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Comprehensive Evaluation of Landscape Features of Traditional Villages in the Middle Section of the Yarlung Zangbo River Basin from the Perspective of Landscape Genes

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Abstract The typical traditional settlements in the middle section of the Yarlung Zangbo River basin are taken as the research object. The landscape gene theory is introduced, and an evaluation index system is built from the four dimensions of material, culture, ecology and human settlement landscape genes. The analytic hierarchy process (AHP) is used to determine the index weight, and TOPSIS is used to calculate the closeness of villages. The research results show that the sequence of criterion weight is B1 material landscape gene>B2 cultural landscape gene>B3 ecological landscape gene>B4 human settlement landscape gene. The rating of "very good" is C1, C10, the rating of "good" is C2–C3, C11–C14, C15–C17, and the rating of "average" is C4–C9, C18–C23. The TOPSIS closeness values of Junba Fishing Village (0.836 5) and Tunda Village (0.650 3) are level I, the TOPSIS closeness values of Jiari Village (0.506 3) and Balang Village (0.467 1) are level II, and the TOPSIS closeness values of Chikang Village (0.201 5) and Dadong Village (0.196 8) are level III. The research results provide theoretical reference and practice for the landscape protection and planning of traditional villages in the plateau.

Keywords Landscape genes, The Yarlung Zangbo River basin, Traditional settlements, Landscape features, Evaluation research

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The traditional settlements in the Yarlung Zangbo River basin are the unique product of the long-term symbiosis of natural geography and national culture in the Qinghai–Xizang Plateau. Their landscape forms condense the survival wisdom adapted to the plateau environment and the spiritual connotation of the integration of multi-ethnic cultures. Traditional settlements are the material carriers of regional culture[1], and their landscape forms are formed by the long-term interaction among natural environment, historical context, and human activities. The Yarlung Zangbo River basin straddles the core area of the Qinghai–Xizang Plateau. The diverse terrain and climate from alpine meadow to humid valley in the basin are integrated with the production and life practices of Tibetan, Menba, Loba and other ethnic groups, and traditional settlements with diverse forms and rich connotations have been bred. The "landscape genes" accumulated in the site selection, layout, architectural form, and folk activities of these settlements are not only the adaptive embodiment of coping with natural challenges such as high-altitude and frigid, strong winds, and concentrated precipitation, but also the core carrier of ethnic cultural identity and historical memory inheritance.

With the promotion of new urbanization policies[2], the contradiction between the protection of traditional villages and the construction of new towns is becoming increasingly apparent, posing many challenges to traditional settlements in the basin: some settlements blindly transform stone buildings and traditional architectural styles to meet tourism functions, while productive landscapes such as farmland and water mills are occupied by commercial facilities. Intangible cultural heritage such as Guozhuang dance, Tibetan opera, and traditional wooden construction techniques are facing the risk of inheritance discontinuity. The current academic research on the settlements in this region mainly focuses on describing the characteristics of individual buildings or analyzing macro spatial layout, lacking systematic identification of landscape core elements from the "gene" level and quantitative evaluation of their preservation quality, and resulting in a lack of precise guidance for protection and renewal work. It is of urgent significance by strengthening scientific exploration such as mining and evaluation of cultural landscape genes of traditional villages[3].

The theory of landscape genes provides an effective solution to this problem, with its core being the extraction of inheritable and iconic core elements from the landscape, and revealing the formation mechanism and evolution laws of landscape morphology. By constructing a scientific evaluation system to quantitatively analyze the current quality of landscape genes, the focus and shortcomings of traditional settlement protection can be clarified, providing a basis for formulating the targeted strategies. Based on this, this study combined the regional characteristics of the Yarlung Zangbo River basin to build a landscape gene evaluation model, aiming to provide theoretical and practical reference for the protective development of traditional settlements in this region.

