International Journal of New Developments in Engineering and Society
ISSN 2522-3488 Vol. 8, Issue 5: 60-69, DOI: 10.25236/IJNDES.2024.080510

Construction of Traditional Village Landscape Quality Evaluation Index System Based on Fuzzy Comprehensive Evaluation Method

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Abstract: *The research on the evaluation of rural landscape quality has emerged as countries in the world protect their rural landscapes in the process of urbanization. Its appearance provides a reference for the planning and design of rural landscapes, and also plays an active role in the protection and development of rural landscapes. This article aims to study the construction of traditional village landscape quality evaluation index system based on fuzzy comprehensive evaluation method. Based on the analysis of the traditional village landscape system, the method of landscape quality evaluation, the application of the Internet of Things technology in the traditional village landscape informatization, and the principle of constructing the evaluation index system, the traditional village landscape quality evaluation index system was constructed. Take traditional villages in Wuyi area of Jiangmen City as an example, the traditional village landscape quality evaluation index system was applied in practice by taking a questionnaire survey to professionals. The results show that, as far as the landscape quality of traditional villages is concerned, experts believe that village layout and site selection is the most important factor, and traditional architecture and intangible culture are of similar importance.*

Keywords: *fuzzy Comprehensive Evaluation Method, Internet of Things, Traditional Village Landscape, Landscape Quality, Evaluation Index System*

1. Introduction

The evaluation of the landscape quality of traditional villages can aim at protecting the existing beautiful natural environment of traditional villages, using existing tourism resources, and promoting economic development [1-2]. The diversity of traditional village landscape types, cultural diversity, aesthetic value and leisure functions determine the unique advantages, conditions and operation methods of traditional village landscapes and traditional ecotourism, and enable the development of village landscape resources [3-4].

The empirical method has become the main research method for evaluating landscape quality in the second half of the 20th century. It is mainly used in environmental management practices. The method of evaluating landscape perception and experience dominates the entire research field [5-6]. The application of semantic difference SD and landscape quality evaluation methods in psychology is not limited to the participation of experts in the evaluation, but the participation of the public, through extensive data analysis, quantitative analysis of the results [7-8]. In the process of evaluating Spanish rural landscape quality, J Gong, Y Xie, Cao E and others first conducted on-site investigations of landscape elements, determined quality evaluation factors, and then evaluated the elements and landscape quality. The rating series is based on the public's landscape quality scores, and experts evaluate landscape quality data [9]. Ruan X, Huang J, Williams D, etc. stated in their study on the quality assessment of highway landscapes in the United States that after determining the assessment factors, first an expert assessment will be carried out, and then the public will complete the landscape

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assessment [10]. The application of this method has been recognized and applied by many researchers, and some representative results have been achieved in the evaluation of landscape quality such as plant diversity, water system scale, and urban park mobility. In many landscape quality evaluation studies, the impact of artificial elements on different types of landscapes has two different positive and negative states [11-12]. In addition, this method of combining public and professional methods uses pre-simulated models to evaluate the quality of the landscape.

Wuyi region has a unique traditional village spatial characteristics. The study of the landscape quality evaluation of traditional village in Wuyi area of Jiangmen City in this article can reflect the advantages and disadvantages of existing landscapes to a certain extent, which is conducive to the protection and renewal of traditional villages; it is helpful to establish the landscape level and positioning goals of traditional villages; it is beneficial to the sustainable development of Chinese traditional villages; it provides a practical and feasible theoretical evaluation method for the scientific construction of traditional villages.

2. Traditional Village Landscape Quality Evaluation Index System Based on Fuzzy Comprehensive Evaluation Method

2.1 Methods of Landscape Quality Evaluation

(1) AHP

The analytic hierarchy process is a multi-factor analysis method that quantitatively analyzes the quality problem data and uses a variety of data classification to determine the weighting factors. Its characteristic is to model, quantify, simplify, systemize, structure and mathematicalize the mathematical thinking process of complex systems for effective analysis. The processing ability of the analytic hierarchy process that combines qualitative and quantitative analysis is suitable for problems with complex structure, lack of required data, and difficulty in complete quantification. The Analytic Hierarchy Process is widely used in various fields of my country's social economy, including energy, planning, economy, scientific research, etc., and has a wide range of concerns and applications [13-14].

