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Exploration of the causality between area changes of green spaces and waterlogging frequency in Beijing

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1. Introduction

Climate change has drawn great attentions on environment protections worldwide (Deng and Zhao, 2014; Scott and Sugg, 2015). Due to the rapid changing environment, waterlogging in China has become the main battle field to combat climate change, among which green spaces areas are supposed to be an important factor of waterlogging in the future (Close and Davidson, 2003; Isla et al., 2014; Wang et al., 2013). Researches on land use/land cover change have been ongoing for a long time (Deng et al., 2012; El Kharraz et al., 2012; Syrbe and Walz, 2012). Along with research extension, current researches are mainly focus on the process of land type changes (Li et al., 2015; Song et al., 2015; Verburg et al., 2002), the driving mechanisms (Deng et al., 2015; Lambin and Meyfroidt, 2011; Luo et al., 2014), and the ecology-economy relationship (Deng et al., 2013; Lambin and Meyfroidt, 2010; Liu et al., 2012; Wu et al., 2013). Land resources are the premise of all human activities. Along with the development of science and technology, more and more attention has been directed at the long-term sustainable use of land resources (Lambin and Meyfroidt, 2010; Tilman et al., 2011). In China, the long-term demand for economic growth has accelerated the development in politics, culture and education, which may also brought damages to the urban eco-environment (Brock and Taylor, 2005; McCarter et al., 2011). The last decades of 20th century witnessed fast urbanization in China. Currently, the urbanization rate (percentage of urban permanent population in total population) of eastern China is up to 62.2%. In contrast, the urbanization rate is merely 48.5% for the Middle part of China and 44.8% for Western China (Wu et al., 2013). From 1978 to 2013, the urban permanent residents of China had grown rapidly from 0.17 billion to 0.73 billion, the urbanization rate increased from 17.9% to 53.7%, and the number of cities rose from 193 to 658 accordingly (Wei and Ye, 2014). During the urbanization, a considerable quantity of cities and urban agglomerations have emerged, such as the agglomerations in Beijing-Tianjin-Hebei, Yangtze River Delta, and Pearl River Delta (Yang et al., 2012). These big cities are all featured with numerous skyscrapers, which promote the urban development but also imperil the human security of life and properties of the citizens (Wei and Ye, 2014).

Regarding the overall development of China, the total number of extreme climate events (with hourly precipitation > 50 mm) in recent years rose from 168 in 1978–1988 to 184 in 1989–1998, and to 231 in 1999–2008. As the urban heat-island effect becomes more and more severe, the occurring probability of extreme rainstorm will enlarge in the future (Longxun et al., 2003; Mokhov, 2009; Tan et al., 2010). Theoretically, as the rainstorm falls down, the precipitation or continuous precipitation overwhelms the urban drainage capability and then induces large-area flooding, leading to urban waterlogging (Wu et al., 2012; Yin et al., 2011). Since 2015, urban waterlogging has challenged many cities in China. On one hand, the objective causes of urban waterlogging are the relatively excessive long duration rainfall and the very weak urban drainage system, on the other hand, is the insufficient green spaces relative to large areas of hardened surfaces. The traditional urban construction had no long-term planning. Consequently, lacking of well-designed city structure and the original geographical landscapes, big-city diseases tend to occur (Ord et al., 2013; Taylor, 2015; Zhao et al., 2010). This study on water logging is mainly concentrate on water drainage system, the relation between different land use type, water drainage and water logging recovery

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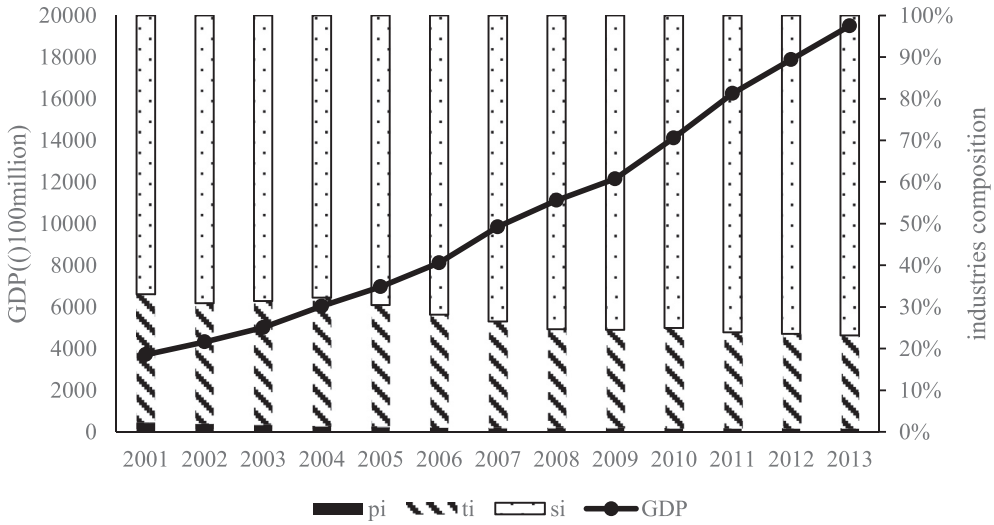

