Pol. J. Environ. Stud. Vol. 34, No. 4 (2025), 4977-4986
DOI: *10.15244/pjoes/190600* ONLINE PUBLICATION DATE: 2024-12-04

Short Communication

Assessing Green Leisure Space Equity and Accessibility in the Yangtze River Delta: A Geo-Spatial Analysis Using Multi-Source Data Integration

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Received: 25 April 2024
Accepted: 28 June 2024

Abstract

The integration of Geographic Information Systems (GIS) into sustainability studies is crucial for advanced urban planning and ecological management. This study explores the distribution and accessibility of urban green spaces as critical ecological services, particularly in the context of post-pandemic recovery and urban resilience. Utilizing a comprehensive spatial database, this research involves the extraction of Point of Interest (POI) data specific to green spaces within Yangzhou, a representative city in the Yangtze River Delta, China. The analysis employs the two-step floating catchment area (2SFCA) method to quantitatively assess green space accessibility for local residents. Our findings reveal pronounced disparities in green space accessibility between urban and peri-urban zones, highlighting substantial environmental inequity. These disparities suggest a need for targeted urban planning interventions. By employing a multi-modal evaluation framework, this study not only underscores the variations in urban green space accessibility but also proposes GIS-based strategies for enhancing spatial planning at both micro and macro urban scales. The outcomes serve as a foundational tool for policymakers to devise more equitable distributions of ecological services, thereby fostering sustainable urban ecosystems and enhancing the quality of life for all city dwellers.

Keywords: Ecological Services, GIS, Spatial Accessibility, 2SFCA, Yangtze River Delta

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Introduction

Green space refers to areas specifically designated to improve ecology, protect the environment, provide recreational sites for residents, and enhance the landscape. The relationship between green space and healthy living has become a prominent environmental topic and governance priority, particularly in China. With rapid economic growth, the public's demand for a healthy living environment and physical well-being has increased. As living standards rise, people seek more than just basic necessities; they pursue higher levels of satisfaction, including self-actualization, as described by Maslow's hierarchy of needs. Physical health is a crucial aspect of self-actualization. Zheng et al. [1] argue that the National Fitness Program (2021-2025) in China is a necessary response in the post-epidemic era, emphasizing the need for 'material' foundations to enhance national physical health. Tang et al. [2] suggest that as public fitness and health become national priorities, more people will engage in outdoor sports and leisure activities. However, many in China have not yet fully adopted health-conscious and environmentally friendly lifestyles. According to socio-technical systems theory, the lack of infrastructure and green space contributes to a highly intense and stressful living environment. In this context, it is essential to assign a clearer role to green spaces in promoting health and fitness.

With China's rapid economic reforms and industrial productivity growth, the country has experienced explosive urban construction. However, this urban boom has brought significant challenges related to resources, the environment, and social equity. Large-scale construction projects and extensive land use have diminished green spaces and exacerbated air pollution, leading to an imbalanced urban ecology and a deteriorating living environment. Some local governments and real estate developers have prioritized economic gains from land over ecological protection and public needs, often neglecting sustainability. This development culture lacks a 'human-centered' approach to urban planning and architectural design, directly impacting residents' living conditions. To move towards sustainable development, the creation of green leisure spaces has become increasingly important.

'Green leisure' refers to leisure activities that align with the principle of harmonious coexistence between humans and nature [3]. In the face of global climate change, balancing residents' needs with environmental protection has emerged as a critical challenge for local policymakers. Achieving a reasonable and equitable distribution of green leisure spaces is a key solution to this issue. Pouya and Aghlmand [4] highlight the essential role of green leisure spaces in promoting physical activity and providing refuge during the COVID-19 pandemic. These spaces offered crucial benefits for public health and well-being when many other recreational options were unavailable. Recognizing these benefits, Chinese governments have increasingly focused on the construction of green leisure spaces. There has been a significant rise in the number and area of such spaces, with many derelict houses and areas being redeveloped into green leisure areas. Despite these efforts, there remains a significant issue: the accessibility of green leisure spaces. While their numbers have increased, many of these spaces are not easily reachable for a large portion of the population. Long travel distances and high time costs prevent residents from utilizing these spaces effectively, diminishing their potential benefits [5]. This mismatch between the availability of green spaces and their actual use underscores the necessity of rational and strategic planning.

