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Early Warning, Emerging Issues and Futures

Emerging Sponge Cities

Background

The UN Environment Foresight Briefs are published by UN Environment to, among others, highlight a hotspot of environmental change, feature an emerging science topic, or discuss a contemporary environmental issue. The public is thus provided with the opportunity to find out what is happening to their changing environment and the consequences of everyday choices, and to think about future directions for policy.

Introduction

As global populations converge steadily into cities (UN, 2017), fast growing cities are suffering with intensified hydroclimatic hazards. In China, more cities are facing challenges associated with urban sustainability and urban water issues such as aging/outdated water and wastewater infrastructures, urban flooding and a high frequency of extreme weather (Li et al., 2017; Lv and Zhao, 2013). Among these, urban flooding is one of the most frequent and hazardous disasters that can cause enormous impacts on the economy, environment, city infrastructure and human society (Li et al., 2017). The emerging concept and construction of "sponge cities" is an effective approach to solving urban rainstorms (Liu et al., 2015; Xia et al., 2017) and seeks to enhance cities capacity on flood prevention. (Liu et al., 2017). The concept is green, natural and sustainable. It emphasizes the principle of ecological priority which is necessary to realize a win–win situation for urbanization and environmental protection. A sponge city refers to sustainable urban development including flood control, water conservation, water quality improvement and natural ecosystem protection. (Liu et al., 2017).

Floods in cities across China in 2016 caused as much as US$45 billion worth of damage.
Source: http://www.climatesignals.org/sites/default/files/styles/article_image/public/events/CHINA-FLOOD_0.jpg?itok=FMjhQ4cY

Why is this issue important?

Cities are the drivers of social and economic growth of countries around the world. They are responsible for 75 per cent of global economic activity, 66 per cent of the world's overall energy consumption and 70 per cent of all greenhouse gas emissions (UN-Habitat, 2016). China is the biggest developing and most populous country in the world with 1.41 billion people (UN, 2017). The country is at a stage of rapid urbanization along with extremely good economic growth (Xia et al., 2017; Liu et al., 2017).

Cities in China are responsible for more than 80% of China's Gross Domestic Product (NDRC 2016). By 2015 the urban population accounted for 56.1% of the total population up from for 10.6%, 19% and 26.4% in 1949, 1980 and 1990 respectively (Pan et al., 2015; Jiang et al., 2018). Urbanization on such a massive scale has hardly ever been seen in human history (Wei and Ye, 2014). Rapid urbanization since the early 1990s has exacerbated urban water problems, manifested prominently in a lack of consideration of the natural environment, irrational land-use structures and patterns, and poor drainage systems (Xu et al., 2016; Liu et al., 2017). Challenged by abnormal climatic events, record-breaking rainfall easily results in widespread floods in cities, and in China, urban flooding has become even more frequent, pervasive and severe (Liu and Xia, 2016). While 641 out of 654 Chinese cities are exposed to frequent floods, at least 130 cities have experienced flooding nearly every year (Lv and Zhao 2013, TFUFPSI 2014). In a 2010 study by the Ministry of Housing and Urban–Rural Development, 62% of the 351 cities investigated showed that they had witnessed flooding from 2008 to 2010 (Lv and Zhao, 2013).

Urban flooding in China poses a severe threat to the safety of lives and properties of urban residents, and have large environmental and socioeconomic repercussions.

