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Smart Urban Green Space Management

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Abstract

Smart Urban Green Space Management is an emerging concept that uses data-driven technology and solutions to manage and improve green spaces in a city. This approach includes various controls and determinants, such as technology and data, mobility, energy and resource management, community engagement, governance, and policy. By integrating these controls and limitations, city planners and managers can develop effective strategies and initiatives to improve the availability and quality of green spaces in the city. The benefits of smart urban management of green spaces include improved air and water quality, reduced impact of urban heat islands, increased biodiversity, as well as social and recreational benefits. This paper provides an overview of the concept of smart urban management of green spaces, its controls and limitations, and its impact on urban spaces in the city.

Keywords: *Smart urban management, green spaces, technology, data, mobility, energy management, resource management, community engagement, governance, sustainability.*

Introduction

Smart urban green space management is an emerging field that focuses on the use of technological and data-driven methods to enhance the management, maintenance and preservation of urban green spaces. With rapid urbanization and population growth, the importance of urban green spaces is becoming increasingly recognized as they provide many environmental, social and economic benefits, such as reducing the impact of urban heat islands, improving air quality, promoting physical activity, and increasing property. Smart urban green space management involves the integration of various technologies, such as sensor networks, geographic information systems (GIS), mobile applications, and remote sensing, with traditional methods of urban green space management. This integration allows real-time data collection and analysis on various aspects of green spaces, such as soil moisture, temperature and air quality, which can be used to inform management decisions and improve public health and performance of green spaces. One of the main benefits of smart urban management of green spaces is the ability to optimize resource utilization and reduce costs. For example, by using sensor networks to monitor soil moisture levels, irrigation systems can be automatically adjusted to deliver the right amount of water to green spaces, reducing over-irrigation and water wastage. Similarly, using remote sensing and GIS technologies, urban planners can identify underutilized or poorly managed areas, and allocate resources more efficiently. Moreover, smart urban management of green spaces also involves the participation of citizens in the management process. Mobile applications and social media platforms can be used to solicit citizens' opinions on the quality and accessibility of green spaces, as well as provide them with information on upcoming events and activities. This engagement can help build a sense of community and ownership around green spaces, which in turn can lead to increased use and support for their maintenance and preservation. (Li et al., 2022; del Cerro & Molinero, 2023)

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Research Problem

The research problem lies in the lack of knowledge about the determinants and standards of smart urban management and its impact on green spaces in the city in order to provide existing recommendations to improve the quality of green spaces in the city while promoting sustainability through smart urban management to reach solutions based on technology and data to improve the management and maintenance of green spaces in urban areas. Research Objectives: The study aims to provide knowledge in the determinants and standards of smart urban management and its impact on green spaces, and the study will discover the following questions: How does smart urban management affect green spaces in the city? What are the best practices for integrating smart urban management and green spaces into the city, and how can city planners and managers design effective strategies to promote sustainable and livable urban environments? Objectives include: (Stojanović et al., 2022)

- Enhance the efficiency and effectiveness of resource use: Smart urban management of green spaces aims to optimize the use of resources such as water, energy and labor, using sensor networks, geographic information systems and other technologies to monitor and adjust resource use today.
- Improving the quality and accessibility of urban green spaces: Using mobile apps and social media platforms, citizens can provide feedback on the quality and accessibility of green spaces, which can be used to inform management decisions and improve the overall user experience.
- Promote sustainability and environmental health: Smart urban management of green spaces aims to reduce environmental impacts such as air and water pollution and mitigate the impact of urban heat islands by increasing the number and quality of urban green spaces.
- Encourage citizen participation and community engagement: By involving citizens in the management process, smart urban management of green spaces can help build a sense of community and ownership around green spaces, which can lead to increased use and support for their maintenance and preservation.

