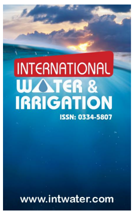


International Water and Irrigation
Volume 44 Issue 1 (2025)
ISSN: 0334-5807
Pages 442 - 453

Evaluation and application of low carbon neighborhoods based on large language model

Peng He, Zhihui Chen*, Zhaoxian Deng, Chen Luo

Changsha University of Science & Technology, Changsha 410075, China

*Corresponding Author.

Abstract: Against the backdrop of global warming, urbanization is accelerating and the number of urban residents is increasing day by day. As the main body of energy consumption and carbon emissions, the low-carbon transformation of cities has become an urgent issue that needs to be addressed. The planning, construction, and renewal of low-carbon neighborhoods, as the fundamental units of urban low-carbon development, are crucial for achieving the overall carbon neutrality goal. However, the current evaluation of low-carbon neighborhoods mainly relies on the subjective judgment of experts, lacking unified scientific quantitative standards and effective evaluation methods. The aim of this study is to introduce big data modeling methods into the evaluation research of urban low-carbon blocks, and construct a low-carbon block evaluation index system based on big language models. This system identifies five main evaluation dimensions, including spatial form, travel mode, efficiency, complete facilities, and green ecological environment, extracts specific evaluation content and standards for each dimension, and selects representative indicators for quantitative evaluation. The research methods include literature review, expert consultation, field investigation, Delphi method, analytic hierarchy process, etc., to ensure the scientific and accurate evaluation. The research results show that the constructed low-carbon block evaluation index system can effectively reflect the low-carbon construction level of the block. Through empirical research on S district, it was found that the low-carbon construction level in the area meets the standard, but there is still room for improvement. This study not only provides scientific basis for the evaluation of low-carbon neighborhoods, but also offers new ideas and methods for urban low-carbon development. Its importance and potential impact lie in promoting the low-carbon transformation of cities, facilitating the transformation and upgrading of the construction industry, improving the environmental quality of urban neighborhoods, and contributing to addressing global climate change.

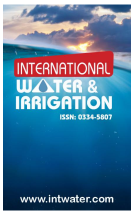
Keywords- large language model; Low carbon block; Carbon neutral; Evaluation index system; Computer technology.

1. Introduction

In the context of global warming and the drive toward carbon neutrality, cities—being the primary sources of energy consumption and carbon emissions—are confronted with an urgent need to transition to low-carbon models. The planning, construction, and renovation of low-carbon blocks, as foundational units of urban low-carbon development, are essential for achieving national carbon neutrality goals. However, current evaluations of low-carbon blocks predominantly rely on subjective assessments from experts, lacking standardized, scientifically grounded metrics and effective evaluation tools. Therefore, this thesis aims to introduce big data modeling techniques into the evaluation of urban low-carbon blocks, integrating them with urban spatial patterns and carbon neutrality objectives. This approach is intended to enhance the precision and intelligence of low-carbon block assessments.

2. Relevant Concepts

2.1 Urban Blocks



The term "urban block" originates from the English word "block," with the letters b, l, o, c, and k representing five key concepts: business, leisure, openness, community, and kindness.

Heath et al（1996）have defined urban blocks as areas composed of buildings of varying functions and scales, and as pedestrian-friendly environments with diverse ownership structures. These blocks are generally small in scale, multifunctional, capable of meeting various needs, and are designed to minimize the use of motor vehicles [1].

Xiao (2006) defines urban blocks as bounded urban areas, where the enclosure created by city roads forms a combination of interconnected elements within the block [2]. Liu (2007) further clarifies that blocks consist of land designated for construction, buildings, and surrounding environments within closed urban areas, encompassing both above-ground and underground spaces [3]. Xiao (2011) offers a broader definition, describing urban blocks as areas with clear physical boundaries, distinct identities, and characteristics linked to their functional and economic roles. These blocks form a system of interconnected blocks with specific spatial forms and social homogeneity, underscoring their functional importance [4]. Qiu (2015) emphasizes that urban blocks are areas primarily organized around streets, featuring well-developed living infrastructure and a variety of functions, including elements such as streets, buildings, and public squares [5].

