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Evaluation of Living Environment Quality in Urban Residential Areas under the Concept of Urban Renewal—A Case Study of Binjiang District, Hangzhou, China

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Abstract: As urbanization continues to advance globally, the issue of "urban ailments" has become increasingly prominent. To promptly identify problems arising from urban development, it is crucial to investigate not only the quality of human habitats at the city and regional scales but also the micro-level living environments. Indeed, studying residential living conditions enables the specific problems within urban planning to be unearthed, facilitating timely adjustments for the improvement of urban habitation. However, a precise and objective methodology for accurately measuring the quality of residential living environments is still lacking. In recent years, the urban renewal concept has proven to be proactive in enhancing the living environment quality of residential areas. In this study, we focus on residential areas within Hangzhou's Binjiang District, China, and integrate diverse datasets including real estate websites, digital mapping platforms, remote sensing imagery, points of interest (POIs), and land-use planning data. By examining and analyzing the urban renewal concept, we establish a comprehensive set of evaluation indicators for the living environment quality in residential areas, including five aspects: residential and environmental factors; transportation and communication; education and culture; lifestyle and leisure; and healthcare and well-being. Subsequently, a holistic assessment of the Binjiang District is conducted. Our research findings demonstrate that in the context of urban renewal, the proposed living environment quality evaluation method, based on multi-source data, exhibits significantly higher practicality and effectiveness. The residential environment in Binjiang District exhibits a spatial pattern with higher quality in the northern regions and lower quality in the southern regions. Across different dimensional layers, the residential and environmental quality shows a higher trend along the river areas and a lower trend in the internal areas, as well as higher quality in newly developed sections compared to older ones. The transportation and communication quality exhibits a decreasing trend radiating from multiple core areas. In other dimensions, there is a concentration of high-quality residential areas in the administrative vicinity and surrounding Binjiang University Town. Hotspot analysis further substantiates a significant spatial correlation between the quality of the living environment and the degree of agglomeration, highlighting a positive relationship between the two factors. This study provides a solid basis for the spatial planning of urban public service facilities and holds significant research and practical value.

Keywords: urban renewal; urban living environment; urban resilience and spatial planning; evaluation framework; spatial planning

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1. Introduction

Urban renewal, as an active urban development strategy, aims to reshape the cityscape and optimize urban spatial arrangements to meet the surging demands of a growing population, which further enhances the quality of living environments. By refurbishing old districts, repurposing land, and establishing essential public service facilities, urban renewal endeavors to create a more habitable and delightful residential experience for inhabitants, ultimately elevating the overall quality of urban residential areas. In the contemporary era of rapid urbanization, the living environment quality in numerous urban residential areas remains in dire need of regeneration. On the one hand, urbanization fosters population concentration, resulting in land scarcity, traffic congestion, rising living costs, and severe environmental pollution. Consequently, it would increase the strain on the capacity of urban living environments. On the other hand, rising expectations for urban living standards have driven the aspiration to reside in cities with excellent ecological environments, efficient transportation, superior public services, and healthy communities. These factors impose heightened demands for constructing sustainable and harmonious urban living environments. Thus, it is of vital significance to evaluate the living environment quality of urban residential areas through the assessment method, which is based on the urban renewal paradigm for realizing sustainable urban development and improving residents' well-being.

Research on the evaluation of the quality of urban living environment quality can be traced back to the environmental protection movement of the 1970s when people focused on the environmental pollution caused by industrialization and urbanization. Problems such as air pollution, deteriorating water quality, and noise disturbances were particularly prominent during this period. The Vancouver Declaration, issued during the inaugural United Nations Conference on Human Settlements in 1976, identified that human habitat is a scientific issue of global significance that requires urgent attention. Subsequently, scholars began to assess and improve the quality of urban living environments, aiming to address the health, safety, and comfort needs of residents. As an urban revitalization strategy, the attention to urban renewal concepts has evolved in recent years, transitioning from a sole emphasis on improving the physical environment to comprehensive renewal, encompassing social, economic, and material dimensions. Therefore, the evaluation of urban human habitation environments based on the principles of urban renewal has garnered growing interest among scholars.

Considering the complex and diverse nature of cities, which encompass myriad material, social, and cultural factors, the living experiences of urban residents are shaped by multifaceted interactions. Consequently, effective evaluation of urban living environments mandates a comprehensive consideration of multiple factors, including but not limited to natural environmental quality, built infrastructure, social service facilities, resident satisfaction, and sustainable development [1]. Moreover, scholars emphasize expanding the scope of evaluation and conducting in-depth explorations. For instance, Reeves [2] argued for the full consideration of gender equality and empowerment in the evaluation of living environment quality. Charoenkit and Kumar [3] explored strategies for evaluating living environment quality among low-income groups. Adewunmi et al. [4] advocated for the inclusion of sanitation facilities in comprehensive assessments of living environment quality. McNeill et al. [5] examined the dimensions of living environments and the diverse mechanisms through health-related behaviors. Schetke et al. [6] assessed the sustainability and resource efficiency of potential residential areas. Sebti et al. [7] stated the concept of bioclimatic adaptation in desert architecture and evaluated its impact on microclimate conditions. In fact, research on the evaluation of living environment quality in urban residential areas based on the concept of urban renewal mainly centers on three critical aspects: urban renewal strategies, the involvement of stakeholders in urban renewal, and the outcomes of urban renewal initiatives. It is worth noting that research on the outcomes of urban renewal primarily focuses on three aspects. Firstly, from an economic perspective, it is crucial to assess the impact of urban renewal on the local economy [8]. Most scholars employ interview-based investigations to explore the effects of urban renewal on local development [9,10]. This kind of research concentrates on specific case areas, conducting point-based studies on material renewal. These studies indicate that flagship renewal projects, such as the construction of large shopping centers, play a significant role in reshaping the city's image, strengthen local identity, generate employment opportunities, and provide essential goods to the low-income population in downtown areas [11]. Secondly, from the standpoint of public policy, it examines the degree of privatization of public functions in urban renewal projects involving public–private cooperation. For example, assessments of the social effects of culture-led urban renewal are often coupled with research on creative cities and the creative class [12]. Such research mainly encompasses the adoption of cultural strategies to propel urban renewal, attracting new residents and the creative class, as well as analyzing their social structural characteristics and evaluating the impact of public art on achieving social integration. Thirdly, from a sociological perspective, it conducts investigations into the social equity implications and other related forms of deprivation triggered by urban renewal. Most scholars have critically studied the changes in local social structures caused by urban renewal projects, along with negative effects such as displacement, gentrification, and social segregation [13]. Additionally, some other scholars have specifically examined the impact of urban renewal from the perspective of marginalized groups, e.g., women [14].

Scholars have employed diverse analytical data and research methods to investigate living environments. Among the prevalent approaches, indicator systems as mediators for evaluating living environment quality, with composite index analysis and spatial analysis serving as primary methods, are frequently used [15]. Previously, Cui et al. [16] evaluated living environment quality in the Beijing–Tianjin–Hebei region between 2010 and 2016 by employing government statistical data and employing the analytic hierarchy process (AHP) and entropy weighting methods to select indicators and determine their respective weights at the urban scale. Gawai et al. [17] analyzed the regional livability index of the Mumbai metropolitan area by utilizing remote sensing data and questionnaire survey data and leveraging geographic information systems (GISs) to analyze urban green space distribution. Liu [18] presented the Sustainable Human Settlement Development Index (HSSDI) model to evaluate the sustainability of urban living environments. Bao et al. [19] assessed urban living environment quality across four dimensions using mathematical statistics and geographical information methods based on Maslow's hierarchy of needs. At the regional scale, Zhang and colleagues [20] rigorously examined the concept of livability in Lanzhou, China, employing a systematic approach that encompasses spatial analysis and cluster analysis methodologies. Fu et al. [21] evaluated urban livability in Changchun, China, by extracting land-use classification information using GIS and remote sensing technology and applying principal component analysis to assess livability. In recent years, the maturation of information technology has ushered in a new trend of using big data and related techniques to explore living environments. Thus, research in this field has transitioned from primarily relying on statistical surveys to the comprehensive utilization of multi-source spatio-temporal data. Long et al. [22] established a monitoring index system for living environment quality based on multi-source data, paving the way for new directions in living environment research. Ta et al. [23] investigated the efficiency of residents' commuting and its relationship with living environments based on GPS location information. Xiong et al. [24] scrutinized the relationship between urban public facilities and living environments by leveraging point of interest (POI) data. Shen et al. [25] conducted a study of residents' daily activity space based on their GPS trajectories.

