TITLE: INTEGRATED WATER MANAGEMENT APPROACH: TTHE SPONGE CITY PROJECT IN SHENZHEN

ISSUE AREAS

☐ ICT and SMART technology ☐ Sustainable mobility ☒ **Land use and nature-based solutions**
☐ Clean energy ☐ Sustainable solid waste management ☐ Building energy efficiency
☐ Innovative urban governance ☐ Behavioral change

OVERVIEW

China initiated the *Sponge City Programme* (SCP) in 2014 to address urban water management and resilience in China and as a means to support ecological civilization implementation. The Ministry of Housing and Urban-Rural Development (MoHURD) selected 30 pilot cities to implement sustainable urban water management approaches to resolve urban waterlogging, water storage and discharge, water quality, and urban heat island effects. A national technical guidance was also released by MoHURD to guide the implementation and facilitate localization as the pilot cities create the technical guidelines and evaluation criterias. As the SCP matures, the pilot cities even incorporate sponge city planning approaches into the long-term urban and sustainable development plans.

Shenzhen is a coastal megacity with 24 million population located in South China along the Pearl River Delta. The economic powerhouse has been selected as one of the Phase 2 pilot cities for SCP in 2016 and the city's SCP design and experience highlighted the innovative 'Shenzhen approach' in localizing and implementing SCP, with successful results. The key elements included in Shenzhen's SCP include: 1) detailed pre-assessments of its natural resources, hydrological characteristics, and climatological elements for spatial planning; 2) integrated water management plan ; 3) customized design according to the living environment and ecological conditions.

THE CHALLENGE - WHY HAS THE CITY TAKEN ACTION

Urban flooding risk is increasing in frequency and intensity. In the past 40 years, Shenzhen turned from a laid back fishing village to a spectacular economic center in southern China. However, rapid urbanization comes at a cost. The naturally marshy environment exacerbated by land cover change, population density and local climate change directly influenced urban surface runoff, urban flooding and the flood risk. According to the national and municipal flooding disaster assessment in 2016, there were 446 flooding points[1] in Shenzhen, with a maximum flooding area of 500,000 square meters (m^2), a maximum flooding depth of 2.5m, and a maximum flooding duration of four hours (Zhang et al., 2016).

Water pollution has been a serious problem in Shenzhen Bay and the Pearl River Delta. As the frontier of international trade, Shenzhen hosts numerous factories with serious negative environmental impacts, such as textile and IT manufacturing. However, the lack of environmental

[1] Flooding Point: 1) type one: waterlogging time excesses 30min; the depth is more than 0.15 m; and waterlogging range is more than 1000 m^2; 2) type two: for under concave bridge area, it means waterlogging time excesses 30min; the depth of waterlogging is more than 0.27m (Shenzhen Online, 2018; Zhang et al., 2016).

regulation back in the early 21st century resulted in severe pollution in the water bodies. Pollution source control is worsened by incomprehensive sewage management.

Water security and limited drinkable water resources in Shenzhen. Shenzhen's per capita access to water resources is 154.54 cubic meters (m^3), one-thirteen of the nationwide average, making it one of the top ten water-scarce cities in China (World Water Atlas, n.d.). In comparison, the United Nations' definition of absolute scarcity threshold is 500 m^3. It is estimated that Shenzhen will face water shortages of 690 and 890 million m^3 by 2020 and 2030 respectively (International Water Association, n.d.). Meanwhile, water conservation has been a core environmental conservation practice in China, which is embedded in national development strategies, such as non-renewable energy conservation and low-carbon development (Sun, 2017).

GOALS AND OBJECTIVES

The Sponge City concept is a paradigm shift from the traditional grey infrastructure approach of steel and pipes to green and natural infrastructure, such as rain gardens to restore natural habitat and functions. Using this paradigm, Shenzhen aims to have more than 20% and 80% of the built-up areas to meet the standards of a sponge city by 2020 and 2030 respectively.

Objectives:

- **Water security:** effective prevention of urban flooding disasters
- **Water environment:** water treatment on polluting sources, to ensure the improvement of water quality
- **Water ecology:** ensure the volume capture ratio of annual rainfall exceeds 70%
- **Water resources:** effective use of rainfall, recycled water, seawater and other non-conventional water resources
- **Institutional setting:** Development of sponge city planning & construction control framework, technical specifications and standards, investment and financing mechanism, performance assessments and incentive mechanism.