(2) Fuzzy comprehensive evaluation method

The basic steps of the fuzzy comprehensive evaluation method are as follows[15-16]:

First, establish a fuzzy judgment matrix

The set of elements is a fuzzy set composed of various factors that affect the evaluation target, and it is represented by the letter U[17]. Establishing the index factor evaluation set, that is, the fuzzy evaluation set composed of evaluation grades, which is represented by the letter V. The fuzzy subset of the membership degree of the index factor, that is, the fuzzy mapping relationship from the element set U of the i-th index factor to the evaluation set V is as follows:

$$R_i = \left[r_{i1}, r_{i2}, ..., r_{in}\right] \tag{1}$$

The fuzzy comprehensive evaluation table R is an evaluation set composed of n index coefficients, which represents the fuzzy relationship of the evaluation object from the data set to the evaluation set [18], the fuzzy matrix R is:

$$R = \left(r_{ij}\right)_{nm} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{n1} & r_{n1} & \cdots & r_{nm} \end{bmatrix} \tag{2}$$

For the index factor i, it represents the percentage of the total number of people who agree to the evaluation level j in the evaluation of the total index factor V. For example, when evaluating a certain index factor, the number of people who think that the index factor is very good, good, average, and very bad are 32%, 45%, 18%, and 5% respectively. The overall index score is as follows:

$$R_i = \left[0.32, 0.45, 0.18, 0.05\right] \tag{3}$$

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Second, the first-level fuzzy comprehensive evaluation

According to the fuzzy combination formula, the sum of the fuzzy judgment table and the weight of each index layer is multiplied by the matrix composition function to achieve a complete first-level evaluation of the index layer:

$$A_i = W_i \times R_i \tag{4}$$

Third, the secondary comprehensive evaluation:

In the second level of the fuzzy overall scoring model, UK is regarded as an element, Ai is regarded as an indicator scoring vector, and the fuzzy overall scoring level of target U is considered as follows:

$$R = (A_1, A_2, ..., A_n)^T \tag{5}$$

Then perform fuzzy comprehensive calculation on the total weight W of the first-level indicator layer and the R rating panel to obtain the overall second-level rating reflecting the landscape evaluation of the landscape layer:

$$A = W \times R \tag{6}$$

Fourth, evaluation result judgment, result vector analysis

The FCE assessment results reflect the participation in the assessment process of each level being assessed. The blur vector is a number, but it does not represent a specific number. The ambiguous crisis process represents the distribution of a subset of its rating levels. When interpreting the results of the fuzzy overall assessment, follow the principle of participating in the fuzzy assessment to the greatest extent. For example, a fuzzy vector looks like this:

$$R_i = [0.40, 0.30, 0.20, 0.10] \tag{7}$$

It shows that the fuzzy evaluation result is "excellent".

2.2 Application of Extracting Information Points of Traditional Village Landscape Quality Evaluation Index

The Internet of Things is a way of information dissemination based on the Internet, which connects things through sensors to achieve the purpose of perception. More precisely, the Internet of Things is a kind of "Internet of Things connection". The core foundation is still the Internet, which is a network that is constantly expanding and expanding based on the Internet.

RFID wireless technology plays an important role in the Internet of Things. In wireless sensor networks, RFID wireless technology is the nervous system of the Internet of Things, and it is the link between RFID electronic tags and real application scripts and single applications. Its unique capabilities make the RFID radio frequency identification system very suitable for working in harsh environments without manual intervention, providing new ideas for technical applications. The rapid development of RFID technology is critical to the progress of the Internet of Things [19].