Unfortunately, the current literature indicates a current dearth of comprehensive assessments of urban residential living environment quality based on the principles of urban renewal. Present research predominantly concentrates on singular effect evaluations, such as the degree of privatization of public functions, the economic revitalization impact, and the societal outcomes of urban displacement. Furthermore, assessments predominantly focus on larger scales, such as cities or regions, with comparatively limited attention given to evaluating the living environment within specific urban spaces. However, since the development status can vary within the same region, resulting in differences in the quality of living environments, conducting analyses based on residential plots can offer valuable micro-level insights into existing challenges within urban planning and development. Moreover, existing research tends to lean toward theoretical and conceptual exploration, with evaluations relying heavily on survey questionnaires and expert judgments, leading to substantial workloads and subjectivity. Additionally, real-time applicability and practicality need to be further improved. Finally, when compared with traditional data, big-data-driven evaluations of human habitation environment quality demonstrate notable advantages, including high sampling rates, extensive data volumes, strong continuity, high real-time capabilities, and relatively low costs. However, some limitations are obvious, such as the predominance of single big data applications and less focus on research combining multiple data sources, which may sometimes not be exactly as expected.

To address these problems, this study adopts the perspective of achieving urban renewal and enhancing urban resilience. We comprehensively integrate diverse data sources, including real estate websites, digital map platforms, remote sensing imagery, POI data, and land-use planning data, to develop an evaluation indicator system for residential living environment quality across five dimensions: residence and environment, transportation and communication, education and culture, lifestyle and leisure, and healthcare and well-being. This study takes Binjiang District of Hangzhou (Figure 1) as the research object and discusses the feasibility of using multiple data sources to evaluate the residential environment quality. The proposed research methodology holds substantial implications for analyzing the spatial distribution of living environment quality within cities and optimizing urban planning and development.

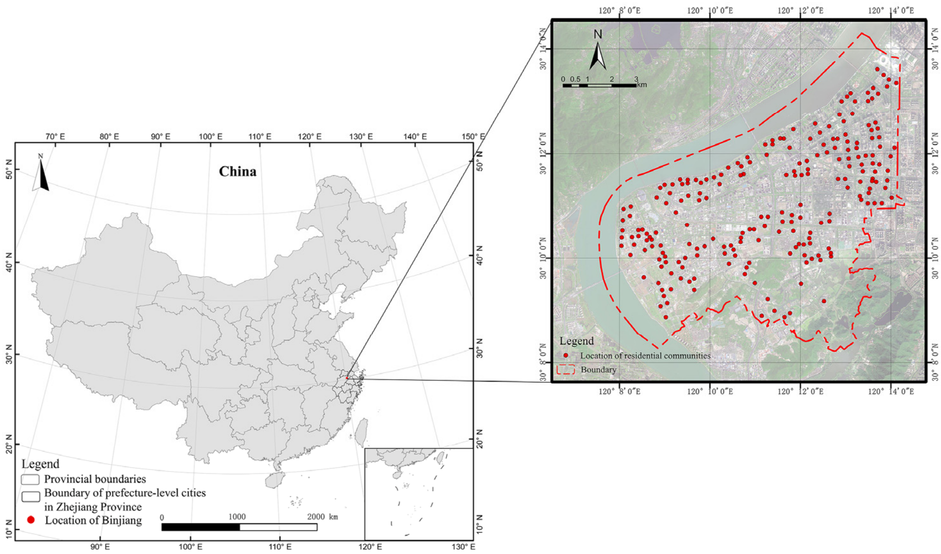

Figure 1. The study area (Binjiang District, Hangzhou, China).

2. Materials and Methods

2.1. Indicator Selection

In the context of urban renewal, the establishment of an evaluation indicator system for urban human habitation environment quality should comprehensively capture the distinctive features of the living environment. It is imperative to adhere to the principles of scientific, hierarchical, quantifiable, and comparable indicator selection. Furthermore, it is essential to emphasize the regional attributes of the indicators and take the unique developmental characteristics of the study area into consideration. In practical application, China's assessment system for residential environment quality typically integrates national and local development policies to meet the socio-economic demands of a specific period and is closely integrated with local governance and institutional development. In addition to assessing the living conditions within urban areas, the performance of municipal governments and their subsidiary departments is often incorporated within the evaluation scope. Consequently, the design of China's residential environment indicators emphasizes operational feasibility, measurability, and authoritative standards to enable potential cross-sectional comparative analyses. In assessing residential environment quality outside China, international organizations have accumulated extensive experience, leading to the establishment of more mature indicator systems and evaluation frameworks. In recent years, more attention has been paid to the "green ecology" aspect. It is worth noting that countries such as the United Kingdom have developed relatively independent annual monitoring systems to implement residential planning [15]. Table 1 provides an overview of practical case studies related to the evaluation of residential environment quality.

The academic community has conducted extensive and in-depth research on the evaluation index system for assessing the quality of human settlements, yielding rich research outcomes. Long Ying et al. [22], guided by the principles of "completeness, quantifiability, people-oriented approach, and data compatibility", developed a comprehensive framework centered around six major objectives, including urban functionality, population and development, resources and environment, community vitality and urban characteristics, and urban safety and emergency response. They constructed a comprehensive set of indicators to monitor the urban human settlement environment, providing detailed information on data sources and algorithms for each indicator. Liu Song and Liu Binyi [18] emphasized settlement conditions, settlement construction, and sustainability. They derived human settlement evaluation indicators from various aspects, including residential conditions, resource allocation, urban ecological environment, public service infrastructure, social stability, intellectual capacity, and economic capacity. Zhang [26], who employed both objective and subjective perspectives, categorized the indicator system into five main aspects: urban safety, environmental health, convenience of life, ease of transportation, and residential comfort. Zhang and Wei [27] focused on the impact of human activities on the environment and conducted quality assessments across five dimensions: socioeconomic environment, natural ecological environment, public facility construction, environmental resource protection, and environmental management capability. Xiao [28], starting from the perspective of urban livability, identified five evaluation aspects including excellent ecological environment, social safety and harmony, comprehensive public services, efficient and convenient transportation, and a comfortable and relaxed lifestyle. Although scholars differ in the way they classify target levels, there is a general convergence at the specific indicator level. Zhang [26] contends that a livable city should exhibit characteristics such as environmental health, natural beauty, convenient transportation, safety, social harmony, and favorable living conditions.

Based on existing research, the refinement of human settlement planning, and urban development characteristics, we formulated an evaluation indicator system for residential living environment quality based on the principles of urban renewal. The system primarily consists of five dimensional layers: residential and environment, transportation and communication, education and culture, lifestyle and recreation, and healthcare and well-being. Each dimensional layer comprises four indicators (as shown in Table 2). In the education and culture dimensional layer, we selected four indicators: proximity to kindergartens, primary schools, middle schools, and cultural venues. The distance to public primary and secondary schools reflects the scientific and rational distribution of compulsory education resources, while cultural venues cater to the cultural needs of different age groups, including museums, cultural centers, libraries, exhibition centers, and youth centers. The healthcare and well-being dimensional layer contains indicators such as proximity to elderly care institutions, comprehensive hospitals, density of basic medical services, and density of sports facilities. Comprehensive hospitals are the most important facilities for health services, and basic medical services meet residents' daily healthcare needs. This becomes especially significant during the COVID-19 pandemic in 2020, as people pay more attention to the fairness and comprehensiveness of medical resource allocation. The residential and environment dimensional layer encompasses basic physiological needs. Indicators such as housing prices, building age, and greenery coverage provide intuitive reflections of housing conditions and quality, while the distance to parks and green spaces reflects the external residential environment and meets residents' daily needs for leisure and recreation. The transportation and communication dimensional layer addresses the connectivity needs of residents. Indicators such as bus stop density and distance to public parking lots reflect the convenience of internal transportation within the city, while communication and logistics points reflect external connectivity. The lifestyle and recreation dimensional layer includes indicators such as proximity to commercial centers, density of convenience stores and supermarkets, density of dining establishments, and density of entertainment venues. Large supermarkets are the main form of urban commercial facilities and, together with other elements, meet the daily life and leisure needs of residents.