Previous Studies

A study [10] dealt with the role of the information environment in building the smart city, which is one of the latest trends in urban design using artificial intelligence and human intelligence capabilities. The research indicates that the smart city is one of the applications of the information revolution, which aims to enhance the performance and efficiency of service, health, economic, social and environmental in the city. Studies indicate that urban uses of the information environment in the smart city are scarce, so there is a need to study the role of the information environment in achieving the smart city initiative. The study also confirms the role of interdisciplinary information thought in achieving the smart city initiative. The descriptive and analytical research was used to analyze the various variables in building the smart city, and the research concluded that the information environment plays a vital role in building the smart city, and achieving the basic principles of partnership, pluralism and sustainability of city intelligence. A study [17] discusses the importance of green space planning and sustainable landscape design in smart cities, taking into account the different demands for public green spaces. The authors highlight the benefits of public green spaces, such as improving the physical and mental health of citizens, reducing the effects of an urban heat island, and enhancing the overall aesthetic appeal of the city. The article also stresses the need to integrate sustainable design practices into the creation of public green spaces, such as the use of native plant species, reducing water consumption [9], and enhancing biodiversity. The authors suggest that planning priorities in smart cities be set to create diverse green spaces that meet the needs of different residents, including gardens, parks and urban forests. The article concludes by emphasizing the importance of collaborative efforts between various urban planners, landscape architects and citizens in creating sustainable and accessible green spaces in smart cities. A study [32] examined changes used for urban

land and the impact of urban green space conversion on urban heat islands in Baghdad. The research focuses on studying the impact of converting green spaces into urban spaces on the warming of the city and the increasing spread of heat islands. The research also examines the positive impact of green spaces in reducing heat in the city and regulating its temperature. Descriptive and analytical research has been used to analyze changes in urban land use and their impact on heat islands in Baghdad [18]. The research concluded that the conversion of green spaces into urban spaces leads to an increase in the temperature of the city and the spread of heat islands, while green spaces reduce heat and regulate the temperature of the city. The research recommends the importance of continuing to provide green spaces in urban cities and protecting them from conversion into urban spaces, while maintaining a balance between the economic and environmental aspects of urban city development. Several studies have examined the relationship between urban engineering and the distribution of urban heat islands (UHI), with UHI being denser in built-up areas. UHI intensity also varies within built-up areas depending on the type of urban composition, with built-in organic forms having the lowest UHI rates. Building density and classification also affect UHI and overall environmental performance, affecting pedestrian comfort and safety. To mitigate UHI, urban design and density can be adjusted to include urban green spaces, green and blue infrastructure, and home gardens. Afforestation of sidewalks, green urban spaces and roof gardens has been found to increase green spaces and improve outdoor thermal comfort conditions. Architects and designers used climate-responsive strategies, such as the use of patios, to cool high temperatures and reduce commuters' thermal environmental stress. (Efendioglu & Durmaz, 2022)