In recent years, the term "Accessibility" has become increasingly prominent in urban planning and environmental studies. Research on the accessibility of green spaces and public facilities is burgeoning, reflecting its growing importance in creating livable urban environments. The concept of accessibility has been a subject of interest for Western scholars since as early as the 1860s and 1870s. In contemporary studies, accessibility continues to be a critical focus, particularly regarding landscape and green space accessibility. Recent scholarly work has yielded significant insights into this area. For instance, Moura et al. [6] proposed that the accessibility of open spaces can be quantitatively assessed using dispersion and accessibility indices. This approach provides a numerical measure of how well these spaces serve the surrounding community. Similarly, Yang and Su [7] emphasized that the accessibility of open spaces can be analyzed through their connectivity with the surrounding environment, highlighting the importance of integrated urban design. Stessens et al. [8] utilized GIS spatial analysis to examine the distance from open spaces as a primary factor in their accessibility study. They compared the accessibility of open spaces across Flemish and four other cities, taking into account various elements such as the natural environment, cultural and historical context, sense of space, quietness, and available facilities. This multifaceted approach underscores the complexity of accessibility and its reliance on multiple contributing factors. Huang et al. [9] developed a macroscopic evaluation model for urban green space accessibility based on the physical potential energy model. Their model incorporates parameters such as population density, land use, transportation networks, and the scale of green spaces. This comprehensive model emphasizes the spatial distribution patterns of urban green spaces and their effectiveness in providing services to residents, offering a broad view of how green spaces contribute to urban livability. Guo et al. [10] introduced a quantitative evaluation model for the green space accessibility index that is both user-friendly and verifiable with current technology. This model takes into account traffic costs, green space size, population distribution, and other relevant factors. By incorporating these variables,

the resistance model established by Guo et al. provides an objective and accurate method for assessing green space accessibility. These studies collectively illustrate the evolving understanding of accessibility in urban contexts. They highlight the importance of quantitative and qualitative methods in evaluating how well green spaces meet the needs of urban populations. As urbanization continues to accelerate, ensuring equitable access to green spaces remains a crucial challenge for urban planners and policymakers. By leveraging advanced modeling techniques and comprehensive evaluation frameworks, future research can further refine our understanding of accessibility and contribute to the creation of more inclusive and sustainable urban environments.

The timeliness of green space accessibility has begun to receive increased attention in recent years. Although many scholars have studied the accessibility of various spaces, there remain significant shortcomings in data acquisition and accuracy. More diversified and timely data are becoming favored by researchers because such data can better inform policymaking and environmental governance. For instance, Xue [11] evaluated the accessibility of green spaces in Beijing using Point of Interest (POI) data, finding that the accessibility between green spaces and commercial spaces in the city is low. Similarly, Zhang et al. [12] used POI data to analyze production-living-ecological facilities across China, illustrating how urban planning can be adjusted based on these insights. Consequently, multi-source data represented by POI data has shown great potential for future research. This communication aims to investigate the accessibility of green leisure spaces in Yangzhou, a coastal city in the Yangtze River Delta, using multi-source data, particularly POI data. By employing spatial analysis methods such as kernel density estimation and spatial autocorrelation analysis, we seek to explore the current state of green leisure space accessibility in Yangzhou. The study intends to provide a comprehensive understanding of how well these spaces serve the urban population and to identify areas that require improvement. Ultimately, our research will contribute to more informed urban planning and policy decisions, promoting equitable access to green leisure spaces and enhancing the overall quality of urban life.

Materials and Methods

Overview of Study Area

The Yangtze River Delta (YRD), a key hub in China's economic globalization, is situated on the country's east coast. Among its representative cities, Yangzhou stands out with its unique natural environment characterized by a well-developed water system, dense woodlands, and expansive plains. This advantageous geographical position has spurred Yangzhou's rapid economic growth in recent years, making it a focal point for studying the development of green leisure spaces. To ensure the robustness and reliability of our data, we have sourced it from multiple credible sources, specifically: (1) Administrative Divisions and Population Data: This data is sourced from the sixth census and encompasses 99 communities (villages) within Yangzhou, covering a total area of 6,591.21 square kilometers. This comprehensive census data provides a reliable demographic foundation for our analysis. (2) Yangzhou Green Ground Layer Data (2018): Based on Open Street Map data from 2018, this dataset identifies 622 land patches in the study area, each with a green area exceeding 500 square meters. Collectively, these patches cover a total area of 25.87 square kilometers, which constitutes 0.39% of the total study area. Open Street Map data is widely recognized for its accuracy and up-to-date information, making it a robust source for geospatial analysis. Additionally, we utilized Points of Interest (POI) data from AMAP, a leading provider of digital maps and navigation services in China, known for its high precision and frequent updates. This inclusion of POI data enriches our study by offering detailed insights into the accessibility and distribution of green leisure spaces within Yangzhou. The distribution of green leisure spaces, as illustrated in Fig. 1 and Table 1, is a key aspect of this study. We focus on how these spaces are integrated within the urban fabric of Yangzhou, contributing to both the ecological and recreational amenities of the city.