HOW DID STI PROVIDE A LOW CARBON AND CLIMATE RESILIENT SOLUTION?

(STI as a means of implementation)
☐ Improved decision making ☒ **Offering a low-cost solution** ☒ **Inclusive decision making**
☒ **Improved governance** ☒ **Behavioural change**

(STI as a direct technical solution)
☒ **Cleaner/more eco-friendly infrastructure** ☒ **Cleaner/more eco-friendly equipment**
☐ Faster/better/larger data availability/processing

- How was it innovative? (What enabling policies were employed? What were the local/national government's policy targets, goals and strategies? Were new S&T approaches developed or existing S&T approaches enhanced? Was the city's geography/culture capitalised upon?)

SCP as a planning concept and technical solution to urban water management

The SCP is an integrated urban water management approach to address urban surface runoff, water pollution, and flooding risks. It is a holistic planning mechanism although it shares similarities with other urban water governance concepts, such as Low Impact Development (LID), Sustainable Urban Drainage System (SUDS), and Water Sensitive Urban Design (WSUD). Prior to the SCP pilot, Shenzhen started the LID experiment in Guangming New Area (now Guangming District), back in 2004 (Shenzhen Government Online, 2017). The LID sought to address urban surface runoffs during heavy rainfall episodes through LID construction elements, to allow water infiltration, retention, and storage. In Guangming, the new areas provided the possibility to test out a variety of LID designs:

Guangming has 26 LID projects incorporated within the new developments, residential and industrial areas, parks, and roads. For example, Guangming People's Sports Centre has been built with green roofs, rain gardens and perious pavements, which have a capacity to capture more than 60% of annual rainfall. New roads include sunken green spaces, permeable driveways, bicycle paths, and sidewalks (International Water Association, n.d.).

The previous LID projects at Guangming District laid the foundation for the SCP implementation at the city-scale. Instead of ad-hoc LID projects and in-situ solutions, the SCP is seen as a comprehensive masterplan to accelerate the city's actions in sustainable development and urban resilience. The grey, green, and blue infrastructure are designed systematically to foster their social-ecological functions. For example, green infrastructure (e.g., greenbelt) is integrated into grey infrastructure (e.g., paveways), functioning in different stages of water catchment, purification and storage.

SCP as a new paradigm shift in urban planning and design

Institutionally, the SCP was initiated to explore pathways towards China's low-carbon and eco-city development. It transforms the 'modernism' ideology of urban planning and water management, to a more sustainable and comprehensive one (Chinese Society for Urban Studies, 2015). Apart from managing runoff and avoiding urban flooding, the SCP intends to mobilize water spatially and temporally. Compared to urban design concepts in the past decades that 'concrete is the blood of a city', for the SCP, both green and blue infrastructure are reintroduced into urban planning. The success of the SCP also requires integrated thinking and management of the water bodies, as cross-departmental collaboration harmonized Shenzhen Water Strategy (2019), with active public participation.

- What science and technologies were used? (What does it do? How does it work? How does it address the challenge?)

The Sponge City technology incorporates different functionalities and technical components, including: stormwater catchment; water purification; infiltration; and water storage, mimicking the natural water systems. Two of the main functionalities used in Shenzhen are introduced in this section, which are stormwater catchment and permeable pavements.

Bioretention catchment and greenbelt for stormwater management

The technical guidelines developed by the MoHURD provided a list of approaches qualified as 'sponge infrastructure'. As flood risk and the experience gained from the Guangming LID design reinforced Shenzhen's priority to address stormwater management through the SCP design.

Bioretention catchment and greenbelt are mandatory for the newly constructed driveways in Guangming District. Rainwater can be stored, channeled and stored as underground water through the catchment and greenbelts as permeable pavements, as shown in Figure 1.

