A Preliminary Study on the Sustainable Development of High-Density Cities

Lu Xing *

Department of Environmental Design, Beijing Forestry University (BJFU), Beijing, China

* Corresponding Author Email: luciasing@163.com

Abstract. In the process of development of high-density cities in China, it has become important to promote the intensive and compact use of urban land, explore the efficiency of land resource use, and create a dynamic environment that is mobile, convenient, and pedestrian-friendly. In order to address a series of challenges of high-density urban development, this paper mainly analyzes the high-density urban development patterns in Japan, and Singapore regions. The study concludes that three-dimensional cities and transit-oriented integrated development are the key strategies to achieve this goal. This paper explores trends and sustainable practices in high-density urban development. This paper sorts out the development framework of high-density cities and discusses the construction characteristics and development trends of contemporary high-density three-dimensional cities from the perspectives of land use, green building assessment, traffic management, and public participation. This paper compares the focus of different measures in different regions, as well as the intensive development of public space and vertical greening measures, which have certain reference values for the sustainable development of high-density cities in China.

Keywords: High-density cities, Sustainable development, Green, Transportation.

1. Introduction

According to the Built Environment Density in Major Cities in China 2023 report, the urbanization rate of China's resident population increased from 60.2% to 65.2% from 2018 to 2023. This indicates that China's urbanization is still in the zone of rapid development. Cities are absorbing more and more population to gather rapidly in core metropolitan areas. Under the influence of the trend of rapid population mobility, cities inevitably started the exploration and practice of high-rise and high-density. High-density urban land presents the characteristics of high building volume ratio, high building coverage, and dense high-rise buildings, as well as high-intensity space for urban development and construction. However, the population and construction intensity brought by high-density cities have triggered a series of environmental problems, including air pollution, water shortage, and noise problems. The orderly development of high-density cities will have a positive impact on urban economy, ecology, social stability, and space utilization, and bring power and vitality to urban development. However, at the same time, it has to face ecological challenges such as the obvious urban heat island effect, declining quality of human habitat, and poor environmental quality. The urban design of high-density areas needs to ensure that the advantages of perfect infrastructure, full of community vitality, and efficient public transportation system can be brought into play, while at the same time avoiding the problems arising from high-density environments, so that people in high-density environments can still enjoy the treatment of low-density spaces, such as parks, greenery, and public spaces.

This paper aims to summarize and analyze contemporary trends in high-density cities, with a focus on combining current urban development status with applied solutions. Through the evaluation of green buildings and secondary analysis of urban green transportation planning, this paper will provide sustainability planning oriented to the development of high-density cities to meet the various challenges that arise during the development process.

2. Exploration of Sustainable Development of High-Density City

To cope with a series of problems arising in the development of high-density cities, various cities have carried out a series of explorations from different perspectives, and this section mainly explores the direction of sustainable development of high-density cities in terms of green buildings and green transportation.

2.1. Green Building and Three-Dimensional City Concept

With the improvement of human construction technology, more and more viaducts, underground roads, tracks, and other infrastructure have appeared in the city, and large-scale three-dimensional spaces have been built to meet the needs of people's modern life, such as roof gardens, aerial commercial streets, sunken squares, etc. In these urban design practices, the spatial organization combines commercial space, office space and urban public greening, and the spatial function tends to be a complex space with multiple functions from a single-function special space. The exploration of the transformation of the city from a "two-dimensional plane" to a more refined "three-dimensional space"[1]. This transformation prompts people to think more systematically about the "three-dimensional city", and explores the challenges of the construction and development mechanism of three-dimensional urban space, the performance of space use, the quality of public space, and the continuity of the pedestrian system.

