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Public perceptions of and willingness to pay for sponge city initiatives in China

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ABSTRACT

As a result of global climate change, urban flooding has become a global concern in recent years because of its significant negative impacts on cities. To cope with the frequent occurrence of urban flooding in recent years as well as water shortages, China has started a new nationwide initiative called Sponge City intended to increase urban resilience. This study aimed to examine public perceptions of and knowledge about urban flooding and sponge city construction, as well as the public's willingness to support sponge cities through two options, which includes (1) paying a domestic water fee surcharge and (2) buying government-issued credit securities. We found that most respondents knew about urban flooding and sponge cities, and also supported sponge city construction. Residents believed that government grants and public-private partnerships (PPP) should be the main financial sources for sponge city construction. However, respondents also accepted 17% of the domestic water price as a surcharge to be used for sponge city construction. Meanwhile, the willingness to pay (WTP) for government-issued credit securities for sponge city construction was 55% of the average annual capital surplus. We also found that occupation, education, and income were the main factors affecting respondents' WTP to support sponge city initiatives. Though increasing water prices by a certain amount will be acceptable to the public, a more properly designed PPP model should be considered and promoted by the government to overcome financial insufficiencies and ensure the sustainability of the sponge city initiative.

1. Introduction

In recent years, urban flooding has become a global concern because of its significant negative impacts on cities which include threats to urban safety, the economy, and people's daily lives. As a result of climate change, the frequency, intensity, and distribution spans of extreme weather conditions have increased in recent years, especially short term rainstorms (Kundzewicz et al., 2014; Schreider et al., 2000). Consequentially, large amounts of precipitation accumulate in cities, leading to surface-water accumulation and urban flooding. Urban drainage systems are intended to cope with such situations. However, the increase in extreme events may already exceed the capacity of drainage systems, especially where there are obsolete designs that have not been significantly improved. In addition, as a result of urbanization, the increase in impervious surfaces has led to increased surface runoff, increased runoff velocity, decreased time concentration, and decreased water quality, which have caused severe hydraulic problems and increased the possibility of urban flooding during storm events (Dietz, 2007). Moreover, urbanization involves converting some "natural" lands (e.g., forest and grasslands) for residential or commercial use. Diverse vegetation that existed prior to development is replaced by impervious surfaces or monoculture grasses in residential green areas that are trimmed regularly and inundated with pesticides and fertilizers (Davis, 2005). Converting natural land for residential or commercial use significantly alters the water balance and increases areas with impervious surfaces. Large areas of impervious surfaces cannot absorb, maintain, filter, or purify rainwater and cause severe urban flooding. Studies have also shown that when impervious areas reach a certain ratio, habitat and water-quality indicators rapidly decline (Wang et al., 2001).

Constructing conventional storm water management facilities (drainage systems) is the main approach for dealing with storm

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water, aiming to quickly divert runoff from impervious surfaces to gutters and finally to wastewater treatment. Conventional facilities cannot absorb, maintain, or purify water to relieve water scarcity or recharge underground water. Conventional facilities can also cause more diverse pollutants to enter storm water, reduce the possibility of pollutant removal during overland flow, and create greater runoff peak flows (Davis, 2005). As an alternative to using conventional management facilities, low-impact development (LID) has been advocated to mimic the natural hydrology of a site by deploying decentralized micro scale control measures to manage storm water in developed countries (Ahiablame et al., 2012; Coffman, 2002). Aside from storm water runoff reduction (peak and volume), LID also aims to increase infiltration, recharge groundwater, protect stream and enhance water quality (Hunt et al., 2010). LID, which was first piloted in Prince George's County, Maryland, aims to preserve a predevelopment hydrology through drainage system designs that manage storm water at the source with micro scale control measures. Typical LID practices (e.g., bio-retention, green roofs, pervious pavement, cluster layouts, and grass swales) have proven to be effective for reducing the impairments of impervious surfaces (Ahiablame et al., 2012; Chen et al., 2013; Davis et al., 2003; Dietz and Clausen, 2006).

Studies of different areas have shown that LID practices significantly reduce the negative effects of storm water and increase the resilience of sites to against precipitation patterns caused by climate change (Liu et al., 2014; Pyke et al., 2011). Integrating different LID practices is more effective for reducing runoff and peak flow than adopting single LID practice (Liu et al., 2014). However, LID practices and other climate change adaptations still face challenges: high costs, the increased demand for urban land resulting from economic growth, and low public perceptions (Filatova, 2014).

