https://doi.org/10.37420/j.eeer.2023.006

Research on Environmental Safety Evaluation of Urban Parks Based on Analytic Hierarchy Process: A Case Study of Four Urban Parks in Fuzhou City

Yun Gao[1,*]

[1] School of Art and Design, Fuzhou University of International Studies and Trade, Fuzhou, Fujian Province, China, rachel0223gaoyun@163.com

***Corresponding author,E-mail: rachel0223gaoyun@163.com**

Abstract

In this study, Analytic Hierarchy Process was used to construct the environmental safety evaluation level of physical spatial layout, social environment guidance and security technical means as the evaluation criteria. In addition, using the complete evaluation index system constructed after the weight value is given, the environmental safety of the four research object urban parks in Fuzhou city is evaluated, and the comprehensive evaluation grade is divided. The results show that: 1) The each evaluation index in the criterion layer is ranked from high to low as physical spatial layout (0.4097), security technical means (0.3244), social environment guidance (0.2659); 2) In the factor layer, the top 5 places in the overall weight value order of the evaluation index factors are CCTV monitoring (0.1040), organization of social activities (0.0840), lighting (0.0827), plant furnishing (0.0806), mixed crowd (0.0743); 3) In terms of environmental safety construction of the four research object urban parks in Fuzhou city, the comprehensive evaluation results are that Wenquan park is in Grade I (Very Good), Xihu Park and Chating Park are in Grade II (Good), and Wangzhuang Nanhu Park is in Grade III (Average).

Keywords: Urban park, Analytic Hierarchy Process, Environmental safety, Evaluation index system

1 INTRODUCTION

According to the China Statistical Yearbook-2021, China's per capita GDP and urbanization level have been rising steadily since 1997, while the urban crime rate has been rising by(State Statistics Bureau, 2021). Urban park provides residents with health, safety, rest, recreation and other service functions. It plays a very important role in the outdoor activities of residents, and its construction directly affects the quality of the city. Because the service content of urban parks is to meet the proximity of people with different characteristics, various types of crime or disorderly behavior occur from time to time in urban parks with open space attributes(Kim et al., 2014), and parks and other open spaces are easy to become the cradle of crime under the situation of urban decline. In Maslow's 5-level Hierarchical Theory of Needs, people's demand for safety is second only to physiological demand. Safe environment is the basic premise for human beings to engage in social activities, and also the bottom line for a city to operate and maintain sustainable development. Due to the large population density, intensive human activities, limited construction land and other factors, how to use the limited urban park resources to create an environment that can prevent crime and disorderly behavior, and is more suitable for residents' safe use, has become an urgent social problem to be solved.

At present, China promotes the construction of natural ecological protection, landscaping, leisure, entertainment, health and sports, and emergency shelter to promote the functions of urban parks, but does not pay necessary attention to the problem of crime prevention in urban parks. Based on this point of view, this study uses Analytic Hierarchy Process, which combines qualitative and quantitative evaluation methods, to turn the abstract environmental safety characteristics into a concrete operational multi-level comprehensive evaluation system, which has certain guiding significance for the construction of urban parks with environmental safety characteristics.

2 Survey of the Research Object

2.1 Survey of the Research Object City

Fuzhou is the capital city of Fujian Province, which is located in east China, eastern Fujian, the lower reaches of Minjiang River and coastal areas, with the Pacific Ocean in the east. Between east longitude 119°18'~120°31' and north latitude 25°15'~26°39', the total administrative area is 11,968km2 and the built-up area is 416km2. According to the Fuzhou National Economic and Social Development Statistical Bulletin (Fuzhou national economic and social development statistical bulletin, 2022) which is released by the Fuzhou Bureau of Statistics in 2016-2021, the forest coverage rate of the city has increased slowly from 56% to 58.41%, and the total area of urban parks and green space has increased significantly, from 3,507.25hm2 in 2016 to 5,471.70hm2 in 2021. From 2016 to 2020, the green space coverage rate, per capita urban parks and green space area in the built-up area continued to increase, and the new urban parks and green space area in the city reached the highest point in 2020. However, due to the impact of COVID-19, the three data above all decreased in 2021, as shown in Figure 1.

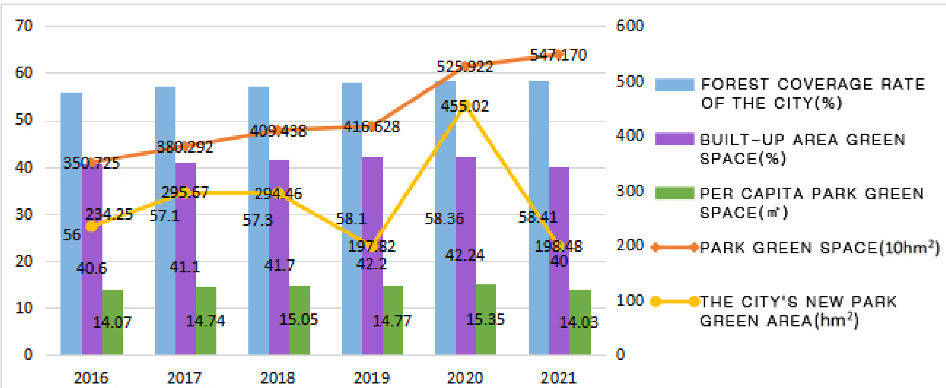

Figure 1. Statistics of urban parks and green space in Fuzhou City from 2016 to 2021.

