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Climate Change and its Impact on the Green Space, Baghdad City

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Abstract

The impact of climate change on modern cities has become a reality and represents one of the greatest environmental challenges facing modern cities and humanity in the current century through a rapid rise in temperature rates. With the rapid change of the urban area in the world's cities, smart green urban spaces have been fragmented, causing weakness, the deterioration and dysfunction of these urban elements. Therefore, the research problem is the lack of comprehensiveness of the available knowledge about the potential of smart green urban spaces in controlling environmental challenges in modern cities. The research aims to provide knowledge about the important factors related to environmental challenges, identify their impact, and the percentage of impact on smart green urban spaces. Due to the use of artificial intelligence in many fields, including education, medicine, scientific discoveries, industry, energy, environment, robotics, and others so There must be a role in finding solutions or addressing environmental challenges, so the research hypothesis is that artificial intelligence plays an important role in designing and managing smart green urban spaces and addressing environmental challenges in modern cities.

Keywords: *Smart Green Urban Spaces, Environmental Challenges, Artificial Intelligence (AI)*.

Introduction

Sim and Miller's study (2019) addressed the strengths and weaknesses of using big data analytics in park planning and design. By knowing, what activities park users want and the satisfaction of users with various activities?, While the study of Kamani and Paydar (2023) confirms that pathway design features in urban parks are vital in facilitating leisure walking and main-taining a minimal rate of physical activity, hence enhancing public health. Addas, (2023) Urban green spaces (UGSs) are becoming more and more popular in the current day when it comes to the development of smart cities (SCs). Although UGSs are now few, their significance in improving health and life expectancy has grown. The Sjöman2022 the increasing use of smart technology in urban green space management. The application of smart technologies typically includes multiple sensors, smartphones, internet connections, etc., working together to make green space management more inclusive and effective, Nabil2022 discussed monitoring the impact of using smart technologies in designing public parks and studying the impact of using smart technologies in public parks as the most important element in the urbanization system, as it works to improve the environment, health and safety and helps in psychological stability for people, which confirms the quality of life.

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Previous studies	Results	Lack of knowledge
Sim, J., & Miller, P. (2019)	The results from social media analytics found notable things such as positive tweets about how the railway was turned into a park, and negative tweets about diseases that may occur in the park. Therefore, a survey as traditional data and social media analytics as big data can be complementary methods for the design and planning process.	The research did not address the sustainability characteristics of green spaces and did not address countries' experiences in managing green spaces
Kamani Fard, A., Paydar, M., & Gárate Navarrete, V. (2023).	Ideas can be used by urban planners and designers in the future planning of urban parks in this area. The design characteristics of urban parks' pathways are important in facilitating leisure walking and maintaining the minimum rate of physical activity, thus improving public health. This study examined and explored the relationships between design characteristics as well as certain visual qualities of Cautin Park, the biggest urban park in the Araucanian Region of Chile, and the tendency for walking as well as walking behavior.	Attention to sustainable urban development concepts only and did not address the fields of horticulture and agriculture
Vukovic, N., & Mingaleva, Z. (2023).	The research results confirm that the sensory gardens are a prospective form of urban green zones for citizens, and they are interested in the development of its multisensory concept. According to survey results, the zones of smells and colors in the sensory garden were the most attractive for the respondents. The respondents agreed that the main function of sensory gardens is anti-stress therapy for adults.	It did not address modern systems for dealing with sensory gardens using artificial intelligence.
Addas, A. (2023).	The current study identified the extent of UGS activities in various areas of Graz, Austria, in accordance with World Health Organization (WHO) criteria, and it offers suggestions for enhancing the caliber of future UGS planning. Even in locations with limited area, the suggested study findings indicate that UGS is a viable substitute for improving air quality, resulting in quantifiable and significant reductions in air pollution.	Support new smart applications in smart cities, such as district-level energy and water supply management
Sjöman, J. D., Kristoffersson, A.,	Sustainable Smart Parks (initiated 2008) aims to create an open and innovative arena	The need for smart urban flexibility in

Mercado, G., & Randrup, T. B. (2022).	for the development of future smart green spaces, increase the recreational value of urban green space, and support a sustainable approach to minimize negative environmental impacts in green space management and maintenance.	designing green spaces to cope with unexpected natural disasters
Du, M., & Zhang, X. (2020).	The creation of many little green spaces that are "affordable and accessible" across the city is suggested to be a more suitable policy goal than a few large parks, and it is suggested that spatial patterns of land use may represent a step towards diverse elements of sustainability. It is stated that such a policy approach would create a "win-win" scenario by concurrently promoting social justice and economic development in the context of sustainability. Additionally, this study demonstrated to institutionally driven nations like China how to benefit from Western knowledge on the design of land use patterns that are sustainable for people.	The study did not address the relationship of green spaces to smart urban and the evolution of smart space concepts in climate changes.
Dash, B., & Sharma, P. (2022).	Research by the McKinsey Global Institute found that using artificial intelligence in smart cities would help reduce emissions by 15 percent, reduce water consumption by 30 percent, and reduce average commute time by 20 percent, to make cities more sustainable.	The study did not address how artificial intelligence is used to reduce environmental challenges on the smart green urban spaces of contemporary cities
Nabil Ashry Elnahas, A., & Aziz Botros, M. (2022).	Research has been able to analyze the pros and cons of using smart technologies by analyzing six key elements of landscape, irrigation, furniture, urban facilities, activity spaces, lighting and digital technologies. The research concluded that the use of smart technologies was an imperative and a positive element. The research also concluded that the points had a positive impact and represented 82%.	The study did not address the sustainability of AI software in the management of smart green urban spaces in cities and the possibility of using methods to limit the impact of climate change on urban spaces exclusively.

Table 1. Summary of Previous Literature

1. **Research problem:** Lack of inclusiveness of available knowledge about the potential of smart green urban spaces in controlling environmental challenges in contemporary cities.

2. **Aim: -** To provide knowledge on the most important factors related to environmental

challenges and to determine their impact and the proportion of impact on smart green urban spaces.

3. **Hypothesis:** Artificial intelligence has an important role in designing and managing smart green urban spaces and facing environmental challenges in contemporary cities.