- On 11 November 2010, torrential rain in Guangzhou city caused 26 areas in the city to become waterlogged. In June 2011, torrential rainstorms in Wuhan city flooded 80 or more stretches of road throughout the city, and nearly paralyzed traffic in the city centre (Shao et al., 2016).
- Flooding in Beijing city on 21 July 2012 led to a loss of at least 77 lives, 60,000 people were evacuated and more than 1.6 million people were affected. The direct economic losses were estimated at around US$ 1.6 billion (Qiu, 2012).
- In July 2013, rainstorms in the town of Yanan resulted in the death of 42 people and direct economic losses amounting to more than US$1.9 billion (Shao et al., 2016).
- The massive floods in China in 2016 impacted 60 million people, forced over half million to be evacuated, killed 300 people, and costed China at least US$44.7 billion in damages (Jiang et al., 2018).
- Since 2010, rain-induced flood disasters have led to a damage loss of more than US$15 billion each year in China (Xu et al., 2016). The direct economic loss from floods in China for 2000-2010 amounted to around 1.1 trillion Yuan and for 2011-2013 it amounted to 712.2 billion Yuan. In 2014, direct economic losses were 157.4 billion Yuan (Xu, 2015; Zhang, 2015).

What are the findings?

In recent years, urban flooding caused by extreme rainfall has increasingly occurred across China (Jiang et al., 2018). The rising floods are because of many factors, including more frequent extreme weather events induced by climate change (Liu and Xia 2016) and under-developed urban drainage systems and capacity (Cheng 2013, NDRC 2016). Urbanization has transformed natural landscapes into impervious concrete surfaces with buildings and pavements effectively reducing the capacity of landscapes to absorb rainwater (Jiang et al 2018). Impervious surfaces across Chinese cities have been steadily increasing at an annual rate of 6.5% (Ma et al., 2014). At the same time, there has been a continuous loss of aquatic ecosystems such as lakes and wetlands, along with fragmentation of natural water pathways across cities (Du et al. 2010, Xu et al. 2011, Jiang et al. 2012). Consequently, such development practices and patterns severely reduce the capacity of local landscapes to absorb, store, infiltrate, and retain rainwater and to purify polluted runoff water, exacerbating urban runoff, water and soil pollution, and intensity of flooding (see figure 1) (Jiang et al., 2018).

Figure 1. Hydrological effect of urbanization on river flow across landscapes (Duan et al., 2016).

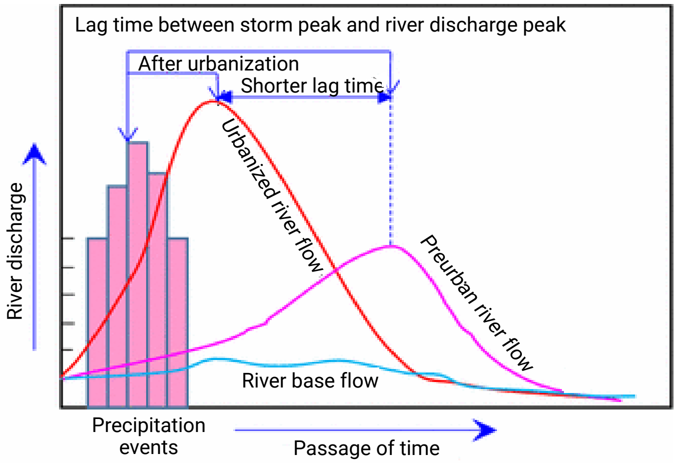
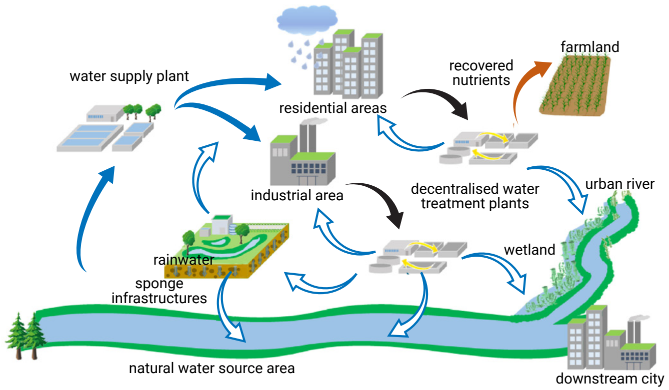


Figure 2. An urban water system with sponge infrastructures, decentralized sewerage systems and ecological rivers



Blue, gray, brown and yellow arrows represent water flow, wastewater flow, resource and energy, respectively (Ren et al., 2017).