2.2. Measurement of Indicators

The data for indicators such as housing prices, building age, and green coverage can be directly obtained from real estate websites. In the case of density-based indicators, we referred to the concept of a 15 min living circle defined in China's "Urban Residential Area Planning and Design Standards" to delineate the spatial extent of each residential community. Specifically, we leveraged the city's road network to calculate the walkable distance within a 15 min radius and subsequently utilized the overlay analysis tools in ArcGIS to compute the density of points of interest. As for distance-based indicators, we employed ArcGIS's nearest facility point analysis functionality to determine the distance between each residential community and its nearest points of interest. During the process of indicator computation, it becomes imperative to standardize the data due to the distinct measurement scales and orientations (positive or negative) associated with each indicator. To address this, we employed the range standardization method to normalize the indicators. Formula (1) is a forward indicator algorithm, which means that the higher the value of an indicator, the more favorable the result of a higher-level indicator. On the contrary, if it is considered that the lower the better, the negative index algorithm is used as shown in Formula (2).

$$Y_{\mathrm{ij}}=\frac{X_{\mathrm{ij}}-\min(X_i)}{\max(X_i)-\min(X_i)}, \tag{1}$$

$$Y_{\mathrm{ij}}=\frac{\max(X_i)-X_{\mathrm{ij}}}{\max(X_i)-\min(X_i)}, \tag{2}$$

where Y_{ij} represents the standardized value of a specific indicator, X_{ij} represents the original value of that indicator, and $\max(X_i)$ and $\min(X_i)$ represent the maximum and minimum values of the original values in that column, respectively.

2.3. Determination of Weights

Considering the comprehensive impact of various factors on the indicators, this study employs the method of mean squared deviation to determine the weights of the indicators. Firstly, the mean values of each indicator are calculated (Formula (3)), followed by the calculation of the mean squared deviation for each indicator (Formula (4)). Subsequently, the weights of each indicator are computed based on the formula for weight coefficients (Formula (5)). Finally, by conducting a weighted calculation on the standardized results of each indicator, the index of human settlement environmental quality for each residential community is obtained (Formula (6)).

Table 1. Review of practical cases of urban living environment quality assessment.

Typical Case	Indicator Coverage	Subject of Evaluation	Evaluation Methodology	Data Sources
One New York: The Plan for a Strong and Just City (2015), The London Plan: Spatial Development Strategy for Greater London (2015), Creating the Future: Tokyo Metropolitan Long-Term Vision (2020), Sydney City Strategic Plan: Sustainable Sydney 2030, et al.	The assessment criteria for the cases commonly encompass indicators such as economic development, environmental preservation, energy efficiency, residential conditions, sustainable transportation, employment, healthcare, elderly care, education, historical and cultural preservation, and community development. These indicators underscore the challenges and opportunities that cities face within specific time frames. For instance, New York City places a prominent focus on the key principle of "equity and fairness." Tokyo, leveraging the occasion of the 2020 Olympic Games, aims to mitigate issues like stagnant economic growth, population decline, and regional development imbalances. London emphasizes the concept of comprehensive planning, accentuating the quality and excellence of urban development. Meanwhile, Sydney highlights the pursuit of sustainable urban growth and enhanced livability.	The assessment focuses on the execution of urban planning initiatives and the advancement of planning policies.	Indicators encompass both qualitative and quantitative types. The evaluation methods employed comprise assigning scores or computing indices.	The data are primarily sourced from government data.
ISO 37120 Urban Sustainable Development Indicator System, International Green Model New Town Standard 3.0, United Nations Sustainable Development Goals Index, and others.	The case evaluation indicators cover major areas including resource and environment, economic development, and social equity.	The evaluation targets include urban service level, quality of life, and degree of sustainable development.	Indicators encompass both qualitative and quantitative types. The evaluation methods employed comprise assigning scores or computing indices.	The data are primarily reported by the cities themselves.
Asian Green City Index, European Green Capital Evaluation Indicator System.	The case indicators are primarily focused on "green" aspects such as energy supply, resource utilization, and ecological environment.	The evaluation targets include urban service level, quality of life, and degree of sustainable development.	Indicators encompass both qualitative and quantitative types. The evaluation methods employed comprise assigning scores or computing indices.	International organizations obtain evaluation data from publicly available official databases or collect them through various channels from government officials and relevant individuals.
Green Development Indicator System.	The case evaluation indicators include municipal facilities, transportation, ecological environment, economic development, resource conservation, rural living conditions, and other indicators.	The evaluation targets the quality of urban living environment.	The indicator type is quantitative indicators. The green development score of cities is calculated using a composite index method.	The data are submitted by various regions and departments.

Table 1. *Cont.*

Typical Case	Indicator Coverage	Subject of Evaluation	Evaluation Methodology	Data Sources
Evaluation Indicator System for China Habitat Environment Award, Scientific Evaluation Criteria for Livable Cities.	The case evaluation indicators include municipal facilities, transportation, ecological environment, economic development, resource conservation, social security, community development, public services, public safety, housing conditions, public participation, and indicators related to historical and cultural heritage as well as urban characteristics.	The evaluation targets the quality of urban living environment.	Indicators encompass both qualitative and quantitative types. The evaluation methods employed comprise assigning scores or computing indices.	The data are submitted by various regions and departments.
Indicator systems for the establishment and evaluation of Chinese Civilization Cities, Chinese National Hygiene Cities, Chinese National Garden Cities, and Chinese National Environmental Protection Demonstration Cities.	The case evaluation content is highly targeted, generally including three aspects: general socio-economic and cultural indicators, specific indicators, and management indicators. The indicators emphasize horizontal comparability and post-evaluation supervision and regulatory requirements. In the setting of the indicator system, there are often preconditions and veto items.	The evaluation targets specific aspects of the quality of urban living environment.	Indicators encompass both qualitative and quantitative types. The evaluation methods employed comprise assigning scores or computing indices.	The evaluation data are primarily submitted by various regions and departments, and they are cross-verified through expert reviews, on-site investigations, questionnaire surveys, satellite remote sensing, and other methods.
Evaluation Indicator System for Building Beijing into an Internationally First-Class Harmonious and Livable Capital, Indicator System for Shanghai Urban Master Plan (2017–2035), Indicator System for Sino-Singapore Tianjin Eco-City, and so on.	The content of case evaluation aligns with the city's positioning and strategic goals, typically including indicators related to economic innovation, green ecology, public services, resilience and safety, and urban governance. As a core legal document guiding urban development, the indicator standards possess a certain level of foresight. In recent years, emphasis has been placed on the dynamic update of indicators and their linkage with implementation and monitoring mechanisms.	The assessment focuses on the execution of urban planning initiatives.	The evaluation method relies on the assessment of monitoring departments involved in the implementation of the plan.	The data are primarily reported by government departments on a regular basis, supplemented by comprehensive analysis of multi-source big data.

Table 2. Indicator system for evaluating residential living environment quality.

Dimensional Layer	Weights	Indicator Layer	Data Sources	Indicator Characteristic	Weights
education and culture	0.166	Distance to kindergarten	POI	–	0.068
		Distance to primary school	POI	–	0.036
		Distance to secondary school	POI	–	0.044
		Distance to cultural venues	POI	–	0.018
healthcare and well-being	0.158	Distance to elderly care facilities	POI	–	0.030
		Distance to comprehensive hospitals	POI	–	0.051
		Density of basic medical services	POI	+	0.045
		Density of sports facilities	POI	+	0.032
residential and environmental factors	0.349	Housing prices in the neighborhood	Real estate websites	+	0.138
		Age of housing in the neighborhood	Real estate websites	–	0.083
		Greening rate of the neighborhood	Real estate websites	+	0.059
		Distance to parks and green spaces	Remote sensing imagery	–	0.069
transportation and communication	0.127	Distance to public parking lots	POI	–	0.025
		Density of bus stops	POI	+	0.062
		Density of communication service points	POI	+	0.015
		Density of logistics and courier service points	POI	+	0.025
lifestyle and leisure	0.201	Distance to commercial centers	POI	–	0.065
		Density of convenience stores and supermarkets	POI	+	0.045
		Density of dining establishments	POI	+	0.026
		Density of entertainment venues	POI	+	0.065

$$E(G_i) = \frac{1}{n}\sum\nolimits_{i=1}^{n} Y_{\text{ij}}, \tag{3}$$

$$\delta(G_i) = \sqrt{\sum\nolimits_{i=1}^{n} [Y_{ij} - (G_j)]^2}, \tag{4}$$

$$W_{\text{j}} = \frac{\delta(G_j)}{\sum_{j=1}^{n} \delta(G_j)}, \tag{5}$$

$$Q_i = \sum\nolimits_{i=1}^{n} Y_{ij} W_j, \tag{6}$$

where $E(G_i)$ represents the mean value of each indicator, $\delta(G_i)$ denotes the mean squared deviation of each indicator, W_j represents the weight of the jth indicator, and Q_i represents the score of human settlement environmental quality for the ith residential community.