In summary, this thesis defines an urban block as a smaller-scale, mixed-use area, delineated by boundary elements such as roads, and serves as a critical space for urban production and daily life. In urban planning, human subjective perception is shaped by three primary spatial scales: micro, meso, and macro. These correspond to the architectural scale, neighborhood scale, and urban scale, respectively [6-7]. The typical size of an urban block ranges from 200m × 200m to 400m × (400–600) m. This scale is considered ideal for fulfilling the diverse needs of urban life, including production, living, and other activities.

2.2 Low-Carbon Planning Technologies

(1) Low Carbon

The concept of "low carbon" was first introduced in 2003 in the UK report Our Energy Future: Creating a Low Carbon Economy. This document emphasized the importance of addressing not only the goals but also the processes and outcomes related to low-carbon initiatives [8-10]. The term "low carbon" refers to the use of indicators that are adaptable to the specific conditions of different regions, enabling more accurate measurement and comparison of the climate change effects induced by human activities [11]. Achieving low-carbon objectives requires the formulation of effective policies and the development of new technologies to reduce carbon emissions in urban residential areas. The ultimate aim of a "low-carbon" approach is to ensure sustainable economic growth while preserving an environmentally sound and livable urban ecosystem.

(2) Low-Carbon Urban Planning

Integrating low-carbon principles into urban planning gives rise to the concept of "low-carbon" urban planning. In contrast to traditional urban planning, low-carbon urban planning places greater emphasis on carbon reduction targets, positioning these objectives as the central aim of urban development [12-14]. This thesis proposes a novel low-carbon planning to address the "bottlenecks" encountered in conventional urban development. Based on this approach, it advocates for a reconfiguration of spatial structures and the coordinated management of carbon emissions across both temporal and spatial dimensions. The ultimate goal is to establish a positive feedback loop that advances low-carbon urban development in China.

It is apparent that low-carbon urban planning primarily focuses on promoting high-intensity economic growth, the organization of green transportation systems, and the adoption of sustainable living practices. The goal is to reduce carbon emissions from land use by assessing emissions, creating relevant indicator systems, and managing these emissions to ensure efficient implementation.

(3) Low-Carbon Planning Technologies

Low-carbon technologies are innovations designed to reduce greenhouse gas emissions. Low-carbon planning applies these technologies across various domains, including urban spatial design, low-carbon industries, transportation, municipal infrastructure, buildings, and ecological systems. The objective is to effectively control and reduce carbon emissions in urban areas [15-16].

2.3 Low-Carbon Concept

In the context of the dual carbon goals, the application of low-carbon concepts has been introduced. This approach aligns with the current requirements for energy conservation and emission reduction, while also meeting the growing energy demands of the population [17]. Based on the low-carbon concept, the fundamental aspects of building construction are as follows:

(1). Energy Conservation and Emission Reduction: The use of renewable resources should be maximized, while the use of non-renewable energy sources, such as geothermal energy, should be minimized to reduce energy consumption.

(2). Pollution Reduction: During the construction process, efforts should be made to minimize pollution. This includes selecting environmentally friendly building materials, using local materials to reduce transportation-related emissions, and protecting the ecological environment [18-19].

Applying the low-carbon concept to construction not only aligns with the broader dual-carbon goals but also helps protect the ecological environment, reduce the greenhouse effect, alleviate climate-related issues, and promote the sustainable development of the construction industry. It enhances the quality of urban block environments and facilitates the transformation and upgrading of the construction sector [20].

3. Development of a Low-Carbon Block Indicator Evaluation System Based on Large Language Models

3.1 Evaluation Dimensions and Content

This thesis aims to establish a low-carbon block evaluation indicator system, guided by carbon neutrality objectives, based on research on the sustainable development of low-carbon blocks both domestically and internationally. The selected evaluation dimensions must be theoretically sound and compatible with the specific characteristics of the area under study. The system identifies five main evaluation dimensions: spatial form, travel patterns, efficiency, infrastructure completeness, and green ecological environment. For each dimension, specific evaluation criteria and standards will be formulated, with representative indicators chosen.

