IJPD The Indonesian Journal of Planning and Development

P-ISSN: 2087-9733 E-ISSN: 2442-983X

Journal Homepage: http://ejournal2.undip.ac.id/index.php/ijpd

Volume 2 No 1, February 2017, 1-10
http://dx.doi.org/10.14710/ijpd.2.1.1-10

OPEN ACCESS

Creating Urban Water Resilience: Review of China's Development Strategies "Sponge City" Concept and Practices

Submitted: 17 November 2016
Accepted: 14 February 2017
Available Online: 27 February 2017

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Abstract

These years China's cities faced urban water security problem caused by natural disaster, man-made disaster, and water shortage. Back to the year 2002 until 2015 several cases were raised such as 2002 Guizhou Duyun slag water pollution, 2014 Lanzhou water benzene poisoning cases and the Han River Excessive Ammonia Pollution in Wuhan, Gansu Hui County blood cadmium poisoning cases. Meanwhile, a rainstorm hit Guangzhou in May 2010, Nanjing rainstorm 7.18, and recently Beijing 7.21 big rainstorm who killed about 79 people and Changsha 4.7 big flood in 2015. The "Sponge City" is the answer for China's water issues. Recorded In October 2013 Professor Lin Bingzhang recommend to build a "sponge city" as storm events and flood mitigation action, then in December, Secretary-General Xi Jinping at the central work conference on urbanisation talked about building a natural reservoir, natural infiltration, natural purification "sponge city." Followed the initiative, "Sponge City Construction Technology Guide - Low Impact Development Storm water system builders" had been released in 2014, project financing policy "Finance Building [2014] No. 838" has been established and until the year 2016, 30 cities has been chosen as sponge city urban construction pilot. The sponge city initiative aims to maximize water reservation and minimise the effects of drought and flooding by recycling and efficiently applying water supplies and reserves (AUSTRADE, 2016). This paper tries to elaborate the Sponge City theory and review of several practices in China's cities to create urban water resilience. This research will conduct theory development analysis, sponge city construction's practices analysis and its performance to actualize urban water resilience.

Keywords: resilience; review of practices; sponge city; urban water

1. Introduction

Government power and intention successfully make urbanisation in China grows rapidly. Within a period of 35 years, urbanisation in China increased rapidly to 30% than in 1978; this figure exceeded even developed countries like the US and the UK (World Bank, 2014). Rapid urbanisation process, continually brings about changes in the larger population, urban services, production, consumption and social welfare have occurred in major cities around the world. Which make the city vulnerable and unable to achieve sustainable development and provide a comfortable standard of living for urban residents (Chen, Tao, & Zhang, 2009). The fast growth of this country produced high impact development where the massive land conversion and urban-rural constructions affected the balance of ecosystems.

Significant changes in rainfall and long rains in certain areas, together with an increase in average temperature state of 1.38^{o}C compared in the year 1951, brought out the change in the river flow and disrupt the absorption rate of groundwater supplies throughout China. The climate change creates extreme rainfall, coupled with the rapid changes in land use, and human behaviour contributes significantly damage

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How to Cite:
Hermaputi, R. L., & Hua, C. (2017). Creating urban water resilience: Review of China's development strategies "sponge city" concept and practices. *The Indonesian Journal of Planning and Development*, *2*(1), 1-10. doi:10.14710/ijpd.2.1.1-10.

the environment more frequent flooding over the last few years in the Yangtze River and the Huai River Basins. Some areas of the north and northeast have decreased in rainfall since 1970, and it caused a drought. Some areas are experiencing the severe drought for the past five years, inflicting the agricultural sector and worsen the economy and local food security.

The one-sided human pursuit of economic interests, ignoring the ecological environment, the limited water resources of any environmental pollutant emissions, resulting severe water pollution in China. China's Ministry housing and urban-rural development survey in 2013 stated that 234 cities flooded in 2013, 641 cities in China are in danger of flooding, and 137 cities experienced floods three times. Storms lead to flood affected more than 230 cities (China Water Risk, 2016). Recently, in July 2015, Hunan City in Changsha hit by the reproduction rainstorm, and the entire city sank. Meanwhile in the western part drought took place. The future may be inclined to make prevention more significant impact and inequities of water resources in the region of China, drought intensity and frequency of floods. The need to adopt a broad choice of options, along with requests climate change and environmental degradation will ensure that water scarcity will create socio-economic losses and ecology.

