



Original article

Public green spaces and human wellbeing: Mapping the spatial inequity and mismatching status of public green space in the Central City of Shanghai

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ABSTRACT

Public green spaces are fundamental and indispensable to urban settlements, given the diverse social, economic and environmental benefits that they can provide. However, the absence of knowledge regarding the allocation and access status quo consistently hinders the suitability and rationality of follow-up green space planning, which could eventually impair the livability and sustainability of cities. This study evaluates disparities in access to public green space for urban residents and the spatial mismatches among public green space provision, residents' visits and the demands of socially vulnerable groups within the Central City of Shanghai. The results show that disparities in public green space accessibility exist pertaining to social status and household composition status. Sub-districts with higher social status or larger proportions of family households composed by children and married inhabitants tend to have better public green space access. In contrast, sub-districts with larger proportions of aged or unemployed populations unexpectedly show worse public green space access. To a certain degree, this reduced access can be considered to be an environmental injustice. Additionally, the mismatches among public green space provision, residents' visits and the demands of socially vulnerable groups are observed to vary in space, indicating potential problems of resource shortage, supply-demand mismatch, underuse and congestion. The findings could offer urban planners and policy-makers insights into optimizing public green space resources and equitably providing proximal public green space to urban residents, especially vulnerable groups, such as children, the elderly and the unemployed.

1. Introduction

It is reported that 54% of the world's population resided in urban areas in 2014, and most of the growing urban population will be concentrated in Asia and Africa in the forthcoming decades (United Nations, 2014). Taking this statement into consideration, the progress of contemporary urbanization has become a challenge calling for joint attention and efforts (Godschalk, 2004; UN-Habitat, 2008). How can we make cities more sustainable and livable with the advancement of urbanization? As the remnant of natural areas in compact cities, urban green spaces have been demonstrated to provide various environmental, social and economic benefits (Heckert, 2013; Tian et al., 2014). These are seen as crucial for contributing to the imminent challenge of urbanization.

Based on ownership, urban green spaces can generally be divided into private and public green spaces (You, 2016). Private green spaces refer to outdoor amenities with restricted accessibility unless otherwise permitted by the owners (e.g., domestic gardens, backyards, and home

gardens) (You, 2016). Public green spaces are deemed as public goods that can be accessed freely by all citizens and mainly encompass vegetated natural spaces (e.g., parks, gardens, forests and woods) and human-modified places (e.g., riverside greenbelts, institutional green spaces, greening squares and plazas) (Shan, 2014; Wende et al., 2012; You, 2016). Despite differing in ownership, public green spaces and private green spaces both play a critical role in maintaining biodiversity and providing various ecosystem services in urban districts (Barbosa et al., 2007; Bolund and Hunhammar, 1999). However, in terms of places that can offer a shared focus to diverse neighborhoods and communities (Barbosa et al., 2007; Hughey et al., 2016), public green spaces provide broader social significance. Thus, in this study, we focus on green spaces that are publicly accessible.

Although studies on environmental justice have broadened to include research on disparities in access to green spaces across different neighborhoods, most of them employ only a basic indicator of socioeconomic status or racial/ethnic minority composition as a moderator between neighborhood socioeconomic status and green space

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accessibility (Hughey et al., 2016; Kamel et al., 2014). Moreover, previous studies have often found variable and contradictory results. For example, whereas some have reported worse accessibility in socio-economically deprived and high-minority neighborhoods (Boone et al., 2009; Dai, 2011; Heckert, 2013), others have observed no remarkable difference (Gilliland et al., 2006; Nicholls, 2001). The simple indicators applied and mixed results found require further advancements in research on public green space equity.

Knowledge on access to public green space for socially vulnerable groups, such as children, the elderly and the unemployed, remains scarce. Children and the elderly are potentially more vulnerable to equity and environmental justice issues because of limitations based on age and ability (Boone et al., 2009; Reyes et al., 2014). Among the limited research, several studies have found inequities in park access for children/youth (Cutts et al., 2009; Reyes et al., 2014), and a few have detected unequal public green space provision to aged populations (Kabisch and Haase, 2014; Yung et al., 2016). In contrast, growing evidence in recent studies underlines the importance of accessible green spaces for the health of children and the elderly. For example, children with high exposure to green spaces are more likely to be physically active and obesity free (Sanders et al., 2015; Wolch et al., 2011), and older adults living in greener neighborhoods will enjoy more physical activities, fewer mental disorders and greater longevity (Gong et al., 2014; Takano et al., 2002). For the unemployed, they are also liable to encounter more social and environmental injustice (Chakraborty et al., 2016; Schwarz et al., 2015). Unemployment leads to a loss of income, an increased risk of poverty, a weakening of social relations, a feeling of social isolation, an absence of daily structure, as well as a deterioration of health (Frasquilho et al., 2016; Giatti et al., 2010). Compared to people who are employed full time, the unemployed tend to spend more time in their community and to rely more on and thus be more vulnerable to the provision of local infrastructure and social resources (Cummins et al., 2007; Giatti et al., 2010). In China's megacities, the populations of children, the elderly and the unemployed are much larger than those of ethnic minorities. In addition, issues on population aging, family downsizing under the enforcement of the one-child policy and employment difficulties have caused significant social concerns (Duckett and Hussain, 2008; Wang, 2014). Given the above discussion, it is necessary to analyze whether public green spaces can be equally accessed by those socially vulnerable groups.

