Evaluation of Urban Park Service Quality Based on Factor Analysis

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Abstract

Urban park is an important component of urban public green space which provides leisure, recreation, activity place, etc. Urban park service quality was evaluated by quantitative method in this paper to provide scientific evidence for renewal and development of urban park. 5 urban parks in Xinxiang, Henan province, China were selected as evaluation samples, and 13 indexes were evaluated, including plant landscape, cultural experience, activity place, ecological environment, road design, topographical management, fitness facilities, water landscape, service facility, night landscape, landscape aesthetics, information mark and shelter landscape. Then the data were analyzed by factor analysis. Results: the information contained in the 13 evaluation indexes had considerable repeatability. Therefore, 5 main factors including landscape elements, sports and entertainment, cultural quality, ecology and night scene and traffic facilities were extracted which accounted for 80.881% of total variation. The number of factor variables was far less than the number of index variables, which reduced the complexity of evaluation and indicated that factor analysis had good dimension-reducing effect. Based on the results of factor analysis, not only the contribution rate of each index and each factor in the park service quality evaluation, but also single factor scores and comprehensive scores in different parks could be obtained, which facilitated the analysis and comparison of service quality of different parks. Our work can provide support for urban park renewal, reconstruction and development, thereby promoting the urban park service quality.

Keywords: *Service, Quality, Factor Analysis, Urban Park*

1. Introduction

Urban park is an important component of urban green space and has high ecosystem service function and values; it is also the main component of urban public green space, which performs the functions of providing leisure, recreation and activity space for urban residents. The evaluation on ecosystem service function and value has been fully developed [1], but less research is carried out on how to evaluate urban park service quality. Urban park construction is mainly undertaken by the government. The users are best qualified to decide whether the park can really satisfy public demand. Therefore, POE (Post-occupation Evaluation) was invented, to measure the applicability for users from the user's point of view. But so far, POE is the direct and qualitative evaluation method, which cannot reflect the interconnection between evaluation information. Therefore, it is high necessity to evaluate the quality of urban park service by quantitative means. Due to high repeatability between the research data of urban park service quality and the large number of indexes, the factor analysis becomes a more suitable analysis tool [2-4]. Proceeding from interdependence among research indexes, this method is a multivariate statistical analysis for summarizing the variables with complex relationship or overlapping information into a few unrelated comprehensive factors. The basic principle is to group the variables according to the correlation levels, to enable higher correlation among variables in the same group and lower correlation across the groups, and the variable in each group represents a common factor. In this way, the evaluation complexity would be effectively reduced.

2. Methods

Xiangyang Park (P_1), Kaifaqu Zone Park (P_2), Muye Park (P_3), Hexie Park (P_4) and the People's Park (P_5) in Xinxiang, Henan province, China were selected as the objects of evaluation. The visitors of these five parks were randomly chosen and required to assess the 13 impact indices, including plant landscape (X_1), cultural experience (X_2), activity place (X_3), ecological environment (X_4),road design (X_5), topographical management (X_6), fitness facilities (X_7), water landscape (X_8), service facility (X_9), night landscape (X_{10}), landscape aesthetics (X_{11}), information mark (X_{12}) and shelter landscape (X_{13}). For the sake of comparison, 50 visitors were randomly chosen in each park for the survey. Likert

five-point scale was adopted in some of the questions of the questionnaire. According to importance degree, the evaluation indices for preliminary screening were divided into "completely unsatisfied, unsatisfied, ordinary, satisfied, very satisfied" and the corresponding score as "1, 2, 3, 4, 5" in sequence.

There were 2 goals in this study: First, the data obtained by these evaluation indexes had high repeatability. Therefore the main factor which influenced the evaluation of urban park service quality could be identified by factor analysis which reduced the complexity of evaluation. Second, by factor analysis, the scores would be analyzed by grading the five urban park service quality so that the park of high service quality or the factor with largest impact on service quality would be selected as the basis for urban park renewal and reconstruction to promote the quality management of the park.

The main steps of factor analysis were as follows: (1) Standardized processing of the data samples; (2) Calculate correlation matrix of the samples; (3) Calculate the characteristic root and characteristic vector of the correlation matrix; (4) Determine the number of main factors according to the accumulative contribution rate that the system required; (5) Calculate the factor loading matrix; (6) Determine the factor model; (7) Analyze the system according to the above calculation results.