In 2014, the Chinese government began to implement a plan to construct sponge cities to address the environmental threats to its urban centres (Shao et al., 2016) including publishing preliminary technical guidelines, setting targets, and establishing a regulatory framework (Jiang et al., 2018). An enormous investment was commitment to promote rainwater retention and sustainable use, integrated with urban development (Jiang et al., 2018).

The sponge city initiative is devoted to finding various ecologically suitable alternatives to transform traditional urban infrastructures into green infrastructures that can capture, control and reuse precipitation in a useful, ecologically sound way (Liu et al., 2017).

The development pattern seeks to realize natural accumulation, infiltration and purification through urban planning, construction management, and adsorption infiltration effect of rainwater (GOSC, 2015).

Model of a sponge city in China, Yangming Archipelago, Changde

According to Liu et al., (2017) the main guidelines of the sponge city concept include three parts: (1) Protecting the original ecological environment of cities including natural rivers, lakes, wetlands, ponds, ditches, meadows, woodlands, and other ecosystems; (2) Remediation of contaminated waters and other damaged natural ecological systems by recovering the ecosystem service function of destroyed systems using ecological techniques; (3) Low Impact Development and water logging prevention concept through a series of separate and small source control facilities such as highly permeable and breathable pavements, squares and communities, grassed swales, rain gardens, bio-retention facilities and green roofs.

Per the guidelines of sponge city construction, the construction area should cover more than 20% of the whole urban city (Xia et al., 2017).

Sponge infrastructures are more flexible and easier to be integrated in city regions and implemented without disruption to traffic and other public utilities to improve storm water management, restore ecosystem services, and enhance climate change resilience (Ren et al., 2017).

What has/is being done?

To promote a sustainable urbanization strategy, two batches of pilot sponge cities were selected by the Chinese government, 16 in 2015 and 14 in 2016, with a committed investment of between 400-600 million Yuan (or 60-90 million USD) per year per city over 3 years (2016-2018) (Jiang et al., 2017).

The 30 cities will pilot green roofs, constructed wetlands, increased tree cover and permeable pavements to capture, slow down and filter storm water. The government also mandates the integration of green and gray infrastructure into the sponge city construction.

The "Guiding Opinions on Promoting Sponge City Construction" specifies that at least 70% of rainwater should be soaked into the underground instead of being discharged into the nearest rivers and lakes (SC, 2015).

By 2020, 20% of cities in China should have modern drainage systems and infrastructures that allow for efficient infiltration of rainwater, with the number rising to 80% by 2030.

Figure 3. Location of pilot sponge cities

(data source: Liu et al., 2017

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Many of the sponge cities have done well.......

- The pilot sponge projects in Xiamen and Wuhan have already achieved positive outcomes. The reconstructed areas of Xiamen, a coastal city developing 236 projects and costing over US$1.12 billion, endured Typhoon Nepartak without waterlogging (Chinadaily, 2016). Wuhan, which has invested over US$311 million in 104 projects, efficiently managed heavy storms on 11June 2016.
- Nanning city stresses ecology and ethnic preservation through embracing the "sponge city" concept. Through construction of wetland parks, rain corridors, storage and other facilities to form a systematic water system, the city is able to absorb precipitation for drinking and irrigation through permeable pavements and wetlands. Ecological rain corridors and underground water storage system in the surrounding mountains increase water supply to the city, expand green space; and ensure flood control, drainage, irrigation and sewage treatment system of 18 inland rivers. The local government further planned to build 23 drainage basin districts, 10 sponge functional areas, and 202 management control areas in line with the sponge concept (Wei et al., 2017; Zhang et al., 2016).
- Lingang, in Shanghai's Pudong district, hopes will become China's largest sponge city and a model for other cities lacking modern water infrastructure. Lingang aims to cover rooftops with plants to green the city, create wetlands for rainwater storage, and create permeable pavements that store runoff water, allowing it to evaporate to moderate temperatures (Zweynert, 2017).