3.2 Indicator Evaluation Methods

3.2.1 Indicator selection

When selecting indicators, principles such as scientific validity, representativeness, operability, and comparability must be followed. Methods like literature review, expert consultations, and field surveys will be employed to identify potential indicators. The Delphi and Analytic Hierarchy Process (AHP) will be used to prioritize and rank these candidate indicators. A comprehensive evaluation indicator system will then be established [21-22].

3.2.2 Weight calculation

In the process of constructing the evaluation system, determining the weight of each indicator is a critical step. Traditional methods for weight calculation include subjective weights (e.g., expert scoring, AHP) and objective weights (e.g., entropy method, PCA) [23]. This thesis applies the Analytic Hierarchy Process (AHP) to set the weights for each indicator. Eighteen experts were invited to score the indicators, using a 1-9 scale to assess their relative importance. A judgment matrix was constructed based on these evaluations, and analysis was performed accordingly. Based on this, the root method was used to calculate the weights. The product of the row elements was taken, followed by calculating the nth root $\overline{W_i}$, and then the weight W was calculated according to formula (1).

$$W_i = \frac{\overline{W_i}}{\sum_{j=1}^{m} \overline{W_j}} \tag{1}$$

To avoid logical errors, a consistency check was conducted. The maximum eigenvalue λ_{max} and the consistency index (CI) were calculated:

$$\lambda_{max} = \frac{1}{n} \sum_{i=1}^{n} \frac{(AW)_i}{W_i} \tag{2}$$

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{3}$$

When CR= CI/RI, the judgment matrix passes the consistency test. Based on this, the weights for each indicator can be determined. As an example, using a standard residential floor for the analysis, a judgment matrix was constructed with a maximum eigenvalue of 5.188, RI=1.11, and CR=0.0424, as shown in Table 1. In the consistency test, the weights for the standard floor were determined. The method for index hierarchy is the same as described above.

Table 1. Judgment Matrix and Consistency Test Results for Standard Residential Floor

Evaluation Dimensions	Space (S)	Facilities (F)	Transportation (T)	Greenery (G)	Efficiency (E)
Space (S)	1	0.2	0.33	3	5
Facilities (F)	5	1	3	7	9
Transportation (T)	3	0.33	1	5	7
Greenery (G)	0.33	0.14	0.2	1	1
Efficiency (E)	0.2	0.11	0.14	1	1

Table 2. Judgment Matrix Results for Residential Block Criterion Layer and Weights

Evaluation Dimensions	Space	Facilities	Transportation	Greenery	Efficiency	Eigenvector	Weight Value
Space	1	0.2	0.33	3	5	1	0.13
Facilities	5	1	3	7	9	3.94	0.51
Transportation	3	0.33	1	5	7	2.04	0.27
Greenery	0.33	0.14	0.2	1	1	0.39	0.05
Efficiency	0.2	0.11	0.14	1	1	0.32	0.04

Table 3. Consistency Test Results

Item	Value
Maximum Eigenvalue	5.188
Consistency Index (CI)	(5.188 - 5) / (5 - 1) = 0.047
Average Random Consistency Index (RI)	1.11

Consistency Ratio (CR)	0.047 / 1.11 = 0.0424 < 0.1

3.2.3 Evaluation model and calculation method

This thesis focuses on low-carbon blocks as the research subject and adopts a weighted sum multi-criteria integrated evaluation to more accurately reflect the degree of low-carbon development. Using a pre-established baseline value as a reference, the low-carbon construction of various communities is assessed. The evaluation criteria for low-carbon blocks, drawn from both domestic and international frameworks, are applied to assign scores. For indicators that meet the baseline value, a score of 1.0 is given, indicating that the indicator performs well in terms of low-carbon construction. For indicators that do not meet the baseline requirements, a score of 0 is assigned, signifying that improvements are needed. A comprehensive evaluation of low-carbon construction levels in urban areas of China is then conducted using the weighted sum multi-indicator method.