Theoretical Framework

First We Will Define The Following Concepts

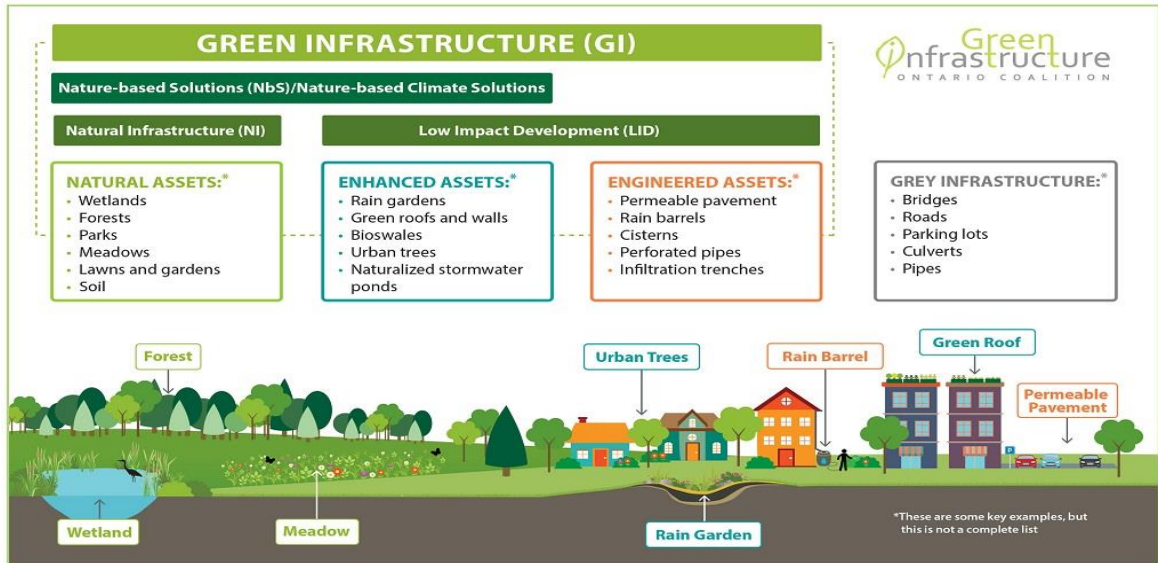
- The concept of green spaces: green spaces are an essential component of smart urban management, and are called green open spaces such as gardens, parks, pastures, forests, grasslands, agricultural lands and other natural spaces[30],[11]. Smart urban management can help cities improve the management and maintenance of green spaces, with technology and data-driven solutions: Promotes energy efficiency. [19] Water conservation, using sensors to monitor soil moisture levels and plant health to improve irrigation efficiency and reduce water wastage [1], [20]. Biodiversity [33], providing habitats for wildlife [17]. Data-driven decision-making where data analytics help improve maintenance schedules, reduce costs, and improve quality [7], [8]. Accessibility, such as secure accessible corridors and entrances [32], [34]. It promotes economic development by attracting tourists, increasing the value of real estate, providing opportunities for local businesses, and creating jobs in areas such as technology, data analysis and maintenance[9], [19].

Figure. 1. Design of green spaces as part of urban management of the city



- The concept of smart management of green spaces: the concept of smart management of urban green spaces includes the use of technology and data to manage and maintain green spaces in cities [11]. This approach aims to increase the availability and quality of green spaces, which may have a positive impact on the environment and the well-being of urban dwellers [2] [18].

Figure. 2. Types of green infrastructure in urban administration of the city



Smart Urban Management

The theoretical framework for smart management of urban green spaces includes several basic concepts and principles. One of these is the idea of a "smart city," which refers to the use of technology and data to improve urban systems and services. In the context of green spaces, this means using sensors, monitoring systems and other technologies to track environmental conditions, monitor plant growth and manage water levels [22]. Another key concept is environmental management, which involves the use of environmental principles and practices to manage natural resources and promote sustainability. This includes practices such as sustainable landscaping, water conservation, and integrated pest management, which can help reduce the environmental impact of urban green spaces while improving their quality and accessibility [19]. (Sánchez-García et al., 2022)

The Smart Management Framework for Urban Green Spaces emphasizes the importance of collaboration and community engagement. This includes working with local stakeholders, [20] such as residents, businesses and community-based organizations, to identify their needs and priorities and involve them in the planning and management of green spaces [21]. This can help build support for green space initiatives and ensure that they respond to community needs and preferences [11]. By integrating these concepts and principles, cities can create green spaces that are not only beautiful and accessible, but also contribute to a healthier and more sustainable urban environment [8]. Smart management of urban green spaces can help ensure effective management and maintenance of green spaces, promoting the well-being of urban dwellers and the long-term sustainability of cities [13]. (Sundriyal et al., 2023)

Smart Urban Management Standards: the following table presents the main indicators for each standard

identified in the literature review as standards for smart urban management of green spaces:

Tab. 1. Smart urban management standards

Standards	Main indicators
Energy Efficiency	Leveraging renewables. Maximize energy consumption. Energy-efficient lighting and equipment.
water conservation	Smart irrigation system Water Saving Fittings Rainwater harvesting
Biodiversity	Selection of native plant species Providing habitats for wildlife Eco-corridors for wildlife
movement Accessibility	Provide secure, easily accessible passages and entrances. Includes people with disabilities or limited mobility. Accessible amenities such as Seats (benches), bathrooms, water fountains and drinking sources.
Data Traffic	Use data analytics for maintenance and management. Management Decision Making. Predictive analytics for maintenance and management. Real-time monitoring of green spaces.
Skilled Workers	Skilled individuals and cadres are qualified for data analysis and decision-making Trained cadres to operate and maintain technology and systems
Privacy & Data	Data Compliance with Data Protection Regulations
Data Security	Transparently collect and manage data. Secure data storage and management. Protection of Personal Information.