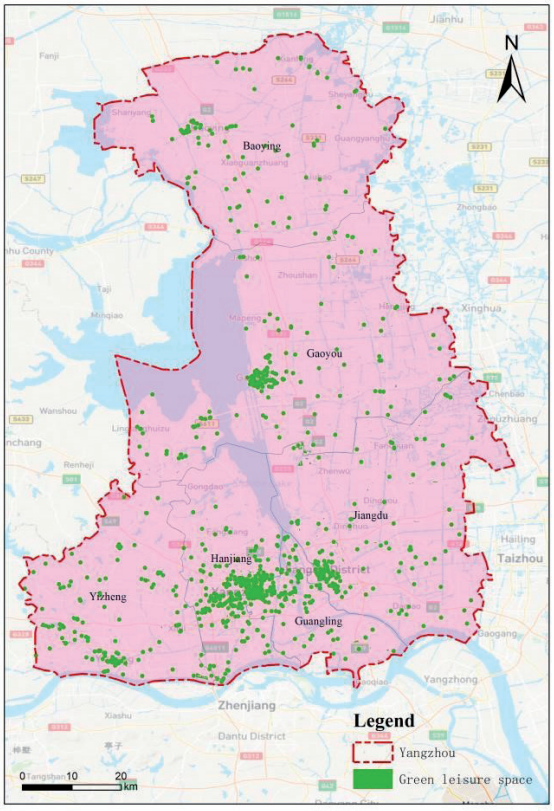

Fig. 1. Distribution of Yangzhou Green Leisure Space.

Table 1. Statistics of Green Leisure Space.

District/County	Green Leisure Points	Areas (km²)
Baoying	99	0.732
Gaoyou	172	1.550
Guangling	187	4.269
Hanjiang	271	10.303
Jiangdu	154	2.702
Yizheng	126	6.260

Kernel Density Estimation

Kernel Density Estimation (KDE) stands out as a powerful statistical method, particularly suited for analyzing the clustering and discrete distribution characteristics of point data. The applicability of KDE in various fields, notably in geographic information systems (GIS), ecology, and urban planning, can be attributed to several key factors. Firstly, KDE excels in reflecting geographical attenuation, showcasing how the intensity or frequency of phenomena diminishes with increasing distance from a point of interest [13, 14]. Moreover, KDE aligns seamlessly with the First Law of Geography, which states that "everything is related to everything else, but near things are more related than distant things." In KDE, areas closer to a core or point of interest are assigned greater radiation values, indicating a stronger relationship or similarity. This principle is crucial in spatial analyses, where the proximity of data points often has significant implications. Another critical aspect of KDE is its method of attribute value distribution. With the position of the selected element point as the center, the attribute value of the points is distributed in a circle with a radius of h. The attribute value decreases with the increase of the distance from the center. In the calculation process, the closer it is to the grid center, the more weight it is assigned [15, 16]. The calculation formula is:

$$f(s) = \sum_{i=1}^{n} \frac{1}{h^2} k\left(\frac{a_s - a_i}{h}\right) \quad (1)$$

Where $f(s)$ is the kernel density function at position s, h is the attenuation distance threshold, n is the number of points, k is the space weight function, and $a_s - a_i$ is the distance between position s and core element i. A 500 mm distance threshold is selected for analysis to integrate the average influence range of green leisure centers. The distance 500 mm is chosen because it can effectively reflect local hotspot information and overall layout characteristics.

Two-step Floating Catchment Area (2SFCA) Method

The 2-Step Floating Catchment Area (2SFCA) method is an advanced technique used for calculating accessibility, primarily utilizing a gravity model approach [17, 18]. This method is particularly relevant for assessing the accessibility of amenities such as green leisure spaces. Essentially, the 2SFCA method involves establishing a service threshold for the green leisure space, which serves as a benchmark for determining accessibility. This threshold represents the maximum distance or travel time considered acceptable for users to access these facilities [19]. By setting this threshold, the method accounts for how far people are willing to travel, thereby providing a realistic measure of accessibility. This approach not only evaluates the proximity of green spaces but also considers the ease with which people can reach them, making it a robust tool for urban planning and environmental studies.

The main steps of the 2SFCA are as follows: In the first step, take the center of gravity of each interest point j, select or assume a spatial distance d_0, and form its spatial scope. Count the number of demanders falling at each demand point k in the scope. The number of potential demanders at the supply place j is obtained using distance decay weights and summing them [20, 21]. Then divide the area of supply land j by the total number of potential demanders to calculate the supply-demand ratio R_j.

$$R_j = S_j / \sum_{i\in\{d_{ij}\le d0\}}^{n} G(d_{ij}) D_i \quad (2)$$

Where d_{ij} is the distance between demand point i and interest point j; d_0 is the space distance set by the supply ground; $G(d_{ij})$ is a Gaussian function reflecting the distance decay effect; and S_j is the magnitude of the demand subject ($d_{ij} \le d_0$) within the threshold with i as the center. S_j is the magnitude value of supply capacity at point j.

In the second step, for each demand i, the space scope is formed given the space distance d_0. The spatial accessibility A_i of demand place i is obtained by adding up the supply-demand ratio R_j of supply place j falling in this scope.

$$A_i = \sum_{i\in\{d_{ij}\le d0\}}^{n} G(d_{ij}) R_j \quad (3)$$

R_j is the supply/demand ratio of supply point j within the acceptable distance range of the demand point i ($d_{ij} \le d_0$); d_{ij} is the distance between the demand point i and the center of gravity j of the supply place. The description of other indicators is the same as the first step; a larger value of indicators indicates better accessibility.