The climate characteristics of Fuzhou city are obvious, belonging to the typical subtropical monsoon climate, which is very conducive to the growth of plants, and provides favorable conditions for the construction of the city's green space and the creation of an ecological city. Fuzhou city has a long summer time, short winter time, almost no frost weather, rich climate resources, suitable temperature, abundant rain. This study surveyed the climate and temperature data of Fuzhou city in 2021(Fujian Provincial Climate Bulletin, 2021), and found that the temperature from October to November was 24℃~19℃, the sunshine hours were more, and the rainfall was at the lowest value of the year, which is the most suitable time for citizens to conduct various activities in the urban park. Therefore, the time period for the survey of the object parks was selected to be on sunny days from October to November in 2022.

2.2 Overview of the Research Object Urban Parks

In this study, four urban parks, Xihu Park and Wenquan Park in Gulou district, Chating Park in Taijiang district and Wangzhuang Nanhu Park in Jin'an district, were selected as research objects. The basic information of the four urban parks are as follows.

Xihu Park is a city-wide comprehensive park with an area of 51.52hm2 and the opening time of 5:30~22:30. The park has four entrances and exits of the road, facing the main intersection. There are no subway stations around the park, but there are 5 bus stops. The east and west sides of the park are residential areas, the north side is cultural facilities, and the residential areas and schools in the south side. The road layout of the park is suitable, and the mixture of different types of park users is high, so the facilities used to support the activities of the population are relatively sufficient. In addition, the layout of lighting and CCTV monitoring is reasonable, and the identification system is clear and sufficient, which is convenient for people to find a way out.

Wenquan Park is a city-wide comprehensive park with an area of 17.7hm2, and opens 24 hours a day. The park is surrounded by residential areas and commercial areas, and there are eight exits, and they are aimed at the surrounding residential areas. And there are bus stops are set up next to four of exits, which is convenient for residents to enter the park and also prone to unsafe factors to flow into the park. Occasionally, there are individual homeless people sleeping out in the park. All kinds of facilities in the park are fully arranged, and different types of social activities can be carried out in the meantime in the park. Park users are mainly elderly, children, housewives, and young activists, as well as primary school students who do after-school physical exercises and games. The park has arranged security patrols and professional plant managers to trim the vegetation. The park is in a very clean and tidy environment.

Chating Park is a special historical site park with an area of 3.57hm2, of which the water occupies an area of about 2hm2, and opens 24 hours a day. The park is surrounded by residential areas, commercial areas and schools. There are three exits, one of which has bus stops and subway lines nearby. The facilities in the park are mainly leisure facilities, but there is a lack of convenience and sports type facilities. It is worth noting that the design of barrier-free access for the disabled is excellent. The layout of the park road is mainly the tour routes around the water, and lighting and CCTV monitoring are arranged along the road, but the quantity is not sufficient. Security personnel are only on duty at designated posts, with no dynamic patrol. The height of the obstacle of the park border is insufficient, and the potential unsafe personnel easily avoids CCTV monitoring and enters the park.

Wangzhuang Nanhu Park is a community park with an area of only 0.86hm2, which is open 24 hours a day. There is each one exit of the north and south of the park facing the residential area, and there are no bus stations and subway lines around. The park has a small area, but there are many users of different ages and the purpose of use. The active space, sports equipment area, and board game area of the elderly are gathered in a narrow space. The middle-aged and elderly people who love square dancing and the young basketball players "seize" the field site, and the overlapping use function and layout of the space in the park are very unreasonable. There are almost no signs in the park, there are piles of garbage around the dustbin, and the environment is not clean enough. The situation of CCTV monitoring installation was terrible, with only one installation remaining. The height of the wall of the park boundary is not enough, making it easy to climb and enter. Due to the lack of blocking facilities for the diversion of people and cars at the exit, the situation of parking electric motorcycles in the park is serious.

The photos are shown on the environmental status survey of the above four urban parks(i.e., Figure 2).

Figure 2. Survey photos of the current situation of four urban parks.

3 METHOD

3.1 Establish the Evaluation Level

The Analytic Hierarchy Process was developed by Professor Thomas L.Saaty at the Pennsylvania University Wharton School in the 1970s (Saaty & Vargas, 1979). Based on the characteristics of the problem and the purpose to achieve, Analytic Hierarchy Process decomposes a problem into multiple constituent factors. According to the correlation and affiliation between the factors, each factor is assembled according to levels to form a well-structured and coherent analytical structure model to solve the problem (Liu et al., 2016). This method has been widely used in the evaluation of ecological (Cheng et al., 2022), service function (Guo, 2022), landscape visual quality (Yang & Tang, 2020), plant ornamental (Wei & Zhang, 2017) and other aspects of urban park landscape, and has achieved some research results, but there is still a lack of scientific research on the construction of urban park environmental safety evaluation system.

