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Post-Occupancy Evaluation of the Improved Old Residential Neighborhood Satisfaction Using Principal Component Analysis: The Case of Wuxi, China

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Abstract: Recently, many Chinese cities have initiated improvement projects aimed at enhancing living conditions in older residential neighborhoods. Urban improvement should be closely linked to the needs of occupants to determine "what to improve". Governmental initiatives and the various stakeholders involved in the project influence the impact of improvement efforts. The objectives of the study are essential to identify the factors influencing occupants' satisfaction and to evaluate whether the occupants are satisfied with the improved old residential neighborhoods. This study conducts a post-occupancy evaluation (POE) of improved outdoor spaces in old residential neighborhoods, focusing on neighborhoods in Wuxi, China. A principal component analysis (PCA) was used to evaluate residents' efficacy and satisfaction with the enhancements implemented in outdoor spaces. The methodology involved collecting data through surveys and on-site observations, which were then analyzed to identify the pivotal factors impacting the effectiveness of these improvements. The results indicated that enhancing outdoor spaces had a substantial positive impact on residents' quality of life, social interactions, and physical activity levels. Additionally, the PCA identified accessibility, safety, and aesthetic quality as the main factors contributing to resident satisfaction. This study offers valuable insights for urban planners and policymakers aiming to rejuvenate aging residential districts, emphasizing the importance of data-driven approaches to improve the design and functionality of outdoor spaces.

Keywords: post-occupancy evaluation; principal component analysis; old residential neighborhood; outdoor space; occupant satisfaction

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1. Introduction

1.1. Research Background

Neighborhood improvement programs are interventions that focus on specific locations in order to improve urban neighborhoods that are experiencing distress [1,2]. These programs are widely used in North America, Europe, and other regions as a means of promoting economic development [3–5]. An essential aspect of most improvement initiatives is the acknowledgment of the necessity for collaborations among public, commercial, and non-profit organizations to tackle the entrenched issues of underprivileged areas [6]. The implementation of privately led initiatives to promote coordinated tactics can significantly contribute to improving economically challenged urban areas [1]. However, some countries have also introduced government-funded multi-agency place-based programs, such as Federal Empowerment Zones, to encourage sustainable community development [1].

Old residential neighborhoods refer to areas where the overall use and structure lag behind contemporary requirements, and facilities are relatively modest. These neighborhoods are typically characterized by residential complexes built over 15 years ago [2,7–9].

They often exhibit significant damage to housing, inadequate hardware facilities, a lack of funds for renovation, and urgent needs for remediation by residents [10–12]. Disadvantaged neighborhoods emerged as a significant global socioeconomic concern during the 20th century [2]. Underprivileged areas worldwide, particularly in urban developments in China, commonly host old neighborhoods [2,13]. According to the Ministry of Housing and Urban–Rural Development, there are approximately 170,000 historic residential complexes in Chinese cities [2,14]. With rapid urbanization, residential neighborhoods constructed in the 1980s and 1990s face several issues, including a lack of green spaces, insufficient amenities, malfunctioning infrastructure, inefficient use of space, and poor sanitation conditions [15–17]. These urban neighborhoods, primarily situated in city centers, are numerous and significantly impede positive urban development. Old residential neighborhood satisfaction specifically refers to whether residents living in older neighborhoods are satisfied with their living environment [18,19]. The residents themselves are the subject of this satisfaction. The decline of older neighborhoods and the resulting poverty have a detrimental effect on inhabitants' contentment with their neighborhoods, since it assesses the degree to which neighborhood conditions meet the needs of the residents [20]. The growing discontent among people in the neighborhood intensifies their desire to go elsewhere [21–23]. From a social cohesiveness standpoint, elevated residential mobility hinders the process of social integration, weakens social relationships, and diminishes social control, ultimately resulting in a detrimental loop of neighborhood unhappiness [24,25]. Furthermore, when considering satisfaction as a distinct aspect, discontent with one's neighborhood has a negative impact on total life satisfaction. As a result, planners and policymakers around the world strive to optimize the welfare of inhabitants in aging communities by efficiently utilizing scarce resources, either through rejuvenating neighborhoods or undertaking extensive reconstruction projects. Therefore, in order to promote successful neighborhood revitalization, it is crucial for planners and policymakers to comprehend the fundamental characteristics of a neighborhood that contribute to its residents' pleasure.

Recently, the Chinese government has prioritized the restoration and expansion of old residential neighborhoods. The "13th Five-Year Plan", unveiled in 2016, outlined a systematic approach to thoroughly refurbishing these areas [2]. In 2017, the Ministry of Housing and Urban–Rural Development encouraged experimental initiatives aimed at refurbishing these complexes [14]. However, these policies largely rely on directives from higher authorities and a centralized government framework, providing expedient solutions that fail to fully meet the population's needs, particularly regarding outdoor spaces. Revitalizing older neighborhoods is a critical urban concern, especially in rapidly developing nations like China. As urban areas grow, older residential neighborhoods face challenges related to deteriorating infrastructure, changing social dynamics, and environmental degradation [2,14]. Addressing these challenges requires a thorough assessment and strategic measures to improve residents' well-being.

1.2. Post-Occupancy Evaluation

Post-Occupancy Evaluation (POE) is a technology developed in the United States and has been in use since the 1960s. POE has been described as "an investigation of the designed environment concerning its human users" [26]. The systematic and rigorous evaluation of buildings after they have been erected and occupied for some time, known as POE, is a comprehensive approach to assessing building operational performance [27].

POE is a critical process in assessing the effectiveness of architectural designs and improvements in residential neighborhoods, particularly for old populations [28–31]. It involves a systematic assessment of residents' satisfaction, the functionality of spaces, and the overall performance of the built environment after it has been occupied [28,30,32–35]. The primary goal of POE is to gather data that can inform future design decisions, ensuring that residential environments meet the needs of their inhabitants effectively.

In the context of old residential neighborhoods, POE becomes even more significant due to the unique requirements of elderly residents [33]. These requirements include

accessibility, safety, comfort, and social interaction opportunities, all of which are crucial for promoting the well-being and quality of life of older adults [36–39]. Conducting a thorough POE helps to identify whether the improvements made in these neighborhoods are successful in addressing these needs. The POE process typically involves several steps: defining objectives and scope, data collection, analysis, interpretation and reporting, feedback, and implementation [40].

The POE of this study focuses on the effectiveness of improvements made in old residential neighborhoods. By employing PCA, we aim to distill complex data into principal components that represent the most significant factors affecting resident satisfaction and neighborhood performance. This analytical approach allows for a nuanced understanding of the impact of various design elements and interventions, thereby providing valuable insights for enhancing the living conditions of elderly residents.

Despite advancements in studying old residential neighborhoods and applying POE techniques, several gaps remain [29,31,36,38,41]. The use of advanced analytical methods like PCA is limited, often relying on basic statistics that miss the complexity of residents' experiences [42–44]. Most POE studies focus on short-term evaluations, neglecting long-term impacts [45–47]. Research is predominantly in Western countries, limiting generalizability, especially in Asia and China, and highlighting the need for comparative studies in diverse contexts. Studies often adopt a narrow focus, missing multidisciplinary insights. Current POE frameworks prioritize technical aspects over residents' subjective experiences, emphasizing the need for resident-centric metrics [28,30,31]. The potential of smart technologies and IoT for enhancing POE through improved data collection and analysis remains untapped [48]. Addressing these gaps will advance understanding and inform interventions to enhance the quality of life for elderly residents.

The importance of this study lies in its ability to provide empirical evidence on the effectiveness of recent neighborhood improvements, which can inform future urban renewal strategies. By using PCA, the study can distill complex data into key factors that contribute to successful neighborhood revitalization, offering insights that are both actionable and scalable. The potential impact extends beyond Wuxi, as the findings can be generalized to similar urban contexts, providing a valuable framework for policymakers and urban planners worldwide. This study not only contributes to the academic discourse on post-occupancy evaluation but also has practical implications for enhancing the quality of life in old neighborhoods, ensuring that renovation efforts meet the actual needs of residents, and promoting sustainable urban development. This choice ensures that the findings are generalizable to similar urban contexts, enhancing the study's relevance and potential impact on broader urban planning and policy-making efforts. In order to fill the above research gap, the aims of the present study are as follows: (1) to identify the factors that affect an old residential neighborhood in China; (2) to discover the inter-relationship between each barrier and elaborate the influencing path of the critical barriers; and (3) to provide suggestions for sustainable improved neighborhood.

