Analysis of Spatial Accessibility and Equity of Urban Parks in Guiyang

Yiling Gao*

Harbin Normai University, Harbin, Heilingjiang, 150500, China

*gaoyiling0730@163.com

Abstract. Urban parks are crucial to the quality of life for residents, but in rapidly urbanizing China, their balanced distribution has always been a problem. This study evaluates the spatial accessibility and fairness of urban parks in Guiyang, a mountainous city, using an improved Gaussian based gravity model within the geographic information system framework. Network analysis calculates the time spent on travel, and the Gini coefficient measures fairness. The results show significant spatial differences, with clear differentiation from the core to the periphery. The central area is easily accessible, while the suburbs and newly developed areas are difficult to reach. The high Gini coefficient (0.573-0.644) once again proves that the distribution of parks that people can go to is very unfair. The research summary states that ordinary vegetation coverage covers up the serious shortage of parks that can actually be used. It is recommended to carry out targeted planning interventions in peripheral areas to promote spatial equity and sustainable urban development..

Keywords: Spatial accessibility; Urban parks; Gravity model; Equity; GIS

1 Introduction

As important public utilities, city parks provide basic environmental, recreational and social functions to the population [1-2]. Their spatial availability has a direct impact on the opportunities for use of green spaces, thus affecting public health, social justice and the sustainability of cities [3]. Nevertheless, the rapid urbanization in China has aggravated the imbalance of park space and population density, which poses new challenges to the fair supply of parks [4].

Various approaches have been used to evaluate park accessibility, such as buffer analysis, minimum distance model, network analysis, and gravity based or two-stage floating basin (2SFCA) approaches [5-7]. These methods have pushed forward how we evaluate where public facilities are placed and figure out if everyone can get to them fairly. Yet, a lot of the studies look at just the city's overall situation or big - picture areas. They often don't pay attention to the differences in money and society among the people living there. Also, even though mountain towns in Southwest

T. Chamaratana et al. (eds.), *Proceedings of the 2026 12th International Conference on Digital Humanities and Frontiers in Social Sciences (DHFSS 2026)*, Advances in Social Science, Education and Humanities Research 1031,
https://doi.org/10.2991/978-2-38476-611-6_93

China, like Guiyang, have special landforms and ways of life for their people, there aren't many real - world studies on them.

The aim of this research is to find out how easy it is to get to urban park spaces in Guiyang and whether it's fair, especially looking at the differences between groups of people with different social and economic statuses [8]. To do this, the study combines space - related information about houses, the number of people, and how much houses cost. It uses a gravity model that has a Gaussian decay function. This study connects how easy it is to get to parks with social and economic signs. The point is to find out the patterns of unequal park services, understand why there's unevenness in where they are, and give both theoretical ideas and practical ways to help with fair city planning.

The fairness of parks and green belts comes from the idea of how easy they are to get to. It shows what green space users need and means that where parks and green belts are should meet the residents' needs. It has clear social and economic features, showing the differences in how easily people in different areas and neighborhoods can get public services. Western related research has constructed a comprehensive evaluation framework to explain the mechanism of unfairness formation, in order to construct or guide future planning. However, relevant research in China is just beginning, and the framework of the fairness system is weak and still in the stage of theoretical exploration. Based on different research perspectives, it is believed that fairness is the rational allocation of public resources. For example, Chen Wen defines fairness from a geographical perspective as the distribution of parks and green spaces, while others believe that fairness refers to equal opportunities to obtain specific benefits and rights. They propose that fairness in parks and green spaces means that all members of the community have equal access to park and green resources, and equal access to park and green resources to provide services. So, it is very important to study the social justice and fairness of public resource service facilities.

