Study on the Evaluation System of Forest Ecological Protection Using Big Data Technology and Adaptive Fuzzy Logic System

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Abstract. This paper takes Hunan Forest Botanical Garden as the research object, and selects 23 indicators from three criterion levels—the regional environmental quality, developing conditions and the characteristic value of scenic spot, to evaluate the ecological tourism development potential. Analytic hierarchy process is used to determine the weight of each index, and the fuzzy comprehensive evaluation method is also applied to evaluate the three criterion levels and the ecological tourism development potential. The results show that the score of ecological tourism development potential of Hunan Forest Botanical Garden is 8.7344, which represents a direction of development from "good" to "great"; the score of regional environmental quality is 9.4038, the highest score among the three criterion levels. It is suggested that the scenic area should maintain its own advantages, enhance tourism characteristics, and strengthen the construction of ecological civilization to promote the in-depth development of ecotourism.

1. Introduction
The concept of “eco-tourism” was first proposed by the World Conservation Union (IUCN) in 1983, and was later defined by the International Ecotourism Association (TIES) in 1993 as “an activity with the responsibility of both protecting the environment and maintaining the lives of local people”. Compared with traditional tourism, the core of eco-tourism is to protect the environment, adhere to the concept of sustainable development, and achieve a harmonious relationship between men and nature [1]. Ornamental plant (animal) tourism, marine tourism, forest tourism and mountaineering tourism are the common forms of eco-tourism [2].

In the past few decades, eco-tourism has made great progress in China. In 2019, China Forest Park received more than 1.8 billion tourists, accounting for nearly 30% of domestic tourists, which creates a comprehensive social output value of 1.75 trillion yuan, with a year-on-year increase of 16.7%. Forest parks are highly favored by people, especially for their beautiful environment and widely distributed natural and human resources [3]. At present, it has become the most important carrier for China to develop ecological recreational activities [4]. On the one hand, the influx of tourists has brought a lot of profits and business opportunities to the forest park, and it has promoted the development of more valuable tourism projects; on the other hand, the number of tourists has a negative impact on the environment and infrastructure of the scenic spots, thus posing a great threat to the management of parks. This article takes Hunan Forest Botanical Garden as the research object, aiming to evaluates its
ecological tourism development potential through mathematical models, hoping to provide some suggestions for its sustainable development.

2. Description of Hunan Forest Botanical Garden

Hunan Forest Botanical Garden, also known as Hunan Tianjiling National Forest Park, is located in Yuhua District, Changsha, Hunan Province. It is the forest park nearest to the urban area. It enjoys a favorable geographical location and transportation. The park covers an area of about 1,800 acres. A large number of plant viewing areas, as well as playgrounds, golf courses and other entertainment places are provided in this botanical garden. It is a comprehensive botanical garden that integrates scientific research and production, science education, and ecological tourism, featuring animals and plants.

The botanical garden is a hilly landform with a gentle terrain. It belongs to subtropical monsoon climate, with a moderate temperature and the rain and heat at the same period. The average annual temperature is 16.9℃. The frost-free period is nearly 280 days. The average annual rainfall is 1400mm. The average annual sunshine hours is 1726h and the average annual relative humidity is 80% [5]. The acid red soil with thicker and medium fertility takes the dominant role in this park, which is suitable for the growth of most subtropical plants. And forest coverage rate is as high as 90%. It is a man-made forest, dominated by evergreen broad-leaf forests. And the rest are water areas and tourist facilities sites. And the park has ex-situ preserved plants of 208 families, 900 genus, more than 3200 species and more than 4000 varieties. The park accommodates, remedies, and domesticates 112 species of wild animals. Fifteen special botanical gardens are established, which include cherry blossom garden, rhododendron garden, tea plantation, etc.

3. Construction of index system

3.1. Construction of evaluation indicators

Figure 1. Evaluation System of Ecotourism Development Potential of Hunan Forest Botanical Garden.