2. Materials and Methods

2.1. Study Site

The research site is located in Wuxi City, Jiangsu Province, China (refer to Figure 1). Wuxi, located in the southern part of Jiangsu Province, shares borders with Suzhou to the east and Lake Tai to the south. As a core city in the Jiangnan Yangtze River Delta and the Suzhou–Wuxi–Changzhou metropolitan area, Wuxi experiences a subtropical monsoon climate, characterized by mild and humid conditions. The total area of Wuxi is 4627.47 square kilometers, with a permanent population of 7,462,135 according to the 2020 census [49].

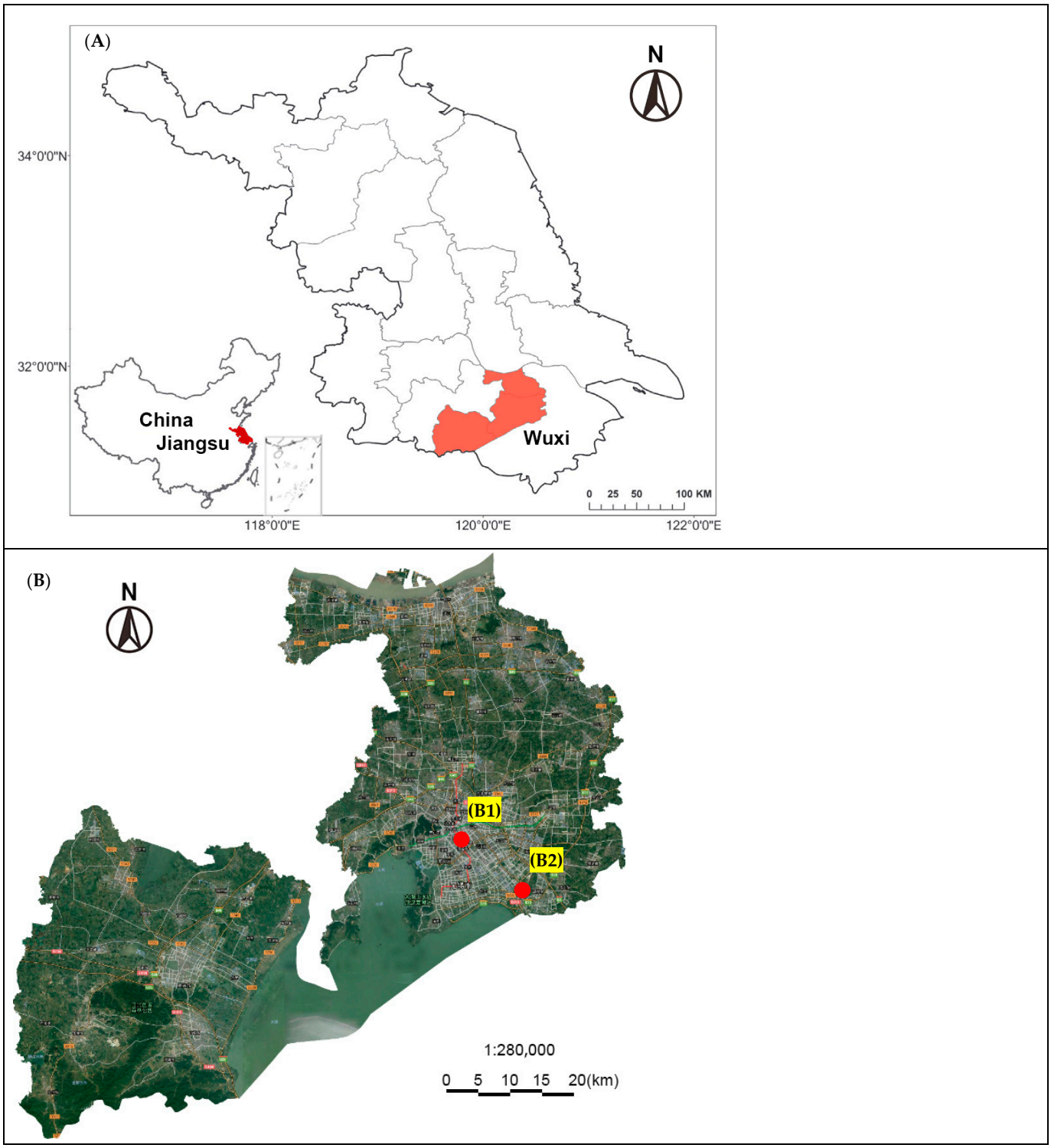

Figure 1. Location of the study area: (**A**) The location of Wuxi in Jiangsu Province, China. (**B**) Topographic map of Wuxi, Jiangsu Province. Source: National boundaries as per the Department of Natural Resources of China, background map. For details as per the open-source data available through BIGEMAP, visit http://www.bigemap.com (accessed on 25 July 2023). B1 is the study site, Oudian neighborhood (West); B2 is the study site, Zhenfa neighborhood.

This study focuses on old residential communities within the Xin Wu District of Wuxi City. Adhering to the concept of "age-friendly", the study aims to address the needs of both the elderly and children. These neighborhoods meet the policy requirements for

neighborhood improvement in Wuxi City and are included in the first batch of neighborhoods to be improved. Due to their representative characteristics of old residential neighborhoods, which include significant infrastructural wear, outdated facilities, and a pressing need for renovation, these neighborhoods exemplify typical old residential areas with varied housing conditions and demographic diversity, providing a comprehensive data set for analysis. Recent improvement projects in these neighborhoods allow for a practical context to apply post-occupancy evaluation methods, assessing the effectiveness of renovations and identifying remaining needs. Additionally, the availability of reliable data, local support from municipal authorities, and alignment with Wuxi's urban development initiatives facilitate a robust study. This choice ensures that the findings are generalizable to similar urban contexts, enhancing the study's relevance and potential impact on broader urban planning and policy-making efforts. Consequently, the renovation of these old communities involves improving building quality, eliminating safety hazards, ensuring the safe operation of infrastructure, optimizing landscaping, and enhancing traffic organization and parking facilities. These residential communities, which were built in the 1990s, are characterized by dilapidated buildings, a lack of green infrastructure, insufficient space, and a higher proportion of vulnerable groups such as the elderly and low-income populations. Therefore, following a selection process, two residential communities, the Oudian Neighborhood (west) and the Zhenfa Neighborhood, were included in the study (Figures 2 and 3). The preliminary survey data provided a summary of the construction period, number of households, building types, and community features of these two neighborhoods (Figures 2 and 3). For more neighborhood information, please refer to Supplementary Materials.

Project name	**Oudian neighborhood (west)**
Location	Wuxi
Number of blocks	48 blocks
The level of each block	5 Floors + 6 blocks
Walk-up apartments	6 Floors + 27 blocks
Walk-up apartments	7 Floors + 9 blocks
Total Area	48,665 m²
Total Building Area	-
Car Parking ground area	620
Green Area in the master plan	22,350 m²
No. of households	938
Population	3100
Construction Year	2000
Nature of ownership	Individual property rights housing

Figure 2. Living environments of Oudian neighborhood (West) in Wuxi, China (Source: the author).

Project name	**Zhenfa neighborhood**
Location	Wu Xi
Number of units	55 units
The level of each block	6 floors (Walk-up apartments)
Total Area	40,855 m²
Total Building Area	69,697 m²
Car Parking ground area	230
Green Area in the master plan	18,571 m²
No. of households	660
Population	2400
Construction Year	2007
Nature of ownership	Individual property rights housing

Figure 3. Living environments of Zhenfa neighborhood (West) in Wuxi, China (Source: the author).

2.2. Sampling

The population of the Oudian neighborhood (west) is about 3100; the population of the Zhenfa neighborhood is about 2300. The total number of people is 5400. In addition, the sample size of the questionnaire was determined using the Taro Yamane technique, with a 95% confidence level. In this study, the effective population size (N) was 5400. The sample error (e) was considered 0.05, indicating a 95% confidence that the sample size accurately represents the population. This process resulted in a sample size (n) of 372 respondents, representing 6.9% of the population (building occupants).

$$n = \frac{N}{1 + Ne^2} = \frac{5400}{1 + (5400 * 0.05^2)} = 372 \quad (1)$$

Equation: A Basic Formula for Ratios. Source: Yamane, (1967) [50].

