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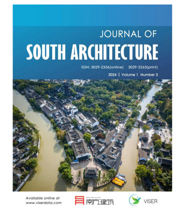

Research on the Measurement and Influencing Factors of Street Vigor in Historic District: A Case Study of Wenming Street Historic District in Kunming

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ABSTRACT: Analyzing the distribution characteristics of the vitality of traditional streets and its influencing factors is of great significance to the sustainable development of historic streets. Taking the Wenming Street Historic District in Kunming City as an example, combining field research and online open-source data to construct a street vitality evaluation index system for historic districts, measuring the distribution characteristics of its street vitality, and analyzing the impact of built environmental indicators on street vitality through stepwise multiple linear regression. Studies have shown that: (1) The street vitality of Wenming Street Historic District presents a spatial distribution characteristic of high in the southeast and low in the northwest, and the distribution of vitality is obviously uneven; (2) accessibility and functional density are significantly positively correlated with street vitality, and street length is significantly negatively correlated. The order of influence is accessibility> functional density> street length. On this basis, the strategy of optimizing the vitality of the streets in the historic districts is proposed in order to provide a reference for the revitalization of the historic districts.

KEY WORDS: historic district; street vitality; sDNA; Wenming Street

Introduction

As a crucial means of promoting the sustainable development of historical districts, vitality revitalization has consistently been a central concern in the conservative and renewal practices of historical districts[1]. In recent years, the concept of dynamic preservation of historical districts has gained significant recognition[2], with moderate commercial development and renovation deemed effective strategies for revitalizing urban vitality[3]. However, it is evident that, in the current process of prudent and incremental revitalization of historic districts, a considerable number of these areas exhibit a coexistence of prosperity and decline, along with an uneven distribution of vitality. Traditional streets, as essential public spaces, serve as the primary venues for interactions and activities among residents and visitors, representing the most direct manifestation of vitality levels within historical districts. This raises critical questions regarding the distribution characteristics of street vitality in revitalizing historical districts and the built environment factors influencing these characteristics.

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Research into these issues will help unveil the deeper driving mechanisms behind the distribution of street vitality, providing support for the comprehensive revitalization of historical district vitality.

Current research methods examining the impact of the built environment on behavioral activities can be categorized into three types: descriptive categorization, subjective preference assessment, and correlational analysis [4]. Early studies primarily employed an environmental behavioral framework, relying on empirical observation and classification of street environments and population activities to reveal intrinsic patterns affecting spatial vitality[5-6]. However, this approach often struggles to ascertain the specific weights of vitality influencing factors. The subjective preference assessment method typically gathers data through expert scoring, surveys, and interview records, utilizing mathematical analyses such as Analytic Hierarchy Process [7] semantic differential method[8], and factor analysis[9] to quantify the weights of various factors impacting specific populations, demanding a high sample size. Correlational analysis predominantly employs statistical methods like correlation and regression analysis to explore the interplay between spatial vitality and the built environment. Due to its objective, intuitive, and detailed characteristics, this method has gained widespread application in recent studies on street vitality. It requires foundational data reflecting vitality indicators and their components, which can be acquired through field research [10-14] or web-scraped open-source data[15-18].

In the realm of research content, current studies primarily focus on the contributions of specific elements to the vitality of historic districts[19-20]. However, it is widely acknowledged that the formation of vitality is influenced by a combination of multiple factors. In this context, Zhang Yuyang and colleagues established an evaluation system for the vitality of historical streets based on Point of Interest (POI) data and WeChat mobility heatmaps. They utilized stepwise multiple linear regression to analyze the influencing factors of vitality in the Shichahai area, highlighting the significant role of historical resources and suitable commercial formats in enhancing the vitality of traditional streets[21]. Similarly, Gao Yuan and others verified the positive effects of functional density and mixed-use development on the vitality of historical districts in Guangzhou through the integration of Baidu heatmaps and POI data[22].

In summary, while existing research has emphasized the contributions of specific elements to the vitality of historical districts, and some scholars have explored the impact of multiple factors using open-source data, several shortcomings remain: (1) Although the methods for scraping open-source data are efficient and convenient, the precision of current datasets is insufficient to support more nuanced research at the scale of historical districts; (2) Previous studies have primarily focused on "population activity density" as a measure of street vitality. However, the public life of streets is diverse and rich, necessitating a comprehensive consideration of the varied contributions of different types of public activities to street vitality.

To address these gaps, this paper examines the historical and cultural district of Wenming Street in Kunming, combining field research and open-source data to construct an evaluation index system for street vitality. This study aims to measure the distribution characteristics of street vitality, employ correlational analysis to uncover specific factors influencing this vitality, and propose corresponding optimization strategies for enhancing street vitality.

1 Research design and indicator system construction

1.1 Conceptual definition

The vitality of streets is fundamental to the vibrancy of cities[5]. While traffic thoroughfares primarily support economic vitality, streets, as venues for public activities, are closely tied to social vitality[23]. The essence of street vitality lies in the diverse activities engaged in by people within these spaces[24]. A vibrant street should cater to the varied needs and experiences of individuals from different backgrounds and age groups[11]. Thus, the "street vitality" examined in this study encompasses both the intensity and frequency of crowd activities as well as the richness of activity types.