3. Construction of Evaluation Index System of Traditional Village Landscape Quality in Wuyi

3.1 Principles for the Construction of the Evaluation Index System

(1) The principle of representativeness

The principle of representativeness means that the indicators in the traditional village landscape quality evaluation index system are representative in some aspects of traditional village landscape quality evaluation. Since it is impossible to establish a comprehensive indicator system, the traditional village landscape quality evaluation indicator system must include key indicators. The so-called key indicators are indicators that can reflect the key aspects of the landscape quality of traditional villages. In addition, the traditional village landscape quality indicator system should not have overlapping indicators. Otherwise, the assessment results will change.

(2) Systematic principle

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The systematic principle refers to the construction of a traditional village landscape quality indicator system, which must include all aspects of the indicators that can evaluate all aspects of the traditional village landscape. From a theoretical point of view, the traditional village landscape quality evaluation indicator system should include four evaluation indicators: the architectural space layer, the layout and location layer, the natural landscape layer, and the intangible cultural layer.

(3) Validity principle

The principle of validity means that there must be some difference in the design of the metric. In other words, there is a certain degree of difference between the evaluation indicators of each evaluation object. Generally speaking, it is impossible for a particular index to have almost the same data in all cities. This shows that the indicator has no degree of discrimination and does not conform to the principle of validity.

3.2 Identification of Evaluation Factors

Through the layer-by-layer decomposition of the evaluation level and evaluation content, the Wuyi traditional village landscape quality evaluation factor set is obtained as shown in Table 1:

Table 1: Traditional village landscape quality evaluation factor set

Target layer	Criterion layer	standard floor	
Landscape quality evaluation of traditional villages A	Human landscape quality evaluation B1	Village layout evaluation C1	Integrity of village spatial pattern D1
			The harmony between the village and the surrounding natural landscape D2
			Village spatial richness D3
			Village location specificity D4
			Longitude of village location D5
		Traditional building evaluation C2	The age of the building D6
			Traditional architectural style regionality D7
			Architectural integrity D8
			Coordination between new and old buildings D9
			Inheritance of traditional crafts D10
	Natural landscape quality evaluation B2	Natural plant community attraction D11	
		Old and famous trees landscape attraction D12	
		Water attractions D13	
		Vegetation coverage D14	
		Plant species richness D15	
	Intangible cultural quality evaluation B3	Intangible cultural space preservation integrity D16	
		The continuity of folk customs in the dungeons D17	
		Attraction and Participation of Folklore Activities D18	
		The richness of intangible culture D19	
		Scarcity of intangible culture D20	
		The authenticity of intangible cultural space D21	

3.3 Construction of Evaluation Index System

Using expert scoring, we get the final evaluation index. The traditional village landscape evaluation index system is shown in Figure 1:

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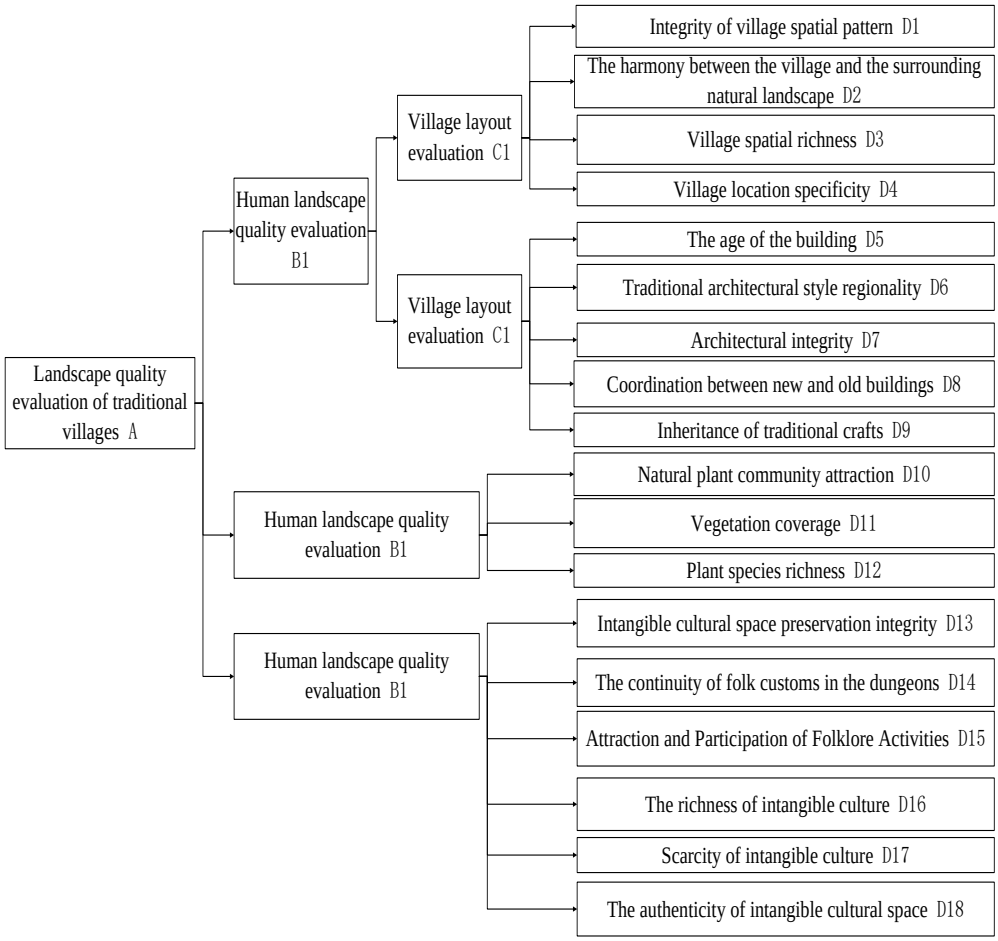

Figure 1: Traditional village landscape evaluation index system

3.4 Determination of the Weights of Evaluation Indicators

3.4.1 Calculation of Indicator Weight

(1) AHP

Analytic Hierarchy Process (AHP) is the use of mathematics and psychology to solve complex and difficult to quantify problems. The principle of Analytic Hierarchy Process is to classify research questions according to the nature of the research questions, and divide these indicators into different levels. This can turn the problem into a problem of categorizing the relative strengths and weaknesses of each index format. Then, by establishing a judgment table, the unified ranking structure of a specific level element relative to the upper level element and the total ranking weight relative to the upper level element are calculated.

1) Steps to use the analytic hierarchy process:

A. Build a hierarchical model

Through the analysis of the research topic, the relationship between the various factors is clarified, the sequence is clarified, and the hierarchical structure model is finally established.

B. Construct a judgment matrix

After the establishment of the hierarchical structure model is completed, the factors in the same level are compared in pairs, and the importance of the two is judged according to the numerical scale of the importance of the pairwise comparison.

2) Construct a judgment matrix

After introducing the analytic hierarchy process, we use relative scales to determine the weights

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between factors, and compare factors with each other to create a judgment matrix, reducing the difficulty of comparing factors with different properties.

Through the above judgment, matrix A is obtained.

$$A=\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n1} & \cdots & a_{nn} \end{bmatrix} \tag{8}$$

The relative importance of lower-level factor D_i and factor D_j to upper-level criterion B_k constitutes a judgment matrix. Taking n factors as an example, matrix $D=(D_{ij})nxn$ is obtained, as shown in Table 2.

Table 2: Judgment Matrix

B_k	D_1	D_2	···	D_n
D_1	D_{11}	D_{12}	···	D_{1n}
D_2	D_{21}	D_{22}	···	D_{2n}
...	...	...	...	...
D_n	D_{n1}	D_{n2}	···	D_{nn}

Among them, $D_{ij}=1/D_{ij}(i\neq j)$ and $D_{ij}>0$.