5. Smart Green Urban Spaces

These mean spaces capable of providing advanced integrated services based on information and communications technology (ICT) and the smart use of urban infrastructure to improve the quality of life of its citizens, through smart projects that should contribute to achieving an integrated vision capable of harmonizing the technologies used and the new services in the various application fields that the smart city works on. (Bašová, S., et al, 2017). The quality and functionality of green spaces depend largely on human intervention, i.e. how natural capital is managed and cared for and how public perception and attitudes towards outdoor and urban green environments shape spatial impact management decisions. One of the key considerations in identifying spaces can be considered the "connectivity triad" of social, environmental and technological systems. It can be the principle that makes spaces smarter and more integrated by their ability to export themselves via fast media to transmit information, and their diverse means governed by a network of information and digital streams (Internet). If spaces can break into this information network, and digital technology is introduced into its work, management and control, they become smart spaces with excellence. As for the time dimension provided by smart spaces, they provide their databases at all times, day and night, during holidays and all tourist seasons, etc., in a way that allows the user to benefit from the services at any time he wants. The intelligence of cities is based on the extent of their dealing with artificial intelligence means and its applications in urban areas. The most important features of smart spaces:

- It has multiple accounts and websites.
- Achieve continuous electronic communication between consumers.
- All its data is digital within different information packages.
- It has an advanced and updated database (urban, population, planning, etc.).
- It has a digital administration that supervises the digital transformation process in it.

These digital features help spaces to enter the virtual world with merit and great speed, and enable them to impose their (smart), personality (Al-Jumaili, 2022)

Public green spaces, which encourage social interaction and physical activity, have both beneficial and bad effects on the physical and social structure of metropolitan areas. (Abaas, Mohammed, 2025, P206) These are open places that depend on the presence of intelligent people and smart lives as the primary hubs of activity connected to the city's socioeconomic classes and the use of contemporary technologies. Urban development requires turning ideas into action in order to find and engage locals in the entrepreneurial process. People must be willing to utilize and share wisely; social engagement is essential and shapes how changes take place. Addressing specific social groups in every activity is also essential since it might be challenging to balance the interests of many interest groups. The activities of each area complement each other in many ways, and environmental quality directly affects not only the air quality and the aesthetics of urban space, but also the residents' enjoyment of the atmosphere and their physical and mental health. Urban spaces are wise and significant for a variety of reasons, including the following:

improving economic development, converting underutilized area, lowering carbon dioxide levels, improving human health, minimizing environmental effect, and more (Jopek, D., 2019).

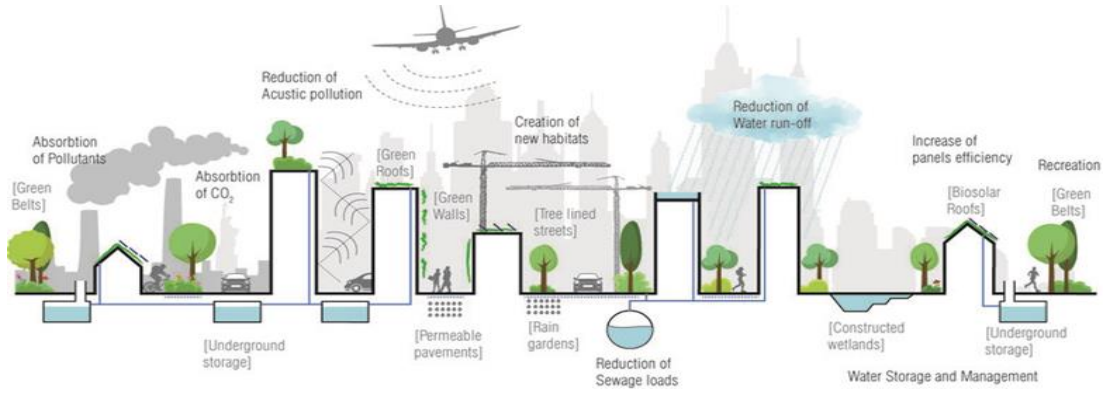


Fig. 1.

Examples Of Urban Green Infrastructure and Their Potential Contributions to the Health and Wellbeing of Urban Dwellers

As knowledge is the all-encompassing framework for data and information, smart urban spaces are defined as the electronic technology-based areas created by the information era and artificial intelligence, progressing from digital to electronic cities and finally from virtual to smart cities. Numerous scholars have described these words' features and created ideas for them. It has been shown that all places rely on artificial intelligence-powered digital technology, and via information networks and intelligent applications, all of them provide interactive services to people and virtual spaces. In the realm of popular culture, artificial intelligence has emerged as a fact that cannot be disregarded. On the ground, this technology has developed into a powerful instrument that is used in every industry. Innovatively constructed smart, sustainable urban areas are more appealing to investors and serve as models for sound design principles, such as commercial ventures that respect the environment. The best answer and a key component in such a place is innovative design, which includes architecture with multimedia interfaces that often double as informative and promotional tools. In order to support their functions, smart urban settings use innovative design elements that use interactive technology that reacts to human behavior to enhance people's comfort and safety. The goal of these solutions is often to provide metropolitan areas a more contemporary appearance and increase their appeal on a social and economic level (Jopek, D., 2019).

Characteristics and specifications of smart green urban spaces: The basic characteristics of the formation of smart green urban spaces and their multiple dimensions. (Praliya, S. et al, 2019), the International Organization for Standardization (ISO) defined smart spaces as a new model of spaces that adopt information technology (Internet, computers, digital data, virtual space, geographic information systems GIS) as an approach to planning, construction and urban management.

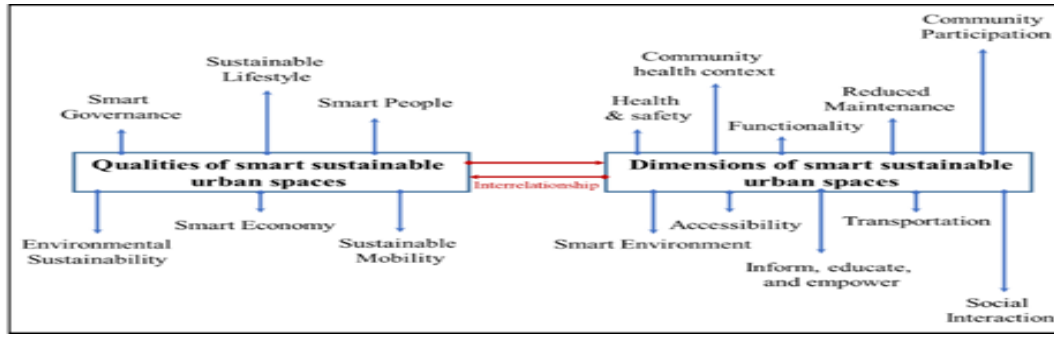


Fig. 2.

The main characteristics and their various dimensions that constitute smart urban spaces

1- **Smart governance** (e-government): The process of developing government work through the use of electronic means to provide and develop government services within smart green urban spaces, to facilitate dealings between the urban space administration, its employees and users to record and follow up on any uncontrolled work, follow up on visitor services, and the development of electronic administration is represented in several axes, the most important of which are:

- Provide information: this is done through the availability of all information and events relating to the inhabitants of the smart green urban space.

- Communication: This is represented by the ability to communicate between the space management, visitors and workers, and its ability to exchange information.

- Electronic transactions: Providing services electronically, such as signing applications, entry and exit surveillance cameras, identification cards, electronic delivery of official papers and documents related to the urban space (Abdullah, 2018, p. 8).

