Entropy Method Based Evaluation for Plant Landscape in Tourist Scenic Spots

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Abstract Taking five scenic spots in southeast region of Tibet as research objects, this paper calculated the weight of plant landscape evaluation system by entropy weight method, and compared the plant landscape in scenic spots from aesthetic effect, ecological harmony and service functions. The results show that the rank of the comprehensive attributes from high to low is as follows: Nanyigou, Lulang Forest, Kading Mountain Waterfall, Yarlung Zangbo Grand Canyon, and Basomtso Lake.

Key words Entropy method, Tibet, Scenic spots, Plant landscape evaluation

1 Introduction

The key to the improvement of ecological tourist site is the construction of plant landscape. It can meet the requirements of landscaping functions and reflecting the ecological benefits. More importantly, it can affect the sensory and psychological landscape value of tourists and residents[1]. In recent years, Tibet, reputed as "roof of the world", has become a choice of destination for ecotourism. From aesthetic effect, ecological harmony and service functions, we made a preliminary analysis and evaluation of plant landscape in five scenic spots (Nanyigou, Lulang Forest, Kading Mountain Waterfall, Yarlung Zangbo Grand Canyon, and Basomtso Lake) in southeast region of Tibet using multi-indicator comprehensive evaluation method, extreme value method, and entropy weight method, in order to provide theoretical basis for design and construction of plant landscape.

2 Overview of the study area

Southeast region of Tibet mainly includes Nyingchi City and southern part of Chamdo Region, located in the intersection of the Himalayas and Hengduan Mountains. The geographical location is 92°09′ - 99°6.5′E and 26°52′ - 32°31.5′N. The average altitude is 3300 m. It is 1150 km long from the east to the west, and 733 km wide from the south to the north. Affected by the warm and humid air current of the Indian Ocean, southeast region of Tibet has warm and humid climate and belongs to the plateau semi-humid monsoon climate zone.

The annual average temperature, the average temperature of the coldest month, and the average temperature of the hottest month decline with the ascending of the altitude. When the altitude ascends for 100 m, the temperature will drop 0.57 - 0.61 ℃, and the frost-free period in the whole year decreases about 7 days. From the tropical Monsoon forest in valleys to the desolate sparse alpine cushion vegetation, there is vertical vegetation zone including evergreen broad-leaved forests, coniferous and broad-leaved mixed forests, coniferous forests, and shrubs and meadows[2-3].

3 Establishment of indicator system and study methods

3.1 Establishment of the plant landscape evaluation indicator system According to the related literature and expert consultation, combined with the comprehensive, scientific, comparable and operable principles of the evaluation indicator, we used quantitative and qualitative method to establish the multi-level indicator system from aesthetic effect, ecological harmony and service functions of the plant landscape in scenic spots. The indicator system consists of 3 Level I indicators and 12 Level II indicators, as listed in Table 1.

3.2 Evaluation methods of plant landscape Information entropy, as a measure of the degree of disorder, can provide certain volume of information, thus it can be used as a mathematical method of objective evaluation indicators. In the process of indicator evaluation, if the value of a certain evaluation indicator is greater, its entropy will be smaller, and the weight will be greater, and it can provide larger volume of useful information; on the contrary, if the evaluation indicator has a smaller value, its entropy will be greater, the weight will be smaller, and it can provide smaller volume of useful information[4-8].

Entropy weight method is mathematical method of comprehensive indicators on the basis of taking into full account the volume of information provided by all factors. As an objective and comprehensive evaluation method, it is a common decision-making method in multi-attribute decision-making theories and methods. It uses information entropy output to determine the weight of evaluation indicators, so as to calculate the comprehensive evaluation value of each scheme. The specific steps are as follows:

(i) Standardization of the raw data matrix: the purpose is to eliminate the influence of different dimensions and different orders

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of magnitude, so as to make mathematical calculation and comparison. In this study, we used extreme values to standardize raw data.