The research on the equity of parks and green spaces in China and internationally has gone through three stages: regional equity, spatial equity, and social equity. In the stage of regional equity, the focus is on using the per capita area of parks and green spaces to measure equity, while also paying attention to equal opportunities and resources for parks and green spaces. With the gradual development of urban governance, research on the social equity of parks and green spaces, which mainly measures the differences between different demand groups, is becoming a hot topic. Related research abroad started earlier, focusing on the fairness of green space access for different ethnic groups, income levels, education levels, and other groups. The current research is mainly divided into two categories: 1) focusing on the equity of different social groups, dividing the population according to socio-economic and residential characteristics, such as Huangju Ju and Jinhexian, revealing the differences in accessibility and distribution of parks and green spaces at the scale of residential areas; Li Xiong and his colleagues pointed out that the degree of inequality in accessibility at the community level is greater than at the street level, and revealed the impact of comprehensive parks and community parks on accessibility; 2) Pay attention to vulnerable groups in society, such as Tang Zilai, Liu Wenping, etc., and analyze the accessibility and potential supply of street scale parks and green spaces;

The focus of research by He Ge, Wang Chunxiao, and others is whether park green space services have a bias towards certain vulnerable groups. There are two vastly different opinions regarding the results of this study. Some people feel that disadvantaged groups in society have poor access to parks and green spaces, and there is a clear trend towards aristocracy in parks and green areas. But another part of the research suggests that disadvantaged groups are not at a disadvantage in park and green space planning..

At present, the study on the social justice of park and greenbelt layout has made great achievements. However, there are still some areas that need to expand: 1) Evaluation units are not compatible with implementing decision bodies. The equity level of park and green space has been researched or analysed, but the accuracy of assessment is low. Or it is based on residential community, individual, etc. as a unit of assessment, which is not conducive to the association with particular practices; when assessing particular groups like older people and low incomes, some studies do not relate them to a particular space; in fact, there are many groups of people living together within a certain space. 2) There is no comparative analysis of the equity between the different types of parks and green spaces. Nowadays, most of the studies are focused on the comprehensive and scale of greenbelt types, with emphasis on the optimization of individual or general layout, but not on the type and coordination arrangement. As an urban governance unit, the special community has a very practical function in allocating public resources. The study on the availability of public utility facilities from the perspective of community differentiation demonstrates the representative role of community types in demand. Therefore, the application of community model to the residents' needs and assessment of the accessibility and equity of the park can be carried out in a certain space.

It is urgent to study the equity of park and green space in the view of community differentiation. In this paper, the community is used as the scale, and the demand differentiation is represented by the community type. Taking Gusu District of Suzhou City as an example, this paper makes a research on the fairness of park and green space. First, we measure and analyse the accessibility of different types of parks and green spaces, and then use scale variance and Searle's coefficient to verify the contribution of different types of park and greenbelt. This article aims at breaking through the previous research on equity, which does not consider the mixed settlement between various groups in a given space. This paper focuses on the fairness of the park and green space in terms of both the needs of people and the provision of the park. The purpose of this paper is to optimize the layout of the garden and greenbelt according to the principle of “human-based”.

2 Study Area

Guiyang, the capital of Guizhou Province, is situated on the east border of Yunnan – Guizhou Plateau in southwest China. The city is characterized by the typical karst topography. It is surrounded by hills and hills, and has a high forest cover ratio. By 2021, Guiyang had a permanent population of approximately 6.1 million, ranking as

one of the key central cities in the southwestern region. In recent years, Guiyang has made full use of its ecological and local advantages to push forward the big data industry. The city has also invested in transport hubs and urban renewal projects to speed up its modernization. Along with the rapid development of the economy and society, the improvement of infrastructure, and the enhancement of ecological protection, Guiyang has achieved remarkable progress in balancing growth and sustainable development.

3 Data and Methods

3.1 Data Sources

The data of Guiyang were collected from many sources. Spatial data sets for urban parks, housing, and road networks are extracted from OpenStreetMap (2020). In the Geographic Information System (GIS), the road network data were used for the calculation of the network distances between residential and city parks. The statistics are based on Guiyang Statistical Yearbook (2024) published by Guiyang Municipal Bureau of Statistics. In measuring driving distances, six categories of roads were taken into account: motorway, trunk, secondary, tertiary, residential/unclassified, and service/driveway. Local GlS-based public facility accessibility evaluation methods for Guiyang central urban area provide technical reference for this research framewprk [9].