Global Spatial Autocorrelation Analysis

Global spatial autocorrelation is a fundamental concept in spatial analysis, describing the degree to which the attribute values of geographic elements are correlated with each other in space [22]. This concept is crucial in understanding how similar or dissimilar these values are within a geographical region. In analyzing spatial patterns, especially in urban settings, tools such as the Moran's I index, global Geary's C, and global Getis-Ord General G are typically employed to assess the degree of spatial association over a region [23, 24].

In this study, we focus on the global Moran's I index to measure the global spatial autocorrelation of Green Leisure space in Yangzhou. This selection is driven by several factors that make the Moran's I index particularly suited for this research: (1) Sensitivity to Spatial Clustering: The global Moran's I index is sensitive to spatial clustering. It helps in identifying whether green leisure spaces in Guangzhou are clustered, randomly distributed, or dispersed. This is vital for understanding the spatial arrangement of these spaces and their accessibility to the public. (2) Comprehensive Measurement: Unlike some other measures of spatial autocorrelation, Moran's I index provides a comprehensive measurement that includes both the intensity and the significance of spatial autocorrelation. This dual focus allows for a more nuanced understanding of the spatial patterns of green leisure spaces. The formula of Moran's I is as follows:

$$\text{Moran's } I = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{m} w_{ij}(x_i-\bar{x})(x_j-\bar{x})}{\sum_{i=1}^{n}\sum_{j=1}^{m} w_{ij}\sum_{i=1}^{n}(x_i-\bar{x})^2} \quad (4)$$

Where: N is the total number of spatial units in Yangzhou, x_i and x_j are the observed values of the proportion of green leisure space in spatial units i and j, respectively. $\bar{x}$ is the proportion of green leisure space in the study area, and W_{ij} is the space weight matrix. The standardized Z-value is often used to test the significance level of the global Moran's I index, and its calculation formula is as follows:

$$Z_{\text{score}} = \frac{I-E(I)}{\sqrt{\text{VAR}(I)}} \quad (5)$$

Where: $E(I)$, $VAR(I)$ corresponds to Moran's I's expected value and variance. When Z_{score}>1.96 or Z_{score}<-1.96(α=0.05), the proportion of green leisure spaces in spatial units has significant spatial autocorrelation. The value of global Moran's I is between [-1, 1]. If Moran's I>0, positive spatial autocorrelation is shown at a given significance level. That is, areas with a higher (or lower) proportion of green leisure spaces are spatially significantly clustered; if Moran's I<0, the opposite is true.

Results

The Overall Distribution of Green Leisure Space

In this research, the use of ArcGIS 10.2 software was instrumental in conducting a detailed spatial analysis of green leisure spaces in Yangzhou. The primary step involved a preliminary verification of the locations of these spaces to ensure the data's accuracy and reliability. This foundational work set the stage for a more in-depth exploration using kernel density analysis, a sophisticated tool within ArcGIS known for its efficacy in visualizing spatial data distributions. The kernel density analysis led to the creation of a density distribution map, vividly illustrated in Fig. 2, which highlighted the spatial patterns of green leisure spaces in Yangzhou. This map revealed several key findings. Firstly, it identified high-density clusters of green leisure spaces, notably in the Hanjiang District and Guangling District. This clustering suggests that these districts serve as primary hubs for green leisure activities in the city, offering residents concentrated areas of greenery and leisure.

Another significant observation from the analysis was the single-core agglomeration pattern of these spaces. This pattern indicates a strong concentration

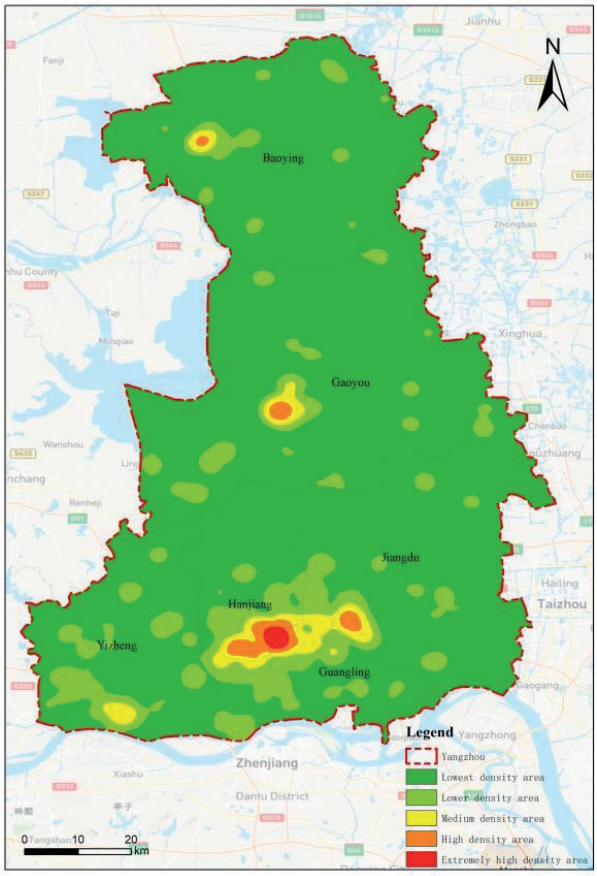

Fig. 2. Kernel Density of Green Leisure space Distribution in Yangzhou.

of green leisure spaces in a central area, with fewer spaces as one moves outward from this core. This spatial arrangement raises important considerations for urban planning, especially in terms of accessibility and equitable distribution of green spaces across the city. Moreover, the study observed a multi-center diffusion network emanating from these high-density areas. This pattern of diffusion, particularly noticeable in the Hanjiang, Guangling, and Jiangdu Districts, implies that while there are concentrated clusters, green leisure spaces also spread into other parts of the city. This dispersion creates a network of green spaces that potentially enhances environmental quality and accessibility to leisure areas for a broader section of the city's population.