Table 1 Indicators of plant landscape evaluation system

Target level	Level I indicator	Level II indicator	Indicator explanation
Plant landscape evaluation for scenic spots	Aesthetic effect	Color	Abundance in colors of plant branches, leaves, flowers, fruits
		Level	Ornamental characteristics of plant community level; perspective distance within the community
		Morphology	The diversity of plant morphology, the regularity of change and the degree of rhythm beauty
		Style	The degree of harmony between plant landscape and other elements of scenic spots
		Texture	The abundance of plant texture
	Ecological harmony	Species diversity	The abundance of plant species
		Community stability	Degree of mixed age of community plants and number of new seedlings
		Heterogeneity of community space	The change of community space, the degree of distribution of natural plaque form at various levels of arbors, shrubs, and grasses
	Service functions	Safety	Degree of safety felt by tourists
		Interest	Degree of interest felt by tourists
		Degree of stop	Degree of green space attracting tourists to stop for appreciation or doing recreational activities
		Accessibility	Degree of tourists appreciating plants in a close distance

When x is a positive indicator, $r_{ij} = \frac{x_{ij} - \min\{x_{ij}\}}{\max\{x_{ij}\} - \min\{x_{ij}\}}$ (1)

When x is a negative indicator, $r_{ij} = \frac{\max\{x_{ij}\} - x_{ij}}{\max\{x_{ij}\} - \min\{x_{ij}\}}$ (2)

where r_{ij} is standardized data of x_{ij}, $r_{ij} \in [0,1]$.

The 12 indicators in this study are positive indicators, thus in the standardization of raw data matrix, we only used formula (1).

(ii) The proportion fij of the j-th indicator to the i-th evaluation object target value, the calculation formula is:

$$f_{ij} = \frac{r_{ij}}{\sum_{i=1}^{m} r_{ij}} \quad (i = 1, 2, \ldots, 5) \tag{3}$$

where m is evaluation object. In this study, it is 5 scenic spots.

(iii) The entropy e_j of the j-th indicator, the calculation formula is as follows:

$$e_j = \frac{1}{\ln m} \sum_{i=1}^{m} f_{ij} \ln(f_{ij}), \; k > 0 \tag{4}$$

where $e_j \in [\,]0,1]$. When $f_{ij} = 0$, $f_{ij} \ln f_{ij} = 0$.

(iv) The calculation formula for the indicator weight:

$$w_j = \frac{1 - e_j}{\sum_{j=1}^{n} (1 - e_j)} (j = 1, 2, \ldots, 12) \tag{5}$$

(v) The calculation formula for comprehensive evaluation of plant landscape in scenic spots is as follows:

$$z = \sum_{j=1}^{n} r_{ij} w_j (j = 1, 2, \ldots, 12) \tag{6}$$

where z is comprehensive attribute value, n is the number of evaluation indicators, r_{ij} is standardized data of indicator, and wj is indicator weight.

4 Case analysis

4.1 Introduction of scenic spots (i) Yarlung Zangbo Grand Canyon is located in Milling County, Nyingchi of Tibet. It is 504.9 km long with the average depth of 5000 m, the deepest point is 6009 m, and it is the world's largest canyon. Its basic characteristics can be summed up with ten words: high, grand, deep, moist, secluded, long, perilous, low, wonder, and picturesque. The Yarlung Zangbo Grand Canyon embraces the mountains and rivers of the Namche Barwa, it cleaves the mountain barrier of Qinghai – Tibet Plateau and the Indian Ocean water vapor. Like a long wet tongue, it transmits steady stream of water vapor to the highlands, making the southeast region of Qinghai – Tibet plateau become a green world.

(ii) Basomtso Lake is located in Gongbujiangda County, Nyingchi City of Tibet. It has altitude of 3700 m, the lake area is more than 6000 mu, the lake is embedded in a high valley like a crescent. It is 12 km long. It is a divine lake and sacred land of Ningma school of Tibetan Buddhist. Integrating snow-capped mountains, lakes, forests, waterfalls, pastures, cultural relics, and ancient temples together, Basomtso Lake has different scenery in different seasons, and various wild and rare plants, it is a paradise in human world. The best season for travel in Basomtso Lake is autumn. In autumn, the sky is high and the weather is fine. From the lake shore to mountains, woods and forests glow with autumn tints. Rich color and tranquil environment are great time for photography lovers. Although Basomtso Lake is located in remote valleys, it is well known for its blue water in lush forests and hills and mountains, and it has become an earliest known scenic spot of Nyingchi City.