$$Y_i = \sum_{j=1}^{n_i} r_{ij} h_{ij} \tag{4}$$

Where:

Y_i represents the comprehensive evaluation value for the i-th evaluation dimension.

n_i refers to the number of indicators included in the i-th evaluation dimension.

r_{ij} is the weight of the j-th indicator under the i-th evaluation dimension. This weight is calculated using methods such as the Analytic Hierarchy Process (AHP), entropy method, or combined weighting method, as discussed earlier.

h_{ij} represents the score for the j-th indicator under the i-th evaluation dimension. Based on whether the indicator meets the reference value, a score of 1.0 or 0.0 is assigned.

i denotes the evaluation dimension number, such as spatial form, travel mode, etc.

j represents the number of different indicators within the same evaluation dimension.

By aggregating the scores of each evaluation dimension, the comprehensive evaluation values of all dimensions are weighted and averaged to determine the low-carbon construction level of the block. The following is the calculation formula:

$$Y_{\text{total}} = \frac{1}{m} \sum_{i=1}^{m} Y_i \tag{5}$$

Where

Y_{total} represents the low-carbon construction level of the evaluated block.

m denotes the total number of evaluation dimensions.

Y_i is the comprehensive evaluation value for the i-th evaluation dimension.

3.2.4 Method for Establishing Reference Values

This thesis employs a multidisciplinary approach, innovatively integrating the research content and methods of large language models to ensure the scientific validity, rationality, and forward-looking nature of the selected data. First, a comprehensive collection and analysis of relevant indicators from authoritative national and international standards, such as the “National Ecological Civilization Construction Demonstration Villages and Towns Indicators” and the “Green Low-Carbon Key Small Town Construction Evaluation Indicators,” was conducted. Next, a comparison was made between the common requirements and differences in various standards, and, based on the development trends in low-carbon construction in China, the evaluation indicators were extrapolated to establish initial reference value ranges. Subsequently, the results from authoritative research reports, such as the “2016 China Sustainable Development Strategy Report” and the “2018 China Urban Transportation Report,” were systematically used. Based on a large volume of data and empirical analysis, the theoretical and practical issues of urban low-carbon development in China were explored. Using the “Large Language Model” as a foundation, a new research framework was constructed. Methods such as simulation calculations and case comparisons were employed to conduct in-depth empirical analysis of the new indicators. The rationality and feasibility of the model were verified through simulations and case comparisons, and appropriate reference values were determined based on these results. Finally, building on the findings from the previous three stages of research, the mutual influence and interdependencies between the indicators were carefully considered. Model parameters were adjusted and optimized accordingly. To ensure the scientific integrity and authority of the research, industry experts were enlisted for evaluation and validation.

4. Low-Carbon Block Planning Application and Evaluation Practice

4.1 Evaluation Results and Analysis

The Block S was selected as a case study area for this empirical research on land use patterns (Figure 1). The research project is located in the city center, on the southern bank of the Yangtze River. The area is primarily residential, with commercial and service facilities concentrated along both sides of the roads. Parks and plazas are mainly arranged around rivers and highways. The total planned area is 551.43 hectares, with over 93% of the projects under construction. Based on relevant statistical data from the Block S, weighted calculations were performed for the indicators listed in Table 2, yielding the evaluation results for the block's low-carbon development level. The low-carbon construction level of the block was then assessed, revealing a score of 0.6. This indicates that the low-carbon construction in the area meets the required standards, fulfilling the demands of low-carbon development, and the development trend is favorable (Table 3). For blocks with a score below 0.6, low-carbon construction is deemed not up to standard and requires improvements to achieve full low-carbon transformation. From the evaluation of the low-carbon degree, the two selected residential buildings in the Block S meet low-carbon building requirements. However, there is still significant room for improvement overall (Table 4).

