

A Case Study of ABC Water System Innovation in Singapore

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Abstract

Singapore is located in Southeast Asia. Although highly urbanised, the land area is small and lacks water resources. Its water resources account for only 1.43% of total land (Ho, 2021). Due to special geographical and climatic characteristics, the scarcity of water resources urgently requires rational planning and utilisation of land resources to cope with increasing urban development and water demand. For this reason, water resources management is considered an important part of environmental and ecological conservation by the Singaporean government.

Keywords: Singapore, water system, infrastructure, urban innovation, green space

1. Introduction

Since its independence in 1965, Singapore has gradually established an extensive water resources network and water conservancy infrastructure. In particular, the ABC (Active, Beautiful and Clean) Water Innovation Strategic Development Plan, launched by Singapore's National Water Agency (PUB) in 2006, aims to address water shortages and the challenges of developing innovative water systems by harnessing the potential of water bodies to improve the environment and quality of life (University of Pennsylvania, 2020). The government of Singapore has decided to adopt innovative solutions for the management of water resources and the delivery of water services to create a modern, green city based on innovation by integrating water into the lives of the city and its residents. This report will take the ABC Water System Innovation Policy in Singapore as a case to analyse the policy environment in which water infrastructure innovation practices occur and are implemented, and clarify the background of the implementation of this innovation and its impact on the future.

2. How the ABC Water Innovation Works

2.1 The Innovation Project

To solve the increasingly severe urban development and water supply problems in Singapore, PUB launched the ABC Waters Programme in 2006, which has become the focus of water innovation development. The project aims to invest in and transform Singapore's original waterways and reservoirs beyond their original drainage and storage functions (Center for Liveable Cities (CLC), 2017). The biggest effect of this policy is to change the original function of the infrastructure, create more uses of the infrastructure, and bring more value to the limited living space.

Its methods mainly include the use of modern science and technology with cutting-edge technology to integrate the natural environment and urban development. ABC water management integrates rainwater systems in all aspects, advocating rainwater harvesting to reduce runoff from the public waterway network. For example, PUB maximises rainwater collection through green rainwater infrastructure (University of Pennsylvania, 2020), thereby reducing flood risk during heavy rains. As another example, the Waterway Ridges housing project adopted ABC Waters' design and green waterways to promote the use of natural systems to manage stormwater flow (Khoo, 2018). Further, instead of bringing rainwater into the city, more plants are brought into the city. The

ABC water project also preserves wetlands, rainforests, and swamps in the city to utilise plants and soil to retain rainwater (CLC), 2017). Lorong Halus Wetland is a famous Wetland park in Singapore, where plants are planted to absorb underground rainwater and clean water, as well as to provide habitat for animals (Yau et al., 2017). Therefore, this innovative scheme integrates the whole process of water treatment through technical methods, from water collection to drainage and sewage treatment, which are all allocated to certain facilities for treatment (Lin, 2017). This not only improves the efficiency of the water cycle but also solves some problems of water resource utilisation efficiency and water-related natural disasters.

With the vision of developing beyond the original function of the infrastructure, the ABC plan has transformed many reservoirs and waterways into large recreational facilities and living communities. For example, Bedok Reservoir previously provided only basic water storage functions. However, considering its geographical location in the centre of residential areas, the government transformed it into a water sports centre from the perspective of planning with more urban characteristics, instead of demolishing it, which has become a unique scenic line of residential areas.

At the same time, PUB manages demand by creating a shift in the way Singaporeans perceive water. The government has initiated education on water resource protection to strengthen awareness of the importance of water among Singaporeans from an early age and to raise residents' awareness of ecological protection. It enables residents to establish a stronger relationship with water resources, so that they pay more attention to and know how to protect water. The local government also held "adoption projects", such as encouraging schools or companies to adopt a reservoir and maintain it regularly, which promoted the sense of responsibility of the community to participate in environmental management (Yau et al., 2017).

2.2 Expected Outcomes

Through scientific planning and improvement, the project can reduce the shortage of water resources and the situation of run-off flooding in Singapore, and effectively coordinate the relationship between rainwater and water supply. It is expected to maximise the use of water infrastructure and create community spaces where people and water can coexist. It can greatly enhance public awareness of water conservation and create an environment in which people can live in harmony with nature. Most importantly, it will improve water quality and protect the urban environment, which will lead to green and sustainable development and improve people's quality of life.

3. The Purpose of the Innovation and Its Potential Impact

3.1 Background

Singapore's unique geographical environment and urbanisation background promote the government's innovative practice of water resource management. Cities face the threat of increased flood risk due to rising sea levels and an increased frequency of extreme rainfall events caused by climate change, as well as increased impervious areas and runoff due to increased urbanisation (Yau et al., 2017). In addition to Singapore's small geographical location and land area, the dense urban population lives in an uncertain natural environment. Therefore, how to balance the challenges of urbanisation and the ecological environment is a key issue facing Singapore. Further, Singapore's water shortage has prompted municipal leaders to develop a strategic water management transformation. Driven by the vision of cherishing water resources and developing clean rivers, the government plans to invest in building cleaner and more efficient water systems that will bring greater benefits to residents and protect national resources.