Singapore is committed to sustainable development by integrating greenery into the built environment. Kampung Admiralty is Singapore's first integrated public development that maximizes land use by integrating public facilities and services (Fig.1). The vertical greening of the project combines the three-dimensional urban space design, and the community garden on the upper floor embodies the design concept of "terrace" greening, ensuring the diversity of biology, functions, and facilities, and enriching the spatial structure level of architectural landscaping and the artistic effect of three-dimensional landscape. Kampung Admiralty further increases the green area on the building surface, which forms a canopy with vertical diversity and continuous horizontality, creating low-temperature microclimate conditions, reducing the heat island effect in local areas, reducing harmful gases and noise, and improving the living environment of residents. The project also has an efficient water collection and utilization system that collects, cleans, and recycles rainwater for the domestic portion of the water, plant irrigation, and water features. At the same time, solar panels use solar energy to power the two residences, and the benefits of the wind shafts increase natural lighting, reducing the need for artificial lighting and saving energy. This kind of low-energy-intensity, low-energy building can be labeled as a green building, and optimizing the energy use of green buildings is one of the focuses of green buildings [2].

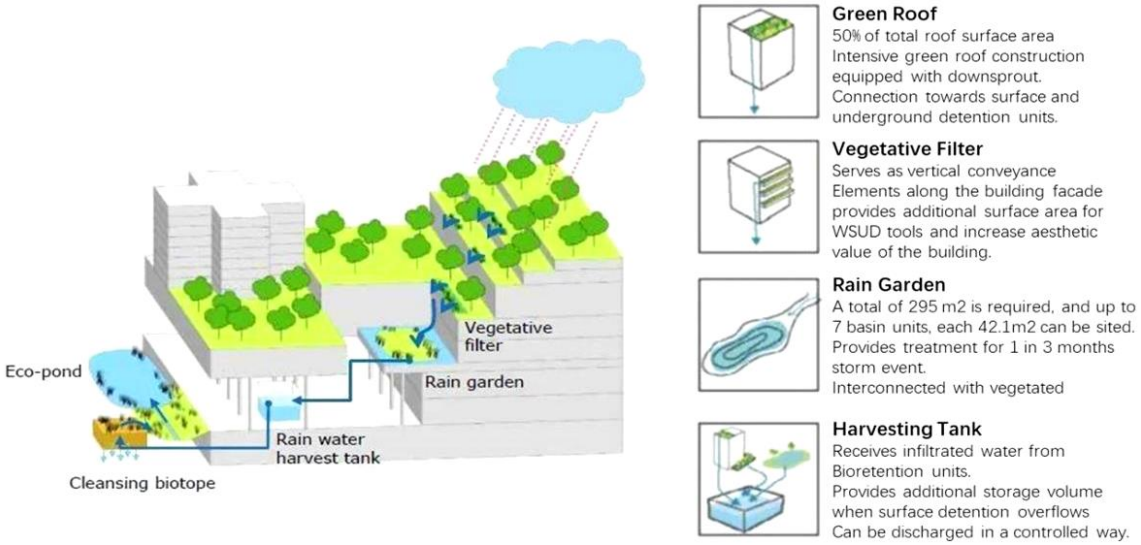

Figure 1. Kampung Admiralty Green building illustration; Sustainable design and technology [3].

2.2. Transport-Oriented Urban Development Model

Next, this paper takes Tokyo and Singapore as examples to provide a feasibility analysis for the sustainable development of high-density cities from transport-oriented urban development. Among high-density cities, Tokyo has successfully adopted the Transit Oriented Development model (TOD). This model integrates residential, commercial, and office functions by building integrated development projects around transportation hubs to improve land use efficiency and transportation convenience. In terms of land use efficiency, the TOD model makes full use of the land around the transportation hub in Tokyo through reasonable planning and layout. By constructing high-density integrated development projects around transportation hubs, land use efficiency can be maximized. In addition, Tokyo's TOD model focuses on integrating different functions, such as residential, commercial, and office functions in integrated developments around transportation hubs. This can provide convenient living and working conditions, and reduce people's commuting time and transportation costs. In terms of transportation convenience, Tokyo has a developed transportation network, including subway, light rail, bus and other modes of transportation. The dense layout of these transportation facilities provides the basis for the implementation of the TOD model, making it easy for people to move around the transportation hub and reduce their dependence on private cars. As a high-density city with a population density of 6,410 people per square kilometer, Tokyo pays attention to urban planning and design during the implementation of the TOD model and creates a livable urban environment by means of reasonable building height, road layout, and green design. This not only improves the quality of life of the residents but also increases the value of the land. In general, the key to the success of Tokyo's TOD model in land use is the efficient use of land resources, mixed-use development, dense transportation networks, and good urban planning and design. These experiences can provide a reference for other cities in the implementation of TOD model.