2.4. Hotspot Analysis

In order to gain a deeper understanding of the current status and variations in the quality of urban residents' living environment, this study employs spatial autocorrelation analysis to measure the correlation patterns of residential environment factors. Spatial autocorrelation analysis is a method used to assess whether spatial features exhibit correlation with neighboring features. If the distribution of the study object in space demonstrates certain patterns rather than randomness, it is considered that there is spatial autocorrelation. In this study, the overall spatial distribution of the residential environment quality is examined through the application of the global Moran's I index. Furthermore, the local Moran's I index is employed to explore the "hotspot" and "coldspot" areas of specific attributes (e.g., high-quality and low-quality) within the residential environment, revealing distinct spatial patterns of regional polarization. Areas with significant hotspots above the 90% confidence level are identified as clusters of high-quality residential environments, while areas with significant coldspots above the 90% confidence level indicate clusters of low-quality residential environments. Insignificant areas imply that the spatial characteristics of the residential environment are not distinct.

The global Moran's I index and local Moran's I index are represented by Formulas (7) and (8), respectively.

$$I = \frac{n}{S_0} \times \frac{\sum_{i}^{n}\sum_{j}^{n} w_{ij}(y_i - \overline{y})(y_j - \overline{y})}{\sum_{i}^{n}(y_i - \overline{y})^2}, \tag{7}$$

$$I_i = \frac{(y_i - \overline{y})(y_j - \overline{y})}{S^2} \sum_{i=1}^{m} (y_j - \overline{y}), \tag{8}$$

where I represents the global Moran's index, and I_i represents the local Moran's index. Both indices range between -1 and 1. A positive value indicates spatial positive correlation, showing a tendency of research units to exhibit spatial clustering. Conversely, a negative value indicates spatial negative correlation, suggesting a tendency of research units to exhibit dispersed distribution. In the formulas, y_i and y_j represent the observed values of spatial units i and j, respectively. w_{ij} denotes the spatial weight matrix, and S_0 represents the sum of all elements in the spatial weight matrix. $\overline{y}$ represents the mean value of the regional units. Typically, standardized Moran's I value (Z-score) is used to test the statistical significance of the results, where $Z_t = [I - E(I)]/\sqrt{var(I)}$, and $E(I)$ and $var(I)$ denote the mathematical expectation and variance, respectively. A positive and significant Z-value indicates positive spatial autocorrelation, implying that similar observation values tend to cluster in space. Conversely, a negative and significant Z-value suggests negative spatial autocorrelation, implying that similar observation values tend to disperse. A Z-value of zero indicates that the observation values exhibit independent random distribution. Here, m denotes the sample size, and S^2 represents the sample variance.

3. Results

3.1. Overall Evaluation

By utilizing selected indicators and their corresponding weights, the Livability Environment Quality Index for Binjiang District was calculated. Using the natural break method, the index was divided into three quality levels: high (0.666–0.867), medium (0.580–0.667), and low (0.411–0.579), as shown in Figure 2. It is obvious that the overall residential environment quality in Binjiang District exhibits a spatial pattern of higher quality in the northern areas and lower quality in the southern areas. Moreover, high-quality residential areas demonstrate a certain degree of clustering, primarily concentrated in the northwest and northeast regions. These areas are close to the district government, university campuses, sports centers, and historical towns and therefore benefit from relatively well-developed public and lifestyle amenities. Conversely, low-quality residential areas are mainly distributed in the southern and peripheral regions of Binjiang District. These areas are either located far from the central business district or fall within newly developed zones, resulting in limited external connectivity and relatively inadequate infrastructure. Areas with moderate-quality residential environments are more widely dispersed and often situated between high- and low-quality regions.

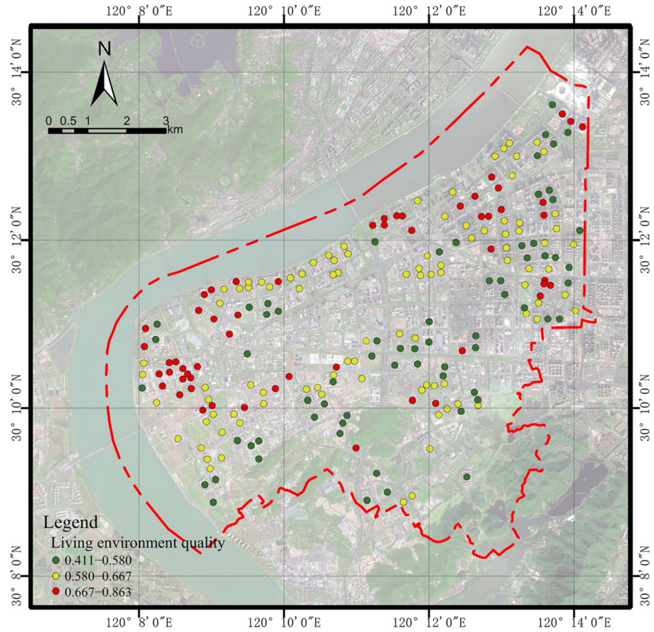

Figure 2. Distribution of residential living environment quality in Binjiang District.

3.2. Dimensional Evaluation

Based on the analysis of the overall spatial pattern of urban livability environment quality in Binjiang District, a spatial analysis of the five criteria elements of livability environment quality is conducted (Figure 2) to explore more refined mechanisms influencing residential spatial quality. The criteria are ranked in terms of their importance based on weights: housing and environment, living and leisure, education and culture, healthcare and health, and transportation and communication.

Figure 3a presents the housing and environment quality. It clearly shows a pattern of high quality along the riverside areas, low quality in the interior, high quality in the northern region, low quality in the southern region, high quality in the newly developed areas, and low quality in the older areas. High-quality residential areas were primarily concentrated in the northeast Olympic sports area and the district government area, comprising newly constructed residential communities such as Shuiyin City, Tongren Chunjiang Times, and Baijin Coast. These residential areas boasted pleasant surroundings and high green coverage, offering scenic landscapes and abundant vegetation coverage with strong functional accessibility. Moderate-quality residential areas were mainly distributed near Binjiang University City in the northwest and the northern riverside areas, with some presence in the older urban areas. Low-quality residential areas were predominantly concentrated in the old urban areas, such as the southern side of the Xixing residential area in the eastern part, encompassing numerous older and outdated residential complexes and including industrial workers' supporting communities and staff dormitories. These areas faced challenges such as poor environmental quality, inadequate supporting facilities, and high population density.