Establishing a suitable index system is very important for evaluating the development potential of ecotourism in the botanical garden. Through the selection and confirmation of the index, the
connotation of the sustainable development of ecotourism in the botanical garden can be comprehensively evaluated. This article uses "China Forest Park Scenic Resource Quality Assessment GB/T18005-1999" as the main reference material. By reading literature and consulting experts [6], the thesis selects 23 indicators from three criterion levels--the regional environment, developing conditions and the characteristic value of scenic spot, to comprehensively evaluate the ecotourism development potential of the botanical garden, hoping to provide a reference for its in-depth development (Fig.1).

3.2. Determination of indicators weight

We use the Analytic Hierarchy Process (AHP), a combination of qualitative and quantitative method, to determine the weight. It is an important means to deal with complex and unstructured decision-making problems, thus is widely used. Through this method, a complex problem can be divided into several levels and factors, and the factors are compared and calculated to obtain the weight values of different indicators and subsystems, so as to provide a basis for decision-making. Each indicator is assigned with a quantified value of 1-9 [7]. The higher the ratio of factor $i$ and factor $j$, the more importance the former factor is. The weights of the evaluation index system of ecological tourism development potential of Hunan Forest Botanical Garden are shown in the following table 1. The above indicators have passed the consistency test.

Table 1. The weight of the evaluation index system of the ecological tourism development potential of Hunan Forest Botanical Garden.

| Target layer | Criteria layer | Weight in-group | Index layer | Weight in-group | Weight between-group |
|--------------|----------------|-----------------|-------------|-----------------|---------------------|
| A            |                |                 | $C_1$       | 0.1717          | 0.0572              |
|              |                |                 | $C_2$       | 0.1600          | 0.0533              |
|              |                |                 | $C_3$       | 0.0280          | 0.0093              |
|              |                |                 | $C_4$       | 0.1362          | 0.0454              |
|              |                |                 | $C_5$       | 0.1288          | 0.0429              |
|              |                |                 | $C_6$       | 0.1308          | 0.0436              |
|              |                |                 | $C_7$       | 0.0767          | 0.0256              |
|              |                |                 | $C_8$       | 0.1677          | 0.0599              |
|              |                |                 | $C_9$       | 0.0365          | 0.0122              |
|              |                |                 | $C_{10}$    | 0.1019          | 0.0340              |
|              |                |                 | $C_{11}$    | 0.1275          | 0.0425              |
|              |                |                 | $C_{12}$    | 0.1544          | 0.0515              |
|              |                |                 | $C_{13}$    | 0.1203          | 0.0401              |
| $B_1$        | 0.3333         |                 | $C_{14}$    | 0.1537          | 0.0512              |
|              |                |                 | $C_{15}$    | 0.1936          | 0.0645              |
|              |                |                 | $C_{16}$    | 0.1122          | 0.0374              |
|              |                |                 | $C_{17}$    | 0.0888          | 0.0296              |
|              |                |                 | $C_{18}$    | 0.0620          | 0.0207              |
|              |                |                 | $C_{19}$    | 0.2137          | 0.0712              |
|              |                |                 | $C_{20}$    | 0.1055          | 0.0352              |
| $B_2$        | 0.3333         |                 | $C_{21}$    | 0.1749          | 0.0583              |
|              |                |                 | $C_{22}$    | 0.2060          | 0.0687              |
|              |                |                 | $C_{23}$    | 0.1492          | 0.0497              |
4. Fuzzy Comprehensive Evaluation of Evaluation System

4.1. Determination of the evaluation elements and the set of comments
According to the evaluation system of ecotourism development potential (Fig.1), the evaluation element is \( A = \{B_1, B_2, B_3\} \). Among them, the single-element subset \( B_i (i = 1, 2, 3) \) are:
- \( B_1 = \{C_1, C_2, C_3, C_4, C_5, C_6, C_7, C_8\} \)
- \( B_2 = \{C_9, C_{10}, C_{11}, C_{12}, C_{13}, C_{14}, C_{15}, C_{16}\} \)
- \( B_3 = \{C_{17}, C_{18}, C_{19}, C_{20}, C_{21}, C_{22}, C_{23}\} \)

