Integration Characteristics of Slow Blue-green Space Based on Ecological Livability: A Case Study of the Central Urban Area of Wuhan

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Abstract Urban planning often faces issues of spatial separation between blue and green spaces, as well as the lack of integration in slow traffic networks. The development and shaping of urban slow, blue, and green spaces often proceed along separate paths. However, building an ecological and livable city requires the integrated development of slow, blue, and green spaces. Taking the central urban area of Wuhan as a case study, this research uses ArcGIS visualization, walking accessibility analysis, and landscape pattern index analysis methods. By overlapping slow traffic spaces with blue and green spaces, the study explores the distribution of slow, blue, and green spaces and the integration characteristics of slow + blue-green spaces, categorizing them based on walking time and spatial aggregation. The results show: 1) In the central urban area of Wuhan, blue spaces are predominant in the Yangtze River basin, the Han River – Sha Lake – East Lake – South Lake, Yangchun Lake – East Lake – South Lake – Yezhi Lake, and Longyang Lake – Moshui Lake directions, with clear dominant patches, while other areas show average performance; 2) Green spaces have good patch dominance and connectivity along the Qingshan Park – East Lake Greenway – Moshan – Ma'anshan Forest Park; 3) The integration of blue and green spaces is best along the Yangtze River, East Lake, and South Lake; 4) Areas such as Sha Lake Park in Wuchang District, East Lake Scenic Area in Hongshan District, the South Lake – Yezhi Lake corridor, Moshui Lake and Longyang Lake in Hanyang District, and the northern and southern parts of the Yangtze River are characterized by better integration of slow blue-green spaces. Through the overlay analysis of walking accessibility and landscape pattern indices of blue-green spaces, the study significantly reflects the integration characteristics of slow blue-green spaces in Wuhan's central urban area. This research aims to provide references for the planning and design of urban slow blue-green spaces and the construction of livable and ecological cities, offering practical guidance for creating a healthy urban ecological living environment and for urban ecosystem restoration and management.

Key words Ecological livability; Slow blue-green space; Walking accessibility; Landscape pattern index; Spatial integration

DOI 10.19547/j.issn2152 – 3940.2024.06.004

With the rapid development of China's social economy, urban environmental issues such as the heat island effect, water pollution, and garbage siege have become increasingly prominent, threatening people's living environment. Under the national strategy of ecological civilization, the vigorous development of urban ecology and the people's demand for a happy life have made the ecological livability of cities an important part of urban construction[1]. Although the current territorial spatial planning integrates ecological patterns with urban construction on a macro level, it lacks detailed control over residents' daily lives[2]. Planning and design often face the problems of spatial separation between blue and green spaces and the lack of integration in slow traffic networks. As a medium that connects ecological spaces such as blue and green spaces with urban spaces, the slow traffic system is an important part of improving urban living quality. Therefore, it is crucial for the development of ecological livability in cities by studying the integration of slow blue-green spaces.

Current research on the integration of slow, blue, and green spaces, both domestically and internationally, focuses on two aspects: one is the ecological perspective, considering the impact of blue-green space integration on healthy cities[3–4], ecology[5–7], resilient cities[8–9], and urban pattern optimization[10–11]; the other is the urban design perspective, focusing on the integration of slow traffic, blue spaces, or green spaces at various levels[12–14]. Most studies on the integration of slow traffic systems are based on walking accessibility. Accessibility is a method of quantifying spatial structure through topological analysis. Research on accessibility, both domestically and internationally, includes studies on the accessibility of various urban spaces, such as analysis of pedestrian accessibility on open spaces (green spaces)[15–16] and service facilities (construction)[17] starting from supply – travel – demand, as well as comprehensive studies based on user needs and satisfaction from a perceptual perspective[18–21].

In summary, existing research mostly focuses on single or dual elements of slow traffic, blue, or green spaces, lacking exploration of the integration of "slow + blue + green" spaces under the background of ecological livability. Against the backdrop of Wuhan's vigorous development of an ecological and livable city, residents' demand for a good ecological living environment has increased. The rational planning and layout of slow traffic systems and blue-green spaces are not only requirements for improving residents' living environments but also for Wuhan's ecological city construction. Therefore, this paper uses land use data and road data from Resources and Environment Science Data Center of Chinese Academy of Sciences, and takes the central urban area of Wuhan as a case study. Based on ArcGIS software and the Frag-

Received: November 1, 2024 Accepted: December 20, 2024

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stats platform, the location information of slow blue-green spaces in Wuhan is extracted. Using network analyst and landscape pattern index analysis, the maximum patch index, patch cohesion index, and aggregation index of blue and green spaces are calculated, and the spatial distribution characteristics of blue-green spaces are visualized. At the same time, by analyzing the walking accessibility of blue-green spaces (slow traffic system), the study explores the interconnections between slow blue-green spaces, thereby obtaining the integration of slow blue-green spaces. It helps provide planning and design references for the ecological livability construction of Wuhan's central urban area.

1 Overview of study area

1.1 Study scope As shown in Fig. 1, the study range is the central urban area of Wuhan, generally defined as the area within the Third Ring Road of Wuhan. The study area includes Wuchang, Hankou, and Hanyang, which are the central areas of Wuhan's old city. Together with the Yangtze River, Han River, and other water systems, they form the basic landscape pattern of Wuhan's central urban area.

