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Shopping Mall Site Selection Based on Consumer Behavior Changes in the New Retail Era

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Abstract: As a product of the development of e-commerce over a specific period of time, the "new retail model" breaks the barriers between the traditional retail industry and e-commerce. Supported by Internet technology, it builds a new business model of "physical store + e-commerce + logistics" through the integration of online, offline, and logistics, which also leads to a great change in consumer behavior. Therefore, in order to meet consumer demand and achieve the long-term development of shopping malls, while taking into account the fair allocation of urban space resources, the indicators and methods of shopping mall site selection evaluation in the new retail era will be significantly different from traditional shopping mall site selection decisions. In this paper, the Wuhan East Lake Hi-Tech Zone is selected as the research object, and a comprehensive AHP-GIS assessment model is proposed. By investigating the impact of consumers' behavioral changes on shopping mall location in the new retail era, a suitability evaluation system containing eight evaluation indicators is constructed, and the weights of each factor are determined using hierarchical analysis. At the same time, GIS is used to process the spatial analysis of the indicators, and combined with the weights of the factors, superposition analysis and quantitative research are carried out. Finally, based on the correlation analysis between ratings and customer flow, the suitability evaluation results are further supported in order to provide a more objective and scientific basis for the location of shopping malls from the perspective of the change in consumer behavior under the new retail model, and to put forward universal suggestions for the construction and development of shopping malls in the future.

Keywords: new retail; shopping malls; consumer behavior; site selection decision; AHP-GIS

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1. Introduction

The spatial expansion and competition of commercial activities have been important research topics in geography, economics, and other disciplines [1]. As a commercial complex providing comprehensive services to consumers in a specific area, the reasonable layout of shopping malls plays a crucial role in developing the urban economy, allocating circulation resources and meeting residents' consumption needs [2]. An appropriate shopping mall location can better serve surrounding residents and enable operators to obtain a larger consumer group and better business income, thus maintaining a lasting advantage in long-term commercial competition [3].

Currently, Western scholars primarily focus on traditional location models to explain the impact of land rent on the location of commercial facilities [4–6], while some researchers pay more attention to the spatial structure and hierarchical system of urban commercial areas [7–10]. In China, numerous scholars have explored the relationship between shopping malls' operational efficiency and the factors affecting their location choice from an economic perspective [11]. They have employed multi-layer fuzzy comprehensive evaluation [12,13], structural equation modeling [14], and the Huff probability model to investigate four major

indices: economic environment, social environment, natural environment, and infrastructure. Their findings indicate that the regional economy, shopping district environment, consumption level, and transportation accessibility significantly influence shopping mall location choices, with consumption level and transportation accessibility positively correlating with shopping malls' operational efficiency [15,16].

In the field of geography, some scholars have gradually carried out research on the location planning and evaluation of commercial complexes and shopping malls. Most existing studies combine point-of-interest (POI) data [17,18] with the analytic hierarchy process (AHP) [19,20], spatial interaction models, and other methods [21,22] to construct shopping mall location models and calculate the degree of geographic location advantage. The evaluation factors in these research results are mostly related to economic development level, population concentration, and transportation cost. However, most of these studies lack attention to the association between consumer behavior and the spatial layout of shopping malls, and there is still a gap in the research on shopping mall location in the context of the new retail era, characterized by the deep integration of online and offline sales through the Internet [23,24]. Furthermore, there is a lack of consideration for spatial justice and urban "people-oriented planning" [25]. Therefore, more accurate, scientific, and reasonable indicators and methods are urgently needed for shopping mall layout strategies in the new retail era.

The business model and consumer preferences of Chinese shopping malls have experienced two main phases [26,27]: Initially, shopping malls primarily adopted the business-to-consumer (B2C) model, relying on offline physical stores and generating profits by purchasing commodities in large quantities from suppliers and selling them in smaller quantities to final consumers or social groups. However, with the development of Internet technology and payment methods in China, the e-commerce model focusing on online sales has rapidly emerged. The "online shopping + logistics and distribution" business model has greatly changed consumers' shopping behavior, naturally possessing advantages such as low operating costs, wide market range, rich commodity variety, and shopping convenience, resulting in huge losses for brick-and-mortar retail stores with only a single offline sales channel [28].

As Generation Z (people born between 1995 and 2010) gradually becomes the main consumer group [29], their higher spending power, demand for consumer experience, and personalization have made offline shopping, with its unparalleled advantages in experience and immediacy, favored by consumers once again [30]. The traditional e-commerce operation mode has been challenged by the declining growth rate of online users [31]. To address this situation, Alibaba, China's largest e-commerce company, introduced the concept of "New Retail" in 2016 [32,33], a model that bridges the gap between online e-commerce and offline retail stores [34]. In the new retail era, offline stores attract customers and provide experiential opportunities, while online stores offer order placement and transaction services. Specifically, the new retail model is centered on consumer demand and utilizes state-of-the-art technologies such as "big data, mobile Internet, artificial intelligence, blockchain, and modern logistics" to reconstruct and integrate the retail industry's "people, goods, and field" components [35,36]. In this context, shopping malls can continue to leverage their offline experience and service advantages while expanding their sales channels to gain more opportunities. This shift has also led to changes in consumers' behavioral patterns, such as enjoying instant services, pursuing personalization, focusing on experience and quality, emphasizing social entertainment, fragmentation of consumption time, inclination towards mobile shopping, and increased consumer initiative [37–39]. These changes have rendered the traditional shopping mall site selection indicators potentially inapplicable.

Nowadays, sustainable urban planning with a "people-oriented" approach has become a new consensus [40]. As shopping malls are resources shared by urban residents for shopping, recreation, and interaction, their reasonable allocation is also an essential manifestation of the city's improved livability [41]. However, due to differences in residents' needs across city areas and individualized preferences, blindly carrying out simple equal-

ization of allocation according to living area standards may lead to resource mismatch [42]. To achieve modern and efficient urban governance and optimal use of spatial resources, the distribution of shopping mall sites has shifted from the initial pursuit of per capita "equal quantity" to a "balance of supply and demand" that focuses on the behavioral changes of various social groups under population segmentation. The change in consumer behavior within the radius of shopping malls should be taken as an important reference for site selection [43].

Although new retail is currently the most mature business model unique to China, its development is constrained by urban population density, labor costs, and logistics efficiency. As a product of e-commerce development at a specific stage, it may still serve as a reference for the future business model of shopping malls in the high-density built-up environments of East Asia and Western developed countries, and its site selection model has reference value [44].

In this study, we select the Wuhan East Lake New Technology Development Zone (WENTIDZ), a typical area of the new retail model, as the research object. Leveraging the visual expression and spatial analysis functions of a geographic information system (GIS) and based on the influence of consumer activity transformation in the new retail era, we first identify population density in micro spatial units using mobile phone signaling data with excellent precision and timeliness [45]. Next, we clarify the spatial distribution characteristics of shopping malls in the research area by combining basic urban geographic data. We analyze the accessibility of the commercial area by applying the Gaussian two-step floating catchment area (GA_2SFCA) model, which comprehensively considers both demand and supply aspects [46]. Moreover, we apply the Shannon diversity index to calculate the mixing degree of shopping mall functions of the shopping malls [47] and evaluate the diversity of business models and the resilience of the commercial area for sustainable development. Finally, using the analytic hierarchy process (AHP), we construct a shopping mall site suitability evaluation model in the context of the new retail era, analyzing the influencing factors of shopping malls' spatial distribution in terms of the objective environment, consumer objects, traffic conditions, and economic costs. We optimize the weights of the evaluation factors to propose a multi-objective spatial siting strategy that balances supply and demand. By conducting a correlation analysis between the newly added shopping mall locations and customer traffic and ratings from 2017 to 2023, we further validate the model evaluation results to provide objective, scientific, and operable guidance for the future layout planning of shopping malls.

