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Evaluation of Ecological Vulnerability in a Tourist Attraction

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Abstract: Eco-environment provides the material basis for people to survive and develop. The eco-environment in a tourist destination determines the developing prospect of its economy and society. Based on identified influencing factors and evaluation index selection principle of ecological vulnerability in a tourist attraction, the paper established a corresponding evaluation index system. In combination with years of related environmental monitoring data, an analytic hierarchy model was used to compute weight coefficients of all evaluation indices. The ecological vulnerability in a tourist attraction was accordingly divided into four levels: I low vulnerability, II intermediate vulnerability, III high vulnerability, and IV ultrahigh vulnerability. They were graded, with local data records of previous year as the reference. Then, membership function was employed to establish a fuzzy comprehensive evaluation matrix, on whose basis an evaluation model for ecological vulnerability in a tourist attraction was built up as well. Finally, the paper undertook simulation calculation on relevant data in Weifang city, Shandong province, and the simulation result is congruent with local situations. The scientific, professional and rational method proposed in the paper provides theoretical basis for evaluation of ecological vulnerability in a tourist attraction.

Keywords: *eco-environment, tourist attraction, weight, membership function, evaluation*

1. Introduction

Along with the flourishing tourism and the improved means to transform nature, ecological and environmental problemsin a tourist attraction have gradually drawn social attention. During the process of tourism construction, production and consumption, factors such as a rush for quick results, haphazard exploitation and improper management have posed a threat to the ecological safety and environmental safety in the tourist destination. As a result, the sustainability of the tourism resources is spoiled, which hampers the sustainable development of the tourism.

At present, domestic tourism blooms, with an increasingly upward ratio of tourist economy to GDP. Meanwhile, eco-environments in tourist destinations deteriorate. According to statistics, about 22% of developed ecotourism zones are damaged, and about 11% degenerate. Tourist attractions have born the ever-increasing burden of ecological and environmental problems (e.g., heaps of garbage in Jiuzhaigou Valley, Qingdao Golden Beach with green mosses spreading all over, etc.). As a summary, eco-environments in tourist destinations are vulnerable. A disregard for preservation of eco-environments in a tourist attraction will inevitably affect the expansion of local tourism and even the whole society. Therefore, research into eco-environments in tourist destinations has become an issue that cannot be ignored. It is of great theoretical and practical meanings to conduct studies on eco-environments in tourist destinations, as they can not only enrich the contents of disciplines such as tourism science, geography and ecology, but also activate further research. The essence of evaluation of ecological vulnerability in a tourist attraction is: through research into ecological vulnerability, its cause, ecological restoration and reconstruction, etc., the coordinated development of tourism, population, resources, environment and so on can be realized in a locality.

2. The Evaluation System of Ecological Vulnerability in a Tourist Attraction

2.1. Analysis of the influencing factors of ecological vulnerability in a tourist attraction

The eco-environment in a tourism area is vital to the local tourism economy and the lives of the residents, while an eco-environment system in a tourism area consists of numerous complicated factors, such as tourism resources, natural resources, tourists, and service of local scenic areas. There is a divergence of influencing factors for vulnerability of an eco-environment in a tourist attraction due to the complexity of its components. During the process of researching into ecological vulnerability in a tourist attraction, it is a must to take into account both the structure and characteristics of the eco-environment and the pressure that it encounters.

2.2. The selection principle of evaluation indices for ecological vulnerability in a tourist attraction

The number of the evaluation indices should be moderate, neither excessive nor too few. A plethora of indices will render them dependent with each other at the same time when the necessary computation becomes too complicated. An evaluation with too few indices may produce one-sided result, i.e. failing to reflect the real conditions of vulnerability.In this

connection, in order for a scientific, comprehensive, systematic evaluation of ecological vulnerability in a tourist attraction, the following index selection principles should be observed:

(1) Scientific

The intention of eco-vulnerability evaluation for a tourist attraction is to precisely reflect the characteristics and internal structure of the locality, serving for the provision of scientific theoretical basis for related decision-making. Therefore, the selected indices should be able to allow full play to the features and real change conditions of the eco-vulnerability in a tourist destination. Only when evaluation methods, index system and weight determination are all scientific can the evaluation result be endowed with scientific value and reference basis.