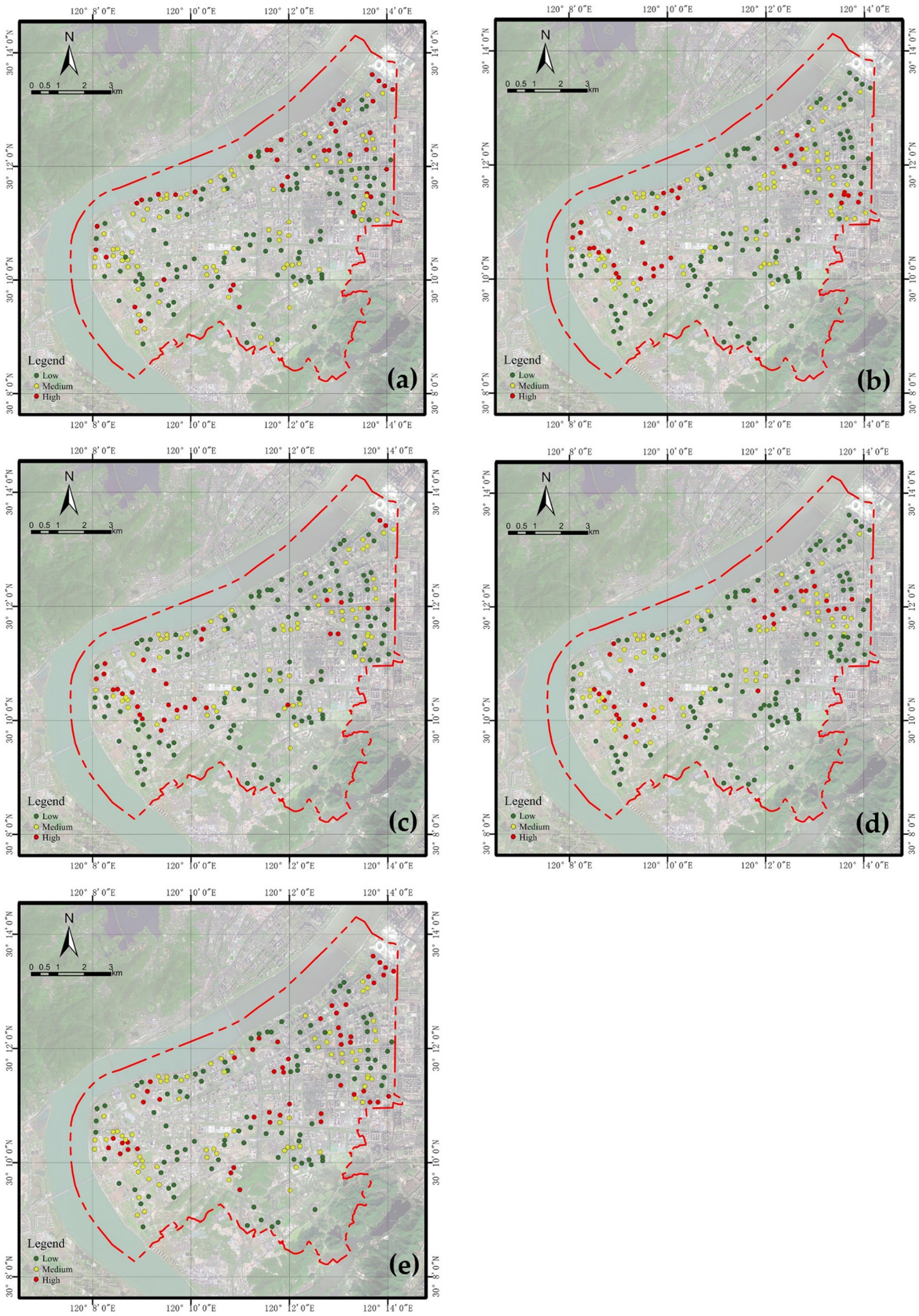

Figure 3. (**a**) Housing and environmental quality; (**b**) quality of life and leisure; (**c**) quality of education and culture; (**d**) quality of healthcare and health; (**e**) quality of transportation and communication.

The living and leisure quality displayed two concentrated areas of high-quality residential communities in the western and eastern regions as shown in Figure 3b. The western area included the university city, while the eastern area encompassed office buildings. These areas experienced significant population flow and provided well-developed commercial, dining, and entertainment services. Moderate-quality residential areas were mainly located between high-quality and low-quality areas. Low-quality residential areas were relatively scattered, primarily situated in the peripheral regions of Binjiang District. These areas lacked comprehensive commercial centers, and neighborhood businesses were also dispersed, making it difficult to meet residents' needs for daily life, leisure, and shopping.

Figure 3c shows that education and culture high-quality residential areas were primarily concentrated in the older urban areas surrounding the western university city. Although these areas had a high population density, they benefitted from the facilities provided by the university city and concentrated abundant educational and cultural resources. Additionally, a small portion of high-quality residential areas was found near the district government in the northeast. Low-quality residential areas were mainly distributed in the southern and central parts, such as the resettlement housing areas and the peripheral regions of Binjiang District. These areas suffered from inadequate educational facilities and a scarcity of cultural resources. It is necessary to allocate primary and secondary schools, as well as supporting kindergartens, in accordance with the "Urban Residential Area Planning and Design Standards" of China, to improve the layout of compulsory education facilities and to establish a comprehensive system of cultural facilities at the municipal, regional, and community levels to meet residents' cultural and educational needs. Alternatively, educational, and cultural facilities within a 5–10 min or 15 min walking distance within the community living circle should be planned according to standards.

In terms of healthcare and health quality, high-quality residential areas were concentrated in the district government area in the northeast and the surrounding areas of Binjiang University City in the northwest, as shown in Figure 3d. These areas accommodated the majority of healthcare service facilities and community health service stations, ensuring comprehensive basic medical services. In contrast, other areas, particularly the southern regions, exhibited lower healthcare and health service quality. Efforts should be made to enhance basic medical services in the old urban areas and newly developed residential areas, especially considering the increasing focus on the accessibility and equity of medical resources, particularly during the COVID-19 pandemic. Additionally, the provision of grassroots sports facilities and residents' daily fitness activities have received more attention.

In Figure 3e, the transportation and communication quality displays a trend of multiple core points radiating outward with decreasing quality. High-quality residential areas were mainly concentrated in Binjiang University City and its surrounding areas in the northwest (including the Qiantang River Bridge area and the Changhe Science and Innovation Park residential area) and the district government and Olympic Sports Center areas in the northeast. These areas exhibited high population density and high transportation demands, benefiting from well-developed transportation infrastructure. Moderate and low-quality residential areas were mainly distributed in the southern old urban areas. These areas suffered from insufficient transportation planning and relatively lower demand. In the future, further optimization and improvement of the rail transit routes should be considered, particularly regarding functional replacement demands in low-vitality old residential areas.

3.3. Spatial Pattern of Hotspots

After conducting a global spatial autocorrelation test on the calculated scores for residential environment quality in the Binjiang District, the results indicated significant spatial autocorrelation and pronounced clustering patterns. Moran's I index was found to be greater than 0, the p-value was less than 0.05, and the Z score was positive. These findings demonstrate that both the overall score and the scores of individual criteria for residential environment quality exhibit noticeable spatial autocorrelation. Building upon these results, a hotspot analysis was conducted to examine the distribution of high- and low-quality residential environments in the Binjiang District (as shown in Figure 4). The analysis revealed substantial spatial disparities in urban residential environment quality. Although the scale of clusters is different, there are clusters of high-quality living environments along the Qiantang River and around the government administrative areas. In contrast, low-quality residential environments were primarily concentrated in the southern part of the Binjiang District, with scattered small patches on the eastern edge.

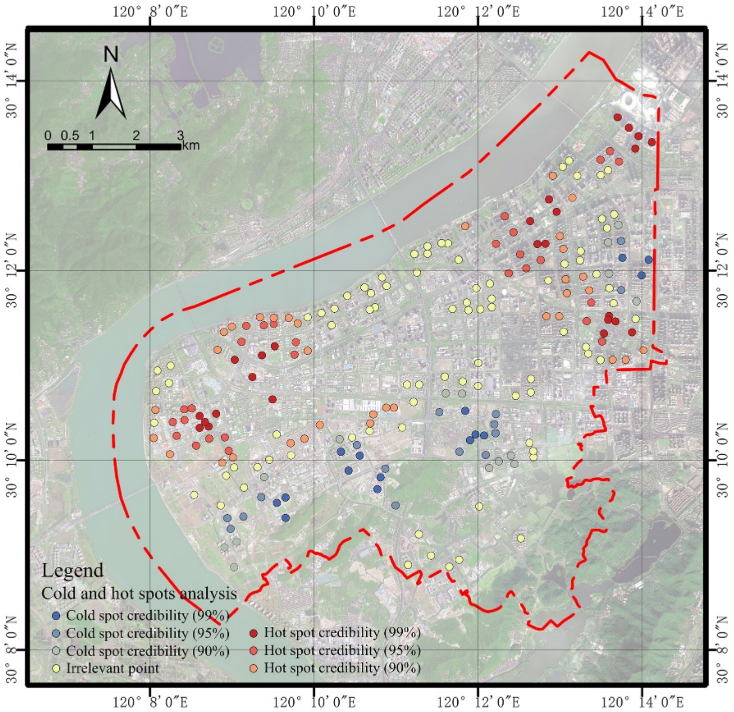

Figure 4. Hotspot analysis.

