The development of ecological smart cities in the post-epidemic era

Jiaxin Yi *

School of Architecture, Design and Planning, University of Sydney, Sydney, Australia

* Corresponding author: jiyi2209@uni.sydney.edu.au

Abstract. With the accelerated development of globalization and urbanization, the advent of the post-epidemic era means that the world has begun to enter the recovery stage, and the rapid development of urbanization has caused cities to transform from a decentralized model to a centralized model. The growing population puts cities under tremendous pressure. This paper studies the case of Barcelona, analyzes and summarizes the development of Barcelona's ecological smart city, as well as the practical application of information technology and Internet of Things technology, and discusses the challenges faced by smart cities. The concept of ecological smart city consists of the Internet, openness, intelligence, innovation and green to form an urban planning framework. Lay out smart sensors according to the size and shape of urban space, and use smart technology to activate the city's ecosystem. The digitalization and IoT technology services of smart cities are not only conducive to the tracking and prevention of the epidemic, but also conducive to the recovery and development of the city in the post-epidemic era. Smart cities represent the development of a city that is more efficient, sustainable, and livable. The development trend of smart cities is characterized by the integration of advanced technologies to improve the quality of life of urban residents, improve sustainability, and optimize city operations. Finally, it provides some suggestions and experiences for the development of smart cities in the world and expectations for the future of this field of research.

Keywords: Post Covid-19 era, Smart City, City's Ecosystem.

1. Introduction

In the post-epidemic era, the COVID-19 pandemic faced by the world has triggered a rethinking of urban space. After 2020, COVID spread rapidly between countries, resulting in high mortality rates. On March 11, 2022, World Health Organization (WHO) assessed the coronavirus pneumonia as a pandemic [1]. This pandemic trend disrupts cities and transforms cities and spaces. Especially in the central business district [2], due to the high urban population and building density, crowded spaces are conducive to the spread of the epidemic. Anti-epidemic interventions have reduced people's use of public spaces and people's quality of life, thus leading to recession [3].

The economic, transportation and social connectivity of cities, as well as the contracted development of cities make cities key transmission areas for infectious diseases [4]. These characteristics make cities vulnerable during the pandemic [5]. The epidemic has posed challenges to public health and culture, prompted people to rethink the design of building types and public spaces, and thus, promoted the concept of smart cities with intelligent network systems and digital management [6].

In the post-epidemic era, cities need advanced technology and urban environment even more. Currently, smart cities have become the best solution to address urban challenges. It can optimize urban space, green space, transportation and water resources management through data and IoT technologies, and detect and monitor through technologies such as sensing technology, camera and visualization [5]. In addition, under the influence of the epidemic, smart services in cities are conducive to epidemic prevention, control and recovery [4]. Smart cities use information technology and innovation capabilities to connect urban systems and services, which can govern and serve the city more efficiently. The use of computer technology can carry out the design and interactive experience of virtual space, and improve the accuracy of data, providing guidance for future urban architectural space structure design [7]. From the perspective of urban planning, the future

development of the city needs to provide more public spaces and green spaces, and accurate data comes from the support of advanced information technology. Research on ecological smart cities in the post-epidemic era can promote the sustainable development of cities, including creating public open spaces, reducing pollution, protecting the ecological environment and water resource utilization, improving the well-being and health of residents, preventing natural disasters, improving community services and intelligent traffic management, etc. Therefore, in the post-epidemic era, studying the development of ecological smart cities is crucial to the sustainability of cities and the human living environment.

This paper combines the characteristics of the post-epidemic era, takes the successful ecological smart city of Barcelona as an example, and analyzes the development of ecological smart cities in the post-epidemic era. Through the research of this article, urban planners can gain an in-depth understanding of how the combination of information technology and ecological environment can promote the sustainability of urban environment and economy, achieve fair and reasonable allocation and efficient management of urban resources, and create a livable life. This paper will use the case study of Barcelona to explore and demonstrate how Barcelona successfully transformed into a smart city through information technology, and to solve the following research questions:

① How does the Barcelona Municipal Government formulate strategies and take actions to transform?

② What are the specific applications and implementation of IoT technology in Barcelona?

③ What are the various obstacles and challenges faced by smart cities?