Respond those urban water security problems, December 2013 China's General Secretary Xi Jinping Speaking at the central work conference on urbanisation talked about building a natural reservoir, natural infiltration, and natural purification "sponge city." Furthermore, in 2014 The Ministry of Housing and Urban released "Sponge Technology Guide- Low Impact Development Storm water System Builders" and issued the financial law No.838 year 2014 "to carry out the central financial support sponge urban construction pilot work notice (Water Treatment Agent, 2015). China "sponge city" concept refers to "the sustainable urban development includes storm water management and water conservation," according to the opinions of the General Office of the State Council (Green Roofs Australasia, 2016). Up to 2016, 30 cities have been selected and designated as pilot cities to test out the idea. These cities can gain access to get financial aid to help with their sponge city development. Each level of cities will get cash injection up to 600 million per year. It argues that sponge city concept is the comprehensive solution to urban flooding and droughts than storm water management, and it has the closer principal to eco-city and low-carbon city theory. China put the conviction on this concept in transforming the traditional model of urban storm water management and intensifies urban water security in China.

Urban resilience refers to the ability of an urban system and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales to maintain or rapidly return to desired functions in the face of a disturbance, to adapt, to change, and to transform systems that limit current or future adaptive capacity quickly (Meerow, Newell, & Stults, 2016). Furthermore, ICLEI Resilient Cities Agenda 2015 defined resilience city as a city that is prepared to absorb and recover from any shock or stress while maintaining its essential functions, structures, and identity as well as adapting and thriving in the face of continual change. Building resilience requires identifying and assessing hazard risks, reducing vulnerability and exposure, and lastly, increasing resistance, adaptive capacity, and emergency preparedness.

Urban sponge (sponge city), as the name suggests is to use to describe the physical characteristics of a sponge a function of the city. Sponge city, this relations concept of urban development and urban hydrology has been discussed and studied by many scholars recently. Bunster-Ossa (2013) explained that sponge city described as a city that acts like a sponge which soaking the rain, as the processing of natural events, resolves water security issues, and in three cases illustrate the different scales, the city is implementing the specific storm water management design, including rainwater and filtering manipulation landscape. Essentially, sponge city is a concept of how we make cities more permeable. Water and flow needed a place to go, and where the location is crucial. These areas can include storm water parks, green spaces designed for flood and can absorb and accommodate the excess rain water and planted by a particular species that can withstand flooding. It could take the form of porous pavement so that rain water drops run down the drain. There is also a water plaza, as applied in Rotterdam, and other techniques that can absorb and accommodate the excess rainwater and treat water pollution.

This research talked about the resilience of the city, urban water security, strategy development, and sponge city itself. When discussing the urban resilience, we may have heard about the concept of sustainable development that has been promoted to be adopted in our cities recent years. Especially with the announcement of the SDGs for 2030 by the United Nations, the world realm is now racing the race to implement sustainable development in various aspects and implementing various innovations. SDGs empower and encourage us to do action in many things, and the highlight is making cities and human settlements inclusive, safe, resilient, and sustainable. It became the primary challenge for present and future urban. Besides that, SDGs inside also contained the urgency of taking action to combat climate change and its impact. Furthermore, the last but not least is to ensure availability and sustainable management of water and sanitation for all. Those three points mentioned before are supported each other in the aim to reach sustainable development goals and related to this paper theme. By promoting sustainable development, cities become more resilient or called as urban resilience.

This paper discusses urban water resilience development strategy which took the crucial role in creating a resilient city. Creating urban water resilience needs to be considered and assessed many aspects. The important things are the action. Therefore the development strategy needs to be formulated. The development strategy in this paper means an adaptation and protection actions in doing city development related to water safety and storm-water management. This development strategy has the ultimate goal which to create urban water resilience. Mainly major development strategies are Government

and Expert formulation. Meanwhile, this paper will only discuss general overview about sponge city concept and construction in China.

2. Methods

This research aims to elaborate China's Sponge City theory and review of its practices in China's cities to create water resilient city. This research has backgrounds such as the happening of Climate change, rapid urbanisation, and human behaviour which become potential factors that are causing annual temperature and precipitation change, land over-development, and environmental pollution. Those bring about excessive storm water, significant loss of natural green buffer zone, and surface freshwater supply decreased. Therefore flooding and drought emerge and threatens urban water security. Respond to those, action needed to solve urban floods and drought. After a loss of much human life, nature, and economy the urgent disaster mitigation needs to be applied. We need to know the definition and justification of sponge city concept and how it performs to solve the urban water problems in China. To answer the research question, the author set several goals such identifying sponge city concept development, Sponge City practices, the relation of sponge city and other storm water management, and the relation to sponge city and urban water resilience. This research will conduct quantitative and qualitative analysis, by present facts and review the theory, and give some opinions. Sponge city concept development will be conducted by descriptive analysis to present the facts. Sponge city practices analysis will use the descriptive review. Meanwhile, the relation of sponge city with other storm water management and sponge city with urban water resilience by examining the theories. Finally, the output is to reveal sponge city concept and its performance to actualize urban water resilience that answers the research question.

