Suitability evaluation of rural tourism based on AHP and fuzzy evaluation method

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Abstract: In order to study the suitability of rural tourism development and prevent the blind development of rural tourism, we have identified 12 evaluation indicators of natural resources and human resources from three aspects: tourism resources, current development intensity and village development potential. Using AHP and fuzzy evaluation method to quantitatively analyze the various elements of rural tourism development, and evaluate the suitability of village development tourism industry.

1. Introduction
With the upsurge of rural tourism construction, more and more villages choose to develop tourism to achieve rural revitalization. However, in actual work, we will find that some villages are not suitable for tourism. At present, rural tourism is developing from a single form to a diversified one. [1] The location of rural tourism depends mostly on the subjective consciousness of investors and the supervisory intention of the leadership. Lin Xiongbin, Yan Zipin [2] studied the evaluation of rural tourism resources based on AHP; Liu Zichen [3] and other evaluations of Xiangxiang tourism development based on fuzzy analysis. However, research and discussion on the suitability of rural tourism is rarely done. This paper combines the predecessors' research theory, uses AHP to calculate the weight of each element of rural planning, and combines the theory of fuzzy analysis method to quantify each element, and finally obtains the evaluation value of rural tourism suitability. Then we can compare and select villages suitable for the development of rural tourism.

2. Basic principle of suitability evaluation
2.1 Analytic hierarchy process to determine the weight of evaluation indicators at all levels
Analytic Hierarchy Process (AHP) divides decision-making problems into different components, refines and quantifies these factors, simplifies complex location problems into comparison and sorting calculations among various factors, and establishes mathematical parameter models. [4]
2.1.1 Constructing a comparison judgment matrix. The importance of each element of the decision-making layer to the decision-making layer is evaluated, and the judgment matrix $A$, $B_1$, $B_2$, $B_3$ of the pairwise comparison is constructed by the $(1,9,9)$ EM method. Judging the matrix $A$ is shown in Table 1, other judgment matrices are available in the same way.

|    | $A_1$ | $A_2$ | $A_3$ |
|----|-------|-------|-------|
| $B_1$ | $A_{11}$ | $A_{12}$ | $A_{13}$ |
| $B_2$ | $A_{21}$ | $A_{22}$ | $A_{23}$ |
| $B_3$ | $A_{31}$ | $A_{32}$ | $A_{33}$ |

We calculate the maximum eigenvalue and eigenvector of each judgment matrix and check its consistency. The formula is as follows:

$$\bar{\omega}_j = \sqrt[n]{\prod_{i=1}^{n} \theta_{ij}} \quad (i=1, 2, \ldots, n), \quad \omega = (\omega_1, \omega_2, \ldots, \omega_n)^T .$$

Normalize $\omega : \omega = \omega / \sum_{j=1}^{n} \omega_j$, $i = 1, 2, \ldots, n$ to get the approximate value of the eigenvector.

$$W = (\omega_1, \omega_2, \ldots, \omega_n)^T$$

Calculate the maximum eigenvalue of the judgment matrix,

$$\lambda_{max} = \frac{\sum_{i=1}^{n} (AW)}{n\omega_j}$$

Calculate its consistency, $C \cdot I = \frac{\lambda_{max} - n}{n-1}, \quad (n$ is the matrix order$)$

When the consistency ratio $CR = CI / (RI) < 0.1$, the result is acceptable. On the contrary, it is unacceptable. The judgment matrix needs to be revised [6].

2.2 Fuzzy evaluation method to assess fuzzy indicators

Whether the village is suitable for the development of tourism is to consider the characteristics of each element and the impact of each sub-element on rural tourism. A number of experts are selected to divide the level levels of each element to form an evaluation level level decision set. Let $X$ be the set of evaluation factors, $x = \{x_1, x_2, x_n\}$; $Y$ is the evaluation level level decision set, $Y = \{y_1, y_2, y_n\}$. For any $x \in X$, $y \in Y$, the characteristic index (possible degree) of $x$ on $y$. A set of $\{r_{ij}, r_{i2}, \ldots, r_{im}\}$ for each $r_{ij}$ is a characteristic index of $X_i$ with respect to $Y$, $(i = 1, 2, \ldots, m)$. Then use these sets of quantities as the matrix $R = (r_{ij})_{mn}$ which constitutes $n \times m$, and we get the fuzzy relation matrix of $X$ to $Y$.

