Habitat International 71 (2018) 49–59

Contents lists available at ScienceDirect

Habitat International

journal homepage: www.elsevier.com/locate/habitatint

Spatio-temporal disparity between demand and supply of park green space service in urban area of Wuhan from 2000 to 2014

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ARTICLE INFO

Keywords:
Park green spaces
Supply and demand
Spatio-temporal disparity
Traffic mode
Accessibility
Spatial analysis

ABSTRACT

Various green space researches are conducted on spatial and social analysis in regional scale, but few of them focus on the disparities of access to green spaces in spatial-temporal dynamics analysis in small-scale of cities in developing countries. This paper employed integrated approaches to analyze the spatial-temporal disparities between demand and supply of park green spaces (PGSs) of two traffic modes (walking and driving) in grid scale of urban center in Wuhan from 2000 to 2014: the Gaussian-based two-step floating catchment area method calculated the accessibilities; the coefficient of variation measured the changes; and the spatial correlation analysis clarified the effects of spatial disparities by accessibility changes of each mode. Our results indicated that the supply and demand of PGSs both increased. The spatial disparities of park green spaces in urban center of Wuhan and seven districts were significantly different in walking and driving in different periods. The temporal disparities decreased by 4.6% in 2010 and then increased by 90.7% in 2014 in walking, whereas that in driving increased continually (i.e., 13.0% and 41.1% in 2010 and 2014, respectively). Spatial autocorrelation analysis affirmed that the spatial agglomeration of accessibility was profoundly strong stronger, whereas temporal correlation was weak. In addition, we discussed the factors of the changes in disparities by bivariate analysis, which verified that policies and strategies (e.g., urban green space planning, transportation planning and population policy) were the key factors of PGSs accessibility. Decision makers and planners may pay considerable attention on the quality of park services and traffic conditions right along, but the comprehensive effects of surrounding land use and socioeconomic context impacts could not be ignored. The results can provide a comprehensive understanding of the spatial and temporal dynamics of the urban green space, and also help decision makers and planners to balance economic development and green conservation.

1. Introduction

Urban green spaces play an essential role in the preservation of the natural environment and in the connection between humans and nature, which also serve as indicators for the quality of urban life (Chiesura, 2004; Kabisch & Haase, 2014; Kessel et al., 2009; Wright Wendel, Zarger, & Mihelcic, 2012). However, given the rapid urban expansion and population growth, planners face a significant challenge in preserving urban green spaces, especially parks in developing countries (Kabisch, Haase, & Haase, 2010). For sustainable development, this challenge might also present important opportunities in improving the quality and in considering the equitable supply of green spaces for development practices (Shen, Sun, & Che, 2017). Therefore, clarifying the spatial disparity between the demand and supply of urban green spaces in urban planning is necessary. This research will focus on publicly available park green spaces (PGSs), including various parks and roadside green spaces, which will be of benefit to the health and recreation of urban residents.

Some studies investigate the differences of accessibility, "which are referred to as spatial disparities," to public products among different population groups. For example, spatial disparity was used to describe the differences of accessibility to medical care facilities (Comber, Brunsdon, & Green, 2008) and parks among different racial (Donaldson, Ferreira, Didier, Rodary, & Swanepoel, 2016) and socioeconomic groups. Gobster (2010) verified that ethnic minorities visited green spaces less frequently and spent longer time to them than did white people users. Lee and Hong (2013) defined a different perspective as the spatial mismatch of park services between provision and need in the grid unit of 100 m × 100 m and examined the demand population number regardless of various groups. The accessibility of park services

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https://doi.org/10.1016/j.habitatint.2017.11.002
Received 19 August 2016; Received in revised form 8 October 2017; Accepted 1 November 2017
Available online 21 November 2017
0197-3975/

was considered as convenient when their provision was adequate to meet the high demand population (Wolch, Wilson, & Fehrenbach, 2013), and vice versa. Inequality is a similar indicator for measuring the balance of allocation in public facilities, which has also been a major concern of public green space by residents as the proposition of a new type of urbanization in China (Chang & Liao, 2011; Yao, Liu, Wang, Yin, & Han, 2014). However, studies on spatial disparity or inequity concentrate primarily on a region or sub-district scale (Kabisch & Haase, 2014; Wright Wendel et al., 2012); These studies fail to clarify the small-scale areas (e.g., sub-strict and community) of spatial disparities for urban planning. Few empirical studies have investigated the spatial disparity issue in their changes of urban green spaces. Inequity and disparity will increase when demand growth occurs more quickly than the supply growth of PGSs. Therefore, the disparity between provision and need must be defined in spatio-temporal because the findings may vary given that spatial and temporal extensions were considered. Understanding the trends of these extensions is indispensable for future urban green space planning.