2. Materials and Methods

2.1. Study Area

The study area of this paper is the Wuhan East Lake New Technology Industrial Development Zone (WENTIDZ), located in Wuhan City, Hubei Province (Figure 1), which was established in 1988 and became one of the first batch of state-level high-tech industrial development zones in China in 1991. It is adjacent to the main urban area of Wuhan and contains two sub-centers, Luxiang and Bao Creek, which are strategically located in extremely favorable conditions. At the same time, as one of the most active areas of commercial, scientific, and educational activities in Wuhan, the consumer population in this area is mainly teachers and students of universities and employees of high-tech enterprises, who have a higher degree of acceptance of the new retail model, higher income, and more personalized consumer demand. It has led to the prosperous development of the new retail model of shopping malls here and become a typical area to study the spatial characteristics of shopping malls in the new retail era.

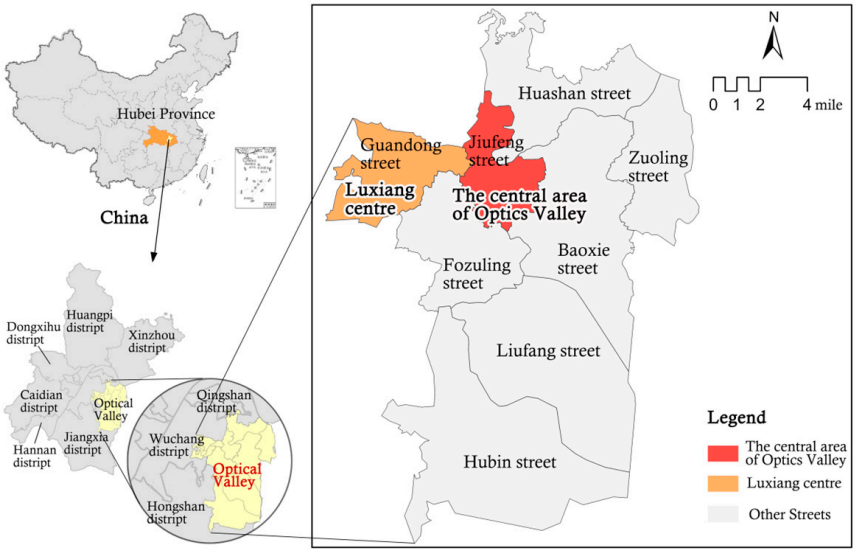


Figure 1. Location analysis map of the Optics Valley area.

Currently, based on field surveys and POI data statistics, there were a total of 64 shopping malls in the WENTIDZ in 2017 (Figure 2). The overall distribution exhibits the following characteristics: Firstly, the service capacity of shopping malls is relatively poor. An analysis of the number and scale of shopping malls on each street of the WENTIDZ reveals an uneven spatial distribution of grades and quantities. Some areas lack high-grade malls to drive overall commercial development, indicating that the development of commercial districts is still immature. Secondly, the commercial construction and consumption levels in the zone are directly related to the LuXiang and central district areas. Based on the distribution of shopping malls to construct a standard deviation ellipse (Figure 3), the distribution of shopping malls is oriented in a northwest–southeast direction, with a "highly concentrated, higher in the north and lower in the south" trend. The statistical sample size within the standard deviation ellipse is 47, covering most of the shopping malls. The strong influence trend is basically consistent with the line connecting the central district and LuXiang, indicating a close correlation of commercial construction and consumption levels between these two central areas.

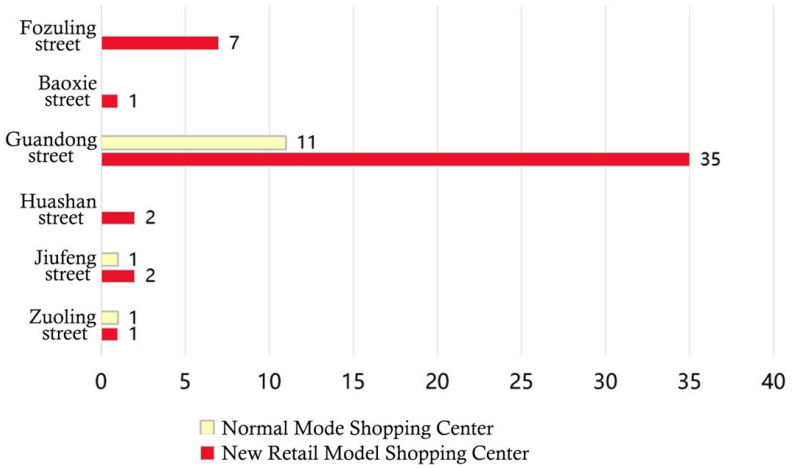


Figure 2. Analysis of shopping mall service capacity.

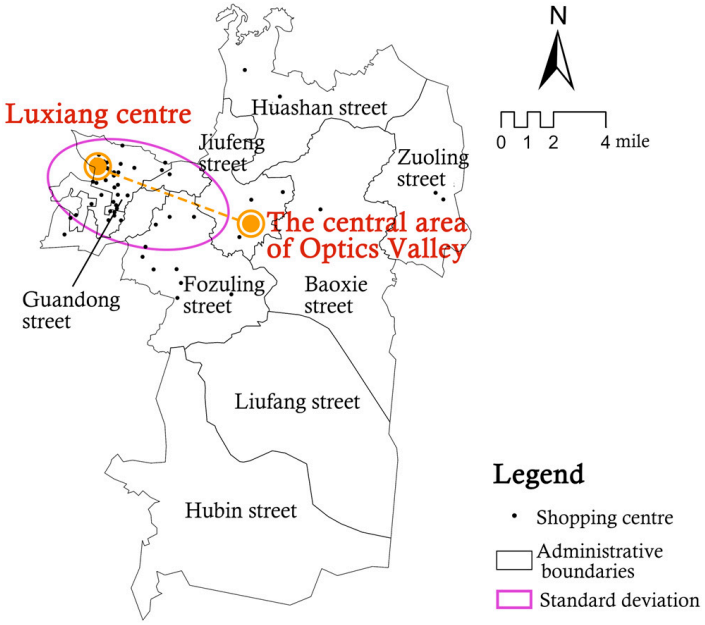


Figure 3. Analysis map of standard deviation ellipse of shopping malls.

2.2. Data Source and Preprocessing

In the context of the new retail model, finding suitable locations for shopping malls is a multi-criteria decision, influenced by various factors such as natural environment and socio-economic conditions. The research team utilized information technologies such as web crawlers and online searches to obtain multi-source data for the study area from 2017 to 2023, including mobile phone signaling data, shopping mall data, residential data, transportation road network data, administrative division data, land use data, and DEM data. The relevant data were converted into spatial vector points or polygons using the ArcGIS 10.8 platform. In the data preprocessing stage, all spatial data were registered, uniformly using the GCS_WGS_1984 coordinate system to ensure data compatibility. Additionally, through questionnaire surveys and interviews, first-hand data on the changes in consumer behavior in the new retail era were obtained (Table 1).

Table 1. Key data and sources.