In contrast, Singapore, as another high-density city, has implemented sustainable urban planning. The city has solved the problems caused by the rapid development of traditional cities through the concepts of humanism, green, energy saving, and livability. On the one hand, Singapore provides affordable housing for residents through the construction of public housing and new towns. Public housing projects are widely distributed in various areas of the city to meet the needs of residents of different income levels. On the other hand, Singapore has focused on developing an efficient public transport system, including the Metro, bus, and light rail. The extensive network coverage of these vehicles makes it easier for residents to travel and reduces private car use, thereby reducing traffic congestion and air pollution. At the same time, Singapore encourages the mixed-use of land in urban planning, that is, the combination of residential, commercial, office and leisure facilities in the same area. This mode can reduce the commuting demand, improve the convenience of life and work efficiency of residents; Environmental protection and greening. Finally, Singapore pays attention to protecting the environment and providing green space. They are actively engaged in urban greening, building parks and gardens, providing leisure and entertainment venues, and improving the quality of life of residents. Singapore's urban development is mainly led by the government, which plays an important role in land planning, housing construction, transportation planning and so on. Government planning and management ensure the overall coordination and sustainability of the city [4].

3. A Framework for Promoting Sustainable High-Density Urban Development

To sum up, high-density cities are characterized by high population concentration, high development intensity and high economic vitality. From the case analysis of urban development in Singapore and Japan, it is found that the sustainable development of high-density cities can be optimized from the following aspects. First, cities need to improve land use efficiency through rational planning and the development of urban interior space. Such as the transformation of urban villages, improving the building density, etc., in order to maximize the use of limited land resources. And establish long-term development planning and green building evaluation standards, encourage buildings to adapt to local conditions and green ecological integration, for example, urban buildings

can adopt renewable energy utilization, energy-saving building design, and other strategies to reduce dependence on energy. Secondly, the city actively promotes the construction of transportation infrastructure, combining walking distance and road travel planning, including the construction and improvement of public transportation systems such as subway, light rail, and bus, in order to reduce traffic pressure and alleviate congestion. Green modes of travel, such as cycling, walking, and bike-sharing, are also encouraged to reduce reliance on roads. Improve the infrastructure construction of electric vehicle systems, the availability of charging piles in residential areas, and reduce carbon emissions of family units. Future cities should also focus on the development of intelligent transportation systems, using advanced scientific and technological means to improve traffic management and operation efficiency, such as intelligent traffic lights, traffic flow monitoring, and regulation systems, in order to optimize traffic flow and reduce congestion.

These are the sustainable development strategies implemented by high-density cities facing the challenge of limited land and resources. Therefore, it is necessary for cities to make efficient use of existing resources, which includes promoting energy-saving and emission-reduction technologies, improving energy efficiency, and promoting a circular economy. The high-density urban development is faced with the problems of high population concentration and the compression of personal living space. It calls for greater attention to social equity and inclusion. This includes providing good public service facilities such as education, health care, and culture, and ensuring that urban residents enjoy equal opportunities and welfare. At the same time, attention should be paid to the needs of vulnerable groups to ensure that they can be integrated into the process of urban development. The sustainable development of high-density cities requires extensive public participation and community construction. This includes encouraging citizens to participate in urban planning decisions, and promoting community autonomy and the sharing economy. Through public participation and community building, urban residents can enhance their sense of belonging and responsibility, and jointly promote sustainable urban development.