(2) Integrity

The eco-environment of a scenic spot is a complex system, and the formation of its vulnerability is a result of combined functions of various factors. Eco-environment vulnerability responds to both natural elements (e.g. landform, topography, hydrology, soil, and plantation) and all kinds of human activities. Therefore, all these impact factors should be taken into consideration when the evaluation index system is established, in a way that selected indices can not only realize complete coverage, but be independent and different from each other. Only in this case can the whole conditions of the eco-environment of a tourist attraction be reflected.

(3) Feasibility

Quantitative indices should be given priority as much as possible, i.e. the selected indices can be preferably measured or judged according to existing data. Meanwhile, it is required that the selected indices be of clear connotations, comply with national and local laws and regulations, and adapt to local conditions with operability and utility as well.

(4) Pertinence

There is a plurality of space-varying factors that impacts on ecological environment of different tourist attractions. The selected indices in the paper target mainly at the problems of ecological environment in Weifang city.

2.3. The evaluation index system of ecological vulnerability in a tourist attraction

Based on the selection principle of evaluation indices for ecological vulnerability in a tourist attraction, in combination with practical situations in Weifang city and across the country, the paper determined the evaluation index system of ecological vulnerability in a tourist attraction, as shown in Table 1.

***Table 1**: The evaluation index system of ecological vulnerability in a tourist attraction*

Objective	Tier-one index	Tier-two index
Evaluation of ecological vulnerability in a tourist attraction	Natural resource	(1)climate (2)water resource (3)land resource (4)forest resource
	Ecological resource	(5)water and soil loss (6)rocky desertification (7)Waste gas pollution (8)waste water pollution (9)pollution of dust and the like
	Social pressure	(10)population density (11)annual tourist arrivals (12)GDP per capita (13)annual tourism receipt
	Social control	(14)afforestation area (15)investment in environmental protection (16)industrial waste treatment (i.e. waste gas, waste water, and solid waste) (17)transformation of tourism environment (18)quality of local residents

2.4. Computation of the weight of evaluation indices of ecological vulnerability in a tourist attraction

The analytical hierarchy process was used to compute the weight of evaluation indices of ecological vulnerability in a tourist attraction, and the result is shown in Table 2-6.

***Table 2:** The comparison matrix of Tier-one index against the Objective tier and the consistency check result*

Objective	Evaluation of Ecological Vulnerability in a Tourist Attraction					Maximum eigenvalue	Consistency ratio
Tier-one index	Natural resource	Ecological resource	Social pressure	Social control	Weight		

Natural resource	1	1/6	1/3	5	0.1238	4.2501	0.0937
Ecological resource	6	1	4	9	0.5956		
Social pressure	3	1/4	1	7	0.2396		
Social control	1/5	1/9	1/7	1	0.0410		

Table 3: *The comparison matrix of Tier-two index against Natural resourcesand the consistency check result*

Tier-one index	**Natural resources**					**Maximum eigenvalue**	**Consistency ratio**
Tier-two index	**Climate**	**Water resource**	**Land resource**	**Forest resource**	**Weight**		
Climate	1	1/5	1/3	1/4	0.0736	4.0514	0.0192
Water resource	5	1	3	2	0.4709		
Land resource	3	1/3	1	1/2	0.1715		
Forest resource	4	1/2	2	1	0.2840		

Table 4: *The comparison matrix of Tier-two index against Ecological environment and the consistency check result*

Tier-one index	**Ecological environment**						**Maximum eigenvalue**	**Consistency ratio**
Tier-two index	**Water and soil loss**	**Rocky desertification**	**Waste gas pollution**	**waste water pollution**	**pollution of dust and the like**	**Weight**		
Water and soil loss	1	5	3	1/4	2	0.1815	5.4410	0.0984
Rocky desertification	1/5	1	1/3	1/8	1/9	0.0365		
Waste gas pollution	1/3	3	1	1/7	1/2	0.0751		
waste water pollution	4	8	7	1	8	0.5587		
pollution of dust and the like	1/2	9	2	1/8	1	0.1482		

Table 5: *The comparison matrix of Tier-two index against Social pressureand the consistency check result*

