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Research Article

Evaluation of Urban Park Landscape Satisfaction Based on the Fuzzy-IPA Model: A Case Study of the Zhengzhou People's Park

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Based on the fuzzy comprehensive evaluation theory, a continuous triangular fuzzy quantitative landscape satisfaction evaluation index is used to comprehensively evaluate the landscape satisfaction of Zhengzhou People's Park. By using the factor analysis method to determine the weight of the evaluation index, an index system of urban park landscape satisfaction evaluation is constructed. And the important expression performance quadrant analysis of the landscape satisfaction evaluation index is combined with the IPA analysis method to propose the improvement of urban park landscape satisfaction. The fuzzy-IPA combination model provides a new way for the satisfaction evaluation of urban park landscape.

1. Introduction

Greenland of urban park is an important part of the urban green space system and ecological infrastructure, as well as an important place for public leisure and recreation [1]. The current sustained and rapid economic growth has accelerated the urbanization process and the construction of urban parks which have developed rapidly. As an important indicator to measure the level of landscape quality in urban parks, landscape satisfaction directly reflects the public's recognition of the park landscape [2]. At present, foreign research on satisfaction evaluation mainly constructs evaluation models to measure through expectation differences, service quality and performance, and nondifferential scores [3]; the quantitative research on satisfaction evaluation in China mainly uses methods, such as hierarchical analysis [4], grey correlation analysis [5], neural network analysis [6], and factor analysis. Satisfaction evaluation of urban park landscape is a comprehensive evaluation combining qualitative and quantitative aspects. As the evaluation index of park landscape is featured with multiobjective and compound attributes, the objectivity of landscape and the subjectivity of landscape cognition [7–9] shall be considered during the evaluation process. A scientific and reasonable satisfaction evaluation of urban park landscape can help to improve the overall landscape quality of urban parks.

Fuzzy comprehensive evaluation uses fuzzy mathematics theory to make an overall evaluation of things or objects that are affected by multiple factors [10]. The fuzzy mathematical algorithm is used for quantitative evaluation to provide a basis for correct decision-making, and it is suitable for solving various nondeterministic problems [11]. There is subjectivity, randomness, and fuzziness in the perception of evaluation indicators by respondents in the process of landscape satisfaction evaluation, while the change levels of evaluation indicators are usually expressed by discrete values, such as the Likert attitude scale, ignoring the continuity between changes [12]. In the fuzzy comprehensive evaluation, the rating of evaluation indicators is nondiscrete; there is a continuous buffer area and the evaluation scores show "ambiguous" in the fuzzy region [13, 14]. Proposed by Martilla and James in 1977 [15], importance-performance analysis (IPA) is a simple, intuitive, and easy-to-use method that is widely used in quality assessment in various services and will be more widely used in the development and application of tourism field. The IPA analysis method simply compares the importance of each impact factor with the actual satisfaction of the audience and analyzes the real evaluation results of these impact factors.

This study uses continuous triangular fuzzy numerical values to quantify comments based on the triangular fuzzy evaluation theory, converts the triangular fuzzy evaluation values of landscape satisfaction indicators into logical values based on the de-fuzzy rule, constructs the evaluation index system of urban park landscape satisfaction with factor analysis, determines the weights of evaluation indicators, and derives quadrant analysis of the satisfaction value and the weight value of evaluation indicators by combining with importance-performance analysis (IPA), the optimization, management, and sustainability of urban park landscape in the future provides scientific guidance that combines quantitative and qualitative.

2. Overview of the Study Area

Zhengzhou People's Park is located on the west of North Erqi Road in the center of the city, and it is built after liberation on the basis of Peng Gong Ancestral Hall and Hu Gong Ancestral Hall, with an advantageous geographical location and convenient transportation around. The park covers an area of 30.14 hectares, including 3.37 hectares of water bodies and 25.41 hectares of green space, with a green space ratio of 83.2% and a green coverage rate of 92.5%. It consists of 11 scenic spots, such as the Bonsai Garden, Magnolia Garden, *Begonia* Garden, Peony Garden, European Garden, Cherry Garden, and Bamboo Garden, and is the largest comprehensive park in the downtown area of Zhengzhou. The park is rich in vegetation and has a natural environment, a large area of garden landscapes. Its planning and design focus on the inheritance of history and culture and the use of Chinese gardening techniques, with a reasonable layout and complete functions, making it an important place for public leisure and entertainment.