To analyze the spatial clusters of high-quality residential environments in the Binjiang District, several spatial distribution characteristics were identified in Figure 5. Areas surrounding Binjiang University Town, the administrative government area, the Olympic Sports Center area, and the Gudun area exhibited the most significant and extensive concentrations of high-quality residential environments. These areas formed a belt-shaped cluster along the river. The key driver behind this spatial distribution pattern is the inclusion of various functional centers, such as political, educational, cultural, and sports facilities. Thus, essential services for the daily life of residents are prioritized and concentrated in these areas, leading to economies of scale. The spatial clusters of low-quality residential environments in the Binjiang District can be categorized into three types, as shown in Figure 6. Firstly, there are newly developed residential areas along the western riverfront and the Dongguan Pule residential area. Although they have relatively good infrastructure and higher levels of residential and environmental quality, these areas are situated far from the city center, resulting in transportation inconveniences. Moreover, these areas predominantly focus on residential functions with poor supporting public service facilities and infrastructure. Therefore, the overall residential environment quality remains relatively lower. However, these areas play a crucial role in accommodating the decentralization of central urban functions and population, making them a priority for optimizing the allocation of urban public services and improving public transportation. Secondly, industrial-area-associated residential communities, primarily represented by the Xixing residential area and scattered smaller neighborhoods, exhibit specific characteristics. These communities are built close to industrial enterprises and predominantly cater to the housing needs of industrial workers. The supporting facilities in these areas are primarily designed to serve industrial production and have not fully considered the residents' quality of life. Furthermore, these communities with longer histories of development are located far from the city center, facing transportation challenges. Lastly, there are areas characterized by resettlement housing, including the Dongguan area and certain neighborhoods near the university town. These areas accommodate low-income residents and individuals affected by land acquisition in suburban areas. The residential areas in these locations have a single function and suffer from a remote location, transportation inconveniences, and a lack of comprehensive supporting service facilities. At present, they are on the relative edge of urban areas and need to be considered comprehensively in the context of rapid urban development.

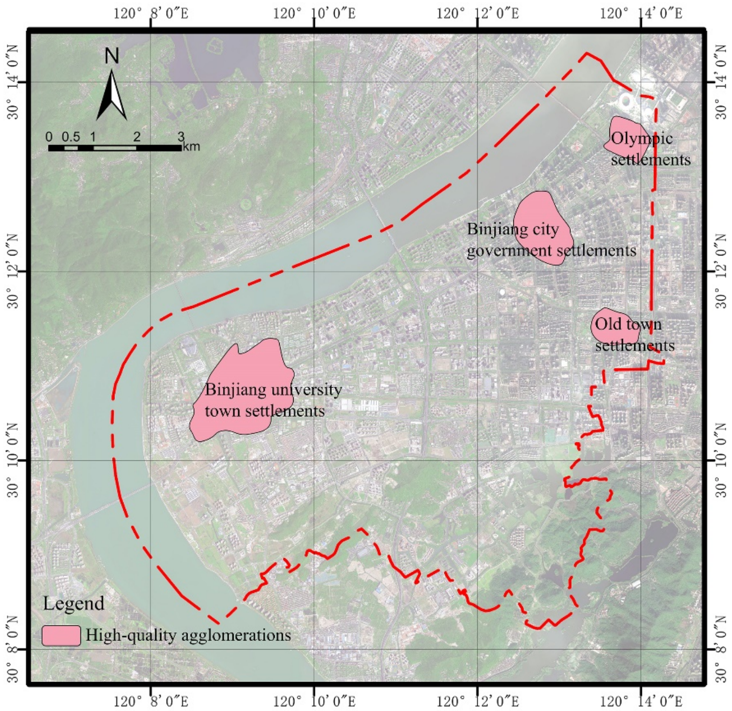

Figure 5. High-quality agglomeration of residential living environment.

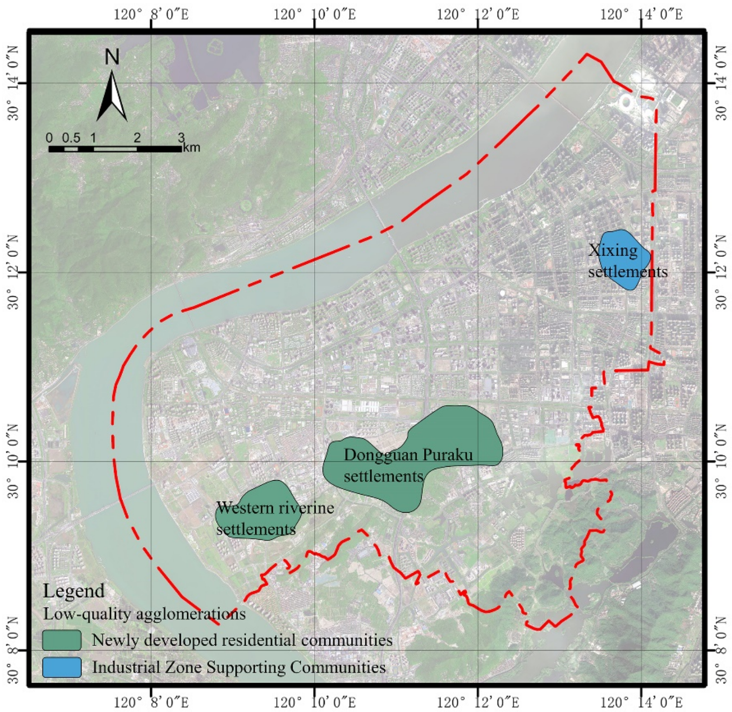

Figure 6. Low-quality agglomeration of residential living environment.

4. Discussion

This study endeavors to investigate an evaluation approach for the quality of urban residential living environments, based on the principles of urban renewal, with a specific focus on the case of Hangzhou's Binjiang District in China. Leveraging a comprehensive integration of diverse data sources, a comprehensive evaluation indicator system to assess the living environment quality within the Binjiang District is formulated.

Our findings demonstrate the feasibility and effectiveness of the multi-source data-based approach for evaluating urban human settlement environment quality. By combining information from various data sources, a more comprehensive and accurate evaluation of the human settlement environment quality is realized. Compared to assessments based on a single data source, such as government statistics or surveys, our approach exhibits enhanced practicality and utility.

In this study, five major factors, including education and culture, healthcare and well-being, housing and environment, transportation and communication, and daily life and leisure, are considered. These factors are integrated to derive an overall score, quantifying the human settlement environment quality. It is revealed that high-quality human settlement environments tend to cluster around urban functional centers, exhibiting a distinct strip-like distribution along the river. The scale of these clusters is comparable to that of low-quality human settlement environments, which is consistent with previous research. For instance, Shen et al. [29] explored the human settlement environment quality in Xuzhou, China, and found that high-quality human settlement environments tend to concentrate around the city center with larger clusters, while low-quality human settlement environments are more scattered and located farther from the city center. Chen et al. [30] investigated the vulnerability of human settlement environments in Chinese urban agglomerations and observed that coastal cities demonstrated better human settlement environment quality on average. Zhou et al. [31] evaluated the human settlement environment quality in Qingdao, China, and identified significant spatial correlations and a positive relationship between the degree of clustering and human settlement environment quality. Guan et al. [32] examined the spatial suitability of urban human settlement environments in Liaoning Province, China, and found a general consistency between the spatial distribution of population economic density and the comprehensive suitability index of human settlement environments.

However, it is important to acknowledge the limitations of this study. The objective evaluation of human settlement environments conducted in this study focuses on residential areas, demonstrating the relative quality of different residential environments within the city and highlighting the spatial distribution characteristics related to environmental health, transportation convenience, urban safety, and daily convenience. Nonetheless, the indicators primarily consider the physical environment, which serves as a means to meet the needs of residents. Evaluation results may vary based on the research perspective and measurement criteria employed. It should be noted that the superiority of objective indicators for human settlement environments does not necessarily imply residents' subjective satisfaction with their living conditions because individuals' perceptions are influenced by their social attributes and personal requirements. Future research should incorporate on-site visits or questionnaire surveys to analyze residents' subjective satisfaction with their living environments, thereby validating the objective evaluation results of urban human settlement environments. Additionally, given the broad scope of human settlement environments, although 20 influencing indicators are considered at a micro-level in our study, data limitations prevented the calculation of numerous socio-economic indicators at a detailed scale. Addressing this issue is crucial for conducting fine-scale evaluations of human settlement environments. Furthermore, incorporating data from different time periods for human settlement environment evaluations would provide a more comprehensive understanding of the development and temporal dynamics of urban human settlement environments.