Tier-one index	**Social pressure**					**Maximum eigenvalue**	**Consistency ratio**
Tier-two index	**Population density**	**Annual tourist arrivals**	**GDP per capita**	**Annual tourism receipt**	**Weight**		
Population density	1	1/3	1/6	5	0.1179	4.1851	0.0693
Annual tourist arrivals	3	1	1/3	7	0.2642		
GDP per capita	6	3	1	9	0.5794		
Annual tourism receipt	1/5	1/7	1/9	1	0.0385		

Table 6: *The comparison matrix of Tier-two index against Social controland the consistency check result*

Tier-one index	**Social control**						**Maximum eigenvalue**	**Consistency ratio**
Tier-two index	**afforestation area**	**investment in environmental protection**	**industrial waste treatment**	**transformation of tourism environment**	**quality of local residents**	**Weight**		
afforestation area	1	5	9	3	4	0.4901	5.1856	0.0414
investment in environmental protection	1/5	1	5	1/3	1/2	0.1052		

industrial waste treatment	1/9	1/5	1	1/6	1/4	0.0364
transformation of tourism environment	1/3	3	6	1	2	0.2284
quality of local residents	1/4	2	4	1/2	1	0.1399

As all the obtained CR are smaller than 0.10, all the comparison matrices pass the consistency test.

Table 7 is a summarization of the weight of evaluation indices for ecological vulnerability in a tourist attraction.

Table 7: *The weight of evaluation indices for ecological vulnerability in a tourist attraction*

Tier-one index	Weight	Tier-two index	Weight
Natural resource	0.1238	Climate	0.0736
Ecological resource		Water resource	0.4709
Social pressure		Land resource	0.1715
		Forest resource	0.2840
Natural resource	0.5956	Water and soil loss	0.1815
Ecological resource		Rocky desertification	0.0365
Social pressure		Waste gas pollution	0.0751
Natural resource		waste water pollution	0.5587
		pollution of dust and the like	0.1482
Ecological resource	0.2396	Population density	0.1179
Social pressure		Annual tourist arrivals	0.2642
Natural resource		GDP per capita	0.5794
		Annual tourism receipt	0.0385
Ecological resource	0.0410	afforestation area	0.4901
		investment in environmental protection	0.1052
		industrial waste treatment	0.0364
		transformation of tourism environment	0.2284
		quality of local residents	0.1399

3. The evaluation model of ecological vulnerability in a tourist attraction

3.1. Establishment of the evaluation index set

Tier-two indices in the evaluation system constitute the evaluation index set, i.e. $U = \{$climate u_1, water resource u_2, land resource u_3, forest resource u_4, water and soil loss u_5, rocky desertification u_6, waste gas pollution u_7, waste water pollution u_8, pollution of dust and the like u_9, population density u_{10}, annual tourist arrivals u_{11}, GDP per capita u_{12}, annual tourism receipts u_{13}, afforestation area u_{14}, investment in environmental protection u_{15}, industrial waste treatment u_{16}, transformation of tourism environment u_{17}, quality of local residents $u_{18}\}$.

3.2. Establishment of the evaluation set

As noted, the ecological vulnerability in a tourist attraction was divided into four levels: I low vulnerability, II intermediate vulnerability, III high vulnerability, and IV ultrahigh vulnerability. A four-tier scale set was built up accordingly, i.e.

$N = (n_1, n_2, n_3, n_4) =$ (I low vulnerability, II intermediate vulnerability, III high vulnerability, IV ultrahigh vulnerability),

The respective scores of the four tiers are (1, 0.75, 0.5, 0.25).

3.3. Determination of the membership degree

The membership function of the said tiers for the ecological vulnerability in a tourist attraction was determined as follows, according to the trapezoid membership function.

Ⅰ Low vulnerability:

$$r_{i4} = \begin{cases} 1, & x < 1, \\ \frac{1}{2}(3-x), & 1 \le x < 3, \\ 0, & x \ge 5. \end{cases}$$

Ⅱ Intermediate vulnerability:

$$r_{i3} = \begin{cases} \frac{1}{2}(x-5), & 5 \le x < 7, \\ 1, & 3 \le x < 5, \\ \frac{1}{2}(3-x), & 1 \le x < 3, \\ 0, & x \ge 7, x < 1. \end{cases}$$

Ⅲ High vulnerability:

$$r_{i2} = \begin{cases} \frac{1}{2}(x-7), & 7 \le x < 9, \\ 1, & 5 \le x < 7, \\ \frac{1}{2}(5-x), & 3 \le x < 5, \\ 0, & x \ge 9, x < 3. \end{cases}$$

IV Ultra high vulnerability:

$$r_{i1}=\begin{cases}1, & 9\le x\le 10,\\ \frac{1}{2}(x-7), & 7\le x<9,\\ 0, & x<7.\end{cases}$$

Where x represents the evaluation score.