Challenges Faced by Cities in Green Spaces

1.1.1. Implementing smart management of urban green spaces can be difficult for cities due to various factors. Some of the challenges faced by cities include: [6]

1. Limited resources: Implementing smart urban green space management requires significant investments in technology and infrastructure, which can be a challenge for cities with limited financial resources.
2. Technical expertise: Smart management of urban green spaces requires technical expertise in areas such as data analysis, sensor technology, and environmental management. Cities may struggle to find employees with the skills and knowledge to implement these systems effectively.
3. Data management: Managing and analyzing data from sensors and other monitoring systems can be complex, and cities may need to invest in data management systems and software to use this data effectively [3].
4. Privacy and security: The use of sensors and other technologies to manage green spaces raises privacy and security concerns, as data collected from these systems may include personal information. Cities must ensure that systems are designed to protect privacy and security. [13]
5. Community Engagement: Smart management of successful urban green spaces requires community involvement. Cities may struggle to engage with diverse communities and ensure that their needs and perspectives are considered in planning and decision-making.
6. Maintenance and sustainability: Smart management of urban green spaces requires ongoing maintenance and maintenance to ensure systems remain effective over time. Cities must consider the long-term sustainability of green space management systems and ensure their resilience to

changes in technology and environmental conditions. [14]

Addressing these challenges requires a collaborative and integrated approach involving stakeholders from multiple sectors, including government, the private sector and society [12], by working together to overcome these challenges, cities can recognize the benefits of smart urban green space management, including improving environmental sustainability and quality of life for urban residents [12].

Controls and Determinants of Smart Urban Management of Green Spaces

Smart urban management of green spaces is a comprehensive approach to the management and development of green spaces in cities and requires the identification and application of controls and determinants to ensure that the goals set are achieved effectively and sustainably [16]. Some of the basic determinants of smart urban management of green spaces can be identified as follows:

1. Use of technology: A smart urban approach to green spaces requires reliance on technology and data to effectively manage and maintain green spaces. The technology used includes sensors, wireless devices, data analytics and artificial intelligence [11].
2. Community Engagement: A smart urban approach to green spaces should include community participation to identify residents' needs and priorities and involve them in planning, implementation and monitoring [4].
3. Sustainability: Green spaces must be designed and developed in a way that promotes environmental, economic and social sustainability, and these factors include the use of integrated water, energy and waste management systems [22].
4. Transparency and governance: Smart urban management of green spaces must have transparency and strong governance to ensure the contribution of all stakeholders and achieve transparency in the decisions taken [25].
5. Maintaining privacy and security: Smart urban management of green spaces must be designed and implemented in a way that ensures the privacy and security of users and the public [24].
6. Integration and coordination: Smart urban management of green spaces must be integrated with inclusive urban management, urban plans, urban planning and other relevant government systems [1].
7. Evaluation and monitoring: The performance of smart urban management of green spaces should be periodically evaluated and improved based on the results derived from the evaluation and monitoring.

Smart urban management of green spaces aims to improve the quality of life in cities and provide a healthy and sustainable environment for residents. By identifying and implementing appropriate controls and determinants, these goals can be achieved effectively and sustainably. Smart urban management of green spaces must be implemented appropriately according to local needs and requirements and must be flexible and adjustable to ensure the achievement of long-term goals. [5]