3. Research Methodology and Data Source

3.1. Questionnaire Design and Sample Analysis. The design of the questionnaire mainly includes three parts: the first part is the basic information of the respondents, including gender, age, education, occupation; the second part is the evaluation variable survey based on triangular fuzzy judgment; the third part is the urban park landscape satisfaction evaluation index system and overall satisfaction. Satisfaction evaluation indicators and overall satisfaction were measured using 5-level comment variables: very satisfied (VS), satisfied (S), fair (F), unsatisfied (US), and very unsatisfied (VUS).

After designing, the questionnaire was distributed on the online platforms. Fifty questionnaires were randomly selected from the returned questionnaires for pre-survey, and the results were fed back into the detailed design of the questionnaire and the revision and improvement of the questions to form the final questionnaire. The questionnaire was distributed at the east, west, and south gates of Zhengzhou People's Park to the public who came to the park from 5 to 8 December 2020. A total of 230 questionnaires were distributed and 203 were returned, of which 186 were valid, with an efficiency rate of 91.6%. The statistical analysis showed that 47.3% of the respondents were male and 52.7% were female, mainly young- and middle-aged people with relatively high education level, and 62.4% of the respondents had obtained college education or above.

3.2. Fuzzy Comprehensive Evaluation of Questionnaire Rubric Variables. The triangular fuzzy values were used in the questionnaire to describe the rubric variables and classified the rubric variables into five evaluation levels [16]: very satisfied (VS), satisfied (S), fair (F), unsatisfied (US), and very unsatisfied (VUS) (Figure 1).

Due to the variability of the respondents in terms of gender, age, occupation, and education, their perceived judgments of the comment variables were not exactly the same. The law of fuzzification (equation 1) was applied to calculate the mean triangular fuzzy values of the respondents' descriptions of the comment variables in the valid questionnaire as the respondents' perceived levels of the comment variables (Table 1):

$$\begin{aligned}\widetilde{A_k} &= \frac{\sum_{i=1}^{n} \widetilde{A_k^i}}{n}\\ &= \frac{\left(\sum_{i=1}^{n} a_{k1}^{(i)}, a_{k2}^{(i)}, a_{k3}^{(i)}\right)}{n}, \quad i = 1, 2, 3, \ldots\ldots, n;\ k = 1, 2, 3, 4, 5,\end{aligned} \tag{1}$$

where $\widetilde{A_k}$ denotes the triangular fuzzy value of the kth variable, $\widetilde{A_k^i}$ denotes the perceived level of the kth variable by the ith respondent, $a_{k1}^{(i)}$, $a_{k2}^{(i)}$, and $a_{k3}^{(i)}$ denote the low, medium, and high values of the triangular fuzzy value, respectively, n denotes the number of respondents, and k denotes the number of comment variables.

3.3. Evaluation of Evaluation Indicators and Overall Satisfaction. Based on the triangular fuzzification of the comment variables, the law of fuzzification (Eq. 2 and Eq. 3) was applied to make overall evaluation to the evaluation indicators and overall landscape satisfaction in combination with the results of the valid questionnaire, whose triangular fuzzy values were defuzzified (Eq. 4), and the weighted average method was applied to calculate the triangular fuzzy values and logical values of the item layer (Table 2):

$$\widetilde{A_j} = \frac{\sum_{i=1}^{n} \widetilde{A_j^i}}{n} = \frac{\left(\sum_{i=1}^{n} a_{j1}^{(i)}, a_{j2}^{(i)}, a_{j3}^{(i)}\right)}{n}, \quad i = 1, 2, 3, \ldots\ldots, n;\quad j = 1, 2, 3, 4, 5, \tag{2}$$

where $\widetilde{A_j}$ denotes the triangular fuzzy value of the jth evaluation indicator, $\widetilde{A_j^i}$ denotes the ith respondent's perception of the jth evaluation indicator, $a_{j1}^{(i)}$, $a_{j2}^{(i)}$, and $a_{j3}^{(i)}$ denote the low, medium, and high values of the triangular fuzzy value of $\widetilde{A_j^i}$, respectively, n denotes the number of respondents, and m denotes the number of landscape satisfaction evaluation indicators.

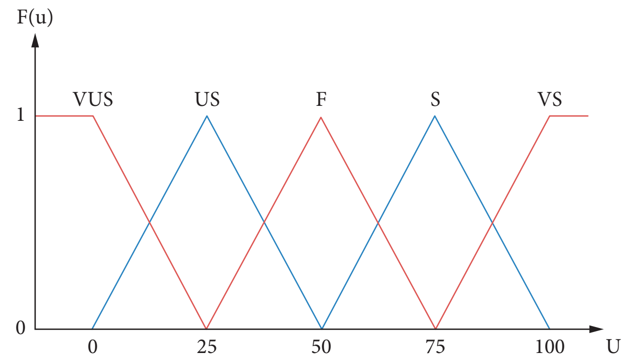

FIGURE 1: The cognitive levels of the ith respondent on the evaluation variables.