Data Name	Source
Topographic and geomorphic data	Geospatial data cloud (http://www.gscloud.cn, accessed on 20 June 2023)
Land use data	Wuhan East Lake New Technology Development Zone Natural resources and planning Bureau (https://www.wehdz.gov.cn, accessed on 20 June 2023)
Mobile signaling travel data	Smart Footprint company (http://www.smartsteps.com/, accessed on 20 June 2023)
POI and AOI data	Gaode development platform (https://lbs.amap.com/, accessed on 20 June 2023)
Road network data	OpenStreetMap (https://openstreetmap.com/, accessed on 20 June 2023)
Urban heat map data	Gaode development platform (https://lbs.amap.com/, accessed on 20 June 2023)

2.3. Research Framework

The analysis and evaluation of shopping mall site selection in the new retail era generally involve the following four steps (Figure 4): (a) firstly, conjunction with the background of the new retail model, traditional shopping mall site selection theories are organized and analyzed, and relevant factors for site evaluation are summarized. (b) Secondly, on-site interviews and surveys are conducted to understand the changes in consumer behavior and demand in the new retail era. The results of these interviews are summarized and compiled, and the weights of various factors are calculated using the AHP after being handed over to the mall operators. (c) Then, GIS is utilized for multi-source data analysis to obtain evaluation results for individual indicators. Based on these results, a weighted overlay is performed according to the obtained weights to generate the site evaluation map for shopping malls in the new retail era. (d) Finally, the correlation between the average daily customer flow data of the shopping mall and the site evaluation scores is checked, and a generalized evaluation method is derived for broader application.

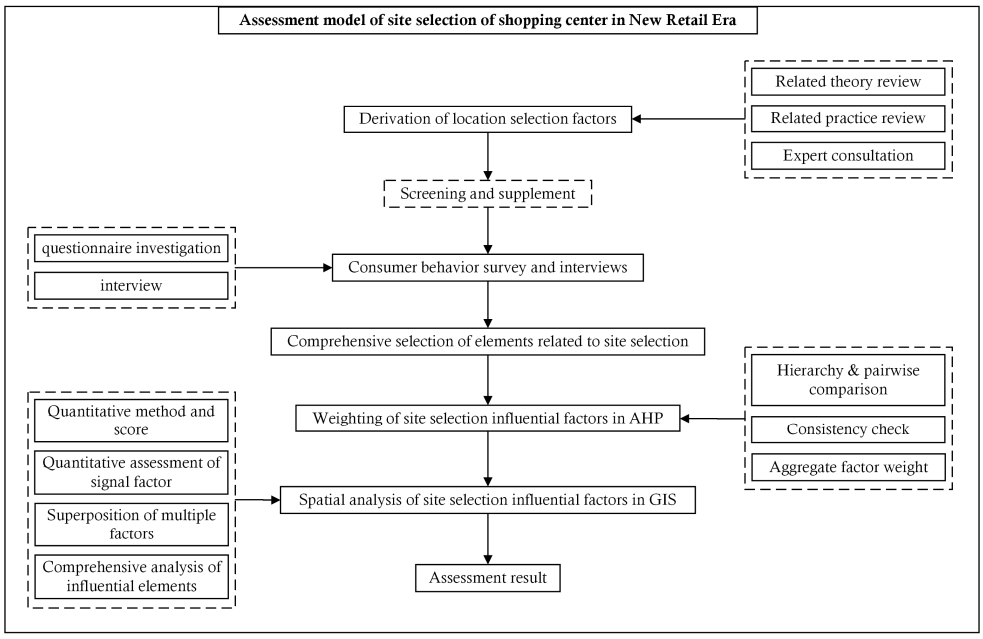
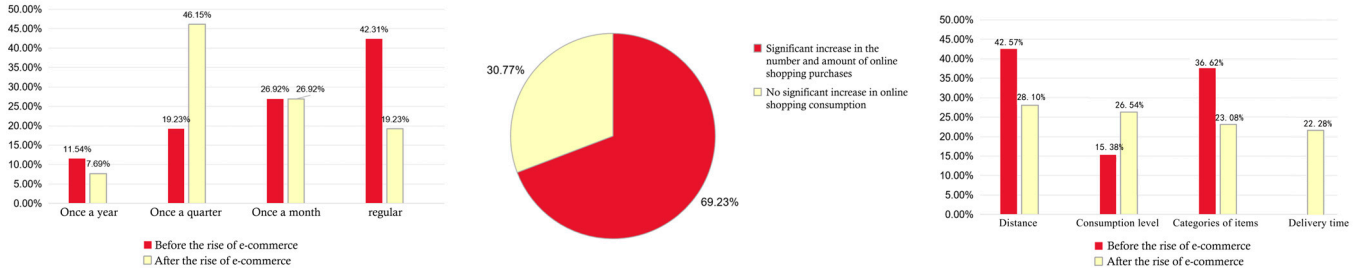


Figure 4. Research framework.

2.4. Analysis of Consumer Behavior Changes in the New Retail Era

With the slowing growth rate of the retail market and the continuous development of e-commerce, traditional retail represented by shopping malls needs to innovate to cater to the era of diversified and personalized consumer behavior. In this context, the new retail model emerged and has been widely embraced by consumers since its rise in 2017, profoundly influencing consumer shopping behavior and habits.

To delve deeper into consumers' real demands and shopping tendencies in the new retail era, the research team conducted random questionnaire surveys and interviews at various shopping malls in the WENTIDZ. A total of 194 valid questionnaires and 83 interview materials were collected. The interviewed consumers were mostly university students and married women with children. Their main consumption categories at shopping malls included dining, clothing, and daily necessities. Based on the survey questionnaire results, the research team conducted a comparative analysis of changes in consumer consumption frequency, consumption shifts, and selection factors before and after the rise of the new retail model (Figure 5).



(**a**) (**b**) (**c**)

Figure 5. Comparison analysis of consumer behavior before and after the rise of e-commerce. (**a**) consumption frequency before and after the new retail model. (**b**) consumption shifts before and after the new retail model. (**c**) selection factors' importance before and after the new retail model.

After the emergence of the new retail model, the frequency of consumers visiting shopping malls generally decreased, as shown in Figure 5a. Further interviews revealed that the majority of consumers believe that their daily consumption cannot be fully realized online, that they still have the need to go to shopping malls in their free time for product experience, dining parties, and recreational networking, and that regular trips to shopping malls are still necessary. As shown in Figure 5b, nearly 70% of respondents significantly increased the frequency and amount of online spending after the emergence of the new retail model, partially replacing their previous offline shopping mall spending. Considerations for shopping malls have also changed, as shown in Figure 5c. In the new retail era, the importance of shopping mall distance has decreased significantly, but due to the increase in the frequency of online shopping, the requirement for the convenience of product delivery has begun to appear. At the same time, although online shopping can provide consumers with more diversified products, in the field of high-grade consumer goods, offline shopping malls are still attracting the majority of consumers, and the requirement of consumers for the consumption grade of shopping malls has increased significantly.

Based on the results of further consumer interviews, it can be seen that the shift in consumer behavior is as follows: ① Compared with the past, consumers' shopping time is more fragmented, and they are more in pursuit of the efficiency of their consumption behavior. Consumers want shopping malls in the new retail era to be closer to the community to reduce travel costs. Or shopping malls are close to public transportation stations to improve the convenience of travel. ② Consumption needs are gradually diversified. Consumer behavior in shopping malls is gradually shifting from purchasing to socializing, and they hope that shopping malls will become a composite place for leisure and entertainment, dining experience, and boutique shopping. Therefore, the construction of shopping malls on the land of the richer industry is more conducive to play a clustering effect, attracting consumers. ③ Pursuit of fast delivery services. Consumers are now accustomed to offline shopping experience, online order payment, door-to-door delivery of new retail service mode; this behavioral change also puts forward new requirements for the speed of commodity distribution. ④ Pursuit of consumer personality. Compared with traditional shopping behavior, consumers nowadays are more inclined to consume personalized or customized goods, which also means that shopping malls need more space to meet consumers' behavioral needs and also means that the land price has become a key factor for developers to consider.