The weight allocation is represented by the fuzzy set $K = (k_1, k_2, \ldots, k_n)$ on $X$. $Ki$ is the quantity index of the factor $x_i$. From $A = KR$, calculated $A = (a_1, a_2, \ldots, a_n)$ represents the probability coefficient of various decisions on the decision set, and then use the principle of maximum membership to select the largest $a_j$ corresponding $y_j$ as the evaluation result.

3. Rural tourism suitability evaluation

3.1 Establishment of Rural Tourism Suitability Evaluation Index System

The rural tourism suitability evaluation system has three levels and 12 secondary indicators. The comprehensive evaluation of rural development rural tourism from three aspects of tourism resources, current development intensity and development potential covers the basic elements of rural development tourism. The establishment of secondary indicators is a refinement of the primary indicators, and it is comparative and computational for the rural areas to be consistent with the
development of rural tourism.

(1) Analysis of rural tourism resources. Rural tourism resources are the basic elements of village development and rural tourism, and are an important factor in attracting tourists. Here we use the four indexes of natural resources, human resources, resource influence and environmental quality to reflect the basic situation of village tourism resources. (2) The strength of the current development zone. It refers to the construction of villages in rural areas, which is a consideration for the amount of investment in construction and construction and the cost of construction. The system quantifies the development intensity of the village from the internal transportation, infrastructure construction and land development intensity of the village to reflect the difficulty of village development tourism construction. (3) The development potential of the village. The village development potential mainly analyzes the relevant planning and policies of the village, location conditions, external transportation, socio-economic development level and the surrounding tourism development.

3.2 Rural tourism suitability evaluation process

3.2.1 Analytic hierarchy process to determine weights. For the importance of each element of the same level relative to the previous level, the (1/9,9) EM method is adopted to select the experts to judge the importance of each level of elements, and according to the evaluation results, construct the judgment matrix of the two pairs. A, B1, B2, B3. The square root method is used to calculate the maximum eigenvalue and eigenvector of the judgment matrix. Obtain the index weights, and the final calculation results are shown in the table.

|   | A   | B1  | B2  | B3  | W_A |
|---|-----|-----|-----|-----|-----|
| B1| 1   | 2   | 1/3 | 0.2222 |
| B2| 1/2 | 1   | 1/6 | 0.1111 |
| B3| 3   | 6   | 1   | 0.6667 |

Table 2. Criterion level relative target level judgment matrix A; B.

| AC          | B               | C                              | Weight | Sort |
|-------------|-----------------|--------------------------------|--------|------|
| Tourist resources B1 | Natural resources C1 | 0.0458 | 7     |
|              | Human resources C2 | 0.0155 | 12    |
|              | Resource impact C3 | 0.1274 | 3     |
|              | Environmental quality C4 | 0.0335 | 8     |
|              | Internal traffic C5 | 0.033  | 9     |
|              | Infrastructure C6 | 0.0182 | 11    |
| Current Development Strength B2 | Difficulty of Land Use Development C7 | 0.0599 | 6     |
|              | Relevant Planning and Policy C8 | 0.3227 | 1     |
|              | Location condition C9 | 0.154  | 2     |
|              | External traffic C10 | 0.0882 | 4     |
| Suitability of Rural Tourism A | Socio-economic Development Level C11 | 0.0298 | 10    |
| Development potential B3 | Circumjacent Tourism Development C12 | 0.0719 | 5     |


Table 4. Judgment Matrix of Rural Tourism Resources Evaluation B1: C1~C4.

| B1 | C1 | C2 | C3 | C4 | $W_{B1}$ | $\lambda_{max}$ | $CI=0.0403$ | $CR=0.046<0.1$ |
|----|----|----|----|----|---------|----------------|----------------|----------------|
| C1 | 1  | 3  | 1/4| 2  | 0.2062  | 4.1228        |                |                |
| C2 | 1/3| 1  | 1/6| 1/3| 0.0699  |                |                |                |
| C3 | 4  | 6  | 1  | 4  | 0.5732  |                |                |                |
| C4 | 1/2| 3  | 1/4| 1  | 0.1507  |                |                |                |

Consistency of judgement matrix is acceptable.