3.2 Methods

Gravity Model for Accessibility In order to measure the spatial availability of an urban park, this study used a gravity based model, which takes into account both supply and travel impedance [10]. The accessibility of residential uniti to all parks within a defined distance threshold is expressed as:

$$A_{i=\ \sum_{j=1}^{n} S_j \times \frac{P_i}{d_{ij}}} \tag{1}$$

Wherein denotes the size of parkj (m ²) as a proxy for the delivery capacity, the distance from the centroid of residential uniti to parkj, and β is the distance decay parameter. The inclusion of residential population data as a demand is to enable the available values to reflect the balance between available green spaces and population pressure. This model is applied under three travel time constraints (5 minutes, 15 minutes, and 30 minutes) to obtain the differences in accessibility within different travel ranges.

Network analysis of travel costs. Conduct network analysis to calculate travel expenses between residences and parks. The road network data is processed in a geographic information system environment to generate a starting and ending point matrix. Firstly, create a matrix of residences to parks to estimate the minimum travel cost between each residential unit and the city park, and then evaluate the

accessibility of residents. Also, set up a park and dwelling matrix. This is done by figuring out the travel expenses from the park to the nearby living areas to assess how each park's services reach. These two matrices combined offer a full - scale evaluation of how easily residents can get to the parks and the parks' service possibilities.

Fairness is gauged with the Gini coefficient. To look into the fairness of how easily parks can be accessed, the Gini coefficient is used to find out the accessibility of all homes. The Lorenz curve is made according to the accumulated share of the population and the availability, and the Gini coefficient is worked out like this:

$$Gini = \frac{A}{A+B} \tag{2}$$

Let A stand for the space between the line of complete equality and the Lorenz curve, with B meaning the space under the Lorenz curve. A higher Gini value shows less equal access, whereas lower figures show a more fairly spread distribution of park services among all people.

4 Results

4.1 Spatial Distribution of Accessibility

Assessing Guiyang's urban park accessibility used driving time limits of 30 minutes, 15 minutes, and 5 minutes, as shown in Figure 1. All limits show a clear core-to-periphery change. Good access mainly clusters in Guanshanshan, Yunlin, and Nanming areas, where urban parks are most dense. In these places, people can usually reach at least one park within a 15-minute drive. These easy-access zones cover about 7.6% of the built-up area and have many different parks, including comprehensive ones, community ones, and specialized ones.

On the other hand, transition areas like Baiyun, Wudang, and southern parts have medium accessibility. There, people often need to take short bike rides or use public transport to get to larger green areas. Peripheral areas, especially Gui'an New District and new residential areas, have the worst access. This is because there are few services and people have to use private cars to visit parks.

The unequal space distribution shows a problem: the fast-growing urban edges don't match where high-quality parks are concentrated in the city center. This means spatial planning needs to be more balanced.

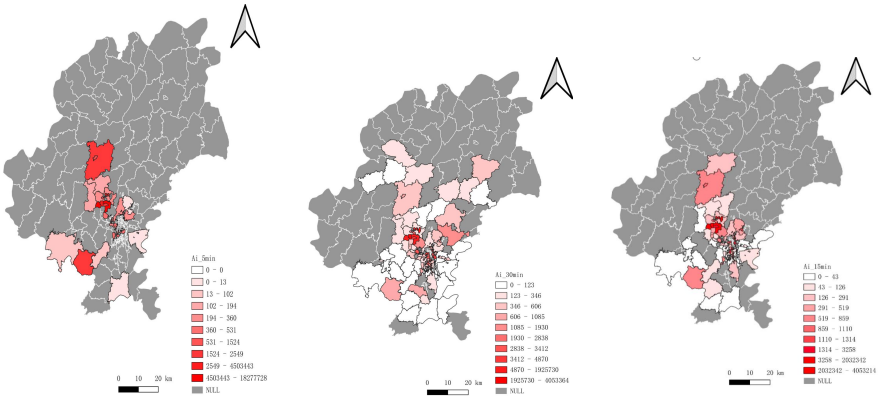

Fig. 1. Spatial Distribution of Urban Park Accessibility in Guiyang under Different Travel Thresholds.

