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Service Quality Evaluation of Urban Parks Based on AHP Method and SD Software

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Abstract: Public satisfaction is the main base to measure the service quality of urban parks. In this study, six factors influencing the service quality of urban parks, namely, place environment, landscape environment, culture environment, eco-environment, traffic environment and facilities environment, were screened and been subdivided into 18 impact indexes. Three-hierarchy Analytic Hierarchy Process (AHP) model consisting of target layer, factor layer and index layer was established and the service quality was selected to be the target layer. Three urban parks of Zhengzhou, Henan Province, namely, People's Park, CBD Park and Zijinshan Park, were the objects to be evaluated and 150 visitors of each park were surveyed about their satisfaction degree with quality service. Super Decisions (SD) software which can perform the AHP calculation, was used to obtain the weight of elements of each layer relative to the elements of the previous layer as well as the sequencing of total weight. Survey data of public satisfaction were combined with element weight to obtain the factor score and comprehensive score of service quality of the three parks. The result indicates that the service quality of CBD Park is the highest and can provide service of high quality to the public. Thus, CBD Park can be used as the model for the renovation and new parks' construction.

Key words: AHP, SD software, service quality, public satisfaction, urban parks

INTRODUCTION

Urban park is the most important part of urban green land system and the main place of public recreational activities as well. Urban parks have many integrated functions (Millward and Sabir, 2011): Improving the eco-environment (Lu *et al*., 2012) and recreational environment (Jim and Chen, 2006), protecting biodiversity and providing a place for cultural activities. Because of the development of economy and public awareness, the green land coverage of China urban parks is low and the green land area per capita is lower than the average level stipulated by United Nations. Therefore, the service quality of urban park needs to be improved. However, it is obvious that the satisfaction degree of the citizens, the objects of service for urban parks, is the most suitable measure of the service quality of urban park. Therefore, public satisfaction (Wang *et al*., 2012; Arnberger, 2012) is the main basis to measure the service quality of urban park. Three problems need to be addressed if evaluate the public satisfaction: Indexes, methods to perform statistics and the standard to evaluate. Concerning the first problem, it is of no question that parks target at the public service as it is a public investment. Therefore, indexes should be determined in accordance with the standpoint of citizens. As to the second problem, there are many indexes to influence the service quality of urban parks, but the importance of them varies, so a scientific method needs to be proposed. AHP (Li *et al*., 2005; Nekhay *et al*., 2009), as a flexible and practical multi-criteria decision-making method to quantitatively analyze the issue of interest, is very suitable for this study. Fuzzy evaluation method which converts the quantitative evaluation into qualitative evaluation in accordance with fuzzy mathematics theory, can be used in solving the problem of public satisfaction evaluation criteria. It solves problems which are fuzzy, non-linear and hard to quantify. The research aim is to evaluate the service quality of urban parks combining AHP method and SD Software.

MATERIALS AND METHODS

Step 1: To build a sample set:

$$S = \{P_1, P_2, P_3\} \quad (1)$$

Three urban parks of Zhengzhou in Henan Province, namely, Zhengzhou People's Park (P_1), CBD Park (P_2) and Zijinshan Park (P_3), were selected to be the evaluation samples

Step 2: To build AHP model: According to the result of previous researches and the combination of expert interviews and public interviews, 6 factors influencing the service quality of urban parks were screened, namely, place environment, landscape environment, culture environment and eco-environment, traffic environment and facilities environment which were subdivided into 18 impact indexes. Three-hierarchy AHP model was established based on these indexes (Table 1)

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Step 3: To use SD software to calculate the weight: Although, the calculation of AHP method is complicated, programmed solution is enabled with SD software (Sun *et al*., 2007; Kizilkaya *et al*., 2011) to simplify the calculation. Model was established in the SD software (Fig. 1). Weight of each element in the layer relative to the element in the previous layer W_{C-B} and W_{B-A} the sequencing of total weight W_{C-A} were obtained. The results passed the consistency check after the pairwise comparison of elements on a 1-9 scale by three experts