2.3. Data Collection

2.3.1. Survey Instruments and Procedure

The POE in the research assesses resident satisfaction as a key criterion. The research employed the case study methodology, utilizing structured questionnaires as the primary means of data gathering. The study employed a probability-random sampling strategy to select a diverse and representative group of participants. To enhance the precision and relevance of the collected data, the participant selection criteria were that individuals must have lived in the neighborhood for a minimum of two years and be at least 18 years old, in accordance with ethical requirements. The purpose of this criteria was to guarantee that participants possessed a comprehensive comprehension of the case study area.

There are two types of questionnaires: paper questionnaires and online electronic questionnaires. Both types contain the same survey information. People mostly received the online questionnaire through community WeChat groups, giving them the option to scan a QR code and complete it on-site. Before submitting, participants were required to fill out all essential information. Residents who completed the questionnaire received a

memento, either a CNY 1 gift card or a CNY 2 children's doll. Five surveyors provided on-site assistance to senior community members by conducting interviews to help them complete the paper surveys.

The semi-closed questionnaire consisted of two parts. The first part gathered residents' basic information, including gender, age, education level, marital status, occupation, number of household members, and house ownership. In the subsequent quantitative analysis, demographic questions were used to understand which personal attributes influenced resident evaluation. The second part assessed residents' perceptions of the renovated old residential improvement project using a 5-point Likert scale to facilitate data analysis.

2.3.2. Ethical Considerations

The Ethics Committee for Research involving Human Subjects of the University Putra Malaysia (JKEUPM) granted approval for the study. Reference number: JKEUPM-2023-352. Informed consent was secured from all participants, ensuring confidentiality and the right to withdraw from the study at any time without consequence.

2.4. Data Analysis

PCA, a robust statistical technique, was employed to reduce the dimensionality of complicated data sets while preserving the most significant information in order to accomplish these goals [51–53]. It is employed to identify the factors influencing resident satisfaction [51]. The project entailed gathering data via surveys delivered to the inhabitants of several refurbished neighborhoods in Wuxi. The poll encompassed inquiries regarding several criteria, including the quality of infrastructure, accessibility, safety, social cohesiveness, environmental conditions, and general satisfaction. PCA was applied to the gathered data in order to discover the primary factors that explain the highest amount of variation in resident satisfaction. By condensing the data into these essential elements, we may gain a deeper comprehension of the various dimensions of community quality and identify the precise locations where enhancements yield the greatest influence.

2.5. Principal Component Analysis (PCA)

PCA was employed to reduce the dimensionality of our data by transforming numerous related indicators into a set of comprehensive, independent indices through mathematical transformations. These comprehensive indices represent the primary components of the original variables and provide a quantitative, intuitive, and efficient means of evaluating the key factors influencing the current condition and satisfaction levels of the old neighborhood. All data analysis was performed using the Statistical Products and Services Solution (SPSS) software, version 26.0. By applying the PCA model, we effectively reduced the data dimension and the number of variables. For a more in-depth understanding of PCA, you can refer to references [54,55]. In conclusion, the current condition and residents' satisfaction with the outdoor spaces in the old neighborhood were quantified using a comprehensive score derived from the principal components. For a visual representation of the PCA method (refer to Figure 4). In this research, the application of the PCA method is to identify and simplify the factors influencing occupant satisfaction.

Let L_k be a linear manifold of dimension k given in the parametric form as

$L_k = \{v_0 + a_1 v_1 + a_2 v_2 + \cdots + a_k v_k\}$, where $a_i \in \mathbb{R}$, $v_0 \in \mathbb{R}^m$ and $\{v_1, v_2, \cdots, v_k\}$ is a set of orthonormal vectors in $\mathbb{R}^m$.

Let $x_i \in \mathbb{R}^m$ be data elements, we will let $x_{i\alpha}$ represent the value of the αth variable for the ith observation, where $i = 1, 2, \ldots, n$ and $\alpha = 1, 2, \ldots, m$. For this thesis, the coordinates will be represented by Greek indices while the observations will be represented by Latin indices. We let X denote an $n \times m$ matrix whose (i, α)th element is $x_{i\alpha}$. That is

$$X = \begin{pmatrix} X_{11} & X_{12} \cdots & X_{1m} \\ X_{21} & X_{22} \cdots & X_{2m} \\ \vdots & \ddots & \vdots \\ X_{n1} & X_{n2} \cdots & X_{nm} \end{pmatrix} \tag{2}$$

For all computations, we assume that the data are centered; this can be achieved by simple translation of the data.

For any pair of vectors x and y, we define the distance function *dist*(**x**, **y**) such that the following axioms are satisfied:

$$dist\ (\mathrm{x},\ \mathrm{y})\ \geq\ 0 \text{ and } dist\ (\mathrm{x},\ \mathrm{y}) = 0 \text{ if and only if } \mathrm{x}\ = \mathrm{y}\ (\text{nonnegative}), \tag{3}$$

$$dist\ (\mathrm{x},\ \mathrm{y}) = dist\ (\mathrm{y},\ \mathrm{x})\ (\text{symmetry property}), \tag{4}$$

$$\mathrm{dist}\ (\mathrm{x},\ \mathrm{z})\ \leq \mathrm{dist}\ (\mathrm{x},\ \mathrm{y}) + \mathrm{dist}\ (\mathrm{y},\ \mathrm{z})\ (\text{triangle inequality}). \tag{5}$$

The orthogonal projection denoted by $P_Y\ (\mathrm{x})$ is defined for an object x and a set of vectors Y as a vector in Y, which minimizes *dist* (x, y), $\mathrm{y}\ \in Y$. That is $P_Y\ (\mathrm{x}) = \underset{\mathrm{y}\in Y}{\operatorname{argmin}} dist\ (\mathrm{x},\ \mathrm{y})$.

When *dist* (x, y) is the Euclidean distance, it can be shown that the orthogonal projection of data x_i, $i = 1, 2, \cdots, n$ to the plane L_k denoted by $\mathrm{P}_L(\mathrm{x}) = \sum_{\alpha=1}^{k} \mathrm{v}_\alpha \langle \mathrm{v}_\alpha,\ \mathrm{x} \rangle$. Where the inner product between any pair of vectors a and $\mathrm{b} \in \mathbb{R}^m$ is given as $\langle \mathrm{a}, \mathrm{b} \rangle = \sum_{i=1}^{m} a_i b_i$.

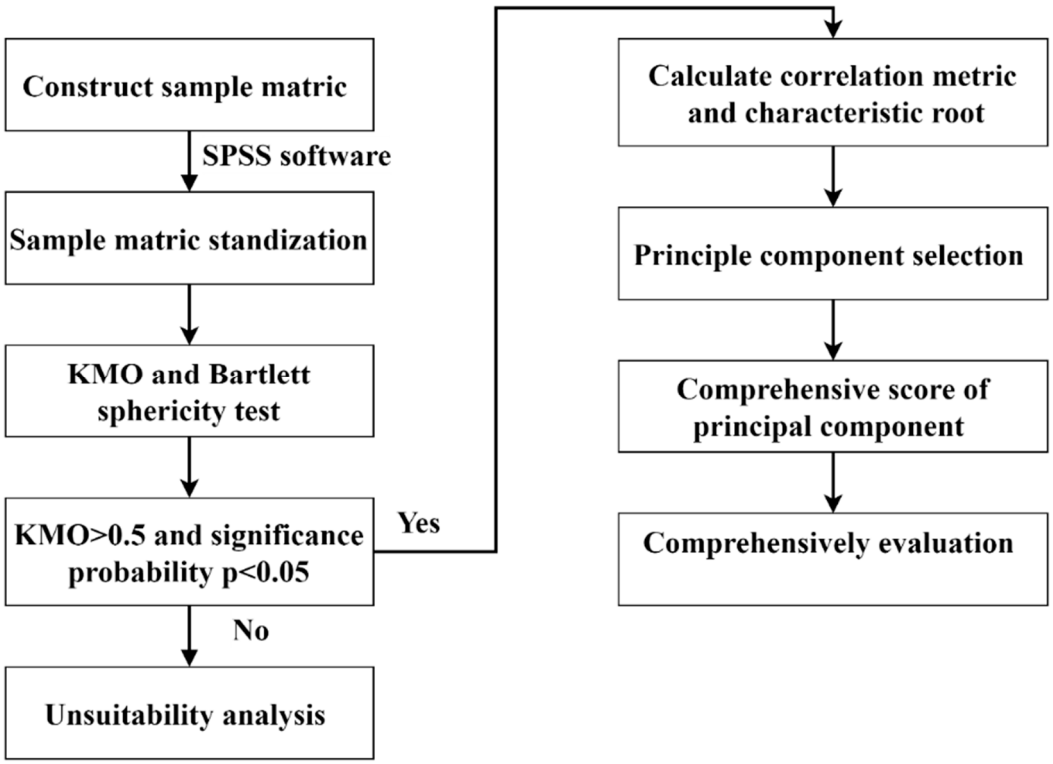

Figure 4. The visual representation of the PCA method (Source: adapted from G. Sun et al. (2023) [51]).