2. **Smart mobility in smart green urban space (**smart movement**):** It includes managing the movement system and movement corridors for electric vehicles and bicycle paths and separating them from walking paths through the availability of smart billboards and applications activated by the administration building within the smart green urban space, relying on information technology and by means of techniques to eliminate movement problems such as congestion at entrances and exits to reduce the creation of thermal discomfort areas, energy consumption and the associated carbon dioxide emissions that cause pollution, and a smart solution was developed, which is to install sensors that monitor air quality, connect surveillance cameras, and update traffic lights, thus helping to improve and develop the quality of life within the smart green urban space. Figure (3).

3- **Smart buildings:** Using networks and electronics and linking them between smart green urban space buildings and their spaces, including service, educational or entertainment spaces. Hence, it reduces the annual operating costs that focus on energy management and water consumption, and using smart agriculture on the facade of buildings that store rainwater or irrigation water and recycle it in watering the plants in order to improve air quality and reduce the heat in the garden near the building.

4- **Smart living (quality and type of life):** Providing activities and events in green spaces that contribute to providing a good quality of life, such as: cultural events, health conditions, ease of

learning and reading, social cohesion, personal security, and tourism events, and linking them to artificial intelligence programs to facilitate the process of moving between events. (Muhammad, 2019, p. 178).

5- **Smart Economy:** It is the most important and followed method in dealing with activities such as e-tourism, e-services, and e-commerce. Using communication and information technologies, the smart economy refers to a global economic structure in which information services control the creation of job opportunities and the production of goods. Moreover, through promoting the space via the Internet networks to attract the largest number of visitors and activate the tourism movement for the city in general and for the smart green urban space in particular.

6- **Smart society:** The possibility of a society moving from a normal society that uses technology to an innovative and smart society capable of reaching smart solutions to all its current problems or to reach future developments and can live in an urban information space, benefit from its services, and deal with its administrative devices, such as: e-government, electronic cards, online shopping, e-commerce, e-mail., (Al-Atla, Al-Zuboon, Khawaldeh, 2022, pp. 190-189).

Fig. 3. Transportation System Management

Smart quality of life (living)	Smart economy	Smart mobility
- High quality of life in various social aspects (education, health care, public safety and housing). - Obtaining high-quality health care services (including e-health or remote health monitoring, and electronic health record management) - Smart electronic small homes, and smart services - Facilitating access to all social services electronically	-Global and regional competitiveness -Spirit of initiative and innovation -High levels of productivity - Broadband networks available to all citizens and companies to support business opportunities - Freedom to choose the location, and the possibility of benefiting the population in rural areas - Promotional e-commerce operations including e-	-Accessibility between urban spaces -Safe transportation (entrances and exits) -nnovative technologies - More efficient and intelligent transportation systems - Effectively utilizing traffic networks in the movement of vehicles and people within urban spaces, to reduce congestion. - New social style: such

	services and online shopping.	as participation in the use of smart carriage, diversity between the use of walking, trolley and bicycle.
Smart environment	**Smart people (society)**	**Smart management**
- Continuous monitoring of pollution - Use of sustainable technologies - Environmental and sustainable energy consumption - Reduce energy consumption through technological innovations while promoting energy conservation and material reuse	-Social and human capital - Qualified, creative and educated citizens -Ability to benefit from smart services based on information and communication technology. -Providing a more consistent learning experience in both urban and rural areas.	-Decision making -Public and social services -Transparency - Democratic processes and inclusion -Linking government organizations and departments - Improving community access to services

Table 2. Dimensions and Factors of the Smart Sustainable City

Smart green urban spaces are a concept developed on the basis of three main pillars: (establishing economic growth, addressing environmental issues, and integrating social justice). Smart green urban spaces are based on the integrated use of the Internet and computing technology. Therefore, spaces are created that use the Internet to sense, measure and transmit data in real time for moving objects. The computing function is similar to the function of the human brain. It is responsible for complex calculations, data analysis and pattern recognition. It also provides remote monitoring, control and feedback. The connection between the different components of a smart city appears within an integrated framework. The most important components of smart green urban spaces are that the spaces are integrated through the integration of cities through three levels, which are (knowledge-based activities, problem-solving institutions, and digital communications infrastructure (Elshamy, 2019, p115-117). These levels include, as in Table (3):

Components	**Characteristics**	**Potential**
People	They have the qualities of creativity, practice and speed of achievement.	They have the ability and potential to use information technology.
Organizations	Services are provided and accelerated, such as educational and health institutions and others (remote service).	Through electronic systems within spaces or units and centers that provide this assistance quickly.
Networks	To transfer and exchange information and data between institutions and individuals at a very high speed.	Transport and exchange through several applications including: fiber optic network, digital subscriber line network, and Wi-Fi wireless networks.
Digital Space	To have a capable information environment (smart spaces)	The individual shares with the institution through networks and

		information via these spaces.
Database	The most important element is the availability of a database within each government system that facilitates transfer and sharing.	Data is collected from government systems, mobile devices and web applications, analyzed and then transformed into valuable activities for decision making and problem solving.
Applications	Important applications in space to spend special events for each individual and institution	Internet and mobile services (smartphones, sensors, tablets).
End users	People, companies and organizations, via sensors, tablets, smartphones or GPS devices.	Interaction at this layer is essential for the city and its spaces to be recognized as smart spaces.

Table 3. Levels of Integration of Smart Green Urban Spaces

Components and elements of smart green urban spaces: These elements form the structure and basic design of the smart green urban space. These components and elements vary and depend on the type, size and planned use. (: Muhammad Arab Al-Moussawi 2020):

1. **Parks and gardens:** These include areas designated for public parks and gardens. These areas can be large and open or small and limited in access and contain different spaces for plants and trees and areas for sitting and relaxation.

2. **Open green spaces:** These include large green meadows and fields that provide open spaces for the public to gather, walk around and enjoy the outdoors.

3. **Aquatic areas:** These include lakes, ponds and other water areas that can be attractive to residents and provide an environment for aquatic plant and animal life.

4. **Trees and plants:** Trees and plants are one of the most important environmental components of green urban spaces. Trees can be of different types, and flowering plants and shrubs add an aesthetic and lively touch to the space.

5. **Paths and Trails:** Paths and trails include roads and paths designated for walking and cycling. These components contribute to providing means of transportation and communication within the green urban space and the city.

6. **Entertainment and sports area:** includes entertainment and games areas and sports areas such as football fields and other sports fields.

7. **Urban furniture:** includes benches, tables, umbrellas, and other items that provide comfort and convenience to visitors.

8. **Artistic and aesthetic elements:** They can add an artistic and aesthetic touch to the green urban space. Statues, monuments and other urban art can be used to enhance the overall appearance of the space.

