Function Analysis of the Urban Green Space Disaster-prevention System Based on AHP

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Abstract: Taking the rebuilt urban disaster-prevention green space system as the study object in Dujiangyan city, Sichuan province after the "5.12" Wenchuan Earthquake in 2008, this paper aims to establish the evaluation system that suits small-sized cities located on the seismic belts such as Dujiangyan. The study employs Analytic Hierarchy Process (AHP) and selects forty-nine closely relevant factors from the four main aspects: urban environment, the spatial structure, the layout of the urban disaster-prevention green space and the emergency shelters and facilities in Dujiangyan. The forty-nine factors are categorized into index and criteria level. Through a questionnaire survey, the study draws the objective assessment of the disaster-prevention function of the urban green space system in Dujiangyan from both qualitative and quantitative perspectives. Based on the analysis of the assessment results combined with the current hardware and software emergency facilities stats quo, this paper proposes strategies for the improvement and perfection of the disaster-prevention green space system in Dujiangyan.

1. Introduction

Dujiangyan city was severely damaged during the "5.12" Wenchuan Earthquake in 2008. After being reconstructed, the city's urban green space system was recovered and its disaster-prevention function has been improved. Dujiangyan is a typical small-sized city that is located on the seismic belt and taken as the object of this study, this paper has evaluated the disaster-prevention function of its urban green space system from both qualitative and quantitative perspectives in the hope of providing useful practical experience and suggestions on the reconstruction of disaster-prevention urban green space system in earthquake zones.

2. Research Areas and Evaluation Method

2.1 Overview of research areas

The city of Dujiangyan is located on the northwest edge of the Sichuan Basin and covers an area of 103 ° 26'-103 ° 47'E and 30 ° 45'-31 ° 22'N. The city is internally connected by roads, rivers, irrigation channels and greenbelts together with the green ecological corridors of the five rivers, which form into a vertical connection network between the elements of"mountain-water-city-forest-weir-field" in the city.

The research area is defined within the scope of Dujiangyan city, which includes three parts: The Main City district, the Yutang district and the Juyuan district.

The Main city district locates in the north of Dujiangyan and expands to the city planning area in the east, and to the Jinma River in the west and Duwen Express way in the south. II. The Yutang district expands to the city planning area with its north, west and south and the Jinma River in the east. III. The Juyuan district expands to the city planning area with its west, south and east and to the

Duwen Express way in the north. The urban construction land area is 45.80km2 with 1732.02hm2 of the green space and 494.24 hm2 of park green area respectively.

2.2 Evaluation method

First, establish the evaluation system based on AHP and measure the index weight. Through an expert's questionnaire survey with their expertise, all the factors that affect the disaster-prevention function of the urban green space in Dujiangyan were divided into four hierarchies with affiliation relationship. Each hierarchy was further divided into several elements. By comparing the weight of each element relative to last hierarchy, the order of priority of each element has been drawn to achieve the function evaluation goal. The full steps in order were – constructing structure of evaluation model based on experts' assessment, establishing judgment matrix, followed by the sequencing of single hierarchy and consistency check and the final sequencing of hierarchies and consistency check [1].

After the evaluation model was established, a questionnaire survey for the citizens was sent out. The survey results were analyzed by AHP which led to the function evaluation results.

3. Construction of Evaluation System and Factor Weight Calculation

3.1 Model construction of the evaluation system

Selection and Confirmation of Evaluation Factors. This paper protocols urban environment, the spatial structure of the urban disaster-prevention green space, the quantitative index of green space layout and the emergency shelters and facilities as four paralleled levels which influence disaster-prevention function of the urban green space system, based on the research results of relevant scholars and aspects of disaster-prevention function evaluation of the urban green space system. At the same time, more than 60 impact factors are put into questionnaires for experts titled Factors choosing of the Disaster-prevention Function Evaluation given to experts on green space research in Chengdu. After their marking, 49 impact factors are chosen to form an initial system structure. 28 questionnaires were issued in this survey, 21 were recovered and 21 were valid.

Construction of Evaluation System with Four Layers. The Evaluation System of the Disaster-prevention Function of the Urban Green Space consists of Goal Layer, Criteria Layer, Index Layer and Alternative Layer. The Alternative Layer consists of the 49 chosen impact factors. The four layers are in affiliation relationship, and each impact factor in one layer is paralleled.