TABLE 1: The triangle fuzzy variables.

Comment variables	Low value	Medium value	High value
VUS	0	6.05	23.04
US	6.72	24.14	47.23
F	27.83	49.09	69.81
S	52.58	75.59	93.01
VS	78.44	92.72	100

TABLE 2: Fuzzy value and logic value of urban park landscape satisfaction.

Item level	Triangle fuzzy value of item level	Item-level logical value	Evaluation index level	Triangular fuzzy value of evaluation index	Logical value of evaluation index
Environmental satisfaction	(57.24, 76.75, 90.60)	75.33	Environmental coordination	(57.30, 76.91, 90.82)	75.48
			Visual aesthetics of the environment	(57.53, 77.13, 90.98)	75.69
			Ecological suitability	(56.88, 76.21, 90.02)	74.83
Facility satisfaction	(29.36, 47.51, 66.20)	47.64	Recreational facilities	(33.70, 52.89, 71.36)	52.71
			Guide facility	(29.92, 47.95, 66.42)	48.06
			Publicity service facilities	(24.45, 41.70, 60.81)	42.17
Traffic satisfaction	(35.05, 53.91, 71.88)	53.69	Road paving design	(30.11, 48.45, 67.15)	48.54
			Barrier-free design	(36.47, 55.30, 72.97)	55.01
			Traffic organization rationality	(38.58, 57.97, 75.53)	57.51
Site satisfaction	(47.46, 66.94, 82.80)	66.03	Location rationality	(47.95, 67.26, 82.91)	66.35
			Functional diversity	(41.59, 61.16, 78.30)	60.55
			Site participation	(52.83, 72.39, 87.19)	71.20
Space satisfaction	(40.25, 59.23, 76.23)	58.74	Scale rationality	(41.65, 60.33, 76.84)	59.79
			Spatial variability	(35.03, 54.12, 72.28)	53.89
			Sense of space security	(44.07, 63.25, 79.57)	62.53
Overall satisfaction	(51.22, 71.34, 86.85)	70.19			

$$\widetilde{TS} = \frac{\sum_{i=1}^{n} \widetilde{TS}^{i}}{n} = \frac{\left(\sum_{i=1}^{n} TS_1^{(i)}, TS_2^{(i)}, TS_3^{(i)}\right)}{n}, \tag{3}$$

where $\widetilde{TS}$ denotes the respondents' perception of overall landscape satisfaction, $\widetilde{TS}^{i}$ denotes the ith respondent's perception of overall landscape satisfaction, $TS_1^{(i)}$, $TS_2^{(i)}$, and $TS_3^{(i)}$ denote the low, medium, and high values of the triangular fuzzy value of $\widetilde{TS}^{i}$, respectively, and n denotes the number of respondents.

$$V_A = \frac{(a_1 + 2a_2 + a_3)}{4}, \tag{4}$$

where V_A denotes the logical value of the fuzzy value $\widetilde{A}(a_1, a_2, a_3)$.

3.4. Construction of Satisfaction Evaluation System of Urban Park Landscape. In order to ensure the reliability of the index data and reduce the influence of subjective judgment on the evaluation results, during constructing the satisfaction evaluation system of urban park landscape, the factor analysis method is used to test the reliability and validity of the evaluation data.

The test to the evaluation indicators of satisfaction of urban park landscape by reliability analysis in SPSS 22.0 showed that Cronbach's alpha reliability value was 0.931, indicating the reliability of the questionnaire was good [17]. The test to the survey data by KMO and Bartlett's spherical test showed that the KMO value was 0.902, which was greater than 0.7, indicating that the structural validity of the questionnaire was good. Bartlett's Sig. was 0.000, indicating that the null hypothesis of the spherical test was rejected and suitable for factor analysis [18]. In the indicator validity analysis, 0.4 was selected as the critical value for factor loading, and indicators with factor loading less than 0.4 were excluded and 15 evaluation indicators were obtained. The factor analysis was carried out on the data to get the factor load matrix after rotation (Table 3), and the cumulative variance contribution of the first five common factors extracted was 78.602% (>60%), which indicated that the five common factors extracted were reasonable. Based on the attributes of the indicators, the extracted common factors were classified into five evaluation aspects, including "environmental satisfaction," "facility satisfaction," "traffic satisfaction," "site satisfaction," "space satisfaction," and "space satisfaction."