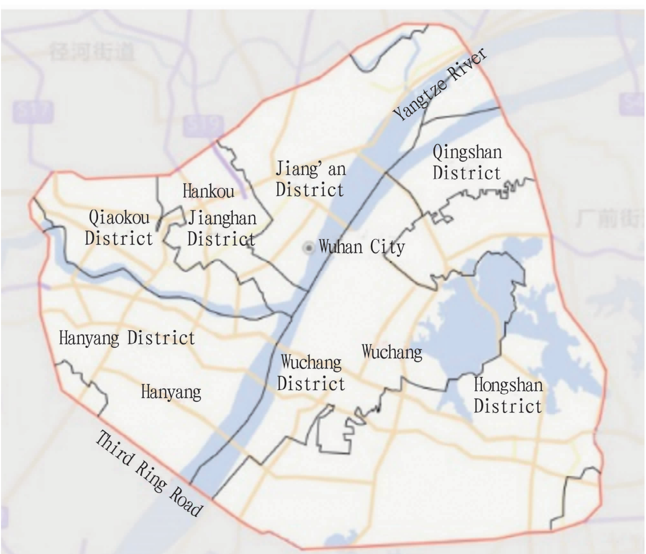


Fig. 1 Study scope

1.2 Distribution of slow blue-green spaces

1.2.1 Slow traffic spaces. According to the *Wuhan Street Full-element Design Guidelines*, the slow traffic spaces in Wuhan's central urban area can be roughly divided into two categories: traffic-oriented slow traffic spaces and non-traffic-oriented slow traffic spaces[22]. The distribution of slow traffic spaces in Wuhan's central urban area is shown in Fig. 2. The slow traffic road system in Wuhan's central urban area presents two main distribution patterns: one is based on the traffic network, where slow traffic roads are mostly set along main traffic arteries and branch roads, ensuring smoothness and convenience while strengthening the functionality of the slow traffic system, suitable for high-density urban environments. The other is the distribution dependent on landscape resources, where the slow traffic system is developed around parks, rivers, and lakes, forming a road layout combined with the landscape. Among them, the slow traffic roads along the Yangtze River and the Han River are distributed in a linear pattern, relying on the waterfront spaces on both banks; the slow traffic roads in the East Lake area presents a ring and patch layout, combining lake landscapes with leisure functions; other scattered slow traffic roads are distributed around major parks and lakes. The distribution of slow traffic spaces in main roads of Wuhan's central urban area has a clear grid-like feature, especially in the central area where the three towns of Wuhan meet. The density of the slow traffic network is high, gradually dispersing outward. In local areas such as commercial districts and densely populated communities, due to the large demand for pedestrian flow, slow traffic spaces show a patchy aggregation feature.

Fig. 2 Distribution of slow traffic spaces in the central urban area of Wuhan

1.2.2 Blue spaces. The distribution of blue spaces in Wuhan's central urban area is shown in Fig. 3. Wuhan's linear water system axis, centered on the Yangtze River and the Han River, runs through the city, forming the main vein of the city's spatial structure. The Yangtze River and the Han River form a "Y" shape within Wuhan, with two east – west mountain ranges running parallel and 27 scattered lakes, forming the city's spatial pattern of two rivers converging and three towns standing[23].

The distribution of lakes in Wuhan's central urban area is scattered and irregular, with poor connectivity between lakes. Lakes are mainly concentrated in Wuchang District, Hongshan District, and Qingshan District south of the Yangtze River, while the distribution of lakes in Hanyang District, Qiaokou District, Jianghan District, and Jiang'an District north of the Yangtze River is sparse, with smaller scales. Medium-sized lakes such as Moshui Lake, Yue Lake, and Longyang Lake are concentrated in Hanyang District, while the other three districts only have scattered small patch-like lakes. The largest lake in the central urban area, East Lake, spans Wuchang District and Hongshan District. Other larger lakes such as Yezhi Lake, South Lake, Sha Lake, and Yangchun Lake are scattered irregularly in Wuchang District, Hongshan District, and Qingshan District, with complex and irregular boundary shapes.

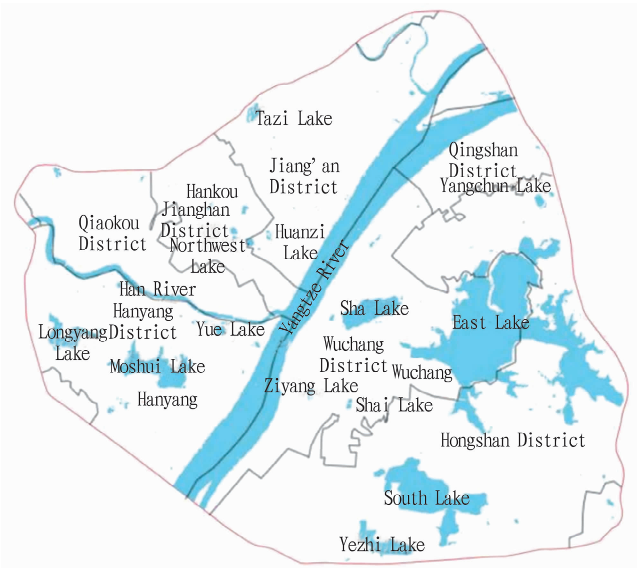


Fig. 3 Distribution of blue spaces in the central urban area of Wuhan

1.2.3 Green spaces. The distribution of green spaces in Wuhan's central urban area is shown in Fig. 4. A mountain range running east – west and intermittently connected, from Guishan in Hanyang District to Sheshan in Wuchang District, the Luojia Mountain in Hongshan District, the Ma'an Mountain, and other green spaces and lakes, together with the north – south Yangtze River axis, form the cross-shaped landscape pattern of Wuhan.