In his paper, "On Lines and Planes of Closest Fit to Systems of Points in Space", Karl Pearson (1901) introduced the first approach to PCA. He proposed approximating multidimensional data by line or plane of 'best fit'. He argues that a good fit will be a line or plane that minimizes the sum of the squares distance of the data set to its orthogonal projection onto the line or plane.

3. Results

3.1. Residents' Socioeconomic Characteristics

The socioeconomic conditions of the neighborhoods under study shed light on the diverse life experiences and challenges faced by the residents [56]. A deep understanding of these characteristics is vital for analyzing the effects of neighborhood improvements across different demographic segments [2,56,57]. The data presented in Table 1 provide an exhaustive overview of the residents' socioeconomic profiles, covering aspects such as gender, age group, educational level, marital status, occupation, household registration, household income, duration of residency, resident population, and housing type. These factors are critical for deciphering the community's complex dynamics and assessing how urban development initiatives influence residents' satisfaction and overall well-being.

Table 1. Summary of Socioeconomic Demographic Profile of Respondents, n = 396.

S/N	General Information of Respondents Profile		Frequency (No)	Total Responses (No)	Percentages (%)	Cumulative (%)
1	Gender	Male	195		49.2	49.2
		Female	201	396	50.8	100.0
2	Age group	18–30	85		21.5	21.5
		31–45	183		46.2	67.7
		46–55	91		23.0	90.7
		56–65	31		7.8	98.5
		>65	6	396	1.5	100.0
3	Educational level	Junior high school or under	27		6.8	6.8
		Senior high school	123		31.1	37.9
		College	211		53.3	91.2
		Postgraduate and above	35	396	8.8	100.0
4	Marital status	Single	62		15.7	15.7
		Married	303		76.5	92.2
		Divorced	27		6.8	99.0
		Widower	4	396	1.8	100.0
5	Occupation/Nature of Employment	Students	91		23.0	23.0
		Corporate sector	201		50.8	73.7
		Public sector	28		7.1	80.8
		Self-employed	26		6.6	87.4
		Unemployed	13		3.3	90.7
		Pensioner	37	396	9.3	100.0
6	Household registration	Wuxi	326		82.3	82.3
		Out of town	70	396	17.7	100.0
7	Household income (yuan/month/per)	<2000	26		6.6	6.6
		2000–4000	82		20.7	27.3
		4000–6000	131		33.1	60.4
		6000–8000	84		21.2	81.6
		>8000	73	396	18.4	100.0
8	Duration of Residency	Less than 2 years	23		5.8	5.8
		2–5 years	70		17.7	23.5
		Up to 10 years	121		30.6	54.0
		Up to 15 years	81		20.5	74.5
		More than 15 years	101	396	25.5	100.0
9	Resident population (per household)/Family Size	1–2 people	76		19.2	19.2
		3–4 people	203		51.3	70.5
		5–6 people	92		23.2	93.7
		≥7 people	25	396	6.3	100.0
10	Nature of Housing	Private house	315		79.5	79.5
		Rented house	59		14.9	94.4
		Public house	22	396	5.6	100.0

This comprehensive demographic profile illustrates the diverse socioeconomic backgrounds of the residents in the surveyed area. The gender distribution among the respondents is nearly equal, with females comprising 50.8% and males making up 49.2%. The age distribution shows that the majority of respondents fall within the 31–45 age group, representing 46.2%. The next largest age groups are 46–55 years at 23.0%, 18–30 years at 21.5%, 56–65 years at 7.8%, and those over 65 years at 1.5%. Regarding educational attainment, most respondents have attained a college-level education, accounting for 53.3%. Senior high school graduates make up 31.1%, those with postgraduate and above education make up 8.8%, and those with junior high school education or less make up 6.8%. In terms of marital status, a significant majority of respondents are married, totaling 76.5%. Single respondents account for 15.7%, divorced respondents are 6.8%, and widowers represent 1.8%.

The occupational distribution reveals that the corporate sector employs the largest segment of respondents, at 50.8%. Students make up 23.0%, public sector employees are 7.1%, self-employed individuals are 6.6%, pensioners are 9.3%, and the unemployed constitute 3.3%. Regarding household registration, the vast majority of respondents are registered in Wuxi, accounting for 82.3%, while those registered out of town make up 17.7%. The monthly household income for most respondents falls between CNY 4000 and 6000, representing 33.1%. Other income brackets include CNY 2000–4000 at 20.7%, CNY 6000–8000 at 21.2%, more than CNY 8000 at 18.4%, and less than CNY 2000 at 6.6%. In terms of the duration of residency, respondents with more than 15 years of residency constitute 25.5%. Other durations include up to 10 years at 30.6%, up to 15 years at 20.5%, 2–5 years at 17.7%, and less than 2 years at 5.8%. Households with 3–4 members are the most common, accounting for 51.3%. Households with 5–6 members follow at 23.2%, 1–2 members at 19.2%, and 7 or more members at 6.3%. The nature of housing indicates that the majority of respondents live in private homes, totaling 79.5%. Those living in rented houses make up 14.9%, and those in public housing constitute 5.6%.

3.2. Main Factors

The study used PCA to show that residents are very satisfied with the outdoor spaces in the improved residential neighborhood. These spaces can be broken down into 12 main categories, which are outdoor recreations, transportation facilities, small parks, public service facilities, the condition of the natural environment, the social and human environment, outdoor security, outdoor lighting, entrance structures, infrastructure, the public environment, and outdoor waste facilities.

In the study of satisfaction levels among residents of improved old residential neighborhoods, various elements were quantitatively assessed for their impact on living quality. Outdoor recreation emerges as a leading factor with an Eigenvalue of 7.476 and contributes 12.461% to the percentage variance, underscoring its vital role in enhancing resident satisfaction. Transport facilities and small parks, each with an Eigenvalue of 4.921 and a percentage variance of 8.202%, highlight the importance of accessible transportation and green spaces in urban living. Public service facilities follow closely, with an Eigenvalue of 4.739 and a percentage variance of 7.898%, indicating the significance of access to essential services in community contentment.

The natural environment condition, with an Eigenvalue of 4.378 and a percentage variance of 7.297%, reflects the value residents place on the quality of their immediate natural surroundings. The social and human environment, with an Eigenvalue of 4.125 and a percentage variance of 6.875%, emphasizes the impact of social interactions and community bonds on overall satisfaction. Outdoor security, with an Eigenvalue of 3.363 and a percentage variance of 5.605%, and outdoor lighting, with an Eigenvalue of 2.658 and a percentage variance of 4.431%, are critical for ensuring residents feel safe and comfortable in their neighborhood.

With Eigenvalues of 2.505 and 2.311 and percentage variances of 4.175% and 3.852%, respectively, entrance structures and infrastructure show how important it is for residents' daily lives that physical structures are well-kept and work properly. The public environ-

ment and outdoor waste facilities, with Eigenvalues of 1.959 and 1.738 and percentage variances of 3.264% and 2.897%, further contribute to overall satisfaction by maintaining cleanliness and aesthetics in communal spaces. Cumulatively, these factors account for a total percentage variance of 79.438%, demonstrating a comprehensive approach to understanding the multifaceted components that contribute to the satisfaction of living in improved aging residential neighborhoods. This analysis underscores the interconnectedness of environmental, social, and infrastructural elements in shaping the living experiences of residents.

