Using GIS to Analyze the Social Service Function of the Parks and Green Spaces in Guilin, China

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Abstract

Parks and green spaces are an indispensable part of the urban ecosystem. Besides their ecological service functions, these open areas have an important role to play in society. When evaluating their social service function, one should take into consideration accessibility, equality, and access. To perform an assessment, with the help of GIS, this study applied a set of evaluation metrics to review the parks and green spaces in Guilin, China from four aspects: service coverage ratio, degree of service area overlap, service area coverage in various residential land use types, and degree of service area overlap within residential land use types. Results revealed 85.1% of residential land fell within the green space service areas and these areas had equitable access as well. There was no suggestion the proportion of the green space service area is higher where residential land is comprised of more costly dwellings compared to the other residential types within the city. Consequently, public green space areas in Guilin attain effective utilization, providing sufficient availability to citizens.

Introduction

Population within cities continue to grow as the urbanization process accelerates, which inevitably results in more and more severe environmental threats (Zhang and Wang, 2001). Pollution, including air, water, solid waste, noise, and light, has an impact on people in many areas of the world. How to improve the urban environment and make the world more livable has become a pressing issue for the international community (Liu, 2000).

Parks and green spaces could provide an important role in regards to environmental protection because they are endowed with several ecological functions such as water and soil conservation, clean air, air conditioning, noise reduction, and solar radiation rejection (Xu, Zhuang, Zhang, and Zou, 2001). All of these are beneficial to improving the quality of life and living standards as well as benefitting urban environments. Therefore, the coverage of parks and green spaces has become a major indicator for favorable urban environments.

Urban residents increase their demand for public green spaces, both in quantity and quality, as their living standards improve (Yin, Kong, and Zong, 2008), which requires the local administrators to provide enough green space and to design the distribution of the areas through rational planning. In the

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past, however, the traditional wisdom often ignored accessibility and fairness when evaluating the green spaces (Yu and Wang, 2008), resulting in an unreasonable and unfair spatial distribution. The former issue is illustrated by lower utilization of the public greenspaces due to their chaotic arrangement. Many cities in China are still confronted with the challenge of having a few parks crowded with people while the rest are nearly empty (Zhu, Li, and Chai, 2002). The latter issue is embodied in inequity; those who live in wealthy neighborhoods can enjoy the public greenspaces while those who live in a slum district are mostly ignored (Lu, Li, and Yan, 2014). The two problems are harmful to the sustainable development of a city and hamper the process of raising people's livelihood. Thus, it is valuable to conduct a quantitative evaluation of the social service function of the public green spaces (Yu and Zhong, 2010).

Geographic information systems (GIS) play an important role in conducting such an evaluation. GIS technology possesses a powerful ability to manage and analyze spatial databases (Qin and Gao, 2008); that is, it can provide visual diagrams or tables to show the results after data collection and scientific analyses. This study uses GIS to conduct an analysis and perform calculations on park and green space data of central parks in Guilin.

Social Service Function

At present, indicators such as "per capita public green areas" and "afforestation coverage in the city" are the main measures used to design and assess the social service of public greenspaces in the international community (Yu and Zhong, 2010). However, these measures cannot reflect a comprehensive network of urban public areas. Besides, the public is likely to pay more attention to factors such as whether the distribution is reasonable or if it is effective and fair to all they serve (Lu, Liu, and Liu, 2011).

Moreover, when calculating the scope of services, scholars, regardless of country, will apply the method of setting a certain radius as the buffer to represent the service area of the parks and green spaces (Li and Liu, 2009). This method is simple and easy but it ignores the complexity of city traffic and oversimplifying people's travel routes. To make analysis of a service area more reliable, network analysis can be used to calculate the service area of the parks and green spaces (Lian, 2010).

Network analysis is based on real transportation networks, which has advantages in calculating accessibility of service facilities. It can simulate certain means of transportation to calculate service area (Jim and Chen, 2003). Network analysis is used to analyze the spatial distribution, optimal route, and service area of limited resources.

In the past, most researchers have measured the service radius from the geometric center of the service (Attwell, 2000); however, this method has a weakness, considering in reality if people reach the entrance of the parks and green spaces, they could still enjoy the service (Cai, Wen, and Cheng, 2011). One of the advantages of network analysis is simulation of reality. Network analysis can not only analyze the accessibility according to the realistic traffic conditions and capacity, but also identify spatial barriers, which makes it more optimal for generating service areas (Zhang, 2012). If the service radius is measured from the entrances of the parks or green spaces, where people would begin to utilize these spaces, the service area can better reflect reality.