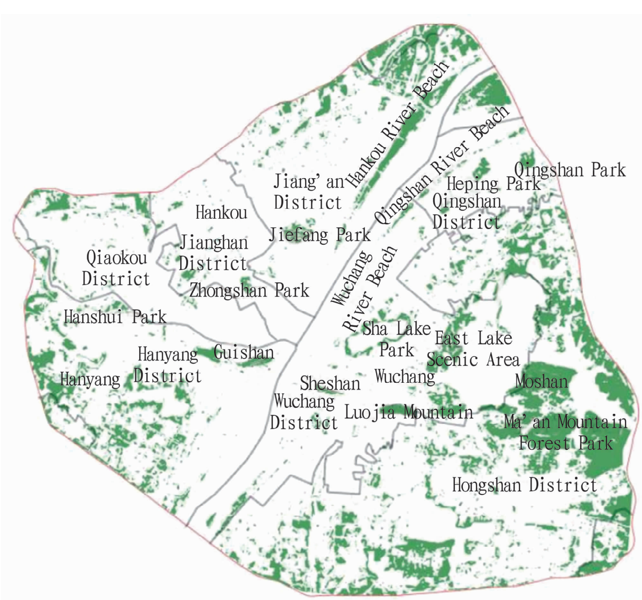


Fig. 4 Distribution of green spaces in the central urban area of Wuhan

Small green spaces in Wuhan's central urban area are mainly distributed in the western part of the central urban area, Hankou, and Hanyang. Large-scale belt-like green spaces exist along the Yangtze River and the Han River, showing a narrow belt-like axial differentiation along the waterfront corridors. Patch-like green spaces are mainly park green spaces and regional green spaces, while belt-like green spaces are mainly distributed along rivers or adjacent to urban roads. Ring-like green spaces are mainly combined with lakes. Among them, Wuchang has the largest green space area, far exceeding Hankou and Hanyang, with large regional green spaces such as Sha Lake Park, East Lake Moshan Scenic Area, East Lake Greenway, and protective green spaces such as Wuchang River Beach Park. Hongshan District has the second-largest green space area, with the largest proportion being the regional green space Ma'an Mountain Forest Park. Jianghan District has the smallest green space area, mainly consisting of park green spaces and square green spaces.

1.2.4 Slow blue-green spaces. The distribution of slow blue-green spaces in Wuhan's central urban area is shown in Fig. 5. Combining water systems and green spaces, the distribution of artery slow traffic spaces along the Yangtze River in Wuhan's three towns is denser than in other areas. The distribution of greenway slow traffic spaces is relatively scattered, mainly in the form of points and patches, distributed in green parks in the central areas of the three towns. Waterfront slow traffic spaces are widely distributed, with 50% distributed in a belt-like pattern along the Yangtze River and the Han River, 30% distributed irregularly around East Lake, and the remaining 20% freely distributed around other smaller water systems.

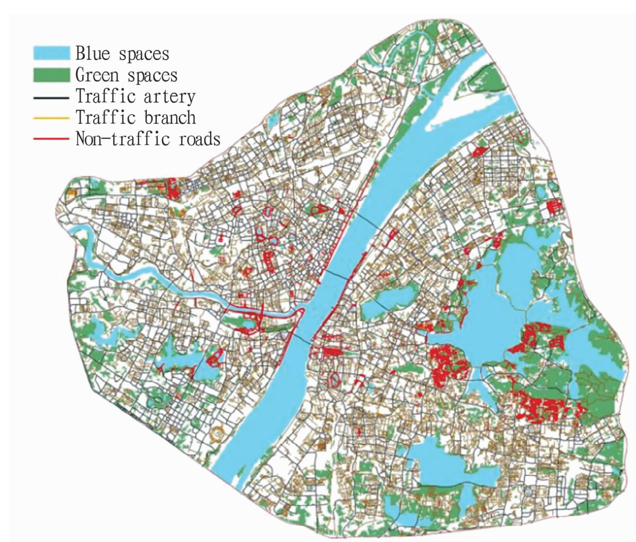


Fig. 5 Distribution of slow blue-green spaces in the central urban area of Wuhan

2 Research methods

2.1 Walking accessibility analysis method for blue-green spaces For blue-green spaces, each space can serve a certain range of living areas[9]. The walking accessibility analysis method for blue-green spaces is shown in Fig. 6. The analysis steps are as follows: ① traffic network construction: ArcGIS software is used to organize road network data, road walking time is calculated, and a walking traffic network dataset is constructed; ② service area network analysis: the river and lake systems and green space data of Wuhan's central urban area is converted into POI data points, and the service area of blue-green spaces in Wuhan's central urban area is established; ③ calculating walking accessibility: the walking time range is set, and the Network Analysis tool is used to calculate the walking accessibility results of blue-green spaces.

2.2 Integration characteristics analysis method for blue-green spaces Based on the Fragstats software, the landscape pattern index analysis of blue-green spaces in Wuhan's central urban area is conducted. The landscape pattern index at the class level is used to quantify the spatial distribution characteristics of different types of blue-green spaces. According to the research needs, three key indicators are selected: the largest patch index (LPI), patch cohesion index (COHESION), and aggregation index (AI), to deeply analyze the scale, connectivity, and aggregation of blue-green spaces, facilitating the evaluation and understanding of the integration effect of slow blue-green spaces in Wuhan's central urban area (Table 1).

