



Research Paper

Exploring the disparities in park access through mobile phone data: Evidence from Shanghai, China

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ABSTRACT

The benefits that urban green resources bring to humanity have received increasing attention, with the evidence from recent studies into public service provision—specifically regarding access to green space—being rather mixed. Despite a growing literature base, there is no consensus among scholars on how to measure green space access properly. The traditional GIS-based approach is criticized for inappropriately specifying geographic units and threshold distances, and for ignoring people's self-movement. This research proposes a novel approach, emphasizing the actual park users' activities, both spatially and temporally. We took advantage of the large dataset available from mobile phones to analyze billions of anonymized data samples in order to characterize the behavioral patterns of millions of people who accessed green space in an experimental procedure. We chose Shanghai as the case study because residential segregation had occurred—expected to be accompanied by issues of environmental justice. The results found that social equity could be achieved, even where territorial inequity was manifest in a high-population-density context that is undergoing rapid urban growth and transition. Shanghai's vulnerable groups are not found to be unequally treated at present, but there are warning signs that market mechanisms may worsen the uneven development. Therefore, the local municipalities are required to re-think how to provide green infrastructure to different social groups, responding to the inequality and uneven development that capital can bring.

1. Introduction

Urban public park access has received increasing attention from both government and scholars alike due to their potential to offer both physical and psychological health benefits to populations, as well as bringing social, economic and environmental benefits to society (Chiesura, 2004; Bedimo-Rung, Mowen, & Cohen, 2005). These benefits include the promotion of the urban ecosystem (McPhearson et al., 2016; Pickett, Cadenasso, Childers, McDonnell, & Zhou, 2016), the accommodation of social interactions (Peters, Elands, & Buijs, 2010), property value (Jim & Chen, 2010; Xiao, Li, & Webster, 2016), mental stress relief (Tyrväinen et al., 2014), physical activities (Kaczynski and Henderson, 2007; McCormack, Rock, Toohey, & Hignell, 2010) and urban biodiversity (Savard, Clergeau, & Mennechez, 2000), among others. In the urban planning field, there is a long tradition of environmental justice studies, concerning issues such as whether all urban residents gain equally, regardless of their race, culture or income. These studies focus on the spatial provision of such social goods (Byrne and Wolch, 2009; Wolch, Byrne, & Newell, 2014; Xiao, Wang, Li, & Tang, 2017c). Given that, as a natural public good, urban parks have not been

supplied infinitely and with a homogeneous distribution over space, the extant literature mainly relies on examining the patterns of accessibility to green services for marginalized social groups (Hughey et al., 2016; Rigolon, 2016; Wolch et al., 2014). For example, Wolch, Wilson, and Fehrenbach (2005) found that deprived residential areas are provided with less green space. Contrastingly, one paper has suggested that vulnerable groups are favored over more affluent citizens in Shanghai with regards to the open space policy and access (Xiao et al., 2017c). Some authors have emphasized the importance of accessibility when assessing the social equity of urban parks, with the most common approach being to employ GIS techniques to measure the potential accessibility of aggregated spatial units; however, many scholars have noted that the choice of accessibility measurement may affect the conclusion with regards the existence of spatial mismatches and inequities (Comber, Brunson, & Green, 2008; Chang & Liao, 2011; Dai, 2011; Lee & Hong, 2013; Luo & Wang, 2003; Neutens, Schwanen, Witlox, & de Maeyer, 2010; Nicholls, 2001; Oh & Jeong, 2007; Rigolon, 2016; Talen, 1997; Truelove, 1993).

Despite a growing amount of research on green service disparity, there is still no consensus on how to measure people's access to green

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space (Wolch et al., 2014), due, in part, to the limitations on the geographical research approach whereby the research reflects the park users' actual access (usage), as well as the users' reported subjective impression of the availability of green space (Wolch et al., 2014; Lucas, 2012). Furthermore, Nicholls (2001) and Talen and Anselin (1998) pointed out that the traditional social equity studies heavily rely on spatial geographic units, such as census tracts, and this approach may ignore people's self-movement (willingness to access public green space). Indeed, Geurs and Van Wee (2004) proposed four types of accessibility, with accessibility at street level either calculated using a place-based perspective or person-based measures (Kim and Kwan, 2003; Miller, 2007). With the increasing pervasiveness of new technologies, individual-level and activity-travel data from sources such as mobile phones and location-based social media (Facebook, twitter etc.) became available, which may provide new opportunities to move beyond place-based and/or infrastructure-based accessibility (Neutens et al., 2010; Shelton, Poorthuis, & Zook, 2015), enabling detailed investigation of people's physical usage of parks. To this end, Neutens et al. (2010) empirically compared different accessibility measures for the equity of urban service delivery, and found that people-based accessibility appeared to be more appropriate, and more conservative. Big data raises new challenges in studies of public health, econometrics and travel behaviors (Mokhtarian, Salomon, & Handy, 2006; Khoury & Ioannidis, 2014; Varian, 2014), in particular for geospatial big data, which has provided some insights into socioeconomic environments and human mobility patterns (Gao, Liu, Wang, & Ma, 2013; Liu, Sui, Kang, & Gao, 2014). In this vein, it is intuitively believed that ubiquitous big data will bring social equity studies into a new era, due to the abundant availability of self-contained information and time-spatial access behaviors.