1 Materials and methods

1.1 Overview of the research area

The middle section of the Yarlung Zangbo River (the middle reaches) refers to Lizi to Pai Town in Milin City, with a total length of about 1,293–1,340 km and a catchment area of about 164,000 km^2. The vegetation types include alpine meadow, coniferous forest, shrub, etc. It is the core zone of humanities and agriculture in Xizang. The beaded shaped valleys with

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alternating wide and narrow are its landmark landform, and there is great potential for development of production, life and ecological space. The traditional settlements in the basin are mainly distributed along the main stream and the tributaries such as the Niyang River, the Nianchu River, the Parlung Zangbo, etc., forming a spatial pattern of "living near mountains and rivers, and living by water". The traditional villages in the middle section of the Yarlung Zangbo River are distributed in a strip along the main stream and tributaries[4-6], forming a diversified settlement pattern represented by wide valley terrace type, tributary valley type, valley manor type, waterfront fishing and hunting type, and suburban cultural tourism type. Jiari Village and Balang Village focus on intangible cultural heritage of song and dance, reflecting the cultural spatial structure of "culture–village–square"; Tunda Village relies on the water grinding and the techniques of Xizang incense to form a highly integrated living settlement of "ecology–production–life"; with Wanhu Mansion and manor as its core, Chikang Village is a typical representative of ancient administrative and aristocratic settlements in Xizang; relying on the unique fishing and hunting culture, Junba Fishing Village has become the only traditional waterfront fishing and hunting village in Xizang; relying on its suburban location and ecological resources, Dadong Village has embarked on a path of traditional village protection and cultural tourism integration in the urban fringe. The six villages together constitute a complete type pedigree of traditional villages in the middle section of the Yarlung Zangbo River, reflecting the human–land relationship[7], cultural inheritance and internal law of spatial form in the plateau valley area.

1.2 Research methods

1.2.1 Analytic Hierarchy Process (AHP). Construction of an evaluation system: a three-level evaluation system of "target layer–criterion layer–indicator layer" is established. The target layer is the comprehensive evaluation of the landscape style of traditional villages in the middle section of the Yarlung Zangbo River basin. There are four types of landscape genes in the criterion layer: material, cultural, ecological and human settlements. The indicator layer contains 23 specific indicators[8-9]. Firstly, it should strictly follow the three-level approach. The target layer focuses on the comprehensive evaluation of landscape style in six traditional villages (based on landscape genes), while the criterion layer and indicator layer are constructed around the integrity, inheritance, and adaptability of landscape genes, in line with the characteristics of traditional villages in the plateau. Secondly, the judgment matrix is constructed. Based on the importance relationship between each level, the 1–9 scale method is used to construct the judgment matrix, as shown in Table 1–3. Finally, the weight calculation and consistency check are performed. By calculating the consistency index CI and the random consistency index RI, the consistency ratio $CR=CI/RI$ is obtained. If the CR of all levels is less than 0.1, the consistency of the judgment matrix is qualified, and the weight allocation is scientific and reliable, as shown in the formulas (1) to (6).

AHP weight calculation and ranking, weight determination: by inviting 15 experts in the fields of landscape architecture, urban and rural planning, and Tibetan culture research, AHP method and 1–9 scale method are used to construct a judgment matrix. The weights of each indicator are calculated, and consistency testing is conducted ($CR<0.1$, ensuring the scientificity of weight allocation). A three-level hierarchy is constructed, and calculation is conducted.

(1) A judgment matrix is constructed for pairwise comparison and judgment, and the judgment results are quantified based on a certain ratio scale to form a comparative judgment matrix (Table 1).

The values of each element in the judgment matrix reflect people's understanding of the relative importance (or advantages and disadvantages, preferences, strengths, etc.) between various factors, and are generally scaled using 1–9 and reciprocal methods.

D_{ij} (i, j=1, 2, …, n) shows the ratio of the importance of the i^{th} factor to the j^{th} factor for A_k. In general, the judgment criteria of D_{ij} are based on Table 2. The scale and its meaning are shown in Table 3.