The evaluation level is divided into five levels:
- \( V = \{\text{great, good, medium, bad, worse}\} \)

4.2. Determination of the membership matrix
This example uses the expert consultation method (Delphi method) to evaluate the evaluation indicators. The membership matrix \( R \) from the evaluation index \( C_i (i = 1, 2, \ldots, n) \) to the evaluation level \( V_j (j = 1, 2, 3, 4, 5) \).

\[
R = \begin{bmatrix}
    r_{11} & r_{12} & \cdots & r_{1j} \\
    r_{21} & r_{22} & \cdots & r_{2j} \\
    \vdots & \vdots & \ddots & \vdots \\
    r_{i1} & r_{i2} & \cdots & r_{ij}
\end{bmatrix}
\]

The results after scoring each index by experts are shown in Table 2.

| Evaluation index | great | good | medium | bad | worse |
|------------------|-------|------|--------|-----|-------|
| C_1              | 0.8   | 0.2  | 0      | 0   | 0     |
| C_2              | 1     | 0    | 0      | 0   | 0     |
| C_3              | 0     | 0    | 0      | 0.2 | 0.8   |
| C_4              | 0.8   | 0.2  | 0      | 0   | 0     |
| C_5              | 0.4   | 0.6  | 0      | 0   | 0     |
| C_6              | 0.6   | 0.4  | 0      | 0   | 0     |
| C_7              | 1     | 0    | 0      | 0   | 0     |
| C_8              | 1     | 0    | 0      | 0   | 0     |
| C_9              | 0     | 0    | 0      | 0.6 | 0.4   |
| C_{10}           | 1     | 0    | 0      | 0   | 0     |
| C_{11}           | 1     | 0    | 0      | 0   | 0     |
| C_{12}           | 1     | 0    | 0      | 0   | 0     |
| C_{13}           | 0.4   | 0.6  | 0      | 0   | 0     |
| C_{14}           | 0.4   | 0.6  | 0      | 0   | 0     |
| C_{15}           | 0.8   | 0.2  | 0      | 0   | 0     |
| C_{16}           | 0.2   | 0.2  | 0.4    | 0.2 | 0     |
| C_{17}           | 0     | 0.2  | 0.2    | 0.4 | 0.2   |
| C_{18}           | 0.2   | 0.2  | 0.4    | 0.2 | 0     |
| C_{19}           | 0.6   | 0.4  | 0      | 0   | 0     |
| C_{20}           | 0     | 0.2  | 0.4    | 0.4 | 0     |
| C_{21}           | 0.8   | 0.2  | 0      | 0   | 0     |
| C_{22}           | 0.6   | 0.4  | 0      | 0   | 0     |
| C_{23}           | 0     | 0.2  | 0.4    | 0.4 | 0     |
4.3. Evaluation results

Taking the regional environment subsystem as an example, the fuzzy comprehensive evaluation calculation process is as follows:

- Weight vector \( A_1 = (0.1717, 0.1600, 0.0280, 0.1362, 0.1288, 0.1308, 0.0767, 0.1677) \).

- From Table 2, the single-factor membership evaluation matrix of the regional environmental subsystem can be obtained:

\[
R = \begin{pmatrix}
0.8 & 0.2 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0.2 & 0.8 \\
0.8 & 0.2 & 0 & 0 & 0 \\
0.4 & 0.6 & 0 & 0 & 0 \\
0.6 & 0.4 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 0
\end{pmatrix}
\]

By using the fuzzy operator, the matrix composition calculation formula is \( M (\cdot, \oplus) \) [8]:

\[
B_1 = A \circ R_1 = [a_{i1}, a_{i2}, \ldots, a_{in}] = [b_{i1}, b_{i2}, \ldots, b_{im}] 
\]

(1)

According to (1), \( B_1 = (0.7807, 0.1912, 0, 0.0056, 0.0224) \).