3. Result and Discussion

3.1 Sponge City Concept Development

The actual concept of the sponge city is very similar to the construction of the Low Impact Development (LID) by the Americans, Sustainable Drainage System in the United Kingdom's (SUDS) and Australia's Water Sensitive Urban Design (WSUD). In 1999, Prince George's County, Maryland proposed the low impact development. It is a new concept in the open space planning and land protection and applying urban storm water management through various strategies to reduce flood, water pollution and improve ecological environment. The Sponge city idea in China is different with LID. The Chinese interpretation requires not only build new urban areas but also redesigning and retrofitting existing urban areas to better access to clean water and reuse water.

These recent years, many kinds of storm water management concept applied. In several countries, the sponge urban construction also being discussed and promoted, such as in Taiwan with their green city and the United States with their low impact development. Meanwhile, back to 2000, natural storm water management was used in the design of housing block in Tianxu Garden Beijing. In 2003 Peking University Professor Li and Yu co-published the first book discuss sponge concept. Then 2004 Shenzhen city recognized as the first to introduce Low Impact Development and promote the creation of a national Guangming New LID storm water utilization demonstration area successfully. Up to 2010, The Tianjin Bridge Construction and Harbin Qunli Rainwater Park accomplished. The achievement made China optimistic about the implementation of green infrastructure. However, along with its cities in China continue to face the urban water security problems are unresolved. Disaster due to climate change and manmade has threatened urban life and environment even caused a huge loss in economy. Floods, drought, rainwater that unsafe to drink due to air pollutants, water pollutants by the chemical factory, all these things make the cities in China on the verge of an environmental crisis. In 2012 Beijing was hit by the massive storm killed more than 70 people, respond this Professor Yu Kongjian sent a letter to Beijing party secretary, that "the establishment of 'green sponge' resolve Beijing storm flood disaster." Even in 2013, Professor Lin Bingzhang recommends building a "sponge city" as storm events and flood mitigation action. Finally, in December 2013, China Secretary General Xi Jinping held Speaking at the central work conference on urbanisation talked about building a natural reservoir, natural infiltration, and natural purification "sponge city" (Yang & Lin, 2015). Table 1 shows timeline of the development of “Sponge City” in China.

Until 2016, 30 sponge city construction selected. These cities in the next three years will be financially supported, municipalities directly under the central government can access RMB600 million per year, meanwhile provincial capital cities get RMB500 million/year, and the rest RMB400 million per year. At the pace of urbanisation, agricultural and conservation land converted, the city facing a significant risk of flooding, drought, and environmental degradation. Thus the Government is optimistic that the sponge city construction is the right step to be more resistant to extreme climate change.

Tabel 1: Timeline- the development of "Sponge City" Concept in China

Year	Case
2000	"Natural Storm water Management" was used in the design of a housing block called Tianxu Garden in Beijing
2003	Peking University professor Li Dihua Yu Kongjian and co-published "Urban Landscape Road: exchange with the mayor." The first book discuss "sponge" concept
2004	Shenzhen City as the first to introduce Low Impact Development and promote the creation of a national Guangming New low-impact development storm water utilization demonstration area
2009	The Tianjin Bridge Construction Accomplished
2010	Harbin Qunli rainwater park Construction Accomplished
2012	Beijing 7.21 large storm killed 79 people
2012	respond the 7.21 Beijing storm disaster, Professor Yu Kongjian sent a letter to Beijing party secretary, that "the establishment of 'green sponge' resolve Beijing storm flood disaster"
2013	In October, international Symposium held in Xiamen Hydrometeorology internationally renowned expert Professor Lin Bingzhang recommend building a "sponge city" as storm events and flood mitigation action
2013	In December, Xi Jinping held Speaking at the central work conference on urbanisation talked about building a natural reservoir, natural infiltration, natural purification "sponge city"
2014	In October, the Ministry of Housing and Urban released "Sponge City Construction Technical Guide - Low Impact Development storm water system builders"
2014	In December, Treasury, Housing, and Urban Affairs, Ministry of Water Resources jointly issued "to carry out the central financial support sponge urban construction pilot work notice" (Finance Building [2014] No. 838)
2015	4.7 Changsha reproduction rainstorm hit the city, Hunan House becomes flooding restart "see the sea" mode.
2015	In September, the government rubber-stamped the development of 16 model "sponge cities" as an ecologically friendly alternative to the gray urban expanses of modern China.
2016	The Ministry of Finance, the Ministry of Housing, and Ministry of Water Resources announced the second batch of national urban construction pilot cities sponge.14 cities

Source: Yang & Lin (2015)

3.2 Sponge City Practices

According to the technical guide of sponge city construction, sponge city means the city that can perform like a sponge (MoHURD, 2014). It has the excellent resilience to adapt to environmental change and response to natural disasters, etc. when rains come, the city should act as water storage, water seepage, water purification, and water reservoir when needed. It can release the storm-water and also store the water. Sponge city construction should apply ecological principles. Thus the natural ways and artificial combination of measures, to ensure urban drainage can accommodate flood, to maximize the accumulation of rainwater in urban areas, infiltration, and purification. Furthermore, sponge city construction process, should co-ordinate natural precipitation, surface water and groundwater system, coordinated water supply, drainage and other water recycling of the links, and consider its complexity and long term. China government realizes the importance of respect for nature, and all the water security problems are the primary responsibilities to solve. Construction of sponge city is a main task of the future urban construction. It is an important part of ecological civilization construction, urbanisation, and the environment to achieve synchronized resources development for future manifestation.