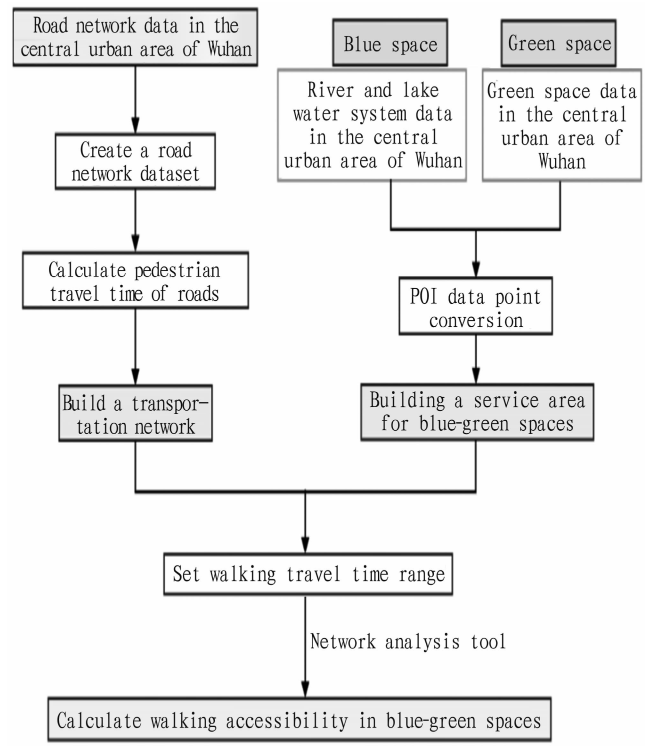


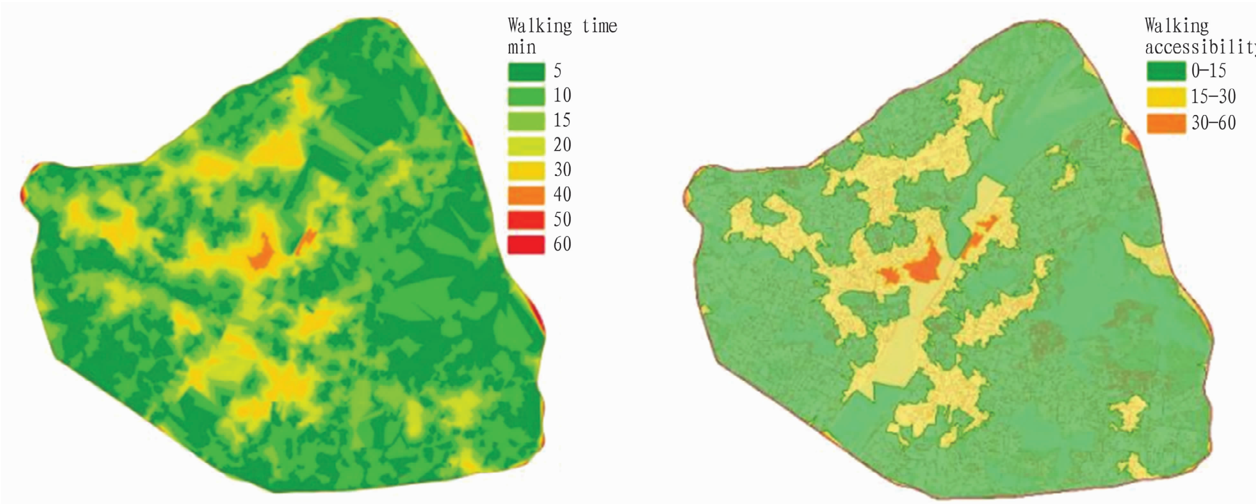
Fig. 6 Walking accessibility analysis method for blue-green spaces

Table 1 Ecological significance of landscape pattern indices

Level	Landscape pattern index	Formula	Ecological significance
Class	Largest patch index (LPI)	$LPI = \frac{a_{\max}}{A} \times 100$ $a_{\max}$ is the area of the largest patch in a landscape or a certain type of patch (m^2)	Measuring the size and relative distribution of the largest patch in the landscape. The higher the value, the larger and more dispersed the largest patch in the landscape
	Patch cohesion index (COHESION)	$COHESION = \left[1 - \frac{\sum_{j=1}^{M} P_{ij}}{\sum_{j=1}^{M} P_{ij}\sqrt{a_{ij}}}\right] \cdot \left[1 - \frac{1}{\sqrt{A}}\right]^{-1} \times 100$ a_{ij} is the area of the j^{th} patch in the ith type of landscape (m^2); P_{ij} is the perimeter of the j^{th} patch in the ith type of landscape (m); A is the total area of the landscape (hm^2)	Measuring the cohesion and internal connectivity within the landscape patches. The higher the value, the higher the connectivity and cohesion between local areas within the patch
	Aggregation index (AI)	$AI = \left[\frac{g_{ii}}{\max \to g_{ii}}\right](100)$ g_{ii} is the number of similar adjacent patches of corresponding landscape types	Reflecting the degree of aggregation of landscape elements. The higher the value, the better the aggregation

3 Research results

3.1 Walking accessibility Taking the blue-green spaces in Wuhan's central urban area as the service area, the walking accessibility of blue-green spaces in Wuhan's central urban area is analyzed using walking time thresholds of 5, 10, 15, 20, 30, 40, 50, and 60 min (Fig. 7). Fig. 7a shows that the walking accessibility of blue-green spaces in Wuhan's central urban area is basically within 40 min, with most areas within 30 min. Only some areas in Hankou have walking accessibility over 30 min, which is worse than other areas. Fig. 7b shows the reconfiguration of the walking accessibility map according to the time layers of the community life circle. It can be seen that in the central urban area, blue-green spaces within a 15-min walking distance are mostly distributed on the periphery of the center, showing a trend of increasing from the inside to the outside. This part of the slow blue-green space is well integrated in the direction of livability.