Green Space Impact

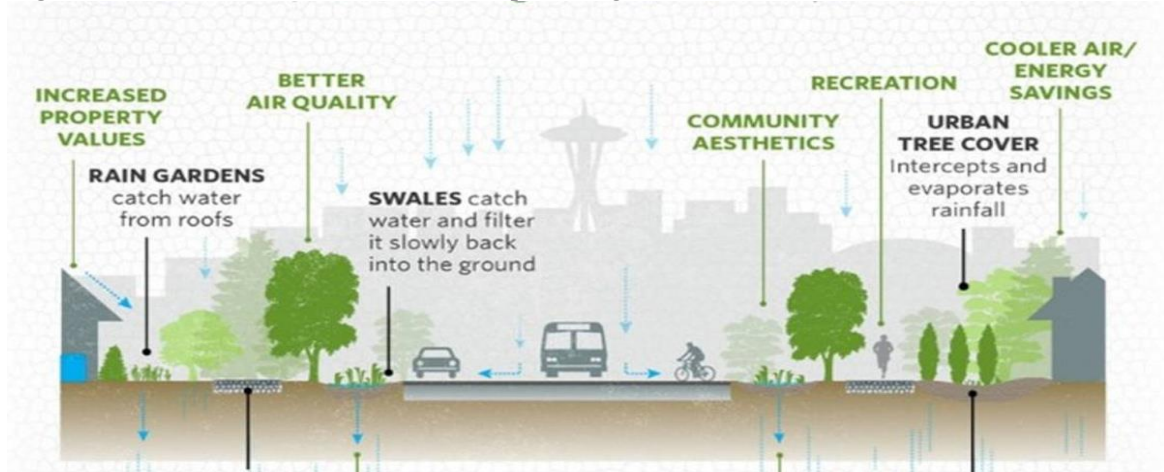
Smart urban management of green spaces can be a powerful tool in improving the quality of life for city dwellers and promoting sustainability in urban environments, and technology and data can play a crucial role in improving the management and design of green spaces.

Other benefits of green spaces that can be achieved through smart urban management include improving the psychological and health quality of life for residents, improving the attractiveness of the city and increasing sustainable tourism, relieving pressure on the city's infrastructure and improving waste and water management. It is also important to consider that smart urban management of green spaces must take place in a balanced and equitable manner among all communities and include the provision of green spaces in slum areas, marginalized and poor [28]. The active participation of local communities and social

and economic partners in the planning, design, implementation and monitoring of green spaces must also be ensured. (Bongardt & Löwe, 2023)

Urban spaces significantly influence life in cities [19], playing an important role in improving the quality of life, the health of residents and the environment. Environmental, social, economic and cultural factors affect urban spaces and their impact on local communities [27].

Figure. 3. Green infrastructure with low-impact designs



The Main Influences Affecting Urban Spaces Are:

1. Improving public health: Urban spaces provide room for physical activity and encourage sustainable and correct mobility, helping to improve the overall health of the population.
2. Improve air quality: green spaces contribute to improving air quality in cities, as they help purify the air from dust and pollutants and improve humidity in the air.
3. Reduce sound pollution: Urban spaces help reduce sound pollution in cities, as they provide sources of noise mitigation caused by traffic and industrial activities.
4. Improving the water cycle: green spaces help maintain ecological balance and improve the water cycle in cities, as they help drain excess water and improve water quality.
5. Improving social life: Urban spaces are sites for social gatherings and interactions and help promote social inclusion and improve social relationships [7]. It must be noted that smart urban management of green spaces cannot be effective without cooperation and partnership between all stakeholders, including local, regional and national governments, private actors, civil society, academia and international organizations. Funding must also be provided for the implementation of projects related to smart urban management of green spaces, improving the digital infrastructure in cities and providing the necessary logistics services to implement these projects.

Case Studies

Global Examples

There are many examples of the application of smart urban management of green spaces in different cities

Singapore

In the city of Singapore [13], a comprehensive approach was applied to reduce urban heat islands, improve air, water quality, and increase the city's biodiversity. Key initiatives in this approach include the creation of public green spaces, parks and natural areas, the application of improved irrigation technology and organic fertilization, and improving air quality by installing air purification systems on roadsides and buildings [37]. Singapore is a leading example in the application of smart urban management to preserve the environment and improve the quality of life in the city. This includes the innovative use of cutting-edge technologies in urban design and natural resource management, such as solar energy, vertical wells, miniature desalination plants and water spray instead of air conditioners. Singapore's smart city also incorporates a holistic approach to environmental conservation [29], including designing green spaces, parks and gardens, applying improved irrigation and organic fertilization techniques, controlling diseases and pests in natural ways, enhancing biodiversity and improving the city's air and water quality. (Afaneh & Bello, 2023)