1.2 Research scope

The historical district of Wenming Street in Kunming dates back to the Dali Kingdom, with its street pattern established during the Kangxi period of the Qing Dynasty. During this time, the area served as a hub for government offices and post stations, characterized by a strong official atmosphere. With the subsequent development of the South Gate commercial area in modern Kunming, the district became home to numerous time-honored brands such as "Fulintang," "Tongqingfeng," and "Liuhuan," gradually transforming into a gathering place for merchants. Benefiting from protective policies, the fabric and streetscape of the Wenming district have been well-preserved, featuring six main streets, including Wenming Street and Jingxing Street, along with 15 smaller alleys[25]. This research focuses on the area delineated by the "Wenming Street Historical and Cultural District Protection Plan (2012-2020)," supplemented by field investigations. The boundaries extend from Wuyi Road in the west to Zhengyi Road in the east, and from Dongfeng West Road in the south to Huashan South Road in the north, encompassing a total area of 23.26 hm^2. The study selects 26 major street segments within this area, divided by intersections, as the research subjects (Figure 1).

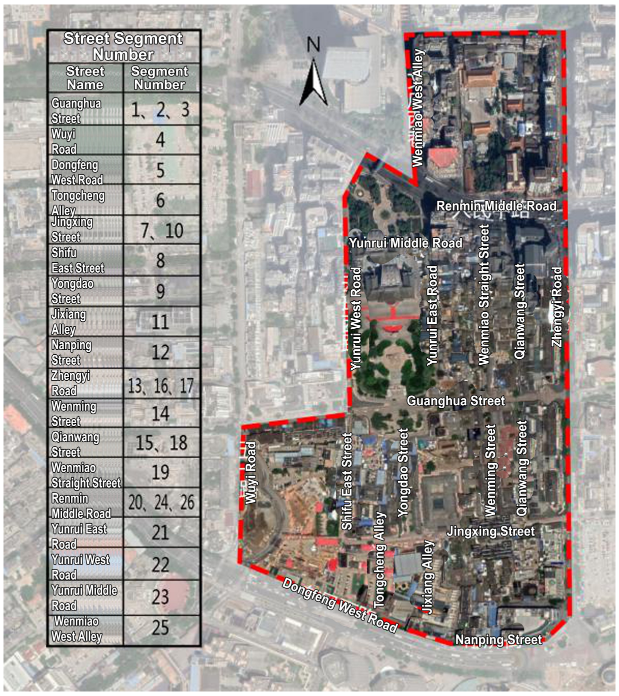

Figure 1 Study area and street segmentation

1.3 Research methodology

First, this study constructs an evaluation index system for the vitality of historical streets by integrating survey data and open-source data. Subsequently, field research and street vitality index analysis are employed to assess the distribution characteristics of street vitality. Finally, stepwise multiple linear regression is applied to reveal specific factors influencing street vitality, and targeted optimization strategies for the built environment are proposed based on the analysis results.

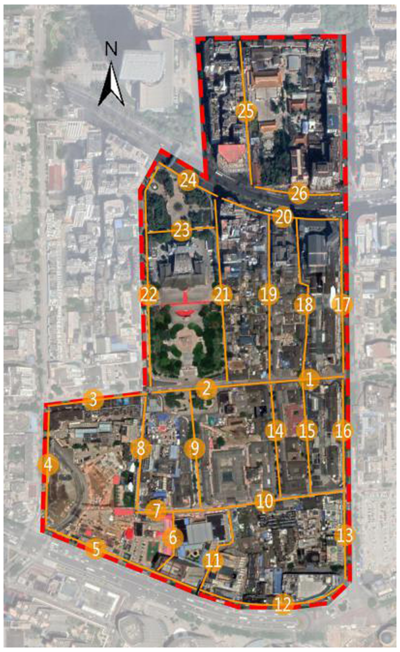

Figure 2 Locations of observation points

1.4 Indicator selection

Drawing on evaluation indicators proposed by relevant scholars[10-22] and considering the unique environmental elements of the district—such as local historical culture and intangible cultural heritage resources—this research develops an index system for evaluating the vitality of historical streets based on external representations and compositional factors.

The external representations of street vitality are primarily synthesized through four indicators: crowd activity density, crowd retention index, diversity of activity types, and diversity of age composition. Crowd activity density is represented by the ratio of measured pedestrian flow to street segment area. The crowd retention index is calculated as the sum of the products of weighted retention time and the number of people retained[26], with the weights determined through expert scoring. Diversity of activity types and age composition diversity are derived using an evenness index approach[11].

The compositional factors of street vitality encompass an analysis of the material spatial attributes and socio-economic characteristics of the streets. This analysis selects indicators across five dimensions: location, accessibility, functionality, interface, and facilities. The "location" is represented by the attractiveness of historical and cultural resources; "accessibility" is assessed through sDNA analysis and transportation convenience; "functionality" includes functional density and functional mix; the "interface" incorporates nine indicators reflecting the physical properties of the street; and "facilities" primarily focus on seating area ratio, billboard density, and trash can density.

1.5 Data sources

The foundational data for this study was obtained from both field research and web-scraped open-source data. Field research documented crowd activity data, street interface data, the quantity of street facilities, street scene photographs, and the distribution of historical resource points. The open-source data included street network information and Points of Interest (POI) from Baidu Maps.

Crowd Activity Data: This was recorded using a cross-sectional pedestrian counting method, categorizing age structure into five groups according to Chinese age segmentation standards: Children, adolescents, young adults, middle-aged individuals, and seniors. To minimize the impact of intersections on pedestrian flow distribution, the midpoints of the 26 streets were designated as observation points (Figure 2). Field research was conducted over four days—two clear weekdays and two clear holidays—during observation periods from 9:30 AM to 12:30 PM and 2:30 PM to 7:30 PM, with data collected every two hours for five-minute intervals.