Affected by the environmental safety of urban parks is an abstract and difficult to define the complex problem, which can be regarded as a "multi-goal decision problem". Therefore, in order to build an evaluation system for abstract environmental safety evaluation, the Analytic Hierarchy Process is used in this study. The Analytic Hierarchy Process model framework includes: 1) Target Layer A (level 1): the key to the research object problem; 2) Criterion Layer B (level 2): the intermediate factor variable used to achieve the purpose, which is the a specific criterion for judging the problem; 3) Factor Layer C (level 3): including the index factors that are decomposed from the Criterion Layer for specific evaluation and measure(Zhong, L., 2015). The Analytic Hierarchy Process model framework is as shown in Figure 3.

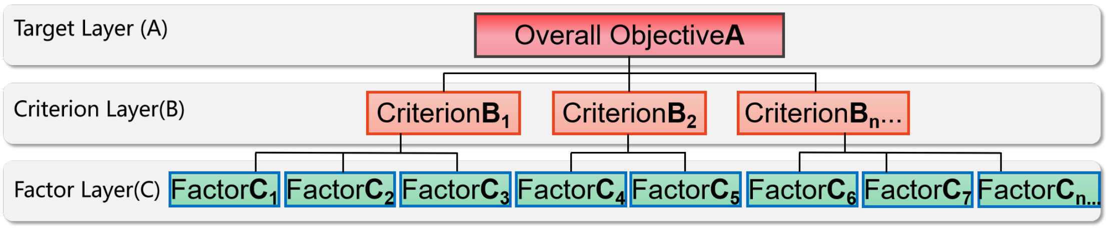

Figure 3. Analytic Hierarchy Process model framework.

After reading the literature related to the environmental safety of urban parks, this study borrowed the research results of predecessors, and conducted field research and actual observation of urban parks in Fuzhou city. It also randomly conducted a deep interview of about 40 minutes per person for several users of parks. On the basis of these preliminary investigations, it is decided to build a quantitative assessment system for the "urban park's environmental safety" as an evaluation system for the overall core goal. This study selected evaluation index factors according to the principles of scientific, independence, rationality, comparability and operability, and combined about 40 experts from related disciplines from landscapes, architecture, urban planning, etc., and visited the current situation of the environmental safety of most urban parks in Fuzhou city. The evaluation hierarchy model was finally determined to be three levels, which are: Target Layer A is to obtain quantitativeness of the environmental safety of urban parks; Criterion Layer B is the intermediate factors involved in the study goal, namely the physical spatial layout, social environment guidance, and security technical means, and these three dimensions of factors as criteria for judging issues in this study; Factor layer C is a set of 16 evaluation index factors that are further refined and decomposed based on the content of the Criterion Layer B, which can be used by expert groups for specific evaluation, measurement, and scoring.

Table 1 shows the relationship between the evaluation hierarchy mode and the direction of the description and influence of the evaluation index factors.

Table 1. Description of the evaluation hierarchy mode and the evaluation index factors.

Target Layer A (level 1)	**Criterion Layer B (level 2)**	**Factor Layer C (level 3)**	**Description of the evaluation index factors**	**The nature and influence direction of evaluation index factor**
A environmental safety evaluation of Fuzhou city urban park	B_1 physical spatial layout	C_1 plant furnishing	The height and density of plants planted. Tall trees should be 2.2m above the ground under the branch clearance height, plant spacing should be more than 1.00m. The height of low shrubs should be less than 1.2m from the ground, and the spacing between plants should be between 10cm and 25cm.	quantitative, two-way (sparse for monitoring control; Intensive favorable park greening)

A environmental safety evaluation of Fuzhou city urban park	B_1 physical spatial layout	C_2 openness of the buildings/ structures	Ensure the openness of the buildings/ structures in the park to avoid dead corners in the building space.	qualitative, positive
		C_3 exit	Create clear roads leading to park entrances and exits, limit the number of entrances and exits, plan the directions of entrances and exits, and try to avoid complex traffic elements such as urban main roads, bus stops and intersections to limit the escape of criminals.	quantitative, reverse(the smaller the number, the easier it is to limit the escape of criminals)
		C_4 road layout	It mainly adopts walking roads, avoids complex and dense road network design, forms ring lines and avoids the appearance of broken roads. It is closely connected with all functional spaces in the park, and has clear crowd movement lines to prevent ineffective flow.	qualitative, two-way(sparse is easy to monitor and control; intensive beneficial park user activities)
		C_5 topography enclosures and elevation variations	The space enclosed by the terrain should be changed in an orderly manner, and the elevation changes play the effect of concealment and privacy and space division. Park users are in it, and have a clear cognition of the hierarchy of public, semi-public and private space.	qualitative, two-way(security surveillance and privacy invasion)
		C_6 park facilities	The setting of convenience facilities, service facilities, recreation facilities, management facilities and barrier-free facilities in parks includes the number, volume, orientation and spacing.	quantitative, two-way(small quantity and small size are inconvenient for park users to use; large quantity and volume hinder security monitoring)
		C_7 identification system	The signage system uses recognizable words, symbols and patterns that are large, bright, readable, and can be seen at night. The maximum distance between road guide signs, entrance and exit signs, location signs, and guide signs should not be greater than 150m.	quantitative, positive
		C_8 boundary barriers	Park boundary barrier setting, transparent (transparent or translucent, smooth material) fences, walls installed in the appropriate height between 1.5m-1.8m, and set the appropriate spacing distance is not more than 10cm.	quantitative, positive