Accessibility

The study on multi-scale green leisure space accessibility in Yangzhou is profoundly illustrated through the use of Geometrical Classification Interval, as depicted in Fig. 3. This visualization method provides a clear and detailed representation of how accessible green leisure spaces are to residents in various parts of the city, particularly focusing on reachability within a 15-minute timeframe. The analysis shows significant spatial disparities in the accessibility of multi-scale green leisure spaces across different regions of Yangzhou. A notable observation from the data is the low accessibility in peripheral urban areas such as Gaoyou, Baoying, and Yizheng. These areas are characterized by smaller populations and, consequently, lower population densities. This demographic aspect likely contributes to the reduced accessibility to green leisure spaces. Furthermore, these peripheral areas might be receiving less attention from government departments in terms of the development and maintenance of leisure spaces, leading to poorer accessibility compared to other parts of the city.

In stark contrast, urban centers like Hanjiang District, Guangling District, and Jiangdu exhibit significantly higher accessibility. The green leisure spaces in these downtown areas of Yangzhou are within convenient reach for most residents. This disparity in accessibility underscores a clear urban-peripheral divide. The downtown areas, with their higher population densities and likely more focused urban planning efforts, offer better access to green leisure spaces. This not only

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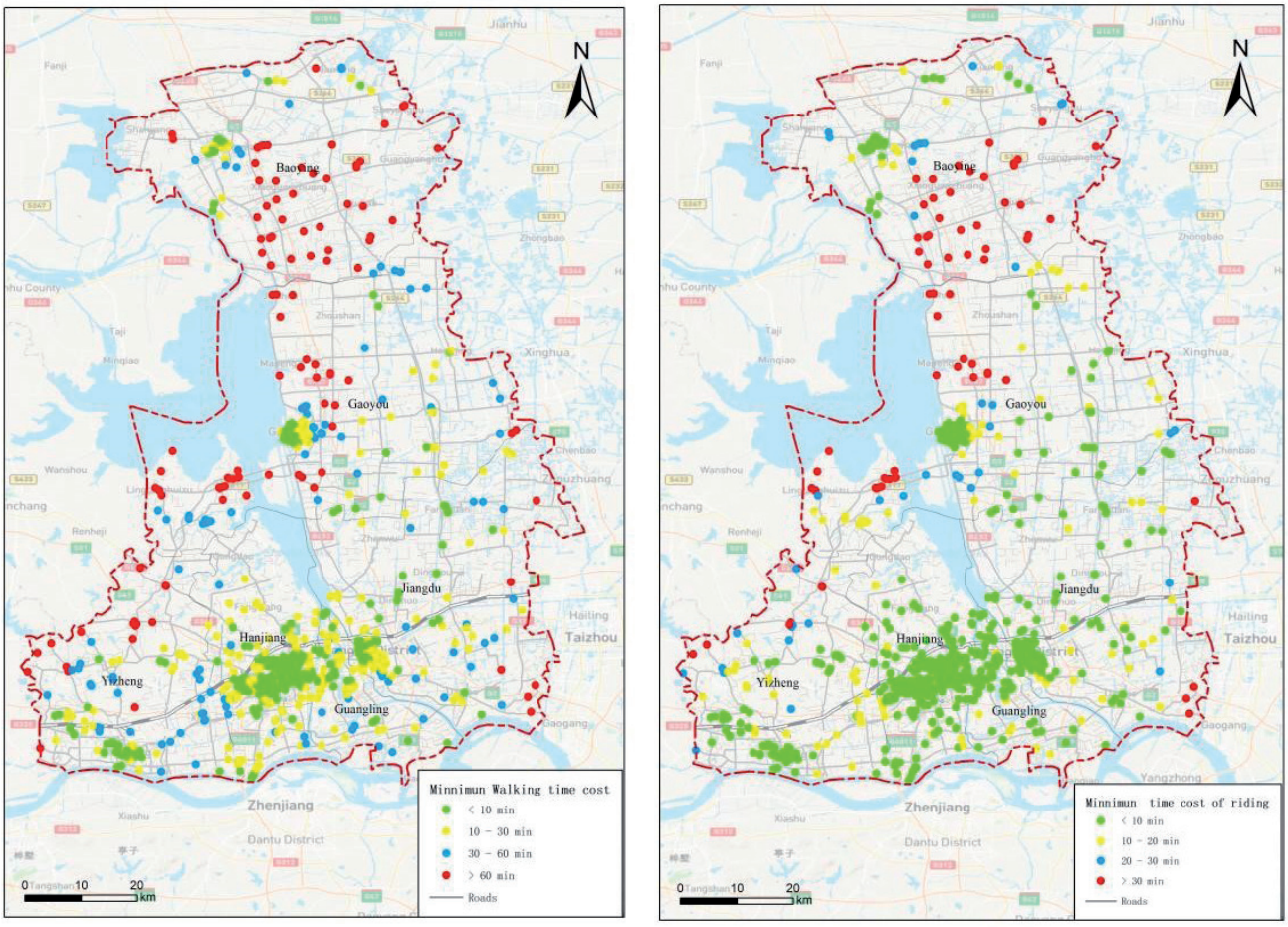