Step 4: To build the comment set: Comment set D was built. According to the Likert scale (Li, 2013) method, comments were divided into 5 degrees: Very dissatisfied, dissatisfied, mediocre, satisfied and very satisfied. Comment set D is obtained after the fuzzy value assignment was performed to comment set and the intermediate value was Med.d_t:

$$D = \{80<d_1\leq 100, 60<d_2\leq 80, 40<d_3\leq 60, 20<d_4\leq 40, 0<d_5\leq 20\} = \{\text{Excellent, Good, Mediocre, Bad, Very bad}\} \quad (2)$$

Table 1: Three-hierarchy AHP model of service quality evaluation of urban parks

Target layer (A)	Factor layer (B)	Index layer (C)
Service quality of parks (A)	Place environment (B_1)	Integrity of place functions (C_1)
		Rationality of place distribution (C_2)
		Richness of place types (C_3)
	Landscape environment (B_2)	General coordination of landscape (C_4)
		Art infection of landscape (C_5)
		Diversity of landscape (C_6)
	Culture environment (B_3)	Rationality of landscape theme (C_7)
		Authenticity of culture expression (C_8)
		Significance of culture characteristics (C_9)
	Eco environment (B_4)	Green quantity (C_{10})
		Green land coverage (C_{11})
		Rationality of green land distribution (C_{12})
	Traffic environment (B_5)	Accessibility of road (C_{13})
		Guide of road (C_{14})
		Hierarchies of road (C_{15})
	Facilities environment (B_6)	Integrity of facilities (C_{16})
		Safety of facilities (C_{17})
		Humanization of facilities (C_{18})

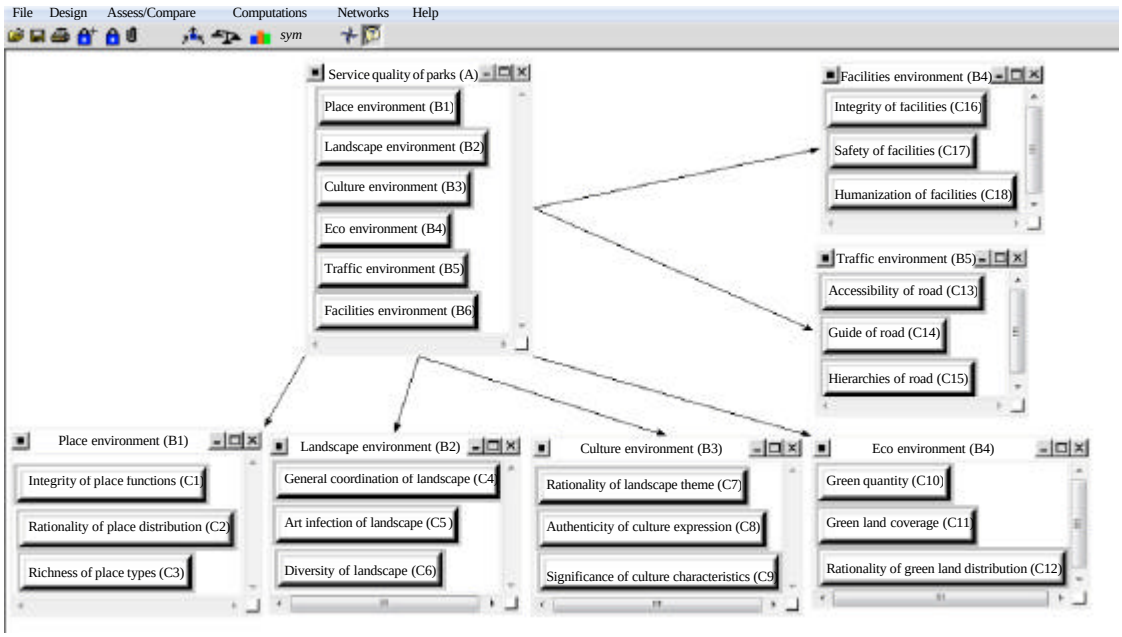

Fig. 1: Three-hierarchy AHP model of service quality evaluation of urban parks in super decisions software

$$Med.d_t = \{90, 70, 50, 30, 10\} \quad (3)$$

Step 5: To build the fuzzy relation matrix: Each index was quantified according to the comment set which means that the fuzzy membership to each evaluation degree of each factor was determined to obtain the fuzzy relation matrix R:

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix}_{n\times m} \quad (4)$$

Step 6: To calculate the result vector of the combined weight matrix and survey data matrix:

$$E_B = W_{C\text{-}B} \circ R_{C\text{-}B} \quad (5)$$

$$E_A = W_{B\text{-}A} \circ R_{B\text{-}A} \quad (6)$$

Step 7: To calculate the score M of all factors and comprehensive score of evaluation samples:

$$M_B = E_B.Med.v_t \quad (7)$$

$$M_A = E_A.Med.v_t \quad (8)$$

M represents the score of evaluation samples.

RESULTS AND DISCUSSION

Weight results: The weights obtained by SD software are seen in Table 2.

It can be seen from Table 2 that in factor layer, eco-environment, place environment, landscape environment, facilities environment, traffic environment and culture environment are arranged in decreasing weight. For the total weight of index layer relative to target layer, the rationality of place distribution, green quantity, general coordination of landscape, rationality of green land distribution and safety of facilities have high weight, with a great influence on the service quality of parks.

Results of public satisfaction survey: Three parks of Zhengzhou, Henan Province (People's Park, CBD Park and Zijinshan Park) were evaluated and 150 visitors of each park were surveyed about their satisfaction with service quality. The result of public satisfaction survey is seen in Table 3.

Table 2: Weight results obtained by SD software

A	B	$W_{B\text{-}A}$	C	$W_{C\text{-}B}$	$W_{C\text{-}A}$
A	B_1	0.2146	C_1	0.1866	0.0400
			C_2	0.5948	0.1276
			C_3	0.2686	0.0576
	B_2	0.1758	C_4	0.5389	0.0947
			C_5	0.1748	0.0307
			C_6	0.2864	0.0503
	B_3	0.0765	C_7	0.1642	0.0126
			C_8	0.6294	0.0481
			C_9	0.2065	0.0158
	B_4	0.1646	C_{10}	0.2603	0.0428
			C_{11}	0.2180	0.0359
			C_{12}	0.5217	0.0858
	B_5	0.1072	C_{13}	0.5666	0.0607
			C_{14}	0.2732	0.0293
			C_{15}	0.1603	0.0172
	B_6	0.2615	C_{16}	0.4517	0.1181
			C_{17}	0.1952	0.0510
			C_{18}	0.3532	0.0923

Table 3: Results made by visitors of each park scoring to the 18 impact indexes of index layer (%)

