Proceedings of the 3rd International Conference on Literature, Language, and Culture Development
DOI: 10.54254/2753-7064/33/20240090

Sponge City Development from the Perspective of Sustainability: A Case Study of China

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Abstract: Traditional urban construction methods often result in the inability of rainwater to penetrate and store effectively, increasing the risk of urban flooding disasters. At the same time, due to the rapid development of urbanization, the problem of water shortage has become increasingly prominent. The sponge city policy aims to transform the urban construction mode, make full use of natural resources and ecological means, realize the natural accumulation, infiltration and purification of rainwater, and improve the city's absorption, storage and release capacity of rainwater, so as to reduce urban flood disasters and alleviate the shortage of water resources. This paper takes China as an example to explore the construction of a sponge city from the perspective of sustainable development. This paper analyzes the current situation and existing problems of sponge cities' development in China, and puts forward the development prospect of PPP model, in order to promote sponge cities' construction and sustainable urban development.

Keywords: Sponge City, Sustainable Urban Development, Urban infrastructure construction

1. Introduction

With the continuous growth of urban population and the acceleration of urbanization process, human settlements have been greatly improved. However, at the same time, cities are faced with more and more challenges, including traffic congestion, water shortage, environmental pollution and other problems. Contradictions in the field of urban ecological environment have become prominent, bringing certain obstacles to residents' human settlements and urban reproduction. It directly affects the sustainability of China's economic and social development. In response to these challenges, the "sponge city" theory has gradually emerged, providing a sustainable urban planning and design paradigm [1].

In recent years, China has continued to introduce and improve institutional arrangements and policies, transform traditional urban construction models and concepts, and explore a low-impact development model that co-exists harmoniously with nature. The sponge city concept provides a new idea for urban planning in China.

Starting from Chinese cities, this paper discusses the construction and development of sponge cities from the perspective of sustainable development. This paper analyzes the current situation and existing problems of sponge city development in China, and explores the principle and development prospect of the Public-Private Partnership (PPP) model. Based on these explorations, the sponge city policy was proposed and gradually promoted, aiming to realize the harmonious coexistence

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between city and nature and promote the sustainable development of the city through scientific planning and construction.

2. Research background and significance

2.1. Definition of a sponge city

Sponge city refers to a city that can adapt to changes in the environment like a sponge, has good resilience in responding to natural disasters, can absorb water like a sponge, and can release water to a certain extent. It has good resilience in adapting to environmental changes and coping with natural disasters brought by rain, and can also be called "water resilient city" [2].

The basic principle of sponge cities is to achieve sustainable urban development and effective management of water resources by imitating the water cycle process of natural systems [3]. The construction of sponge city, that is, the construction of low-impact development rainwater system, mainly refers to the realization of urban benign hydrological cycle through seepage, retention, storage, net, use, discharge and other technical ways, improve the infiltration, regulation, storage, purification, utilization and discharge capacity of runoff and rainwater, and maintain or restore the sponge function of the city.

2.2. Research background

In the context of the continuous development of today's society, China's urban waterlogging has become a major problem threatening social development, so we must further analyze the causes of urban waterlogging, and clarify the current status of urban waterlogging in our country, and build a corresponding prevention and control system, only in this way can ensure the further development of our country's cities [4].

At present, many cities around the world are facing the problem of water shortage. This not only affects People's Daily life and economic development, but also threatens the health of the ecological environment. With the impact of global climate change, the frequent occurrence of rain and flooding has become a problem faced by many cities. How to effectively manage and utilize rainwater resources to reduce the occurrence of urban waterlogging and other disasters has become an important issue of urban sustainable development. The acceleration of urbanization has also led to the destruction of the ecological environment in many cities. How to realize the sustainable management and utilization of water resources has become an urgent problem for urban development. To realize the sustainable development of the city, it is necessary to take effective measures to protect and restore the ecological environment, and the development concept of Sponge City comes into being under such a background.

2.3. Research significance

Sponge cities emphasize the natural accumulation, natural penetration and natural purification of water resources, and improve the city's absorption, discharge and purification capacity of rainwater through the construction of green infrastructure, so as to achieve sustainable use of water resources. This will help solve the problem of urban water shortage and water crisis, and improve the city's water security. The construction of a sponge city can also effectively alleviate the impact of urban rain and flood damage. By strengthening the capacity of urban rainwater discharge and purification, the occurrence of urban waterlogging and other disasters can be reduced, and people's lives and property safety can be guaranteed. At the same time, the construction of sponge cities also helps to reduce urban runoff pollution and protect the water ecological environment. Sponge city emphasizes ecological priority in its development concept, focusing on protecting and restoring the

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urban ecological environment. Through the construction of green infrastructure, increase the urban green coverage rate, reduce the urban heat island effect, and improve the quality of urban ecological environment. To sum up, the research on sponge city development from a sustainable perspective has important practical significance and theoretical value, and plays a positive role in promoting sustainable urban development.