Street Interface Data: This involved field measurements recording the length and width of streets in the Wenming district, the suitable width for pedestrian movement, the height of adjacent buildings, and the lengths of continuous street wall facades on both sides.

Street Facilities: The field survey quantified the area of seating facilities (including suitable seating areas such as tree pits, flower beds, and stones categorized as "seats"), as well as the number of billboards and trash cans.

Street Scene Photographs: After on-site investigations, specific points that could effectively reflect the overall condition of the streets were identified for photography. Photos were taken from a standing perspective at a height of 1.72 meters, aiming to authentically capture the visual experience of pedestrians engaging in street activities (Figure 3).

Distribution of Historical Resource Points: Based on the "Wenming Street Historical and Cultural District Protection Plan (2012-2020)" and supplemented by field research, the locations of 26 historical and cultural resource points were calibrated and recorded in ArcGIS according to their entrance and exit positions (Figure 4).

Vector Street Network: Baidu Maps street network raster images were scraped and then vectorized in ArcGIS according to actual connectivity.

Baidu Maps POI: Data was scraped in May 2020 using Python 3.6, categorized into five functional types: Dining, shopping, accommodation, leisure and entertainment, and life services. Based on the scale and composition of buildings on either side of Wenming Street, a buffer zone of 30 m on each side of the street centerline was established in ArcGIS, yielding a total of 1633 POI data points.

Figure 3 Street walking perspectives

sDNA is an enhanced spatial syntax program that quantifies and visualizes complex spatial relationships through algorithms, aiding research and design processes [27]. In this context, "proximity" is interpreted as the potential of a space to serve as a destination relative to others, while "throughput" reflects the potential of a space to function as a pathway. For the accessibility analysis based on crowd mobility in the Wenming district, standard metric distances of 400 m, 800 m, and 1200 m were chosen, corresponding to walking times of 5, 10, and 15 minutes, respectively, for the sDNA analysis radius.

1.6 Quantification of indicators

This section outlines the quantification of various street vitality evaluation indicators for the Wenming street block, integrating foundational data with relevant statistical methods (Table 1) to facilitate the construction of a multiple regression model.

Table 1 Evaluation index system for street vitality in historic districts

Dimensions	Characteristics	Indicators		Quantification models
Externalrepresentation of street vitality	Vitality	Street vitality index	Crowd-activity Density	Average pedestrian flow per street area
			Crowd Retention Index	Sum of the product of dwell time weight and number of visitors
			Diversity of Activity Types	Diversity of activity types calculated using the evenness index
			Diversity of Age Composition	Diversity of age composition calculated using the evenness index
Constituent elements of street vitality	Location	Attractiveness of historical resources		Total shortest distance from the midpoint of the street to various historical resource points
	Accessibility	sDNA proximity		Proximity analysis using sDNA with analysis radii of 400 m, 800 m, and 1200 m
		sDNA passage		Passage analysis using sDNA with analysis radii of 400 m, 800 m, and 1200 m
		Traffic convenience		Total shortest distance from the midpoint of the street to nearby subway and bus stops
	Functionality	Functional density		Number of Points of Interest (POI) within a 40 m buffer of the street divided by street length
		Functional mix		Functional mix calculated using information entropy, where the functional mix is represented as the ratio of the number of a specific type of POI to the total number of POIs on the street
	Interface	Street length		Length of street centerline
		Street width		Average street width
		Building height		Average height of buildings along the street
		Street aspect ratio		Ratio of average street width to average building height
		Pedestrian-friendly width		Average pedestrian-friendly width
		Continuity of interface		Total length of continuous street wall facades on both sides divided by street length
		Spatial enclosure		Spatial enclosure calculated using pixel values extracted from streetscape photos using Photoshop's histogram function, defined as wall pixel values divided by total pixel values
		Spatial openness		Spatial openness calculated using pixel values from streetscape photos in Photoshop, defined as sky pixel values divided by total pixel values
		Green view ratio		Green view ratio calculated using pixel values from streetscape photos in Photoshop, defined as greening pixel values divided by total pixel values
	Facilities	Seating area ratio		Seating facility area divided by street length
		Density of waste bins		Number of waste bins divided by street length
		Billboard density		Number of billboards divided by street length

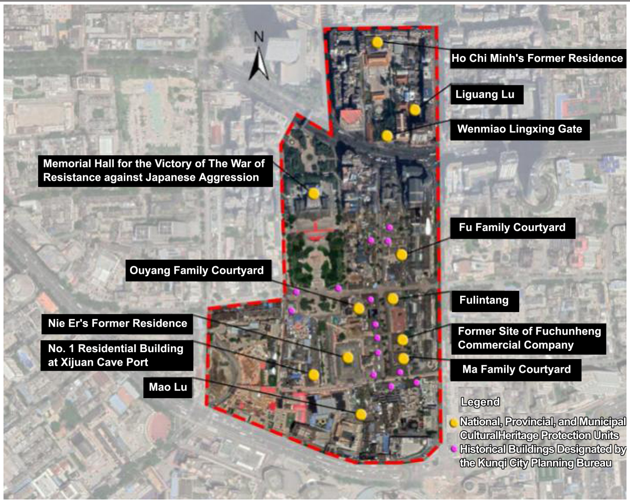

Figure 4 Distribution of historical resource points

2 Distribution characteristics of street vitality

2.1 Analysis of survey results

The field survey provided data on pedestrian flow, age distribution, dwell time, and the variety of activities across various streets over a four-day period.