Extraction method: principal component analysis method; rotation method is the maximum variance method.

In order to test the rationality of the urban park landscape satisfaction evaluation index weight determined by the factor analysis method, the evaluation index weight was verified by the analytic hierarchy process. Firstly, the evaluation indicators are classified according to their relationship, and an evaluation system with a hierarchical structure is established. Then, 10 experts from Henan Agricultural University, Henan University of Science and Technology, Central South University of Forestry and Technology, and Henan Institute of Science and Technology were invited to compare each level of indicators according to the AHP calibration series and then score them to obtain a judgment matrix. After processing, the weight of the evaluation index to the superior index is obtained. After comparative analysis, the weights of the evaluation indicators determined by the AHP and the evaluation indicators determined by the factor analysis method are basically the same in order, which proves that the evaluation indicators' weights of the urban park landscape satisfaction determined by the factor analysis method are scientific and reasonable and can reflect contribution of evaluation indicators to landscape satisfaction.

3.5. Determination of the Weights of Satisfaction Evaluation Indicators of Urban Park Landscape. In order to reduce the errors of subjective judgments, factor analysis was applied to determine the weights of the satisfaction evaluation indicators of urban park landscape (Table 4). Firstly, the variance contribution rate of the five-aspect indicators of the item level was standardized, and the proportion of the variance contribution rate of each indicator to the total variance contribution rate was the weight of each item-level indicator. The weights of the five item-level indicators on the target level landscape satisfaction were calculated as 0.185, 0.200, 0.208, 0.209, and 0.198, respectively. Secondly, the maximum factor loading coefficient of each evaluation indicator was normalized to derive the contribution of the evaluation indicator to the item level, which is the weight of the evaluation indicator. Finally, the weight of each evaluation indicator to the item level was calculated by the weighting method.

4. Analysis of Evaluation Results

4.1. Analysis of the Satisfaction Evaluation of the Urban Park Landscape. Table 2 shows that the overall satisfaction score of Zhengzhou People's Park is 70.19, which is satisfactory, and it indicates that the public is satisfied with the overall satisfaction level of Zhengzhou People's Park. The score of "environmental satisfaction" (75.33) is greater than that of overall satisfaction (70.19), which indicates that the ecological environment in the park is more suitable, the landscape is in harmony with the park environment, the perception of environmental beauty is higher, and the natural environment as a whole is satisfactory. The scores of "site satisfaction" (66.03), "space satisfaction" (58.74), and "traffic satisfaction" (53.69) are lower than that of overall satisfaction (70.19), which is between average and satisfactory, indicating that the public's perception of satisfaction is relatively low and further improvement is required, which indicates that the level of public satisfaction is low and needs to be improved.

In terms of the overall scores of the evaluation indicators, the scores for "environmental coordination," "visual aesthetics of the environment," "ecological suitability," and "site participation" are higher than that of overall satisfaction, which indicates that these four evaluation indicators are in a good state of perception and shall be maintained and strengthened as appropriate.

The scores for "recreational facilities," "barrier-free design," "traffic organization rationality," "location rationality," "functional diversity," "spatial variability," and "sense of spatial security" are lower than the overall satisfaction scores, and the satisfaction level is between average and satisfactory, which indicates that these eight evaluation indicators are important factors affecting the satisfaction evaluation of the park landscape and need to be further optimized and improved. The scores of "road paving design," "orientation indication facilities," and "publicity service facilities" are smaller than the overall satisfaction score, and the satisfaction level is fair, which indicates that there are more problems with these three evaluation indicators and are less well accepted by the public, and it shall be improved and focused on.

4.2. Analysis of the Weights of the Evaluation Indicators of Satisfaction with the Urban Park Landscape. Table 4 shows that the weight values of the evaluation indicators at all levels are relatively balanced. In the item level, the weight values of "site satisfaction" and " traffic satisfaction" are relatively high, accounting for 20.9% and 20.8% of the total weight, respectively, indicating that the public is more concerned

Table 3: Rotated factor loading and variance contribution rate.