		C_9 organization of social activities	Various social activities are organized and carried out reasonably in the park.	qualitative, positive
	B_2 social environment guidance	C_{10} environmental maintenance	Park professionals maintain old facilities and regularly prune plants. Park users voluntarily maintain a healthy environment.	qualitative, positive
		C_{11} disorder behavior management	Graffiti and pasted advertisements will be removed, pet dirt will be treated, homeless people will not be allowed to sleep in the open air, and there will be no smoking, alcohol or gambling in the park.	qualitative, positive
		C_{12} mixed crowd	Park users are mixed by age, gender (children, old or young, male or female), and purpose of use.	qualitative, positive
A environmental safety evaluation of Fuzhou city urban park		C_{13} lighting	Sufficient lighting equipment, sufficient brightness, complete coverage, no lighting dead corners and blind areas, spacing distribution is reasonable, avoid plants or independent zone. Lighting intensity is, general roads and activity areas should not be less than 5Lux, 5-30Lux is a more reasonable range of lighting brightness.	quantitative, positive
	B_3 security technical means	C_{14} CCTV monitoring	There are sufficient CCTV monitoring devices for complete coverage, no monitoring dead corners or blind areas, avoid plants or independent zones, reasonable spacing distribution of equipment, and increase the coverage of key monitoring areas such as the entrance and children's activity areas.	quantitative, two-way(security surveillance and privacy invasion)
		C_{15} security and alarm system	Install the access control system. Set up parking lot entrance gate/fence machine. Set alarm bells in restrooms, activity areas and pedestrian walkways with patterns that anyone can understand.	quantitative, positive
		C_{16} security technicians	Police patrols were placed outside the park to increase surveillance. The park is equipped with full-time security personnel or guards who are responsible for public security management.	qualitative, positive

3.2 Data Acquisition and Weight Value Calculation

3.2.1. Collection of Questionnaires

In order to reduce social contact during the epidemic period, a questionnaire was sent to 25 experts by email during 10 days from August 21 to 30, 2022. The experts' age, major, occupation, educational background and length of experience in the relevant field are also included in the expert questionnaire.

The questionnaire asked experts to compare the evaluation factors of the same level with Pairwise Comparison to determine the relative importance of the two factors and construct a judgment matrix (Xu, 1988). According to the hierarchical relationship of evaluation index factors in Table 1, the judgment matrix of A-(B_1~B_3), B_1-(C_1~C_8), B_2-(C_9~C_{12}), B_3-(C_{13}~C_{16}) is constructed. Experts used 1-9 scale method when making comparison, that is, 1, 3, 5, 7, 9 points represent that the former factor is equally important, slightly important, relatively important, very important and absolutely important compared with the latter factor, while the 2, 4, 6, 8 points represent the intermediate value. If the latter factor is compared with the former factor, then the value is presented by reciprocal.

3.2.2. Determination of Weight Value and Consistency Test

In this study, quantitative analysis software SPSS Statistics 23.0 and Excel 2017 were used to carry out mathematical calculations on the data obtained from the questionnaire feedback of 25 relevant professional experts. In order to ensure the correctness of the order of the importance of each evaluation indicator factor at the same level, it is also necessary to verify the logical consistency of the judgment matrix evaluation completed by experts through the following mathematical calculation, which is called consistency test. The complete calculation verification process is described below.

1) Judgment matrix A

The formula for calculating the root vector A of matrix Ai is(Liu & Peng, 2017):

$$A_i = \sqrt[n]{\prod_{k=1}^{n} C_{ik}} \ (i,k=1,2,\ldots,n) \quad (1)$$

n is the number of evaluation index factors.

C_{ik} is the scale value of the relative importance of the ith factor and the Kth factor.

2) The calculation formula of the weight value of each level of evaluation indicator factor is (Kang, 2018):

$$W_i = \frac{A_i}{\sum_{i=1}^{n} A_i} (i=1,2,\ldots,n) \quad (2)$$

3) The calculation formula of the total ranking weight value of each evaluation index factor is (Liu et al., 2013):

$$F_i = C_{ik} W_k \quad (3)$$

4) The calculation formula of Maximum Eigenvalue λmax of judgment matrix A (Liu et al., 2013):

$$\lambda_{\max} = \sum_{i=1}^{n} \frac{1}{nW_i} \sum_{k=1}^{n} C_{ik} W_k \quad (4)$$

5) The calculation process of CR value for consistency test is:

The ratio between the consistency index CI obtained from the judgment matrix A and the corresponding average random consistency index RI[5] is CR value of consistency test. That is shown in Table 2 below.

$$CI = \frac{\lambda_{\max} - n}{n-1} \quad (5)$$

When CI=0, it has to be exactly the same.

The more CI is connected to 0, the more satisfactory consistency can be maintained.

The larger the CI, the more severe the difference.

Table 2. The value of the average random consistency index RI.

Number of Matrices(n)	1	2	3	4	5	6	7	8	9	10	11
RI	0	0	0.52	0.89	1.12	1.26	1.36	1.41	1.46	1.49	1.52

The calculation formula of CR value is:

$$CR = \frac{CI}{RI} \quad (6)$$

When CR<0.10, the judgment matrix is considered to have statistically satisfactory consistency.