(iii) Kadinggou Scenic Spot is located in the 24 km area in National Highway No. 318 from Lhasa to Nyingchi. With altitude of 2980 m, it is situated on the bank of Nyang River of Yarlung Zangbo River. It has pleasant climate, plentiful rainfall, and dense forests. Kadinggou Waterfall belongs to a granite canyon landscape. Due to the influence of warm and humid air of the Indian Ocean, mountains along the canyon are high and steep, green pines and verdant cypresses spread all over the mountains and cliffs. Rattans and bamboos are covered with the bottom of the valley. Wild flowers such as azalea drift fragrance. The waterfall on the left cliff falls from 200 m high mountains. More amazing thing is that there appears a Buddha in water, which gives the name of Tianfo Waterfall.

(iv) Nanyigou is located in Milin County of Nyingchi County. Nanyigou is rich in vegetation, pasture and water, well protected primitive forests, many beauty spots, and it is the essence of Lhoba folk customs. Nanyigou is 20 km from Minlin County and is a Lhoba village. The road to enter Nanyigou is rugged because it

was used to transport timbers. After trekking about an hour, we came to a primitive Lhoba village surrounded by primitive village. Surrounded by mountains and hills, clouds and mists filled the air. In spring, peach blossoms and azalea are widespread the hills and mountains; in autumn, red leaves are seen on the hills and mountains.

(v) Lulang Forest is located in 80 km area on Sichuan – Tibet Highway. Trees are mainly *Cyclobalanopsis glauca*. In the forest, various birds perch. The azalea sea in Seji Mountain is also a famous scenic spot in Nyingchi. Lulang Forest is 3700 m high above the sea level. It is a typical long strip of plateau mountain meadow. Mountains in both sides are covered by shrubs and dense dragon spruces and pines from the low to high area, forming the forest sea. In the middle, it is the uniform meadow. In the meadow, streams are meandering and thousands of wild flowers blossom competitively. Wooden fences, wooden houses, and villages of farmers and herdsmen are scattered all over like stars in the sky, clouds gather or become separate from time to time. Snow-capped mountains, forest sea, and pastoral sceneries sketch a tranquil and beautiful mountain picture[9-11].

4.2 Calculation of evaluation indicator weight and comprehensive attribute According to the above evaluation method, based on the raw data obtained by expert assessment and tourist questionnaire, we carried out a scientific calculation of plant landscape in 5 ecological scenic spots of southeastern region of Tibet. The calculation results were as follows: the evaluation system has 12 evaluation indicators, according to the theory of entropy weight method, we could know the decision matrix of 5 scenic spots was X.

$$(x_{ij})_{5\times12}=\begin{bmatrix}5.76 & 5.46 & 5.52 & 6.03 & 5.45 & 6.45 & 6.35 & 6.46 & 5.42 & 5.36 & 6.23 & 5.45\\ 7.22 & 7.24 & 7.35 & 6.82 & 7.25 & 7.58 & 8.02 & 8.02 & 6.25 & 6.89 & 6.78 & 7.25\\ 6.85 & 6.45 & 6.53 & 7.11 & 7.12 & 9.89 & 6.54 & 7.03 & 6.02 & 6.13 & 6.78 & 5.89\\ 5.\ ]45 & 5.23 & 5.12 & 4.89 & 4.85 & 5.23 & 5.21 & 5.64 & 5.45 & 6.54 & 7.01 & 6.25\\ 5.86 & 5.87 & 5.42 & 5.68 & 5.46 & 6.01 & 5.98 & 6.10 & 7.23 & 7.14 & 7.25 & 7.16\end{bmatrix}$$