Table 5. Judgment Matrix of Current Development Intensity Evaluation B2: C5~C7.

| B2 | C5 | C6 | C7 | $W_{B2}$ | $\lambda_{max}=3.0092$ | $CI=0.0046$ | $CR=0.0089<0.1$ |
|----|----|----|----|---------|----------------|----------------|----------------|
| C5 | 1  | 2  | 1/2 | 0.2973  |                |                |                |
| C6 | 1/2| 1  | 1/3 | 0.1638  |                |                |                |
| C7 | 2  | 3  | 1   | 0.539   |                |                |                |

Consistency of judgement matrix is acceptable.

Table 6. Judgment Matrix for Evaluating Village Development Potential B3: C8~C12.

| B3 | C8 | C9 | C10 | C11 | C12 | $W_{B3}$ | $\lambda_{max}=5.3831$ | $CI=0.09775$ | $CR=0.0855<0.1$ |
|----|----|----|-----|-----|-----|---------|----------------|----------------|----------------|
| C8 | 1  | 3  | 5   | 3   | 1/4 | 0.231   |                |                |                |
| C9 | 1/3| 1  | 4   | 2   | 1/5 | 0.1323  |                |                |                |
| C10| 1/5| 1/4| 1   | 1/4 | 1/6 | 0.0447  |                |                |                |
| C11| 1/3| 1/2| 4   | 1   | 1/4 | 0.1079  |                |                |                |
| C12| 4  | 5  | 6   | 4   | 1   | 0.4841  |                |                |                |

Consistency of judgement matrix is acceptable.

Obtained from Table 2~5: The first layer of index weights: $k_0=\begin{bmatrix} 0.2222 & 0.1111 & 0.6667 \end{bmatrix}$.

The weights of each index in the second level are as follows: $k_1=\begin{bmatrix} 0.2062 & 0.0699 & 0.5732 & 0.1507 \end{bmatrix}$; $k_2=\begin{bmatrix} 0.2973 & 0.1638 & 0.539 \end{bmatrix}$; $k_3=\begin{bmatrix} 0.231 & 0.1323 & 0.0447 & 0.1079 & 0.4841 \end{bmatrix}$.

3.2.2 Construction of Fuzzy Comprehensive Evaluation Matrix. This article takes two villages in Hengyang as an example. A company wants to select one of the two villages in Hengyang City for tourism development. Firstly, each evaluation factor is assigned by fuzzy scoring method, and each evaluation factor is divided into five grades according to its superiority and inferiority [7]. Ten experts judged each decision-making indicator according to five levels: better, good, general, poor and bad. The results of the judgement are as follows.

According to the evaluation results of the above experts, the fuzzy comments of the A and B programs relative to the various indicators are obtained.
Table 7. The fuzzy comments of the A and B programs relative to the various indicators

| Indicator universe | Weight A | Indicator universe | Weight A | Expert evaluation |
|--------------------|----------|--------------------|----------|-------------------|
|                    | U | | | A plan | B plan |
|                     | | | | Better | Good | General | Poor | Bad | Better | General | Poor | Bad |
| Tourist resources   | 0.2222 | | | | | | | | | | | |
| C1                  | 0.2062 | 0.8 | 0.2 | 0 | 0 | 0.2 | 0.8 | 0 | 0 | 0 | |
| C2                  | 0.0699 | 0.1 | 0.3 | 0.6 | 0 | 0 | 0.2 | 0.6 | 0 | 0 | 0 | |
| C3                  | 0.5732 | 0.2 | 0.8 | 0 | 0 | 0 | 0.1 | 0.8 | 0 | 0 | 0 | |
| C4                  | 0.1507 | 0.5 | 0.4 | 0.1 | 0 | 0 | 0.6 | 0.4 | 0 | 0 | 0 | |
| Current Development | 0.1111 | | | | | | | | | | | |
| Strength            | | | | | | | | | | | | |
| C5                  | 0.2973 | 0 | 0 | 0.3 | 0.5 | 0.2 | 0 | 0.2 | 0.6 | 0.2 | 0 | |
| C6                  | 0.1638 | 0 | 0 | 0.2 | 0.8 | 0 | 0 | 0.8 | 0 | 0 | 0 | |
| C7                  | 0.539 | 0 | 0.3 | 0.7 | 0 | 0 | 0 | 0.7 | 0 | 0 | 0 | |
| Development potential | 0.6667 | | | | | | | | | | | |
| Strength            | | | | | | | | | | | | |
| C8                  | 0.231 | 0.3 | 0.7 | 0 | 0 | 0 | 0.4 | 0 | 0 | 0 | 0 | |
| C9                  | 0.1323 | 0.2 | 0.7 | 0.1 | 0 | 0 | 0.8 | 0.2 | 0 | 0 | 0 | |
| C10                 | 0.0447 | 0 | 0 | 0.0 | 0.3 | 0.2 | 0 | 0.3 | 0 | 0 | 0 | |
| C11                 | 0.1079 | 0 | 0 | 0.1 | 0.5 | 0.4 | 0 | 0 | 0 | 0.2 | 0.6 | 0.2 | |
| C12                 | 0.4841 | 0.1 | 0.6 | 0.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0.2 | 0.5 | 0.3 | |