Then, fuzzily compute \( B_1 \), the calculation formula of each rating index value is:

\[
E = WH
\]

In the formula, \( H \) is the score corresponding to each evaluation level, with 10, 8, 6, 4, and 2 assigned in sequence. It is calculated that \( E_1 = 9.4038 \), which represents a direction of development from "good" to "great". To sum up, \( B_2 = (0.6707, 0.2256, 0.0449, 0.0443, 0.0146) \), \( E_2 = 8.9875 \), between "good" and "great"; \( B_3 = (0.4041, 0.2840, 0.1444, 0.1498, 0.0146) \), \( E_3 = 7.8144 \), a direction from "medium" to "good". According to the maximum membership principle, the closer \( E \) is to 10, the higher the evaluation of the subsystem, and vice versa. The analysis shows that the score of fuzzy comprehensive evaluation of the regional environment is the highest, which means that it occupies an important position in the development potential of ecotourism.

According to the fuzzy comprehensive evaluation of the rating index system subsystem, the weight vector is \( (0.3333, 0.3333, 0.3333) \), and the membership evaluation matrix is:

\[
R = \begin{pmatrix}
0.7807 & 0.1912 & 0 & 0.0056 & 0.0224 \\
0.6707 & 0.0449 & 0.2256 & 0.0443 & 0.0146 \\
0.4041 & 0.2840 & 0.1444 & 0.1498 & 0.0146 \\
0.6185 & 0.2335 & 0.0631 & 0.0666 & 0.0182 \\
0.4041 & 0.0449 & 0.2256 & 0.0443 & 0.0146 \\
0.1912 & 0.0449 & 0.2256 & 0.0443 & 0.0146 \\
0.0056 & 0.0449 & 0.2256 & 0.0443 & 0.0146 \\
0.0224 & 0.0449 & 0.2256 & 0.0443 & 0.0146
\end{pmatrix}
\]

According to (1), \( B = (0.6185, 0.2335, 0.0631, 0.0666, 0.0182) \); according to (2), \( E = 8.7344 \). It can be seen that the potential of ecotourism development in the botanical garden is in a "good" state, and develop towards a "great" one.

5. Conclusions and suggestions

5.1. Conclusions

As a result, the ecological tourism development potential of the Hunan Forest Botanical Garden is 8.7344, a direction from "good" to "great"; the regional environmental quality score is 9.4038, the
highest score in the three criteria layers. To sum up, compared with the regional environmental quality and developing conditions, the characteristic value of Hunan Forest Botanical Garden still has some room for improvement. Its environmental publicity and education, forest health effects, visibility and influence should be strengthened in order to promote the sustainable development of ecological tourism.

5.2. Suggestions

(1) Maintain its own advantages and enhance tourism characteristics. Given its abundant animal and plant resources, it would be great if the park can cooperate with related institutions to carry out rehabilitation and recuperation services, and launch a series of cultural products such as forest health literature and art; in terms of its complete tourism infrastructure, forest exploration can be developed, which allows tourists to exercise while enjoying the scene; in view of the obvious seasonal changes, it is advocated to continue to improve and explore the four flower appreciation activity - "Spring Song", "Summer Love", "Autumn Color" and "Winter Rhyme". The scenic spot should think from the standpoint of tourists, creating tourism products that not only meet the needs of the market but also meet the future development of the scenic spot.

(2) Pay attention to the construction of ecological civilization in scenic spots. The construction of ecological civilization is closely related to sustainable development, and it has played an increasingly important role in sustainable development. Facing dissatisfaction about the forest ecological environment and tourists’ weak environmental awareness, the management department should increase the intensity of law enforcement, carry out necessary ecological protection education for tourists, and accumulate the experience of "environmental interpretation system education". Scenic spots need to improve the use of green management technologies so as to improve the level of environmental management. For example, use "3S" technology to establish a scenic spot environmental monitoring system; use environmentally friendly materials in the construction of scenic spots; expand the scope of the application of clean energy in the park's sightseeing cars, such as solar, wind energy, etc.

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