Fig. 3. Walking a) and Cycling b) Accessibility of Green Leisure space in Yangzhou.

provides recreational and environmental benefits to the residents but also enhances the overall urban living experience. The findings from this study are critical for urban planning and policymaking. They highlight the need for a more equitable distribution of green leisure spaces across Yangzhou, ensuring that peripheral and less densely populated areas are not neglected. Improving accessibility in these areas can significantly enhance the quality of life and provide more balanced urban development. This study, therefore, provides valuable insights for city planners and government officials, emphasizing the importance of inclusive urban development that ensures equitable access to green leisure spaces for all residents, irrespective of their location within the city.

Agglomeration Difference of Multi-Scale Green Leisure Space Accessibility

The application of Moran's I in this study provides a nuanced understanding of the spatial autocorrelation in the accessibility of multi-scale green spaces in Yangzhou. Moran's I, a measure of spatial autocorrelation, is instrumental in revealing the spatial clustering patterns of variables across a geographic area. In this context, Global Moran's I is used to reflect the overall spatial autocorrelation, while Anselin's Local Moran's I focuses on the correlation of a single variable with its immediate surroundings.

The primary objective here is to determine whether the accessibility of multi-scale green spaces in Yangzhou exhibits spatial autocorrelation, which would imply a tendency for areas with similar levels of accessibility to be located near each other. The use of Moran's I to measure spatial agglomeration is crucial in achieving this objective. The results of the analysis are quite revealing. With a Moran's I value of 0.34, a Z score of 8.46, and a P value of less than 0.001, there is a clear indication that the green space accessibility index in Yangzhou exhibits significant spatial agglomeration and autocorrelation. This suggests a strong pattern where areas with similar levels of green space accessibility are clustered together.

The spatial agglomeration characteristics are further elucidated in the findings. Regions with high accessibility are predominantly clustered in the Hanjiang District and other central urban areas. This pattern indicates that central areas of the city are well-

a) b)