Benefits of a sponge city

The sponge city concept has many other benefits besides urban rainwater management, which include improving the ecology, cooling urban temperatures as trees and other plants absorb water and then release it through evaporation, and mitigating urban heat islands which are more pronounced in built-up areas where concrete and asphalt trap heat. Sponge cities increase air humidity, regulate urban microclimates, and reduce public health risks (Liu et al., 2017). Measures taken in sponge cities include covering buildings with green roofs and facades, and creating urban wetlands and trenches to filter run-off water that can be used to replenish aquifers, irrigate gardens and urban farms, flush toilets and clean homes (Zweynert, 2017).

Major challenges

Li et al (2017) highlights a few challenges which may inhibit wide-scale implementation and success of the sponge city initiative. (1) There is an observed weak research foundation for such a large-scale sponge city construction which can unnecessarily restrict the potential positive effects of the initiative. (2) Rather than one model to fit every part of the country, sponge city strategies should be developed based on a careful assessment of local conditions and potentials, and mitigate the problems by leveraging local potential and regional resources. (3) Lack of design standards and codes that consider variations in regional and local conditions has limited the ability of local communities to implement sponge city projects based on local conditions. (4) Sponge city practices may require additional land space when designing new developments or retrofitting existing urban areas and may conflict with other development goals. (5) While sufficient funding for initial construction is allocated, funding needs for future operation and maintenance are not addressed. To attract public–private partnership for sponge city construction, a more robust regulatory environment, with clear laws and an independent regulating agency are essential.

What are the implications for policy?

Enhance the implementation of the SDG 11

Among its 10 targets, Sustainable Development Goal (SDG) 11 seeks by 2030, to enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries. It also seeks, by 2020, to substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement holistic disaster risk management at all levels (UN 2015).

More effort is still needed to promote implementation of sponge cities. Further development in the future will be needed to integrate land use, topographic and geologic conditions in the planning of an urban master plan to suit the actual situation of cities (Liu et al., 2017). With pilot projects largely under construction, monitoring and data collection (on urban hydrology, physical geography, stormwater runoff dynamics, the social economy, water resources, and ecosystems, management strategy and governance) at the project level is, therefore, critically important for ex post evaluation of the effectiveness of the sponge city initiative in the future (Shao et al., 2016; Jiang et al., 2018). All these important aspects demand both technical know-how and strong management skills with governance capacity.

Participatory planning and coordinated governance

Sponge city development approach relies heavily on the extent to which it is incorporated into urban planning and design, a process that should be integrative and dynamic. While implementation of the policy has started in pilot cities, there is a need for joint design, planning and cross-sector coordination, with the participation and engagement in knowledge co-creation of stakeholders, relevant government agencies and developers (Jiang et al., 2018; Dhakal and Chevalier, 2016).

In addition, information management tools are required that allow participatory assessment, interactive design and communication to support coordinated planning and administration (Jiang et al., 2018). Upscaling of best practices to other projects and peer learning between cities need to be facilitated. There is a need for coordination, integration, interaction and synthesis among different policies and management related to urban development. China has many policy initiatives, such as smart cities, eco-cities, and low-carbon cities which may crowd out the initiative of sponge cities.

Investment financing, planning and organization

At the national level, the State Council has set up a progressive goal for the sponge city initiative, requiring the absorption of 70% of rainwater to be used onsite for 80% of developed urban areas by 2030 (Jiang et al., 2018). One big challenge for sponge city development is to identify reliable financing schemes to develop business models that can attract private finance resource (Zhang et al., 2016). Business cases need to be established, which depend critically on reliable financial and economic data related to sponge cities development that can be collected with pilot implementation (Jiang et al., 2018). Given the technical, governance and financial challenges of constructing sponge cities, appropriate project planning with sufficient consideration of implementation time is needed to ensure project quality and reliability (Lv and Zhao, 2013; TFUFPSI, 2014, Jiang et al., 2018)

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Upcoming Brief:

Transboundary air pollution

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