3. Results and Analysis

3.1 KMO and Bartlett's Test

Factor analysis was used to solve the collinear variables, and KMO measure as well as Bartlett's sphere test must be adopted to test index correlation and the applicability of the models. KMO measure was to verify whether the test was applicable for factor analysis; Bartlett's sphere test was to determine mutual independence between variables. Factor analysis must meet the following requirements: the radio between sample number and variable number should be more than 5:1; KMO > 0.5. The results showed that KMO measure of sampling adequacy was 0.636 (Table 1); Bartlett's sphere test value was 1617.688, degree of freedom was 78, significant probability was 0.000, which was less than the significance level 0.05. Accordingly null hypothesis was rejected, which indicated that the indices had strong correlation and factor analysis was applicable. Variable data standardization was automatically executed by SPSS software.

Table 1: KMO and Bartlett's test

Kaiser- Meyer- Olkin Measure of Sampling Adequacy.		0.636
Bartlett's Test of Approx	Sphericity. Chi- Square	1617.688
	df	78
	Sig.	0.000

3.2 Rotating of Factor Loading Matrix

Because the factor loading matrix was not unique, and orthogonal transformation was employed for the loading matrix. In this study loading matrix was rotated by orthogonal transform by maximum variance method in order to simplify the structure of factor loading matrix, which made the square of elements of loading matrix in each column or row to polarize towards 0 or 1. In Table 2, before and after the orthogonal transform, the accumulative variance contribution rate of the five factors were all 80.881%, which showed that 80.881% information of the original 13 indices was retained. Thus, orthogonal rotation did not change the overall interpretability of factor. But after orthogonal transform, the characteristic root of each factor was changed, and the corresponding variance contribution rate of each factor was also changed, which illustrated that factor rotation had reduced the difference in variance contribution rate between the factors. As a result, the interpretability of the factors on the original variables becomes more balanced(Table 3).

In Table 2, the characteristic root of the first main factor was 3.092 which explained 23.788% of total variance; the characteristic root of the second main factor was 2.302, which explained 17.709% of total variance; the characteristic root of the third main factor was 1.739, which explained 13.378% of total variance; the characteristic root of the forth main factor was 1.691, which explained 13.010% of total variance; the characteristic root of the fifth main factor was 1.689, which explained 12.995% of the total variance. Although the sixth main factor explained 3.915% of the total variance, its characteristic root was far less than 1, which showed that the interpretability of this main factor was smaller than the original variable. When the factor number was five, the accumulative variance contribution rate was 80.881%, which indicated that more than 4/5 of the

original variable information would be retained (Table 2). According to Table 2, the main factor 1 indicated that it played a dominant role in index X_1, X_6, X_8 and X_{13}; the main factor correlation coefficient was 0.955, 0.791, 0.863 and 0.895, respectively; and main factor 1 was named landscape element. Main factor 2 indicated that it played a dominant role in index X_3, X_7 and X_9, with a correlation coefficient of 0.926, 0.851 and 0.840, respectively; and factor 2 was named sports & entertainment main factor. The main factor 3 indicated that it played a dominant role in index X_2 and X_{11}, with a correlation coefficient of 0.930 and 0.926, respectively; and the factor 3 was named cultural quality main factor; the main factor 4 indicated that it played a dominant role in index X_4 and X_{10}, with a correlation coefficient of 0.914 and 0.907, respectively; and factor 4 was named ecology and night scene main factor. The main factor 5 indicated that it played a dominant role in index X_5 and X_{12}, with a correlation coefficient of 0.918 and 0.911, respectively; and factor 5 was named traffic facility main factor.

Table 2: Total variance explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.111	23.932	23.932	3.111	23.932	23.932	3.092	23.788	23.788
2	2.362	18.169	42.101	2.362	18.169	42.101	2.302	17.709	41.497
3	1.785	13.727	55.829	1.785	13.727	55.829	1.739	13.378	54.875
4	1.647	12.669	68.497	1.647	12.669	68.497	1.691	13.010	67.886
5	1.610	12.384	80.881	1.610	12.384	80.881	1.689	12.995	80.881
6	0.509	3.915	84.796						
7	0.474	3.647	88.444						
8	0.363	2.793	91.236						
9	0.307	2.361	93.598						
10	0.283	2.178	95.775						
11	0.262	2.018	97.793						
12	0.184	1.416	99.209						
13	0.103	0.791	100.000						

Extraction Method: Principal Component Analysis.