4.2 Equity Assessment of Park Accessibility

The Gini coefficient results show that there is a significant imbalance in the availability of urban parks in Guiyang. The Lorenz curve is significantly different from the perfect equality line, which suggests an uneven distribution of green areas (see figure 2). The inequity is particularly pronounced within short travel thresholds, where residents experience severely limited convenience in accessing nearby parks.

Though pictures taken from far - off show that Guiyang has a large amount of plant cover overall, a big part of the green places mainly serve as background ecological areas in the mountainous outer parts of the city (look at Figure 3). Even though these big areas of green have ecological importance, they are generally not able to be used in daily life. On the contrary, the city parks and plazas that can be got to within 30 minutes are rather small and spread out in different places geographically, and they don't meet the growing needs of the residents. This causes a situation where there is a lack of connection between the living areas (shown in orange) and the green areas that can be used (shown in green), meaning that most of the green resources can be seen but are not actually used in daily activities.

The numerical assessment further brings to light the degree of unfairness. The Gini coefficients for each of the three limits were 0.573, 0.640, and 0.644 in turn, which shows that the unequal situation stays at a high level across different time and space ranges. These research results stress the necessity to increase the availability of urban parks that are easy to reach, particularly in areas where people face a lack of green resources for daily use.

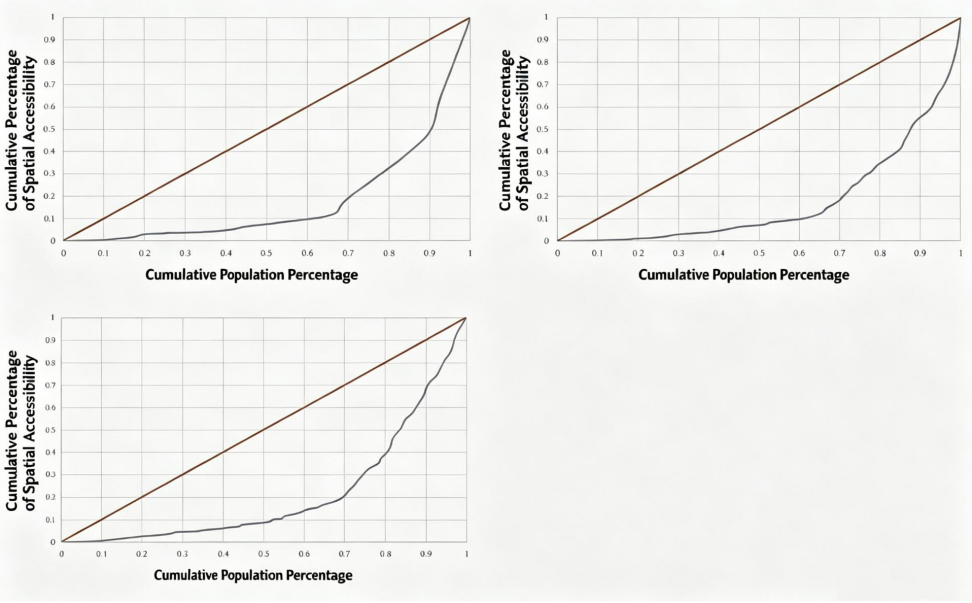

Fig. 2. Lorenz curves of park accessibility under different driving-time thresholds. (a), (b), and (c) correspond to 5-, 15-, and 30-minutes thresholds, respectively.

