreases in the use of smart system or applications in open space or parks in Egypt. Although the criteria of smart people achieved relative weight 8.14% (more than 50% of standard relative weight in the original model).

Table (2) Reference frame for smart public parks and the relative weight of Key Performance Indicators (KPIs)

Main Criteria	Sub-Criteria	Key Performance Indicators (KPIs)	Regional& Global parks						Repetition	Weighting, %
			" AL Mamzar Park" The United Arab Emirates	" AL Janbiyah Eco-Environ. Garden" Bahrain	" Dubai Miracle Garden" The UAE	" Gardens by the Bay" Singapore	" Haidian park" China	Sky garden" London"		
C1. Smart Agriculture	C1-1 Landscape (SOFTSCAPE)	Automatic lawn mowers	1	0	1	1	1	0	4	1.12
		Near-infrared photography	1	0	1	1	1	0	4	1.12
		Green roofs & walls	0	0	1	0	1	1	3	0.84
		Air-pruning plant containers	0	0	1	1	1	0	3	0.84
		Vibrating pollinators	0	0	0	1	1	0	2	0.56
	C1-2 Irrigation	Smart water controllers	1	1	1	1	1	1	6	1.69
		Low-pressure and rotating	1	1	1	1	1	1	6	1.69
		Subsurface drip irrigation- SDI	1	1	1	1	1	1	6	1.69
		Smart water metering	1	1	1	1	1	1	6	1.69
		Graywater recycling	0	0	1	1	0	0	2	0.56
								Total	42	11.8
C2. Smart Governance	C2-1 Digitalis	WI-FI	1	1	1	1	1	1	6	1.69
		Geographic Information system	1	0	1	0	1	0	3	0.84
		Application software	1	0	1	1	1	1	5	1.40
		Digital sensors	0	0	1	1	1	0	3	0.84
	C2-2: Smart Control	Underground rainwater storage basins	0	0	1	1	0	0	2	0.56
		Soil programming and sensitivity	1	0	1	1	0	0	3	0.84
	C2-3: Smart Management	Smart reservation	1	0	1	1	1	0	4	1.12
		Electronic payment	1	0	1	1	1	0	4	1.12
		Intelligent management system	1	0	1	1	1	1	5	1.40
								Total	35	9.81
C3. Smart Environment	C3-1: Controlling Interior and Exterior Environment	Clean energy production	1	0	1	1	1	1	5	1.40
		Weather prediction	0	0	1	1	1	1	4	1.12
		Carbon emissions control	1	0	1	0	1	1	4	1.12
		Convert movement into energy	0	0	0	0	1	0	1	0.28
	C3-2: Smart Lighting	Motion activated lights	1	0	1	0	0	0	2	0.56
		LEDs and fiber optics as art	1	1	1	1	0	0	4	1.12
		Off-grid light fixtures	1	0	1	1	1	0	4	1.12
		Digital additions to LED fixtures	0	0	1	0	1	0	2	0.56
		Lighting shield	0	0	1	1	0	0	2	0.56
	C3-3: Ecological Resources Management	Individual efforts to protect the environment	0	1	1	1	1	1	5	1.40
		Different opinions about environmental protection	1	1	0	0	1	1	4	1.12
	C3-4: Sustainable Resources Management	Actual water consumption /relative consumption to GDP	0	0	1	1	1	1	4	1.12
		Electricity consumption /relative consumption to GDP	1	1	1	1	1	1	6	1.69
								Total	47	13.17
C4. Smart People	C4-1 Visitors qualification Level	Educational level (medium / high)	1	0	1	1	1	1	5	1.40
		Language skills	1	1	1	1	1	1	5	1.40
	C4-2: Lifelong Learning	Cognitive perception	1	0	1	0	0	1	3	0.84
		Continuous education	1	0	1	1	1	1	5	1.40
		Cultural awareness	1	1	1	1	1	1	6	1.69
	C4-3: Ethnic Plurality	Foreign visitors	1	1	1	1	1	0	5	1.40
		Visitors (citizens residing abroad)	0	0	0	1	1	0	2	0.56
		Local visitors	1	1	1	1	1	1	6	1.69
	C4-4: Open Mindedness	Adopting new ideas	1	1	1	1	1	1	6	1.69
		Contributing to volunteer work	1	0	1	0	1	1	4	1.12
		Community participation	1	1	1	1	1	1	6	1.69
								Total	53	14.88

Table (2- continued) Reference frame for smart public parks and the relative weight of Key Performance Indicators