Based on this, the research team compiled and summarized the shift in consumer behavior, which serves as an important reference for the location of shopping malls in the new retail era.

2.5. Shopping Mall Site Selection Research with AHP Process

Hierarchical analysis is a combination of qualitative and quantitative decision analysis methods, often used in multiple criteria, multi-indicator unstructured complex decision-making problems [48–50]. It usually includes the following four steps:

Step 1: Create a hierarchical model.

The site selection of commercial space pursues the maximization of benefits [51]. Compared with the traditional shopping mall site selection pursuing centralization and business circle, the site selection in the new retail era places more emphasis on comprehensive factors such as differentiated competition, proximity to the customer base, fast delivery, convenient public transportation, etc. [52,53]. At the same time, oriented to the demand for customer service, satisfying consumer behavior to obtain greater benefits has become a consensus among the decision makers of the retail industry nowadays [54,55]. Therefore, the research team extensively analyzed the results of the interviews on consumer behavioral changes under the new retail model as an important basis and held discussions with experts and scholars in urban planning and marketing, as well as shopping mall operators, to extensively analyze various factors suitable for the construction of shopping malls, and arrived at 8 factors that best reflect the location of shopping malls in the era of new retail after voting and scoring from the 10 alternative factors. In addition to the topographical conditions, competitors' distribution, radial population, public transportation accessibility, and land price, which are the most frequently concerned factors in traditional site selection [56–58], the convenience of merchandise delivery is included in the index system for the first time [59], and the richness of neighboring industries and the travel cost of the consumers are also taken into consideration so as to satisfy the consumers' demand for the efficiency of the consumption behavior and the functional composite place in the new retail era (Figure 6).

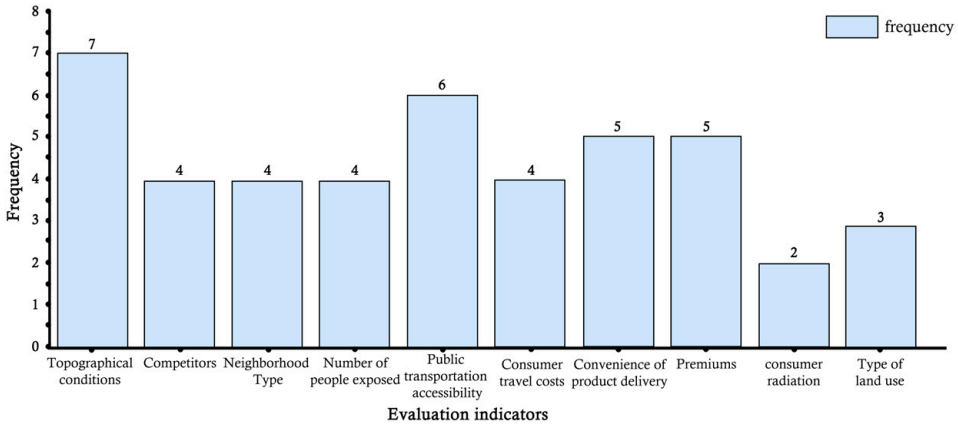


Figure 6. Frequency statistics of evaluation indicators.

Based on this, a three-tier suitability evaluation system was established, including the objective (O), the criterion (C), and the plan (P) (Table 2). The "Objective Environment (C1)" mainly involves the constraints and advantages imposed on shopping malls by the natural and social environment. The "Consumer Object (C2)" evaluates the number of consumers that can be served per unit area of the mall. The "Traffic Conditions (C3)" consider the accessibility of the shopping mall, the travel costs of consumers, and the convenience of product delivery. The "Economic Costs (C4)" consider land costs and the restrictions imposed by policies and plans related to construction.

Table 2. Key indicator description.

Objective (O)	Criterion (C)	Plan (P)	Indicator Description
Suitability evaluation of shopping mall site	Objective Environment (C1)	Terrain and topography conditions (P1)	Determines the cost of land leveling and construction. According to the standard rating, it is considered: not suitable < 0.2% or >20%, relatively unsuitable 15~20%, moderately suitable 10~15%, relatively suitable 5~10%, most suitable 0.2~5%.
		Distribution of competitors (P2)	Determines the competitive relationship with existing shopping centers. Different levels of shopping centers are buffered according to their service areas, and then stacked and classified into five levels, from most suitable to least suitable, according to the natural breakpoint method.
		Abundance of surrounding businesses (P3)	Determines the richness of the existing neighborhood. Measured using the Shannon diversity index and categorized into five levels, from most to least abundant, according to the natural breakpoint method.
	Consumer Object (C2)	Radiated population quantity (P4)	Determines the density of the surrounding consumer population. It is measured using cell phone signaling data and categorized into five levels, from highest density to lowest density, according to the natural breakpoint method.
	Traffic Conditions (C3)	Accessibility of public transportation (P5)	Determine the accessibility of public transportation. Buffer zones are created according to the service radius of different public transportation, superimposed, and categorized into five levels, from the most convenient to the least convenient, according to the natural breakpoint method.
		Cost of transportation (P6)	Determines the transportation cost for residents to reach the shopping center from their homes. Utilizing a modified Gaussian two-step moving search method, it is categorized into five levels, from highest to lowest, according to the natural breakpoint method.
		Convenience of goods delivery (P7)	Determines how quickly the courier can deliver to the customer's home. Using transportation network analysis, it is categorized into five levels, from the quickest to the least quick, according to the natural breakpoint method.
	Economic Costs (C4)	Land price (P8)	Determines the price of available commercial land within the area. It is categorized from most expensive to least expensive according to the natural breakpoint method.

Step 2: Construct the judgment matrix model and assign values.

Use a 1–9 scale on this basis (Table 3), and based on the Delphi method, experts were asked separately. The results were then summarized to obtain the judgment matrix [60].

Table 3. The 9-level quantitative scaling of indicators.

Scale	Meaning
1	Factor *i* is as important as factor *j*
3	Factor *i* is slightly more important than factor *j*
5	Factor *i* is significantly more important than factor *j*
7	Factor *i* is strongly more important than factor *j*
9	Factor *i* is vitally more important than factor *j*
2, 4, 6, 8	Represents the middle value of two adjacent scales
Reciprocal	lf the ratio of element *i* to element j is obtained, the ratio of the importance of element *j* to element *i* is $a_{ij} = 1/a_{ij}$

Where A = (a_{ij}), n = 1, 2, 3, 4, 5. In this formula, a_{ij} represents the comparison result of factor *i* relative to factor *j*, and A is called a pairwise comparison matrix.

Step 3: Calculate the hierarchical weighted vector for each layer and conduct a hierarchical overall ranking.

After constructing the judgment matrix, it is necessary to calculate the weight vector for each factor with the method of a normalized column. The process is as follows: (a) Normalize the matrix by column. (b) Calculate the arithmetic average of each column vector in the judgment matrix A as the final weight C_i. (c) Calculate the maximum eigenvalue λ_{max} and its corresponding eigenvector. (d) Normalize the eigenvector to obtain the index weight of this layer. Calculate the weights of all hierarchical factors relative to the target layer's importance and conduct a comprehensive ranking to obtain the overall hierarchical ranking.