When CR≥0.10, the consistency of the judgment matrix is poor, and the expert data that made the judgment matrix should be properly adjusted and analyzed again.

3.2.3. Example of Weight Value Calculation

Taking the B_2-(C_9~C_{12}) judgment matrix constructed by Expert No. 1 as an example, Table 3 shows this expert's quantitative description of the importance degree among indicator factors. Through consistency test, it is known that the judgment matrix has the correct logical consistency result, so the weight value of C_9~C_{12} evaluation indicator factor is obtained.

Table 3. Judgment matrix B_2-(C_9~C_{12}) and its consistency check.

B_2-(C_9~C_{12})	C_9 organization of social activities	C_{10} environmental maintenance	C_{11} disorder behavior management	C_{12} mixed crowd	Weight Value W_C^n
C_9	1	5/2	5/4	3/4	0.3018
C_{10}	2/5	1	3/2	4/5	0.2031
C_{11}	4/5	2/3	1	2/3	0.1884
C_{12}	4/3	5/4	3/2	1	0.3067
λ_{max}=4.142 *CI*=0.047 *n*=4 *RI*=0.89 *CR*=*CI*/*RI*=0.054 ＜ 0.10, passed the consistency check					

Among the questionnaire results given by 25 experts, the calculation shows that the judgment matrix given by 23 experts completely passes the CR value consistency test, and the answer sheet given by 2 experts violates the logical law of the importance judgment matrix and cannot be used. Therefore, the effective recovery rate of this questionnaire is 91.3%.

3.3 Comprehensive Evaluation Score Value and Grade Division

Among 16 factor level C (level 3) factors, C_1, C_3, C_6, C_7, C_8, C_{13}, C_{14} and C_{15} were evaluated by field measurement and investigation of the park of the research object. The remaining 8 evaluation index factors need to be quantitatively assigned by qualitative evaluation scores of 2 points (very poor), 4 points (poor), 6 points (average), 8 points (good) and 10 points (very good). The author invited 20 graduate students majoring in landscape architecture, environmental design, and engineering architecture from Fuzhou University, Fujian Normal University, Fujian Agriculture and Forestry University, and Fujian Institute of Technology to conduct on-site evaluations and scoring of four research object urban parks from September 2 to October 17, 2022. The evaluation criteria were based on the description, nature, and impact direction of the evaluation index factors in Table 1.

The environmental safety comprehensive evaluation score of the four research object urban parks was calculated by the following formula (Liu & Peng, 2017).

$$F = \sum_{i=1}^{n} WC_i (i = 1,2,\ldots,n) \quad (7)$$

W is the weight value of an evaluation index factor in factor layer C.

C is the score of the evaluation index factor.

$$S = \sum_{i=1}^{n} FW \ (i = 1,2,\ldots,n) \quad (8)$$

S is the comprehensive evaluation score.

F is the score of each evaluation index factor.

W is the weight value of evaluation index factor in Criterion Layer B.

n is the number of evaluation index factors.

The following formula was used to calculate the comprehensive evaluation index C_{CEI}(Lu & Li, 2009). On this basis, the percentage difference method was used to divide the comprehensive evaluation results of the environmental safety of each urban park into four grade standards: I, II, III and IV (Kang, 2018), as shown in Table 4.

$$C_{CEI} = {}^{S}/_{S_0} \times 100\% \quad (9)$$

C_{CEI} is comprehensive evaluation index.

S is the comprehensive evaluation score.

S0 is the ideal value (obtained by multiplying and superimposing the highest score of each evaluation index factor with the weight value).

Table 4. Urban park environmental safety comprehensive evaluation results grade standard.

Comprehensive Evaluation Index C_{CEI}	**100%~80%**	**80%~60%**	**60%~40%**	**40%~0%**
Grade Standards	Grade I	Grade II	Grade III	Grade IV
Meaning	Very Good	Good	Average	Bad

4 EVALUATION RESULTS AND ANALYSIS

4.1. Evaluation Index Factor Weight Value and Ranking Analysis

According to the same mathematical calculation method shown in Table 3, the weight value of each evaluation index factor at each level can be obtained from the judgment matrix constructed by other experts. After the weighted average calculation, the weight value of the environmental safety evaluation index system of urban parks in this study can be obtained. The weighting value is obtained to reflect the different importance of each evaluation index factor to the previous layer of evaluation index. So far, the study has completely constructed the evaluation index system of environmental safety of urban parks, and obtained the overall weight value and ranking of evaluation index factors, as shown in Table 5.

Table 5. Evaluation index system and overall weight value.