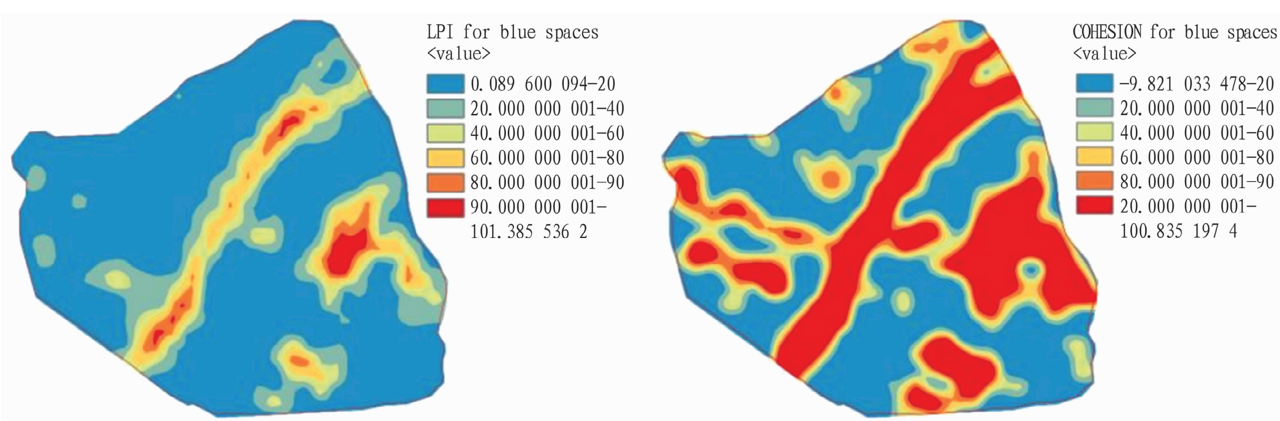


Note: a. 6-level time circle layer; b. 3-level time circle layer in life circle.

Fig. 7 Walking accessibility for blue-green spaces at different time circles

3.2 Landscape pattern index

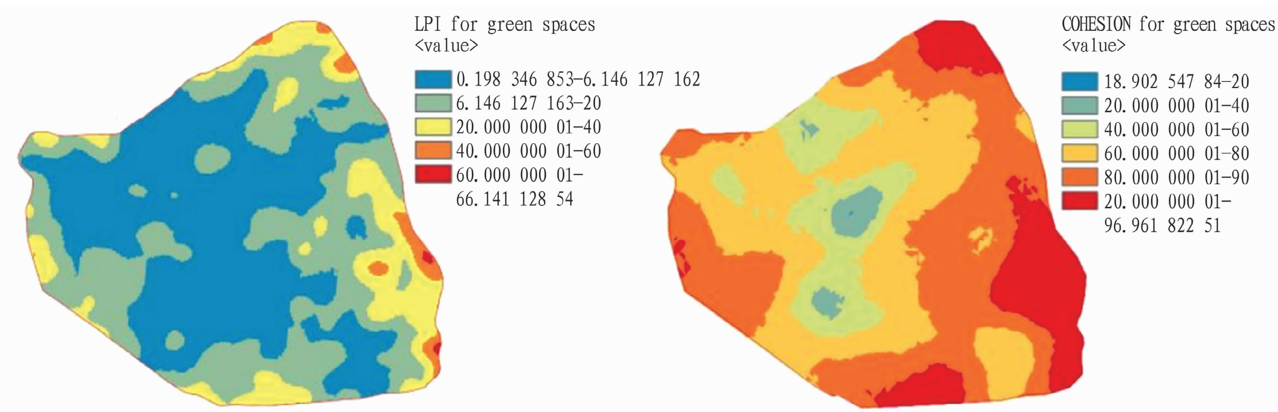
3.2.1 Landscape pattern index of blue and green spaces. Using ArcGIS software, the central urban area of Wuhan is divided into 1 000 m × 1 000 m grids, totaling 582 grids. The Fragstats platform is used to analyze the landscape pattern index of each grid. The results of the landscape pattern index analysis of blue spaces in Wuhan's central urban area are shown in Fig. 8. Fig. 8a shows that the larger the LPI value, the more obvious the patch advantage and the better the landscape ecological benefits. It also shows that blue spaces are more concentrated in the central and western parts of the study area, with the western part being the second most concentrated, and the southwest and northeast parts having sparse blue spaces. Fig. 8b shows that the larger the COHESION value, the higher the connectivity and cohesion between local areas within the patch. The connectivity of blue spaces in the study area is basically the same as in Fig. 8a, indicating that the patch advantage and connectivity in this part of the study area are obvious, and the ecological and service effects of blue spaces are better. Combined with the distribution of blue spaces in Fig. 3, it is found that the blue spaces in Wuhan's central urban area are predominant in the Yangtze River basin, the Han River – Sha Lake – East Lake – South Lake, Yangchun Lake – East Lake – South Lake – Yezhi Lake, and Longyang Lake – Moshui Lake directions, with clear dominant patches, while other areas show average performance.