China has undergone rapid urbanization since the 1980s. As a result of rapid economic growth combined with urbanization and industrialization, China's cities face increasingly serious problems that threaten their sustainability. Urban flooding is one such problem that has drawn a great deal of attention. Extreme weather events caused by climate change and urbanization-induced impervious surfaces and poor drainage systems contribute to urban flooding. Thus, urban flooding has become a major phenomenon in many parts of China, while facing severe water scarcity, especially in northern China (Jiang, 2009). The frequent occurrence of urban flooding creates major inconveniences for citizens and adversely affects the economy. How to cope with urban flooding and increase urban resilience against extreme weather events has become an urgent topic in China.

From a government perspective, China has an advantage in its top-down governmental structure. Accordingly, the central government launched a nationwide initiative called "Sponge City" in 2012. In 2014, the Ministry of Housing and Urban-Rural Development issued a detailed guideline called "Technical Guidance on Sponge City Construction". According to this technical guideline, sponge cities essentially follow the same principles as LID. Sponge cities aims to reduce storm runoff at the source, by prioritizing natural drainage systems and making full use of green belts, roads, and river systems to absorb, maintain, and release water to mimic the city's predevelopment hydrological characteristics. This is expected to reduce urban flooding, increase runoff water quality, save water resources, and improve and protect the eco-environment. Sponge city construction approaches include conserving a city's original ecosystems, recovering and restoring destroyed ecosystems, and employing LID (MHURD, 2014). Sponge city, therefore, has a broad scope that considers the conservation, recovery, and restoration of ecosystems that can serve as water reserves.

Since the launch of sponge city construction, many sponge city plans have been drafted and carried out in different cities. For instance, at the central government level, two batches of pilot cities (30 cities) were selected for sponge city construction in 2015 and 2016 (MOF, 2015, 2016). However, while the government's top-down approach may promote the initial development of sponge cities, their success and sustainability depend on several factors involving different stakeholders, especially the general public. As mentioned earlier, climate change adaptation is restricted by certain factors, including insufficient funding, urban land scarcity, and low public perceptions. Even though China's government has invested in sponge city construction, in many cities the funding is insufficient. Meanwhile, as the urban land supply becomes increasingly strained in many cities, stakeholders may be less willing to participate in the new initiative. Public-private partnership (PPP), which is a cooperative arrangement between one or more public and private sectors, typically in a long term (Hodge and Greve, 2007), has been regarded as an effective way to cope with public goods management in many areas (Barlow et al., 2013; Ghobadian et al., 2004). The government itself has encourage PPP as the main impetus for sponge city construction. However, there is a need for a clearer PPP business model for sponge city development. Thus, public participation is vital for sponge city construction, as it is important in other public involved initiatives (Yuan et al., 2011). Public behaviors and perceptions can significantly influence sponge city implementation of in practice, as with green roofs construction, for example, which is connected to people's daily lives. Financial support from the public is also greatly needed in sponge city construction. Therefore, understanding public attitudes, perceptions and willingness to invest can provide crucial information for sponge city construction.

This study aims to explore public perceptions of urban flooding and sponge city construction, as well as the public's willingness to pay for or invest on sponge cities and the influence of demographic and socio-economic factors. The results can provide critical information and insights for decision makers in city planning and implementation.

The rest of this paper is organized as follows: Section 2 describes the methodology and data collection, Section 3 presents and discusses the results, and Section 4 presents the conclusions and policy recommendations.

2. Methodology and data collection

2.1. Questionnaire design

Questionnaire survey has become an effective and commonly used method to study the behaviors, attitudes, perceptions and willingness to pay for a certain activity (Babaei et al., 2015; Fei et al., 2016; Gu et al., 2016). A questionnaire survey was conducted to gain a full understanding on public perspectives on the sponge city initiatives. As was done is other questionnaire survey studies (Yuan et al., 2015a), the questionnaire was developed based on the finding from introduction part. Since sponge cities in China are closely to urban flooding, the questionnaire was designed to include some information on urban flooding. The questionnaire consisted of the following parts:

a. Brief introduction to urban flooding and sponge cities, and the relationship between urban flooding and sponge city construction
b. Respondents' demographic and socioeconomic information (Gender, Age, Occupation, Education, Income, and Family size.)
c. Respondents' knowledge about urban flooding and their perceptions of reasons for urban flooding and measures to cope with;
d. Respondents' knowledge of sponge cities (information channel) and perspective on sponge city construction (financial source)
e. Respondents' willingness to pay for sponge city construction