2. Research Status

Although the world is paying attention to how smart cities can help the sustainable development of cities, current research on ecological smart cities is very limited. The ecological development of smart cities is mainly reflected in the ability of smart cities to repair themselves. At the same time, smart cities can use information technology to enhance the management of natural resources. However, current management of natural resources is often data-starved. In addition, the management of natural resources requires a lot of financial support and planning, as well as the support of government policies and the supervision of relevant departments. Involving citizens in government sector decision-making and management of natural resources is conducive to building livable and inclusive cities [5]. In addition, smart cities need long-term unified planning and comprehensive utilization, and early establishment of urban early warning and feedback systems. Research in this area is important due to the growing demand for green spaces and livability. The epidemic has highlighted the development trend of ecological smart cities in line with future sustainability [4]. Smart cities should give priority to the city's innovation ecosystem, change the characteristics of traditional cities, and achieve the sustainability of the urban environment with "green" and "smart" innovation [8].

3. Case Study: Take Barcelona Ecological Smart City as an example

3.1. Introduction to case city

The most obvious change of the twenty-first century is the rapid development of urbanization around the world. Cities have become the biggest driving force for a country’s development, and more than half of the world’s population will live in cities, and there will be 60 cities with 5 million people in the world [9]. Among these cities, Barcelona is famous for its unique urban design planning and smart city. Barcelona has a history of more than 2,000 years and is a city full of innovative spirit. Barcelona is the capital of Catalonia in Spain. It has the sixth largest population in the European Union and has a long history and cultural heritage [9]. Besides, Barcelona is a world leader in tourism, culture, finance and information technology [10]. The city has won many smart city awards in recent

years. Therefore, using Barcelona's successful ecological smart city and its experience as the main sample for analysis can provide a comprehensive understanding of the development trajectory of ecological smart cities [8].

3.2. Barcelona strategize and take action to transform

The concept of smart cities can be simply described as deploying information and communication technology in various fields to support sustainable growth and enhance residents' lives through participation and improved economic efficiency [11]. The goal of the Barcelona Smart City initiative is to involve citizens in services and co-innovation processes through open data and the development of living laboratories. In an open environment, citizens can discover and generate positive smart idea. By stimulating the wisdom and interest of citizens through the participatory process, Barcelona combines people, information and urban elements, encourages various government unity and cooperation, and uses Internet of Things technology to change government administrative business processes to facilitate friendly access for residents [11].

Barcelona's smart city measures have four parts: smart governance, smart economy, smart living and smart residents. To support these measures, Barcelona has created an advanced infrastructure using information and communication technologies, providing a powerful network platform to connect various urban elements. The entire city is covered by fiber optic networks and sensors, and Barcelona uses information technology to create a smart city information space [11]. These infrastructures enable connections and interactions between residents and businesses, as well as management. Barcelona combines urban planning with smart technology and follows a top-down strategic plan led by the city council. In 2009, the Barcelona City Council proposed the use of a "smart city" model to improve residents' living standards and the sustainability of the city, making Barcelona a global reference standard model for the development of urban innovative ecological environment [10].

3.3. Specific applications and implementation of IoT technologies in Barcelona

Smart city IoT technologies include sensors, smart cards, actuators, quick response codes, geographical information, GPS, smart social networking, smart environment, business intelligence, cloud computing and a series of other technologies. These IoT technologies are deployed by the Barcelona Municipal Government in various areas, leveraging technology to provide residents with a better quality of life [9]. The first renovation of the Eixample district of the superblock expanded a green city block into 520 blocks, with high-quality and design buildings in the blocks, becoming a model of urban design. In smart planning, through Internet of Things technology, citizens can participate in and share multiple media services, reflecting the inclusiveness of urban planning [10]. Barcelona's eco-smart Plan include alternative energy, green buildings and traffic management, with the aim of reducing CO2 emissions, for example: in 2006, 40.095 square meters of roofs were covered with solar panels, making it the city with the most solar panels in Europe [10].