Target Layer A (level 1)	**Weight Value W_A^n**	**Criterion Layer B (level 2)**	**Weight Value W_B^n**	**Factor Layer C (level 3)**	**Weight Value W_C^n**	**Overall Weight Value W_Z^n**	**Rank**
environmental safety evaluation of Fuzhou city urban park	1.0000	B_1 physical spatial layout	0.4097	C_1 plant furnishing	0.1967	0.0806	4
				C_2 openness of the buildings/ structures	0.1087	0.0445	13
				C_3 exit	0.1078	0.0442	14
				C_4 road layout	0.1099	0.0450	12
				C_5 topography enclosures and elevation variations	0.0642	0.0263	16
				C_6 park facilities	0.1646	0.0674	7
				C_7 identification system	0.1627	0.0667	9
				C_8 boundary barriers	0.0854	0.0350	15
		B_2 social environment guidance	0.2659	C_9 organization of social activities	0.3159	0.0840	2
				C_{10} environmental maintenance	0.2077	0.0552	10
				C_{11} disorder behavior management	0.1968	0.0523	11
				C_{12} mixed crowd	0.2796	0.0743	5
		B_3 security technical means	0.3244	C_{13} lighting	0.2550	0.0827	3
				C_{14} CCTV monitoring	0.3205	0.1040	1
				C_{15} security and alarm system	0.2064	0.0670	8
				C_{16} security technicians	0.2181	0.0708	6

As can be seen from the above Table 5, in Criterion Layer B, the highest weight value is B_1 physical spatial layout (0.4097), followed by B_3 security technical means (0.3244), and the lowest is B_2 social environment guidance (0.2659), which indicates that if a safe urban park environment is to be created, more focus will be placed on the substantial material space layout. Among the factors in Factor Layer C, the top 5 are C_{14} CCTV monitoring (0.1040), C_9 organization of social activities(0.0840), C_{13} lighting (0.0827), C_1 plant furnishing (0.0806), and C_{12} mixed crowd (0.0743). It can be seen that experts are more inclined to start from the installation and layout of CCTV monitoring and lighting equipment, the configuration, design and layout of plants, and the mixing of users of different purposes, ages and genders, believing that these factors will have a stronger impact on the construction of a safe urban park environment.

4.2 Comprehensive Evaluation Results of Each Urban Park

After the calculation process of comprehensive evaluation index, the scores and grades of of four research object urban parks is determined. As shown in Table 6, Wenquan Park obtained the highest C_{CEI} comprehensive evaluation index of 82.45%, and the environmental safety grade was Grade I (Very Good). Xihu Park and Chating Park were followed by 78.24% and 68.87%, respectively, with the environmental safety Grade II (Good). The last one is Wangzhuang Nanhu Park 50.52%, the environmental safety grade is III (Average). The four urban parks selected in this study did not have poor security conditions.

Compared with the comprehensive evaluation scores of the four research object urban parks, the Wenquan Park got the highest scores of 3.2288 and 2.1574 respectively in terms of physical space layout and social environment guidance. Xihu Park received the highest score of 2.4215 in terms of security technical means. However, Wangzhuang Nanhu Park obtained the lowest score in the three criteria, which indicates that the park has significant deficiencies in environmental safety design, with obvious shortcomings that need to be rectified.

Table 6. Scores and grades of environmental safety comprehensive evaluation of four urban parks.

Research Object	Physical Spatial Layout	Social Environment Guidance	Security Technical Means	S	S_0	C_{CEI}(%)	Grade
Wenquan Park	2.7869	2.0796	2.4215	7.2880	9.3152	78.24	II
Xihu Park	3.2288	2.1574	2.3840	7.7702	9.4242	82.45	I
Chating Park	2.6180	1.3722	1.9098	5.9000	8.5664	68.87	II
Wangzhuang Nanhu Park	1.5640	0.9481	1.0825	3.5946	7.1156	50.52	III

5 CONCLUSIONS AND DISCUSSION

5.1 Conclusions

The development of urban park environment safety needs to rely on other scientific technologies and methods. By combing the previous work and conducting an in-depth investigation of urban parks in Fuzhou, this study obtained some internal laws of environmental safety construction of urban parks as well as objective quantitative and qualitative evaluation index factor sets that can be applied in operation, and constructed a complete evaluation index system with a logical analytic hierarchy process method. The construction of the evaluation index system takes into account three aspects of material space, social environment and technical means, and it is reflected through 16 quantifiable index factors. This system provides a new perspective of environmental safety research for urban parks. And this evaluation index system brings together the professional experience and wisdom of the peer experts and scholars in related fields, which can provide effective reference ideas for the managers and designers of urban planning, landscape architecture, landscape design and other industries to determine the best design scheme.

The results of the empirical case of this study are as follows. Firstly, In the criterion layer, the largest index factor weight is physical spatial layout (0.4097), next by security technical means (0.3244), and the last one is social environment guidance (0.2659). Secondly, in the factor layer, the top 5 places of the overall weight value of the evaluation index factor is CCTV monitoring (0.1040), organization of social activities (0.0840), lighting (0.0827), plant furnishing (0.0806), mixed crowd (0.0743). Thirdly, after the quantitative evaluation of the evaluation index system, we can get the clear results on the environmental safety construction of the four research object urban parks in Fuzhou city, the comprehensive evaluation results are that Wenquan Park is in Grade I (the environmental safety is very good), Xihu Park and Chating Park are in Grade II (the environment is good), and Wangzhuang Nanhu Park is in Grade III (the environmental safety is general).

5.2. Discussion

Through investigation and analysis of the research object urban parks, data organization and calculation, verified the Analytic Hierarchy Process can be used to construct an evaluation system for the environmental safety of urban parks, and the advantages and disadvantages of the research object urban parks in environmental safety can be clearly understood through the comprehensive evaluation index and evaluation grade division.Based on the research conclusions in the previous text, the author focuses on three aspects: physical spatial layout, social environment guidance and security technical means, and proposes suggestions that can to some extent prevent criminal behavior and disorderly behavior from occurring in urban parks.