Figure 4. A playground on the roof of a Copenhagen urban building (1)



Copenhagen

Smart urban management of green spaces has also been implemented in Copenhagen in Denmark, where green spaces are designed in line with climate change and reduce the impact of urban heat islands (38). Key initiatives here include creating rooftop gardens, effectively managing water and improving air quality through proper plant planting. [35]

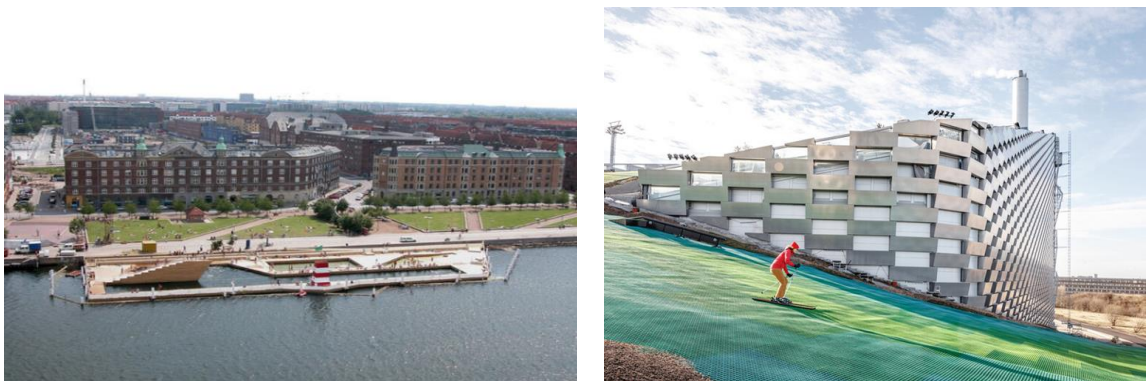


Figure 5. Transforming industrial buildings and port using smart urban technologies(2)

Smart urban management of green spaces in the city of Copenhagen has been applied in other ways as well. The city's green spaces are designed in line with local environmental needs, allowing citizens to take full advantage of the landscape, sports, and leisure activities. [29]

Figure 6. A playground on the roof of one of Copenhagen's urban buildings



Other key initiatives implemented in the city include improving soil quality, improving biodiversity, and creating opportunities for community participation in urban agriculture, school gardens and wildlife parks. [36]

Barcelona

The city of Barcelona, Spain, is one of the leading cities in the use of smart technology and data to improve the management of green spaces in the city. These technologies include the use of smart irrigation technologies and smart design of parks and public green areas and enhancing social interaction and communication with the community to make green spaces more engaging and used [17]. (Comas & Cervera, 2023)

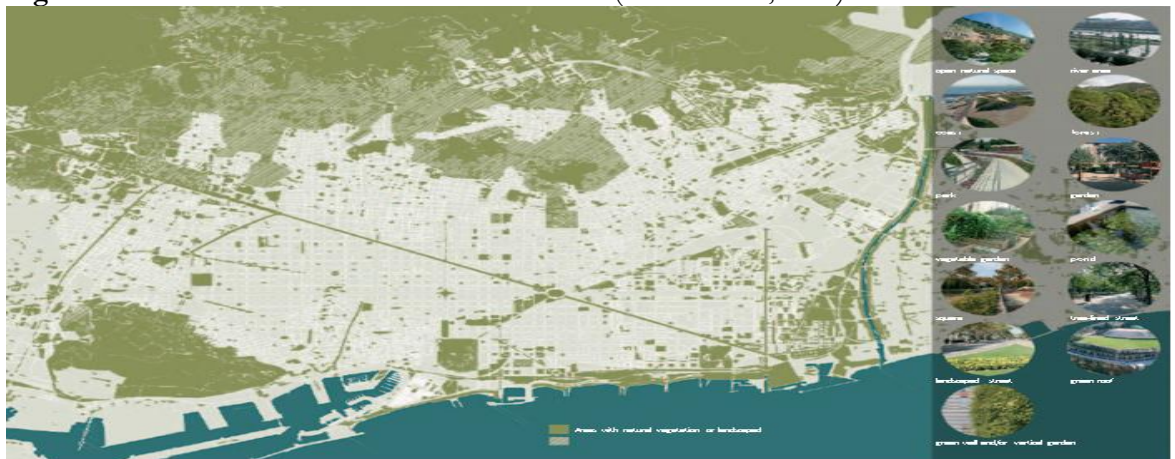
The city uses digital software that uses sensors and data analysis to achieve these goals, to improve the quality of life in the city, save energy and water, and improve the transportation system and waste management. These technologies include the use of optical fiber to improve energy efficiency, the use of smart devices to monitor the level of waste in garbage containers and the improvement of waste collection truck routes and identify specific parking locations using sensors [30]. For garden irrigation, irrigation officials use sensors to track rain and humidity levels and adjust the amount of water used in each area. In this way, sustainability in water use can be achieved and the efficiency of the city's natural resource use improved.