9. **Lighting and Natural Lighting:** Includes well-designed lighting and natural lighting that contributes to making green urban space attractive for use also at night periods.

10. **Celebration and event areas:** These include areas designated for social and cultural events and celebrations. These are some of the main components and elements that can be part

of public green urban spaces, and can be planned and organized in a way that meets the needs of residents and provides a comfortable and attractive environment for enjoying nature and outdoor activities. (Jawhar 2016)

Benefits of smart green urban spaces: The foundation of both urban and national ecological civilizations is landscape development. There are now more options for sustainable landscape design because to scientific and technological advancements. Intelligent landscape design is made possible by new techniques and technology. Achieving the virtuous cycle of landscape and coordinating the growth of the site and its inhabitants are the goals of sustainable landscape design. Sustainable landscape patterns, sustainable landscape materials, sustainable landscape usage, and sustainable management practices are all part of today's sustainable landscape designs. As seen in (Irvine, KN et al., 2010) Table (4).

Sustainable landscape patterns	The landscape pattern should be arranged rationally according to the characteristics of the surrounding environment to maximize the function, taking into account the sustainable principle of smart green urban spaces, the landscape design of parks and squares should meet the requirements of the public while fully embodying the aesthetics and characteristics of urban areas.	For instance, the street's green belt's aesthetics and continuity should be taken into account. The goal of the urban landscape is to provide inhabitants a comfortable setting and scenic views that satisfy their requirements for enjoyment and observation. The industrial landscape highlights the need of noise insulation, air purification, and landscape enclosure.
Sustainable Landscape Materials	Both hard and soft landscape materials are used in landscaping. The term "soft landscape" describes a plant landscape; native flora and wild plants may be used in sustainable plant landscape design.	The use of ecological materials is referred to as "difficult landscape." Ecological materials, such as locally sourced materials, ecologically permeable bricks, ecological concrete, and water filtration systems, are materials that exhibit both good ecological coordination and high performance. (Y. Wang, 2020)
Sustainable landscape use	Along with an urban drainage system, enough irrigation equipment must be processed on the road to replace or enhance soil that is unsuitable for plant development [22]. (M. Serena, 2020) Various plants in the yard may assist expand the capacity of green carbon basins and provide a variety of animal habitats.	Life-supporting characteristics and perceived demands may be satisfied by compatible ecological service functions [23]. (M. Kammerer and others, 2021). In the meanwhile, resource and energy consumption is decreased via the sensible use of natural components like light, wind, and water. (Z. Pan, 2020)

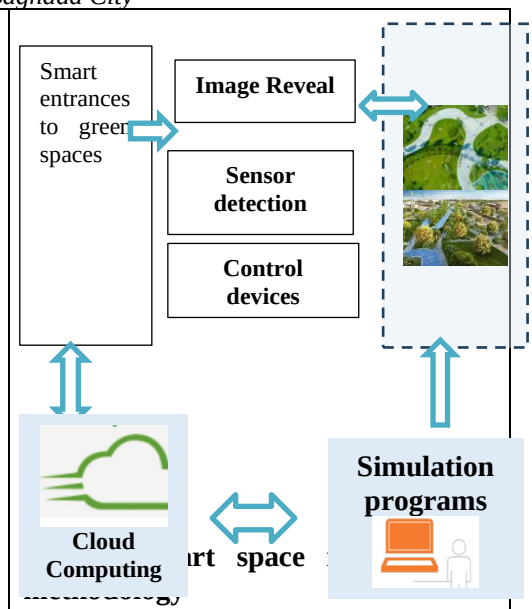
Sustainable management techniques	The creation of a large-scale smart park database via the integration of Internet of Things (IoT) technology with contemporary ecological parks may intelligently link people and environment, achieving mutual induction, mutual understanding, and mutual engagement. (Y. Şenol, 2020)	

Table 4. Benefits of Smart Green Urban Spaces

Environmental Challenges

Climate change due to climate extremes (high temperatures, humidity, rain, dust storms), is a long-term, influential change in the average weather conditions that occurs in a specific area, and includes weather conditions, average temperatures, precipitation rates, and wind conditions. According to NASA, climate change is a widespread global phenomenon caused by the burning of fossil fuels, which releases heat-trapping gases (greenhouse gases) into the atmosphere (water vapor, carbon dioxide, methane, and nitrous oxide).(Talib, Laffta,2024,P36) Other changes include sea level rise, loss of ice mass in the Arctic and Antarctica and icebergs around the world, changes in flowering dates, and severe weather events. The Earth is divided into a specific number of climatic zones. Climate is one of the most distinctive characteristics of the atmosphere. The atmosphere forms an 800 km layer of gases surrounding the Earth. This layer becomes denser as you approach the Earth's surface. The atmosphere is made up of 99% nitrogen and oxygen and 1% carbon dioxide, water vapor and other components. The loss of smart green urban spaces leads to increased urban heat and flooding, which is amplified by climate change, and can threaten human health, well-being and property. It also leads to the degradation of natural ecosystems and the biodiversity they support. (Hadad, 2012, pp. 9-10).

Environmental Challenge	**Effect**
1- Heat waves and high temperatures (the rise in the average temperature in the	-Stressing plants and trees, making them more susceptible to disease and death - Difficulty for people to enjoy smart green urban spaces and migration of large numbers of people.

world represents climate change and the general increase in the average global temperature)	-Increased drought and forest fires have caused the extinction of many plant and animal species. -The thermal effect of this increase varies from site to site according to many factors such as the site on the ground (longitude and latitude), and the ground cover of the site - The oceans were found to have warmed more slowly than land areas. - High temperatures make it difficult for people to live in cities and lead to heat stress, which causes many health problems, including drought and respiratory problems. (Abdulateef,2021)
2- Rain and drought	- Drought drier smart green urban spaces make them less attractive and less able to support plants and animals - Also increases the risk of wildfires. Especially in the Mediterranean and Southern Africa - Low rainfall causes drought, with some areas receiving less than 100 mm of rain per year by the end of the century. It causes a significant difference in rainfall pattern characteristics such as location, shape, quantity and timing. (IPCC, 2007, p. 5)
3- Increase humidity	-It is due to a combination of high temperatures and low precipitation. - Damaging plants and trees. It can also wash soil and nutrients, making it difficult for plants to grow.
4- Dust storms (desertification) due to a combination of decreased rainfall, increased wind speed and desertification.	-Harmful to plants and trees - Harmful to human health and causes respiratory problems, eye irritation and vision problems. - Damages infrastructure and crops, making it dangerous to be in green spaces during a dust storm
5- Sea level rise	- Both the thermal expansion of water and the additional inflow of water into the oceans from Earth's ice sheets lead to a rise in sea level. - It poses a serious threat to many cities and their low-cost spaces, where a large number of the world's population lives one meter above sea level. -The estimates provided by the Intergovernmental Panel on Climate Change in 2007 predicted a sea level rise of about (18-59 cm) by the year 2100 and confirmed that this increase varies from place to place (Beniston, 2010, p. 562).