		P_1					P_2					P_3				
		d_1	d_2	d_3	d_4	d_5	d_1	d_2	d_3	d_4	d_5	d_1	d_2	d_3	d_4	d_5
B_1	C_1	65.3	14.0	13.3	2.7	4.7	88.0	9.3	2.7	0.0	0.0	50.7	16.0	19.3	12.0	2.0
	C_2	68.0	30.0	0.7	0.7	0.7	94.0	3.3	1.3	1.3	0.0	70.7	23.3	1.3	3.3	1.3
	C_3	50.7	43.3	2.7	0.7	2.7	78.7	14.0	6.0	0.7	0.7	76.7	20.0	3.3	0.0	0.0
B_2	C_4	43.3	48.0	3.3	5.3	0.0	70.7	16.7	12.7	0.0	0.0	84.7	14.0	0.7	0.7	0.0
	C_5	90.0	8.7	0.0	0.7	0.7	98.0	0.7	1.3	0.0	0.0	42.0	32.7	19.3	4.0	2.0
	C_6	75.3	21.3	2.7	0.7	0.0	79.3	14.0	5.3	1.3	0.0	56.7	38.0	1.3	3.3	0.7
B_3	C_7	52.0	30.0	14.0	1.3	2.7	78.0	16.7	4.0	0.7	0.7	70.7	16.7	12.0	0.7	0.0
	C_8	64.7	35.3	0.0	0.0	0.0	86.0	8.0	2.0	4.0	0.0	90.0	8.0	0.7	0.7	0.7
	C_9	83.3	13.3	2.7	0.7	0.0	90.7	6.0	3.3	0.0	0.0	58.7	25.3	14.0	2.0	0.0
B_4	C_{10}	58.0	35.3	6.7	0.0	0.0	98.7	1.3	0.0	0.0	0.0	72.7	18.7	8.0	0.0	0.7
	C_{11}	95.3	4.7	0.0	0.0	0.0	89.3	8.7	2.0	0.0	0.0	96.7	1.3	1.3	0.7	0.0
	C_{12}	60.0	30.0	8.0	1.3	0.7	84.0	15.3	0.7	0.0	0.0	68.0	25.3	4.0	2.0	0.7
B_5	C_{13}	86.7	9.3	0.7	2.7	0.7	67.3	24.0	8.0	0.7	0.0	62.0	30.0	4.0	2.7	1.3
	C_{14}	52.0	22.7	14.0	10.0	1.3	94.7	4.0	0.7	0.7	0.0	52.0	34.7	10.7	1.3	1.3
	C_{15}	62.0	30.0	6.7	0.7	0.7	78.0	21.3	0.7	0.0	0.0	71.3	18.7	6.7	1.3	2.0
B_6	C_{16}	54.7	30.0	12.7	2.7	0.0	86.0	12.0	1.3	0.7	0.0	76.0	22.0	1.3	0.7	0.0
	C_{17}	68.7	14.0	6.7	4.7	6.0	96.0	2.0	1.3	0.7	0.0	90.0	8.0	0.7	0.7	0.7
	C_{18}	81.3	11.3	4.7	2.7	0.0	88.0	10.0	2.0	0.0	0.0	69.3	9.3	13.3	6.0	2.0

P_i(i = 1, 2, 3): Investigated park, B_i(i = 1, 2,..., 6): Six factors in factor layer, C_i(i = 1, 2,..., 18): Eighteen indexes in index layer, D_i(i = 1, 2,..., 5): Satisfaction degree according to the 5-point likert scale

Score and comprehensive score of all factors: The factor score and comprehensive score of service quality of three parks were calculated. The calculation of People's Park is illustrated as an example and the result is shown in Table 4.

The result vector E of service quality evaluation was calculated in accordance with step 5-6:

$$E_{B1} = (0.1866 \quad 0.5948 \quad 0.2686) \circ \begin{Bmatrix} 0.653 & 0.140 & 0.133 & 0.027 & 0.047 \\ 0.680 & 0.300 & 0.007 & 0.007 & 0.007 \\ 0.507 & 0.433 & 0.027 & 0.007 & 0.027 \end{Bmatrix}$$

$$= (0.6717 \quad 0.3287 \quad 0.0367 \quad 0.0112 \quad 0.0207)$$

$$E_{B2} = (0.5389 \quad 0.1748 \quad 0.2864) \circ \begin{Bmatrix} 0.433 & 0.480 & 0.033 & 0.053 & 0.000 \\ 0.900 & 0.087 & 0.000 & 0.007 & 0.007 \\ 0.753 & 0.213 & 0.027 & 0.007 & 0.000 \end{Bmatrix}$$

$$= (0.6063 \quad 0.3349 \quad 0.0255 \quad 0.0318 \quad 0.0012)$$

$$E_{B3} = (0.1642 \quad 0.6294 \quad 0.2065) \circ \begin{Bmatrix} 0.520 & 0.300 & 0.140 & 0.013 & 0.027 \\ 0.647 & 0.353 & 0.000 & 0.000 & 0.000 \\ 0.833 & 0.133 & 0.027 & 0.007 & 0.000 \end{Bmatrix}$$