The above four-tier scale set was used for fuzzy evaluation of the said evaluation index set. The corresponding membership matrix was written down, and the fuzzy mapping formed.

$$f: P\to F(N),\ P_i\to \frac{r_{i1}}{n_1}+\frac{r_{i2}}{n_2}+\frac{r_{i3}}{n_3}+\frac{r_{i4}}{n_4},$$

Where $0\le r_{ij}\le 1, i=1,2,\cdots; j=i=1,2,3,4$ .Therefore, the fuzzy evaluation decision-making matrix was:

$$R=\begin{bmatrix} r_{11} & r_{12} & \cdots & r_{14}\\ r_{21} & r_{22} & \cdots & r_{24}\\ \vdots & \vdots & & \vdots\\ r_{s1} & r_{s5} & \cdots & r_{s4}\end{bmatrix}$$

Where $r_{ij}=A(P_i,n_j)$ denoted the membership degree of the evaluation index P_i to be rated as Tier n_j, s represented the number of indices in P_i. The scores were substituted into the membership function, and thefuzzy evaluation decision-making matrix for the corresponding indices were

$$R_1=(r_{ij})_{4\times 4},\ R_2=(r_{ij})_{5\times 4},$$
$$R_3=(r_{ij})_{4\times 4},\ R_4=(r_{ij})_{5\times 4}.$$

3.4. Analysis of the vulnerability evaluation result

With the help of the weighed mean model $M(\cdot,+)$, according to the weight of all evaluation indices, the fuzzy evaluation decision-making matrix of Tier-one index was obtained as

$$R=\begin{bmatrix}\omega_1\cdot R\\ \omega_2\cdot R_2\\ \omega_3\cdot R_3\\ \omega_4\cdot R_4\end{bmatrix}$$

Where $\omega_1=(0.1373,0.6232,0.2395)$,
$\omega_2=(0.7014,0.2132,0.0853)$,
$\omega_3=(0.1373,0.6232,0.2395)$,
$\omega_4=(0.1190,0.2570,0.1656,0.0593,0.0449,0.3543)$.

According to the corresponding weight of Tier-one index, the comprehensive evaluation result Q was obtained as

$$Q=\omega\cdot R=(q_1,q_2,q_3,q_4)$$

Where $\omega=(0.75,0.25)$.

The four-tier scale set $N=(n_1,n_2,n_3,n_4)$ was used for a final computation, and the result was:

$$S=Q\cdot N=(q_1,q_2,q_3,q_4)\cdot\begin{bmatrix}n_1\\ n_2\\ n_3\\ n_4\end{bmatrix}$$

Based on the economical vulnerability of a tourist destination, the solution to the above model is:

(1) If $S>0.7$, the economical vulnerability level of a tourist destination is Ⅳ;
(2) If $0.5<S\le 0.7$, the economical vulnerability level of a tourist destination is Ⅲ;
(3) If $0.3<S\le 0.5$, the economical vulnerability level of a tourist destination is Ⅱ;
(4) If $S\le 0.3$, the economical vulnerability level of a tourist destination is Ⅰ.

4. Simulation computation of the economical vulnerability of in Weifang city

The paper collected the 2015 data of Tier-two index of Weifang city, with which all evaluation indices were graded, and the result is shown in Table 8.