The Chinese Technical Guide to Sponge City Construction also mentioned the ways to build sponge cities need to follow several aspects. First is to promote urban ecosystem protection by maximizing the protection of natural rivers, lakes, wetlands, ponds, ditches and other water ecologically sensitive areas, with sufficient water conservation to deal with the larger intensity of rainfall or even droughts. The second is ecological restoration and repair, by maintaining a certain percentage of ecological space which damaged because of an extensive model of urban construction. The third is low-impact development. By the minimum impact on the ecological environment of urban development and construction by applying rational development control intensity, retain sufficient city's green land, control urban impervious area ratio, to minimise damage to the aquatic environment, and promote the accumulation of rainwater infiltration and purification. Sponge city construction needs to coordinate all aspects of urban development. In the city at all levels, should be guided by the relevant planning concept of low-impact development. Specifically the development of low-impact control objectives, and combined with the development of urban areas or characteristics of the project to determine the appropriate planning and monitoring targets, the implementation of the main content of low-impact development facilities construction. Design stage to deal with different combinations of low-impact development services and scientific and rational plane and vertical design, construction and residential, urban roads, squares and green spaces, water and other planning and construction. The Consideration should include open landscape water, waterfront belt area, construction of low-impact development facilities, to build low-impact development storm water systems (MoHURD, 2014).

In fact, the sponge city concept has been applied in several municipal green infrastructure projects before the central government appointed 30 cities as pilot cities. There were just examples of the micro construction project enough to reflect the hallmark of the implementation of the sponge city concept in

China. According to the technical guide of the sponge city construction, sponge construction of this city can be in the form of a specialized plan that focuses on the physical construction of an urban and detailed plan that concentrates on the policy that is both control and as an indicator of development. While the design guidance consists of the building and its neighbourhood, green space, and square, roads, water system, etc. The following, this paper will present two examples of successful projects applying sponge city concept in China such as Qunli Storm water Park in Harbin City Heilongjiang Province and Jinhua Yanwei Island Park in Jinhua City Zhejiang Province.

3.2.1 Qunli Storm water Park Harbin City, Heilongjiang Province, China

Harbin Qunli Rainwater Park is China's first national urban wetland park constructed to address urban water logging. This park is an example of ecological landscape design using storm water management, municipal works to solve routine failure so that the cities can adapt to urban water problems. According to the technical guide of sponge city construction, the project is as the specialized plan that focuses on green space and urban water logging plan. Since built in 2011, this park effectively plays a major role in addressing urban water logging. Qunli Rainwater Park acts as a green sponge, cleansing and storing urban storm water and coordinated with other ecosystem services to provide native habitats protection, aquifer recharge, leisure use, and emphasizes aesthetics that led urban development. About 2,733 hectares Qunli New Town was established in 2006, it took place on the eastern outskirts of Harbin in Northern China. More than Thirty-two million square meters of building floor area will take 15 years construction, and one-third of million people will live there. Only about 16 percent of the developable land zoned as permeable green space. Floods and water logging have occurred several times in the past. Meanwhile, the groundwater table supply keeps decreasing. This project was started in mid-2009 and completed in November 2010. The landscape architect from TURENSCAPE and Peking University were assigned to design 34 hectares park located right in the middle of Qunli New Town which categorized as a conserved regional wetland. This wetland had severed from its water sources and was under threat. The challenges of this project are about how to preserve the damaged wetland and provide leisure space on the ecological region.