2.1.1 Distribution of crowd-activity density

Average pedestrian flows for weekdays and holidays were calculated and divided by the street area to derive the crowd-activity density distribution for these two time periods (Figure 5). Overall, the activity density during holidays significantly exceeds that of weekdays, with pedestrian concentrations peaking in the afternoon from 14:30 to 19:30 compared to the morning hours. From the perspective of average activity density, Nanping Street (Segment 12), Zhengyi Road (Segment 13), and Jingxing Street (Segment 10) ranked highest with densities of 0.175 people/m^2, 0.156 people/m^2, and 0.151 people/m^2, respectively. In contrast, Yunrui East Road (Segment 21), Yunrui West Road (Segment 22), and Wenmiao West Alley (Segment 25) exhibited sparse activity, with average densities of only 0.008 people/m^2, 0.009 people/m^2, and 0.011 people/m^2. The analysis of crowd activity density reveals a significant uneven distribution of pedestrian flow within the current block.

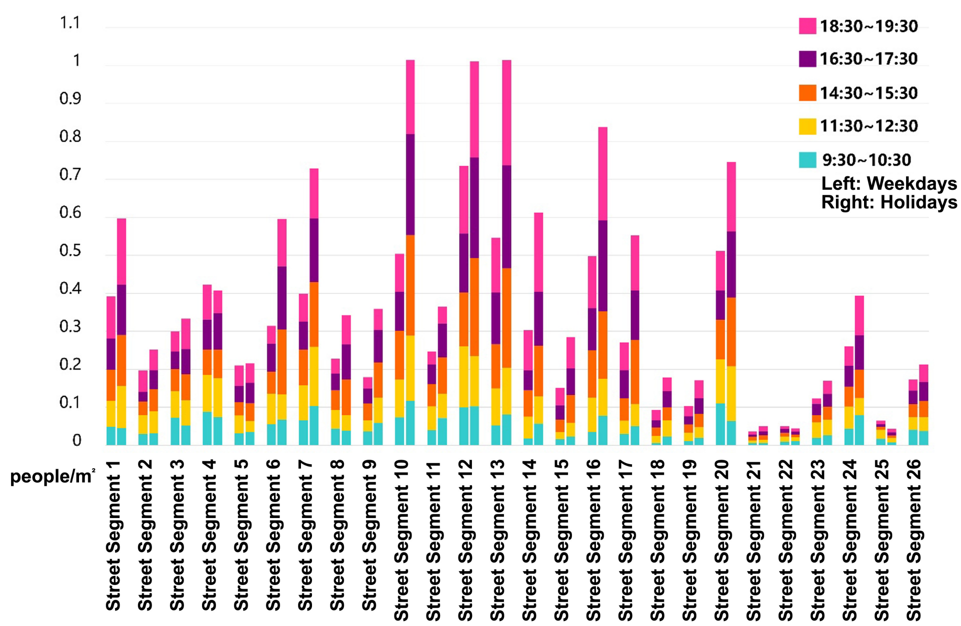

Figure 5 Crowd-activity density

2.1.2 Distribution of crowd age composition

The age composition of pedestrians reflects their preferences to some extent. Analyzing the average values from the four-day survey (Figure 6), it is evident that Zhengyi Road (Segments 13, 16, 17), Wenming Street (Segment 14), and Qianwang Street (Segment 15) have a high proportion of youth, whereas Jixiang Alley (Segment 11), Yunrui West Road (Segment 22), and Wenchang West Alley (Segment 25) exhibit a higher presence of middle-aged and elderly individuals. Observations indicate that streets with a higher proportion of youth are often lined with modern dining and entertainment venues, which attract tourists. In contrast, streets with a significant elderly population, such as Jixiang Alley, are renowned for their flower and bird markets, embodying the daily life memories of "old Kunming residents." Comparatively, streets concentrated with retail and creative commercial culture tend to attract younger demographics, while middle-aged and elderly individuals prefer to engage in activities along streets that maintain traditional functions.