Overall, the 12 significant components cumulatively accounted for 79.438% of the residents' level of satisfaction with the existing outdoor space improvement in the study area. The factors that had the highest level of satisfaction with the outdoor spaces are outdoor recreation (12.481%), transport facilities (12.461%), small parks (8.202%), public service facilities (7.898%), natural environment condition (7.297%), social and human environment (6.875%), outdoor security (5.60%), outdoor lighting (4.431%), entrance structures (4.175%), infrastructure (3.852%), public environment (3.264%), and outdoor waste facilities (2.897%). This implies that the residents were highly satisfied with the modification and adaptation of their outdoor spaces in the neighborhood (see Table 2).

Table 2. The level of satisfaction among residents with the existing improved outdoor spaces in the old residential neighborhood.

Modified Outdoor Spaces	Factors	Factor Loading	Eigen Value	Percentage Variance
1. Outdoor recreation			7.476	12.461
	Creating space for playing by children	0.769		
	Creating space for children's recreational facilities	0.739		
	Creating space for playing by adults	0.719		
	Creating space for outdoor resting	0.702		
	Provision of outdoor seating	0.701		
	Creating space for fitness facilities	0.695		
	Creating space for strolling	0.665		
	Creating space for chess	0.652		
	Creating space for jogging	0.647		
2. Transport facilities			4.921	8.202
	Creating space for non-motorized charging facilities	0.748		
	Creating space for motor vehicles	0.739		
	Creating space for parking for non-motorized vehicles	0.720		
	Optimizing Pavements	0.711		
	Creating space for motor vehicle charging facilities	0.702		
	Repair of pavement drainage spaces	0.691		
	Creating space for the non-motorized shed	0.688		
	—Optimizing Traffic Organization in the neighborhood	0.683		
	Laying of asphalt pavement	0.653		
3. Small park			4.921	8.202
	Replacement of other hardscapes	0.750		
	Provision of Pavilion	0.735		
	Provision of recreational seating	0.726		
	Creating space for softscape	0.704		
	Creating space for a garden path	0.682		
4. Public service facilities			4.739	7.898
	Public transportation is accessibility	0.766		
	Accessibility to educational facilities	0.753		
	Availability of community centers	0.739		
	Accessibility to commercial facilities	0.733		
	Availability of medical stations	0.715		

Table 2. *Cont.*

Modified Outdoor Spaces	Factors	Factor Loading	Eigen Value	Percentage Variance
5. Natural environment condition			4.378	7.297
	Social environment (public security, organization)	0.699		
	Ecological environment (ecology, pollution, taboos)	0.676		
	Greening and Landscape Environment	0.670		
	Optimizing planning layout	0.634		
	Quiet neighborhood	0.629		
6. Social and Human Environment			4.125	6.875
	Neighborhood	0.714		
	Level of public participation	0.697		
	Settlement recognition	0.687		
	Continuity of historical and cultural values	0.674		
	Organization of residential activities	0.632		
7. Outdoor security			3.363	5.605
	Creating space for fire protection gadget	0.707		
	Clearing fire exit and entrance	0.696		
	Clearing firefighting landing	0.685		
	Widening the road to meet the requirements of the fire access lane	0.682		
8. Outdoor Lighting			2.658	4.431
	Repairing the unit headlights	0.700		
	Creating space for street lamps	0.675		
	Creating space for courtyard lights	0.662		
9. Entrance structures			2.505	4.175
	Repairing the main entrance gate	0.675		
	Repairing sub-entrance gate	0.670		
	Creating space gate guard post	0.631		
10. Infrastructure			2.311	3.852
	Repairing the neighborhood wall	0.673		
	Creating space for a ramp for Physically challenged people	0.647		
	Creating space for drying	0.632		
11. Public Environment			1.959	3.264
	Environmental health (road, open space cleanliness) Cleanliness	0.635		
	Residential exterior styling and color	0.628		
	Availability of public square space	0.566		
12. Outdoor Waste facilities			1.738	2.897
	Creating space for garbage bin cleaning site	0.611		
	Creating space for Garbage bins	0.586		
	Creating space for garbage collection and disposal/Garbage collection station	0.559		
Cumulative Variance (Total)				79.438%

This Section presents the satisfactions and dissatisfactions of respondents regarding the improved outdoor spaces of the old neighborhood. These results are derived from the statistical analysis of questionnaires as well as from the findings of open-ended interview questions and observations. All data have been thoroughly analyzed and cross-examined. Table 3 details the satisfactions and dissatisfactions of the improved old neighborhood, including the mean and standard deviation. Figure 5 shows the descending order of the occupants' satisfaction (mean) (see Figure 5).

Table 3. The satisfactions/dissatisfactions of the improved old neighborhood.

Factors	Mean	SD
Creating space for playing by children	3.64	1.24
Creating space for children's recreational facilities	3.64	1.24
Creating space for playing by adults	3.62	1.23
Creating space for outdoor resting	3.66	1.23
Provision of outdoor seating	3.71	1.23
Creating space for fitness facilities	3.61	1.25
Creating space for strolling	3.69	1.22
Creating space for chess	3.56	1.24
Creating space for jogging	3.75	1.22
1. Outdoor recreation	**3.65**	
Factors	**Mean**	**SD**
Creating space for non-motorized charging facilities	3.68	1.21
Creating space for motor vehicles	3.66	1.25
Creating space for parking for non-motorized vehicles	3.67	1.21
Optimizing Pavements	3.71	1.22
Creating space for motor vehicle charging facilities	3.58	1.24
Repair of pavement drainage spaces	3.68	1.20
Creating space for the non-motorized shed	3.52	1.31
—Optimizing Traffic Organization in the neighborhood	3.65	1.20
Laying of asphalt pavement	3.76	1.22
2. Transport facilities	**3.66**	
Factors	**Mean**	**SD**
Replacement of other hardscapes	3.73	1.20
Provision of Pavilion	3.59	1.21
Provision of recreational seating	3.61	1.26
Creating space for softscape	3.52	1.26
Creating space for a garden path	3.62	1.23
3. Small park	**3.61**	
Factors	**Mean**	**SD**
Public transportation is accessibility	3.73	1.18
Accessibility to educational facilities	3.73	1.21
Availability of community centers	3.72	1.20
Accessibility to commercial facilities	3.73	1.17
Availability of medical stations	3.73	1.19
4. Public service facilities	**3.73**	
Factors	**Mean**	**SD**
Social environment (public security, organization)	3.64	1.22
Ecological environment (ecology, pollution, taboos)	3.67	1.18
Greening and Landscape Environment	3.65	1.21
Optimizing planning layout	3.65	1.20
Quiet neighborhood	3.65	1.19
5. Natural environment condition	**3.65**	
Factors	**Mean**	**SD**
Neighborhood	3.71	1.21
Level of public participation	3.62	1.21
Settlement recognition	3.62	1.23
Continuity of historical and cultural values	3.58	1.22
Organization of residential activities	3.57	1.22
6. Social and Human Environment	**3.62**	
Factors	**Mean**	**SD**
Creating space for fire protection gadget	3.70	1.22
Clearing fire exit and entrance	3.71	1.20
Clearing firefighting landing	3.71	1.20
Widening the road to meet the requirements of the fire access lane	3.68	1.21
7. Outdoor security	**3.70**	
Factors	**Mean**	**SD**
Repairing the unit headlights	3.62	1.25
Creating space for street lamps	3.72	1.23