In addition, Barcelona Smart City provides new smart services including fiber optic networks, wifi networks and sensor networks, such as the communication infrastructure fiber optic project launched in 1994 [11]. These smart services represent the true innovation and openness of a city, currently, 90% coverage has been completed. This network has become an important urban system network in Barcelona, and the number of wifi users has grown rapidly since 2013 [12]. Barcelona's IoT technology has enabled broadband coverage throughout the city and a broadband economy, and has provided free services to residents. Residents can connect to the Internet through municipal facilities and public access points [10], and can access to municipal facilities and public service centers, including recreation centers, libraries, municipal advisory offices, parks, and community service centers [9]. As shown in Fig.1.

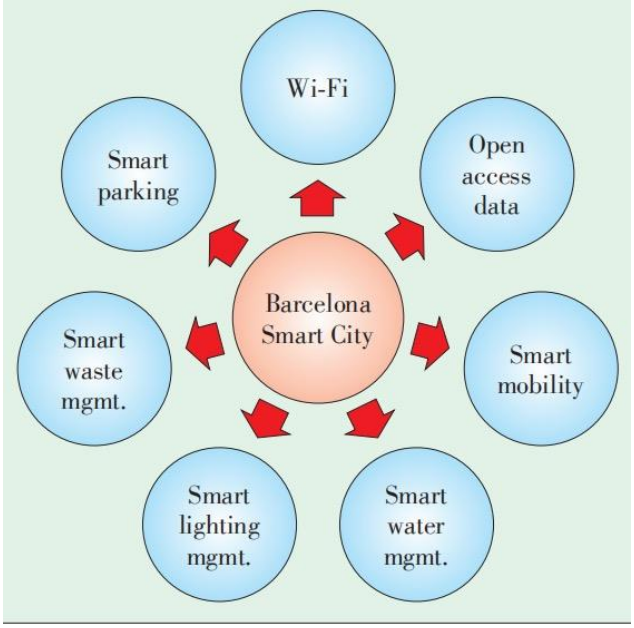

Figure 1. Content of Barcelona Smart City Project

Barcelona's open database collects information and data including street maps, public infrastructure, population, economy and business, and finally applies big data analysis software for sorting and analysis [9]. In addition, the Barcelona City Council and other institutions are cooperating to implement the Barcelona 5G plan to create an open urban laboratory and build Barcelona into a social laboratory for 5G technology in Europe.

Barcelona has established a smart city department to coordinate the services of various departments in infrastructure, urban planning, urban environment, construction, energy and water resources, and create an open and intelligent environment. The new municipal IoT network also includes smart water management, smart lighting, smart waste management, smart transportation and smart buildings, etc. [13], among them, smart water management systems have become a key issue in urban management. Population growth and climate change both affect access to water resources. Barcelona provides safe and good services for urban freshwater transportation and urban ecology (including green spaces and parks) through smart water management technology, using sensor technology to collect information on humidity, temperature and wind speed, and using programs used by computers, smartphones and actuators to automatically adjust the amount of water used for plant irrigation, smart water technology saves Barcelona $58 million per year and has become the best way for people to use water every day [9]. Smart buildings and smart infrastructure also use sensing technology to install smart meters and sensors in buildings to monitor and optimize resources to achieve intelligent resource management [12], for example: the 2012 Barcelona Smart Lighting System Project, combining urban power generation, transmission, distribution, and consumption with information and communication technologies can control street lighting to achieve improvements in energy efficiency [9]. In addition, the Barcelona government has developed the Sentilo platform, which connects 18,000 sensors across the city and monitors many aspects such as weather, electricity usage, water consumption, environmental pollution, noise and air quality. The city uses open data from the city operation platform, ensuring that the public can obtain information at any time and provide real-time and optimized services [12].

3.4. Various obstacles and challenges faced by smart cities

As Barcelona develops as a smart city, the city also faces many challenges. The development and integration of various advanced innovative technologies have brought higher demands for energy and infrastructure, increasing the pressure to find alternative energy sources. Sensor and equipment update technology affects the accuracy of measurements. Smart cities lack unified practices and technical standards, making it difficult to evaluate smart models between cities [12]. The construction

of smart cities will cause new concerns about energy consumption and E-waste creates new urban problems [12]. With low entrepreneurship rates compared to other European cities and a lack of global connectivity [11], and with the city facing cybersecurity and citizen privacy issues, as well as legal and regulatory issues, Barcelona must also find sustainable financial support, despite various problems in the development of smart cities, but Barcelona is working hard to solve these problems through innovative policies and technologies, technical cooperation and citizen participation to create a more ecological and sustainable smart city model for the world.