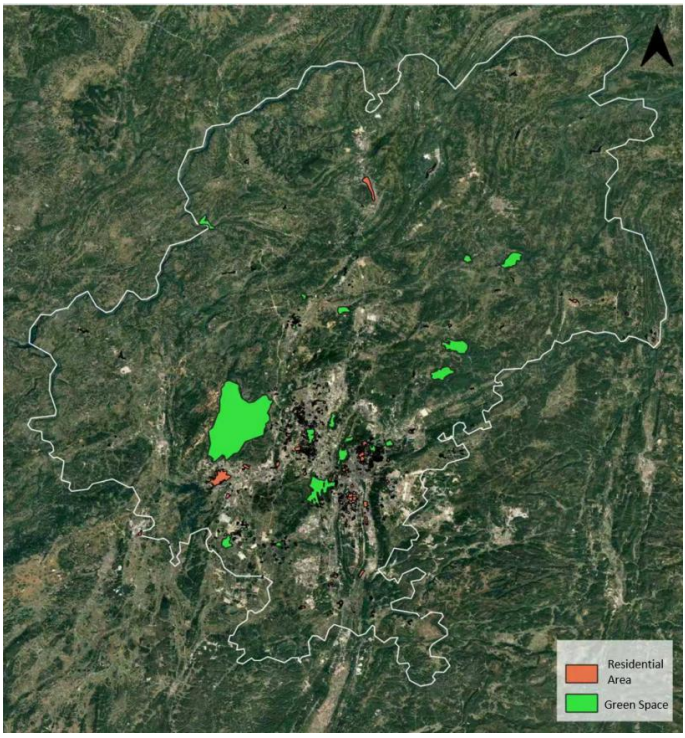

Fig. 3. Spatial Relationship between Residential Areas and Urban Parks in Guiyang.

4.3 District Level Comparison

A study comparing how easily people can get to parks in Guiyang shows a very noticeable difference in their availability across different spaces. The middle parts of the city, especially Yunyan, Nanming, and Guanshanhu, have the best park accessibility. This is because there are lots of parks of different types, like big combined parks and neighborhood parks, spread closely together. These parks let people reach green areas quickly. These districts not only have a history of having public facilities built closely in one place but also have had a lot of money put into projects to make the cities better.

On the other hand, places such as Baiyun, Wudang, and the southern part of Huaxi have a medium level of park accessibility. People living there can go to larger parks, but the parks aren't spread evenly, and often people need to use vehicles to get to them. Areas that are newly being developed, like Gui'an New District, have the hardest time accessing parks. This shows that the building of houses is happening faster than the building of public green spaces.

This difference shows that while the city center has good park services, the edges of the city are falling behind. This causes a clear imbalance between the growing population and the supply of green areas. To fix this problem, it's necessary not just to build more green spaces in the suburbs but also to make how they're spread out better and connect them more with where people live..

5 Discussion

The analysis reveals a pronounced spatial inequity in park accessibility within Guiyang, characterized by a distinct core-periphery divide. The high Gini coefficient across all tourist thresholds highlights the serious mismatch between the availability of urban parks and the population density. There are two main causes of this inequality: the historic concentration of park resources in the center of the city, and the prevalence of large, but not accessible, green spaces in the suburbs and suburbs. So, the deal is, even though the town's got loads of plant cover, a big part of the people often can't turn that into real chances to go out and have fun, especially those who live in the new city parts that are growing super fast. This finding shows how important it is for city planning to tell the difference between green spaces and parks that are useful and easy to get to, especially in hilly places like Guiyang, where the land makes it even harder for people to get to these spots.

6 Conclusion

In this research, the spatial availability and fairness of Guiyang City Park were evaluated by using a gravity model and space analysis method. Results show wide variations in access, with a high degree of availability concentrated in the central core,

and a particularly low level of accessibility in peripheral and newly developed areas. The high level of inequality, measured by a substantial Gini coefficient, shows that the existing park resources do not meet the needs of a significant part of the population. The general vegetation cover is not enough to assess equitable access to recreational services. In order to promote more sustainable urban and social justice, it is essential that future planning prioritise the development of accessible parks and improve transport connections in underserved, high-demand suburbs.

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