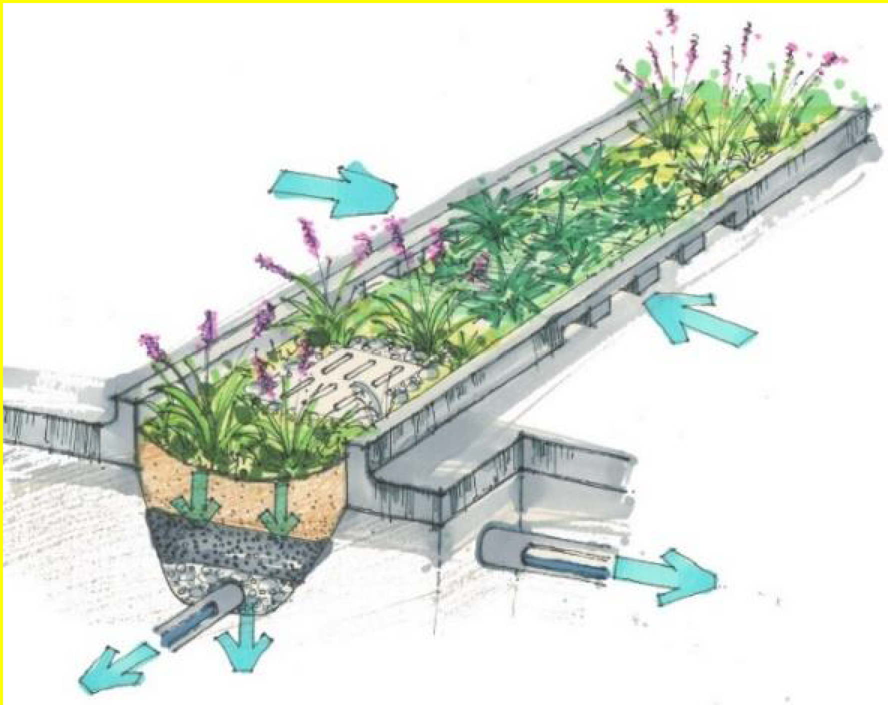

Figure 1: The design of bioretention catchment and greenbelt next to driveways (Source: Shenzhen Sponge City Construction Office, 2017)

The directional arrows show that the gradient and slope of the greenbelt allow stormwater to seep and enter the greenbelt through small channels and permeable pavements. The greenbelt consists of vegetations and materials of different permeability, including vegetations, tree barks, claies, and limestones. They all function together to purify and infiltrate underground for water retention and storage. The gradients and the materials of the driveways allow rainwater to flow through the greenbelt and feed to the greenbelt through the small channels. The greenbelt consists of multiple layers, consisting of plantations, tree barks, claies, and limestones, to store and purify rainwater, and thereby channeling the purified and infiltrated water through the pipes. The underground pipe network channels water towards a storage pond or a nearby sink.

Figure 2: Different types of bioretention catchment, including the rain garden, grass swale, bioretention bond, and bioretention catchment layers according to clockwise direction (Source: Office of the Leading Group for the Implementation of Sponge City Construction in Guangming District, 2017)

The bioretention catchment is customized and applied according to the different natural environment and needs. For example, the rain garden is usually applied in small parks or residential areas. If there is a large area of grassland, grass swale is a feasible approach with small construction efforts, while bioretention ponds are very useful for water circulation at parks and restoration of micro-scale wetland ecosystems.

Permeable pavements

Permeable pavement is seen as 'the lungs of cities', which allows rainwater to seep through immediately, reducing surface runoffs, particularly during heavy rainfalls. They are widely applied at sidewalks, cycling paths, and even roadways (Figure 3). The structural layers are made out of different sizes of rocks, stones, and gravels, mimicking the natural soil layers for natural seeping and channeling of surface water. Without permeable pavements, rainwater is inundated at low-lying areas, causing "urban flood-prone points" or waterlogged areas. The permeable pavements effectively reduce the speed of rainwater and release pressures on the soil layers. Moreover, permeable pavements also generate additional benefits, such as water purification and reducing underground water pollution.