Based on the above data, the fuzzy evaluation matrix of villages A and B is obtained:

\[
C_{1A} = \begin{bmatrix}
0.8 & 0.2 & 0.0 & 0.0 & 0.0 & 0.0 \\
0.1 & 0.3 & 0.6 & 0.0 & 0.0 \\
0.2 & 0.8 & 0.0 & 0.0 & 0.0 \\
0.5 & 0.4 & 0.1 & 0.0 & 0.0
\end{bmatrix},

C_{1B} = \begin{bmatrix}
0.2 & 0.8 & 0.0 & 0.0 & 0.0 \\
0.2 & 0.6 & 0.2 & 0.0 & 0.0 \\
0.1 & 0.8 & 0.1 & 0.0 & 0.0 \\
0.6 & 0.4 & 0.0 & 0.0 & 0.0
\end{bmatrix},

C_{2A} = \begin{bmatrix}
0.0 & 0.0 & 0.3 & 0.5 & 0.2 \\
0.0 & 0.0 & 0.2 & 0.7 & 0.1 \\
0.0 & 0.3 & 0.7 & 0.0 & 0.0
\end{bmatrix},

C_{2B} = \begin{bmatrix}
0.0 & 0.4 & 0.6 & 0.0 & 0.0 \\
0.8 & 0.2 & 0.0 & 0.0 & 0.0 \\
0.7 & 0.3 & 0.0 & 0.0 & 0.0 \\
0.0 & 0.0 & 0.2 & 0.6 & 0.2 \\
0.0 & 0.0 & 0.2 & 0.5 & 0.3
\end{bmatrix},

3.2.3 Evaluation results of computational schemes. According to \(B_N = KCN\), we get

\[
B_{1A} = K_1C_{1A} = \begin{bmatrix}
0.2062 & 0.0699 & 0.5732 & 0.1507
\end{bmatrix} \times \begin{bmatrix}
0.8 & 0.2 & 0.0 & 0.0 & 0.0 \\
0.1 & 0.3 & 0.6 & 0.0 & 0.0 \\
0.2 & 0.8 & 0.0 & 0.0 & 0.0 \\
0.5 & 0.4 & 0.1 & 0.0 & 0.0
\end{bmatrix} = \begin{bmatrix}
0.3619 & 0.5811 & 0.0570 & 0.0 & 0.0
\end{bmatrix}
\]

Similarly, the evaluation results of other evaluation factors of the scheme can be calculated:

\[
B_{2A} = \begin{bmatrix}
0.0 & 0.1617 & 0.4993 & 0.2633 & 0.0758
\end{bmatrix},

B_{3A} = \begin{bmatrix}
0.1531 & 0.5824 & 0.2213 & 0.0432 & 0.0
\end{bmatrix},

B_{1B} = \begin{bmatrix}
0.2030 & 0.7257 & 0.0713 & 0.0 & 0.0
\end{bmatrix},

B_{2B} = \begin{bmatrix}
0.1086 & 0.6703 & 0.1673 & 0.0539
\end{bmatrix},

B_{3B} = \begin{bmatrix}
0.1371 & 0.1323 & 0.2570 & 0.3068 & 0.1668
\end{bmatrix}
\]

4. Results and analysis

Evaluation of rural tourism suitability factors: From the above \(B_{1A}\) and \(B_{1B}\) calculation results, it can be seen that the tourism evaluation factors of the two villages are better and the membership degrees are 94.3% and 92.87% respectively. It shows that the two villages have advantages in developing rural tourism, but in comparison, the village A is more attractive in terms of comprehensiveness.