3.2 Purpose

The main purpose of the ABC innovative programme is to integrate water resources into the urban lives of residents by introducing water resources into the urban environment through innovative projects to better integrate water sources with housing and green space facilities. The core of the main idea is to transcend the utilitarian value of original water conservancy projects, such as reservoirs and canals, and transform them into urban landscapes that transcend their original value and function. This is due to Singapore's limited geographical environment. Most residential areas are surrounded by natural waters, and many rivers and canals are located in or close to the centre of residential areas (CLC, 2017). To achieve both the pursuit of clean cities and ecological protection, the government is determined to implement innovative schemes for water resource protection and water conservancy facilities, and make full use of the potential advantages of water bodies to create innovative ecological spaces by fully coordinating the scope of human activities and water resources. For example, the ABC plan proposes to build parks and green spaces in areas with rich water flow, create eco-protected parks, and develop real estate to create clean and harmonious living spaces.

By contrast, the new innovation programme emphasises bringing water closer to people's lives and creating an environment where human society and nature coexist in harmony, in contrast to the traditional idea that society should protect the ecological environment away from water in the past. This innovative concept transforms the

past state of nature conservation by focusing away from water resources, and successfully integrating water with human life (CLC, 2017). At the heart of water innovation is the alignment of water policy with the goals of sustainable urban development to ensure the long-term sustainable value of water resources. To allow public participation in and manage these important water resources through the cultivation of public awareness of the protagonist, Singapore's environmental protection from the government to the people forms a perfect protection mechanism.

3.3 Influence and Contribution

Through the implementation of the ABC water innovation programme, the potential of watercourses and water bodies to improve the urban environment can be fully utilised. From a social point of view, the scheme not only contributes to stormwater management but also completes the task of centralising the development of the urban landscape. It combines water conservancy facilities with the environment, and gradually develops the original single water supply and drainage facilities into the ecological assets of the city, so that the urban infrastructure is integrated into the residents' entertainment and life. It creates a clean and beautiful urban living environment for society and almost successfully develops a multi-purpose space for water resources; thus, water infrastructure is no longer far away from people's daily lives but has become a part of city life. Further, ABC water innovation is conducive to the collection and management of rainwater, the control of water flooding and water storage, and the minimisation of the impact of river pollution on the public. According to Yau et al.'s (2017) survey results, after the implementation of the ABC water innovation design, the peak flow in the two quarters of heavy rainfall in March and October 2008 was reduced by 33% and 47%, respectively. Furthermore, the newly created cityscape and water entertainment facilities attract more tourists and play a key role in Singapore's tourism industry and economic development. Lastly, the innovative policy is conducive to coping with the negative impacts of climate change, in addition to effectively preventing runoff and reducing peak flow to mitigate floods caused by heavy rainfall.

4. How the Innovation Is Integrated into the Existing System

In the 1980s, Singapore's drainage systems were planned and developed to cope with floods (CLC, 2017). With the rapid development of Singapore's economy and the improvement of social conditions, great changes have taken place in people's quality of life. The original urbanisation construction plan in the past has been unable to meet the living needs of residents, and there is an urgent need to upgrade the existing infrastructure system to create more utilisation value. This has led to the need for changes in the government management of water facilities.

The ABC water solution combines the innovation of the water system with the existing urban infrastructure and effectively integrates the new water infrastructure functions into those of the old infrastructure. In terms of the overall planning of drainage pipelines, Singapore's planning scheme in the early days of the founding of the People's Republic of China was to reserve land by the new waterway in advance for the possible expansion of the drainage network when dividing the drainage deposit areas (CLC, 2017). After the implementation of the ABC scheme, the previously reserved land was successfully developed into a new waterfront recreation area, extending recreational facilities to the seaside. In addition, the ABC Waters Programme has introduced and retained large-scale vegetation that is conducive to stable water bodies, such as rainforests and swamps, which is not only conducive to preventing flooding in flood season but also to beautifying the city and forming a new urban landscape. Rain pools that might otherwise have been lying dormant can be developed into lakes that flourish with trees, and tropical rainforests that are unfit for human habitation are being built with high-rise public housing. For example, the Central Watershed and Bishan Park in the heart of Singapore were originally pristine natural reserves. Dripped by innovative policies, the Singapore government planned and rebuilt the area, creating a scenic river over the original canal, flanked by new park spaces (Yau et al., 2017).

As a result, this innovative scheme successfully integrates the needs of modern society with the local ecosystem, adding more living functions without destroying the original urban landscape. Further, to solve the problem of water supply and demand, PUB retains the reservoir as the original core water supply system, and increases the importance of the reservoir as the urban landscape while retaining the core water supply function of the reservoir. This is an evolution and upgrade of the basic functions of the reservoir on the basis of considering the different interests of different stakeholders. As a consequence, for example, Bedok Reservoir evolved from a small reservoir that previously served only a water collecting function, where water activities were restricted, to a water sports centre later (Yau et al., 2017). The Marina Reservoir is the largest and most urbanised watershed in Singapore, around which ABC plans to build the most iconic commercial and tourist centre in Singapore based on Marina Bay (Khoo, 2018).