Table 5. The Effect of Environmental Challenges on Smart Green Urban Spaces

Climate change (high temperatures, humidity, rain, dust storms) has a significant impact on smart green urban spaces and is likely to become more common in the future. It is important to be aware of these impacts and take steps to protect smart green urban spaces from climate change. Climate change is not a new phenomenon, but what is new is accelerating climate change that exceeds the Earth's natural ability to absorb or adapt. (Article, Climate Change and the Challenges Facing, 2021).

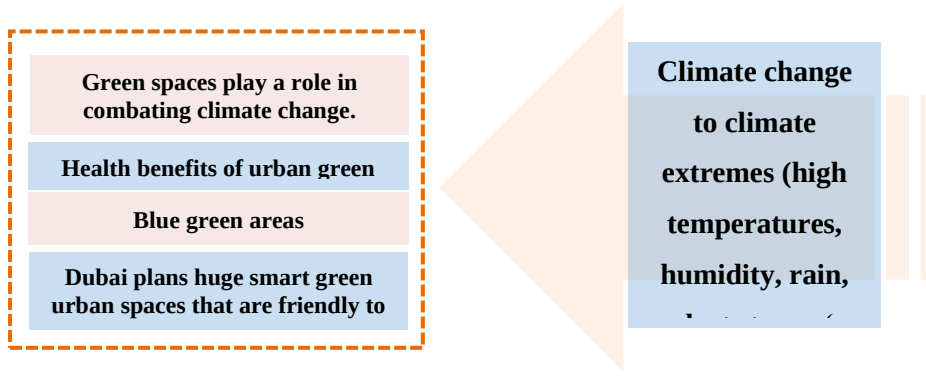


Fig. 5. Climate Change

In the worst case, the global temperature increase will be about 4 ° C as an average, and the determination of the emissions scenario depends on several factors such as population growth, type of economy, technological progress, type of fuel, etc. It should be noted that the impact of the global increase in average temperature is widespread and varies from region to region. It is more severe in high latitudes than in mid- and low latitudes. Accordingly, current climate change is the result of global warming, which is caused by the increase in the concentration of greenhouse gases in the atmosphere. (Environmental Protection Agency, 2013, p. 6) The German Advisory Council on Global Climate Change has confirmed four pathways through which climate change is linked to conflict: (degradation of freshwater resources, food insecurity, increased or changed migration patterns, increased frequency and severity of natural disasters). These paths can be illustrated through the role of AI technologies in mitigating the effects of climate change, such as improving energy efficiency and reducing emissions from the transportation, agriculture and industrial sectors, as well as adapting to the effects of climate change, by predicting extreme weather events. From these methods, we find that AI is not just an advanced technology, but also a powerful tool that can play a crucial role in combating climate change. AI predicts carbon sequestration, hurricanes, floods, droughts, wind movement, environmental pollution and the decline of green urban spaces on the Earth's surface, and helps avoid the impact of electromagnetic hurricanes on the Earth's atmosphere. Moreover, reduce the effects of heat stress, dust storms and water scarcity. In order to adapt to climate change, green urban spaces need to take a number of steps, as including in table. (5).

	The factor	**The impact**	**the solution**
Changes in the climate system	Increases in greenhouse gas concentrations, rising temperatures, and changing rainfall patterns.	- It has a clear impact on ecosystems and natural resources such as soil, water, biodiversity, ecosystems and forests through many interactions that occur from time to time. -It has an impact on societal instability, such as the emergence of	-Investing in green urban spaces -Green urban spaces, such as trees and vegetables, can help mitigate the effects of climate change. Trees can help cool the air and reduce the impact of dust storms. Plants can help absorb rainwater and reduce flooding.

		various forms of violence through riots, the emergence of rebel movements and demonstrations, the spread of drug trafficking, the spread of organized crime, and other illegal phenomena.	
Changes in natural resources	Water, energy and soil	It has harmful effects on the region's population and their capabilities, producing human responses that have an impact on social systems. (and geographic 2023) Al-Khalidi	- Improving water efficiency in order to meet the needs of its growing population. -This can be done by installing water-saving devices, fixing leaks, and educating residents about water conservation. Increases in temperature have been shown to affect the hydrological cycle. The amount, timing, and intensity of rainfall decrease as evaporation rates increase. -Prevent rainwater and stormwater from running off the ground using design components such as rain gardens, constructed wetlands, and rooftop gardens.
Human needs	Food and water insecurity	Social and economic tensions increase, as do health problems, migration, economic deterioration, weak state institutions, and diminishing economic growth in the event of weak government administrations. (Abdul Nabi, 2022, p. 6)	-Urban green spaces need to develop drought-resistant crops in order to be more resilient to climate change. - Urban green spaces need to build infrastructure that can withstand dust storms, by adapting to climate change and mitigating its negative effects.

Table 6. Explaining the Four Paths (According to the German Advisory Council).

Artificial Intelligence:

It is the ability of a machine or device to perform some activities that require intelligence such as actual reasoning and self-repair. The term artificial intelligence (AI) refers to systems or devices that simulate human intelligence to perform tasks and can improve themselves based on the information they collect. Intelligence manifests itself in a number of forms. Some examples of these are:

• Chatbots use artificial intelligence to understand customer issues faster and provide answers that are more efficient.

• AI developers use it to analyze important information from large amounts of text data to improve scheduling.

• Recommendation engines can provide automated recommendations for TV shows based on users' viewing habits. The concept of artificial intelligence is the use of digital or electronic devices such as computers, mobile devices or robots, to explain the performance of tasks associated with intelligent beings so that this intelligence is used to solve any problem. The term artificial intelligence applies to systems that have human intellectual processes such as the ability to reason, discover meaning, and learn from past experiences. Examples of the use of digital devices include discovering proofs for mathematical theorems, playing chess, medical diagnosis, web search engines, and recognizing voice or handwriting ("artificial intelligence", Britannica, Retrieved 9/27/2021. Edited.) There is a connection between artificial intelligence and green spaces. Modern digital developments in artificial intelligence can be used to monitor and manage water as well as energy consumption. Modern digital technologies reduce the amount of waste through smart systems, especially in this field, in smart green urban spaces. The characteristics of smart spaces are linked to their use of artificial intelligence technologies (Zhu, Y., et al., 2023). Figure (6)