Figure 7. Sustainable urban planning for the city of Barcelona(3)



These examples show that smart urban management of green spaces can be effective in improving the quality of life for city dwellers and promoting sustainability in urban environments and this can be achieved using technology, data and good practices in the design and management of green spaces.

Figure 8. Barcelona's Green Infrastructure Network (Basnou et al., 2020)



Melbourne

The city of Melbourne in Australia uses modern technology and data to improve the management and maintenance of green spaces in the city, and to design new parks and green areas to meet the needs of the local community. Smart irrigation and smart design programs have been implemented to improve water and soil quality in green spaces [11]. Technologies used in Melbourne include the use of sensors to monitor water levels and control the amount of water used for irrigation, and the use of internet data to monitor the state of plants and determine the need for water. The city also uses smart design techniques to improve soil quality and save energy, including the use of native plants suitable for local climatic conditions, and the use of green flooring technologies to improve the moisture level in the soil [31].



Figure 9. Roofs and green spaces in the city of Melbourne (4)

Case studies show practical examples of the application of smart urban management of green spaces in cities around the world. These studies demonstrate how technology, data and smart design can be used to improve the availability and quality of green spaces in cities and increase environmental and social sustainability in cities. These case studies are examples of the application of technology, data and smart design in the management of green spaces in cities, and can be used as models to achieve the required change in other cities, improve the management of green spaces and increase their availability and quality, thus achieving environmental and social sustainability in cities (32)

Arabic Examples

Dubai

Dubai is a great example of smart urban management of green spaces, as local authorities work to transform it into a smart and sustainable city. The efforts of local authorities to manage green spaces in Dubai include the use of smart technology and data analysis to improve the management and operation of green spaces in the city (33) and (34).

Figure 10. Emirates Today



Some of Dubai's efforts to manage smart green spaces include:

1. Using smart technology in water and electricity management, improving resource efficiency and saving environmental and economic costs.
2. Identify biodiversity levels and improve management to enhance it.
3. The use of modern technology such as sensory sensing, wireless networks, intelligent monitoring and big data analysis to improve the management and operation of green spaces in cities. (40)
4. Designing green spaces in locations compatible with smart buildings, improving the user experience, and providing integrated services.
5. Through these efforts, Dubai seeks to achieve sustainable development in cities and improve the quality of life in them, as well as achieve environmental sustainability and reduce the consumption of natural resources and harmful emissions. (33)

Dubai is known for its modern infrastructure and innovative approach to urban development. The implementation of smart urban management of green spaces is one such initiative that highlights the city's commitment to sustainable urbanization. By leveraging the latest technologies, Dubai has been able to efficiently manage its green spaces, use smart solutions in managing green spaces and engage residents in managing green spaces [4]. Smart irrigation systems implemented in Dubai Parks and Resorts and Dubai Miracle Garden demonstrate the city's commitment to reducing water use and conserving its natural resources. These initiatives not only improve the sustainability of the city, but also enhance the experience of residents and visitors by creating more livable and attractive urban environments. (39)

Analysis of two case studies according to the specific criteria for smart urban management of green spaces.