(2) Hierarchical list sorting

Hierarchical single sorting is based on the judgment matrix constructed in the previous step, and a certain calculation method is used to obtain the weights of the relative importance of the factors of the previous layer that are related to the current layer.

Assuming that λmax is the largest eigenvalue of the judgment matrix B, and ω is the corresponding eigenvector, the eigenvalue of the vector is solved. First, multiply the elements in the judgment matrix by rows; second, multiply the resulting product to the power of n (n is the order of the judgment matrix). The calculation formula as follow:

$$\omega=(\omega_1,\omega_2,...,\omega_k)^T \tag{9}$$

$$\lambda\max=\sum_{i=1}^{n}\frac{(A\omega)}{n\omega_i}i \tag{10}$$

4. Discussion

4.1 Calculation Results of Indicator Weights

Taking the score of "Expert Six" as a demonstration of the calculation process, construct a criterion-level judgment matrix for objective A. Calculating the consistency index value through Yaahp12.1, the eigenvector 1 of C1, C2, B2, and B3, and the maximum eigenvalue λmax of the weight vector, as shown in Table 3:

Table 3: Target level A criterion level judgment matrix

A	C1	C2	B2	B3
C1	1	2	4	3
C2	1/2	1	3	2
B2	1/4	1/3	1	1/2
B3	1/3	1/2	2	1

Next, constructing paired comparison judgment matrices for the evaluation factor layers of criterion

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layers C1, C2, B2, and B3, as shown in Figures 2(a), 2(b), 2(c), and 2(d) respectively:

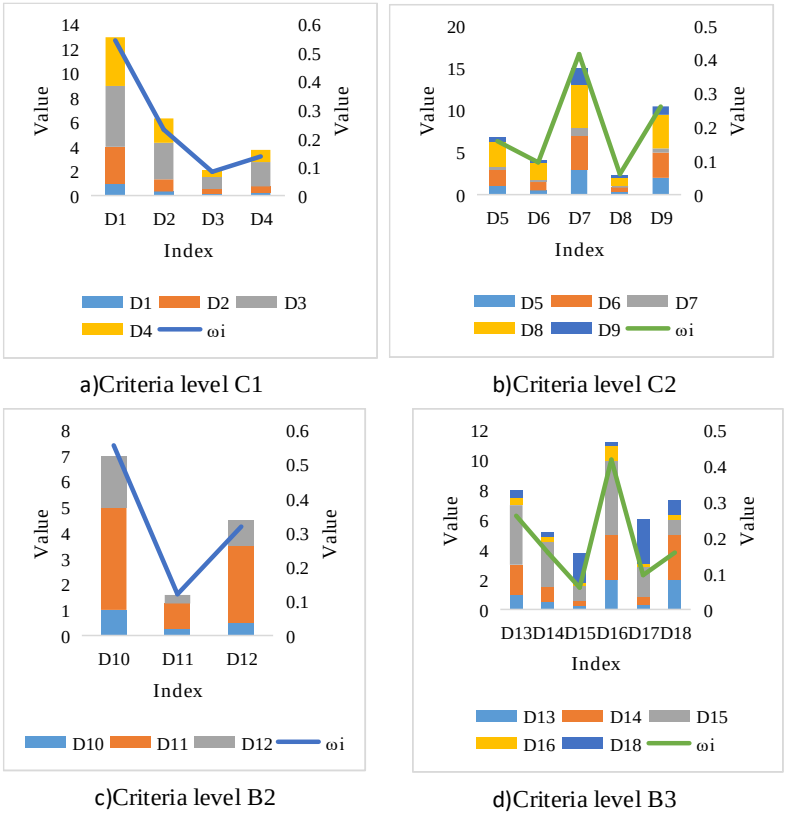

Figure 2: Evaluation factor layer pairwise comparison judgment matrix

The CR values of the five judgment matrices constructed above are all less than 0.1, and all have acceptable consistency. Finally, the weight values of all evaluation factors are obtained by calculation.