The Goal Layer is to evaluate the disaster-prevention function of the urban green space, while the Criteria Layer consists of urban environment, the spatial structure of the urban disaster-prevention green space, the quantitative index of green space layout and the emergency shelters and facilities. In Index Layer there are 14 elements inferred from factors in Criteria Layer: natural environment, artificial environment, building system, disaster-prevention urban green space system, traffic system, disaster prevention park, temporary/emergency safety green space, segregation greenbelt, green escape channel, domestic installation, medical facility, traffic and communications, fire equipment and emergency software facilities, etc. The Alternative Layer consists of 49 impact factors chosen by the experts.

By paired comparison with factors respectively from Criteria Layer and Alternative Layer, the matrix, the largest eigenvalue λ_{max}, weight, and *CR* value for the consistency check are obtained and finally, the weight table of the evaluation system.

3.2 Determination of evaluation factors' values and weights

Weight Table. By using AHP, the evaluation modal finally has its evaluation factors and factors wight, (Table 1).

Evaluation Level. In this research, the marking scheme for evaluation ranges from 0 to 9. Marking and calculation result based on the evaluation system above is in 0-9, too. (table 2)

Table 1: Weight calculation of the evaluation system of urban green space disaster-prevention function

Goal	Criteria	Criteria weight (w)	Index	Index weight (w)	Alternatives	Alternative weight (w)
Evaluation of the Disaster-prevention Function of the Urban Green Space System	Urban Environment (C1)	0.0788	Natural Environment (B1)	0.5000	Type And Distribution of Disasters (A1)	0.5075
					Topography and Landform(A2)	0.2771
					Hydrologic Condition(A3)	0.0666
					Geologic Condition(A4)	0.1489
			Artificial Environment (B2)	0.5000	Density of Population (A5)	0.6370
					Urban Development(A6)	0.2583
					Human Performance Pattern(A7)	0.1047
	The Spatial Structure of the Urban Disaster-Prevention Green Space(C2)	0.3623	Building System (B3)	0.1140	Seismic Class of Buildings(A8)	0.6370
					Density of Building Distribution (A9)	0.2583
					Building Height (A10)	0.1047
			Disaster-Prevention Urban Green Space System (B4)	0.8142	Amount and Scale of Green Space (A11)	0.4571
					Green Space Layout (A12)	0.0910
					Relative Soundness of Green Function(A13)	0.1547
					The Functional Equilibrium Of Green Space(A14)	0.0580
					Green Space/Green channel connectivity (A15)	0.2401
			Transportation System (B5)	0.0718	Transport Road Hierarchy (A16)	0.5370
					Density of Traffic Road Network (A17)	0.2583
					Road Layout Pattern (A18)	0.2047
	The Layout Green Space Quantitative Index (C3)	0.3274	Disaster Prevention Park (B6)	0.4043	Amount of Disaster Prevention Park (A19)	0.0677
					Area of Disaster Prevention Park (A20)	0.2478
					Service Radius (A21)	0.4539
					Per Capita Effective Area (A22)	0.2306
			Temporary/Emergency Safety Green Space (B7)	0.2703	Capacity (A23)	0.2583
					Uniform Distribution Degree(A24)	0.1047
					Service Radius (A25)	0.6370
			Segregation Greenbelt (B8)	0.0738	Width And Length Of Greenbelt (A26)	0.2583
					Integrity of Defensive Circle (A27)	0.6370
					Reasonableness of Plant Configuration (A28)	0.1047
			Green Escape Channel (B9)	0.2516	Width and Length(A29)	0.1246
					Continuity of Green Escape Channel (A30)	0.2636
					Continuity of shelters (A31)	0.0633
					Distance between Buildings and Planning Red Lines (A32)	0.5485
	The Emergency Shelters And Facilities (C4)	0.2315	Domestic Installation (B10)	0.1969	Toilet Amount and Distribution (A33)	0.0900
					Amount and Distribution of Water Supply (A34)	0.2400
					Area of Temporary Tent (A35)	0.4571
					Amount and Distribution of Storeroom for Emergency Reserve (A36)	0.1547
					Amount and Distribution of Power Unit (A37)	0.0580
			Medical Facility(b11)	0.0257	Distribution of Medical Assistance (A38)	0.1608