(i) Through standardization of the evaluation matrix X using the formula (1), we obtained the standardized matrix R.

$$R=\begin{bmatrix}0.1751 & 0.1144 & 0.1794 & 0.5135 & 0.25 & 0.2618 & 0.4057 & 0.3445 & 0 & 0 & 0 & \\ 1 & 1 & 1 & 0.8694 & 1 & 0.5043 & 1 & 1 & 0.4586 & 0.8596 & 0.5392 & 1\\ 0.791 & 0.607 & 0.6323 & 1 & 0.9458 & 1 & 0.4733 & 0.584 & 0.3315 & 0.4326 & 0.5392 & 0.2444\\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.0166 & 0.6629 & 0.7647 & 0.4444\\ 0.2316 & 0.3184 & 0.1345 & 0.3559 & 0.2524 & 0.1674 & 0.274 & 0.1933 & 1 & 1 & 1 & 0.95\end{bmatrix}$$

(ii) Through normalization of the standardized matrix R using the formula (3), *i. e.* dividing each column by the sum of the column, we obtained the normalized matrix F.

$$F=(f_{ij})_{5\times12}=\begin{bmatrix}0.0797 & 0.0561 & 0.0922 & 0.1875 & 0.102 & 0.1354 & 0.1884 & 0.1624 & 0 & 0 & 0 & 0\\ 0.455 & 0.4902 & 0.5138 & 0.3174 & 0.4082 & 0.2608 & 0.4645 & 0.4713 & 0.2538 & 0.2909 & 0.1897 & 0.3789\\ 0.3599 & 0.2976 & 0.3249 & 0.3651 & 0.3861 & 0.5172 & 0.2198 & 0.2752 & 0.1835 & 0.1464 & 0.1897 & 0.0926\\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.0092 & 0.2243 & 0.269 & 0.1684\\ 0.1054 & 0.1561 & 0.0691 & 0.1299 & 0.1037 & 0.0866 & 0.1273 & 0.0911 & 0.5535 & 0.3384 & 0.3517 & 0.36\end{bmatrix}$$

(iii) We calculated the information entropy output value for each evaluation indicator using the formula (4).

The information entropy output value of the first indicator is:

$$e_1=\frac{1}{ln\ 5}\sum_{i=1}^{5}f_{i1}\,ln\,f_{i1}=1-\frac{1}{ln5}(0.0797\ ln\ 0.0797+0.455\ ln\ 0.455+0.3599\ ln\ 0.3599+0.1054\ ln\ 0.1054)=0.7237$$

Similarly, we could calculate the information entropy output value of the other 11 indicators.

(iv) Using the formula (5), we calculated the weight of 12 evaluation indicators, as follows:

$$w_1=\frac{1-e_1}{\sum_{k-1}^{12}(1-e_k)}=(1-0.7237)/[(1-0.7237)+(1-0.7218)+(1-0.6908)+(1-0.8147)+(1-0.7463)+(1-0.7295)+(1-0.7867)+(1-0.7599)+(1-0.6397)+(1-0.8341)+(1-0.8396)+(1-0.7803)]=0.0942$$

Similarly, we calculated the weight of other 11 indicators, as listed in Table 2.

(v) Using the formula (6), we calculated the comprehensive attribute value of 5 scenic spots.

$$z_1=\sum_{i=1}^{12}r_{1j}\,w_i=0.1751\times0.0942+0.1144\times0.0949+0.1794\times0.1054+0.5135\times0.0632+0.25\times0.0865+0.2618\times0.0922+0.4057\times0.0727+0.3445\times0.0819+0\times0.1228+0\times0.0566+0\times0.0547+0\times0.0749=0.1822$$

Similarly, we calculated the comprehensive attribute values of the other four schemes.

4.3 Result analysis From Table 3, results show that the rank of the comprehensive attributes from high to low is as follows: Nanyigou, Lulang Forest, Kading Mountain Waterfall, Yarlung Zangbo Grand Canyon, and Basomtso Lake according to evaluation from aesthetic effect, ecological harmony and service functions.