Table 3. *Cont.*

Factors	Mean	SD
Creating space for courtyard lights	3.63	1.22
8. Outdoor Lighting	**3.66**	
Factors	**Mean**	**SD**
Repairing the main entrance gate	3.75	1.18
Repairing sub-entrance gate	3.67	1.21
Creating space gate guard post	3.69	1.20
9. Entrance structures	**3.70**	
Factors	**Mean**	**SD**
Repairing the neighborhood wall	3.71	1.21
Creating space for a ramp for Physically challenged people	3.70	1.23
Creating space for drying	3.71	1.25
10. Infrastructure	**3.71**	
Factors	**Mean**	**SD**
Environmental health (road, open space cleanliness) Cleanliness	3.70	1.24
Residential exterior styling and color	3.67	1.23
Availability of public square space	3.62	1.26
11. Public Environment	**3.66**	
Factors	**Mean**	**SD**
Creating space for garbage bin cleaning site	3.66	1.24
Creating space for Garbage bins	3.63	1.23
Creating space for garbage collection and disposal/Garbage collection station	3.67	1.21
12. Outdoor Waste facilities	**3.66**	

Mean is the average of all the scores. S.D. is the standard deviation from the mean. N/%—Numbers of Participants/Percentage, 1SD: Strongly Dissatisfied, 2D: Dissatisfied, 3N: Neutral, 4 S: Satisfied, 5SA: Strongly Satisfied. To facilitate the mean statistics in the following text, the subjective evaluation criteria were set as follows: $x \leq 1.5$ represented "Strongly Disagrees", $1.5 < x \leq 2.5$ represented "Disagree", $2.5 < x \leq 3.5$ represented "neutral", $3.5 < x \leq 4.5$ represented "Agree", and $x > 4.5$ represented "Strongly Agree". (Source: the author, 2023).

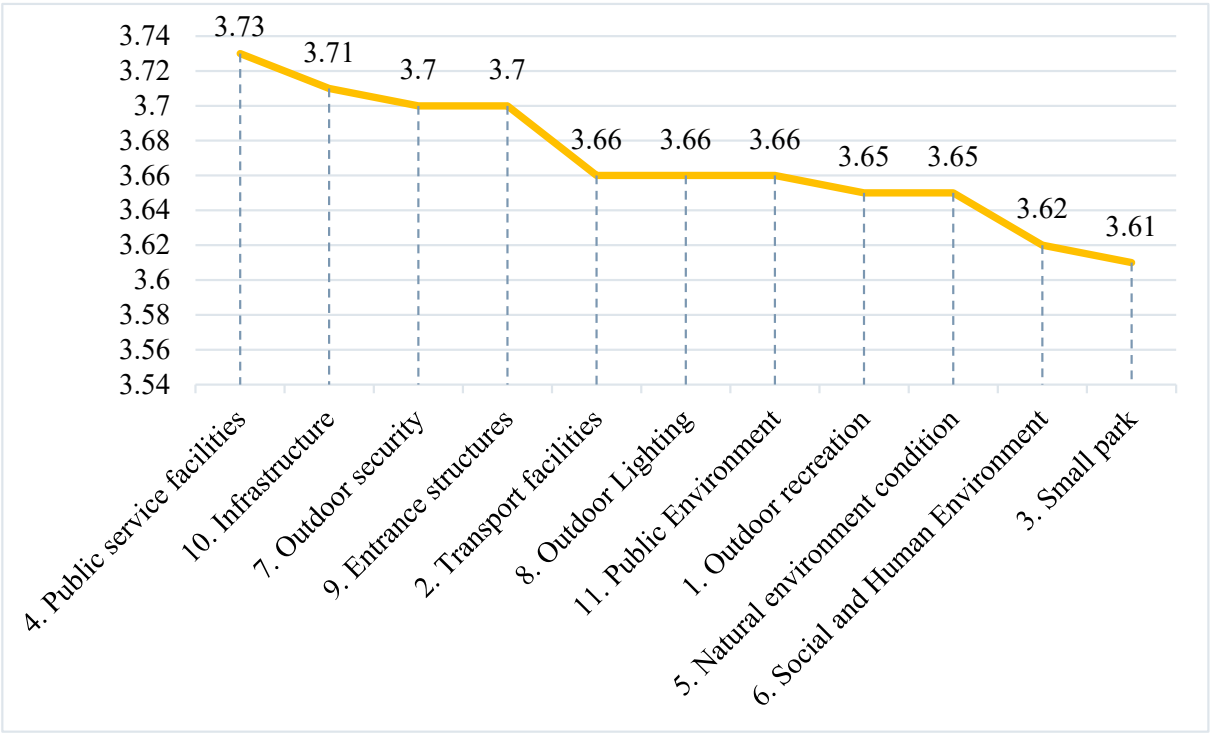

Figure 5. The occupants' satisfaction (Mean) (Source: the author, 2023).

There is a positive correlation between the themes. The table presents the Pearson correlation coefficients between various satisfaction themes related to outdoor spaces and public environments (refer to Table 4). The correlation between each theme demonstrates the close relationship between the satisfaction levels across various aspects of urban infrastructure and services. The presence of positive correlation coefficients, all significant at the 0.01 level (two-tailed), suggests a consistent, positive relationship between these themes. This implies that higher satisfaction in one area is linked to higher satisfaction in others. For example, the correlation coefficient between "outdoor security" and "transport facilities" is 0.678 **, indicating a strong positive relationship. This pattern continues across the board, with coefficients ranging from 0.571 ** to 0.681 **, showing significant positive correlations between all the pairs of themes examined. The significance level (Sig. two-tailed) of 0.000 for all correlations underscores the robustness of these relationships, confirming that the observed correlations are not due to random chance. Furthermore, the sum of squares and cross-products, along with covariance, provide additional statistical details that reinforce the strength and direction of these relationships. Each correlation has a sample size (N) of 396, suggesting a substantial data set from which these correlations originate.

In summary, this table demonstrates that there is a substantial positive interrelationship between various facets of satisfaction related to neighborhood outdoor space and public service environments. The consistent positive correlations suggest that improvements in one aspect of urban environmental quality are likely to be associated with enhancements in others, highlighting the interconnected nature of neighborhood infrastructure and public satisfaction.

Table 4. Correlations of the satisfaction themes.

	Outdoor Security	Transport Facilities	Infrastructure	Public Service Facilities Satisfaction	Outdoor Lighting Satisfaction	Outdoor Waste Facilities Satisfaction	Entrance Structures Satisfaction	Outdoor Recreations Satisfaction	Greenery Satisfaction	Small Park Satisfaction	Natural Environment Condition Satisfaction	Public Environment Satisfaction	Social and Human Environment Satisfaction
Pearson Correlation	1	0.678 **	0.610 **	0.623 **	0.571 **	0.635 **	0.642 **	0.681 **	0.606 **	0.619 **	0.640 **	0.636 **	0.657 **
Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sum of Squares and Cross-products	468.225	302.673	289.672	284.851	277.290	305.773	300.650	317.976	302.269	293.593	292.379	313.364	308.440
Covariance	1.185	0.766	0.733	0.721	0.702	0.774	0.761	0.805	0.765	0.743	0.740	0.793	0.781
N	396	396	396	396	396	396	396	396	396	396	396	396	396

**. Correlation is significant at the 0.01 level (2-tailed).

4. Discussion

The PCA conducted in this study provides a comprehensive understanding of residents' satisfaction with the improved outdoor spaces in old residential neighborhoods in Wuxi, China. The results show that twelve main factors, each significantly contributing to the overall quality of life in these neighborhoods, account for residents' satisfaction levels.

4.1. Outdoor Recreation

With the highest eigenvalue and percentage variance, outdoor recreation emerged as the most crucial factor influencing resident satisfaction. The creation of spaces for various recreational activities such as playing, resting, and jogging underscores the importance of active and passive recreational opportunities in enhancing the quality of life [58–60]. These recreational areas not only provide physical health benefits but also contribute to mental well-being by offering residents a chance to unwind and connect with nature [60,61]. The availability of such spaces facilitates social interactions, fosters community cohesion, and provides a sense of place and belonging, all of which are integral to overall life satisfaction.

This finding aligns with previous studies that highlight the positive impact of recreational spaces on residents' well-being [62–64]. Research has consistently shown that access to parks and green spaces is associated with increased levels of physical activity, reduced stress, and improved mental health. For instance, Giles-Corti et al. (2005) [65] emphasized that residents living in areas with more recreational spaces are more likely to engage in regular physical activities, which can lead to a decrease in chronic diseases and an overall healthier lifestyle [66,67]. Furthermore, the aesthetic and environmental quality of these spaces can enhance residents' perceptions of their neighborhood, leading to greater satisfaction with their living environment.