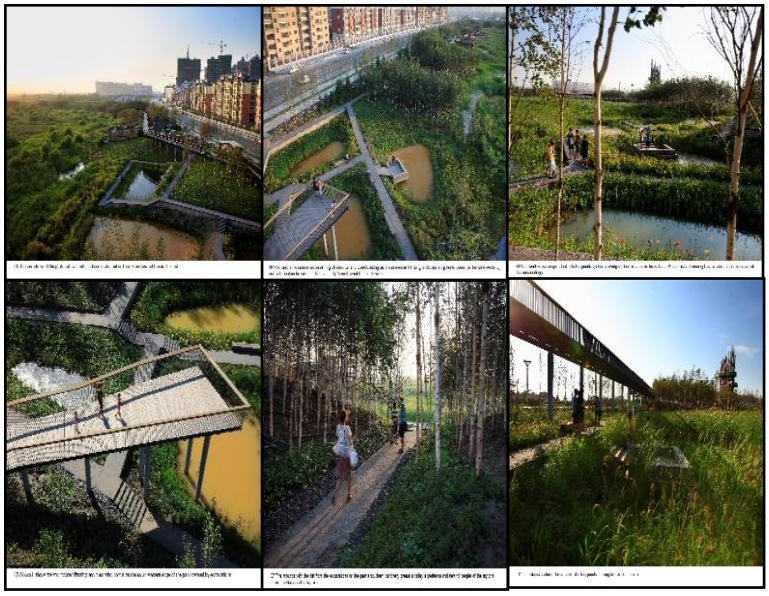

Figure 1. Design Implementation of Qunli Rainwater Park
(Source: ASLA, 2012)

The actual construction results can be seen in Figure 1. Technical design key had been applied points on this rainwater park include below (see Figure 2):

1. Catchment city- meeting wet ground as the delineation for rainwater security pattern that composed of "green sponge complex" casement structure;
2. Cut and fill techniques to form a "spongy terrain" by creating an outer ring of mounds and ponds. It is for storm water filtrating and purifying buffer zone for the core wetland, and a transition between nature and city. These multi-level terrain systems create diverse habitats provide environmental infrastructure and leisure space;
3. Build a "water purification - a reservoir of stagnant water - groundwater covering" multi-level multi-functional wetland system. The multi-stage system is to integrate wetland and subsurface flow meter of wetland flow technology, soil and biological purification, the purified rainwater into the central low-lying wetlands, groundwater recharge. According to "water purification wetland - stagnant reservoir wetland - groundwater covering biodiversity restoration of wetlands," in that order, followed by three kinds of wetland system constructed to produce a variety of ecosystem services;

4. Collecting the advantage of the integration of the terrain, habitat restoration, biological conservation, local leisure, and science education at once;
5. Building the network of paths and platforms as recreational facilities which let people directly see and experience the nature (TURENSCAPE, 2011; Yu et al., 2015).

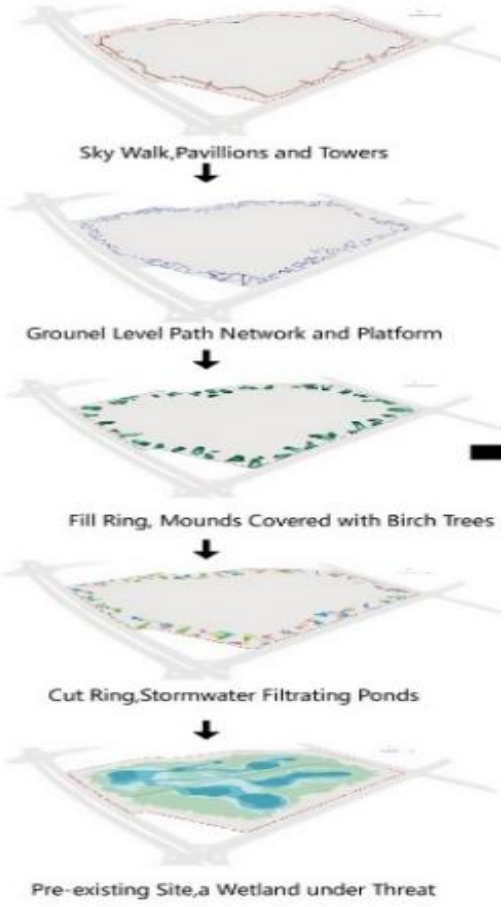

Figure 2. Qunli Storm Water Park Design Concept
(Source: ASLA, 2012)

3.2.2 Jinhua Yanwei Island Park

Jinhua Yanwei Island Park located in the heart of Jinhua City Zhejiang Province. This park is the Jinhua Municipal Planning Bureau project which is designed by TURENSCAPE. The designated area is 26 hectares and categorized as the city park and green space planning. This project completed in May 2014. The site took places on an island that located in the centre of Wu River Jinhua. Most of the land has been developed into a Jinhua City Cultural Centre. Now has Chinese Wu Theatre that curve shaped building on both sides of the island was dense urban area and Riverside Park, but because of the open river barrier, difficult to reach using public cultural facilities on the Island. This island leaving a total of 26 hectares of the floodplain, some part included because sand excavation left crater and rubble, broken terrain, another part is the survived wetlands and dense vegetation. This site by monsoon climate, annually flooded by water, formed a "poplar". The Maple tree is the dominant species in the community is the only remaining downtown Jinhua floodplain habitat for a wide variety of birds and biological asylum, including local landmark significance egret. The challenges of this project are how to provide public space in the city centre while protecting the floodplain habitat, how to deal with floods, adapt and create resilient water land, and how to unite the city from north to south by providing public space and enhance the city's social and cultural identity.