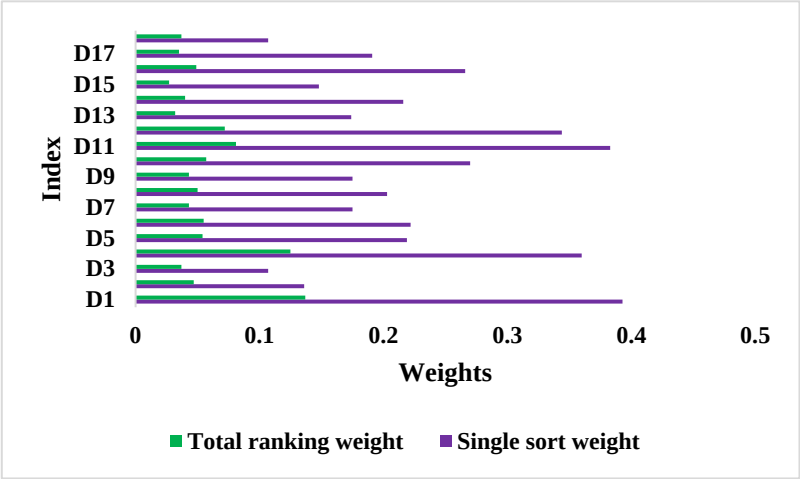

Figure 3: Map of the weight value of the traditional village landscape quality evaluation index

It can be seen from Figure 3 that the four evaluation silver weight values of the criterion level have obvious gradients, the village layout location C1>traditional architecture C2>intangible culture B3>natural landscape B2. Generally speaking, as far as the landscape quality of traditional villages is concerned, experts believe that village layout and site selection is the most important factor, and traditional architecture and intangible culture are of similar importance.

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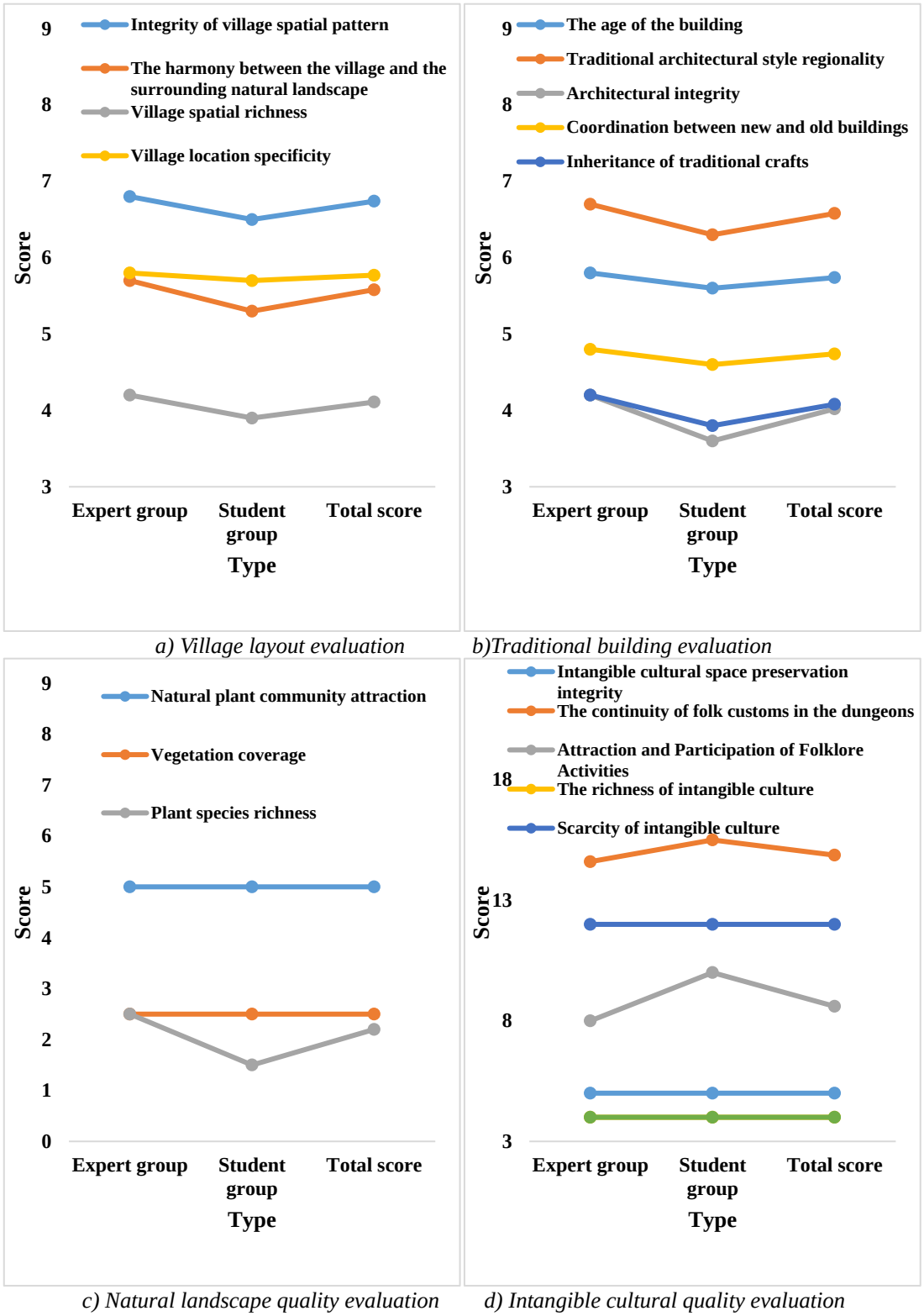
4.2 Evaluation and Analysis