Researchers commonly measure this spatial disparity by estimating the spatial accessibility of PGSs. The calculation of the supply-demand (sd) ratio within a predefined region is a common method (Potestio et al., 2009). The analysis of Euclidean distance or road networks in Geographic Information Systems (GIS) is generally employed to examine the shortest distance to the nearest green space (Kessel et al., 2009). However, people may go to other green spaces rather than to the closest one for fear of dogs and racial attacks, or because of social preferences. Accordingly, the gravity model is employed to address this issue. Hillsdon, Panter, Foster, and Jones (2006) employed the distance as travel friction among green spaces nearby when summarizing the overall green spaces of a study area. Some studies corroborated the interactions between supply and demand requires consideration when evaluating spatial accessibility. Radke and Mu (2000) first proposed the two-step floating catchment area (2SFCA) method to measure spatial accessibility considering the interactions. Luo and Qi (2009) further developed this method as the enhanced 2SFCA (E2SFCA) method, which has been considerably studied in access to health-care (Cervigni, Suzuki, Ishii, & Hata, 2008; Wan, Zhan, Zou, & Chow, 2012) and sport facilities (Higgs, Langford, & Norman, 2015). This method reveals more shortage areas in space, but proposes limited solution on uniform accessibility in each catchment. Dai (2010) introduced the Gaussian function into 2SFCA to solve the uniform problem and discount the access of the catchment. This method could find the deficit areas effectively, thereby resulting in the potential to estimate green space access. Limited research is available on different traffic modes when using this method. The studies of different travel modes, e.g., walking, cycling, commuting (e.g., bus and subway) and driving, are beneficial to the analysis of the spatial accessibility of park green spaces. For measuring the changes of accessibility, the coefficient of variation (CV) is a proper indicator, which could assess the degrees of variation in spatial accessibility in an area and help clarify the tendency of disparities in accessibility (Kim & Sultana, 2015; López, Monzón, Ortega, & Mancebo Quintana, 2009; Monzón, Ortega, & López, 2013). Therefore, this study uses the Gaussian-based 2SFCA and the CV to measure spatial accessibility and disparity changes in two traffic modes. Section 3 describes the details of methods.

Being an economic, political, and cultural center in central China and currently experiencing unprecedented growth and expansion (Teng, Wu, Zhou, Lord, & Zheng, 2011), Wuhan is selected for analysis in this study. Moreover, this city has caused a tremendous green space loss similar to many other cities in China. The study on the matching between the supply and demand of green spaces in Wuhan puts forward the measures to reduce the mismatch, which can improve the quality of residents' lives and provide references for other similar urban green space planning measures. This study aims to examine the spatio-temporal disparity between the supply and demand of PGS services in the different stages of urban center in Wuhan: stage 1 (S1) (year 2000), stage 2 (S2) (year 2010), and stage 3 (S3) (year 2014). This research has three objectives: (a) to clarify the changes of the supply and demand of PGSs, (b) to examine the spatio-temporal disparity in two traffic modes by measuring the accessibility of PGS services and calculating the CV with population weight at different stages, and (c) to analyze and discuss the factors of spatio-temporal disparities between demand and supply as well as their changes by spatial analysis. The achievement of the aforementioned objectives can help solve the following two problems: (1) How spatial disparity changes When the PGSs provision and the needs of residents have been constantly changing in Wuhan center urban; (2) What contributes to the spatio-temporal disparity?

2. Study area and data

2.1. Study area

Wuhan is the capital of Hubei Province with the largest population in central China. The city is located at the intersection of the Yangtze River (the third longest river in the world) in the middle reaches and the Hanshui River (the biggest branch of the Yangtze) rivers. Wuhan consists of 13 administrative districts, including seven central urban districts and six suburban districts (Fig. 1). The population of the central urban districts is approximately 55.67% of the total population in 2014. In 2005, the green space construction of Wuhan was approved to

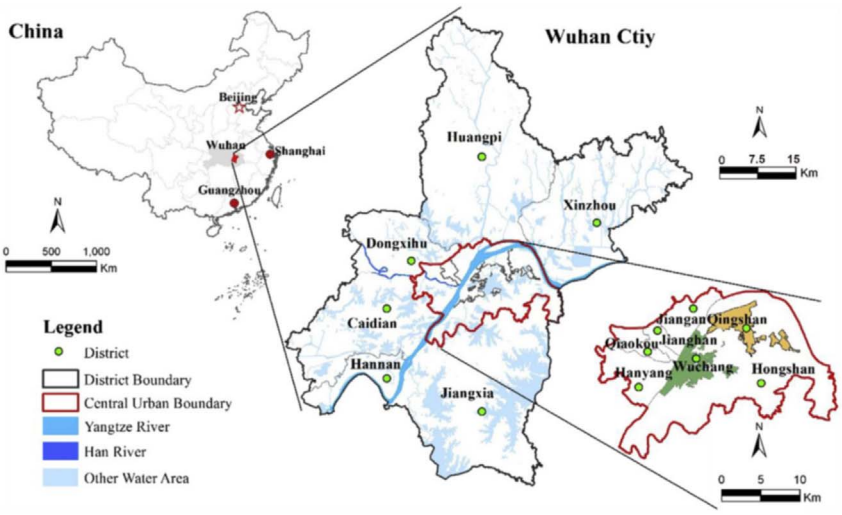

Fig. 1. Location and administrative districts of Wuhan.