(i) In the aesthetic effect and ecological harmony, Nanyigou has the highest attribute value, the next is Lulang Forest. Nanyigou primitive forest is well protected and there are many beauty spots, and it is the essence of Lhoba folk customs. Lulang Forest is 3700 m high above the sea level. Trees are mainly *Cyclobalanopsis glauca*. It is a typical long strip of plateau mountain mead-

ow. Mountains are covered by shrubs and dense dragon spruces and pines from the low to high area, forming the forest sea. The plant landscape of two scenic spots has high richness of colors and level, and the interest, accessibility and the degree of stop are also high.

(ii) In the service functions, Kading Mountain Waterfall has the highest comprehensive attribute value, the next is Nanyigou. Kading Mountain Waterfall (Kadinggou) is closest to Nyingchi City, the plant landscape is close to natural state, the types are various. Due to reasonable design of the scenic spots, tourists can access the green space in a short distance, so the interest, accessibility, and degree of stop are relatively high.

(iii) Yarlung Zangbo Grand Canyon and Basomtso Lake are far from Nyingchi City. In these two scenic spots, the famous beauty spots are Grand Canyon and the magical lake. The plant landscape is mainly natural landscape. Due to special geographical location, this scenic spots is weaker in plant colors, level, and interest compared with other three scenic spots.

(iv) In general, the plant landscape of the five scenic spots in the southeastern region of Tibet mostly remains natural regeneration state with little human intervention. Therefore, the plant landscape configuration is slightly simple, for example, Lulang Forest has high vegetation coverage, but the trees are single in varieties, while Kadinggou has many plant varieties, but the landscape configuration is not scientific enough. Therefore, in the landscape design of the scenic spots, on the basis of maintaining the natural regeneration of the plant, it is recommended to add human theme elements, so as to improve the aesthetic effect, ecological harmony, and service functions.

Table 2 Evaluation results of evaluation system for plant landscape in scenic spots

Level	0.7218	0.0949	3
Morphology	0.6908	0.1054	2
Style	0.8147	0.0632	10
Texture	0.7463	0.0865	6
Species diversity	0.7295	0.0922	5
Community stability	0.7867	0.0727	9
Heterogeneity of community space	0.7599	0.0819	7
Safety	0.6397	0.1228	1
Interest	0.8341	0.0566	11
Degree of stop	0.8396	0.0547	12
Accessibility	0.7803	0.0749	8

Table 3 Attribute values and comprehensive attribute values of level I indicators for 5 scenic spots

	Aesthetic effect	Ecological harmony	Service functions	Comprehensive attribute	Rank
Yarlung Zangbo Grand Canyon	0.1003	0.0818	0	0.1822	4
Nanyigou	0.4359	0.2011	0.2094	0.8464	1
Lulang Forest	0.3488	0.1744	0.1130	0.6312	2
Basomtso Lake	0	0	0.1146	0.1146	5
Kading Mountain Waterfall	0.1107	0.0512	0.3053	0.4671	3

5 Conclusions

Through the entropy weight method, we determined the weight of evaluation indicators. An important part of multi-indicator comprehensive evaluation is the determination of indicator weight. The method of determining the indicator weight generally includes subjective and objective methods. In this study, the subjective method is mainly the expert evaluation and understanding and attention of tourist questionnaire for indicators. There is high degree of subjective judgment. The objective method mainly refers to determining the indicator weight through standardized processing of data on the basis of supplied original information. The objective method has high accuracy and reliability. In view of the comprehensive evaluation results, combined with the analysis on differences in actual situation of scenic spots, we proposed development and construction recommendations. The results are expected to provide certain practical guidance. In the selection of indicators for the evaluation of plant landscape, due to the quantitative and qualitative evaluation of the factors of the plant landscape, there are some factors that may affect the evaluation results. In the future studies, it is required to take comprehensive consideration of the factors of plant landscape, and make more accurate comprehensive evaluation, to provide a scientific basis for construction, transformation and optimization of plant landscape works in scenic spots[12-18].

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