Therefore, this study uses GIS to delinate the service area of green spaces while calculating the service coverage ratio and overlapping ratio to evaluate accessibility of the public green spaces. More importantly, through a comparison of service areas in different residential land use types, study will examine inequities in green space distribution.

Methods

Software

The two software programs applied in this study were Esri's ArcGIS 10.2 and Microsoft Excel. The former was used to create the urban road network, public green areas, residential areas, input relevant data, and then analyze the accessibility and equities of green space areas. Microsoft Excel was used to perform calculations on values obtained from ArcGIS 10.2, and to summarize data for presention in the form of tables.

Data Collection

The first type of data required was related to the road network. High-resolution Google earth imagery of the study area was used as a base map from which to generate a road network. This Google Earth imagery was downloaded from BIGEMAP software and its coordinate system consisted of "Xian_1980_3_Degree_GK_CM_111E". The road network was digitized and built in ArcGIS 10.2 using the imagery as reference and base map to create digital road files for mapping.

The second type of data needed was the location and layout of parks and green spaces in the city. Data was obtained from the Guilin Planning Bureau; parks were classified in five ranks: 5A, 4A, 3A, 2A, and A. Parks were ranked according to the quality of the green spaces as related to amenities, diversity, and other uniquenesses. The higher the rank, the more attractive the park. The parks and green spaces data also required a spatial coordinate system and was consequently was digitized off of the aforementioned imagery. The park data was digitized and attributed for analysis.

The third type of data was related to land use distribution. Data was obtained from the Guilin Land and Resources Bureau. Features came with assigned values of R1, R2, and R3. R1 refers to detached houses such as villas. R2 refers to high-rise blocks of flats. R3 refers to the areas of mixed use – a mixture of housing and industry. Figure 1 provides a layout of assigned property values and other data within the study area.

Analysis and Results

Network analysis and overlay operations were conducted in ArcGIS 10.2 and summarized using Microsoft Excel to assess the service area distribution. The service area analysis was an analysis of accessibility.