C5: Smart Maintenance	C5-1 Malfunctions and Handling	Smart controllers	1	0	1	1	1	1	5	1.40
		Confronting risks and disasters	1	1	1	1	1	0	5	1.40
		Early detection and malfunction	1	0	1	1	1	1	5	1.40
		Fire alarm systems	1	1	1	1	1	1	6	1.69
	C5-2 Efficiency Improving	Periodic maintenance	1	1	1	1	1	1	6	1.69
		Visitors safety insurance	1	0	1	1	1	0	4	1.12
								Total	31	8.7
C6: Smart Mobility	C6-1 Special Needs Services	Movement	1	1	1	1	1	1	6	1.69
		Hearing	1	0	1	1	1	1	5	1.40
		Seeing	1	0	1	1	1	1	5	1.40
	C6-2 Signs	Paths	1	1	1	1	1	1	6	1.69
		Signs	1	1	1	1	1	1	6	1.69
	C6-3 Smart Parking	Cars	1	0	1	0	0	0	2	0.56
		Bicycles	1	0	1	1	1	0	4	1.12
	C6-4 Accessibility	Visitor satisfaction with accessibility	1	1	1	1	1	0	5	1.40
		Visitor satisfaction from park location	1	1	1	1	1	1	6	1.69
	C6-5 IT- Infrastructure	Availability of computers at home	1	1	1	1	1	1	6	1.69
		Availability of broadband home internet	1	1	1	1	1	1	6	1.69
	C6-6 Sustainability of the transport system	Safety traffic	1	1	1	1	1	1	6	1.69
		Use economical cars	0	0	0	1	1	0	2	0.56
								Total	65	18.27
C7: Smart Living	C7-1 Smart facilities	Smart benches	1	0	1	1	1	0	4	1.12
		Solar shade structures	1	1	1	1	1	1	6	1.69
		Solar -powered trash compactors	1	0	1	0	1	0	3	0.84
		Restroom occupancy sensors	1	0	1	1	1	1	5	1.40
		Smart water fountain	1	0	1	1	1	0	4	1.12
		Digital signs	1	0	1	1	1	0	4	1.12
		Automatic bicycle dispensers	0	0	1	0	1	0	2	0.56
		Pedestrian counters	0	0	1	0	1	0	2	0.56
	C7-2 Activity spaces	Interactive play structures	1	1	1	1	1	0	5	1.40
		High performance track surfaces	0	0	1	1	1	0	4	1.12
		Pool ozonation	0	0	0	1	0	0	1	0.28
		Energy generating exercise equipment	0	0	0	1	1	0	2	0.56
		Outdoor DJ booths	0	0	1	0	0	1	2	0.56
		Hard surface testing equipment	0	0	1	0	1	0	2	0.56
								Total	46	12.98
C8: Cultural, Civilizational and heritage identity	C8-1 Cultural Identity	Historical / heritage / functional reference	0	1	0	1	0	0	2	0.56
		Political / social / economic significance	1	0	1	1	1	1	5	1.40
		Civilized features	1	1	1	1	1	1	6	1.69
	C8-2 Mental Image	Landmarks	1	0	1	1	1	0	4	1.12
		Paths	1	1	1	1	1	0	5	1.40
		Edges	1	0	1	1	1	1	5	1.40
		Nodes	1	1	1	1	1	0	5	1.40
		Districts	1	1	1	1	1	0	5	1.40
								Total	37	10.37
								Total of the eight Criteria	356	100

Table (3) Application of the proposed model for assessing smart parks on Al-Azhar Park in Cairo.

