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Urban green space accessibility changes in a high-density city: A case study of Macau from 2010 to 2015

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ABSTRACT

Urban Green Spaces (UGSs) are important for urban residents' well-being, especially in dense urban areas. This study uses Macau, a high-density city in Asia, as a case study area and tracks changes in the distribution of UGS accessibility across space and across population groups from 2010 to 2015. Based on the two-step floating catchment area model (2SFCA), the results indicate that UGS accessibility is distributed unevenly across space and population groups in Macau. Over time, however, UGS accessibility became more evenly distributed, despite the decline in overall UGS accessibility. These changes are attributable to the policies of upgrading UGSs and building micro-scale UGSs. These results shed light on how future policies can enhance UGS equity in high-density urban areas.

1. Introduction

The benefits of urban green spaces (UGSs) are widely acknowledged. A UGS is an indispensable infrastructure in urban areas. Much research has noted UGSs' ecological benefits (Chen and Jim, 2010; Mcpherson, 1992), environmental benefits (Boone et al., 2009; Kabisch and Haasea, 2014), recreational benefits (Talen and Anselin, 1998; Rigolon and Flohr, 2014), psychological benefits (Yao et al., 2014; Mensah et al., 2016), and economic benefits (Coolen and Meesters, 2012; Kabisch et al., 2015). Because of the many benefits, UGSs should be regarded as essential public services, and UGS planning and design should examine the equality of its distribution (Coolen and Meesters, 2012; Guzman et al., 2017; Tian et al., 2014; Xiao et al., 2017).

This research tracks changes in the distribution of UGS accessibility across space and population groups in Macau. We focus on accessibility because it is an important instrument in UGS planning, particularly in evaluating the equity of UGS distribution (Lindsey et al., 2001; Wright Wendel et al., 2011; Dai, 2011; Lee and Hong, 2013). Accessibility is defined as the spatial ease of reaching activities, opportunities, services, and goods. It is commonly applied in empirical studies that assess spatial equity (e.g. Talen and Anselin, 1998; Fransen et al., 2015; Foth et al., 2013; Meter et al., 2011). These studies reveal spatial inequality in the distribution of essential opportunities and services, and the results provide implications for decision making.

This research uses Macau, a high-density Asian city, as the case study area. Existing literature on UGS accessibility generally uses cases in North America and Europe (Higgs et al., 2012; Cameron et al., 2012; Rojas et al., 2016). Access to UGSs could be different in Asian countries, where urban landscape and settlement patterns are different (Wolch et al., 2014; You, 2016; Fan et al., 2017; Xiao et al., 2017). Additionally, UGSs are particularly important in densely populated urban areas where UGSs would have great benefits (Li et al., 2011; Cameron et al., 2012; La Rosa, 2013), and thus it is imperative to study UGS accessibility in high-density cities. Furthermore, distinct Asian culture, social norms, policies and planning processes could affect residents' access to UGSs. But existing literature has not adequately investigated UGS accessibility in Asian cities.

We also investigate the effects of policies on UGS accessibility. The city government of Macau published a UGS Planning Outline in 2010, aiming to increase UGS coverage and maintain its quality. Main policy instruments include strategically upgrading UGSs and building micro-scale UGSs. Comparing UGS accessibility before and after the policy interventions can illuminate effectiveness of UGS policies.

The purposes of this research are: (1) to examine the spatial distribution pattern of UGS accessibility in Macau; (2) to explore difference in UGS accessibility between population groups; and (3) to track changes in UGS accessibility from 2010 to 2015 and evaluate the effects of UGS policies.

The remainder of the paper is structured in the following way. The next section reviews literature on UGS accessibility and UGS policies. Section 3 describes the study area, data sources, and methodology. Section 4 presents the empirical results, followed by the concluding

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section of findings and policy implications.

2. Literature review

Accessibility measures the spatial ease of reaching opportunities (Handy and Niemeier, 1997). Much research has focused on access to jobs (Hu, 2015a, 2015b; Wang and Chen, 2015), to transit (Chandra and Vadali, 2014; Foth et al., 2013; Xu et al., 2015; Wang et al., 2016; Zhang et al., 2016), to public facilities (Roy and Thomas, 1981; Meter et al., 2011; Talen and Anselin, 1998; Luo, 2004), and to food outlets (Roy and Thomas, 1981; Meter et al., 2011). These studies suggest that accessibility is an important indicator for assessing spatial equity (Dai, 2011; Lee and Hong, 2013).

UGS accessibility has gained much attention in recent years. Empirical studies can be grouped into two streams (Zhou, 2012; Rigolon, 2016). The first stream investigates the spatial variation of UGS accessibility, particularly by comparing UGS accessibility of inner cities and suburbs. The findings are mixed depending on the case studies and the methods for measuring UGS accessibility. Most case studies show higher UGS accessibility in suburban areas where UGS supply is higher or population density is lower, such as in Atlanta, Georgia (Dai, 2011), Baltimore, Maryland (Boone et al., 2009), cities in Illinois state (Zhou and Kim, 2013), Catania, Italy (La Rosa, 2013), and Berlin, Germany (Kabisch and Haasea, 2014). A few studies show higher UGS accessibility in inner cities either because of more UGS supply or shorter travel distance to UGSs. These case studies are located in Asia and South America, such as Daegu, Korea (Lee and Hong, 2013) and cities in Chile (Rojas et al., 2016).