3. Sponge city construction in China

3.1. The current construction status of sponge city in China

China's urban drainage system lacks a waterlogging prevention and control system, mainly adopting underground channel drainage, and there is no system to consider the storage of rainwater. It is generally believed that rainwater should be collected into the river outside the city as soon as possible to avoid the production of urban waterlogging. However, due to the increasingly developed human traffic, the hardening of the road surface gradually increased, increasing the pressure on the municipal drainage pipe, but also increasing the burden.

At present, China has dozens of sponge city pilots. After years of sponge city construction, the ecological environment and water environment of the pilot cities have been effectively improved.

At present, there are already 60 sponge city pilot cities in China.

3.2. The problems of sponge city construction in our country

The construction of sponge cities currently has some limitations.

The first major challenge in the construction of sponge cities comes from the complexity of urban stormwater management itself. Under the changing conditions of climate and urban development, the objectives of urban stormwater management are becoming more and more multi-dimensional and complex over time. On the one hand, urban rainwater management must meet the requirements of urban drainage; On the other hand, stormwater management needs to be integrated with water and environmental requirements related to urban development, such as restoration or maintenance of natural waterbasins, pollution reduction, ecosystem protection, stormwater harvesting and reuse, etc [5].

The second problem is that It is difficult to renovate the built communities. In the construction of a sponge city, the important task is to carry out "spongy" transformation of the built communities, especially the communities where water often occurs. However, the construction of the old community that has been built is very difficult and is regarded as a "thorn bone" in the industry.

The third problem is that Construction standards are unclear. Some pilot city functional departments are not very clear about the content of sponge city construction, thinking that it is to repair roads, collect rainwater and so on. In fact, the goals of each pilot city are different, some focus on saving water resources, some focus on solving waterlogging, and some focus on solving water pollution. Lacking of scientific construction standards, it is easy to make the construction of sponge city detour, or even the opposite.

The matching of government departments is not synchronized.Sponge city construction requires planning, urban construction, water, landscape and other departments to fully coordinate "step by step". Especially in the construction of new urban areas, even if it is not a pilot city, it must be planned in advance. At present, on the one hand to invest a lot of money, on the other hand, a large number of traditional road-hardened new communities continue to be built, not only leading to repeated investment waste, but also easy to show the transformation speed can never catch up with the embarrassment of urban expansion.

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The lack of steady returns. Different from the underground pipe gallery, sewage treatment and other chargeable operation projects, the general sponge city project belongs to the public welfare project, and the later operation and maintenance expenditure is large.

4. Sponge city construction path in China

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5. Public-private partnership (PPP) model

5.1. What is the PPP model

In recent years, in order to solve the resource and environmental problems of recyclable rainwater resources and alleviate urban waterlogging, sponge city construction has been extended from pilot cities to local scale development. In the large-scale development of sponge city construction under the new situation in China, PPP mode has gradually become the main mode of ecological environment and infrastructure construction such as sponge city construction [6].

The concept of the integration of PPP model and sponge city construction has been widely recognized by people as soon as it was launched, and with the passage of time, private capital has become more and more involved in the construction of PPP model sponge city, which not only greatly promoted the effective construction of sponge city, but also allowed enterprises to obtain more profits [7]. The PPP model of Sponge City refers to the financing model in which the government and social capital cooperate to participate in the construction of Sponge City. Under this model, the government and social capital jointly bear the investment, construction, operation and other risks of sponge city construction through cooperation, so as to achieve resource sharing and complementary advantages, and promote the sustainable development of Sponge City.

The Guiding Opinions on Promoting the Construction of Sponge Cities put forward that government guidance and social participation should be adhered to. The decisive role of the market in allocating resources and the regulation and guidance role of the government actively promote the Public-Private Partnership (PPP) model, and attract social capital to participate extensively in the construction of sponge cities.

The PPP model works well in infrastructure, such as sewage treatment projects. However, the PPP model is used in sponge cities, how to calculate public services? Sponge cities are equivalent to building an ecological green space system. How to calculate this part of the service is a difficult point, and the PPP model is still difficult to apply in the construction of sponge cities.