Step 4: Perform consistency testing.

The consistency index is calculated using the following formula (CI):

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

The consistency ratio is calculated using the following formula: (CR):

$$\mathrm{CR} = \frac{CI}{RI} \tag{2}$$

where, *n* is the order of the judgment matrix and CI is obtained from the table based on the order of the judgment matrix. When CR < 0.1, it can be considered as passing the consistency test; otherwise, it is considered as failing, and the judgment matrix needs to be modified. After testing, the CR values of each layer in this study are all less than 0.1, indicating that they pass the consistency test. Consequently, the weights of each influencing factor are determined (Table 4).

Table 4. Weights for each factor.

	Objective Environment (C1)	Consumer Object (C2)	Traffic Conditions (C3)	Economic Costs (C4)	Weights of Each Factor
	0.1737	0.2389	0.3589	0.2286	
Terrain and topography conditions (P1)	0.1637				0.2602
Distribution of competitors (P2)	0.4127				0.0867
Types of surrounding businesses (P3)			0.0881		0.0867
Radiated population quantity (P4)					0.2389
Accessibility of public transportation (P5)		1		1	0.0210
Cost of transportation (P6)	0.4236		0.4872		0.0465
Convenience of goods delivery (P7)					0.1713
Land rice (P8)			0.4247		0.0886

2.6. Site Selection Analysis Based on GIS and Multiple Data Sources

After determining the factors influencing shopping mall site selection through a literature review and expert consultations, a hierarchical structure model was constructed. Subsequently, ArcGIS 10.8 platform was used to conduct various spatial data processing and analysis calculations. Then, the natural breaks method was employed to assess the scores of the eight indicators within the area [61]. And based on land boundaries available for commercial use in the upper-level planning, the evaluation results were clipped. Finally, the results were visualized for presentation.

In the evaluation process, mobile signaling data, known for its convenience, reliability, and high accuracy, were used to calculate the population coverage of shopping malls. The diversity of surrounding businesses was assessed using Shannon's diversity index. The calculation of consumer travel costs utilized an improved Gaussian 2-step floating catchment area method (GA_2SFCA), while the convenience of goods delivery employed network analysis. These three indicators involve complex calculations, but also reflect that the article is centered on the decision-making of shopping mall site selection based on the transformation of consumer shopping behavior in the context of the new retail model.

2.6.1. Assessment Factors for Objective Environmental (C1)

The objective environmental assessment factors for shopping mall site selection include terrain and topography conditions (P1), distribution of competitors (P2), and types of surrounding businesses (P3). The specific calculation methods are as follows:

① The terrain and topography conditions (P1) were determined by calculating the slope of the DEM of the WENTIDZ using the Surface Analysis tool in GIS.

② The distribution of competitors (P2) was determined by generating buffer zones around the existing shopping malls' points of interest based on their respective service radius corresponding to their levels using the Euclidean distance method.

③ The types of surrounding businesses (P3) are measured using Shannon's diversity index (SHDI), which is calculated using the formula:

$$H = -\sum (P_i)(lnP_i) \quad (3)$$

where H refers to the diversity index and P_i refers to the proportion of the i-th type of business type in the grid unit area. SHDI = 0 indicates that the unit consists of only one land type, and the higher the SHDI index, the more land types are present within the unit [62].

Using GIS for mapping processing, a map of objective environmental assessment factors for site selection can be obtained (Figure 7).

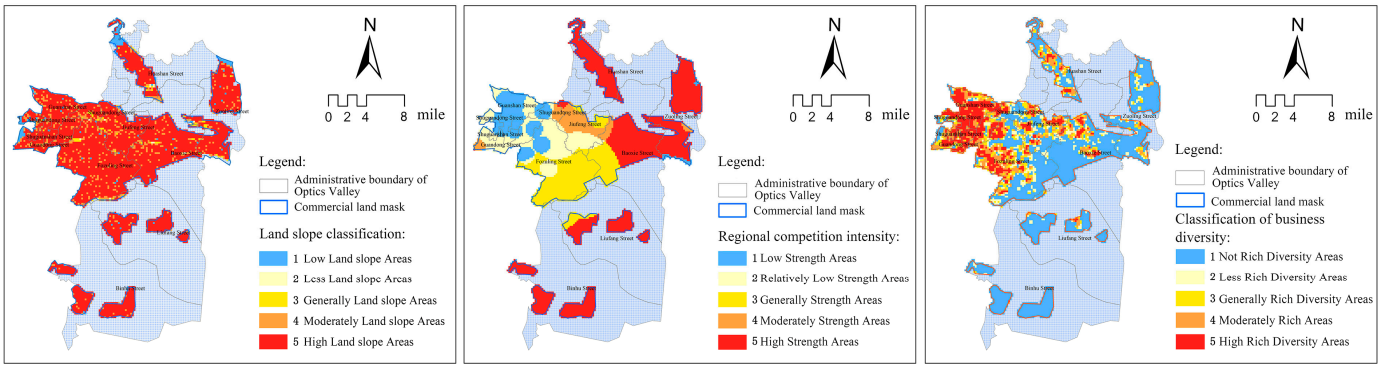


Figure 7. Assessment factors for objective environmental suitability.

2.6.2. Assessment Factors for Consumer Object (C2)

The assessment of consumer objects for shopping mall site selection utilizes the population count radiated by the radiated population quantity (P4). The specific calculation method is as follows.

The density of consumer objects in shopping malls is an approximation of population density using Kernel Density Analysis, which utilizes weekly averaged mobile phone signals data to approximate the population of consumers (Figure 8).

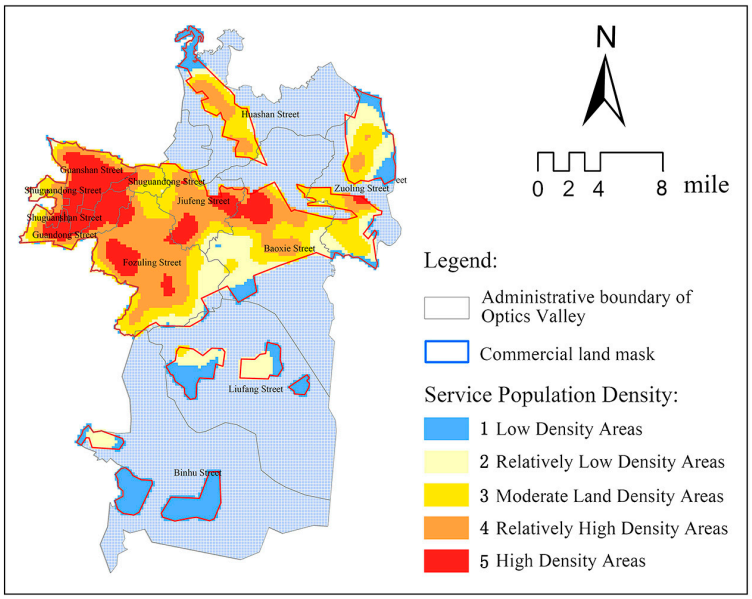


Figure 8. Factors for evaluating consumer object suitability.

2.6.3. Assessment Factors for Traffic Conditions (C3)

The assessment factors of traffic conditions for the site selection include accessibility of public transportation (P5), cost of transportation (P6), and convenience of goods delivery (P7). The specific calculation method is as follows.