In conclusion, the emphasis on outdoor recreation as a pivotal element of resident satisfaction underscores the multifaceted benefits of recreational spaces. By providing avenues for physical exercise, relaxation, and social engagement, these spaces play a vital role in promoting a healthy and fulfilling lifestyle for residents. Therefore, urban planning and policy-making should prioritize the development and maintenance of high-quality recreational areas to support the well-being of the community.

4.2. Transport Facilities and Small Parks

Both factors, each with a significant eigenvalue and percentage variance, highlight the necessity of accessible transportation and green spaces. These elements are vital in urban living, promoting ease of movement and providing essential green spaces that improve environmental quality and resident well-being [68,69]. Accessible transportation systems, including well-maintained roads, efficient public transit, and safe pedestrian pathways, ensure that residents can move around the city with ease [70]. This ease of movement reduces commute times, lowers transportation costs, and enhances access to employment, education, and healthcare services. The availability of reliable and efficient transport options is crucial for the economic and social vitality of urban areas, enabling residents to lead productive and fulfilling lives.

In addition to transportation facilities, small parks play a crucial role in enhancing the livability of urban environments [71,72]. These green spaces provide residents with accessible areas for leisure, exercise, and social interaction [73]. They contribute to the overall aesthetic appeal of neighborhoods, offer a respite from the urban hustle, and create opportunities for community-building activities. The presence of small parks in densely populated areas is particularly important, as they offer a much-needed balance between built environments and natural elements, promoting mental health and well-being.

The importance of these facilities is well-documented, showing that they significantly enhance urban livability [74,75]. Research indicates a correlation between accessible transport and green spaces, higher levels of physical activity, reduced stress, and improved social cohesion [76], for instance, highlighted that well-integrated transport networks and the availability of parks can lead to more sustainable urban development by encouraging

the use of public transit and reducing reliance on private vehicles, thus lowering urban pollution levels. Furthermore, the integration of transport facilities and green spaces into urban planning can lead to the creation of more resilient and adaptable cities. By ensuring that residents have simple access to transportation and green areas, cities can better cope with challenges such as population growth, environmental changes, and economic fluctuations. This holistic approach to urban planning not only improves the quality of life for residents but also contributes to the long-term sustainability of urban environments.

4.3. Public Service Facilities

Access to essential services, such as educational facilities and medical stations, is crucial for community satisfaction. These services constitute the backbone of urban infrastructure, enabling residents to lead productive and healthy lives.

Access to quality education is a fundamental right and an essential factor in individual and community development. Schools, colleges, and universities not only impart knowledge but also serve as community hubs where social interactions and extracurricular activities foster personal growth and social cohesion [11]. The presence of reputable educational institutions within easy reach increases a neighborhood's desirability, attracts families, and contributes to a stable and engaged community. Medical stations and healthcare facilities are indispensable in ensuring the well-being of residents [77,78]. Proximity to healthcare services enables timely medical attention, which is vital for preventing and managing health conditions [79,80]. This accessibility is particularly important for vulnerable populations, such as the elderly and those with chronic health conditions. Moreover, the presence of well-maintained and accessible public service facilities can have a positive impact on property values and economic development. Areas with superior public services are often more attractive to investors and businesses, leading to job creation and economic growth. This, in turn, can create a virtuous cycle where improved services lead to greater community satisfaction, which further attracts resources and development. In conclusion, the accessibility and effectiveness of public service facilities are paramount to achieving high levels of community satisfaction.

4.4. Natural Environment Condition

Natural surroundings, including greening and landscape environments, play a significant role in resident satisfaction [81]. The presence of trees, parks, and other green spaces contributes to the aesthetic appeal of a neighborhood, providing residents with visually pleasing and refreshing areas to relax and unwind [82,83]. The emphasis on ecological quality and a quiet neighborhood environment highlights the residents' preference for serene and pollution-free surroundings. Ecological quality encompasses various elements such as air and water purity, soil health, and biodiversity [84]. Clean air and water are fundamental to a healthy living environment, reducing the incidence of respiratory and waterborne diseases. The presence of diverse plant species, well-maintained gardens, and natural landscapes also contributes to reducing urban heat islands, improving the microclimate of residential areas.

This preference is consistent with research showing that natural environments contribute to mental and physical health. Studies have shown that exposure to natural settings reduces stress, enhances mood, and promotes overall well-being. Studies have found that people living near green spaces are more likely to engage in physical activities such as walking, jogging, and cycling, which are beneficial for cardiovascular health and fitness. Additionally, natural environments provide a conducive setting for social interactions and community gatherings, fostering a sense of community and belonging among residents. Furthermore, the presence of natural elements in urban settings can mitigate the effects of pollution. Trees and plants act as natural air filters, absorbing pollutants and releasing oxygen, thereby improving air quality. They also play a crucial role in managing stormwater, reducing the risk of flooding, and maintaining the hydrological balance. Quiet, green neighborhoods offer a respite from the noise and bustle of urban life, allowing residents to

enjoy a peaceful living environment that enhances their quality of life. In conclusion, the condition of the natural environment is a crucial determinant of resident satisfaction.

4.5. Social and Human Environment

This factor underscores the impact of social interactions and community bonds on overall satisfaction. The social and human environment includes a variety of elements that contribute to residents' sense of belonging and collective identity. Elements such as neighborhood recognition, public participation, and the continuity of historical and cultural values are integral to community cohesion and satisfaction [85]. Public participation in community activities and decision-making processes enhances the democratic fabric of the neighborhood, ensuring that residents have a say in matters that affect their daily lives. This active involvement strengthens communal ties and promotes a sense of ownership and responsibility towards the neighborhood. The continuity of historical and cultural values plays a significant role in maintaining the unique identity and heritage of a community [66,86]. Local traditions, festivals, architecture, and public spaces often reflect these values, serving as tangible reminders of the community's history and collective memory. Preserving these cultural elements fosters a sense of pride and continuity among residents, bridging generational gaps and creating a cohesive community fabric.

Social cohesion is known to enhance community resilience and individual well-being [72,83]. The strong social networks and support systems inherent in cohesive communities provide residents with emotional, practical, and financial support during times of need, thereby enhancing overall resilience. Moreover, positive social interactions and a supportive community environment can reduce feelings of isolation and loneliness, which are detrimental to mental health. Engaging in community activities and having a reliable social support network can enhance self-esteem, reduce stress, and improve overall life satisfaction. Research has shown that communities with high levels of social capital, characterized by trust, norms of reciprocity, and active civic engagement, tend to have better health outcomes, lower crime rates, and higher educational attainment [69,87]. In conclusion, the social and human environment is a vital determinant of resident satisfaction.

4.6. Safety and Security

Outdoor security and lighting are critical for residents' comfort and safety. These elements play a pivotal role in shaping the perception of safety within a community, directly influencing residents' willingness to utilize outdoor spaces during both day and night. The significant satisfaction levels in these areas indicate that improvements in safety measures and lighting infrastructure are essential for fostering a secure living environment [88,89]. Adequate lighting is a fundamental aspect of urban design that enhances visibility, reduces crime, and promotes a sense of safety among residents. By increasing the likelihood of spotting offenders, well-lit streets, parks, and public spaces deter criminal activities, thereby reducing opportunities for crimes like theft, vandalism, and assault. Additionally, proper lighting can prevent accidents and injuries by improving visibility for pedestrians, cyclists, and drivers, contributing to overall public safety.

Beyond crime prevention, lighting also affects the usability and attractiveness of outdoor spaces. Well-illuminated areas encourage residents to engage in evening activities, such as walking, jogging, and socializing, thereby promoting an active and vibrant community life. The psychological comfort provided by excellent lighting can enhance the quality of life, as residents feel more secure and confident in their surroundings. Ensuring safety is paramount for the usability of outdoor spaces [82,90]. Research has shown that environments perceived as safe and secure are more likely to be utilized by residents, leading to increased physical activity, social cohesion, and overall well-being [72,85]. These measures not only prevent crime and accidents but also enhance the usability and attractiveness of outdoor spaces.