$$= (0.6646 \quad 0.2989 \quad 0.0286 \quad 0.0036 \quad 0.0044)$$

$$E_{B4} = (0.2603 \quad 0.2180 \quad 0.5217) \circ \begin{Bmatrix} 0.580 & 0.353 & 0.067 & 0.000 & 0.000 \\ 0.953 & 0.047 & 0.000 & 0.000 & 0.000 \\ 0.600 & 0.300 & 0.080 & 0.013 & 0.007 \end{Bmatrix}$$

$$= (0.6717 \quad 0.2586 \quad 0.0592 \quad 0.0068 \quad 0.0037)$$

$$E_{B5} = (0.5666 \quad 0.2732 \quad 0.1603) \circ \begin{Bmatrix} 0.867 & 0.093 & 0.007 & 0.027 & 0.007 \\ 0.520 & 0.227 & 0.140 & 0.100 & 0.013 \\ 0.620 & 0.300 & 0.067 & 0.007 & 0.007 \end{Bmatrix}$$

$$= (0.7327 \quad 0.1628 \quad 0.0530 \quad 0.0437 \quad 0.0086)$$

Table 4: Result vector (E) combining the weight matrix and survey data matrix

P_i	E_{Bi}	Matrix				
P_1	E_{B1}	0.6717	0.3287	0.0367	0.0112	0.0207
	E_{B2}	0.6063	0.3349	0.0255	0.0318	0.0012
	E_{B3}	0.6646	0.2989	0.0286	0.0036	0.0044
	E_{B4}	0.6717	0.2586	0.0592	0.0068	0.0037
	E_{B5}	0.7327	0.1628	0.0530	0.0437	0.0086
	E_{B6}	0.6683	0.2027	0.0870	0.0309	0.0117
	E_A	0.6654	0.2653	0.0527	0.0222	0.0096
P_2	E_{B1}	0.9490	0.0771	0.0300	0.0097	0.0020
	E_{B2}	0.7794	0.1313	0.0859	0.0037	0.0000
	E_{B3}	0.8567	0.0902	0.0260	0.0263	0.0011
	E_{B4}	0.8898	0.1022	0.0080	0.0000	0.0000
	E_{B5}	0.7651	0.1811	0.0484	0.0059	0.0000
	E_{B6}	0.9318	0.0934	0.0155	0.0045	0.0000
	E_A	0.8784	0.1072	0.0341	0.0066	0.0005
P_3	E_{B1}	0.7351	0.2258	0.0532	0.0420	0.0115
	E_{B2}	0.6923	0.2414	0.0412	0.0202	0.0055
	E_{B3}	0.8038	0.1300	0.0530	0.0097	0.0044
	E_{B4}	0.7548	0.1835	0.0445	0.0120	0.0055
	E_{B5}	0.6076	0.2948	0.0626	0.0209	0.0141
	E_{B6}	0.7637	0.1478	0.0542	0.0257	0.0084
	E_A	0.7300	0.2013	0.0509	0.0242	0.0084

E_{Bi}(i = 1, 2,…, 6): Factor's result vector of factor layer; E_A: Result vector of target layer

$$E_{B6} = (0.4517 \quad 0.1952 \quad 0.3532) \circ \begin{Bmatrix} 0.547 & 0.300 & 0.127 & 0.027 & 0.000 \\ 0.687 & 0.140 & 0.067 & 0.047 & 0.060 \\ 0.813 & 0.113 & 0.047 & 0.027 & 0.000 \end{Bmatrix}$$