① Accessibility of public transportation (P5) is assessed using the multi-ring buffer analysis] tool of GIS. This method creates multiple buffer zones around POIs for bus and subway stations based on their service radius and level, then overlays and analyzes these buffer zones.

② The calculation of cost of transportation (P6) is a crucial aspect of consumer decision-making when choosing shopping destinations, and it is the focus of this analysis. The study group calculated the time required for residents of the WENTIDZ to reach shopping malls of different grades using two modes of transportation: walking and driving. We employed the Gaussian distance decay function, established a multi-level search radius, and incorporated the improved GA_2SFCA, considering both supply- and demand-side competitive effects. This allowed for a multidimensional evaluation of travel costs. The specific steps are outlined below [63].

The basic idea of the improved GA_2SFCA method is to conduct two separate searches based on supply points and demand points within a certain threshold range. The cumulative supply–demand ratio for each demand point is obtained by adding the supply–demand ratios of supply points within the search radius, representing the travel cost.

Step One: For each supply point j, search for all demand points i within a search radius d_0 centered at j, and calculate the supply–demand ratio (R_j), using the following formula:

$$R_j = \frac{S_j}{\sum_{i\in\{d_{ij}\le d_0\}} P_i f_{d_{ij}}} \tag{4}$$

$$f_{d_{ij}} = \begin{cases} \frac{e^{-\frac{1}{2}\times\frac{d_{ij}}{d_0}} - e^{-\frac{1}{2}}}{1-e^{-\frac{1}{2}}}, & d_{ij} < d_0 \\ 0, & d_{ij} \ge d_0 \end{cases}, \tag{5}$$

where d_{ij} in Equation (1) refers to the distance between demand point i and supply point j; S_j refers to the supply scale of supply point j, which in this study is approximated by the level and scale of the shopping mall; and P_i refers to the demand scale of demand point i, which is estimated by the potential population that can be served by the shopping mall within their respective search radius using both walking and driving modes. Within the walking radius, the population proportion is set to 1. Outside the walking radius and within the driving radius, based on the 2017 Wuhan Statistical Yearbook, the private car ownership per household in Wuhan is 30.12 per hundred people. Thus, within the driving radius, the population proportion is set to 0.3012. In addition, $f_{d_{ij}}$ refers to the distance decay function, which in this study is represented by a Gaussian function and can be derived from Equation (2); d_0 in Equation (2) refers to the search radius; and d_{ij} refers to the walking and driving travel distances, calculated as the farthest distance reachable within a 20 min travel time.

Step Two: For each demand point k, search all supply points j within a search radius d_0 centered at k. Utilize Equation (3) to assign weights to the supply–demand ratio R_j for shopping malls closer than the distance threshold, then calculate the accessibility A_i for both walking and driving modes. Sum up all accessibility measures to obtain the overall accessibility A for the residential area to the shopping mall.

$$A_i = \sum_{i \in \{d_{ij} \le d_0\}}^{k} R_j f_{d_{ij}} \tag{6}$$

③ Convenience of goods delivery (P7) is determined through network analysis_service area analysis of GIS. This involves evaluating the coverage area for deliveries by delivery personnel within 10, 15, 20, 25, and 30 min from the urban new retail shopping malls and their distribution warehouses, represented as POI, by first mapping the locations of these malls and warehouses in the GIS, then conducting a network analysis to simulate the transportation paths and conditions, and finally performing a service area analysis to determine the spatial extent that can be reached within each specified time interval, thereby creating detailed coverage maps that visually represent the delivery reach for each time frame.

Using GIS for mapping processing, a transportation condition assessment factor map for shopping mall site selection is generated (Figure 9).

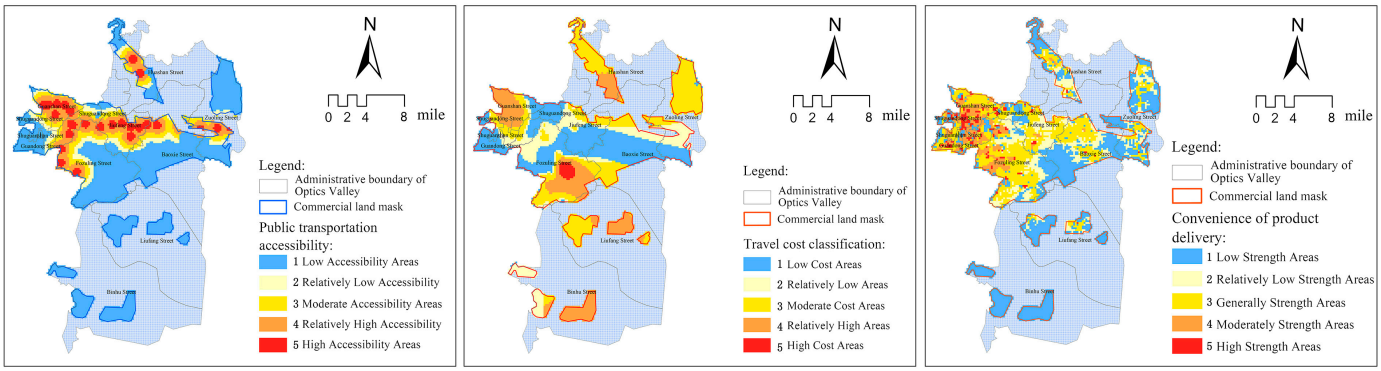


Figure 9. Suitability assessment factors for transportation conditions.

2.6.4. Assessment Factors for Economic Costs (C4)

The evaluation of economic costs is based on the Land Price (P8) of commercial land in the WENTIDZ. The specific calculation method is as follows.

Based on the "Commercial Land Grade and Base Land Price in WENTIDZ", a land price map of Optics Valley is created. After deducting forests, water systems, and beaches, vector data are converted to raster and reclassified. Using GIS for map processing, the economic cost evaluation factor map for shopping mall location is obtained (Figure 10).

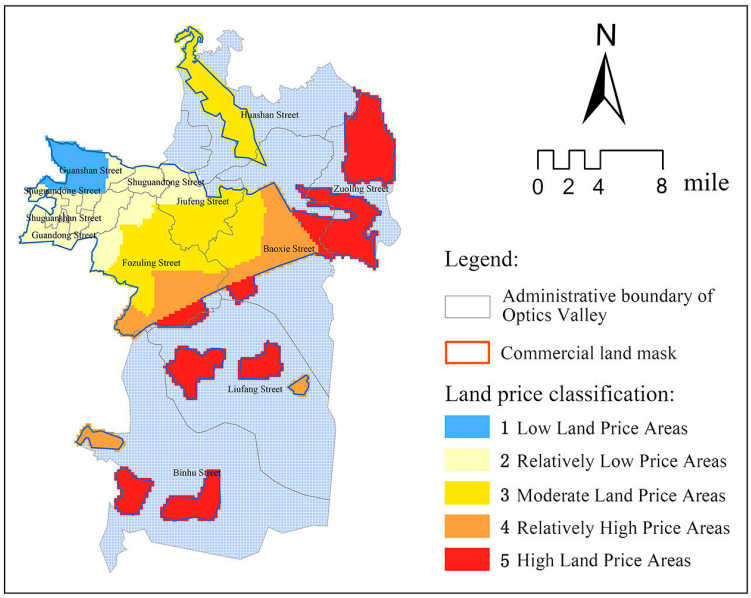


Figure 10. Suitability assessment factors for economic costs.