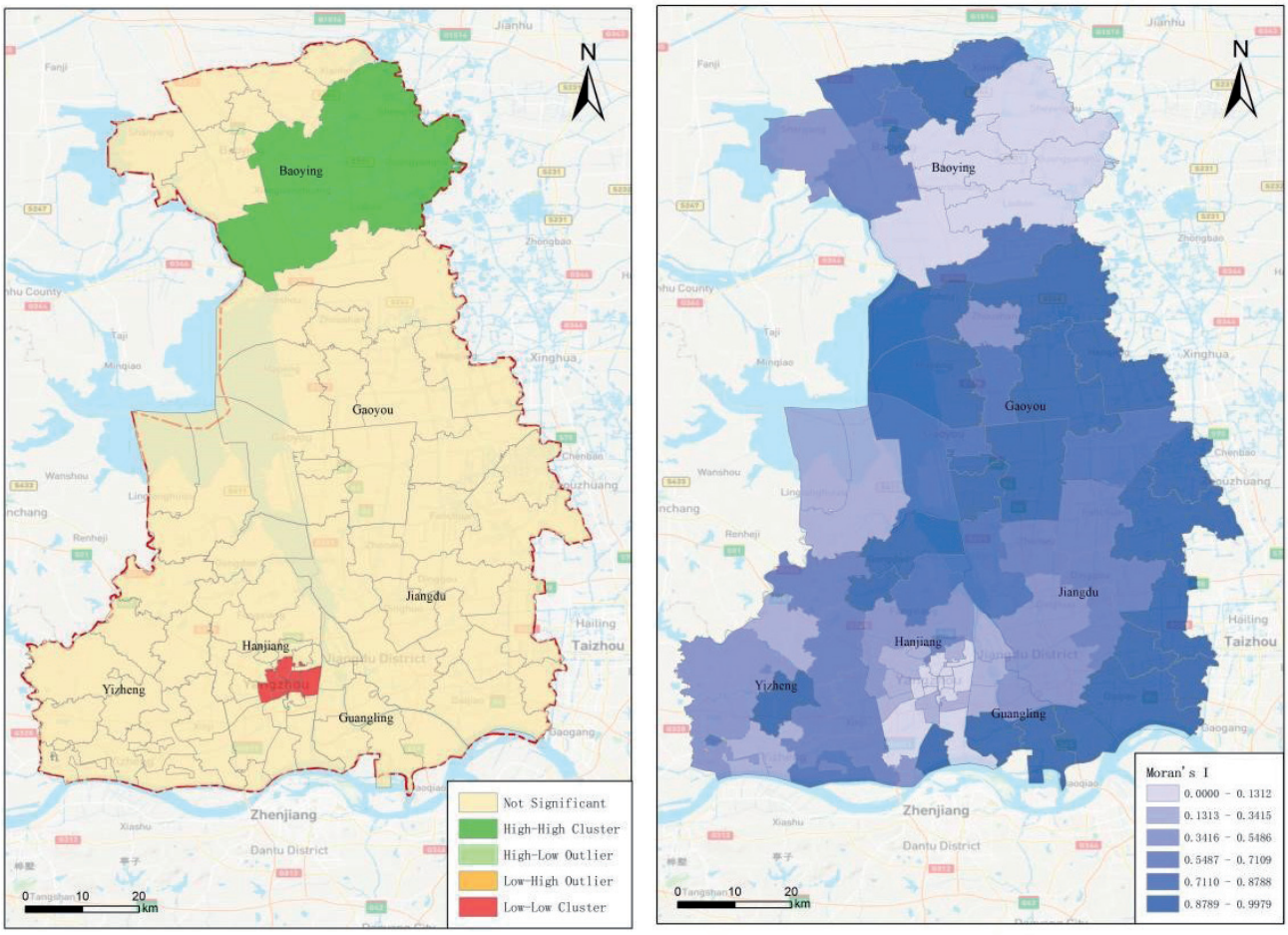

Fig. 4. Spatial Pattern of Accessibility Clustering a), Moran's I b) and Accessibility z-value c).

c)

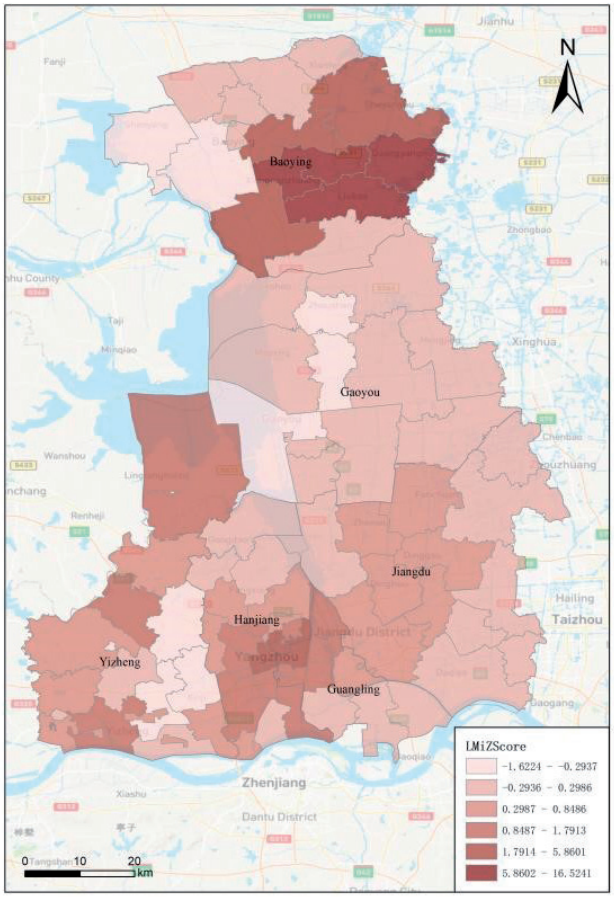

Fig. 4. Continued.

served in terms of green space accessibility. Conversely, areas with low accessibility, such as Baoying County, demonstrate a distinct cluster, highlighting disparities in green space distribution (as shown in Fig. 4a). Further exploration of the spatial correlation degree (illustrated in Fig. 4b and 4c) reveals that regions with a high spatial correlation in low-low value clusters are mainly located in Yuexiu District and the western part of Haizhu District. These areas exhibit a pattern where low accessibility to green spaces is a common characteristic. On the other hand, high-high value clusters indicating areas with consistently high accessibility reach their peak in Huadu District and extend to the eastern part of Baiyun District.

These findings underscore the uneven distribution of green space accessibility in Yangzhou. The use of Moran's I in this analysis not only confirms the presence of spatial autocorrelation but also provides a detailed understanding of where and how these patterns manifest. This information is vital for urban planners and policymakers, as it highlights the areas that require more attention to ensure equitable access to green leisure spaces across the city. The study thus offers valuable insights that can inform targeted interventions to improve urban environmental quality and enhance the well-being of residents in all districts of Yangzhou.