Fig. 1. Regional GDP and industry composition during 2001–2013 in Beijing (industries composition; pi: primary industry, si: second industry; ti: tertiary industry).

capacity. In this study, we committed to probe the risks of waterlogging and the effect of green spaces in Beijing started from the situation of the waterlogging.

In 2010, the Ministry of Housing and Urban-Rural Development in China conducted special investigations into waterlogging in 351 cities. Results showed that up to 62% of the cities were affected by waterlogging during 2008–2010, and about 137 cities suffered three or more incidents. Among the affected cities, 90% and 74.6% of them had a maximum water depth over 15 cm and 50 cm respectively, and 78.9% of cities suffered a inland inundation over half an hour, and 57 cities had the maximum flooding time of more than 12 h (Lee et al., 2011). Waterlogging due to rainstorms is prevalent in Beijing, Shanghai, Wuhan, Nanjing, Xiaan, Changsha and Hangzhou.

This paper mainly analyzed the relationship between area changes of green spaces and waterlogging frequency in Beijing. The structure of the paper is as follows. Section 2 shows the detail description of study area and data that will be used in this paper, Section 3 reveals data and statistical descriptions, Section 4 illustrates the empirical model, followed by section 5 is the conclusion part and section 6 gives future discussion.

2. Study area and data process

Beijing, the political center of China, located in the northwest edge of North China Plain and adjoins Tianjin and Hebei Province. Beijing has a typical temperate of semi-humid continental monsoon climate with hot rainy summer and dry cold winter. The elevation is high in the northwest and low in the southeast. In addition, the main living areas are placed on the southeast part.

Beijing witnessed a rapid economic development in 2001–2013, and the regional gross domestic product (GDP) significantly increased (Fig. 1). So far as the industry composition, the proportions of three industries changed very regularly. Clearly, the proportions of the primary and second industries gradually declined from 2001 to 2013, while the proportion of the third industry grew up. These trends are closely correlated with the long-standing cultural heritages and development orientation in Beijing.

The road areas in Beijing increased year by year and varied very greatly from 2001 to 2013 (Fig. 2). The built-up areas rapidly

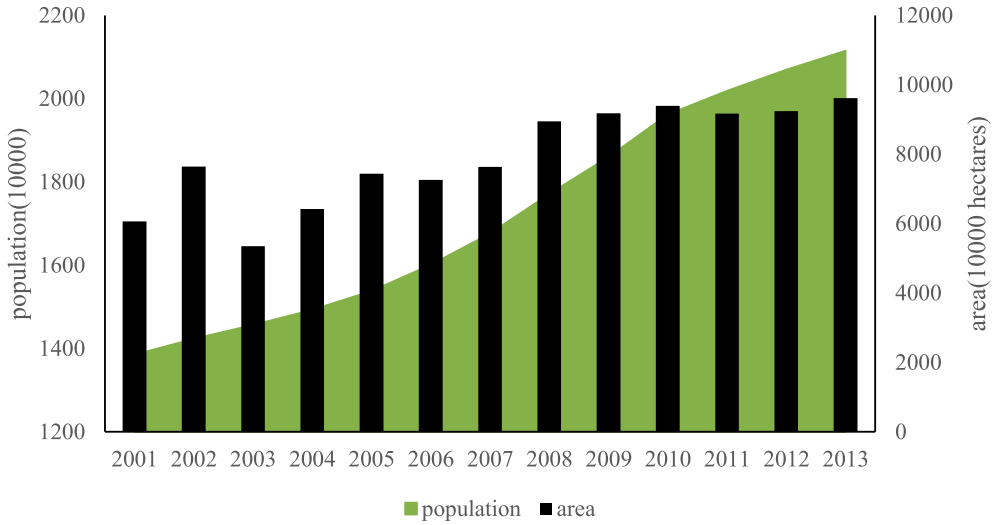

Fig. 2. Road areas and number of permanent population.

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