4.1.1 Residential block analysis

From a spatial perspective, the overall scale of the residential area is large, which hinders residents' mobility and leads to high emissions from long-distance commuting. From a transportation standpoint, the bus stations around the community generally meet the needs of residents, and the traffic organization is relatively reasonable. In terms of efficiency, the residential occupancy rate is relatively high, but improvements are still needed in waste sorting and the utilization of new energy sources. Regarding facilities, the selected community's educational infrastructure is mostly adequate, though provisions for elderly transportation and convenient facilities like supermarkets need further enhancement. Due to its proximity to the Bihe River, the green space along the waterfront and open areas are relatively well-developed. However, the existing green spaces within the residential block still do not meet the carbon-reduction demands.

4.1.2 Commercial service block analysis

From a spatial perspective, the efficiency of land use for commercial purposes in this area is high, but the operational energy consumption of the buildings is significant, necessitating an urgent transition to low-carbon practices. In terms of transportation, there is a need to promote public transportation, with a focus on electric buses, and to improve the commercial pedestrian network and surrounding environment. In terms of efficiency, over 95% of the waste in the area is treated harmlessly, while the city's overall waste treatment rate remains low. From a green space perspective, commercial blocks generally rely on hard paving, with the green areas along the streets serving as the primary method to reduce carbon emissions during construction.

4.1.3 Industrial block analysis

From a spatial perspective, the industrial distribution in this area is somewhat dispersed, leading to higher carbon emissions from the industries. In terms of transportation, the road network density in this area is relatively low, which limits the efficiency of industrial transport. The urban sewage treatment rate reaches 88% (Table 5), and clean energy and related infrastructure are in place. The region's gentle hilltop terrain and extensive green space help mitigate environmental pollution caused by industrial production, reducing carbon emissions from production spaces within the area.

4.1.4 Mixed-use block analysis

From a spatial perspective, this area is highly mixed, forming a highly efficient and complex space. In terms of efficiency and facilities, the level of green renovation in the utility networks and infrastructure of older residential areas is low. The greening of drainage systems and residential facilities still requires further enhancement. Regarding green space, the parks and green areas surrounding the block provide valuable services to residents, helping to reduce carbon emissions from residential spaces.

Table 4. Evaluation Indicator System for Four Types of Blocks

Block Type	Weight	Evaluation Dimensions	Weight	Indicator
Residential Block	0.13	Space	0.46	Block scale (ha)
			0.35	Percentage of street-level commercial space (%)
			0.19	Percentage of energy-efficient buildings (Grade A and above) (%)
	0.27	Transportation	0.48	Number of bus stops within 5 minutes' reach of the block (%)
			0.52	Percentage of green transportation in the block (%)
			0.45	Residential building occupancy rate (%)
	0.04	Efficiency	0.18	Waste sorting collection rate in the block (%)
			0.37	Renewable energy utilization rate in the block (%)
			0.24	Kindergarten and elementary school accessibility within 5 minutes
	0.51	Facilities	0.32	Elderly day-care center accessibility within 5 minutes
			0.27	Accessible fresh market or marketplace within 5 minutes
			0.17	Physical fitness facilities accessibility within 5 minutes
	0.05	Greenery	0.53	Accessibility to nearby park and green space within 5 minutes
			0.47	Public green space ratio in the block (%)
Commercial Service Block	0.23	Space	0.37	Underground space utilization rate (%)
			0.63	Percentage of energy-efficient buildings (Grade A and above) (%)
	0.33	Transportation	0.42	Accessibility to bus stops within 5 minutes in commercial blocks