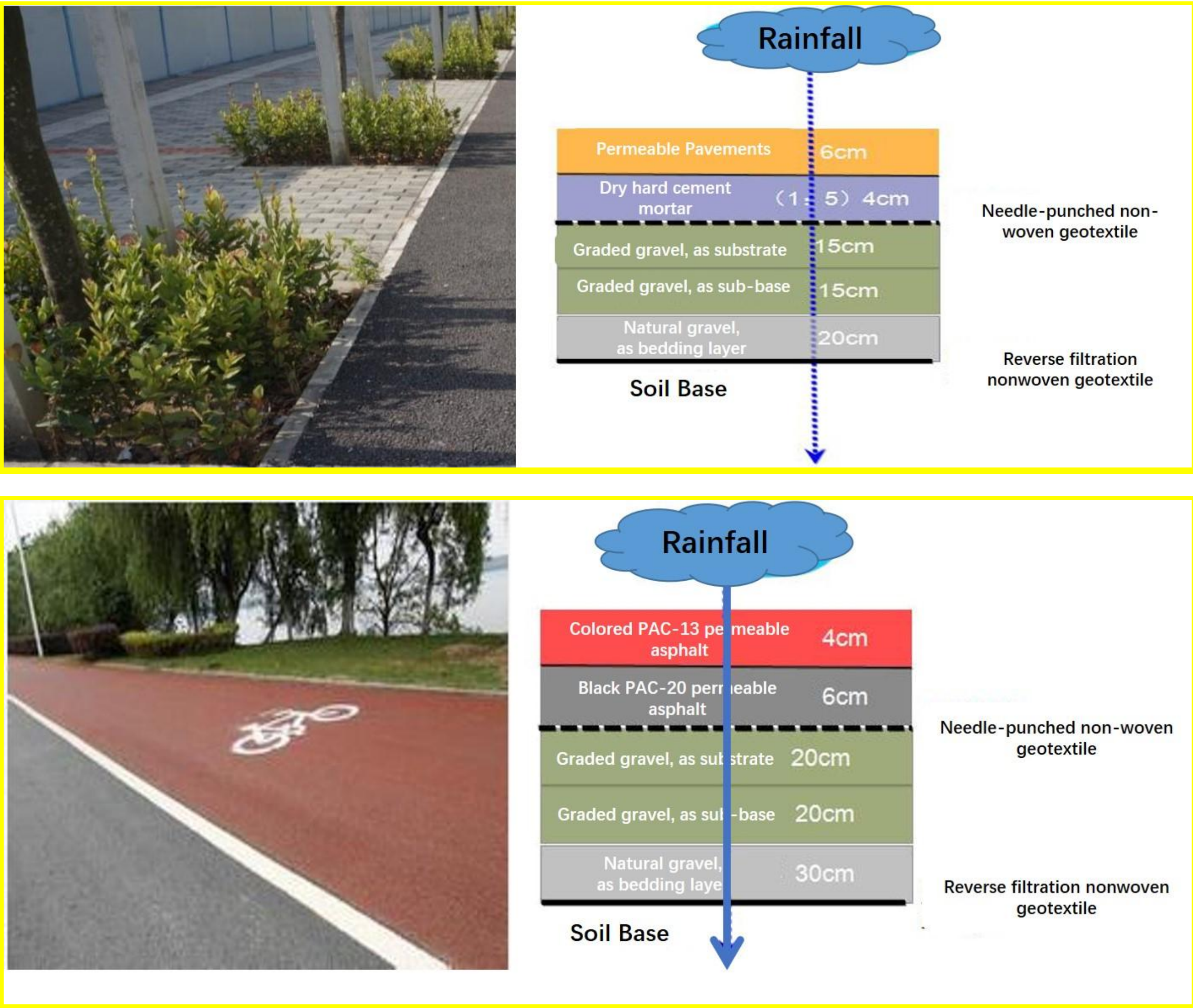

Figure 3: Permeable pavements used for sideways (above) and cycling paths (below) applied in Guangming District (Source: Office of the Leading Group for the Implementation of Sponge City Construction in Guangming District, 2017)

There are significant achievements for No.38 roadway, as the 'fully-sponged' one: the overall volume ratio of rainfall annually is up to 60%; half of the pollutants brough by rainwater can be reduced by more than half; and there is also 15% reduction of water consumption (Crystal News, 2016).

KEY AREAS OF CONSTRAINT/SUPPORT

INFRASTRUCTURE REQUIREMENT

See the previous session as examples.