Evaluation index	Environmental satisfaction	Facility satisfaction	Traffic satisfaction	Site satisfaction	Space satisfaction
Environmental coordination	0.748				
Visual aesthetics of the environment	0.771				
Ecological suitability	0.707				
Recreational facilities		0.786			
Guide facility		0.802			
Publicity service facilities		0.746			
Road paving design			0.761		
Barrier-free design			0.750		
Traffic organization rationality			0.850		
Location rationality				0.689	
Functional diversity				0.779	
Site participation				0.857	
Scale rationality					0.731
Spatial variability					0.703
Sense of space security					0.831
Variance contribution rate	14.522	15.756	16.368	16.412	15.544
Cumulative variance contribution rate	14.522	30.278	46.646	63.058	78.602

Table 4: The judgment result of evaluation index weight about landscape satisfaction of urban parks in Zhengzhou.

Target level	Item level	Item-level weight	Index level	Index level weight	Total weight
A city park landscape satisfaction	B1 environmental satisfaction	0.185	C11 environmental coordination	0.336	0.062
			C12 environmental visual beauty	0.346	0.064
			C13 ecological suitability	0.318	0.059
	B2 facility satisfaction	0.200	C21 recreational facilities	0.337	0.067
			C22 guide facilities	0.344	0.069
			C23 publicity service facilities	0.319	0.064
	B3 traffic satisfaction	0.208	C31 road paving design	0.322	0.067
			C32 barrier-free design	0.318	0.066
			C33 traffic organization rationality	0.36	0.075
	B4 site satisfaction	0.209	C41 location rationality	0.296	0.062
			C42 functional diversity	0.335	0.070
			C43 site participation	0.369	0.077
	B5 space satisfaction	0.198	C51 scale rationality	0.323	0.064
			C52 space variability	0.31	0.061
			C53 space security	0.367	0.073
	Average				0.066

about both site and traffic in park recreation activities. Improving the functionality and participatory nature of the landscape and optimizing the traffic organization and road layout are important measures to improve park satisfaction. The weighting of "facility satisfaction" and "spatial satisfaction" is slightly lower than that of the first two indicators, accounting for 20% and 19.8% of the total weighting, respectively, indicating that the spatial perception of recreational facilities and activity places in parks is an important factor in park landscape satisfaction. The setting up of facilities with human care and practical functions, and the shaping of activity spaces with appropriate scale and orderly changes and a sense of security play an important role in improving park satisfaction. "Environmental satisfaction" is the lowest ranked indicator, accounting for 18.5% of the total weighting, but its weighting is not significantly lower than that of the previous indicators; therefore, the coordination, ecology, and visual aesthetics of the landscape environment in parks shall not be ignored.

The weighted average value of the 15 evaluation indicators is 0.066. The evaluation indicators that are greater than the weighted average value include seven items, such as site participation, traffic organization rationality, sense of spatial security, functional diversity, guide facilities, recreational facilities, and road paving design; the evaluation indicators that are less than the weighted average value include seven items, such as visual aesthetics of the environment, environmental coordination, ecological suitability, publicity service facilities, location rationality, scale rationality, and spatial variability. The weight value of barrier-free design is equal to the average value of the weights.

4.3. IPA Analysis of the Factors Influencing Satisfaction of the Urban Park Landscape. The IPA evaluation model was used to analyze the factors affecting the satisfaction of the landscape of Zhengzhou People's Park, the quadrant distribution of satisfaction evaluation indicators (Figure 2) was drawn with the mean value of the weights of the 15 evaluation indicators (0.066), and the comprehensive score of the overall satisfaction evaluation of the landscape of Zhengzhou People's Park (70.19) is drawn as the boundary.

From Figure 2, the first quadrant is the area of high weighting and high satisfaction, i.e., the "advantage area," which includes C43 site participation, indicating that the participatory and experiential nature of park open space places has a significant impact on landscape satisfaction and public perceptions of satisfaction, and the public's perception of satisfaction is also higher. Therefore, on the basis of maintaining the strengths, the participatory design of park activity areas shall be further optimized to meet the public's requirements for the landscape of places.

The second quadrant is the area of high satisfaction and low weighting, i.e., the "maintenance area," which includes the evaluation indicators, such as C11 environmental coordination, C12 visual aesthetics of the environment, and C13 ecological suitability. The corresponding item-level indicator is "environmental satisfaction," which is a fundamental factor affecting the satisfaction of the park landscape. Although the weighting of the evaluation index is not too high, the satisfaction value from the public is high, which indicates that the ecological and natural environment has a high landscape value. The evaluation indicators for the "maintenance area" shall be further improved while maintaining their strengths so that the level of public satisfaction will be kept.