	Traffic and Communications(B12)	0.1239	Parking Apron (A39)	0.5891
			Escape Route Sign(A40)	0.3568
			Broadcasting Facilities (A41)	0.0540
	Fire Equipment (B13)	0.2817	Fire Fighting Equipment (A42)	0.4485
			Fire Demand (A43)	0.2590
			Monitoring System(A44)	0.0748
			Fire Engine Access (A45)	0.2178
	Emergency Software Facilities (B14)	0.3717	Disaster Warning(a46)	0.3528
			Government Emergency Command (A47)	0.3528
			Self-Saving Knowledge (A48)	0.1049
			Disaster Prevention Drill (A49)	0.1895

Table 2: Assessment level control

Level	Excellent	Good	Medium	Bad
Details	With Excellent Disaster Prevention Function	With Good Disaster Prevention Function	With Medium Disaster Prevention Function	With Bad Disaster Prevention Function
Mark Range	Above 7	6-7	5-6	Below 5

4. Evaluation of the Disaster-prevention Function of the Urban Green Space System in Dujiangyan

4.1 Data sources and sample

Data sources of this research are from questionnaires and the Construction Bureau of Dujiangyan. 480 questionnaires were issued in the three target districts and each district with 160. 151, 147, 153 were recovered respectively in Yutang district, main city area, Juyuan district. In total, 451 were recovered and 451 were valid, the valid rate is 93.95%. During the questionnaires respondents are chosen randomly, and their gender, age, education degree are out of consideration.

4.2 Evaluation of the disaster-prevention function of the Dujiangyan urban green space

Evaluation Criteria. According to the evaluation system that is established, when doing the evaluation, the importance of each evaluation impact factor is presented in 5 levels and relative marking criterion is listed in the questionnaires to make people's grading easier.

Analysis of Questionnaires. After statistics on the results of the questionnaires, scores of the Alternative Layer, Criteria Layer and Index Layer are calculated successively according to the weight of the evaluation system of urban green space disaster-prevention function. By operating the formula below:

$$D_b = \sum_{1}^{n} CiWi \quad (1)$$

The score of level 0 is got.

Table 3: The Dujiangyan urban green space disaster-prevention score for level 0

Evaluation of the Disaster-Prevention Function of the Urban Green Space System	Urban Environment C1(0.0788)	Spatial Structure of the Urban Disaster-Prevention Green Space C2(0.3623)	Quantitative Index of Green Space Layout C3(0.3274)	The Emergency Shelters and Facilities C4(0.2315)
Score	5.0478	6.3128	7.7590	5.7901
Wight	0.0788	0.3623	0.3274	0.2315
Final Evaluation Score			6.5656	

5. Discussion

5.1 Evaluation results

The score of Dujiangyan urban green space system disaster-prevention function is 6.5656. That is to say, Dujiangyan's green space system now has good disaster-prevention function. The layout of green space quantitative index is excellent; the spatial structure of the urban disaster-prevention green space is good, and the emergency shelters and facilities is medium, which means the most urgent thing is to improve the emergency shelters and facilities.

Taking both the situation of Dujiangyan fieldwork and the evaluation result into consideration, the following conclusions are got:

Dujiangyan is more at risk due to its special geographical location.

In general, the spacial structure of city disaster-prevention is good, but some traffic monitoring equipment should be improved.

The layout of Dujiangyan disaster-prevention urban green space is excellent.

Facilities of disaster-prevention green space system in Dujiangyan need to be improved urgently.

5.2 Suggestions on construction of the urban green space system in Dujiangyan after Wenchuan Earthquake

Grasp the post-disaster reconstruction opportunity to rearrange the residential land and population distribution reasonably.

The ability of supporting facilities in the green space should continue to be strengthened according to the expected usage in aspects such as energy supply equipment, emergency drinking water devices, lighting devices, sanitary fittings, emergency medical facilities, communication facilities and fire safety facilities [9].

Reform the original small green space timely to exert their ability of disaster-prevention.

Improve the awareness of people's sense of building and maintaining disaster-prevention green space, as well as the legal supervision.

Traffic roads at all levels of the city need to be cleaned, certain intelligent traffic management equipment should be supplied to make sure the road is accessible.

More publicity of urban green space disaster-prevention function and manoeuvre in certain site is needed to improve citizens knowledge and application ability.

References

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