Design Features of this project are focus exploring how to adapt with floods by applying building adaptability, vegetation adaptability, and 100% permeable pavement design to achieve resilient ecological landscape; build the networks and paths through the pedestrian path and bridge system, the establishment of community ties. The design implemented smart streamline design which the original streamlined construction site on the seasonal flow and steady stream of flow organically woven together to dissolve the venue and solving the contradiction between free river flow and the everyday use of recreational space, creating a resilient social landscape (see Figure 3).

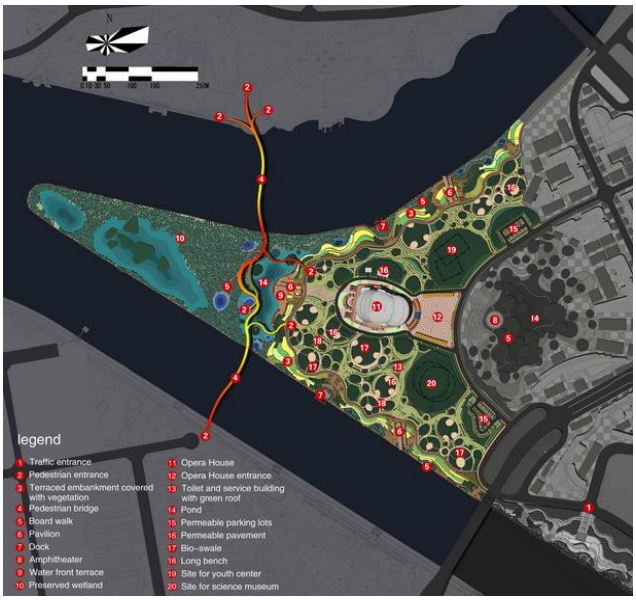

Figure 3. Yanwei Island Design Concept and the Site plan
(Source: China Landscape, 2015)

According to the site plan, many facilities and infrastructures included traffic and pedestrian entrance, terraced embankment pedestrian bridge, pavilion, dock, boardwalk, pond, bio-swale, permeable space, the long bench and site for youth and cultural centre. All of these constructions implement the resilient design strategy include Adaptive design to retain the natural and ecological restoration; Adapt with Water Resilient Design; Connecting the city and nature, history and future resilient of gangway; and Dynamic streamline weaved the resilient of spatial experience (TURENSCAPE, 2014).

Figure 4 showed that the island park built applying elevation consideration design that emphasized the sponge city form (a). The appearance of the park during the dry season (b) and flood season (c) showed the design of flood adaptation. The design still preserves the original vegetation and habitats (d). This park apparently designed not only for habitats preservation but also emphasized the connection between ecological and social activity (e and f).

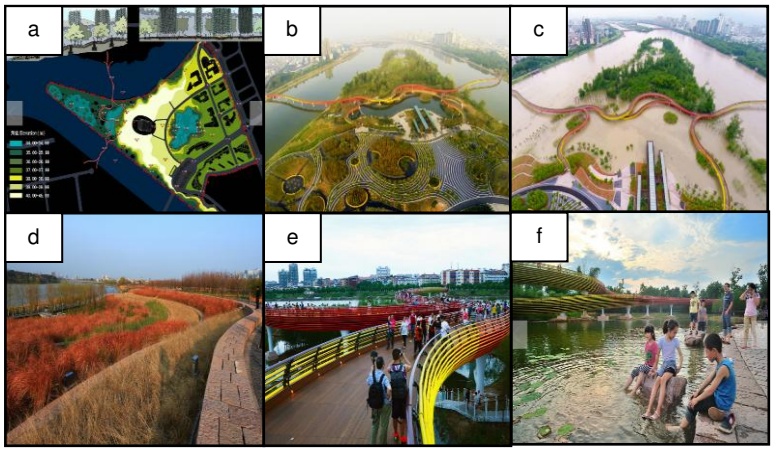

Figure 4. Design Implementation of Yanwei Island Park
(Source: China Landscape, 2015)

3.3 Relation Sponge City with Other Storm water Management

The study of storm water management system started late in China, the existing urban planning and storm water management system is not coherent and lagging behind. Meanwhile, massive and fast development of China Cities brings about severe storm water problems as mentioned before. Storm water management is the action to manage and control surface runoff. Currently urban storm water management has been adopted in urban design, such The United States' the best management practices (BMP), low impact development (LID), The United Kingdom sustainable drainage system (SuDS), New Zealand's low-impact urban design and development (LIUDD), and Australian water-sensitive urban design (WSUD).