5.2.1. Build a Safe Physical Space Environment

In terms of the layout planning and design of material space, the following eight points should build a defensive urban park environment. Firstly, in the plant planting configuration design, the clearance height of tall trees should be controlled above 2.2m, and the distance between arbor plant spacing should be above 1.0m. The height of low shrubs should be controlled below 1.2m above the ground, and the distance between shrubs should be more suitable between 0.01~0.25m, and the planting density should be maintained to ensure one side of the line of sight permeability. Secondly, the location layout of buildings or structures should not be in the remote corner of the park, should try to avoid road corners or dense plant planting areas, the surrounding should be reserved more open buffer space, to avoid the appearance of architectural space dead corners. Thirdly, limit the number of entrances and exits in the park, and the design layout of the entrance and exit direction should be located on secondary roads with low road grade and low traffic flow, avoiding complex traffic elements such as close bus stops or intersections. The high traffic flow and disorderly areas not only increase the difficulty of public security management at the entrance of the park, but also facilitate the escape of criminals. Fourthly, optimize the layout and organization of parkways, with trails as the main form of a loop, clear movement lines, and prevention of ineffective flow. Nodes should be connected to the functional areas of the park to avoid dead ends. Fifthly, users have a clear understanding of the hierarchical distinction between open spaces, semi open spaces, and private spaces enclosed by terrain slopes, with a slope height difference of 3.0-3.5m being the most suitable range. Sixth, various facilities in the park can meet the usage needs of various park users, and the volume should not be too large and the layout should not be too dense; For example, service facilities such as trash cans and water dispensers should be spaced between 50-100m at the edges of areas with concentrated pedestrian flow, main pedestrian roads, and near rest seats; The service radius of the bathroom should not exceed 250m, and a convenient bathroom for children should be set up near the children's playground. Seventh, the signage system for entrances and exits, restrooms, management offices, road guidance, etc. in the park should be designed with clear text or patterns that are easy for the elderly and children to read and understand, large in size, bright in color, and can be recognized in the distance or at night. The maximum spacing should not exceed 150m. Eighth, the method of setting up transparent (transparent or semi transparent, smooth material) fences, fences, and walls should be adopted to strengthen the boundary barriers of the park and form a sense of differentiation between internal and external fields for park users.

The main purpose of building a safe material space environment is to create a good space for park users to watch and assist each other, improve the penetration of user visual communication, increase the possibility of mutual monitoring, and thus reduce the possibility of criminal and disorderly behavior.

5.2.2. Improve the Safety Quality of Social Environment

In terms of improving the safety and quality of the park's social environment, construction can be carried out from the following four points. Firstly, organize and carry out a variety of social activities in a reasonable manner to promote the use of urban parks by citizens, such as cultural performances, small commodity sales, catering tasting, group fitness exercises, etc., in order to increase the number of users of urban parks. Secondly, facilities, equipment, and equipment should be made of sturdy materials with high wear resistance and durability. Arrange professional personnel to regularly repair and maintain old facilities in the park, regularly trim and take care of plants, and maintain unobstructed lighting and CCTV monitoring. Park users have a sense of responsibility for the space they use, spontaneously maintain a hygienic environment, and eliminate the phenomenon of dirty, disorderly, and poor spaces. Thirdly, specialized personnel should be assigned within the park to remove graffiti and paste advertisements, treat pet waste, eliminate homeless people from camping, and prohibit smoking, drinking, and gambling within the park. Fourthly, by organizing activities, providing supporting facilities and functional spaces, encourage park users of all ages, genders, and usage purposes to visit the park for use.

5.2.3. Strengthen Safety Management Technology and Means

In terms of strengthening the technical means of urban park safety management, we will build from the following four points. Firstly, studies have shown that 40% of criminal activities occur on roads with lighting levels below 5 Lux during the night time, while the proportion of crimes occurring on roads with lighting levels above 20 Lux is 3% (Wang & Zhu, 2016). So improving the lighting intensity of 5-30Lux in urban parks during nighttime hours will greatly contribute to the prevention and control of criminal and disorderly behavior. At the same time, attention should also be paid to the sufficient distribution of lighting points, reasonable spacing, and complete coverage of the park, to prevent glare and not be obstructed by vegetation or signage systems. Secondly, similar to the layout of the lighting environment, the layout of CCTV monitoring equipment should also be sufficient, reasonably spaced, and achieve full coverage of the park without blind spots, without being obstructed by vegetation or signage systems. Thirdly, install park access control to record the user's identity, and set up park parking lot entrance gates or fence machines to identify vehicles entering and exiting. Among the numerous urban parks in Fuzhou, only a few have installed emergency call alarm systems at the main entrances and exits, which is far from sufficient to support users in finding and using emergency situations. Therefore, the deployment and installation of emergency call alarm systems is urgent. Fourthly, the park should be equipped with professional security personnel to conduct identity checks, patrols, and inspections of users. Security booths should be set up at entrances and exits for security personnel to carry out their work.