A Proposed Model for Measuring the Performance of Smart Public Park						
Main Criteria	Sub-Criteria	Key Performance Indicators (KPIs)	Weighting, %	Evaluation, %	Assessment	Sub-Total, %
C1. Smart Agriculture	C1-1 Landscape (SOFTSCAPE)	Automatic lawn mowers	1.12	1.12		
		Near-infrared photography	1.12	0	○	
		Green roofs & walls	0.84	0	○	
		Air-pruning plant containers	0.84	0	○	
		Vibrating pollinators	0.56	0	○	1.12
	C1-2 Irrigation	Smart water controllers	1.69	1.69	•	
		Low-pressure and rotating	1.69	1.69	•	
		Subsurface drip irrigation- SDI	1.69	1.69	•	
		Smart water metering	1.69	0	○	
		Graywater recycling	0.56	0	○	5.07
					Total	6.19
C2. Smart Governance	C2-1 Digitalis	WI-FI	1.69	0	○	
		Geographic information system (GIS)	0.84	0	○	
		Application software	1.40	0	○	
		Digital sensors	0.84	0.84	•	0.84
	C2-2 Smart Control	Underground rainwater storage basins	0.56	0	○	
		Soil programming and sensitivity	0.84	0	○	0
	C2-3 Smart Management	Smart reservation	1.12	0	○	
		Electronic payment	1.12	1.12	•	
		Intelligent management systems	1.40	0	○	1.12
					Total	1.96
C3 Smart Environment	C3-1 Controlling Interior and Exterior Environment	Clean energy production	1.40	0	○	
		Weather prediction	1.12	0	○	
		Carbon emissions control	1.12	0	○	
		Convert movement into energy	0.28	0	○	0
	C3-2 Smart Lighting	Motion activated lights	0.56	0	○	
		LEDs and fiber optics as art	1.12	0	○	
		Off-grid light fixtures	1.12	0	○	
		Digital additions to LED fixtures	0.56	0.56	•	
		Lighting shield	0.56	0.56	•	1.12
	C3-3: Ecological Resources Management	Individual efforts to protect the environment	1.40	0	○	
		Different opinions about environmental protection	1.12	0	○	0
	C3-4: Sustainable Resources Management	Actual water consumption /relative consumption to GDP	1.12	1.12	•	
		Electricity consumption /relative consumption to GDP	1.69	1.69	•	2.81
					Total	3.93
C4 Smart People	C4-1: Visitors qualification Level	Educational level (medium / high)	1.40	1.40	•	
		Language skills	1.40	1.40	•	2.80
	C4-2 Lifelong Learning	Cognitive perception	0.84	0	○	
		Continuous education	1.40	0	○	
		Cultural awareness	1.69	1.69	•	1.69
	C4-3 Ethnic Plurality	Foreign visitors	1.40	1.40	•	
		Visitors (citizens residing abroad)	0.56	0.56	•	
		Local visitors	1.69	1.69	•	3.65
	C4-4 Open Mindedness	Adopting new ideas	1.69	0	○	
		Contributing to volunteer work	1.12	0	○	
		Community participation	1.69	0	○	0
					Total	8.14

Table (3- continued) Application of the proposed model for assessing smart parks on Al-Azhar Park in Cairo

C5 Smart Maintenance	C5-1 Malfunctions and Handling	Smart controllers	1.40	0	○	1.69
		Confronting risks and disasters	1.40	0	○	
		Early detection and malfunction	1.40	0	○	
		Fire alarm systems	1.69	1.69	•	
	C5-2 Efficiency Improving	Periodic maintenance	1.69	0	○	1.12
		Visitors safety insurance	1.12	1.12	•	
					Total	2.81
C6 Smart Mobility	C6-1 Special Needs Services	Movement	1.69	1.69	•	1.69
		Hearing	1.40	0	○	
		Seeing	1.40	0	○	
	C6-2 Signs	Paths	1.69	1.69	•	3.38
		Signs	1.69	1.69	•	
	C6-3 Smart Parking	Cars	0.56	0	○	0
		Bicycles	1.12	0	○	
	C6-4 Accessibility	Visitor satisfaction with accessibility	1.40	1.40	•	3.09
		Visitor satisfaction from park location	1.69	1.69	•	
	C6-5 IT- Infrastructure	Availability of computers at home	1.69	1.69	•	1.69
		Availability of broadband internet in homes	1.69	0	○	
	C6-6: Sustainability of the transport system	Safety traffic	1.69	1.69	•	1.69
		Use economical cars	0.56	0	○	
					Total	11.54
C7 Smart Living	C7-1 Smart facilities	Smart benches	1.12	0	○	4.21
		Solar shade structures	1.69	1.69	•	
		Solar -powered trash compactors	0.84	0	○	
		Restroom occupancy sensors	1.40	1.40	•	
		Smart water fountain	1.12	0	○	
		Digital signs	1.12	1.12	•	
		Automatic bicycle dispensers	0.56	0	○	
		Pedestrian counters	0.56	0	○	
	C7-2 Activity spaces	Interactive play structures	1.40	0	○	0.56
		High performance track surfaces	1.12	0	○	
		Pool ozonation	0.28	0	○	
		Energy generating exercise equipment	0.56	0	○	
		Outdoor DJ booths	0.56	0.56	•	
		Hard surface testing equipment	0.56	0	○	
					Total	4.77
C8 Cultural, Civilizational and heritage identity	C8-1 Cultural Identity	Historical / heritage / functional reference	0.56	0.56	•	3.65
		Political / social / economic significance	1.40	1.40	•	
		Civilized features	1.69	1.69	•	
	C8-2 Mental Image	Landmarks	1.12	1.12	•	6.72
		Paths	1.40	1.40	•	
		Edges	1.40	1.40	•	
		Nodes	1.40	1.40	•	
		districts	1.40	1.40	•	
					Total	10.37
					Total of the eight Criteria	49.71
The indicator was not achieved inside the garden, the indicator needed to be assessed					○	
The indicator was achieved inside the garden					•	

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