$$= (0.6683 \quad 0.2027 \quad 0.0870 \quad 0.0309 \quad 0.0117)$$

$$E_A = (0.2146 \quad 0.1758 \quad 0.0765 \quad 0.1646 \quad 0.1072 \quad 0.2615) \circ \begin{Bmatrix} 0.6717 & 0.3287 & 0.0367 & 0.0112 & 0.0207 \\ 0.6063 & 0.3349 & 0.0255 & 0.0318 & 0.0012 \\ 0.6646 & 0.2989 & 0.0286 & 0.0036 & 0.0044 \\ 0.6717 & 0.2586 & 0.0592 & 0.0068 & 0.0037 \\ 0.7327 & 0.1628 & 0.0530 & 0.0437 & 0.0086 \\ 0.6683 & 0.2027 & 0.0870 & 0.0309 & 0.0117 \end{Bmatrix}$$

$$= (0.6654 \quad 0.2653 \quad 0.0527 \quad 0.0222 \quad 0.0096)$$

The factor score and score M of comprehensive service quality were calculated in accordance with step 7-8 and the result is presented in Table 5.

$$M_{B1} = 90\times0.6717+70\times0.3287+50\times0.0367+30\times0.0112+10\times0.0207 = 85.840$$

$$M_{B2} = 90\times0.6063+70\times0.3349+50\times0.0255+30\times0.0318+10\times0.0012 = 80.251$$

$$M_{B3} = 90\times0.6646+70\times0.2989+50\times0.0286+30\times0.0036+10\times0.0044 = 82.319$$

$$M_{B4} = 90\times0.6717+70\times0.2586+50\times0.0592+30\times0.0068+10\times0.0037 = 81.756$$

$$M_{B5} = 90\times0.7327+70\times0.1628+50\times0.0530+30\times0.0437+10\times0.0086 = 81.386$$

$$M_{B6} = 90\times0.6683+70\times0.2027+50\times0.0870+30\times0.0309+10\times0.0117 = 79.730$$

$$M_A = 90\times0.6654+70\times0.2653+50\times0.0527+30\times0.0222+10\times0.0096 = 81.854$$

It can be seen from Table 4 that eco-environment, place environment and facilities environment of CBD Park have high service quality as well as high comprehensive

Table 5: Scores (M) of all factors and comprehensive score of each park

M_{Bi}	P_1	P_2	P_3
M_{B1}	85.840	92.618	86.000
M_{B2}	80.251	83.743	81.926
M_{B3}	82.319	85.517	84.427
M_{B4}	81.756	87.636	83.417
M_{B5}	81.386	84.133	79.218
M_{B6}	79.730	91.310	82.644
M_A	81.854	88.468	83.146

M_{Bi}(i = 1, 2,…, 6): Factor score of factor layer; M_A: Comprehensive score of target layer

service quality, showing that the Park with integrated function can provide services of high quality to the public. Although, the scores of some factors of People's Park and Zijinshan Park are high, the total score is lower than that of CBD Park. The reason is that People's Park and Zijinshan Park have been built for a long time. People's Park is the earliest one and has not been innovated since it was built. It cannot meet the requirements of the public in the aspect of facilities environment. Zijinshan Park was renovated in the 90's which improved the overall quality. CBD Park was built in 2005 and the process of planning, designing, construction, management and maintenance drew attention from the government. It has become a central green land of Zhengdong new district of Zhengzhou, playing an important role in improving urban environment. In order for management to be responsive to the public, park professionals need to understand public attitudes about urban parks (Baur *et al*., 2013). Service quality of urban parks appears to be correlated with landscape planning and design (Golicnik and Thompson, 2010). This study can be of benefit for future landscape design and renewal of urban parks.

CONCLUSION

The service quality of urban parks can be evaluated from factors of place environment, landscape environment, culture environment, eco-environment, traffic environment and facilities environment and these factors were subdivided into 18 indexes.

Three-hierarchy AHP model was established based on these factors and indexes, with SD software to calculate the weight of each factor relative to the factor of the previous layer and sequencing of total weight.

Weight was combined with the factor score and comprehensive score of service quality of all parks from the data of public satisfaction survey. The results of evaluation also can be the reference for the renovation and new park's construction.

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