2.6.5. Evaluation of the Suitability of Shopping Mall Site Selection in the New Retail Era through Geographic Spatial Analysis

Each assessment factor was weighted and summed using ArcGis software to derive the values of the adaptive assessment results for each assessment unit [64]. The natural breakpoint method was used to classify the assessment results into unsuitable zone, less suitable zone, moderately suitable zone, highly suitable zone, and very highly suitable zone, and finally the overall evaluation of the construction of the new retail model shopping mall in the WENTIDZ completed.

3. Results and Analysis

3.1. Assessment Results for Shopping Mall Site Selection in the New Retail Era

After obtaining the evaluation results of the eight indicators mentioned above, the weighted overlay of the eight assessment results was conducted using GIS according to the weights of each influencing factor obtained. Additionally, the natural breaks method was employed to divide the study area into "Unsuitable Areas", "Less Suitable Areas", "Generally Suitable Areas", "Moderately Suitable Areas", and "Highly suitable Areas" (Figure 11). Among the evaluated areas, the suitable areas cover approximately 1.61×10^8 square meters, accounting for 66.12% of the total area. This includes highly suitable areas (56.73%), moderately suitable areas (11.58%), and generally suitable areas (31.69%). In contrast, the unsuitable area covers approximately 8.23×10^7, accounting for 33.88% of the total area.

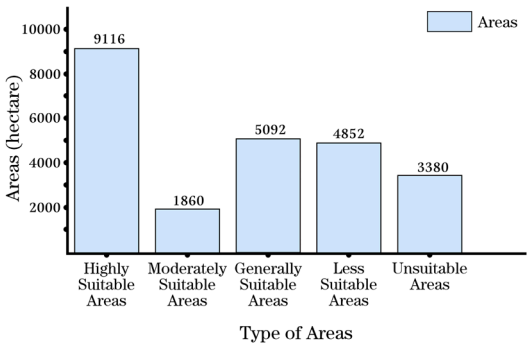


Figure 11. Statistical chart of suitable shopping mall site selection in the WENTIDZ.

Generally speaking, the highly suitable area for the location of shopping malls in the Donghu Hi-Tech Zone shows a group-like distribution pattern, with more in the north and less in the south. Among them, Guanshan Street, Guandong Street, Jiufeng Street, and Fozuling Street all belong to the traditional commercial activity intensive area in the Donghu Hi-tech Zone, which can become the suitable concentration area for shopping mall location in the new retail era under the pressure of competition from existing shopping malls and high land price, not only because of its rich industry and good business environment but also because of the large number of colleges and residential areas around it, which have a large number of consumer objects. At the same time, the region's good transportation infrastructure makes it highly accessible and the speed of delivery services also makes it stand out in the location of shopping malls in the new retail era. Furthermore, due to the government's investment in public transportation and infrastructure in Huashan Street, the traffic conditions and business environment in the area have improved significantly, while due to the large number of high-tech enterprises stationed in Zuoling Street and Leopard Creek Street, the large consumer population and, at the same time, smaller competition in this area of the shopping malls and lower land prices also make the suitability of its location higher.

Liufang Street and Binhu Street, located in the south of Donghu Hi-Tech, are less suitable for the location of shopping malls in the new retail era. There are various reasons for this, although the land price is low and there are fewer shopping malls in the area, so the intensity of competition is low. However, the lack of business foundations, the lack of industry richness, and the lack of sufficient consumer population as well as poor transportation conditions in the region limit the construction of shopping malls in the new retail era. At the same time, there are many lakes and mountains in the area, and there is the Liangzi Lake Ecological Protection Zone, which prevents large-scale development and construction due to the government's requirements for environmental protection (Figure 12).

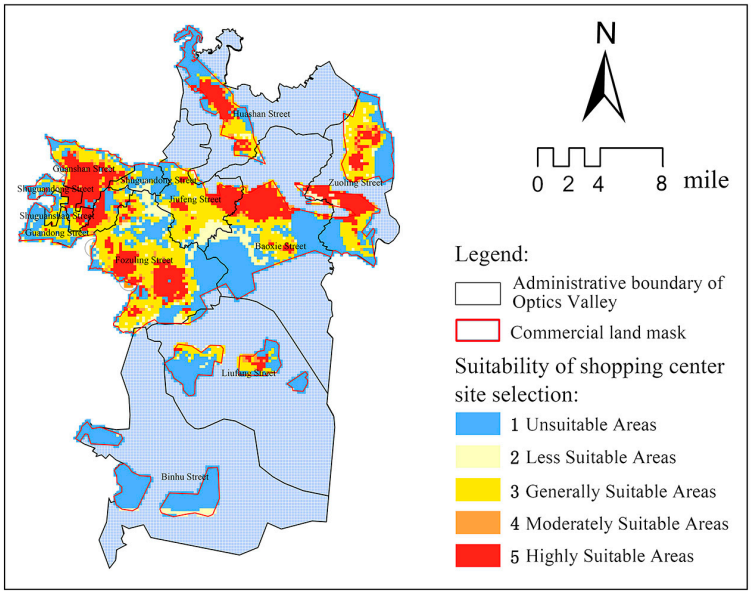


Figure 12. Suitability assessment map for shopping mall site selection in the new retail era.

3.2. Analysis and Validation of New Shopping Mall Site Selection

Since the "new retail model" was first proposed in 2017, there have been nearly seven years of development. In 2017–2023, a total of 18 shopping malls were planned and selected, of which 12 were completed and put into operation; during the same period, 8 shopping malls were closed (Figure 13). By analyzing the sites of new shopping malls and closed shopping malls with the new retail-era shopping mall site suitability evaluation chart, the

following observations can be made: ① The sites of shopping malls in the new retail era have gradually changed from centralized to decentralized and have gradually expanded outward from the central business district of Luxiang. This is because shopping mall operators want to choose to build shopping malls more often in areas that are close to the consumer population and, at the same time, have lower competition and land rent. ② The 12 new shopping malls that have been built and put into operation are all located in areas that are suitable for site selection, including 8 in highly suitable areas, 3 in more suitable areas, and 1 in a generally suitable area. Concurrently, one of the eight closed shopping malls was in the highly suitable areas for it, while two others were located in areas that were generally suitable.

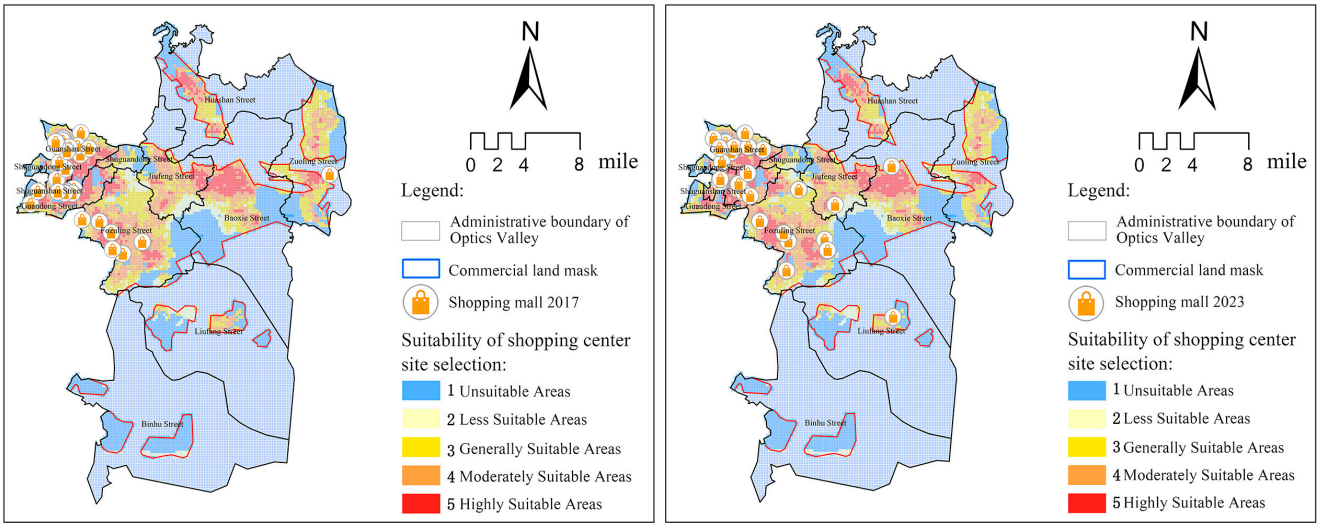


Figure 13. Map of changes in shopping mall distribution, 2017–2023.