According to the statistics of the government and Social Capital Cooperation Center of the Ministry of Finance, since 2015, the quantity of Sponge City construction PPP projects in China has shown a trend of rising and then falling, 2015-2017, with the rapid landing of two batches of pilot sponge city construction projects, the number of Sponge City construction PPP projects around the country has grown more, since 2018, the number of PPP projects has declined. As of November 2020, only two new sponge city PPP projects have been launched throughout the year (Figure 1).

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Figure 1: The quantity of PPP projects

The PPP model can use social capital and market forces to provide abundant financial and technical support for the construction of sponge cities. Sponge city construction needs to be realized with advanced technology and professional design schemes, and the PPP model is the way to promote the synergy between social capital and government investment, so that the project can be better developed. In order to better realize the construction of sponge city, China should continue to adopt the PPP model.

5.2. The development prospect of PPP model

The development of the Sponge City PPP model largely depends on several factors, including policy support, market demand, technological innovation and risk management.

First, policy support is crucial for the development of the Sponge City PPP model. The government plays a key role in promoting the construction of sponge cities, providing support and guidance for Sponge City PPP projects by formulating relevant policies and planning. For example, the government can provide financial subsidies, tax incentives and other measures to reduce the investment risk of social capital and improve the attractiveness of projects. At the same time, the government can also strengthen supervision and evaluation to ensure the quality and efficiency of the project.

Secondly, market demand is also an important factor affecting the prospect of Sponge City PPP model. With the acceleration of urbanization and the challenge of climate change, the problem of urban stormwater management is becoming increasingly prominent, and the market demand for Sponge City construction is growing. This provides a broad development space for the Sponge City PPP model. At the same time, with the increasing attention of the public to the ecological environment and sustainable development, the awareness and acceptance of the environmental protection concept of Sponge City is also gradually improving.

In addition, technological innovation is also a key factor in promoting the development of Sponge City PPP models. Sponge City construction involves technological innovation and integration in many fields, including rainwater collection technology, ecological restoration technology, intelligent management system and so on. With the continuous progress and application of science and technology, the technologies in these fields will continue to be broken through and optimized, providing stronger technical support and solutions for Sponge City PPP projects.

However, the PPP model of Sponge City also faces certain risks and challenges. Factors such as long project cycle, slow return on investment and high policy risks may have a certain impact on the smooth implementation and operation of the project. Therefore, the establishment of a sound risk management mechanism and policy support system is the key to ensure the sustainable development of Sponge City PPP model.

To sum up, the prospect of the Sponge City PPP model largely depends on the combined effect of several factors, such as policy support, market demand, technological innovation and risk management. Under the conditions of strong policy support, strong market demand, active technological innovation and effective risk management, the PPP model of Sponge City is expected to achieve broader development space and better development prospects.

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6. Conclusion

With the support of national policies, although the concept of the sponge city was proposed late in our country, the construction has been promoted very rapidly. At present, China's sponge city construction technology is still in the initial stage, and there are still many problems to be solved and improved. More advanced low-impact development technologies and facilities are needed to fill weaknesses and loopholes, and provide a strong guarantee for the construction of sponge cities with Chinese characteristics.

With the progress of science and technology, more innovative technologies may be applied to the construction of Sponge Cities in the future. For example, the use of artificial intelligence, big data, the Internet of Things and other technologies can more accurately predict and regulate rainwater runoff, and improve the construction effect of sponge cities. The construction of Sponge Cities is not only to solve the problem of flood disasters and water shortages, but more importantly to restore the ecological function of the cities. Future research may focus more on how to promote the restoration and enhancement of urban ecosystems through sponge city construction. The construction of sponge cities also needs the participation and support of all aspects of society. Future studies may explore how to better guide the public to participate in the construction of sponge cities and improve the public's awareness and acceptance of the concept of sponge cities. Laws and regulations are the important guarantee of sponge city construction. Future research may focus on how to improve the legal and policy system of sponge city construction to provide a strong legal guarantee for the sustainable development of sponge cities.

In short, sponge city is an urban development concept with sustainable development characteristics. By improving the urban water supply and drainage system, it reduces the pressure of water resources, protects the ecological environment, and improves the quality of life of residents. The construction of sponge city can not only save operating costs, but also build rainwater collection system, improve the construction level of water supply and drainage system, and strive to create a livable and comfortable living environment. In the future, we should continue to promote the development of sponge city concept and apply it widely in urban planning and construction.

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