			0.28	Pedestrian network density in commercial blocks (km/km²)
			0.30	Pedestrian spatial connectivity in commercial blocks
	0.19	Efficiency	0.48	Space utilization rate in commercial blocks (%)
			0.52	Building energy consumption per unit space in commercial blocks (10,000 m²)
	0.13	Facilities	0.57	Proportion of renewable energy use in commercial blocks (%)
			0.43	Coverage rate of waste sorting collection points in commercial blocks (%)
	0.12	Greenery	0.50	Proportion of public green space (%)
			0.50	Percentage of tree-lined streets along commercial areas (%)
	0.24	Space	1.00	Green factory rating
	11	Transportation	1.00	Proportion of clean energy vehicles in industrial blocks (%)
Industrial Block	0.25	Efficiency	0.21	Building coefficient in industrial blocks (%)
			0.18	Building occupancy rate in industrial block factories (%)
			0.07	Land productivity in industrial blocks (10,000 yuan/acre)
			0.33	Energy consumption per unit GDP (tons of standard coal/10,000 yuan)
			0.21	Industry-specific carbon emission index
	0.23	Facilities	0.38	Recycling level of energy facilities (%)
			0.34	Comprehensive utilization rate of industrial solid waste (%)
			0.28	Water reuse rate in industrial block factories (%)
	0.17	Greenery	1.00	Percentage of tree-lined streets along commercial areas (%)
Mixed-Use Block	0.19	Space	1.00	Functional compatibility of block (%)
	0.29	Transportation	0.31	Number of bus stops within 5 minutes' walking distance in mixed-use blocks (count)
			0.22	Pedestrian sidewalk proportion in mixed-use blocks (%)
			0.17	Green travel proportion in mixed-use blocks (%)
			0.30	Proportion of on-street parking in mixed-use blocks (%)
	0.11	Efficiency	0.41	Building space utilization rate in mixed-use blocks (%)
			0.29	Waste sorting collection rate in mixed-use blocks (%)
			0.30	Sewage treatment rate in mixed-use blocks (%)
	0.32	Facilities	0.24 0.32 0.27 0.17	Kindergarten and elementary school accessibility within 5 minutes
				Elderly day-care center accessibility within 5 minutes
				Accessible fresh market or marketplace within 5 minutes
				Physical fitness facilities accessibility within 5 minutes
	0.09	Greenery	0.53	Proportion of parks and green spaces covered within 5 minutes in the community (%)
			0.47	Percentage of tree-lined streets along commercial areas (%)

Table 5. Proportion of tree-lined streets along mixed-use blocks (%)

Block	Block Type	Space	Transportation	Efficiency	Facilities	Greenery	Total Score
Block 1	Residential Block	0.52	0.51	0.53	0.53	0.51	0.52
Block 2	Residential Block	0.68	0.53	0.52	0.51	0.49	0.60
Block 3	Commercial Service Block	0.62	0.58	0.49	0.46	0.55	0.55
Block 4	Commercial Service Block	0.68	0.42	0.57	0.43	0.51	0.52
Block 5	Industrial Block	0.23	0.32	0.36	0.58	0.73	0.46
Block 6	Industrial Block	0.27	0.44	0.45	0.54	0.75	0.49
Block 7	Mixed-Use Block	0.71	0.58	0.49	0.66	0.61	0.64
Block 8	Mixed-Use Block	0.63	0.53	0.41	0.42	0.58	0.57

Figure 1. Selection of Block S

4.2 Guidelines for Low-Carbon Development

4.2.1 Residential blocks — strict control of scale to promote green travel

In the long term, Block S should consider both "low-carbon space" and "low-carbon efficiency." This includes controlling the block's scale and emphasizing compact, efficient land use. In residential construction, the promotion of "green buildings" should be prioritized, with the adoption of energy-saving products to reduce water and electricity consumption. Given that Block S is located in a mountainous area, mostly consisting of low hills, it is essential to enhance the guidance for residents on green travel. Improving accessibility to public transportation facilities, such as bus stops, will reduce carbon emissions.

4.2.2 Commercial-services blocks — promote energy-efficient buildings to improve efficiency

For the commercial-services blocks in Block S, the focus should be on green building practices, low carbon emissions, and high efficiency. These buildings should be well-insulated and make full use of natural light to reduce energy consumption. It is crucial to integrate the area's cultural and regional characteristics, combining low-carbon energy with natural resources. The design of green buildings should be supported by comprehensive, multi-level ecological systems that contribute to improving the local microclimate.