Accessibility was interpreted as an expression of a resident's desire and

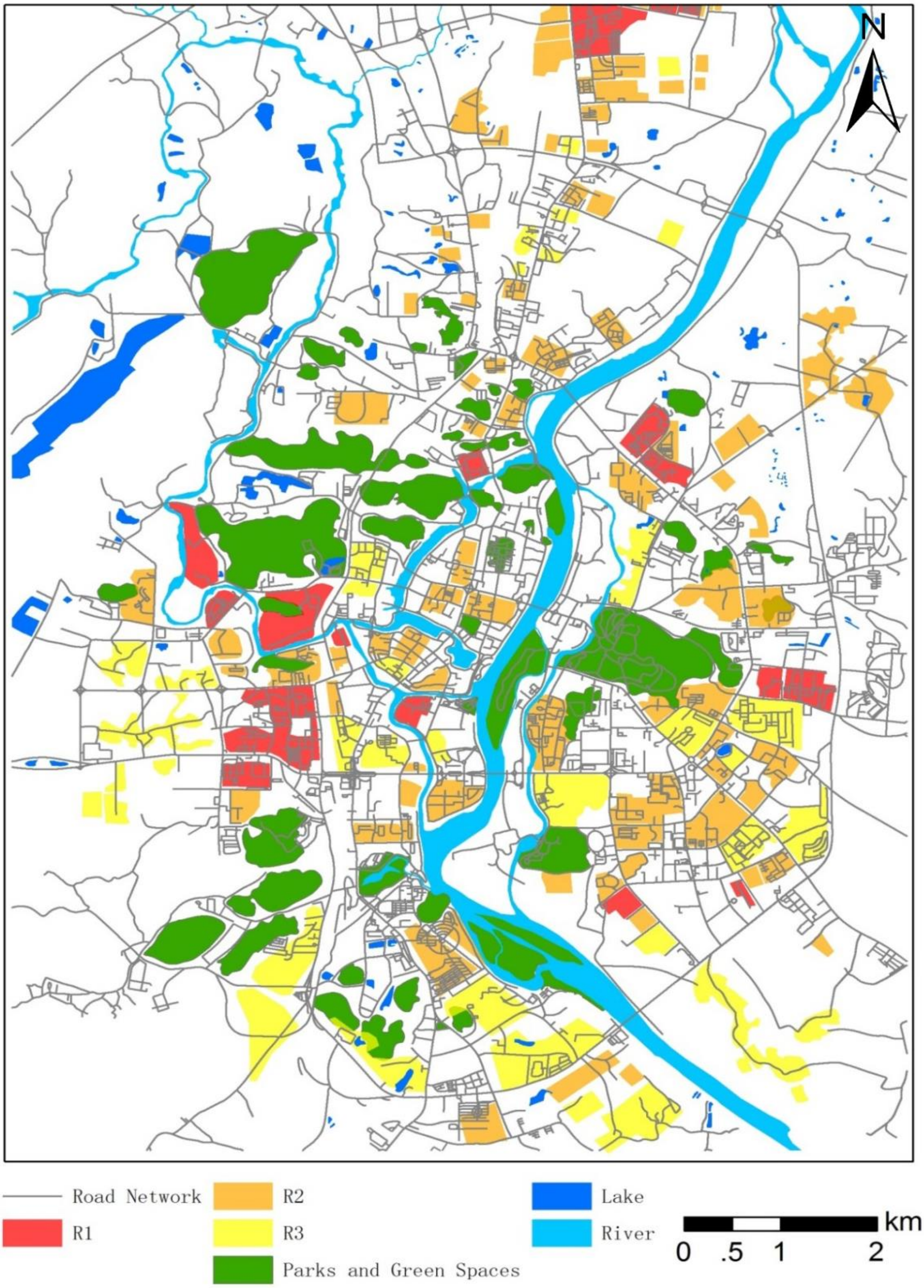

Figure 1. Foundational data for the analysis. R1 refers to detached houses such as villas. R2 refers to high-rise blocks of flats. R3 refers to the areas of mixed use – a mixture of housing and industry.

ability to overcome resistance (such as distance, time, and cost) to travel to a facility. It simply determines how difficult it will be to travel to one place from another place. A network dataset was required to help establish road data for mapping purposes in ArcGIS 10.2. According to a related study, Zhang (2012) used different service radii to calculate service areas according to the different grades of parks and green spaces (Table 1).

This study used the same radii as mentioned in Zhang (2012). Using ArcGIS Network Analyst, entrances of parks and green spaces were designated as sources, and the service areas were calculated with the specified radii (Table1). Last, all the service areas were merged (Figure 2). Finally, a coverage ratio of the green spaces in the city was calculated (Table 2).

Table 1. Service radius of each grade park.

Class	A	2A	3A	4A	5A
Radii (m)	1000	2000	3000	4000	5000

Table 2. Results of the service area calculation.

Study Area	Service Area	Percentage
119,762,283 m^2	76,099,176 m^2	63.54%

The second phase included intersecting park service areas, which were calculated on the first step, with residential land data. The goal of this phase was to determine which parts of the residential area fell within and outside of park service areas. In addition, this phase help to explore and determine the proportions of R1, R2, and R3 in the service area (Figure 3).

The resulting table was exported into Microsoft Excel to determine the overall coverage and percentage of land in the three residential land use types (Table 3).

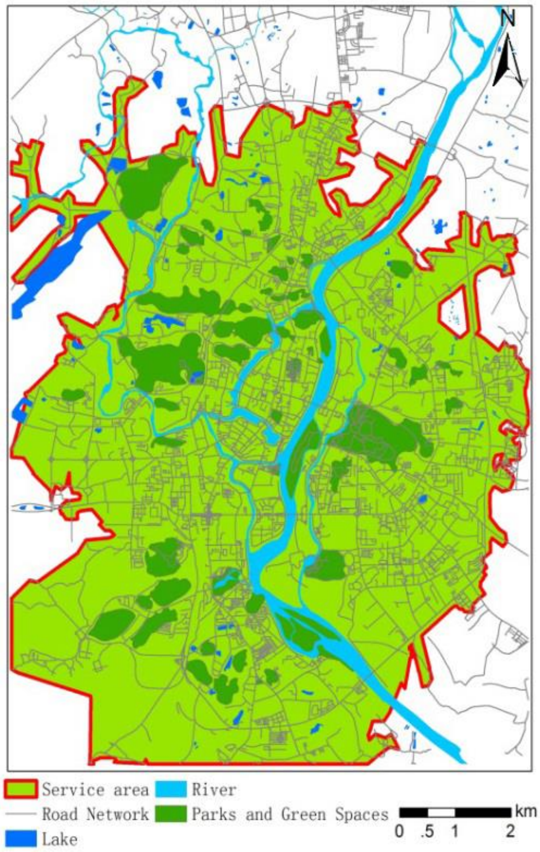

Figure 2. Service/study area of the parks and green spaces.