POLITICAL COMMITMENT, POLICIES, AND REGULATIONS

Under the *Guiding Opinions on the Construction of Sponge Cities* (2015), China's State Council set an ambitious national target for Chinese cities to transform the urban areas to absorb, retain and reuse 70% of the rainwater. Political commitment and national support serve as a significant factor for Shenzhen's achievement for the SCP. Prior to the SCP, the LID has already raised cross-departmental awareness on the necessity to enhance and engage in urban resilience. Therefore, Shenzhen, especially Guangming District, was more equipped and fully prepared for the SCP implementation. Shenzhen responded rapidly after being selected as a SCP pilot by formulating comprehensive, stage-by-stage planning and technical instructions. There are also supporting policies at municipal level, such as financing and budgeting that were officially approved in early 2018.

THE SCALE OF THE PROGRAMME/PROJECT

The SCP is a city-wide programme, covering the entire Shenzhen. The implementation is multifaceted at each zone. According to the *Shenzhen's SCP planning and action plan (2016)*, the city is categorized into six sponge zones: ecological conservation zone, ecological containment zone, ecological buffer zone, function enhancement zone (on built-up sponge areas), function improvement zone (on environmental restoration areas), and function optimization zone. Based on the categorization, the plan recommends distinguished lists of elements for residential areas, public spaces, factorial and storing areas, paveways, urban renewal areas, water bodies, and parks and green spaces. Each project site contextualizes the design for application.

TECHNOLOGY CAPACITY

As presented in the previous section (see 'science and technology'), the 'sponge infrastructure' was defined at the national level, and customized with more localised indicators corresponding to Shenzhen's climatological and geographical characteristics. Considering the heavy precipitation in the tropical climate within a short-period and prone to monsoon seasons, Shenzhen further customised its standards of sponge construction: compared to the volume capture ratio of annual rainfall 70%, some districts in Shenzhen heads to 75% for better performance on surface water management (Shenzhen Planning and Land Resources Committee & Shenzhen Urban Planning and Design Co., 2019). Both permeable pavements and water retention can largely contribute to the reduction of flooding risk and flash floods.

COST AND FINANCING /BUSINESS MODEL

The financing and budgeting plan (2018) provides guidelines for Shenzhen's SCP implementation. It mainly consists of two sources: public funding and private investments. The governmental budget is mainly used for core projects like water management and restoration, incentivizing SCP-related research, and infrastructure construction. To engage the private sector into SCP construction work, the Public-Private Partnership (PPP) model is incentivized, especially on sponge infrastructure and restoration projects. SCP application and technical research institutes can be partly funded. Green building standards initiated by Shenzhen also encouraged several private companies to select green and nature-based materials for building upgradation.

HUMAN RESOURCE CAPACITY

N/A

INSTITUTIONAL SET-UP

Cross-departmental task force teams have been set up at both municipal and district levels.At the municipal level, Shenzhen Sponge City Construction Office takes responsibility in planning and coordination, while at the district level, District Sponge City Construction Offices are established. Considering the SCP implementation in Shenzhen synergizes with water environmental restoration, the Water Affairs Bureau at municipal and district levels also play a core role.

KEY BENEFICIARIES

For urban water resilience, Wang et al. (2021) identify Shenzhen's SCP has a full inclusion of most categories, especially increased water resilience around overall runoff control and comprehensive rainfall runoff coefficient. Compared to other SCP cities, Shenzhen has a consistent monitoring and accumulation of SCP's potential to urban heat island mitigation. Moreover, from an ecological and biological perspective, reintroduction of riparian plantations can gradually increase urban biodiversity. This process can further contribute to ecological restoration, recovering the completion of the ecosystem. These long-term impacts and indicators might not be included in the initial design of the program, but can be monitored to enhance the comprehensive benefits of ongoing programs.

The improved environmental and ecological performances can create a more sustainable, livable and resilient space for residents and local communities. The 'flooding points' used to occur frequently in residential areas when there were heavy rains, which contained risks and sometimes endangered human lives. Tackling this issue provides a safer living environment for residents, and also guarantees daily commutes. Besides, there are several enhanced ecosystem services such as educational and recreational functions, which are getting valued due to the COVID pandemic.

TIMELINE

In 2016, Shenzhen became one of the second batches of the *Sponge City Program Pilot Cities*. It implemented the SCP in two phases: in 2016 as the planning and pilot phase to meet the 2020 goal; and in 2019 as an optimized SCP action plan for 2020-2030.

However, as introduced in the previous sections, the LID in Shenzhen started earlier than the SCP at Guangming in 2004. The SCP in Shenzhen is built on the LID practice, transforming these technical solutions into sustainable development strategies, reflecting how district-level experience can be scaled and replicated at the city-level.