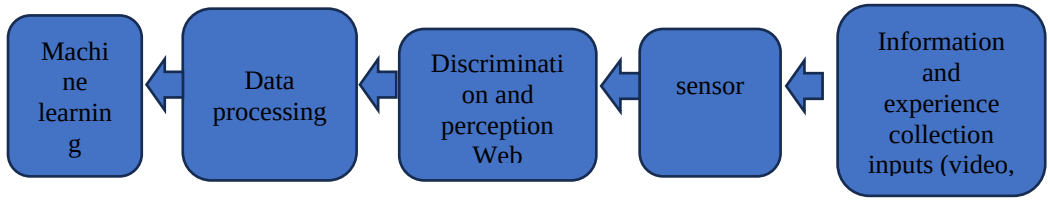


Fig. 6. The Characteristics of Smart Spaces Are Related to the Use of Artificial Intelligence Technologies

Green spaces and parks can help reduce the heat island effect of a building. This moderates the temperature of a project site and reduces the amount of energy required to operate the building. Urban heat island effects are defined as a five to nine degree Fahrenheit increase in temperature between an urban center and the surrounding rural area. The increased need for industrial cooling during hot summer months releases additional greenhouse gases because of this abnormally high temperature, adding to the problem of global warming. The tremendous heat emitted by urban structures is a significant factor from man-made heat sources (such as vehicles, power plants, air conditioners, etc.) Living green roof and wall systems, urban trees, open green spaces, light-colored paving materials, and photovoltaic shade canopies can be used in our designs to help reduce this problem. We can take urban forests as an example. Urban trees can reduce temperature by providing shade to air conditioning units and outdoor areas. (Zhu, Y., et al.,

2023).

The Role of Artificial Intelligence and Climate Change and Its Impact on Green Spaces:

Climate change is a challenge that requires innovative solutions that are more advanced than traditional methods. Artificial intelligence (AI) has emerged as a means to combat climate change as follows (Shawqi, Ahmed, Khaled, 2021): -

1- **Climate modeling and forecasting:** One of the most important uses of artificial intelligence to combat climate change is its ability to enhance climate modeling and forecasting. Through it, the learning mechanism is activated and advanced machine learning algorithms analyze large data sets, including variables such as (temperature, precipitation, and atmospheric composition). To reach more accurate climate forecasts, which helps policy and decision makers anticipate changes in weather patterns and extreme events and prepare for it.

2- **Improving renewable energy:** Switching to renewable energy sources is an important element in reducing carbon emissions. Artificial intelligence plays a role in improving the efficiency of renewable energy systems. Machine learning algorithms analyze real-time data from solar panels, wind turbines, and other renewable energy sources to predict energy production, to achieve the best in current power grids. Artificial intelligence is used in the maintenance of renewable energy infrastructure, leading to an increase in its lifespan and a reduction in overall costs.

3- **Smart Grids for Energy Management:** They play an important role in energy management. These smart systems leverage real-time data and machine learning algorithms to efficiently balance energy supply and demand. Smart grids can identify and address inefficiencies, reduce energy losses during transmission, and integrate a higher proportion of renewable energy sources into the grid. By optimizing energy distribution and consumption, smart grids contribute to a more sustainable and resilient energy infrastructure.

4- **Precision agriculture for sustainable food production:** The agriculture sector is both a contributor to climate change and a victim. AI technologies, such as precision agriculture, offer solutions to improve agricultural practices. Machine learning algorithms analyze data from sensors, satellites, and drones to provide farmers with insights into soil health, crop conditions, and pest management. It enables more precise and sustainable agricultural practices, reduces environmental impact, and improves overall crop yields.

5- **Climate Change Adaptation Strategies:** AI plays a key role in developing adaptation strategies to address the impacts of climate change. Predictive modeling and analytics help identify vulnerable areas and populations, allowing for the formulation of targeted adaptation plans. Machine learning algorithms analyze historical climate data to predict which areas are most vulnerable to sea level rise, extreme weather events, or changes in rainfall patterns. This information helps develop resilient infrastructure and community strategies to mitigate the impact of climate change. https://www.skynewsarabia.com/business/1673357

6- **Monitoring and combating deforestation:** Deforestation is a major contributor to climate change, releasing stored carbon dioxide into the atmosphere and disrupting ecosystems. AI technologies, including satellite imagery analysis and machine learning algorithms, enable real-time monitoring of deforestation activities. These tools can detect illegal logging, identify areas at risk, and support conservation efforts. By providing actionable insights, AI helps authorities and environmental organizations take rapid action to protect endangered forests.

(Alzahrani, A., 2022)

7- **Carbon capture and sequestration:** Carbon capture and sequestration techniques (CCS) are critical in reducing CO2 emissions from industrial processes. Artificial intelligence is used to improve carbon dioxide capture and storage processes, making the process more efficient and cost-effective. Machine learning algorithms analyze data from carbon capture facilities to improve capture rates, reduce energy consumption and improve overall performance. These developments are crucial to the transition to a low-carbon economy.(Hasan, Abed,2023,P65)

8- **Sustainable Mobility Solutions:** AI is driving innovations in sustainable mobility, helping to reduce greenhouse gas emissions. Intelligent vehicle traffic management systems, powered by machine learning, improve traffic flow; reduce congestion and fuel consumption to easily access smart urban spaces. Autonomous vehicles within spaces, guided by AI algorithms, offer the potential to improve fuel efficiency and reduce emissions. AI supports the development of electric and hybrid vehicles by improving battery performance and charging infrastructure.

9- **Smart waste management and recycling:** Effective waste management and recycling are key elements for a sustainable future. AI applications are helping to improve waste sorting processes through robotic systems equipped with computer vision. Machine learning algorithms help identify recyclable materials, reducing pollution and improving recycling rates. AI-based analytics help reduce the environmental impact of waste disposal .(ALKareemAl-Ameen,Al-Hamdany ,2018)Modern technology and the use of AI techniques contribute to reducing the volume of solid waste per capita by 10 to 20 percent. The establishment of smart waste management aims to improve the efficiency of waste collection, transportation, sorting, reuse and recycling, by monitoring the movement of different types of waste from source to disposal, through mechanisms using sensors and internet connectivity. (Abdel-Sadek, 2022, article)

10-**Global collaboration and climate research:** AI facilitates global collaboration and information sharing among scientists, researchers, and policymakers working on climate-related issues. AI-powered collaborative platforms enable the integration of diverse data sets, fostering a deeper understanding of climate change impacts and potential solutions. Machine learning algorithms analyze research findings from around the world, identifying patterns and interrelationships that contribute to more effective climate policies.

11- **Smart water management:** Modern technology can also reduce water consumption by 20 to 30 percent. In many countries in the world, especially developing countries, water leakage from pipes is the largest source of water waste. This problem can be addressed by deploying sensors equipped with artificial intelligence technologies that detect and track leakage sources, which can reduce losses resulting from water leakage to 25 percent. (Al-Ward, Zaki, 2014, p. 104)

12- **Motivating environmental behavior:** Artificial intelligence is interested in positive environmental behavior by encouraging awareness and directing individuals and institutions towards environmentally friendly practices such as agriculture, management, design, etc. Through personal awareness campaigns, providing accurate data on environmental impacts and climate change such as the impacts of smart green urban spaces on our actions, and through motivation, AI motivates us to change our behaviors in the public interest. https://www.skynewsarabia.com/business/1673357

13- **Disaster control and rehabilitation:** Artificial intelligence can be used to analyze situations and provide immediate responses when environmental disasters such as climate change occur.