In UK practice, SUDS consist of a range of technologies and techniques used to drain storm water or surface water in a manner that is more sustainable than conventional solutions. SuDS are aimed more at

water quantity than quality control (Defra, 2011), although they are deemed to comply with water quality standards provided they comprise appropriate components of a defined treatment train. Meanwhile, WSUD as a "philosophical approach to urban planning and design aims to minimise the hydrological impacts of urban development on the surrounding environment. Storm water management is a subset of WSUD directed at providing flood control, flow management, water quality improvements and opportunities to harvest storm water to supplement mains water for non-potable uses". The term LID distinguishes the site-design and catchment-wide approach from the typical storm water management approach and typically involved transport to large end-of-pipe detention systems. In contrast, LID was characterized by smaller scale storm water treatment devices such as Bioretention systems, green roofs, and swales, located at or near the source of runoff. The LID, WSUD, and SUDS created the improvement of water quality, the protection of aquatic ecosystems and the mitigation of flooding (Fletcher et al., 2015).

The sponge city concept is quite similar to the LID storm water management concept. However, the Chinese interpretation requires redesigning and retrofitting existing urban areas, and designing new urban areas to better capture, clean and reuse water. It does not only aim to manage surface runoff, water conservation, and rainwater purification but also promoting green infrastructure and natural habitat conservation through protection, mitigation, and preparation. The sponge city's storm water management theory connotation of development and progress defined the ecological urban storm water management ideas and integrated way. The Sponge City concept establishment and promotion for promoting the construction of the urban storm water management system and an efficient solution to the urban development process of ecological water problems pointed the way.

Sponge city construction should co-ordinate with the LID including storm water drainage system and the surface runoff drainage system. The essential element to creating foundation sponge city construction such as for adapting low impact development storm water system by surface water infiltration, storage, transfusion, and purification function. Also effectively control the total runoff; supply traditional drainage system that coherent with a low impact development drainage system to collect runoff, transfusion, and emissions. Additionally, excessive storm water runoff drainage system for storm sewer drainage systems to deal with more than the standard design of storm water runoff through storage tank, deep tunnels, or other artificial water bodies.

3.4 Relation Sponge City with Urban Water Resilience

The cities nowadays have to begin formulating effective development strategies that have a resistance to global climate change and energy scarcity. "Resilience" has become an important principle for the strategic planning and design required to increase the capacity of urban areas face an uncertain future. In enhancing the resilience capacity, each city needs to adapt the planning and design of development that can respond to the pressures of economic, social, and physical along with the threat of population change, global climate change, and resource scarcity.

Improving the individual systems that make up a city will increase the resilience of the city overall. Resilient systems need to withstand, respond to and adapt more readily to shocks and stresses. A right, applicative and comprehensive solution also needed to realize the resilient. Therefore, the Chinese government took the sponge city concept as the right solution to solve their urban water's problem and as the action to enhance their city resilience. In China, a 'sponge city' refers to the "sustainable development concept of the city including flood control and water conservation." Sponge city construction can minimise the damage to the aquatic environment of the existing city and to achieve efficient use of rainwater resources, will ease the shortage of urban water problems. The sponge city has a correlation with the low impact development which handles storm water management. However sponge city is different, sponge city can treat the maximum function of the integrated management of ecological, consider aquatic ecosystem protection and utilize the rainwater resources. Sponge city implementing acts of urban water ecological environment protection, for the better management of sustainable urban development

Deal with the problem of urban water in the main cities of China, sponges city adapts to answer the question of how city manage its urban water logging, how quickly the water discharged and distributed; hope the drought city can fulfil their water needs; how to create groundwater and urban water bodies protection from pollution. For such problems, sponge cities should be made to manage the flow of surface water, runoff controls the emergency, the decline of urban flooding, absorb, capture and filter water quickly, and regulate issues of drainage flow. In wet periods, the sponge is expected to save the city from hazardous stress and absorb rainwater as much as possible to prepare for the use of the dry season. Sponge city is also able to conduct a water purification steps that can reduce waste discharge by utilizing urban ecology.

The expected performance of sponge city is the city can stream during floods and can spit water when drought. Comprehensive acts of "infiltration, stagnation, storage net, streaming" to minimise the impact of urban development and construction of the ecological environment, so that controlled more than 70% of the rainwater. The city's urban construction stage sponge goal to water logging prevention and non-point source pollution abatement were based, supplemented by storm water resource utilization. There are several primary functions such as urban drainage water logging can enhance the ability to effectively reduce storm water runoff pollution, promoting the use of rainwater resources, alleviate the urban heat island effect. For such roles, sponge city becomes the leading solution to enhance urban water resilience.

3.5 Reveal the Sponge City Concept Performance to Actualize Urban Water Resilience

Urban resilience is the main agenda to face the challenges of climate change and energy scarcity. Enhance the resilience capacity makes each city is able to adapt and respond the threats, shocks, and stresses in the future. Revolution and changes needed in the strategic planning and design in order to increase the resilience. According to ARUP (2015) resilient cities should demonstrate seven qualities which are reflectiveness, resourcefulness, robustness, redundancy, flexibility, inclusiveness, and integration. Sponge city construction in China considered fulfilling the seven qualities above, more precisely it is a better concept to create urban water resilience since urban water security has become the important global agenda of sustainable urban and rural development.