IMPACTS

CARBON REDUCTIONS

No adequate data.

RESILIENCE

The SCP significantly supported urban water management and enhanced urban resilience by reducing the impact of flooding and improving water quality and its ecosystem services. By 2020, Shenzhen met the ambitious goal to transform 20% of the urban area by 2020 to meet the Sponge City requirements, which is about 312.7 km^2 of total area. The goal is to achieve 80% by 2030.

These areas absorb and use 70% of the local rainfall, significantly strengthening Shenzhen's adaptive capacity towards urban flooding (Xu et al., 2020). Since Guangming District is at a more mature implementation stage, the volume capture ratio of annual rainfall is up to 72%, implying that more than half of the stormwater is infiltrated and stored for different purposes, such as garden irrigation (Guangming Government Online, n.d.).

Besides that, it also improves urban livability due to the expanded green space and landscaping in core urban areas and cleaner water quality in most rivers. Local residents are also able to enjoy nature and public space during the COVID-19 period, as part of enhancing social resilience, from an individual- to community-level.

CO-BENEFITS (e.g. JOB CREATION, AIR POLLUTION REDUCTION ETC.)

The SCP implementation in Shenzhen happened in parallel to the environmental restoration and ecological civilization agendas that are prioritised by both the national and local governments. It facilitated a more holistic and integrated approach to urban water management. Shenzhen applied a cluster of ambitious actions towards green development. For instance, the implementation of *Shenzhen water quality improvement work plan (2015-2020)* (Shenzhen Water Quality Control Command, 2015) improved the water quality at the beginning stage, and gradually restored the whole water-based ecosystems. From January to September in 2021, eight rivers in the core urban districts met Level IV-II of the national surface water standards. The water quality is now even suitable habitat for fishes and other aquatic animals (Environmental quality standards for surface water, 2002; Shenzhen Water Affairs Bureau, 2021).

Other practices such as offshore environmental protection and conservation, large-scale ecological buffers, management on local and invasive species were undertaken. These interlinking projects and actions together contribute to the overall environment improvement.

FACTORS FOR SUCCESS

There is a systematic planning on the SCP in Shenzhen. The previous experience of Guangming LID navigated Shenzhen with the possibility of integrated water management. Thus, surface water management, sewage treatment, and risk management of urban flooding are functioning while supporting each other.

The program is proactive in engaging stakeholders, which creates practical approaches. Rather than regarding the SCP as a public investment with single-sourced funding, the incentive mechanism maximised the participation of private sector and research institutes. Customised solutions are provided through the large-scale implementation with hundreds of projects.

The development of localised standards and technical guidelines can further contribute to next steps. Based on the first stage practices, an optimized action plan was released in 2019 for Shenzhen's SCP practice 2020-2030.

LESSONS LEARNED

OPPORTUNITIES, CHALLENGES, AND SCALING UP

Capitalizing on the national commitment and political opportunity, Shenzhen fits the development agenda and maximizes its impacts through a series of supporting actions, including scaling-up district-level practices and working with different actors and private sectors. For example, Shenzhen worked with the Natural Conservancy (TNC) to engage private and public sectors in creating rooftop gardens, greening sidewalks and parks. Rooftop gardens were especially popular among communities and attracted companies to also pilot and transform their buildings (The Nature Conservancy, 2018).

To achieve scalability, the SCP concept should go beyond city-level initiatives in managing surface rainfall and water bodies by engaging more private sectors or local communities. In doing so, Shenzhen also published *Promoting Green Buildings in Shenzhen* (2013). It is to introduce SCP concepts to inspire and guide individual actors in terms of material choice, roof design and water circulation principles. For example, the Public Art Centre in Bao'an District (figure 4), known as 'rain box', successfully integrated rainwater harvesting as part of the architecture design. The water tanks on the rooftop collects and purifies rainwater and they are channeled through the giant glass tunnels to the artificial terraces and rain gardens underneath.