Simulation technology can be used to provide models for disaster management and plan strategies for rehabilitation and recovery from environmental disasters that harm human health. (Article, 2024 https://ww.arabiaweather.com/ar/content)

The climate impact of artificial intelligence programs on smart green spaces: These applications simulate human intelligence and its extraordinary capabilities in terms of learning, development and creativity, as they have become an important role in raising the human sciences to a higher level. Artificial intelligence programs try to simulate the best possible way to act and think like humans, in order to reduce the time and effort to complete a specific task or project. Artificial intelligence is not limited to a specific field of science, but in engineering, business administration, health care systems and others in order to facilitate things with the help of technology to achieve development in various sciences. These apps have been developed to transform from a helpful tool to an indispensable tool in our daily lives. Whether it's information gathering, education, retail, travel, or fintech, there's always an AI app to help. These apps include ChatGPT, Siri, Cortana, Amazon Alexa, Google Assistant, Replika, Robin, Socratic, Hound, and ELSA. Robin makes virtual assistants fun to explore, offering a wide range of quick commands that you can give it to start executing right away. Robin can be used to check the weather and news, and it is also a great choice for users who drive a lot to get help in choosing the best routes and the ideal time to drive throughout the day. The application is characterized by an easy-to-use interface and a quick response to voice commands. By giving a voice command, the application starts performing many activities such as text messages, starting calls, reminding of appointment schedules, navigating via the Global Positioning System (GPS), and much more. Artificial intelligence has become part of the daily life of the individual, starting from helping him navigate cities and avoiding traffic congestion, to using virtual assistants to help him perform various tasks, and today the use of artificial intelligence has become ingrained for the public good of society (Shawky, et al., 2020, p. 7).

AI Deals with Environmental Challenges	**Environmental Challenge**	**Indicator**
-Activate the learning mechanism and evaluate advanced machine learning algorithms - Analyzes data from sensors, satellites and drones to provide farmers with information on soil health, crop conditions and pest management. This allows for more precise and sustainable farming practices, reduced environmental impact, improved overall crop yields, heat and drought-resistant crops and control of deforestation in open spaces.		Climate Modeling Precision Agriculture for Sustainable Food Production
-Artificial intelligence improves the efficiency of renewable energy systems. -Machine learning algorithms analyze real-time data from solar panels, wind turbines, and other renewable energy sources to predict energy production.	2- Rain and drought	Energy Management Environmental Natural Resource Use Biodiversity

-Using the Earth Lab (EarthLab) is a new facility for numerical simulation of the Earth science system using data and computational power to enhance the skills of numerical models for predicting rainfall. The Center for Meteorology is working to expand the scope of its response to the challenges of increasing water stress around the world. -Machine learning algorithms monitor cloud movements with smart computers - Optimize water flow in urban green spaces (storm water) based on predictive models of rainfall and flooding. By intelligently directing water away from spaces in vulnerable areas, smart drainage systems prevent water accumulation and reduce the risk of flooding in urban areas.		Climate Modeling
-Meteorologists work to collect data, using artificial intelligence systems to forecast storms by integrating satellite and ground-based observatory data. By activating mobile phone applications and using a system called DAPS (Dust Assimilation and Prediction System). This system can provide 48-hour forecasts. The system uses data assimilation, in which observational data is combined with an AI model to ensure accurate forecasts. This system makes the process matic. Deep learning algorithms are used for forecasts by removing bias in the observational data. With details about how intense, the storm is and how the dust is spread across different areas.	3- Dust storms	Irrigation and watering management and smart agriculture to reduce desertification
-Aerial imaging and analysis tools are used to protect urban spaces, and automated analyses of images from satellites and drones enable monitoring of the effects of climate change on the environment Benefiting from air humidity by using robots that convert air humidity into water that can be used for drinking and agriculture by passing through several stages.	4- Increase humidity	Water management
-Understanding and forecasting sea level trends, integrating data from sources such as satellite imagery, ocean temperature	5 -Sea level rise	Smart management

readings, and atmospheric data - Leveraging data from satellites and ocean sensors. These smart AI devices provide continuous information on ocean temperatures, ice sheet masses, and sea level rise. Algorithms analyze this data, identifying patterns and trends that might elude human analysts. -Algorithms help identify areas where intervention can significantly mitigate sea level rise. One of the most innovative AI applications in this context is (development of automated flood barriers)		
- Using algorithms, machine learning and applications installed on the devices of employees and users to accurately deliver information to them to use fast means of transportation and through smart applications to control time. Artificial intelligence can be used to develop self-driving cars and reduce emissions of toxic gases from their various sources. Reducing private cars and relying on electric cars and bicycles during heat waves. -Waste is collected in urban spaces due to rain, storms or human use. Artificial intelligence, for example, uses smart containers that automatically sort by sensors and provide information about their size, time of filling and emptying by workers, and then recycles them using an internal camera attached to the processing unit. And by providing an application that can be downloaded on phones to find the nearest container in the urban space.	6- All Environmental Challenges	Smart mobility inside and outside smart green urban spaces Waste management

Table 7. Research Indicators

Case study / Dubai Sustainable City

Dubai is the first sustainable residential city in the Emirate of Dubai that respects sustainable urban standards and takes into account the social, economic and environmental aspects that preserve humans and the environment from producing clean energy and giving priority to designing smart green urban spaces that include all services and facilities. An integrated city provides its residents with a healthy, sustainable life free of carbon emissions and with a green belt and clean energy. It relies on harnessing the outputs and tools of artificial intelligence, smart mobility initiatives and a wide range of smart services in innovative ways that use information and communications technology to improve the quality of life and at the same time meet the

needs of current and future generations. The city aims to transform about 1000 government services into electronic services in the following main sectors: transportation, infrastructure, communications, financial services, urban planning, and electricity. Through the application of (open and easy access to data, smart transportation, optimal utilization of energy resources, smart urban spaces and beaches, police smartphone applications, new main control rooms, (Sajwani, 2023).

Fig. 7. Dubai Sustainable City

Applying Indicators to the Sustainable City of Dubai

A- **Climate Modeling:** The environment in a city that sees temperatures over 40 degrees Celsius for four or five months of the year presents a difficulty, since it has the capacity to produce enormous quantities of solar energy for both internal use and export to the unified grid. By building residential units with solar panels to provide 60% of the energy required for each unit, the city embraces ecologically responsible engineering concepts. It has reduced climate change by providing bicycle routes, jogging tracks, and intelligent green urban areas. Green buildings and green urban areas will be a key component of the answer to preventing global warming, lowering climate change, and getting rid of excessive temperatures. Lightweight facades may lower energy needs and, therefore, emissions related to the production and delivery of building supplies to the construction site. Additionally, sustainable design may lessen the negative effects of building on the environment and human health. Buildings with adequate insulation, for instance, may save heating expenses in colder climates and cooling expenses in hot ones.