The second stream of literature investigates the disparity of UGS accessibility across population groups of different socioeconomic status. For example, in Leicester, UK, Indian, Hindu, and Sikh groups have limited access to UGSs (Comber et al., 2008). In the Los Angeles metropolitan region, Latinos, African Americans, and low-income neighborhoods have more congested parks (Sister et al., 2010). In Atlanta, Georgia, African-American and Asian neighborhoods have poorer access to UGSs than white neighborhoods (Dai, 2011). In Chilean cities, women have relatively lower access to UGSs than men because of women's lower travel mobility (Rojas et al., 2016). Generally, socioeconomically disadvantaged and racial/ethnic minorities have lower UGS accessibility than other population groups (Wolch et al., 2014; Rigolon, 2016).

In measuring UGS accessibility, Talen (2003) summarizes five types of methods: container, coverage, minimum distance, travel cost, and gravity-based measures. Each method has its drawbacks. Container and coverage measures are used in UGS accessibility studies in Bryan, Texas (Nicholls, 2001), but these two measures ignore the spatial distribution of UGSs and of their users and thus overlook the amount of UGS supply and demand. Minimum distance and travel cost measures are used in UGS accessibility studies in Seoul, South Korea (Oh and Jeong, 2007) and Cardiff, Wales (Higgs et al., 2012), but they ignore the characteristics of UGS users. Gravity-based measures tend to be preferred in recent literature because they consider the spatial distribution of both supply and demand (Kwan, 1998; Radke and Mu, 2000; McGrail and Humphreys, 2009).

Previous empirical research identifies three types of UGS development policies (Rigolon, 2016). The first type is to enhance UGS proximity by building new UGSs, such as pocket parks near residents (Talen, 2010). The second type is to increase the total UGS area size, specifically through large-scale, new UGS construction. Nevertheless, the second type of policies is difficult to implement in dense urban areas where land is scarce (Wolch et al., 2005; Sister et al., 2010). The third type is to improve UGS quality through improving service and maintenance levels (Rigolon and Flohr, 2014; Rutt and Gulsrud, 2016). Among the three types of policies, the first and the third are commonly applied in high-density urban areas. However, few scholars have investigated the effects of these policies, and such investigation requires longitudinal analysis.

The amount of literature on UGS accessibility has increased in recent years, but major gaps still exist. First, although there are sporadic UGS studies based on Asian cities, very few have investigated UGS inequality. Rigolon (2016) conducts a review of 49 empirical studies on inequality in UGS accessibility. All 49 empirical studies use case studies in the U.S. or Europe. Second, little research has investigated changes in UGS accessibility over time, which can reflect the outcomes of UGS policies (Fan et al., 2017).

Therefore, in this study, we analyze distribution of UGS accessibility across space and across population groups in Macau, a high-density Asian city. Moreover, we track UGS accessibility changes from 2010 to 2015 to understand the effects of UGS policies.

3. Data and methodology

3.1. Study area

Macau is located in the southeastern coastal area of the People's Republic of China (PRC). It is a core city of the Pearl River Delta megaregion, 60 km west of Hong Kong and 110 km south of Guangzhou. High density is a prominent characteristic of Macau.

According to the 2011 Macau population census, the total population of Macau was 552,503, and population density was 19,800 per km^2 in 2010. The average size of UGS per capita was only 1.89 m^2, lower than 20% of the 10 m^2 standard recommended in Chinese Urban Land Use Planning Standards (2011) and also lower than 25% of the minimum UGS requirement of 9 m^2 per inhabitant recommended by the World Health Organization (Rojas et al., 2016). Efficient and equitable allocation of UGS resources is more challenging in Macau than in many other cities.

Macau was a colony of Portugal for almost 450 years. On December 20, 1999, Macau was returned to PRC. Since then, it has experienced fast growth under the “one country, two systems” policy. As a result, the city is characterized by diverse UGSs of both Chinese and Portuguese styles. Additionally, people living in Macau have different backgrounds. The total population of 552,503 included 14,770 Filipinos, 5020 Portuguese, and 22,924 foreigners from other countries in 2010. The different backgrounds affect residents' usage of UGSs (Li et al., 2016; Song et al., 2012).

The left side of Fig. 1 shows the location of the Macau Special Administrative Region. The region consists of two parts: the peninsula and the island. The peninsula is a highly dense urban area and is a historical district that holds 84.88% of the total Macau population. UGSs in this area were planned and constructed in a compact pattern (Chu, 2015). The island is newly built and of relatively lower density. Because this research aims to examine UGS accessibility in high-density urban areas, we focus on the peninsula and refer to it as Macau hereafter. The study area is of 9.3 km^2, with a population of 469,009 in 2010 and 540,020 in 2015. The population density was greater than 50,000 persons per km^2 in 2015. The study area includes seventeen census zones whose average size is 0.55 km^2. The zonal size ranges from 0.21 km^2 in the center to 2.14 km^2 in the fringe.

The study area is divided into three areas: the historical area, the border area and the reclamation area. These three areas have different UGS styles, housing conditions, and population compositions (Yuan, 2011; Chu, 2015):

(1) The historical area is the earliest urban settlement area composed mainly of houses and churches built before 1840. It has nine census zones and is the center area of Macau. UGSs in this area are preserved for historical values; most of them are elaborately designed with good recreational facilities. The average UGS size is small. Houses in this area maintain a traditional style of high density but low building height. Housing price is lower than the reclamation area but higher than the border area. Because of their historical