Chinese Government adapts sponge city concept as the practical step to increase their urban water resilience after experiencing many urban water security problems such as floods, drought, and water scarcity. Sponge city construction should be able to minimise the damage to the aquatic environment of the existing city and to achieve efficient use of rainwater resources, will ease the shortage of urban water problems. The sponge city has a correlation with the low impact development which handles storm water management. Sponge city concept can treat the maximum function of the integrated management of ecological, consider aquatic ecosystem protection and utilize the rainwater resources. The Chinese technical guide of sponge city construction stated that "the city government should implement as city sponges (MoHURD, 2014). The primary responsibility for the development of low impact construction systems storm water, coordinated planning, soil, drainage, roads, traffic, landscape, hydrology and other functional departments to carry out the construction of low-impact in the planning process of a relevant content system construction of storm water. Overall urban planning should be innovation planning ideas and methods, the development of the low-impact storm water system as a significant new urbanisation and the construction of ecological civilization". The quote above gives us a general overview of how sponge city construction is enhancing the urban water resilience.

The Chinese government does have several considerations behind the decision to implement sponge city construction. First, sponge cities have the wide range of options wide-ranging cost. Data from the China Ministry of Housing and Urban-Rural development 2014 showed that the installation cost of each type of construction, location, and economic factors ranges from around USD 22/m^2 for constructed treatment wetlands to USD 426/m^2 for the storm water planter. However, data from the pilots (Beijing and Harbin Project) in China show even lower costs (Green Roofs Australasia, 2016). The construction cost should consider many additional benefits to residents, create more recreational areas, healthy environment, increased biodiversity, cooler temperature, and preventing upcoming natural hazards. Economically efficient, Sponge city is likely the best solution for China urban water security and enhancing their urban resilience.

Second, floods make losses of the billions amount and create urban areas more prone. The average annual loss from floods in China for 2000-2013 increased. Flood cause loss not only in large amounts of money but also human life, damage buildings, and paralysis city. The costs become greater if the indirect economic loss is included such as disruption of communication and transportation system, shortage of raw material and important nature object and resources. Limited infrastructures and nature destruction make the urban areas more prone to flooding; it is hard to make water infiltrate the ground since runoff can be very significant beyond the expectation. Drainage systems were designed to deal with runoff in urban areas, through pipelines buried underground. However, the drainage system in China is prone to extreme weather conditions. Therefore sponge city construction is urgently needed. Sponge city construction is also promising a result that annual runoff control rate can reach at least 85% (Green Roofs Australasia, 2016). Additionally, a sponge city functions not only for flood control but can also help with water conservation and water purification.

The Chinese Technical guide to Sponge City Construction mentioned the ways to build sponge cities need to follow several aspects. Such as promoting urban ecosystem protection, ecological restoration, and repair, low-impact development of the storm water system (MoHURD, 2014). Harbin Qunli Rainwater Park and Jinhua Yanwei Island Park as mentioned before reflected the example of sponge city construction. Both of them are the best lesson learn to create more sponge cities in China. Their plan focuses on green space and urban water logging plan by adapt design to retain the natural and ecological restoration, creating green space, public space as well as water catchment area. These constructions implement the resilient design strategy to enhance urban water resilience.

4. Conclusion

The Chinese government took the sponge city concept as the right solution to solve their urban water's problem and as the action to enhance their city resilience. In China, a ‘sponge city' refers to the "sustainable development concept of the city including flood control and water conservation." The "Sponge City" is formed in response to China's water issues. In December 2013, Secretary General Xi Jinping at the central work conference on urbanisation talked about building a natural reservoir, natural infiltration, and natural purification "sponge city." The Chinese government does have several considerations behind the decision to implement sponge city construction such as the sponge cities has the broad range of options wide-ranging cost of construction and the urgent action to solve floods that make the loss of billions amount and create urban areas more prone. The Chinese Government selected 30 cities as a pilot for sponge city construction. Chinese Central Government will financially support these cities in the next

three years. Qunli Storm water Park in Harbin City Heilongjiang Province and Jinhua Yanwei Island Park in Jinhua City Zhejiang Province is the best sponge city piloting project in China currently. They are the specialized plans that focus on green space and urban water logging plan by adapt design to retain the natural and ecological restoration, creating green space, public space as well as water catchment area. Sponge city construction establishment and promotion will help the cities to tackle their urban water issues and protect their ecological water ecosystems. Through this concrete action, China successfully reflected best practices to enhance their urban water resilience.

Acknowledgement
This paper is sponsored by Zhejiang University and Zhejiang Provincial Government of People Republic of China.

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