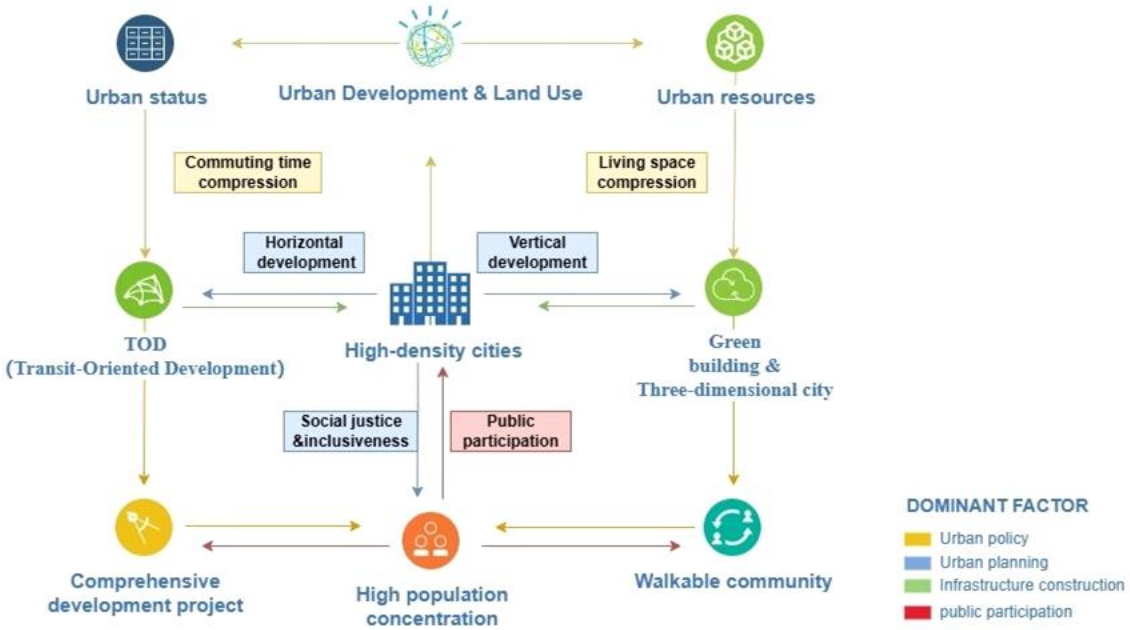

Figure 2. High-density urban sustainable development framework diagram (Photo/Picture credit: Original).

Finally, by strengthening the coordination and integration of planning, land management, traffic management and other aspects of high-density cities, the overall efficiency of urban operation and quality of life can be improved. It is important to note that specific responses may vary from city to city, as factors such as a city's stage of development, geographical conditions and policy environment can affect how and how effectively a city responds to challenges. Moreover, urban development is a dynamic process, and city managers and planners need to constantly adapt and respond to new

challenges and changes [5]. The sustainable development of high-density cities requires comprehensive consideration of urban planning, resource utilization, environmental protection, social equity and other factors. As shown in Fig.2, only when these aspects are balanced and coordinated can the sustainable development of high-density cities be achieved.

4. Conclusion

From the perspective of sustainable development of high-density cities, this paper summarizes the effective practice and exploration of different high-density cities by case analysis and discusses the measures and framework of sustainable development of high-density cities. Through case analysis, urban vertical development maximizes the utilization of urban land resources and satisfies the living needs of residents. Three-dimensional cities improve the efficiency and quality of space use, establish a continuous pedestrian system, and reduce the public's dependence on transportation. In terms of green buildings, vertical greening and rainwater collection and recycling systems are adopted to maintain a local micro-ecological climate in the city to combat the "heat island effect" in high-density urban problems. The concept of green buildings and three-dimensional cities lays a foundation for the long-term ecological development of high-density cities by space utilization and resource conservation. Transit-oriented development (TOD) maximizes the efficiency of urban land use from the aspect of traffic grid and urban multi-functional development, facilitates the travel of residents, reduces the use of private vehicles, and avoids the problem of urban road congestion. Based on the current status of urban development and the trend of promoting urban sustainable development, the research and evaluation of a sustainable development framework for high-density cities is an important indicator to measure future urban development. By learning and drawing on effective measures between cities, China's high-density cities have improved urban operation management methods and spatial system organization models such as three-dimensional cities. Among them, the advantages and disadvantages of urban accessibility, resilience, and built environment density for future development are still worthy of further exploration.

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