Moreover, the majority of the indicator data utilized to support this investigation stem from geographical image computations. These cartographic images are sourced from conventional methods such as remote sensing image interpretation. Although traditional image processing methods encounter certain challenges in terms of accuracy, their amalgamation with on-site validation ensures the veracity of the data. In recent years, the acquisition of data based on imagery and the evaluation of specific object quality have garnered escalating attention. Subsequent research endeavors could derive insights from the heightened precision offered by deep neural networks in visual signal quality measurement. Techniques such as score-based models, rank-based models, multi-task models, and region of interest (ROI) technologies could be harnessed for image data acquisition in prospective investigations [33–36]. When designing integrated subjective and objective evaluation methods, inspiration can be drawn from research in the field of image quality assessment. This approach involves utilizing both models and human ratings to characterize the quality of real-world scenarios, followed by the development of objective techniques to predict these evaluations [37–43].

5. Conclusions and Suggestions

5.1. Conclusions

The assessment of urban residential living environment quality based on the principles of urban renewal holds crucial research and practical significance, and it offers valuable insights and applications in optimizing the allocation of urban public service facilities. In this study, we focused on the Binjiang District in Hangzhou and employed a range of data sources, including remote sensing imagery, point-of-interest data, and land-use planning data, to construct a comprehensive evaluation index system for urban residential environment quality.

This index system encompassed five key aspects: residential and environmental factors, transportation and communication, education and culture, lifestyle and leisure, and healthcare and well-being. Through the utilization of comprehensive index methodology and hotspot analysis, a holistic assessment of residential environment quality was conducted, leading to the following key findings:

(1) The quality of the living environment in Binjiang District exhibits distinct spatial variations. Consistent with previous research findings, areas with higher living environment quality are primarily concentrated around the university campus and the district government center and gradually decrease to the suburbs. Future urban renewal planning needs to comprehensively consider both the revitalization of central areas and the balanced development of peripheral regions to promote sustainable progress in the economy, society, and environment.

(2) In terms of specific criteria for the living environment, there is an overall pattern of higher residential and environmental quality along the riverside areas, lower quality in the inner regions, higher quality in the new districts, and lower quality in the old districts. The quality of transportation and communication shows a trend of multiple core points radiating outward with decreasing quality. Other criteria indicate that high-quality residential areas are mainly concentrated in the district government zone and the vicinity of Binjiang University City. Future urban renewal will focus on improving spatial efficiency and social equity.

(3) Hotspot analysis reveals a positive correlation between the quality of the living environment and the degree of aggregation. Communities with high living environment quality have higher agglomeration degrees than those with low living environment quality. Future urban renewal planning should not only concentrate on enhancing the quality of life in highly clustered areas but also adopt a decentralized development strategy to create a livable environment in the surrounding areas, achieving a rational distribution of population and resources.

5.2. Suggestions

Based on the current state and comprehensive evaluation results of residential environment quality in Binjiang District, it is crucial for relevant authorities to tailor their approaches and devise distinct development strategies according to the unique characteristics of each region's residential environment during the urban planning and construction process. Hence, on the basis of the research conclusions, the following recommendations are put forward:

First and foremost, advancing the renovation and enhancement of living spaces and environments in the older city residential areas is imperative. This requires the judicious allocation of parklands and green spaces to improve the quality of residential environments. In order to solve the problem of population aging in the elderly community, it is necessary to further improve the elderly care facilities to meet the specific needs of this population. By utilizing nearby parks and squares, tailored spaces for elderly activities can be created while offering personalized elderly care services to effectively tackle the social issues arising from population aging.

Secondly, leisure, education, culture, healthcare, and transportation are shared factors contributing to substandard residential spaces. It is vital to propel the equalized development of essential public services within urban regions, employing an intensified layout for large-scale public facilities such as commercial centers, supermarkets, libraries, sports arenas, and comprehensive hospitals. Given the resource constraints of these facilities, their limited numbers must cater to a broad service coverage.

Lastly, the construction of residential environments should align with the city's development and construction goals. For instance, Binjiang District in Hangzhou aspires to become a nationally recognized hub for independent innovation, an exemplary zone for the digital economy and its applications, and an internationalized new city offering a harmonious and livable environment. Future planning initiatives should leverage the district's ecological resources and reinforce the connection between the Binjiang landscape corridor and the mountainous ecological landscape. Additionally, by capitalizing on the strategic layout of critical urban arteries and rail transportation networks, synergistic integration between diverse functional zones can be achieved, effectively linking significant urban functions with key landscape nodes.

Furthermore, in addressing how to achieve sustainable urban residential development and enhance urban resilience under the framework of urban renewal, a range of measures can be implemented. Firstly, comprehensive planning plays a pivotal role. Prior to initiating renewal projects, conducting risk assessments is essential to identify potential impacts and threats, thereby formulating appropriate adaptive strategies. Secondly, emphasis should be placed on diversified and flexible infrastructure. By incorporating diverse infrastructure elements, the city's capacity to respond to various types of shocks can be strengthened, minimizing the impact of single-point failures. Thirdly, the integration of green infrastructure should be promoted, which can effectively mitigate flooding, improve air quality, and provide valuable ecosystem services. Fourthly, disaster risk management deserves considerable attention. Upgrading buildings to withstand natural disasters, implementing measures to reduce risks like floods and fires, and establishing emergency response plans are crucial components of the strategy. Fifthly, active engagement and collaboration with community residents are imperative. Meaningful community involvement can provide invaluable insights, ensuring that renewal projects align with the interests and needs of local residents. Sixthly, the application of innovative technologies is highly recommended. Smart city technologies hold the potential to enhance traffic management, resource utilization, and energy efficiency, consequently bolstering urban sustainability and adaptability. Seventhly, fostering collaborative partnerships is essential. By forging strong partnerships among governmental bodies, private sectors, academia, and social organizations, resources and expertise can be effectively pooled, leading to more impactful urban renewal efforts and resilience enhancement. Lastly, continuous monitoring and evaluation are indispensable. Persistent assessment of resilience enhancement can help identify potential areas for improvement and inform future renewal projects. By comprehensively integrating these recommendations, urban renewal endeavors can effectively enhance urban resilience, enabling cities to proactively face future challenges and adapt to dynamic changes.