4.2.3 Industrial blocks — guide industrial transformation toward green development

Block S is primarily focused on energy-saving and environmental protection industries, with a growing number of large-scale energy-saving and environmental protection enterprises. In the future, the development of renewable energy should be promoted, along with the scaling up of clean energy companies. The focus should be on guiding the clustering of enterprises and avoiding the extensive development of land for scattered businesses. Based on this, a positive approach to guiding the development of the tertiary industry in Block S is proposed, leveraging the block's natural beauty and cultural resources to build a new type of green industrial system. For Block S, appropriate resources, such as wind, natural gas, and geothermal energy, should be selected based on the specific conditions to develop new energy industries and promote the circular economy. At the same time, considering the block's unique geographic environment, optimizing the road network and increasing its density will alleviate the isolation between remote settlements and reduce long-distance transportation carbon emissions.

4.2.4 Mixed-use blocks — enhance public service facility coverage

Mixed-use blocks should focus on low-carbon efficiency and low-carbon facilities. For mixed-use communities in Block S, dominated by low-quality old residential areas, there has been insufficient consideration of the needs of vulnerable groups such as the elderly and children. These groups should be treated as key factors in "carbon reduction" efforts. The urban planning should aim to meet the daily needs of residents within a 5-minute living radius, improving the service level of facilities. The scale of these facilities should be reasonably planned to reduce carbon emissions during operation and maintenance.

5. Conclusion

Evaluating the degree of low-carbon development is not only the premise and foundation for scientifically formulating low-carbon development plans but also a crucial basis for guiding low-carbon planning, construction, and management. This thesis, using a typical urban block in China as a case study, constructs a "comprehensive" evaluation framework based on five dimensions: "spatial layout," "transportation and mobility," "energy efficiency," "infrastructure," and "greening and ecology." By considering the specific national context, the evaluation system was meticulously designed and adjusted to ensure its scientific validity and practical applicability.

Throughout the research process, this thesis generated a series of valuable conclusions that not only provide a theoretical basis for low-carbon development but also offer feasible guidance for practical implementation. However, there are still some limitations in this study. First, due to challenges in data availability and completeness, the quantitative analysis of some evaluation indicators may not be sufficiently in-depth. Second, given the complex factors involved in low-carbon development, the proposed indicator system, though as comprehensive as possible, may still overlook some critical elements. Finally, due to the regional specificity of different areas, the low-carbon construction guidelines and emission reduction measures suggested in this thesis may require further refinement and optimization.

With the continuous advancement of data collection and processing technologies, there is potential to further improve the evaluation indicator system, enhancing its accuracy and specificity. Additionally, through ongoing field research and case analysis, a deeper understanding of the internal mechanisms and key elements of low-carbon development can be achieved. This will provide robust support for the formulation of more scientifically sound and reasonable low-carbon development plans. Moreover, strengthening interdisciplinary collaboration and introducing expertise and methodologies from various fields could collectively advance the practical implementation of urban green and low-carbon development.

Acknowledgements

This work is supported by Natural Science Foundation of Hunan Province(2024JJ8332), Foundation of Hu'nan Educational Committee (21B0290) and Foundation of Ministry of Education of China (HZKY20220364).