In addition to the coverage rate, and in order to ensure equitable access, city administrators should also consider the overlap of the park and green space service areas. Thus, the third phase consisted of a Union operation; that is, an overlay analysis was conducted to determine overlap in the service areas of the parks and green spaces.

The resulting table was exported to Microsoft Excel to quantify the overlapping areas (Table 4). Then, different colors were used to symbolize different degrees of overlap on the map (Figure 4). The darker the color, the higher the degree of overlap.

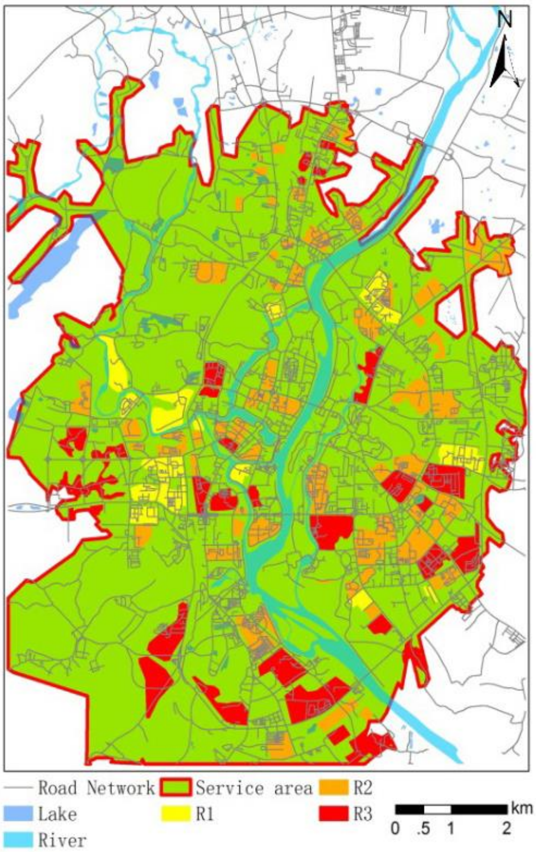

Figure 3. Residential land in the service area.

Table 3. Each residential land use type in the service area.

	Area （m^2）	Percentage （%）
R1	2,538,154	16.24
R2	7,192,055	46.01
R3	5,902,182	37.76
Total	15,632,391	100

Table 4. Areas and percentages of each overlap.

Degree of overlap	Area （m^2）	Percentage（%）
1	19,827,892	26.22
2	17,154,595	22.68
3	15,670,539	20.72
4	17,753,941	23.48
5	5,214,304	6.90

For residents, in addition to thinking about whether they live within the service area, they also may express interest about park selections in their surrounding area. Many within larger cities value parks and the type of parks or green spaces. A selection of green spaces ares provides experiences and variability for those visiting parks and green spaces.

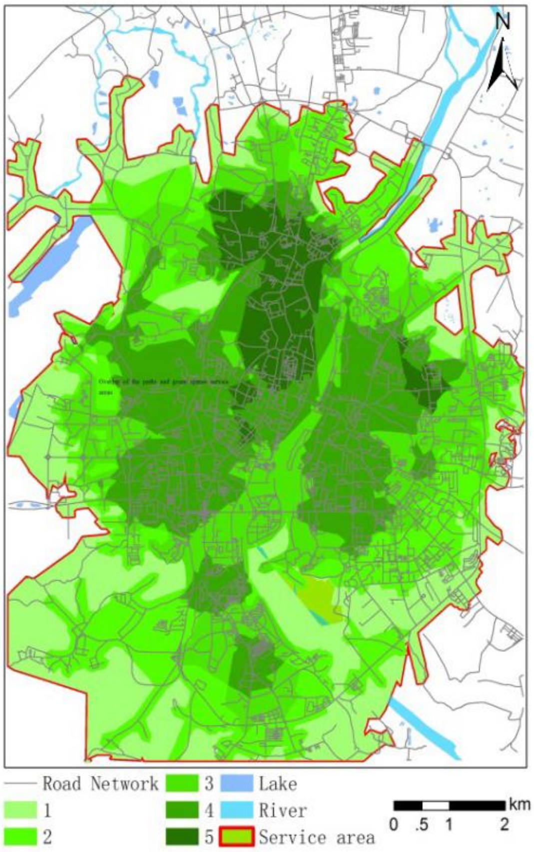

Figure 4. Overlap of the parks and green spaces. Darker the color is greater overlap.