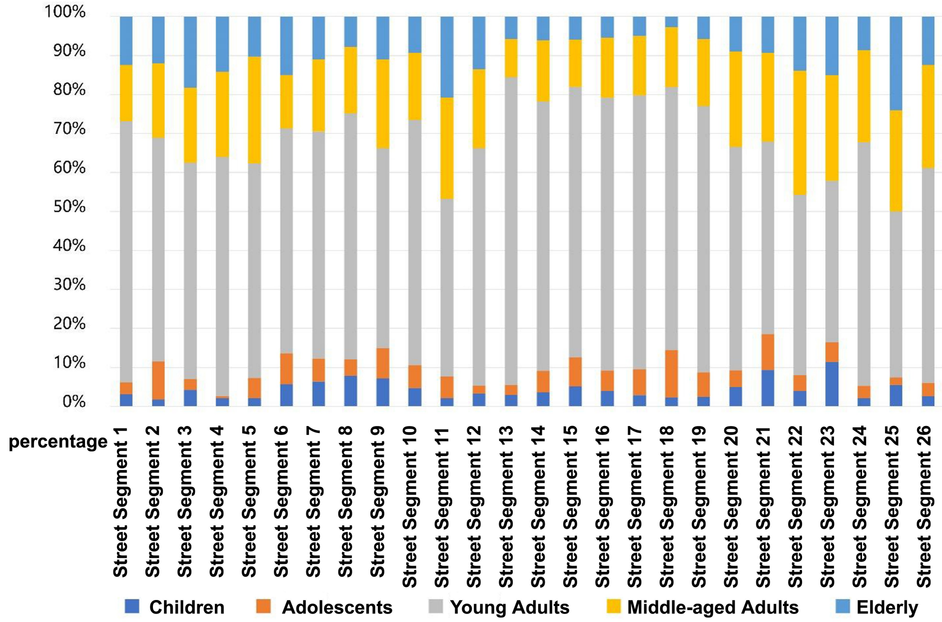

Figure 6 Age composition of the crowd

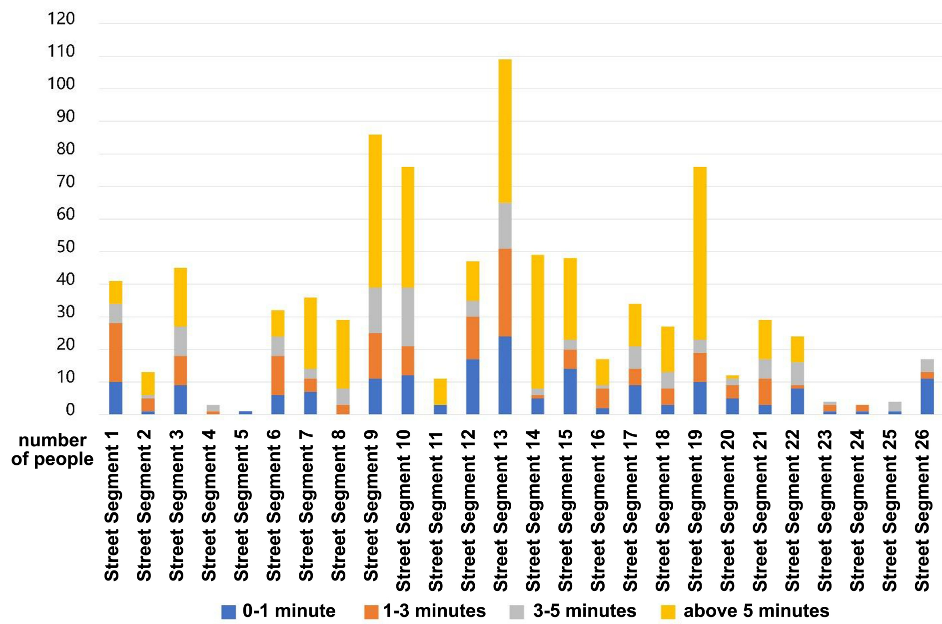

Figure 7 Crowd retention time

2.1.3 Distribution of crowd dwell time

Dwell time is another critical indicator of street vitality, calculated as the average from the four-day survey data (Figure 7). In terms of the number of people lingering, Zhengyi Road (Segment 13), Yongdao Street (Segment 9), Jingxing Street (Segment 10), and Wencheng Straight Street (Segment 19) demonstrate a significant number of individuals, with a considerable proportion staying for over 5 minutes. Field observations reveal that Yongdao Street and Jingxing Street feature numerous movable shops selling cultural goods and snacks, attracting crowds who linger to shop and explore. Conversely, Zhengyi Road and Wencheng Straight Street have commercial setups on both sides, where people gather to rest or dine. In contrast, streets like Wuyi Road (Segment 4) and Dongfeng West Road (Segment 5), which lack resting facilities and have sparse shops, primarily serve as thoroughfares, leading to minimal dwell time for pedestrians.

2.1.4 Distribution of crowd activity types

A vibrant street fosters diverse activities and attracts more passersby. According to Jan Gehl's theory, pedestrian activities were categorized during the survey into necessity activities, spontaneous activities, and social activities (Figure 8). Necessity activities encompass those necessary for daily life, such as commuting and cleaning; as seen in Figure 8, Guanghua Street (Segment 3) records four types of necessity activities, indicating that this segment serves as a vital route to the community hospital, fulfilling essential daily functions. Spontaneous activities refer to those undertaken at individuals' discretion, such as sunbathing, shopping, and strolling. Yongdao Street (Segment 9) excels in this regard, showcasing ten types of spontaneous activities. Social activities involve interactions, such as conversations and gatherings; Jixiang Alley (Segment 11) and Zhengyi Road (Segment 13) exhibit three types of social activities, suggesting that their environments are conducive to interaction. The variety of activity types provides insight into the street's activity atmosphere, with segments like 9 and 13 offering a lively and comprehensive environment. In contrast, Dongfeng West Road (Segment 5) sees hurried pedestrians, as its environment does not support diverse activities.