4. Conclusion

The research theme of this article is to explore the development of ecological smart cities in the post-epidemic era. This article takes Barcelona as an example to analyze the development model of smart cities. Especially in the post-epidemic era, the development of smart cities has become unstoppable. Through the analysis and discussion of this article, the practical application technology and importance of information technology and the Internet of Things in smart city construction are summarized, proving that cities can achieve sustainable development by relying on innovative technologies.

Only with the recognition and support of national development strategies and local governments can ecological smart cities be truly constructed and developed. Just like Barcelona's urban transformation, the smart city can develop through top-down support from national policies and departmental planning, and also achieved economic growth. The successful experience of Barcelona's smart city is worth learning from. But there are still many issues that require more time to understand and resolve. It is worth noting that in this urban transformation, stakeholder participation is particularly important. Stakeholders can provide valuable insights into the needs and development of the city. In addition, digital services for citizens will create new social gaps. Smart cities should avoid causing new social inequality problems, citizen participation and interaction should become a priority in smart city construction, and promote cooperation and synergy between various departments.

The construction of smart cities also depends on urban policies, characteristics and market needs. Different urban development strategies have different urban smart projects. A city's smart strategy will be based on which model is adopted, whether it is open innovation or closed innovation, and the city's business and economic model ultimately leads to different results.

References

[1] Who. int.Listings of WHO's response to COVID-19.2022. [online] Available at: <https://www.who.int/new s/item/29-06-2020-covidtimeline> [Accessed 27 August 2022].

[2] Brail, S. and Kleinman, M. Impacts and implications for the post-COVID city: the case of Toronto. 2022, 15 (3), 495 - 513.

[3] Mouratidis, K. and Yiannakou b, A., 2022. [online] https: //doi.org/10.1093/cjres/rsac022. Available at: <https://www.researchgate.net/publication/355196951_-COVID-19_and_urban_planning_Built_environment_health_and_well-being_in_Greek_cities_before_and_during_the_pandemic> [Accessed 27 August 2022].

[4] Zhoujiao, T. Post-epidemic era: Reflections and suggestions on the construction path of Smart Cities', Proceedings of the 2021 5th International Seminar on Education, Management and Social Sciences (ISEMSS 2021), 2021, [Preprint]. doi:10.2991/assehr. k. 210806. 179.

[5] Hui, C.X. et al. 'Greening smart cities: An investigation of the integration of Urban Natural Resources and Smart City Technologies for Promoting Environmental Sustainability', Sustainable Cities and Society, 2023, 99, 104985.

[6] Capolongo, S. et al. COVID-19 and Cities: from Urban Health strategies to the pandemic challenge. A Decalogue of Public Health opportunities', Acta Biomed.2020, [Preprint]. doi: 10.23750/abm. v91i2.9515.

[7] Cai, Z. New Space, new thinking, and new guidance', Advances in Social Science, Education and Humanities Research,2022. [Preprint]. doi:10.2991/assehr. k. 220205.037.

[8] Mora, L. and Bolici, R. The Development Process of Smart City Strategies: The Case of Barcelona', FUTURE CITY — COMBINING DISCIPLINES 2016.

[9] Madakam, S. and Ramachandran, R. Barcelona Smart City: The Heaven on Earth (Internet of Things: Technological God)', ZTE COMMUNICATIONS, 2015, [Preprint]. doi: 10.3969/j.

[10] Zygiaris, S. Smart City Reference Model: Assisting planners to conceptualize the building of Smart City Innovation Ecosystems', Journal of the Knowledge Economy,2012, 4 (2), 217 – 231.

[11] Bakıcı, T., Almirall, E. and Wareham, J. A smart city initiative: The case of Barcelona', Journal of the Knowledge Economy, 2012, 4 (2), 135 – 148.

[12] Nerds, A. The future of internet of things in Smart Cities - Barcelona Case Study, Custom Software Development Company Poland.2023, Available at: https://angrynerds.co/blog/the-future-of-internet-of-things-in-smart-cities-ba rcelona-case-study/ (Accessed: 17 November 2023).

[13] Angelidou, M. Four European smart city strategies', International Journal of Social Science Studies, 2016, 4 (4).