3.3 Service Quality Score of Each Urban Park

According to the factor score coefficient matrix (Table 4), the factor score function was constructed:

F_1=-0.309X_1+0.010X_2-0.002X_3+0.012X_4-0.026X_5+0.257X_6+0.279X_8+0.000X_9+0.014X_{10}+0.002X_{11}+0.014X_{12}+0.290X_{13};

F_2=-0.006X_1+0.003X_2+0..403X_3-0.035X_4-0.025X_5+0.022X_6+0.375X_7-0.019X_8+0.365X_9-0.004X_{10}-0.005X_{11}+0.005X_{12}+0.000X_{13}

F_3=-0.002X_1+0.536X_2-0.002X_3-0.007X_4-0.029X_5-0.042X_6-0.010X_7+0.051X_8+0.009X_9+0.012X_{10}+0.533X_{11}+0.007X_{12}+0.014X_{13}

F_4=0.004X_1-0.012X_2-0.000X_3+0.544X_4-0.052X_5+0.039X_6-0.027X_7-0.034X_8-0.023X_9+0.538X_{10}+0.016X_{11}+0.058X_{12}+0.027X_{13}

F_5=-0.003X_1-0.020X_2+0.14X_3-0.007X_4+0.546X_5-0.013X_6+0.056X_7-0.026X_8-0.031X_9+0.014X_{10}-0.002X_{11}+0.540X_{12}+0.024X_{13}

According to the variance contribution rate in Table 3, score function of urban park service quality evaluation was f (X) = 0.23788F_1+0.17709F_2+0.13378F_3+0.13010F_4+0.12995F_5. The research data were substituted into the score function. The single factor score and comprehensive score of service quality of 5 parks were analyzed and averaged, and the results can be seen from Table 5. The Data in Table 5 were processed, $F_x^{'} = \frac{F_x - \min}{\max - \min} * 40 + 60$, while ensuring its distribution to fall in the range 60 to 100 (Table 6).

According to Table 6, each park had factors that ranked at the top, which indicated that all the parks had certain factors that met the public demand. In terms of

comprehensive service quality evaluation, the Hexie Park and the People's park had a higher score, and the reason was that the high impact factors of these two parks ranked higher, which was very consistent with the actual situation: Hexie park was the key government construction park in Xinxiang in the year 2006, which was under strict regulation from overall planning to specific design and to construction quality. And the People's Park is a comprehensive park with 50 years of history.

Table 3: Component matrix and rotated component matrix

	Component					Rotated Component Matrix				
	1	2	3	4	5	1	2	3	4	5
X_1	0.954	0.022	0.001	0.040	-0.049	0.955	-0.011	-0.025	-0.035	0.013
X_2	-0.051	-0.005	0.793	-0.131	-0.465	-0.008	0.013	0.930	-0.025	0.005
X_3	-0.025	0.905	0.102	-0.087	0.161	-0.001	0.926	0.003	0.061	-0.027
X_4	-0.123	0.206	-0.093	0.827	-0.295	-0.035	0.004	-0.019	0.914	-0.024
X_5	0.008	-0.213	0.466	0.236	0.731	-0.040	-0.019	-0.009	-0.097	0.918
X_6	0.785	0.105	-0.069	0.083	-0.027	0.791	0.060	-0.093	0.037	-0.014
X_7	-0.003	0.808	0.124	-0.095	0.223	0.011	0.851	-0.009	0.009	0.048
X_8	0.863	-0.021	0.060	-0.041	-0.101	0.863	-0.044	0.066	-0.097	-0.021
X_9	-0.019	0.825	0.071	-0.141	0.096	0.002	0.840	0.018	0.017	-0.097
X_{10}	-0.118	0.264	-0.038	0.819	-0.272	-0.029	0.072	0.016	0.907	0.008
X_{11}	-0.078	-0.016	0.800	-0.077	-0.457	-0.033	-0.001	0.926	0.022	0.035
X_{12}	0.094	-0.198	0.498	0.400	0.624	0.066	-0.049	0.050	0.080	0.911
X_{13}	0.890	0.033	0.047	0.083	-0.034	0.895	0.003	0.005	0.005	0.058