The third quadrant is the low satisfaction and low weighting area, i.e., the "nonconcern area," which includes indicators such as C23 publicity service facilities, C41 location rationality, C51 scale rationality, and C52 spatial variability. Although the satisfaction scores and weightings of these indicators are relatively low, their impact on the quality of the park landscape shall not be ignored.

The fourth quadrant is the area of low satisfaction and high weighting, i.e., the "area of concern," which includes C21 recreational facilities, C22 guide facilities, C31 road paving design, C32 barrier-free design, C33 traffic organization rationality, C42 functional diversity, and C53 sense of space security, and the evaluation indicators mainly focus on the level of "facility satisfaction" and "traffic satisfaction." This shows that the design of park recreational facilities and road traffic has an important influence on the overall satisfaction of the landscape, while the public's perception of their actual experience is very low. In the construction of the park landscape, we shall strengthen the improvement and optimization of the indication of "area of concern," reasonably set up recreational service facilities, improve the road traffic organization, and create activity places with reasonable spatial layout and various functions, so as to improve the level of satisfaction of the park landscape.

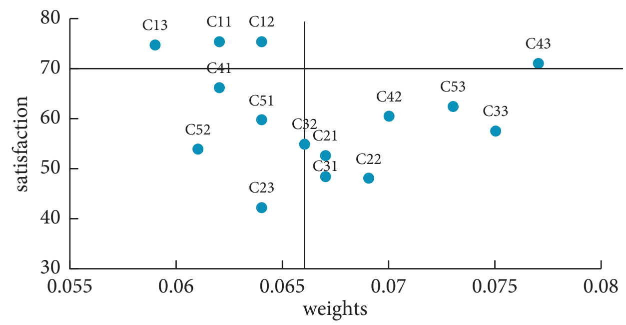

Figure 2: The IPA analysis of urban park landscape satisfaction evaluation.

5. Conclusions and Recommendations

Based on the triangular fuzzy evaluation theory, the traditional discrete numerical comment variable description method is changed in the study, and continuous triangular fuzzy comment variables are used to describe the urban park landscape satisfaction evaluation indicator, and a fuzzy comprehensive evaluation of the Zhengzhou People's Park landscape satisfaction is carried out. Through the exploratory factor analysis of the survey data of Zhengzhou People's Park, it is concluded that there are 5 evaluation dimensions and 15 evaluation indicators in the landscape satisfaction evaluation system, and the weight of the evaluation indicators is determined. After analysis to the landscape satisfaction evaluation indicators with the IPA analysis method, it is concluded that it is in the "advantage area" if the satisfaction score and weight value of the "site participation" in the evaluation indicators are both high, which requires attention and maintenance of its advantages; the evaluation indicators of the two aspects of "facilities satisfaction" and "traffic satisfaction" are mainly located in the "concern area," which are the main factors affecting the landscape quality of urban parks. The improvement of its quality is conducive to the improvement of landscape satisfaction and shall be focused and optimized; the "environmental satisfaction" dimension indicators are in the "maintenance area." Although the weight of the evaluation indicators to the landscape satisfaction is low, the satisfaction scores are high, and their advantages shall be kept; although indicators such as "publicity service facilities," "location rationality," "scale rationality," and "spatial variability" are in "nonconcern area" with a low weight and low satisfaction, their impact on landscape quality shall not be ignored. During the construction of the urban park landscape in the future, we shall focus on the indicators of "advantage area" and "concern area," take into account the indicator of "maintenance area," and coordinate the indicator of "nonconcern area" so that the level of park landscape satisfaction can be effectively improved.

The study attempts to evaluate urban park landscape satisfaction by the fuzzy-IPA model, which provides a quantitative reference and basis for the construction of urban park landscape, the continuous fuzzy comment variable can more truly reflect the evaluation subject's cognitive level of the landscape object and reduce the subjective error of evaluation; the weight of the evaluation index determined by the factor analysis method is used to obtain the importance of the evaluation index to the landscape satisfaction; the importance-performance analysis method obtains the quadrant analysis chart of the satisfaction value of the evaluation index and the importance of the evaluation index and divides and proposes the evaluation index into different categories; but there are still some shortcomings: the selection of indicators for the questionnaire of the urban park landscape satisfaction is relatively simple, the number of questionnaires distributed is limited, and the error handling of the survey results is insufficient, which fails to fully reflect the public's perception of urban park landscape satisfaction, and it shall be further improved and adjusted in future research.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that there are no conflicts of interest with any financial organizations regarding the material reported in this manuscript.

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