As a theoretical evaluation, public green space accessibility offers useful reference and guidance for urban green space planning, yet real-world public green space visits or utilization may diverge from the planned goals. The utilization of public green space can be affected by various factors besides public green space accessibility (Hughey et al., 2016; Wang et al., 2015). With particular concerns to socially vulnerable groups, we should also question whether their public green space demands can be satisfied based on the status quo of public green space provision and utilization. However, previous studies have mainly focused on one specific dimension, seldom synthetically analyzing potential incoordination among public green space accessibility, residents' visits and the demands of socially vulnerable groups.

To depict real-world public green space visits, new data sources are expected. Recently, the ubiquitous big data shed new lights on social science practices for the self-contained abundant information and the enriched analysis methods (Liu et al., 2015). Many social media platforms (e.g., Twitter, Foursquare, Jiebang and Sina) support check-in option, which allows users to share their location-based information on the internet (Bao et al., 2013). To date, check-in records have already been used to study what is related with geographic spatial distribution or user behavior (Cheng et al., 2011; Li et al., 2013). Particularly, Bao et al. (2013) suggests that the distribution of check-ins closely relates to the real spatial pattern, which helps to support business and city construction planning. Given all of the above arguments, it would be prospective to use check-in records as an alternative to explore public green space visits. Targeted intervention strategies can be drawn up

efficiently after discerning spatial mismatches among public green space accessibility, residents' visits and demands of socially vulnerable groups.

In aiming to close the aforementioned knowledge gaps in public green space research, this study selects the Central City of Shanghai as the study area, and the overall objectives are (1) to identify spatial inequities of public green space provision among different resident groups by analyzing disparities in public green space accessibility based on local socioeconomic status and demographic characteristics; (2) to identify spatial mismatches and potential problems among public green space provision, residents' visits and the demands of socially vulnerable groups (namely, children, the elderly and the unemployed) by comparatively analyzing the values of public green space accessibility, the visit density and the demand index of the vulnerable groups.

2. Data and methods

2.1. Study area and data sources

Shanghai Municipality, located in the middle of China's mainland coastline, is considered the economic, financial, trade and shipping center of China. In addition, following Tokyo and Delhi, Shanghai is the world's third largest city with approximately 23 million inhabitants (United Nations, 2014). Shanghai's Central City, referring to the domain within the Outer Ring Road, covers an area of approximately 660 km² (Xiao et al., 2017). The population density in the Central City is extremely high since nearly half of the municipality's population is concentrated in this area (Fig. 1). According to the Shanghai Statistical Yearbook, the per-capita public green space area of Shanghai Municipality was approximately 7.6 m² in 2015 (Shanghai Bureau of Statistics, 2016), which is lower than the World Health Organization's recommendation of a minimum of 9 m² (World Health Organization, 2010). At this stage, large public green spaces are under construction in the outlying suburbs; nevertheless, the public green space is still in short supply within the congested Central City (Chinese Society for Urban Studies, 2002). Given these circumstances, research on the current allocation status of public green space resources and the prompt identification of potential public green space problems is of primary importance for future green space planning and management.

The units of analysis for this study are township-level subdivisions (n = 116), including 84 sub-districts, 28 towns, and 4 special areas. Based on China's three-tier administrative division system, township-level (similar to the US census tracts level) subdivisions are the smallest administrative units. Like many extant urban China studies, this study relies on administrative boundary data and national census data available at the township level (Xiao et al., 2017). In the following sections, we use "sub-district" to represent township-level subdivision for simplicity and clarity.

The data used in this study came from several sources. First, digitalized layers of the road network, public green spaces and residential parcels were originally obtained from the Shanghai Municipal Bureau of Planning. In total, 1213 public green spaces were distinguished within (n = 1213) the study area, including parks, street gardens, greening forests, greening squares and plazas, greenways, and sports grounds, as shown in Fig. 2(a). Second, demographic data at sub-district level were extracted from the sixth Shanghai Census of 2010. Third, the Jiebang check-in records employed in this research have already been used in prior studies on inter-urban trip and spatial interactions (Liu et al., 2014; Wu et al., 2014). Specifically, as one of the largest location-based social network platforms in China, Jiebang was widely used during the time on which this study focused (Lian et al., 2014; Yang et al., 2017). Users can 'check-in' to online places as they visit offline places to win prizes (Sun et al., 2015; Yang et al., 2017). Check-in data were examined and used as an indicator of residents' visits to public green spaces since the number of check-ins positioned within public green space can reflect the magnitude of residents' visits to a certain

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