Tab. 2. Analysis of two case studies according to the criteria set for smart urban management of green spaces.

Standard	Case Study One: Dubai City Case Study	Case Study Two: Singapore City
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Energy efficiency	Uses solar lighting and irrigation and Energy Saving LED Lighting	Using Solar Panels for Power Generation Energy-saving LED lighting
water conservation	Automated and intelligent irrigation systems, sensor-based monitoring of soil moisture levels, remote monitoring and control of irrigation systems.	Rainwater harvesting system
Biodiversity	Choose native plant species Public parks and other green areas Nature reserves and provide the necessary spaces for wild animals and plants.	Extensive vertical gardens
Accessibility	Accessible corridors and entrances, for people with Special needs or limited mobility	Inclusive design for people with Special needs or limited mobility
Decision Making	Predictive Analytics for Maintenance	Optimization and Maintenance
Planning Secure data storage and management	Protection of Personal Information	Protection of Personal Information
Skilled individuals	Trained personnel to operate the technology maintenance and decision-making	Skilled data analytics personnel and qualified cadres for maintenance and decision-making
Privacy and data transparency	Transparency of data collection	Data collection compliance with data protection and Security Administration & Regulations

The analysis shows that both studies include several specific criteria for smart urban management of green spaces. These study cases illustrate the potential benefits of implementing smart urban management strategies for green spaces.

Discussion and conclusion

Improving green spaces in cities is an important topic that needs serious attention. It is important to understand the challenges of implementing smart urban management strategies, including high costs, lack of adequate data and expertise, and potential resistance from stakeholders. However, the benefits of smart urban management of green spaces outweigh these challenges. They help improve the quality of life for the population, reduce resource consumption and waste generation, economic growth and innovation. Improving green spaces in cities through smart urban management can lead to improved air quality and provide opportunities for exercise and relaxation, contributing to improving the quality of life of residents. By using sustainable landscape practices and managing natural resources responsibly, cities can reduce their environmental impact and contribute to a more sustainable and resilient urban environment. Therefore, we must focus on improving knowledge of the determinants and standards of smart urban management and their impact on green spaces in the city. Research and technologies must be supported to develop smart solutions to improve green spaces in cities. When implementing smart urban management strategies, we must take into account the challenges associated with this approach and overcome them in a responsible and sustainable manner. (Estok, 2023)

Recommendations

The following recommendations can be made to improve green spaces in cities through smart urban management: Promote research and development:

1. Research and development in the field of smart urban management should be strengthened and knowledge of the determinants and standards of smart urban management and its impact on green

spaces in the city should be improved. Research and technologies can help develop smart solutions to improve green spaces in cities.

2. Enhance cooperation: cooperation between different actors, including government institutions, private companies, civil society and residents should be strengthened to improve the management of green spaces in cities. Cooperation should include the exchange of knowledge, expertise, data and technology, and the provision of the necessary financial and human resources.
3. Improving the quality of green spaces: the quality of green spaces in cities should be improved by using available data to monitor environmental conditions and manage resources such as water. Cities can promote the growth of natural plants and trees, which can improve air quality and provide other environmental benefits.
4. Technological modernization: modern and advanced technology must be used in the management of green spaces in cities to improve the efficiency of their management and improve the quality of life for residents. Technology can be used to monitor environmental conditions, manage resources, analyze data, and develop smart applications to help manage green spaces in cities.

Notes

1. See: <https://aawsat.com/home/article/2780906> (Last Access: 31\5\2023).
2. See: <https://www.beesmart.city/en/strategy/smart-environment/smart-cities-in-spain-the-commitment-to-a-green-economy> (Last Access: 31\5\2023).
3. See: <https://www.beesmart.city/en/strategy/smart-environment/smart-cities-in-spain-the-commitment-to-a-green-economy> (Last Access: 31\5\2023).
4. See: <https://www.architectureanddesign.com.au/features/comment/green-cities-become-mainstream> (Last Access: 31\5\2023)

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