Table 4: Component score coefficient matrix

	Component				
	1	2	3	4	5
X_1	0.309	-0.006	-0.002	0.004	-0.003
X_2	0.010	0.003	0.536	-0.012	-0.020
X_3	-0.002	0.403	-0.002	0.000	0.014
X_4	0.012	-0.035	-0.007	0.544	-0.007
X_5	-0.026	0.025	-0.029	-0.052	0.546
X_6	0.257	0.022	-0.042	0.039	-0.013
X_7	0.000	0.375	-0.010	-0.027	0.056
X_8	0.279	-0.019	0.051	-0.034	-0.026
X_9	0.000	0.365	0.009	-0.023	-0.031
X_{10}	0.014	-0.004	0.012	0.538	0.014
X_{11}	0.002	-0.005	0.533	0.016	-0.002
X_{12}	0.014	0.005	0.007	0.058	0.540
X_{13}	0.290	0.000	0.014	0.027	0.024

Due to the limited availability of data, some indices which can reflect urban park service quality were not incorporated into the evaluation. For example, as most of the people lacked professional knowledge of biological diversity, this index was abandoned. In addition, increasing the number of people surveyed can enhance the

evaluation accuracy. In the future study, evaluation indices and the number of people surveyed will be improved so that the model can more accurately reflect the real condition of park service quality.

Table 5: Single factor score and comprehensive score of urban park service quality

	F_1	F_2	F_3	F_4	F_5	Total
P_1	-0.20425	-0.21277	-0.03037	0.379961	-0.00991	-0.04218
P_2	-0.05905	-0.0221	0.145947	-0.04169	0.062979	0.004325
P_3	-0.12597	0.279184	-0.02396	-0.07153	-0.10717	-0.00696
P_4	0.13888	-0.10379	0.214343	-0.17391	0.01505	0.022661
P_5	0.250394	0.05948	-0.30596	-0.09283	0.039051	0.022163

Table 6: Sequence of urban park service quality by single factor score and comprehensive score respectively

No	F_1	Rank	F_2	Rank	F_3	Rank	F_4	Rank	F_5	Rank	Total	Rank
P_1	60.00	5	60.00	5	81.19	4	100.00	1	82.86	4	60	5
P_2	72.77	3	75.50	3	94.74	2	69.55	2	100.00	1	88.69	3
P_3	66.89	4	100.00	1	81.68	3	67.39	3	60.00	5	81.73	4
P_4	90.19	2	68.86	4	100.00	1	60.00	5	88.73	3	100	1
P_5	100.00	1	82.14	2	60.00	5	65.86	4	94.37	2	99.69	2

4. Conclusions

Urban park service quality can be evaluated by 13 indicators, including plant landscape, cultural experience, activity place, ecological environment, road design, topographical management, fitness facilities, water landscape, service facility, night landscape, landscape aesthetics, information mark and shelter landscape.

Because the data obtained by these evaluation indices had high repeatability, 5 main factors which affected urban park service quality evaluation were extracted by factor analysis, including landscape elements, sports and entertainment, cultural quality, ecology and night scene and traffic facilities. The number of factor variables was far smaller than the number of index variables, which reduced the complexity of the evaluation and indicated that factor analysis had better dimension-reducing effect.

Based on the results of factor analysis, the contribution rate of each index and factor in urban park service quality evaluation as well as single factor score and comprehensive score of different parks could be obtained. The results can be used as the basis for urban city park renewal and development, which would promote the overall service quality of urban park.

References

[1] Y. Zhang, Z. F. Yang, and X. Y. Yu, "Measurement and evaluation of interactions in complex urban ecosystem", Ecological Modelling, Vol.196, 2006, pp.77-89.

[2] Y. H. Tian, G. S. Cheng, L. J. Lu, and W.H. Liu, "Factor analysis of identifying pillar industries in ChongQing service industry", Energy Procedia, Vol. 5, 2011, pp.1326-332.

[3] Roy D. Berghaus, Jason E. Lombard, Ian A. Gardner, and Thomas B. Farver, "Factor analysis of a Johne's disease risk assessment questionnaire with evaluation of factor scores and a subset of original questions as predictors of observed clinical paratuberculosis", Preventive Veterinary Medicine, Vol.72, 2005, pp.291-309.

[4] Antoni Wibowo and Mohammad Ishak Desa, "Nonlinear robust regression using kernel principal component analysis and R-Estimators", International Journal of Computer Science Issues, Vol. 8, No 2, 2011, pp.1694-0814.

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