Through the specific analysis of the 12 newly completed shopping malls, the following characteristics can be summarized: shopping malls with a large area and high service level are not located in areas where shopping malls were originally concentrated but are located in areas with good transportation conditions and close to residential areas, proving that the location of shopping malls in the new retail era has gradually shifted from "location-oriented" to "consumer-oriented". Most of the new shopping malls in the areas where the original shopping malls are clustered and the competition is fierce are mostly complementary to the original shopping malls, and most of them are shopping malls with smaller floor areas and lower service levels, and their dominant businesses are mostly catering and entertainment, etc., which differentiate themselves from the existing businesses around them and form a differentiated competition, so as to satisfy diversified needs of consumers under efficient shopping behaviors. By evaluating the business conditions of the newly completed shopping malls, the shopping malls in the highly suitable and more suitable areas are in good business condition and have more offline customer traffic. The shopping malls located in the generally suitable areas have lower transportation accessibility, but their scale and service levels are lower, mainly serving the residents in the surrounding areas, and their business conditions are generally acceptable.

The specific analysis of the closure of the three shopping malls located in the more suitable and generally suitable zones shows that, in addition to the malls' own poor management and outdated facilities, there is also a deviation between the evaluation indicators and the actual situation. The completion of the construction of the new viaduct led to the shading of the shopping malls located in the more suitable zones, while noise, pollution, and the deterioration of the shopping environment led to a decrease in consumers, which ultimately led to the closure of the shopping malls.

3.3. Validation of Shopping Mall Site Selection Model in the New Retail Era

Validate the accuracy of the shopping mall site selection suitability model for the new retail era by analyzing the correlation between the site selection evaluation results and the average weekly customer flow. Through telephone interviews with 68 normally operating shopping malls in the Donghu Hi-Tech Zone, we obtained data from 33 of them. Considering that the different sizes and service levels of different shopping malls may have an impact on the average weekly flow, we take the ratio between the average weekly flow of shopping malls and the service level of the shopping malls as the standardized average weekly flow of shopping malls and conduct a Pearson correlation analysis between the evaluation results of the location selection of shopping malls and the results of the evaluation of the location selection of shopping malls. Pearson correlation analysis was conducted to obtain the scatter plot and correlation coefficient as follows (Figure 14).

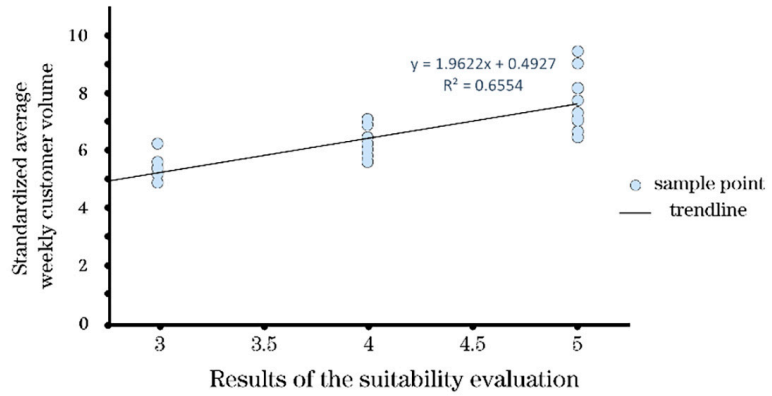


Figure 14. Scatterplot of correlation analysis.

Finding

The result shows that the correlation coefficient $|r| = 0.8043$, which is greater than 0.8, indicating that the two are highly linearly positively correlated. It can be seen that this model has a good effect on the location decision of shopping malls in the new retail era, but the actual shopping mall location factors may be more complicated than those mentioned in the text, and the closure of some shopping malls that are in the appropriate area for location may not be explained well.

4. Discussion and Conclusions

This study constructed a multi-level assessment system based on factors such as objective environment, consumer behavior, transportation conditions, and economic costs. By integrating subjective consumer behavior interviews with objective weightings using the AHP-GIS comprehensive evaluation model, the suitability of shopping mall site selection in the WENTIDZ under the new retail model was thoroughly evaluated. In comparison to previous evaluations' suitability, this paper established an indicator system based on changes in consumer behavior. Leveraging the ArcGIS platform, methods such as Shannon's diversity index, improved GA_2SFCA, and transportation network analysis were employed to calculate indicators. Furthermore, the study compared the spatial and temporal distribution changes of shopping malls before and after the new retail era and utilized correlation analysis to further confirm the scientific and referential nature of the site selection model. The following conclusions were drawn:

(a) Based on the research and interviews on changes in consumer behavior, it is evident that consumers generally welcome shopping malls under the new retail model. This process has also reshaped their consumption behavior characteristics. Firstly, consumers increasingly seek convenient shopping methods, making factors such as transportation accessibility, lower travel costs, and fast delivery crucial considerations. Secondly, consumers place greater emphasis on the experiential aspect of consumption, with offline

behavior focusing on experiential activities and online consumption gradually increasing. Consequently, the continuous expansion of newly built shopping malls' areas has made land prices an important factor, favoring areas with lower land prices that are away from traditional city centers. Lastly, the enhanced social and entertainment attributes of shopping malls in the new retail era, coupled with the diversity and richness of surrounding business formats, have become key considerations in site selection decisions.

(b) Based on the spatial vectorization display of POI data, there were 12 new shopping malls added in 2023 compared to 2017, with the majority concentrated in Guandong Street and a few scattered in Fozuling Street. Overlaying the kernel density analysis maps of the two periods reveals that after the rise of the new retail model, malls are more dispersed compared to before, with high kernel density values slightly shifting towards the southeast. Additionally, there is a trend of forming new clustering points south of Guandong Street. Both observations indicate that shopping malls are moving towards areas more suitable for development, according to the evaluation results. Furthermore, all newly added malls in the years following the rise of the new retail model are located in the most suitable areas, further confirming the scientific and referential nature of the site selection model established in this paper.

(c) The site selection decision for shopping malls in the new retail era is a multidisciplinary and multi-objective comprehensive decision-making process. This study constructs and applies a site selection model primarily from the perspective of consumer behavior, which is the most obvious angle. However, there are still some limitations. For example, due to constraints in data acquisition methods, there may be issues with the accuracy of the research outcomes. Also, due to limitations in decision-making ability, some primary indicators may have relatively simplistic evaluations. In future research endeavors, efforts should be directed towards enhancing accuracy and universality. This can be achieved through more comprehensive evaluations of driving factors and by employing more comprehensive analytical methods. These improvements will enhance the accuracy and applicability of the model, thereby increasing its practical value.

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