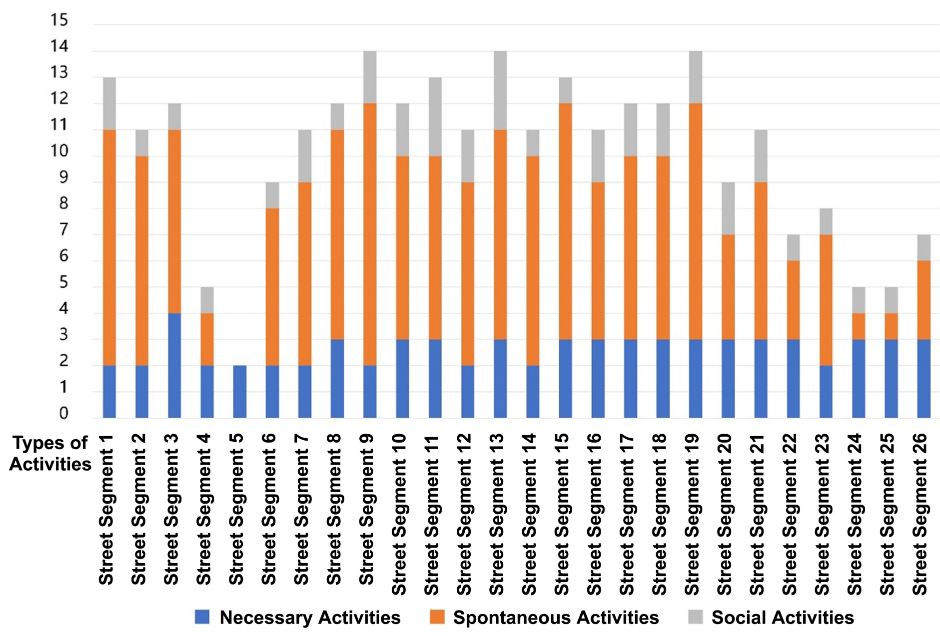

Figure 8 Types of crowd activities

2.2 Distribution characteristics of street vitality

2.2.1 Street vitality index

Given that the assessment of street vitality levels is significantly influenced by subjective factors, it is challenging to determine the contributions of the four aforementioned indicators through the objective weighting method. Therefore, the expert scoring method and statistical averaging were employed. The arithmetic mean of the scores from ten experts, which underwent consistency testing, was used to establish the weights for the four indicators. The average values of the data collected over four days were normalized accordingly.

2.2.2 Distribution characteristics of street vitality

As illustrated in Figure 9, the streets within the Wenming street block exhibiting the highest vitality are Zhengyi Road (Segment 12), Nanping Street (Segment 13), and Jingxing Street (Segment 10), with vitality indices of 0.068, 0.067, and 0.065, respectively. Conversely, the three streets with the lowest vitality indices are Wenmiao West Alley (Segment 25), Yunrui East Road (Segment 22), and Yunrui West Road (Segment 21), which have vitality indices of 0.015, 0.017, and 0.017, respectively. The vitality indices indicate a spatial distribution of vitality in the Wenming street block characterized by high levels in the southeast and low levels in the northwest. Notably, the vitality index of Zhengyi Road is over four times greater than that of Wenmiao West Alley, highlighting a significant unevenness in the current vitality distribution. From the perspective of the built environment, the question arises: what factors contribute to these observed phenomena? To explore this further, the author conducted a stepwise multiple linear regression analysis to identify the specific factors influencing the differential distribution of street vitality.

Figure 9 Street vitality index

3 Factors influencing street vitality

Due to significant differences in values of the independent variables, which may lead to unstandardized coefficients approaching zero (less than 0.0001), all 22 independent variables were normalized before constructing the multiple linear regression model. The model is represented by the following equation:

$$Y = \beta_0 + \beta_i X_i + \varepsilon, i = 1, \cdots, 22$$

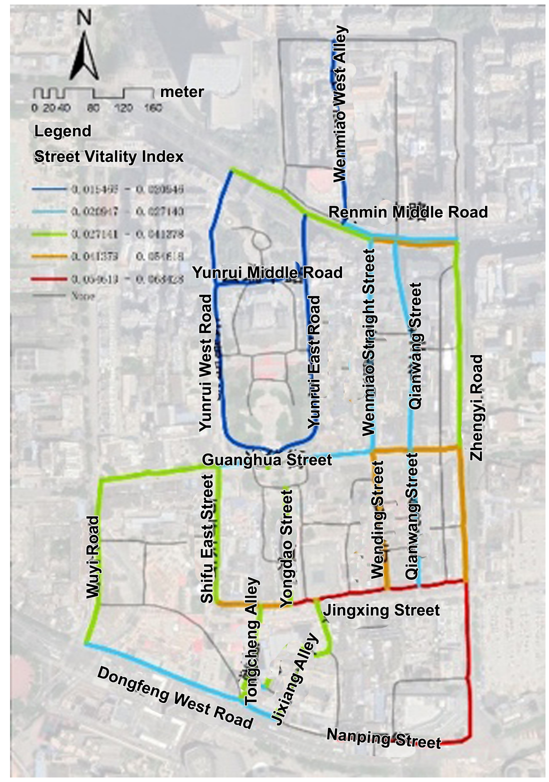

Figure 10 sDNA accessibility (r=1200 m)

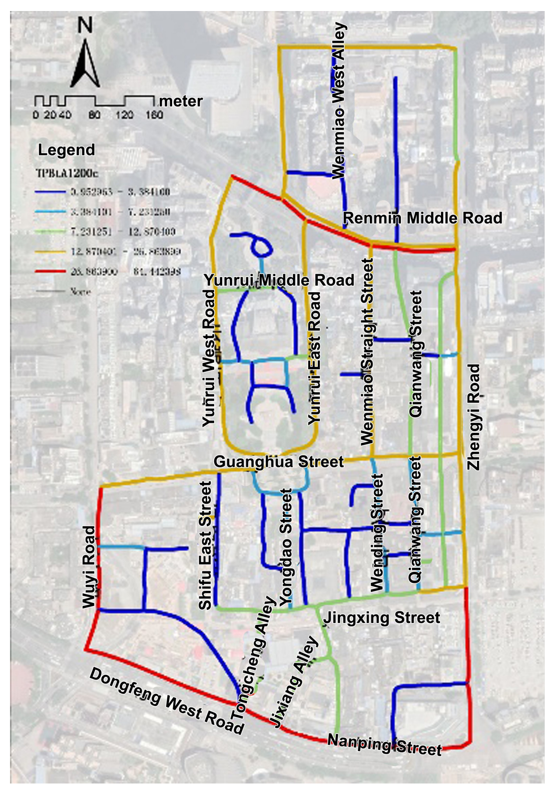

Figure 11 sDNA permeability (r=1200 m)

In this equation, the dependent variable Y represents the street vitality index, while the independent variable X_i

corresponds to various elements constituting street vitality.