B- **Smart agriculture and biodiversity:** The use of precision agriculture depends on the use of technology to produce sustainable food and provide 20 organic farms to produce local food, in addition to individual farms to produce agricultural materials on site and maintain afforestation and reduce crops, such as the use of sensors and big data in the artificial intelligence program and the Internet of Things by monitoring the growth of plants and crops. Green urban spaces in the Sustainable City in Dubai occupy about 70% of the total area of the project, as it has about 20,000 diverse trees, half of which are for ornamental purposes and the other half are fruit trees, an organic farm to provide the city's residents with a large part of their food needs, and 10,000 trees, from different categories. The focus is on the impact of biodiversity and ecosystem health through a biodiversity assessment programme and the use of dedicated monitoring equipment to measure the impact of the urban environment on biodiversity and ecosystem health, using advanced monitoring equipment including ultrasound recorders for bats and audio recorders for birds, for example. More significantly, there are many domes that hold plants and vegetables for local consumption. A "green spine" that runs through the heart of the complex offers a beautiful green vegetation area. According to the project's management team,

a single container-sized vertical farming facility may produce up to four tons of strawberries. Additionally, residents are urged to use organic farming practices to cultivate their own food on parcels of land next to their homes. The complex's core has a verdant "green spine," and more significantly, it has many domes that contain vegetables and plants for local use.

C- **Energy Management: -** Smart green urban spaces in the sustainable city depend on meeting all the power needs of the residents of the complexes by generating them from solar energy by rationalizing and consuming energy. They have been supplying 600.000 square feet of solar panels. That produce 50% of the energy consumed in the city. The city aims to reduce carbon emissions by reducing the use of traditional means of transportation and replacing them with electric vehicles and 40 thousand solar panels distributed on the roofs of villas, buildings and parking lots. The city offers a concept that achieves sustainable living, through residential units to ensure energy efficiency, and the use of environmentally friendly building materials. Energy saving without its residents bearing any maintenance fees. The smart green urban spaces in the Sustainable City in Dubai rely on producing clean energy and expanding the scope of these smart green urban spaces, which in turn produce clean air and make the atmosphere in the city's residential areas calm, reassuring and free of any pollution. All of the city's sustainable housing is provided with clean energy produced through solar panels distributed throughout the project. Solar panels are installed on the rooftops of almost every building and parking space in the residential complex to create a green economy for sustainable growth and the use of clean and renewable energy sources. This energy generation is sufficient to fulfill most of the local community's demands. The north facades have well-insulated windows, while the south-facing facades are shuttered to keep the sun out. Light colors are used on all surfaces to reflect sunlight and lessen the strain on air conditioners.

D- **Waste Management:** Waste is recycled through a new station for collecting and managing electronic waste, in cooperation with a company to ensure a greener future, and by smart containers equipped with cameras and data linked to the mobile phone of the workers. The electronic waste dump station operates around the clock and is a free and effective solution for managing electronic waste for residents and general users. By placing their waste from electronic devices in this station, it will later be collected and transported to the recycling facility and its contents will be sorted according to type, so that the useful parts and useful materials that contain raw materials necessary for manufacturing new products will be reused, while the useless parts will be disposed of according to a process that does not produce any harmful emissions.(Al-Ameen, Al-Hamdany,2018)

E- **Water management (irrigation):** The city includes through the reliance on smart systems brokered by artificial intelligence, including an intelligent water system that reduces water consumption to 30%. Refined water from home uses will be used to protect trees plantations in smart green urban spaces. Recycling wastewater for irrigation, the city has a system for separating black and grey water and treating the grey water for reuse in smart green urban spaces in the city. Recycling wastewater for irrigation, the city has a system for separating black and grey water and treating the grey water for reuse in smart green urban spaces in the city. The average daily water consumption is 162 liters per person, compared to the average of 278 liters in Dubai. The Dubai City Administration used soil and moisture sensors and computers to control irrigation, irrigation method, daily irrigation rate, quantity and times by analyzing data according to the plants' needs to reduce water consumption. Artificial intelligence technology is used to manage irrigation water to determine the appropriate irrigation time and quantity as needed by using soil moisture and temperature sensors, transferring and analyzing data to predict

future needs, and using drip irrigation to reduce energy and water consumption, increase productivity and reduce costs.(Hasan, Abed,2023,P64)

F- **Smart Mobility:** The Sustainable City in Dubai provides an environmentally friendly internal transportation system based on solar-powered vehicles and horse-drawn carriages that are allocated to the guests of the tourist resort, especially for transportation within the smart green urban spaces. This local community encourages residents to walk in shaded areas (more than 80% of the residential complex area is free of cars) and ride bicycles. Participation in electric vehicle rides is the main mode of vehicle mobility within the complex, and an increasing number of residents choose to take advantage of charging points at the accommodation site by purchasing electric vehicles to move within smart green urban spaces and between their corridors, by creating jobs for the population and encouraging local products. .(Shaheen, Bahgat, & Hassan,2018)

G- **Smart management:** It includes increasing the area of smart green urban spaces and depends on the use of advanced technologies to manage resources and enhance movement within urban spaces using data and analysis to improve maintenance and create a smart healthy environment for workers and visitors, and it is through the integration of monitoring systems. The systems included in the green urban spaces of the sustainable city of Dubai include smart lighting systems, waste and water management, enhancing rainwater and flood management, monitoring air quality, reducing the environmental footprint, improving environmental quality of air, water, noise, and urban heat islands, protecting natural reserve areas, developing environmental corridors, providing public parks and a high-quality entertainment system, and increasing food security through urban agriculture and food production (Dubai Urban Plan 2040, article) Figure (8)

Fig. 8. Smart Applications in the Sustainable City of Dubai

Conclusion

In general, smart green urban spaces are urban spaces that use smart technologies to improve the quality of life in them. Dealing with climate change requires multidisciplinary efforts and integrated strategies to ensure the sustainability of cities and their spaces and to ensure the health and safety of residents. The use of artificial intelligence to reduce climate change represents a qualitative leap in improving the quality and sustainability of smart green urban spaces and in order to activate and achieve participation and interaction between humans and nature and by relying on some methods including irrigation management, monitoring plants, energy and waste, reducing water consumption, using climate modeling and analyzing environmental data to achieve efficiency in the use of resources, enhancing biodiversity and providing smart green urban spaces with fast and innovative technologies to provide an attractive environment for

tourists and residents.

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