Table 8: *Vulnerability evaluation result in Weifang city*

Objective	Tier-one index	Tier-two index	Score
Evaluation of ecological vulnerability in a tourist attraction	Natural resource	Climate	7
	Ecological resource	Water resource	6
		Land resource	6
Evaluation of ecological vulnerability in a tourist attraction	Social pressure	Forest resource	7
	Social control		
Evaluation of ecological vulnerability in a tourist attraction	Natural resource	Water and soil loss	8
	Ecological resource	Rocky desertification	7
Evaluation of ecological vulnerability in a tourist attraction		Waste gas pollution	5
	Social pressure	waste water pollution	6
	Social control	pollution of dust and the like	9

	Natural resource		
	Ecological resource Social pressure Social control Natural resource	Population density	5
		Annual tourist arrivals	6
		GDP per capita	8
		Annual tourism receipt	8
	Ecological resource	afforestation area	8
		investment in environmental protection	8
		industrial waste treatment	5
		transformation of tourism environment	8
		quality of local residents	9

The evaluation results were substituted into the membership function, and the fuzzy evaluation decision-making matrix of the economical vulnerability in Weifang city was obtained as

$$R_1=\begin{pmatrix}0&1&0&0\\0&0.5&0.5&0\\0&0.5&0.5&0\end{pmatrix},\quad R_2=\begin{pmatrix}0.5&0.5&0&0\\0&1&0&0\\0&0&1&0\end{pmatrix},$$

$$R_3=\begin{pmatrix}0&1&0&0\\0&1&0&0\\0&1&0&0\end{pmatrix},\quad R_4=\begin{pmatrix}0&0&0.5&0.5\\0&0.5&0.5&0\\0&1&0&0\\0&1&0&0\\0.5&0.5&0&0\\0&1&0&0\end{pmatrix}.$$

Through computation, the final evaluation score was

$$S=Q\square N=0.6750025$$

Since $0.5<S\le 0.7$, the economical vulnerability level of Weifang city is Ⅲ

5. Conclusion

The quality of ecological environment of a tourist destination, an important factor of regional development, concerns the level and future direction of regional development. The paper starts with the influencing factors of economical vulnerabilityof a tourist destination, and conducts quantitative and qualitative evaluation of the vulnerability of the eco-environment status and its influencing factors in a tourist attraction, by use of analytic hierarchy process, fuzzy comprehensive evaluation, etc.

References

[1] Ustasfon, Dnaielingl, Maerus D. Defining Sustainallle Development: Enviormnenatl and Investment Perspectives and Implications [J]. International Journal of Public Administration, 1999, 22(6).

[2] DOW K. Exploring differences in our common future [J].The meaning of vulnerability to global environmental change. Geoforun, 1992, 23:417-436.

[3] Daniel D Evan, John Thams. Water in desert Ecosystems [M].America: Academic press, 1981.

[4] Howard Green, Colin Hunter and Bruno Moore .Assessing the environmental impact of tourism development: Use of the Delphi technique [J].Tourism managernent.1990, 11(2):111-120.

[5] Gallop in G C. Linkages between vulnerability, resilience, and adap tive capacity. Global Environmental Change, 2006, 16 (3): 293 – 303.

[6] Fang Hongqi, Yang minzhong. Principle of urban engineering geological environmental analysis. Beijing, China building industry press, 1999

[7] Dong Jun Liu Guozheng. Geological hazard situation in China. Chinese journal of hazard reduction, 2002, 03:1-2;

[8] HongJiang, zhi-gang liu. Fuzzy mathematics comprehensive evaluation method in the application of the regional geological environmental quality evaluation. Engineering geological, hydrogeological, 1996.6 P. 44-55

[9] ZongHui. Hazard risk assessment method of semi-quantitative evaluation. Geological hazards and environmental protection, 2003, Vol. 14 No. 2

[10] FeiYuMing. GIS and its application in geological hazard research. Dr. Huang, the first three national youth engineering geological symposium corpus, chengdu university of science and technology press, 1992, P. 510-519

[11] zhang jun, Du Dong chrysanthemum, such as regional geological hazard environment system and the basic idea of comprehensive evaluation model. Chinese journal of geological hazards and prevention, 1994, 5 (4) : 26-32

[12] liang-kui jiang. The application of the fuzzy consistent matrix in the analytic hierarchy process (ahp). Journal of Shanghai maritime university, 1998, 12 (2) : 55 to 60

[13] Ji-jun zhang. Fuzzy analytic hierarchy process (quantificating. Fuzzy sets and systems, 2000, 14 (2) : 80-88

[14] Yue-jin lv. Sort of fuzzy analytic hierarchy process (ahp) based on fuzzy consistent matrix. Fuzzy sets and systems. 2002 (2) : 79-85