Note: a. LPI index; b. COHESION index.

Fig. 8 Landscape pattern index of blue spaces in Wuhan's central urban area

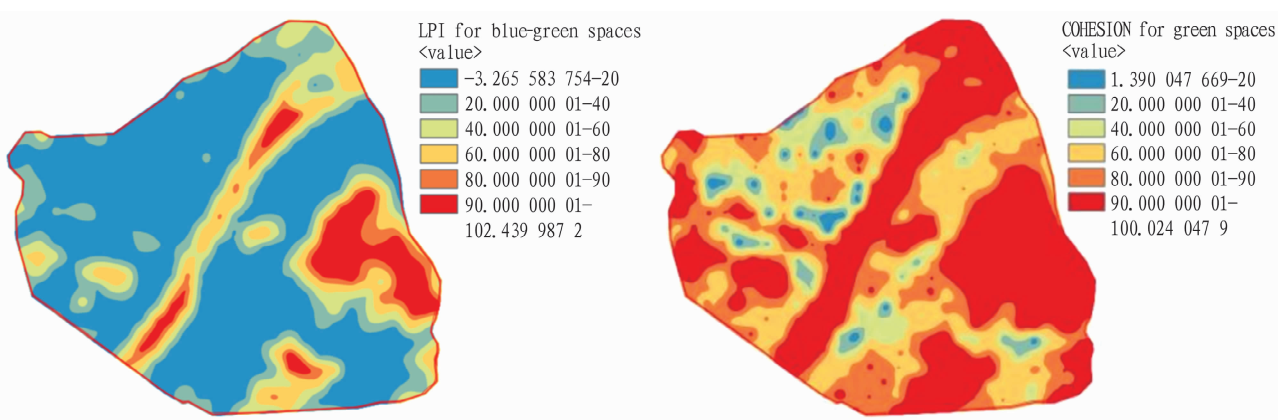
Fig. 9 shows the landscape pattern index analysis results of green spaces in Wuhan's central urban area. It shows that green spaces are more concentrated in the surrounding areas of the study area, while the central part has sparse green spaces, especially in the central and northwestern parts. Combined with the distribution of green spaces in Fig. 4, it is found that the green spaces in Wuhan's central urban area gradually spread from the center to the periphery, showing a pattern of smaller green space scales in the west than in the east. The eastern green spaces with good patch advantage and connectivity are mainly distributed along the Qingshan Park – East Lake Greenway – Moshan – Ma'an Mountain Forest Park line, with some patches with good benefits and connectivity distributed along the Yangtze River-the Han River belt. The rest is scattered in the internal areas of the study area, forming other green spaces.



Note: a. LPI index; b. COHESION index.

Fig. 9 Landscape pattern index of green spaces in Wuhan's central urban area

3.2.2 Landscape pattern index of blue-green spaces. Fig. 10a shows the LPI of blue-green spaces, and Fig. 10b shows the COHESION of blue-green spaces. Compared with Fig. 8 – 9, it is clear that the largest patch index and connectivity of blue-green spaces are more advantageous than those of single blue or green spaces, and the ecological and residential benefits generated are far greater than those of single spaces.



Note: a. LPI index; b. COHESION index.

Fig. 10 Landscape pattern index of blue-green spaces in Wuhan's central urban area

Fig. 11 shows the aggregation index (AI) analysis results of blue-green spaces in Wuhan's central urban area. It shows that the larger the AI value, the better the aggregation of the landscape. Combined with the distribution of slow blue-green spaces in Fig. 5, it is found that the blue-green spaces in Wuhan's central urban area have the best aggregation along the Yangtze River, East Lake, and South Lake, followed by Longyang Lake, Moshui Lake, Yue Lake, Yezhi Lake, and Zhongshan Park. The aggregation of blue-green spaces in other areas is average.

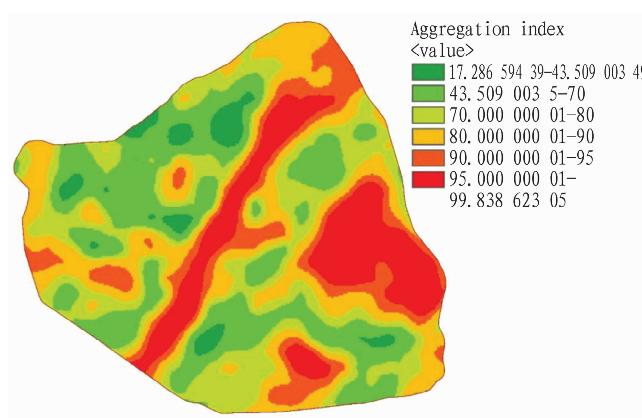


Fig. 11 AI index of blue-green spaces in Wuhan's central urban area

3.3 Integration of slow blue-green spaces The results of the landscape pattern index analysis show that some areas in Wuhan's central urban area have patch advantages in single elements of slow blue-green spaces, which can have a positive impact on ecology and living experience. However, the aggregation and radiation effects of single spaces are limited, and the integration of multiple spaces can more effectively exert overall ecological and residential benefits. By combining walking accessibility and landscape pattern index analysis, the integration effect of slow blue-green spaces within the region can be identified accurately. Therefore, by overlaying the walking accessibility of blue-green spaces with the landscape pattern index, the integration effect of slow blue-green spaces is divided into six levels, as shown in Table 2. The research indicators for the integration of slow blue-green spaces are categorized into walking accessibility indicator of slow blue-green spaces and the aggregation index of blue-green spaces. The former is classified according to living circles, while the latter is divided based on the actual conditions of the central urban area of Wuhan.