In the first step, each of the 22 independent variables was sequentially introduced into the model for stepwise regression analysis. Variables that did not pass the significance tests were removed from the model.

In the second step, four variables remained in the model: sDNA proximity (r= 1200 m), sDNA passage (r= 1200 m), functional density, and street length. The adjusted R^2 value was found to be 0.702, indicating a good fit.

In the third step, the model passed the F-test (F= 15.716, p= 0.0000, α= 0.05), represented by the equation:

Street Vitality Index= 0.077+ 1.449 × sDNA Proximity (r= 1200 m) + 0.354 × sDNA Passage (r= 1200 m) + 0.368 × Functional Density + 0.265 × Street Length.

The variance inflation factor (VIF) for all independent variables was less than 5, and the Durbin-Watson (D-W) statistic was approximately 2, indicating that the model does not suffer from multicollinearity or autocorrelation, thus confirming the overall robustness of the constructed model (Table 2).

Table 2 Results of stepwise regression analysis

	Unstandardized coefficient		Standardized coefficient	t	p	VIF	R^2	The adjusted R^2	F
	B	Standard error	Beta						
Constant	0.077	0.018	—	4.251	0.000**	—	0.75	0.702	F(4,22)= 15.716, p= 0.000
sDNA proximity (r= 1200 m)	1.449	0.52	0.464	2.79	0.011*	2.319			
sDNA passage (r= 1200 m)	0.354	0.079	0.743	4.463	0.000**	2.327			
Functional density	0.368	0.068	0.619	5.436	0.000**	1.088			
Street length	-0.265	0.123	-0.247	-2.152	0.043*	1.106			
Dependent variable: street vitality index									
D-W value: 2.045									
* p< 0.05 ** p< 0.01									

Based on the standardized coefficients and p-values, it is evident that sDNA passage (r= 1200 m), sDNA proximity (r= 1200 m), and functional density have a significant positive impact on the street vitality index, while street length exhibits a significant negative impact. The influence of these factors, ranked from greatest to least, is as follows: sDNA passage (r= 1200 m) > functional density > sDNA proximity (r= 1200 m) > street length.

3.1 Accessibility

The influence of sDNA passage and proximity (r= 1200 m) on the vitality of streets within the Wenming street block is substantial (Figures 10-11). According to space syntax theory, this suggests that the likelihood of streets being selected as destinations or routes within a 1200 m range increases, thereby enhancing their vitality. Given that the Wenming street block prioritizes pedestrian movement, it can be argued that the accessibility of streets within a 1200 m (15-minute) walking radius significantly influences people's natural travel choices within the district. This assertion is predicated on the angular connectivity between the streets.

3.2 Functional density

Functional density along both sides of the street is another crucial factor influencing the vitality of streets within the Wenming street block. Streets with higher functional density tend to attract greater pedestrian traffic. For instance, Nanping Street (Segment 12), a typical commercial pedestrian thoroughfare, achieves a functional density of 1.09 (Figure 12) and a vitality index of 0.067. In contrast, streets in the southwestern corner of the Wenming street block demonstrate low functional density and vitality indices. This phenomenon reflects the potential for a positive feedback loop, where higher functional density along the street fosters increased crowd activity, thus promoting mutual enhancement between street functions and pedestrian engagement.

3.3 Streetlength

There exists a significant negative correlation between street length and the street vitality index, indicating a potential aversion among pedestrians towards streets that lack visible endpoints. For example, Yunrui West Road (Segment 22), the longest street in the block, measures 364 m in length (Figure 13), yet has a vitality index of only 0.017. This underscores the importance of appropriate street lengths in maintaining street vitality. However, it is crucial to note that the lengths of streets in historical blocks are the result of many years of evolution, reflecting a complex spatial fabric developed over time. Therefore, in the context of preservation and renewal practices, attention must be paid to the accessibility of longer streets and the functional density along their corridors.

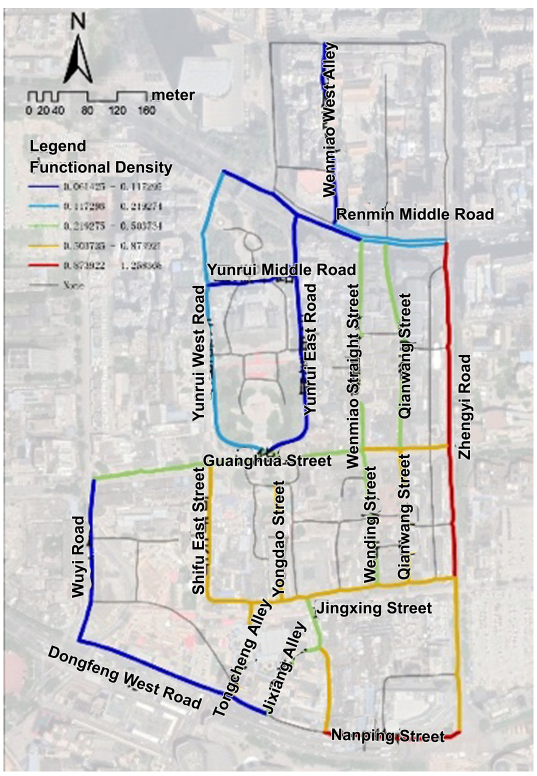

Figure 12 Functional density

4 Strategies for optimizing street vitality in historical blocks

Empirical research indicates considerable variations in street vitality within the Wenming street block, with accessibility, functional density, and street length significantly influencing vitality in historical areas. Given the context of existing stock planning, addressing the preservation and renewal of historical blocks is vital for enhancing urban quality. Thus, exploring how to revitalize traditional streets is critical for guiding new rounds of renewal design.