This study attempted to contribute in this area, examining the environmental justice of urban parks in Shanghai via a big data approach. We focused on real spatial-temporal park activities with the lens of people-based accessibility, utilizing billions of anonymized data samples collected from mobile phones to characterize the behavioral patterns of millions of people who accessed the green space. We adopted the notion of social position method (SPM) (Ahas & Mark, 2005) to conduct three types of accessibility study: the average green access rate, the average OD (Origin–Destination) distance per day and the average time spent per day at sub-district (Jiedao) level. We chose Shanghai as the case study, since it has seen serious residential segregation problems emerge (Li & Wu, 2008), and we apply the association made by Logan (2016) in stating that environmental injustice can be accompanied by social stratification and housing segregation. Moreover, we carefully adopted the framework from Talen and Anselin (1998) and Lucas, van Wee, and Maat (2016)—employing Lorenz curves and the Gini index—to detect the spatial inequality of the patterns of green space accessibility. Specifically, since the evidence available is still relatively scarce (Wolch et al., 2014), this research re-examines the hypothesis that the present distribution of urban public parks discriminates against the marginalized population in Shanghai (due to the rapid urban growth and urban transition).

The remainder of the paper is organized as follows: an assessment of the relevant evidence of environmental justice, along with a green space access measurement is provided in Section 2. Sections 3 and 4 explain the methodology adopted and the data sources used in this study. Analysis and results are presented in Section 5 and finally, a summary of key findings and discussions is made in Section 6.

2. Literature review

2.1. Environmental injustice in access to urban green space

In 2016, 54.5% of the world's population lived in urban areas (UA, 2016), and cities around the world faced an ever-increasing variety of challenges (Childers et al., 2015), such as climate change. The urban

population is projected to increase to nearly 70% by the middle of the century, making the building of sustainable ecology cities essential for future development. As Pickett et al. (2016) and Zhou, Pickett, and Cadenasso (2017) stated, the ecology of urban ecosystems is highly complex, including biological, social, and built components; therefore, it requires the urban designer and urban planner to pay attention to whether the provision of ecology opportunity is equally assigned, as the egalitarian perspective believes that society should give everyone equal rights (Sen, 2011).

Rawls (2009) argues that justice should not focus on the provision of social goods. The extant literatures on environmental justice studies is mostly concerned with the spatial provision of environmental amenities in minority communities—especially urban parks—since they are known to bring both direct and indirect benefits to people's health and wellbeing (Byrne, Wolch, & Zhang, 2009; Hughey et al., 2016; Wolch et al., 2014; Xiao et al., 2016). Given that green space cannot be evenly distributed within the city, the core concern of present environmental justice studies is to examine whether there are specific social groups that are discriminated against with regards their socioeconomic status, ethnic-racial characteristics, age, gender or other factors (Boone, Buckley, Grove, & Sister, 2009; Jacobson, Hengartner, & Louis, 2005; Lineberry, 1977; McConnachie and Shackleton, 2010).

The extant literature shows that equity studies on green space provision seem quite mixed. For instance, regarding a park's potential accessibility, Talen (1997) found that those areas with a high proportion of ethnic minorities are associated with lower levels of park access in US cities. Moreover, the spatial distribution of “green resource street trees” is also inequitable concerning race and ethnicity, income, and housing tenure (Landry & Chakraborty, 2009). Similar findings are reported by Gobster (2002), who found that ethnic minorities traveled longer distances and less frequently to gain green access than white users. Concerning the equity of park quality, Hughey et al. (2016) found that vulnerable neighborhoods tend to have poorer-quality parks.

However, other previous studies have found varying and contradictory results, inconsistent with the environmental justice hypothesis, especially in the US context. For example, Lineberry (1977), Mladenka and Hill (1977) and Mladenka (1989) asserted that there is no particular discrimination against low-income neighborhoods. More recent studies by Nicholls (2001) and Lindsey, Maraj, and Kuan (2001) examined the green disparity issue in Indianapolis, Indiana, and both studies found that minorities or low-income groups were not systematically disadvantaged regarding access to urban greenways. Boone et al. (2009) found that parks serving a predominantly black demographic were more heavily utilized than parks that served a predominantly white demographic in Baltimore.

As several scholars have stated, environmental injustice became an emergent problem in China (Wolch et al., 2014; Xu, Xin, Su, Weng, & Cai, 2017), where, due to some institutional limits, some specific social groups experience unequal access to the job and housing markets—in particular for domestic migrants (Li & Wu, 2008; Solinger, 2006). Without local residency (also known as “Hukou”), they may not be entitled to social and financial benefits (Chan, 2009). Recent evidence has shown that even within the same city, the conclusion of the existence of equity may not be consistent. For example, Xiao et al. (2017c) followed Talen (1997)'s approach to examine the spatial equity in an urban public park in Shanghai. They utilized a gravity-model-based measurement for accessibility at the local residential committee level, stating that there is no overt environmental injustice issue for vulnerable groups. By contrast, Shen, Sun, and Che (2017) examined the same issue at a sub-district level based on individuals' geo-referenced social media information, employing the two-step floating catchment area method for determining a visitor's check-in record. Their results show that disparities of public green space accessibility do exist in Shanghai.

Such inconsistent empirical findings may raise some challenges for equity planning, management, and decision-making for the local municipality (Rigolon, 2016). Indeed, several scholars have stated that

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