Based on the above results, the fuzzy evaluation matrix of the scheme is further constructed:
According to $A=K_0B$, the overall evaluation results of villages A and B are calculated:

$$A_A=\begin{bmatrix} 0.3619 & 0.5811 & 0.0570 & 0.0000 & 0.0000 \\ 0.0000 & 0.1617 & 0.4993 & 0.2633 & 0.0758 \\ 0.1531 & 0.5824 & 0.2213 & 0.0432 & 0.0000 \\ 0.2030 & 0.7257 & 0.0713 & 0.0000 & 0.0000 \\ 0.0000 & 0.1086 & 0.6703 & 0.1673 & 0.0539 \\ 0.1371 & 0.1323 & 0.2570 & 0.3068 & 0.1668 \end{bmatrix}$$

According to $A=K_0B$, the overall evaluation results of villages A and B are calculated:

$$A_B=\begin{bmatrix} 0.1668 & 0.3068 & 0.2570 & 0.1323 & 0.1371 \\ 0.0539 & 0.1673 & 0.6703 & 0.1086 & 0.0000 \\ 0.0000 & 0.0000 & 0.0713 & 0.7257 & 0.2030 \end{bmatrix}$$

$$B_A=\begin{bmatrix} 0.0000 & 0.0432 & 0.2213 & 0.5824 & 0.1531 \\ 0.0758 & 0.2633 & 0.4993 & 0.1617 & 0.0000 \\ 0.0000 & 0.0000 & 0.0000 & 0.0570 & 0.5811 \\ 0.1371 & 0.1323 & 0.2570 & 0.3068 & 0.1668 \end{bmatrix}$$

According to the principle of maximum membership degree, the comprehensive evaluation results of the tourism suitability of two villages in A and B are concluded: the overall evaluation result of village A is better, and the overall evaluation result of village B is good.

Determine the total score:

In order to integrate the suitability of rural tourism, the fuzzy reviews A are combined into one number. According to the opinion of the expert group, give each level of comments a weight $W$, let $W_1 = 100$, $W_2 = 80$, $W_3 = 60$, $W_4 = 40$, $W_5 = 20$. Therefore, the total score of the rural tourism suitability assessment is:

$$S_A=\sum_{j=1}^{4} a_{jA} \cdot W_j = 100 \times 0.1825 + 80 \times 0.5354 + 60 \times 0.2157 + 40 \times 0.0581 + 20 \times 0.0084 = 76.516$$

$$S_B=\sum_{j=1}^{4} a_{jB} \cdot W_j = 100 \times 0.1365 + 80 \times 0.2615 + 60 \times 0.2617 + 40 \times 0.2231 + 20 \times 0.1172 = 61.54$$

According to the above results, the suitability of the development of tourism in A Village is good, which is consistent with the actual expert advice. Therefore, the evaluation method combining the analytic hierarchy process and the fuzzy comprehensive evaluation method has practical significance in the process of selecting rural development rural tourism.

5. Conclusions and Discussion

Analytic Hierarchy Process (AHP) is used to analyze the weight of 12 factors to the decision-making level, among which the related planning and policy weights are the largest (0.3227). This shows that in rural development, the upper planning and local government policies are decisive to the direction of rural industrial development. The weight of location condition is 0.154, which indicates that the suitability of rural tourism development in villages is closely related to their location. The development of villages will be affected by urbanization. The villages with better location have innate advantages. The source of tourists and the level of consumption of tourists will have an important impact on rural tourism. The third place is the resource influence of villages (0.1274). Villages with great influence have a great attraction for tourists and can provide a good source of tourists for rural development. The external traffic (0.0882), the surrounding tourism development (0.0719), the difficulty of land development (0.0599), natural resources (0.0458), environmental quality (0.0335) and internal traffic (0.033) weights of villages have little difference. The weights of infrastructure status and human environment in the suitability of rural tourism are at least 0.0182 and 0.0155, respectively. Although they are relatively small, they cannot be ignored when considering the suitability of rural tourism.
The evaluation method combining analytic hierarchy process and fuzzy comprehensive evaluation method transforms the stereotype of rural tourism development into quantification, so that the suitability of village development rural tourism is expressed in the form of numbers. As far as possible, avoiding the supervisory nature of the rural tourism site selection, this method can greatly reduce the waste of resources. Thereby guiding the healthy development of the rural tourism industry, making rural tourism investment more rational and reducing investment risks.

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