5. Key Learnings Drawn from the Implementation of the Innovation Programme

5.1 Advantages

The ABC innovation plan in Singapore is successful in terms of its final results. For example, it achieves the goal of simultaneously protecting water resources and urbanising development. By using the water around people's lives, it has solved many links, including water resource management, sewage treatment, creating urban living space and civic education, which reflects good policy results. Further, it improves the living conditions and environment of Singapore and preserves many local characteristics and architectural heritage (Tortajada, 2017).

What are the key reasons for Singapore's water innovation? Importantly, Singapore's unique social environment promotes the innovation of its infrastructure system. Therefore, on the basis of pursuing urbanisation development, making use of limited land resources and infrastructure to provide a clean living environment for a large number of people is a key policy for Singapore's national development. Fortunately, Singapore's cultural and institutional background provides the necessary support and advantages for the implementation of the plan. The government of Singapore has always attached great importance to environmental protection and its impact on people's living environments and healthy lives. As a result, there is a common understanding of water innovation across the government and strong support from government leaders. In addition, Singapore attaches great importance to innovation and the development of science and technology. In implementing water system reform measures, the government works closely with water resource companies, academic institutions, and government agencies from all over the world to actively learn advanced industry knowledge and concepts.

Further, the participation and collaboration of various agencies is a key advantage in the effective implementation of the ABC water innovation development programme. PUB's new approach to water resource management is to protect the basic hydrological and drainage functions of waterways while placing greater emphasis on the participation of key stakeholders, such as the public (CLC, 2017). Yap Kheng Guan, one of the directors from PUB, highlighted the importance of cooperation between non-governmental organisations and the public, and emphasised that different stakeholders can understand each other by not seeing each other as rivals or competitors and removing barriers to participating in the development of the country (CLC, 2017). Such a policy approach has proven to be more conducive to uniting domestic private and public stakeholders and concentrating scattered efforts to improve the quality of projects. Moreover, PUB also encourages active cooperation with local private enterprises to absorb and adopt the research facilities and management experience of private enterprises. Thus, the technological advantages of some private enterprises good at using biological engineering to deal with waterways have enhanced the cooperation between the government and them. Further, working with the private sector can also bring financial capacity to the project (Tortajada, 2017). The project's promotion of the involvement of local communities (schools and individuals) in the conservation of water resources is also an advantage of the project's success.

5.2 Disadvantages and Challenges

However, Singapore's structural challenges remain. First, according to a 2015 report by the World Resources Institute, Singapore will become one of the most water-stressed countries by 2040 (Khoo, 2018). This shows that although the existing environmental development system in Singapore has achieved obvious results, its overall influence is limited. Second, as ABC water innovation is a huge project, rebuilding the original water conservancy facilities will inevitably encounter the regional dividing line between residential areas and natural areas planned by the government in the past. It is necessary to blur these lines with innovation planning. However, breaching these lines could run into opposition from stakeholders, such as local residents. This is also one of the "generational" conflicts that often occur before a new policy is implemented. The solution to this problem may involve PUB coordinating and communicating with housing, transport, and other government departments. Even in highly urbanised developed countries, a common problem is the differences between new policies and old policies, and providing a sufficient public opinion window is one of the ways to alleviate policy conflicts.

In general, local context, culture, and socio-economic factors have all played a positive role in the success of the ABC water innovation programme. However, the current water innovation system in Singapore still has the problem of decentralised management. In addition, the lack of large-scale management and capital is the key obstacle and bottleneck for the innovation of water facilities (Mvulirwenande & Wehn, 2020).

5.3 Lessons Learned from ABC Innovation

First, water policy should be synchronised with sustainable urban development. Singapore has balanced the dual issues of urbanisation development and environmental protection. With unified thinking, a single solution can solve as many different problems as possible, greatly improving decision-making efficiency, which is worth learning from other countries. Second, it involves multiple stakeholders, especially the private sector. The private sector can provide not only capital but also technology.

However, the fragmentation of the policy system will bring fatal problems to the development of innovation. For

example, it is key to have a stable investment and a certain scale of working capital to support the implementation of innovation policies. The Singaporean government and PUB actively negotiated with private enterprises and obtained a lot of financial support, which eliminated the risk of a delayed plan caused by a lack of funding. Second, due to the nature of the ABC project, which still blurs the line between administration and planning, cooperation between agencies is essential.

6. Major Findings and Conclusion

In conclusion, Singapore's innovative water infrastructure has created new social, cultural, and economic values, pushing Singapore to the forefront of water innovation and management. In the world, it is still a model for sustainable development in other countries. In response to the challenge of scarce land and water resources, the government of Singapore has effectively integrated water resources with urban development through water innovation policies, and used water as an asset and wealth to improve the urban living environment through upgrading the water network. The result is not only the combination of human society and the ecological environment, effectively improving the living environment of local residents; it also encourages public participation in water conservation through education, narrowing the gap between citizens' lives and the country's development vision. In general, the key reasons for Singapore's innovation success lie in its clear vision and good leadership. Only leaders with a broad vision are open to new ideas.

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