The fourth phase was to perform an Intersect operation and aggregate with results from prior phases. The goal of this stage was to obtain the degree of overlap between the residential land and the service area.

Results showed the quantity of available public green spaces in a residential district. The more overlap, the more available green spaces. Tables were then exported into Microsoft Excel to obtain summary values including area and percentage within different degrees of overlap (Table 5; Figure 5).

Table 5. Each residential land use type in each degree of green space service area overlap.

Degree of Overlap	Type of Residential Land	Area（m^2）	Percentage（%）
1	R1	100,416	5.39
	R2	797,746	42.85
	R3	963,603	51.76
	Total	1,861,765	100.00
2	R1	291,643	8.63
	R2	1,137,992	33.68
	R3	1,949,028	57.69
	Total	3,378,662	100.00
3	R1	402,973	12.38
	R2	1,839,462	56.50
	R3	1,012,973	31.12
	Total	3,255,408	100.00
4	R1	1,296,586	32.03
	R2	1,565,185	38.67
	R3	1,185,937	29.30
	Total	4,047,708	100.00
5	R1	78,014	10.11
	R2	693,371	89.89
	R3	11	0.00
	Total	771,397	100

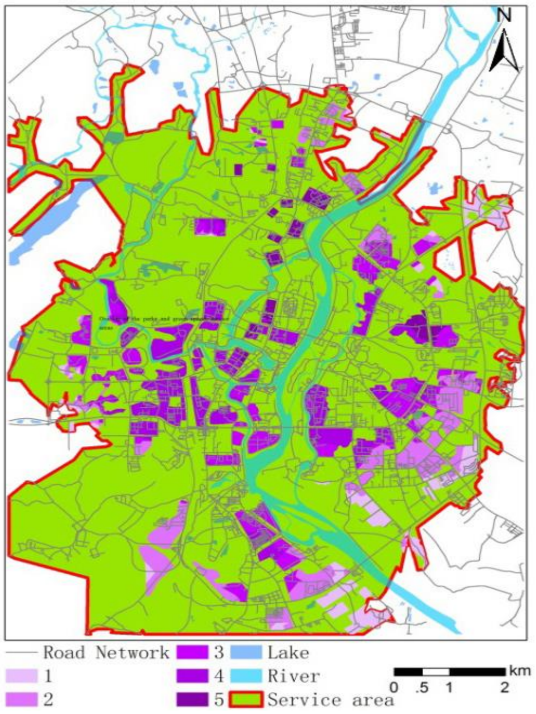

Figure 5. Overlap of parks and green space in residential areas. Darker colors = more overlap.

Conclusion

Results of this study identified the following:

1. The service area and green coverage in the city.
2. The residential area and percentage within the service area.
3. Area and percentages of different degrees of service area.
4. Areas and percentages of service area overlap in various residential types.

The social service function is a significant component of the overall expectations within the community and study area. Green spaces provide a level intangible features and value to society.

This begs for the appropriate need to develop a planning system to help incorporate more parks and green spaces. When constructing parks and green spaces, designers should not only be concerned about their quantity, accessibility, but distribution should be taken into consideration as well.

With the help of GIS, this study helped explore green space and park accessibility in Guilin. Results suggested first and foremost, Guilin City has achieved high green space area coverage; 85.51% of residential areas are located in the green service areas, although the green space areas only account for 63.54% of the entire city. In absence of detailed population distribution in each neighborhood, the study assumed an even distribution of citizens throughout the city. In other words, this study used the residential land to green space ratio to replace the population to green space ratio.

Second, each green space service area has a high degree of overlap with other service areas, suggesting citizens could enjoy the social service provided from multiple green spaces. The above two results suggest the green space areas in the city appear equitably balanced for accessibility for citizens in the city.

Third, the residential land ratio in the service area suggests that the distribution of green space in the city is relatively equitable. The proportion of the R1 residential land use class is approximately equal to that of the R2 and R3 land use classes within the bounds of the city's green space social service.

Lastly, the overlap of green space indicates there is little difference in green space accessibility between those who live in higher class (R1) districts and those who live in other districts. The last two findings seem to support the city is reasonably fair in providing green areas to all the residents. The wealthy, who tend to live in R1 areas (detached houses such as villas), do not enjoy more convenient or larger areas of the public green spaces.

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