In this study, due to some subjectivity and one sidedness in the selection of evaluation index factors affecting the safety environment evaluation of urban parks, the construction of the evaluation system is not transparent and comprehensive enough to a certain extent. Therefore, in future research on the environmental safety evaluation of urban parks, the differentiation of evaluation index factors will be considered more reasonably, scientifically, and comprehensively, making the evaluation results more objective, specific, and accurate. This will provide a more solid theoretical basis, optimized design strategies, and more effective practical guidance for the safety environment construction of urban parks in Fuzhou city and even nationwide. Future researchers can comprehensively enhance the sustainable construction of urban parks from the perspective of spatial prevention and control and the creation of a safe atmosphere(Gao & Kim, 2022), based on the premise and principles of vigorously drawing on international advanced experience, solidly considering the national conditions and different types of urban park green spaces.

ACKNOWLEDGMENTS

This work was supported by the The Ministry of Education’s Humanities and Social Sciences Research Project(Youth Fund Project)2023 “Research on the Panoramic Management of the Heritage Corridor of the Historical and Cultural Blocks in Minjiang River Basin”, grant number 23YJC760030.”

REFERENCES

Cheng, L. L., Huang, S., Dong, J. W., Chen, X. Y., & Zheng, Y(2022). Research on the analysis and evaluation of the spatial differences of ecological functions of urban parks from the perspective of big data. Chinese Landscape Architecture, 38(1), 106-111. http://dx.doi.org/10.19775/j.cla.2022.01.0106.

Fujian Provincial Climate Bulletin (2021). http://fj.weather.com.cn/zxfw/qhgb/03/3527254.shtml. (accessed on 01-11-2022)

Fuzhou national economic and social development statistical bulletin. http://tjj.fuzhou.gov.cn/. (accessed on 01-11-2022)

Gao, Y., & Kim, S. B. (2022). A study on the application of CPTED theory in urban parks and green spaces. Art and Design, 2(5), 68-71. http://dx.doi.org/10.16824/j.cnki.issn10082832.2022.05.019

Guo, J. B. (2022). Evaluation and Optimization of Social Servive Spatial Characteristics of Urban Parks in the Capital Functiona Core Area Based on POI Data. Master. Thesis. Beijing: Beijing University of Civil Engineering and Architecture. http://dx.doi.org/10.26943/d.cnki.gbjzc.2022.000158

Kang, X. Q. (2018). Evaluation on plantscape of eight parks in Guilin by AHP method. Journal of Northwest Forestry University, 33(06), 273-278. http://dx.doi.org/10.3969/j.issn.1001-7461.2018.06.43

Kim, S. B., Heo, J. H., & Eum, J. H. (2014). A study on the application of CPTED theory to the physical environmental improvement of city parks-In the case of children’s parks in dalseo-gu, daegu. Journal of Korean Society for People, Plants and Environment, 17(3), 195-202. http://dx.doi.org/10.11628/ksppe.2014.17.3.195

Liu, R. X., & Peng, Y. Y. (2017). Evaluation of plant landscape in the seaside green space based on analytic hierarchy process. Journal of Northwest Forestry University, 32(4), 288-293. http://dx.doi.

org/10.3969/j.issn.1001-7461.2017.04.49
Liu, T., He, M., Wang, Y. X., & Yan, Y. Q. (2016). Comprehensive evaluation on the satisfaction for water park in Tianjin with the AHP and kano model. Journal of Shandong Agricultural University (Natural Science Edition), 47(3), 417-424. http://dx.doi.org/10.3969/j.issn.1000-2324.2016.03.019
Liu, Y. N., Zhang, B. J., & Wang, T. (2013). Assessment of tourism resource and development strategies based on AHP method in Tangyin. Journal of Capital Normal University(Natural Science Edition), 34(1), 72-76. http://dx.doi.org/10.19789/j.1004-9398.2013.01.015
Lu, J. G., & Li, S. Y. (2009). Study on the synthetical assessment of park plant landscape and its application. Journal of Nanjing Forestry University(Natural Science Edition), 33(06), 139-142.
Saaty, T. L., & Vargas, L. G. (1979). Estimating technological coefficients by the analytic hierarchy process. Socio-Economic Planning Sciences, 13(6), 333-336. http://dx.doi.org/10.1016/0038-0121(79)90015-6
State Statistics Bureau. (2021). China Statistical Yearbook-2021. Beijing: China Statistics Press.
Wang, J. J., & Zhu, J. N. (2016). Strategy study of lighting design based on CPTED. Architecture & Culture, (2), 134-135.
Wei, L. L., & Zhang, L. N. (2017). Exploitation prioriy of wild ornamental plant resources in Kunshan ecological forest park. Chinese Agricultural Science Bulletin, 33(2), 67-72.
Xu, S. B. (1988). Principle of analytic hierarchy process. Tianjin: Tianjin University Press.
Yang, Y., & Tang, X. L. (2020). The evaluation and factor analysis of the visual quality of scenic forest landscape: A case study of purple mountain national forest park in Nanjing. Chinese Landscape Architecture, 36(06), 135-140. http://dx.doi.org/10.19775/j.cla.2020.06.0135
Zhong, L.(2015). The study of urban green space based on child Safety——A case study of Nanchang city. PhD. Thesis. China: Jiangxi Agricultural University.