Table 2 Integration level of slow blue-green spaces

Integration level/indicator	Walking accessibility of blue-green spaces	Aggregation index of blue-green spaces
Level one	Walking time≤15 min	Above 90%
Level two	Walking time≤15 min or 15 min < walking time≤30 min	80% – 90% or above 90%
Level three	15 min < walking time≤30 min	80% – 90%
Level four	Walking time≤15 min or 30 min < walking time≤60 min	Below 80% or above 90%
Level five	15 min < walking time≤30 min; 30 min < walking time≤60 min	Below 80% or 80% – 90%
Level six	30 min < walking time≤60 min	Below 80%

Fig. 12 shows the integration status of slow blue-green spaces in the central urban area of Wuhan. As can be seen from Fig. 12, in the central urban area of Wuhan, Sha Lake Park in Wuchang District, East Lake Scenic Area in Hongshan District, the corridor from South Lake to Yezhi Lake, parts of Moshui Lake and Longyang Lake in Hanyang District, and areas along the north and south banks of the Yangtze River have better integration of slow blue-green spaces. The main reasons for this are the abundant blue-green resources in these areas and the high density of pedestrian networks. In addition, the slow blue-green spaces in other areas along the Yangtze River, Jiefang Park and Zhongshan Park in Qiaokou District of Hankou have poorer integration compared to the aforementioned areas. This is mainly due to the insufficient density of slow traffic networks and the limited amount of green space along the Yangtze River with rich water resources, which hinders effective integration of slow blue-green spaces within these areas. The integration of slow blue-green spaces in other areas is generally moderate. This is primarily because the blue-green resources in the central urban area of Wuhan gradually increase from the inside to outside, with fewer green spaces and water systems in the inner areas, leading to poorer integration of slow blue-green spaces due to the distribution of these resources.

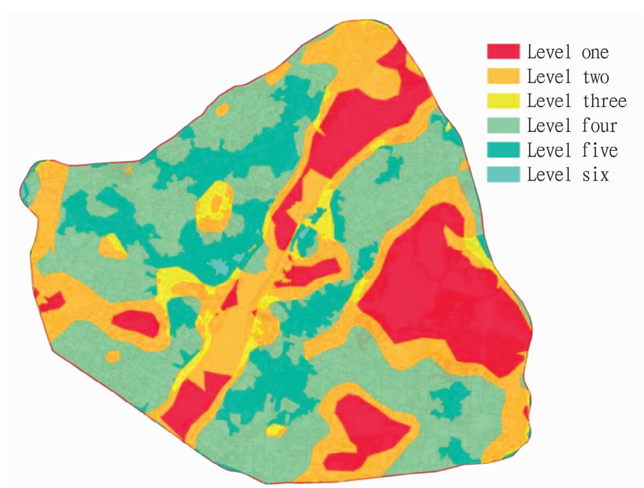


Fig. 12 Integration status of slow blue-green spaces in Wuhan's central urban area

4 Conclusion

This study focuses on the slow blue-green spaces in the central urban area of Wuhan. Using the ArcGIS and Fragstats platforms, it conducts a detailed measurement of the accessibility of blue-green spaces in the central urban area of Wuhan from the perspective of slow traffic and quantifies the aggregation degree of blue-green spaces from an ecological perspective, thereby examining the integration of slow blue-green spaces in the central urban area of Wuhan. The main conclusions include:

(1) By combining landscape pattern indices with walking accessibility, the integration characteristics of slow blue-green spaces in the central urban area of Wuhan are analyzed deeply from both ecological and residential perspectives. The results show that Sha Lake Park in Wuchang District, East Lake Scenic Area in Hongshan District, the corridor from South Lake to Yezhi Lake, parts of Moshui Lake and Longyang Lake in Hanyang District, and some areas along the north and south banks of the Yangtze River have high levels of integration in slow blue-green spaces, offering significant ecological and social benefits. The high-density distribution of blue-green spaces and convenient walking accessibility in these areas provide dual support for urban ecosystem services and residents' quality of life.

(2) The patch advantage of single element in slow blue-green spaces has a positive impact on the ecological environment and residential experience, but their aggregation and radiation effects are limited. Multi-space integration can more effectively enhance overall ecological and residential benefits. By overlaying the walking accessibility of blue-green spaces with landscape pattern indices, the integration effects of slow blue-green spaces are classified into six levels based on walking time and spatial aggregation degree. This classification significantly reflects the integration characteristics of slow blue-green spaces in the central urban area of Wuhan, providing a scientific basis for optimizing the configuration of slow blue-green spaces and enhancing overall benefits.

(3) The integration effect of slow blue-green spaces mainly depends on the layout of non-traffic slow traffic roads. Considering the characteristics of blue-green spaces in the central urban area of Wuhan, it is necessary to reasonably plan and set up slow traffic spaces, especially strengthening the construction of slow traffic spaces along riverfront areas to improve connectivity, making it more convenient for residents to access blue-green spaces. This optimization not only helps build a more comprehensive ecological network but also effectively enhances the livability and walking experience of urban life.