References

[1] Heath, T., Oc, T., & Tiesdell, S. (1996). Revitalising Historic Urban Quarters. Routledge. https://doi.org/10.4324/9780080516271
[2] Xiao Liang. Study on the Scale of Urban Blocks. Tongji University, 2006.
[3] Liu Daiyun. Shaping up the Block Scale in Creation of Urban Design. Architectural Journal, 2007(6).
[4] Xiao Yan. Preliminary Exploration of Urban Block Planning under the Green Scale. Huazhong University of Science and Technology, 2011.
[5] Qiu Jin. A Brief Discussion on Urban Blocks. Jiangxi Building Materials, 2015(18): 2. DOI: CNKI: SUN: JXJC.0.2015-18-016.
[6] Wang Renhe. Research on the Plant Landscape Planning and Design of Green Business Blocks—A Case Study of Hongqiao Green Valley in Shanghai. Henan Agricultural Journal, 2018, 481(29): 35-36.
[7] Long Haihui. Research on the Development and Construction of Urban Financial Central Business Blocks. South China University of Technology, 2015.
[8] Sun Chengguang. Analysis of the Status and Influencing Factors of Community Resident Participation in Low-Carbon City Construction—An Empirical Survey in Chengyang District, Qingdao. Huazhong University of Science and Technology, 2013.
[9] Cao Yi, Zhang Li, Guo Jing, et al. Application Prospects of Low-Carbon Power Market Development Based on Large Language Models. Smart Power, 2024, 52(2): 8-16.
[10] Chen Jinfu, Zhu Xiaoyu, Ren Lijuan. From Low-carbon Campus to Low-carbon Block——With the Example of Campus Change of Huazhong University of Science and Technology. Chinese Landscape Architecture, 2011, 27(4): 4. DOI: 10.3969/j.issn.1000-6664.2011.04.017.
[11] Lin Chenhui, Wu Hao. International Practices And Exploration in Carbon Reduction Planning for Low-Carbon Neighborhoods. Human Settlements, 2022(1): 28-31.
[12] Song Ke. Research on the Indicator System and Policy for Green, Low-Carbon, Livable Blocks from a Detailed Planning Perspective: A Case Study of a Demonstration Block in an Urban Renewal Area of Shijiazhuang City. Wen Yuan (Middle School Edition), 2022(5): 676-678.
[13] Chen Meiyi, Hu Hong. Carbon Metabolism Mode Identification and Adaptive Renewal Strategies for Urban Blocks: A Case Study of the Historical and Cultural Block in Changting County, Fujian Province. Urban Planning, 2024(5).
[14] Xue Xiaoning, Yin Wenchao, Huang Fei, et al. Micro-Innovation of Green Technologies in Beijing's Blocks and Research on Implementation Paths. China Science and Technology Achievements, 2023, 24(20): F0002-F0002.
[15] Singleton A D, Spielman S. Segmentation using large language models: A new typology of American neighborhoods.EPJ Data Science, 2024, 13(1). DOI:10.1140/epjds/s13688-024-00466-1.
[16] Schiffers R, Kern D, Hienert D. Evaluation of Word Embeddings for the Social Sciences.ArXiv, 2023, abs/2302.06174.DOI:10.48550/arXiv.2302.06174.

[17] Chepurova A, Bulatov A, Kuratov Y, et al. Better Together: Enhancing Generative Knowledge Graph Completion with Language Models and Neighborhood Information. 2023.

[18] Liang R N, Anacleto E A J, Meneses C N. Fast 1-flip neighborhood evaluations for large-scale pseudo-Boolean optimization using posiform representation. Computers & operations research, 2023, 159(Nov.):1.1-1.16.DOI:10.1016/j.cor.2023.106324.

[19] Zheng X. Robot Translation Based on Computer Vision for Cultural Psychology of English Culture Education.International Journal of Humanoid Robotics, 2023, 20(2/3). DOI:10.1142/S0219843622500062.

[20] Tulkens S, Sandra D, Daelemans W. Orthographic Codes and the Neighborhood Effect: Lessons from Information Theory.European Language Resources Association, 2020.

[21] Ejiogu K U. Risk Terrain and Multilevel Modeling of Street Robbery Distribution in Baltimore City.SAGE Open, 2023, 13(4). DOI:10.1177/21582440231216195.

[22] Lu J, Nazarian N, Hart M A, et al. Novel Geometric Parameters for Assessing Flow Over Realistic Versus Idealized Urban Arrays.Journal of Advances in Modeling Earth Systems, 2023, 15(7). DOI:10.1029/2022MS003287.

[23] Leng Hong, Zhao Yan, Yuan Qing. The Path toward Carbon Reduction through Urban Form Control. Urban Planning Journal, 2023(1): 54-61. DOI: 10.16361/j.upf.202301008.