Discussion

As a leader in green leisure space development within the Yangtze River Delta, Yangzhou offers a microcosm of the challenges and opportunities in urban environmental planning. One of the most striking aspects revealed by the study is the phenomenon of "suburban polarization" in the distribution of green leisure spaces. This term aptly describes the scenario where high-accessibility regions, typically characterized by high population densities, enjoy a concentration of green leisure facilities. In contrast, low-accessibility regions, often coinciding with less developed and less populated suburban areas, exhibit a scarcity of such amenities. This pattern not only reflects a disparity in urban development but also raises concerns about social equity and environmental justice. The suburban areas, despite their potential for providing substantial green leisure spaces, remain underserved, leading to an imbalance in urban ecological benefits and recreational opportunities. The application of the 2-Step Floating Catchment Area (2SFCA) method, considering multiple transportation modes, further illuminates the spatial discrepancies in green leisure space accessibility. It highlights a significant urban-suburban divide in Yangzhou, with downtown areas showing commendable green space coverage accessible within a 15-minute walk or cycle. This indicates a successful urban design in central areas, aligning with the global trend towards creating '15-minute cities' where essential services and amenities are within a short distance from residents. However, the stark contrast in the outer urban areas, which fall short of this standard, is a glaring issue. This discrepancy not only reflects an uneven distribution of urban amenities but also suggests potential areas for future urban development and planning focus. Furthermore, the study uncovers a notable gap in the development of residential leisure facilities, particularly in suburban areas. Despite local government efforts to enhance public leisure facilities, the specific needs of residential areas seem to have been overlooked. This gap points to the necessity of a more holistic approach to urban planning, one that considers the diverse needs of different urban and suburban areas and strives to provide equitable access to leisure spaces.

The findings also highlight the underlying socio-economic dynamics influencing the distribution of green leisure spaces. The concentration of such spaces in high-density, economically vibrant areas contrasts sharply with their scarcity in economically modest suburban regions. This disparity may reflect broader patterns of resource allocation and investment priorities, which tend to favor more affluent and densely populated urban centers. These patterns suggest a need for policies that promote more balanced development, ensuring that all residents, regardless of their socio-economic status or geographic location, have access to high-quality green leisure spaces. Moreover, the long-term impacts of these disparities on urban health and well-being are significant.

Access to green spaces is crucial for physical health, providing areas for exercise, relaxation, and social interaction, which are essential for mental well-being. The lack of accessible green spaces in suburban areas could lead to increased health disparities, contributing to higher levels of stress, reduced physical activity, and poorer overall health outcomes among residents in these regions. Addressing these issues requires a multifaceted approach. Urban planners and policymakers must prioritize the equitable distribution of green leisure spaces, integrating considerations of social equity into urban development plans. This includes increasing investment in suburban areas, enhancing public transportation links to green spaces, and ensuring that new developments incorporate sufficient green spaces. Additionally, community involvement in the planning process is crucial to ensure that the needs and preferences of local residents are adequately addressed.

In summary, while Yangzhou's efforts in green leisure space development are commendable, there remains a significant urban-suburban divide that needs to be addressed. By focusing on equitable access and considering the socio-economic and environmental factors influencing green space distribution, future urban planning can create more inclusive and healthier urban environments. This study underscores the importance of a balanced approach to urban development that prioritizes both economic growth and environmental sustainability, ultimately improving the quality of life for all residents.

Conclusions

The research on green leisure space accessibility in Yangzhou yields several important conclusions. Firstly, while the downtown areas of Yangzhou enjoy relatively high coverage of green leisure spaces, the outer urban areas exhibit a notable deficiency, reflecting a significant gap in green space development. Secondly, the evident suburban polarization and spatial agglomeration in green space accessibility necessitate a more balanced approach to urban planning and development. Thirdly, the need for more focused development of residential leisure facilities is apparent. The study underscores the importance of green leisure spaces for both environmental and public health benefits. Considering the substantial land area and high costs associated with their construction, this research provides a valuable reference for the reasonable layout of such spaces, particularly in suburban areas. It also offers insights into constructing these spaces in the most economical manner.

In conclusion, this study highlights significant disparities in green leisure space accessibility within Yangzhou, particularly between the well-served downtown areas and the underserved suburban regions. The findings emphasize the need for more equitable urban planning to ensure all residents have access to green leisure spaces, which are crucial for environmental sustainability and public health. However, this research is subject to several limitations. Firstly, the analysis is confined to accessibility metrics, which, while important, do not capture other critical factors such as the quality, usability, and maintenance of green leisure spaces [25-27]. Secondly, the study relies on data from specific sources, which may have inherent biases or inaccuracies. Thirdly, the temporal aspect of green space accessibility – how it has changed over time and its impact on urban development – was not addressed. Future research should explore these additional dimensions to provide a more comprehensive understanding of green space accessibility. Furthermore, incorporating community feedback and preferences could enhance the relevance and impact of the findings, ensuring that green leisure space development aligns with the needs of the local population. By addressing these limitations in future studies, urban planners and policymakers can develop more holistic and effective strategies for enhancing green space accessibility and improving the overall quality of urban life.

Acknowledgments

This work is supported by the research project of Zhejiang Federation of Social Science in 2024, "Integration of Industry and Education Helps Digital culture Empower Rural Revitalization: A Study on Cooperative Entrepreneurship of higher vocational Students Returning to their hometowns" (Project Number: 2024N130)

Conflict of Interest

The authors declare no conflict of interest.

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