Figure 4: Rain Box, the Public Art Centre of Bao'an District, Shenzhen (Source: Turenscape, 2018)

SUSTAINABILITY

The SCP brings nature back to cities by applying blue-green design and the concept is successfully mainstreamed as part of the city's spatial planning and urban design, breaking the "concrete urbanisation" paradigm in China. These blue and green infrastructures, also known as Nature-based Solutions (NbS), are very effective responses to different urbanisation problems, ranging from surface water and stormwater management, to air purification, urban noise cancelling, and carbon sinking.

Shenzhen's phased-approach in application strengthened the institutional capacity and thus, the sustainability of the project as the technical know-hows and political awareness increased. From the implementation of LID in 2004, to the SCP at a larger scale in 2016, and the determination of expanding the SCP to the most areas of the whole city, Shenzhen's capacity on learning, doing, feedbacking, and accelerating is impressive. It reveals how adaptive Shenzhen is and the process of experimentation leads to useful real-world application.

TRANSFERABILITY

The SCP technology is widely tested and piloted in different climatic zones and regions in China, including Shenzhen. Many of the elements and individual solutions can be easily transferred and adapted at varying scales, at the building, community, park, district, or even city-level. The core principle is to test the different solutions that suit the local environmental conditions (high precipitation or dry area), temperature, soil conditions, and needs. Another key component is the integrated water management approach that considers water resource protection, water treatment and purification, stormwater management, and landscaping. All of these require harmonization between policies and collaboration between departments and stakeholders guided by clear political commitment.

EFFICIENCY/EFFECTIVENESS

N/A

INSTITUTIONAL CONSTRAINTS/SUPPORTS

As the SCP has been one of the key outcomes of ecological civilization in China, there is a strong support for SCP and thus, financing and investment into the research, application and implementation.

FURTHER INFORMATION / CONTACT

Kelly Dai, Program Officer, ICLEI East Asia Secretariat

kelly.dai@iclei.org

REFERENCES

Chinese Society for Urban Studies. (2015). Practice of low-carbon ecological model—The connotation, way and prospect of sponge city 低碳生态模式践行-海绵城市的内涵、途径与展望. In *China Low Carbon Eco-city Development Report (2015)* 中国低碳生态城市发展报告（*2015*）(pp. 64–75).

Crystal News 晶报多媒体数字报刊平台. (2016, September 22). *More than 80% of the city's built-up areas will meet the requirements of sponge cities in 2030 2030*年我市建成区八成以上将达海绵城市要求. http://jb.sznews.com/html/2016-09/22/content_3623298.htm

General Office of the State Council 国务院办公厅. (2015, October 16). *General Office of the State Council on the guidance of promoting the construction of sponge cities* 国务院办公厅关于推进海绵城市建设的指导意见. http://www.gov.cn/zhengce/content/2015-10/16/content_10228.htm

Guangming Government Online 光明政府在线. (n.d.). *Guangming District Phoenix Area wins in sponge city pilot performance evaluation* 光明区凤凰片区在海绵城市试点绩效评价中夺冠. Retrieved 20 October 2021, from http://www.szgm.gov.cn/xxgk/ztzl/SpongeCity/

International Water Association. (n.d.). *Shenzhen*. International Water Association. Retrieved 22 October 2021, from https://iwa-network.org/city/shenzhen/

Environmental quality standards for surface water 地表水环境质量标准_中华人民共和国生态环境部, GB 3838-2002 (2002). https://www.mee.gov.cn/ywgz/fgbz/bz/bzwb/shjbh/shjzlbz/200206/t20020601_66497.shtml

Office of the Leading Group for the Implementation of Sponge City Construction in Guangming New District 光明新区海绵城市建设实施工作领导小组办公室. (2017). *On the issuance of "Guangming New Area sponge city Construction Technology Guide* 关于印发《光明新区强基惠民项目海绵城市建设技术指南》的通知 http://swj.sz.gov.cn/ztzl/bmzdgz/hmcsjs/zhyw/201912/P020191202641094816078.pdf

Promoting Green Buildings in Shenzhen 深圳市绿色建筑促进办法, (2013). http://www.sz.gov.cn/zfgb/2020/gb1144/content/post_7130799.html

Shenzhen Finance Committee 深圳市财政委员会 & Shenzhen Sponge City Construction Office 深圳市海绵城市建设工作领导小组办公室. (2018). *On the issuance of "About the Municipal Finance Notice on the Implementation Plan for Supporting Sponge City Construction (for Trial Implementation)* 关于印发《关于市财政支持海绵城市建设实施方案（试行）》的通知 http://swj.sz.gov.cn/ztzl/bmzdgz/hmcsjs/zhyw/201805/P020180529419417546269.pdf