a) Village layout evaluation *b)Traditional building evaluation*

c) Natural landscape quality evaluation *d) Intangible cultural quality evaluation*

Figure 4: Landscape quality evaluation results

According to the evaluation results of the landscape quality of Village S in Figure 4, the site selection score in the evaluation of the human landscape of Village S shows that the evaluators have a higher evaluation of its layout and site selection. Both in terms of the completeness of the spatial pattern and the coordination between the village and the surrounding environment, the score is high, which is consistent with the actual environment of Village S and reflects the landscape value of the

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village layout and site selection. The evaluators gave a high overall evaluation of the village's traditional buildings, including the application of regional materials and the preservation of traditional buildings. The evaluation of the coordination of new and old buildings is low. From the field investigation of the natural environment of S village, it can be known that the village is rich in natural resources and good natural landscape. The evaluation of the intangible cultural layer from Figure 4 shows that the evaluators have a high evaluation, which is in line with the objective fact that there are various folk activities in Village S and the intangible cultural space is well-preserved.

5. Conclusions

Traditional village landscape is an important foundation of China's rural environment and an important part of Chinese folk culture. At the same time, the traditional village landscape is also a historical portrayal of local lifestyle, rural culture and urban development. The rational protection and design of the traditional landscape of the village is based on maximizing the value of the traditional landscape of the village, and the objective evaluation of the quality of the traditional landscape of the village is the rational use of the traditional landscape of the village. Traditional village landscape is an important content in rural construction, and it is a link between urban and rural areas. The research on the landscape quality of traditional villages is to better develop and utilize local resources, effectively promote the sustainable development of rural construction, and hope to provide a reference for the research of similar areas.

Acknowledgement

This work was supported by the 2023 youth project of the philosophy and Social Sciences Planning of Guangdong Province, "construction and characteristics of landscape gene map of Wuyi traditional villages based on Rough Set Theory", NO: GD23YYS17.

Guangdong Province Philosophy and Social Sciences Planning 2022 one of the results of the youth topics, NO: GD22YYS04.

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