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References

1. Chen, C.Y.; Zhang, W.Z.; Zhan, D.S.; Li, X.L. Quantitative evaluation of human settlement environment and influencing factors in the Bohai Rim area. *Prog. Geogr.* **2017**, *36*, 1562–1570.
2. Reeves, D. Putting women and gender in the frame–A consideration of gender in the Global Report on Human Settlement Planning Sustainable Cities 2009. *Habitat. Int.* **2014**, *43*, 293–298. [CrossRef]
3. Charoenkit, S.; Kumar, S. Environmental sustainability assessment tools for low carbon and climate resilient low income housing settlements. Renew. *Sust. Energ. Rev.* **2014**, *38*, 509–525. [CrossRef]
4. Adewunmi, Y.; Chigbu, U.E.; Mwando, S.; Kahireke, U. Entrepreneurship role in the co-production of public services in informal settlements− A scoping review. *Land Use Pol.* **2023**, *125*, 106479. [CrossRef]
5. McNeill, L.H.; Kreuter, M.W.; Subramanian, S.V. Social environment and physical activity: A review of concepts and evidence. *Soc. Sci. Med.* **2006**, *63*, 1011–1022. [CrossRef]
6. Schetke, S.; Haase, D.; Kötter, T. Towards sustainable settlement growth: A new multi-criteria assessment for implementing environmental targets into strategic urban planning. *Environ. Impact Assess. Rev.* **2012**, *32*, 195–210. [CrossRef]
7. Sebti, M.; Alkama, D.; Bouchair, A. Assessment of the effect of modern transformation on the traditional settlement 'Ksar'of Ouargla in southern Algeria. *Front. Archit. Res.* **2013**, *2*, 322–337. [CrossRef]
8. Kim, H.W.; Aaron McCarty, D.; Lee, J. Enhancing Sustainable Urban Regeneration through Smart Technologies: An Assessment of Local Urban Regeneration Strategic Plans in Korea. *Sustainability* **2020**, *12*, 6868. [CrossRef]
9. Wang, J.; Yang, Y.; Huang, H.; Wang, F. Stakeholder Management in Government-Led Urban Regeneration: A Case Study of the Eastern Suburbs in Chengdu, China. *Sustainability* **2022**, *14*, 4357. [CrossRef]
10. Pollard, J.S. From Industrial District to "Urban Village"? Manufacturing, Money and Consumption in Birmingham's Jewellery Quarter. *Urban Stud.* **2004**, *41*, 173–193. [CrossRef]
11. Kipfer, S.; Keil, R. Toronto Inc? Planning the competitive city in the new Toronto. *Antipode* **2002**, *34*, 227–264. [CrossRef]
12. Sacco, P.; Tavano Blessi, G. The Social Viability of Culture-led Urban Transformation Processes: Evidence from the Bicocca District, Milan. *Urban Stud.* **2009**, *46*, 1115–1135. [CrossRef]
13. Zheng, H.W.; Shen, G.Q.; Wang, H. A review of recent studies on sustainable urban renewal. *Habitat Int.* **2014**, *41*, 272–279. [CrossRef]
14. Olabisi, Y.S. Gender issue and urban renewal development: An examination of challenges of evicted market women in Lagos State, Nigeria. *Am. J. Rural. Dev.* **2013**, *1*, 19–25.
15. Wang, Y.T.; Wang, X.R.; Dou, Z. Study on the application of the index system of urban human settlements quality evaluation: Based on the practice of pilot cities. *J. Hum. Settl. West China* **2021**, *36*, 50–56.
16. Cui, F.Q.; Tang, H.P.; Zhang, Q. Evaluation of urban livability and analysis of influencing factors in Beijing-Tianjin-Hebei region: Empirical research based on panel data from 2010 to 2016. *J. Beijing Norm. Univ. Nat. Sci.* **2018**, *54*, 666–673.
17. Gawai, N.; Phadke, A. Quality of urban life: Identification of livable urban spaces within Mumbai metropolitan region. *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci.* **2018**, *XLII-5*, 117–121. [CrossRef]
18. Liu, S.; Liu, B.Y. Study on Evaluation Index System of Sustainable Development for Urban Human Settlement. *Urban Plan. Rev.* **1999**, *5*, 35–37.
19. Bao, J.; Zhang, Y.; Li, X.; Guo, Q. From Survival to Self-Actualization: Quantitative evaluation of human settlement environment from the perspective of hierarchy of needs theory: A case study of An hui Province. *Urban Stud.* **2020**, *27*, 88–95.
20. Zhang, Z.B.; Ju, J.L.; Chen, Z.J. Evaluation of urban livability and its spatial characteristics in Lanzhou. *Acta Ecol. Sin.* **2014**, *34*, 6379–6389.

21. Fu, B.; Yu, D.; Zhang, Y. The livable urban landscape: GIS and remote sensing extracted land use assessment for urban livability in Changchun Proper, China. *Land Use Pol.* **2019**, *87*, 104048. [CrossRef]
22. Long, Y.; Li, M.Y.; Li, J. Monitoring of Chinese human settlement environment quality based on new data: Indicator system and typical cases. *Urban Dev. Res.* **2018**, *25*, 86–96.
23. Ta, N.; Zhao, Y.; Chai, Y.W. Built environment, peak hours and route choice efficiency: An investigation of commuting efficiency using GPS data. *J. Transp. Geogr.* **2016**, *57*, 161–170. [CrossRef]
24. Xiong, W.Y. The Urban Settlement Research in the Perspective of Public Facilities: A Case Study of Nanjing. *Mod. Urban Res.* **2010**, *25*, 35–42.
25. Shen, Y.; Chai, Y. Daily activity space of suburban mega-community residents in Beijing based on GPS data. *Acta Geogr. Sin.* **2013**, *68*, 506–516.
26. Zhang, W.Z. The core framework of livable urban construction. *Geography* **2016**, *35*, 205–213.
27. Zhang, Z.; Wei, Z.Q. Study and application of urban human settlements assessment system. *Ecol. Environ.* **2006**, *15*, 198–201.
28. Xiao, L.Y. Study on indicator system of global livable cities and international comparison of Guangzhou. *J. Urban Stud.* **2019**, *40*, 58–63.
29. Shen, S.; Ma, Y.; Hu, T.H. Research on evaluation of urban human settlements quality based on multi-source data. *J. Hum. Settl. West China* **2022**, *37*, 48–54.
30. Chen, J. Temporal-spatial assessment of the vulnerability of human settlements in urban agglomerations in China. *Environ. Sci. Pollut. Res.* **2023**, *30*, 3726–3742. [CrossRef]
31. Zhou, J.; Liu, L.; Li, H.; Pei, D. Evaluation and analysis on suitability of human settlement environment in Qingdao. *PLoS ONE* **2021**, *16*, e0256502.
32. Guan, Y.; Li, X.; Yang, J.; Li, S.; Tian, S. Spatial differentiation of comprehensive suitability of urban human settlements based on GIS: A case study of Liaoning Province, China. *Environ. Dev. Sustain.* **2022**, *24*, 4150–4174. [CrossRef]
33. Zhai, G.; Min, X. Perceptual image quality assessment: A survey. *Sci. China-Inform. Sci.* **2020**, *63*, 84–135. [CrossRef]
34. Min, X.; Gu, K.; Zhai, G.; Yang, X.; Zhang, W.; Le Callet, P.; Chen, C.W. Screen content quality assessment: Overview, benchmark, and beyond. *ACM Comput. Surv.* **2021**, *54*, 1–36. [CrossRef]
35. Min, X.; Zhai, G.; Zhou, J.; Zhang, X.P.; Yang, X.; Guan, X. A multimodal saliency model for videos with high audio-visual correspondence. *IEEE Trans. Image Process.* **2020**, *29*, 3805–3819. [CrossRef] [PubMed]
36. Min, X.; Zhai, G.; Gu, K.; Yang, X. Fixation Prediction through Multimodal Analysis. ACM Trans. *Multimed. Comput. Commun. Appl.* **2016**, *13*, 1–23.
37. Min, X.; Gu, K.; Zhai, G.; Liu, J.; Yang, X.; Chen, C.W. Blind quality assessment based on pseudo-reference image. *IEEE Trans. Multimed.* **2017**, *20*, 2049–2062. [CrossRef]
38. Min, X.; Ma, K.; Gu, K.; Zhai, G.; Wang, Z.; Lin, W. Unified blind quality assessment of compressed natural, graphic, and screen content images. *IEEE Trans. Image Process.* **2017**, *26*, 5462–5474. [CrossRef]
39. Min, X.; Zhou, J.; Zhai, G.; Le Callet, P.; Yang, X.; Guan, X. A Metric for light field reconstruction, compression, and display quality evaluation. *IEEE Trans. Image Process.* **2020**, *29*, 3790–3804. [CrossRef]
40. Min, X.; Zhai, G.; Gu, K.; Zhu, Y.; Zhou, J.; Guo, G.; Yang, X.; Guan, X.; Zhang, W. Quality evaluation of image dehazing methods using synthetic hazy images. *IEEE Trans. Multimed.* **2019**, *21*, 2319–2333. [CrossRef]
41. Min, X.; Zhai, G.; Gu, K.; Liu, Y.; Yang, X. Blind image quality estimation via distortion aggravation. *IEEE Trans. Broadcast.* **2018**, *64*, 508–517. [CrossRef]
42. Min, X.; Zhai, G.; Zhou, J.; Farias, M.C.; Bovik, A.C. Study of subjective and objective quality assessment of audio-visual signals. *IEEE Trans. Image Process.* **2020**, *29*, 6054–6068. [CrossRef] [PubMed]
43. Min, X.; Zhai, G.; Gu, K.; Yang, X.; Guan, X. Objective quality evaluation of dehazed images. *IEEE Trans. Intell. Transp. Syst.* **2018**, *20*, 2879–2892. [CrossRef]