Shenzhen Government Online, 深圳政府在线. (2017, May 12). *Guangming New Area is the only demonstration area of low impact development and comprehensive utilization of rainwater in China* 光明新区是全国唯一低影响开发雨水综合利用示范区 – 投资环境. http://www.sz.gov.cn/cn/zjsz/fwts_1_3/tzfw/tzhj/content/post_1352534.html

Shenzhen Online 深圳政府在线. (2018, February 22). *The definition of flooding point* 内涝点的定义是什么？ – 河道. http://www.sz.gov.cn/hdjl/ywzsk/shuiwj/hd/content/post_7864244.html

Shenzhen Planning and Land Resources Committee 深圳市规划和国土资源委员会 & Shenzhen Urban Planning and Design Co. 深圳市城市规划设计有限公司. (2019). *Shenzhen Sponge City Construction Special Planning and Implementation Plan (Optimization): Text* 深圳市海绵城市建设专项规划及实施方案（优化）*:* 文本 http://pnr.sz.gov.cn/attachment/0/850/850388/5841591.pdf

Shenzhen Sponge City Construction Office 深圳市海绵城市建设工作领导小组办公室. (2017). *Working Brief on Shenzhen's Sponge City Construction* 深圳市海绵城市建设工作简报 (2017.1-6). http://swj.sz.gov.cn/ztzl/bmzdgz/hmcsjs/gzjz/201703/P020170327526599091388.pdf

Shenzhen Water Affairs Bureau, 深圳市水务局. (2019). *Shenzhen Water Strategy 2035 (draft)* 深圳水战略*2035*（征求意见稿）.

Shenzhen Water Affairs Bureau, 深圳市水务局. (2021, October 18). *Progress of water pollution treatment in Shenzhen (as of September 30, 2021)* 深圳市水污染治理工作进展情况（截至*2021*年*9*月*30*日）. http://swj.sz.gov.cn/ztzl/ndmsss/szswrzl/gzjz/content/post_9263352.html

Shenzhen Water Quality Control Command 深圳市治水提质指挥部. (2015). *Shenzhen water quality improvement work plan (2015-2020)* 深圳市治水提质工作计划（*2015-2020*）http://swj.sz.gov.cn/ztzl/ndmsss/szswrzl/zcfg/201612/P020161205575544002369.pdf

Sun, J. 孙金颖 (Ed.). (2017). *Technical Guidelines for Newly-built Pilot Low-Carbon Communities in Urban Areas* 城市新建社区低碳试点建设技术导则. China Environmental Science Press 中国环境出版社.

The Nature Conservancy. (2018). *Nature in the Urban Century: A global assessment of where and how to conserve nature for biodiversity and human beings*. The Nature Conservancy.

Turenscape, 土人设计. (2018, June 14). *The Public Art Centre of Bao'an District, Shenzhen* 深圳宝安区公共文化艺术中心. https://turenscape.com/project/detail/4750.html

Wang, J., Xue, F., Jing, R., Lu, Q., Huang, Y., Sun, X., & Zhu, W. (2021). Regenerating Sponge City to Sponge Watershed through an Innovative Framework for Urban Water Resilience. *Sustainability*, *13*(10), 5358. https://doi.org/10.3390/su13105358

World Water Atlas. (n.d.). *Shenzhen Water Situation – World Water Atlas*. Retrieved 2 December 2021, from https://www.worldwateratlas.org/en/events/shenzhen-design-week/shenzhen-water-situation

Xu, D., Ouyang, Z., Wu, T., & Han, B. (2020). Dynamic Trends of Urban Flooding Mitigation Services in Shenzhen, China. *Sustainability*, *12*(11), 4799. https://doi.org/10.3390/su12114799

Zhang, L. 张亮, Yu, L. 俞露, Ren, X. 任心欣, & Sun, X. 孙翔. (2016). Sponge City Construction Strategy in Shenzhen Based on Historical Flooding Investigation 基于历史内涝调查的深圳市海绵城市建设策略. *China Water Supply and Drainage* 中国给水排水. https://www.upr.cn/news-thesis-i_19436.htm