This study primarily examines the integration effects of slow blue-green spaces in the central urban area of Wuhan by analyzing the walking accessibility and spatial aggregation degree of blue-green spaces. However, the analysis of slow traffic roads mainly focuses on the perspective of walking traffic, lacking consideration centered on residents' needs. Additionally, the study of blue-green spaces is more concentrated at the meso and macro levels, without fully exploring their micro-level characteristics and impacts. Future research could start from residents' satisfaction, social evaluation, and the micro-level perspective of slow blue-green spaces, to further enrich the understanding of slow blue-green space integration. Moreover, more precise and refined transformation strategies are proposed to enhance the integration benefits of slow blue-green spaces and the quality of the residential environment.

References

[1] LI H. The "Chinese paradigm" of ecological city planning and construction[J]. Urban Development Studies, 2013, 20(12): 69 – 75.

[2] HUANG D, YI FR, WANG SZ, *et al.* Blue-green space pattern and indicator system in territorial planning[J]. City Planning Review, 2022, 46(1): 18 – 31.

[3] ZHOU K, CHEN YY, CHEN Z. Health-oriented urban green open space supply[J]. Journal of Human Settlements in West China, 2021, 36(2): 11 – 22.

[4] ZHANG HX, STEFFEN N, CAROLINE N. Healthy blue space design: A methodological framework for translating the health benefits of blue space exposure and perception into design practices[J]. Landscape Architecture, 2024, 31(7): 39 – 47.

[5] JIAO XX, ZHANG YJ, LIU XM, *et al.* Construction and integration evaluation of blue-green space index system of typical rivers and lakes in Shanghai[J]. Resources and Environment in the Yangtze Basin, 2023, 32(5): 995 – 1004.

[6] HANNAH B, SUZANNE M, CLAIRE B, *et al.* Identifying, creating, and testing urban planning measures for transport walking: Findings from the Australian national liveability study [J]. Journal of Transport & Health, 2016, 5: 151 – 162.

[7] LI MYX, HUANG Q, SCHAFER J. Qualitative analytical method for urban green open space structure in Germany[J]. Landscape Architecture, 2022, 29(12): 12 – 19.

[8] CHEN JS. Spatial planning strategies of blue and green river space integration from urban resilience viewpoint[J]. Planners, 2020, 36(14): 5 – 10.

[9] HAN XT. Integration of blue-green spaces in the Xinxiang urban section of the Wei River under the concept of resilient cities[D]. Tai'an: Shandong Agricultural University, 2024.

[10] ZUO X, XU BW, LIU H. Green space pattern optimization research based on the blue-green synergy degree evaluation[J]. Landscape Architecture Academic Journal, 2022, 39(5): 30 – 36.

[11] PEI P. Research on the landscape pattern of green open spaces in the Wuhan metropolitan area[D]. Wuhan: Huazhong Agricultural University, 2009.

[12] YU JL, WU XY, SHI HZ, *et al.* Design and practice of gardens in urban green space renewal in Shanghai[J]. Chinese Landscape Architecture, 2024, 40(7): 25 – 31.

[13] LIU CJ, GAO J. Dimensions' structure and their relations of the perceived accessibility in the waterfront of metropolis: Taking Pujiang waterfront of Shanghai City for example[J]. Urban Problems, 2017(12): 33 – 39.

[14] CHEN Y, HU XW. Pedestrian-friendly neighborhood built environment and urban design strategy: A case study of three waterfront residential areas in Sweden[J]. Architecture Technique, 2021, 27(5): 110 – 113.

[15] HUANG L, LAN Q, LUO T. Study on comprehensive measurement of public green space accessibility in megacity from the perspective of social equity: With the central urban area of Chengdu as an example[J]. Chinese Landscape Architecture, 2024, 40(8): 43 – 49.

[16] WANG ZB, TIAN Y, WANG YC, *et al.* Accessibility analysis on blue-green space of urban residential buildings under walking mode: Taking the main urban area of Handan City as an example[J]. Journal of Hunan City University: Natural Science, 2024, 33(5): 44 – 50.

[17] WANG YL, WANG TP. Research on the optimal configuration of urban sports facilities based on graded accessibility: A case study of Anning in Lanzhou[J]. Geomatics & Spatial Information Technology, 2024, 47(4): 26 – 29.

[18] NING L, DENG ZX, ZOU Y. Supply and demand evaluation of urban park green space from the perspective of aging population: A case study of Jianghan District in Wuhan City[J]. Forest Inventory and Planning, 2024, 49(5): 221 – 230.

[19] CHANG WX, ZHANG YQ, FU X. Assessment of green space accessibility incorporating sentiment analysis: An improved 2SFCA method [J]. Journal of Geo-information Science, 2024, 26(10): 2243 – 2253.

[20] ZHENG DY, ZHOU XY, JI DL, *et al.* Research on the influencing factors and spatial evaluation of travel distance for elderly people visiting parks: Taking 80 parks of Wuhan central urban area as an example[J]. Chinese Landscape Architecture, 2024, 40(6): 77 – 83.

[21] WANG YW, ZHANG W, MA XY, *et al.* A study on the accessibility of outdoor sports space for urban school-age children: A case study of the Huilongguan area of Beijing[J/OL]. Chinese & Overseas Architecture, 2024(11): 72 – 77.

[22] Wuhan Urban Planning and Design Institute. Wuhan street full-element design guidelines[S]. 2020.

[23] XU T. Design of humanistic greenways based on the geographical characteristics of Wuhan City[D]. Wuhan: Wuhan University of Technology, 2020.