4.7. Infrastructure and Entrance Structures

Well-maintained physical structures, including entrances and infrastructure, are pivotal for daily life [91,92]. Well-maintained infrastructure ensures reliability, reduces the risk of breakdowns, and minimizes disruptions to daily life. Entrance structures, including gateways, doorways, and other points of entry, play a significant role in defining the character and accessibility of buildings and neighborhoods [57]. These structures not only serve functional purposes by providing access, but they also contribute to a place's aesthetic appeal and identity. Thoughtfully designed and well-maintained entrance structures can enhance the visual coherence of urban areas, create a sense of welcome, and reflect the cultural and historical significance of a community [93,94]. High-quality infrastructure enhances the quality of life by providing residents with safe, reliable, and convenient access to essential services and amenities. For instance, well-paved roads and efficient public transportation systems reduce commute times and improve mobility, while modern water and sanitation systems ensure public health and environmental sustainability.

Designing infrastructure with a focus on visual appeal and harmony with the surrounding environment can significantly enhance the overall attractiveness of urban spaces. This includes the integration of green spaces, public art, and architectural elements that reflect local heritage and identity. Aesthetic infrastructure not only improves the visual landscape but also fosters a sense of pride and belonging among residents. Regular upkeep and timely repairs are essential to prolong the lifespan of physical assets, prevent deterioration, and ensure safety. Neglected infrastructure can lead to hazards, reduced functionality, and decreased property values, negatively impacting residents' quality of life. Engaging with residents in decision-making processes ensures that infrastructure developments align with their needs and preferences. This participatory approach can lead to more sustainable and accepted outcomes, fostering a sense of ownership and responsibility among community members. In conclusion, well-maintained infrastructure and entrance structures are essential for creating functional, safe, and aesthetically pleasing urban environments.

4.8. Public Environment and Waste Facilities

Cleanliness and waste management are fundamental to resident satisfaction [93,94]. High satisfaction levels with the public environment and waste facilities indicate that maintaining cleanliness and proper waste disposal is crucial for a pleasant living environment [94,95]. Effective waste management practices encompass a variety of processes, including waste collection, recycling, treatment, and disposal. Regular and efficient waste collection services prevent the accumulation of waste, which can attract pests, produce unpleasant odors, and create health hazards. By ensuring that waste is collected and disposed of in a timely and sanitary manner, cities can maintain a cleaner and healthier public environment. Public awareness campaigns and accessible recycling facilities are key components in fostering a culture of sustainability and environmental responsibility among residents.

Proper waste disposal is not only a matter of public health but also a crucial aspect of urban aesthetics. Well-maintained waste facilities, including trash bins, recycling centers, and waste treatment plants, contribute to the overall appearance and functionality of urban areas. Clean streets, parks, and public spaces enhance the visual appeal of neighborhoods, making them more attractive and enjoyable for residents.

The importance of waste management is further underscored by its impact on environmental health. Effective waste management practices help to reduce pollution, conserve natural resources, and protect ecosystems. By minimizing the release of harmful substances into the air, water, and soil, cities can promote a healthier environment for all living organisms. This, in turn, supports biodiversity and the sustainability of urban ecosystems. Public participation is crucial to maintaining cleanliness and effective waste management. Residents play a key role in ensuring that waste is disposed of correctly and that recycling practices are followed. Community engagement programs that educate and motivate residents to participate in waste management efforts can lead to more effective and sustainable

outcomes. Involving the community in waste management planning and decision-making processes can also increase public support for and compliance with waste management policies. In conclusion, the cleanliness of the public environment and the efficiency of waste facilities are essential for creating a pleasant and healthy living environment.

4.9. Limitation of the Study

While this study contributes valuable insights into the POE of residential satisfaction in improved old neighborhoods in Wuxi, China, through the application of PCA, it is crucial to recognize certain limitations that may affect the generalizability and rigor of the findings.

Firstly, the geographic scope of this research is confined to Wuxi, a specific urban context within China. The socio-economic, cultural, and environmental conditions unique to Wuxi may not be reflective of other urban settings, particularly those in different regions or countries with diverse urban development trajectories and cultural backgrounds. Consequently, the external validity of the study's results may be constrained, necessitating similar investigations in varied contexts to corroborate the findings. Secondly, the cross-sectional nature of the data collection, which captures residents' satisfaction at a single point in time, presents another limitation. Residential satisfaction is a dynamic construct that may evolve in response to changes in the neighborhood environment, economic fluctuations, or shifts in the personal circumstances of the residents. A longitudinal approach, tracking satisfaction over an extended period, would provide a more nuanced and temporally sensitive understanding of residents' experiences. Thirdly, the reliance on self-reported data introduces potential biases inherent in survey-based research. Respondents may have been influenced by social desirability bias or may have interpreted survey questions in varying ways, leading to possible inaccuracies in the data. Moreover, while the sample size was adequate for conducting PCA, it may not fully capture the heterogeneity of the population, which could limit the representativeness of the findings. Fourthly, although PCA is a robust method for dimensionality reduction and identifying key components that influence residential satisfaction, it inherently involves a degree of data abstraction and loss of information. The interpretation of principal components is partly subjective, and alternative statistical methodologies could yield different insights or emphasize distinct aspects of the data set. Lastly, the scope of this study was primarily concentrated on assessing residents' satisfaction with the physical and social improvements in their neighborhoods. However, other critical dimensions, such as the long-term sustainability of these improvements, the environmental impacts, and the perspectives of urban planners, policymakers, and other stakeholders, were not extensively explored. Future research would benefit from adopting a more holistic framework that integrates these additional factors to provide a more comprehensive analysis.

In summary, while this study advances the understanding of residential satisfaction in the context of improved old neighborhoods in Wuxi, these limitations should be acknowledged. They highlight the necessity for caution in the interpretation of the results and underscore the importance of further research to address these identified gaps.

5. Conclusions

This study evaluated improvements in outdoor spaces in old residential neighborhoods in Wuxi, China, using the POE method and employed PCA to identify key factors influencing resident satisfaction. The critical elements identified include outdoor recreation, transport facilities, small parks, public service amenities, natural environment conditions, social and human environment, safety and security, and infrastructure and waste management. The findings emphasize the interconnections among urban infrastructure components, underscoring the need for an integrated approach to urban planning. Enhancements in one area can positively affect others, thus improving overall resident satisfaction. For example, improving outdoor security can elevate the effectiveness of transport facilities, while well-maintained green spaces can boost both environmental quality and social cohe-

sion. This study shows that improving outdoor spaces significantly improves residents' quality of life, social interaction, and physical activity levels. The study also found that residents' satisfaction with improvements was closely related to the accessibility, safety, and aesthetic quality of the services and facilities provided. Consequently, urban planners and policymakers should adopt strategies that address multiple facets of the urban environment simultaneously to maximize benefits. Future research should focus on longitudinal studies to evaluate the long-term effects of outdoor space improvements on resident satisfaction and well-being. The incorporation of advanced data analytics and machine learning can offer deeper insights into the complex dynamics of urban environments. Moreover, engaging residents through participatory planning and evaluation processes can ensure that interventions are responsive to their needs and preferences.

The significance of this study lies in its methodological and practical contributions. Methodologically, the application of PCA offers a robust approach to distilling complex, multidimensional satisfaction factors into key components, allowing for a more precise analysis of what drives resident contentment in older neighborhoods. This approach not only simplifies the assessment process but also enhances the accuracy of the findings, providing a clear picture of the most influential factors. Practically, the findings of this research have substantial implications for urban planners, policymakers, and developers. By identifying the critical factors that contribute to resident satisfaction, this study can inform future redevelopment projects, ensuring that resources are allocated effectively to maximize the well-being of residents. Moreover, the insights gained from the case of Wuxi can be generalized to other urban contexts facing similar challenges, offering a template for improving residential satisfaction in aging neighborhoods globally. In conclusion, this study provides valuable insights into the factors contributing to resident satisfaction in old residential neighborhoods. A holistic, data-driven approach to urban planning can help cities create more livable, sustainable, and resilient communities, ultimately enhancing residents' quality of life.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/ijgi13090318/s1, Figure S1: an aerial view of the Oudian neighborhood; Figure S2: photos of the improved site, Oudian neighborhood; Figure S3: an aerial view of Zhenfa neighborhood; Figure S4: photos of the improved neighborhood; Table S1: before improvement and after improvement; Table S2: before improvement and after improvement.

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