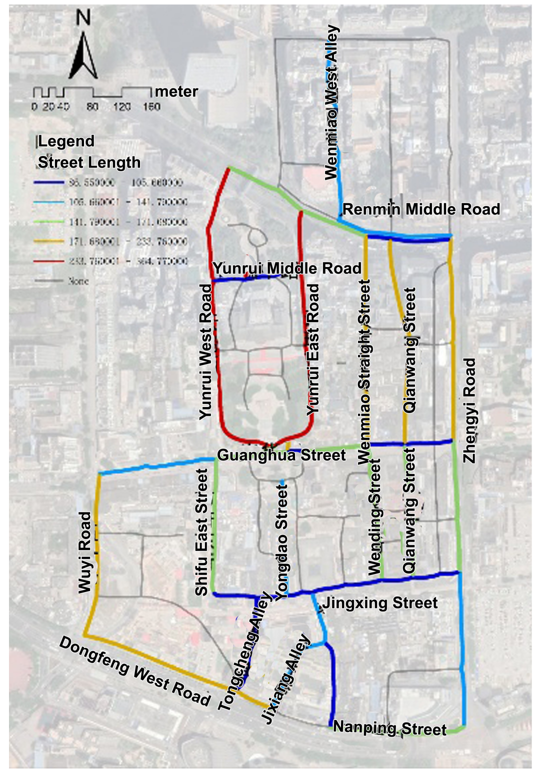

Figure 13 Street length

4.1 Enhancing pedestrian accessibility

According to space syntax theory, the interaction between space, function, and pedestrian flow creates a multiplicative effect: streets with higher accessibility attract more people, which in turn stimulates the development of functions along the street. This enrichment of functions contributes to increased street network density, establishing a positive feedback loop. For instance, while Shifu East Street exhibits appropriate functional density and street length, its vitality is compromised by low accessibility. To address this, measures can be taken to maintain the original spatial fabric while selectively opening alleyways to improve connections with main streets. Additionally, redesigning signposts and related facilities can enhance visual guidance for visitors, thereby attracting pedestrian traffic and fostering functional density.

4.2 Encouraging the design of public open spaces

Street length significantly influences street vitality;

however, adherence to the authenticity of historical blocks necessitates that the spatial fabric of these areas not be easily altered. Excessively long streets can lead to visual fatigue for pedestrians. Therefore, encouraging the creation of diverse and engaging public open spaces is a feasible approach. On one hand, it is essential to design open spaces in areas adjacent to traditional streets where conditions allow, to meet the diverse needs of pedestrian activities. On the other hand, the addition of commercial outdoor seating and movable shops can enhance the shopping and visiting experience for pedestrians.

4.3 Diversifying business types and strengthening thematic guidance

Functional density is correlated with the number of storefronts along the street; thus, increasing storefront density can enhance the pedestrian experience and offer varied shopping options. For instance, Wenmiao Straight Street benefits from good accessibility and suitable street length, yet its low functional density hampers the enhancement of street vitality. Observations reveal that the street primarily features dining and general hardware outlets, indicating that a lack of diverse business types and sparse storefront density restricts vitality. Therefore, it is crucial to diversify business types and increase store density, encouraging street vendors to engage passersby in public life. Additionally, it is important to strengthen thematic guidance for street functions; for example, Jixiang Alley is renowned for its flower and bird market, while the adjacent Yongdao Street attracts tourists through the sale of antiques and collectibles. Strengthening the thematic guidance of street functions helps create differentiated competition and reinforces pedestrians' awareness of the historical block's overall environment.

5 Conclusion and discussion

Through field research and the aggregation of open-source data, this study attempts to construct an evaluation index system for street vitality in historical blocks, measuring the distribution characteristics of vitality within the Wenming street block. Based on the identification of factors influencing street vitality, corresponding optimization strategies are proposed. The research indicates that: (1) The street vitality in the Wenming street block exhibits a spatial distribution characterized by higher levels in the southeast and lower levels in the northwest, revealing a pronounced imbalance; (2) Accessibility and functional density have a significant positive correlation with street vitality, while street length shows a significant negative correlation, with their respective influence ranked as accessibility > functional density > street length.

In addition to pedestrian activity intensity, street vitality is represented by age composition, dwell time, and activity types. The public life within street spaces is vibrant and diverse, and field observations confirm that the composition of the crowd and the variety of activities collectively contribute to the formation of lively public spaces. The new data environment offers opportunities for studying urban spaces at macro and meso scales. The innovative combination of open-source data and field research at the neighborhood scale presents a novel approach. Future research can analyze the differing experiences of various individuals regarding traditional street vitality while increasing the collection and analysis of subjective and objective information from community residents, designers, and managers. This will facilitate the implementation of strategies to enhance pedestrian accessibility, encourage the creation of public open spaces, and diversify business types in urban historical blocks. Ultimately, this fosters a spontaneous awareness across society for preserving the essence of historical culture, allowing historical blocks to retain cultural memory while evolving into vibrant public spaces.

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Figure and table sources

All figures and tables in this manuscript were prepared by the author.

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