By pairwise comparison, the comparison matrix of the criterion layer and the indicator layer can be obtained. By solving the matrix, the weights of each indicator in the criterion layer and the indicator layer can be obtained.

(2) Hierarchical sorting.

$$\overline{W_i}=\sqrt[i]{\prod_{j=1}^{i} D_{ij}}\quad (i=1, 2, 3, \cdots, n) \tag{1}$$

(3) Normalization.

$$W_i=\frac{\overline{W_i}}{\sum_{i=1}^{n}\overline{W_i}} \tag{2}$$

The vector $\overline{W}$ is normalized to obtain a set of weight coefficients.

$$W=(W_1, W_2, \cdots, W_n) \tag{3}$$

(4) The maximum eigenvalue of the judgment matrix is calculated.

$$\lambda_{max}=\sum_{i=1}^{n}\frac{(PW)_i}{nW_i} \tag{4}$$

where $(PW)_i$ shows the i^{th} factor of the vector (PW), and n is matrix order; i, j=1, 2, 3, ⋯, n.

(5) Consistency check.

$$CI=\frac{\lambda_{max}-n}{n-1} \tag{5}$$

$$CI=\frac{CI}{RI} \tag{6}$$

Table 1 Judgment matrix

A_k	B_1	B_2	⋯	B_n
B_i	D_{11}	D_{12}	⋯	D_{1n}
	D_{21}	D_{22}	⋯	D_{2n}
	⋯	⋯	⋯	⋯
	D_{n1}	D_{n2}	⋯	D_{nn}

Table 2 *RI* values for matrices of orders 1–10

Order	RI
1	0
2	0
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49

Table 3 Importance indicators used in AHP method

Importance level	Definition	Description
1	Equally important	B_i and B_j are equally important
3	Slightly important	B_i is slightly more important than B_j
5	Important	B_i is more important than B_j
7	Very important	B_i is very important compared to B_j
9	Extremely important	B_i is extremely important compared to B_j
2, 4, 6, 8	Between the two	If necessary for comparison, the median of each importance level can be taken
Symmetry	If B_i is assigned a certain value when compared to B_j, then the ratio of B_j to B_i is the reciprocal of the above value	This is a reasonable inference

When CI<0.10, it is considered that the judgment matrix has satisfactory consistency, otherwise it needs to be readjusted.

The RI values of matrices of orders 1–10 are shown in Table 2–3.

1.2.2 TOPSIS sorting of landscape genes. The TOPSIS method is used to rank the comprehensive evaluation values of rural landscapes. By calculating the positive and negative ideal solutions, the distance between the evaluation value and the ideal solution is calculated, and finally the degree of closeness is calculated. After normalizing the data, the rural landscape styles of the case villages are ranked, and it is confirmed that the highest comprehensive evaluation value is the main gene of the village[10-11].

(1) Raw data matrix.

$$X=(x_{ij})6\times 23, x_{ij} \in \{1, 2, 3, 4, 5\} \quad (7)$$

(2) Vector normalization.

$$r_{ij}=\frac{x_{ij}}{\sum_{i=1}^{6} x_{ij}^{2}} \quad (8)$$

(3) Weighted standardization matrix.

$$z_{ij}=\omega_j\times r_{ij}, \sum_{j=1}^{23}=1 \quad (9)$$

(4) Positive and negative ideal solutions.

$$z_j^+=\max_i z_{ij} z_j^+=\max_i z_{ij}, z_j^-=\min_i z_{ij} \quad (10)$$

(5) Euclidean distance.

$$D_i^+=\sqrt{\sum_{j=1}^{23}(z_{ij}-z_j^+)^2}, D_j^-=\sqrt{\sum_{j=1}^{23}(z_{ij}-z_j^-)^2} \quad (11)$$

(6) Calculation formula for comprehensive score (closeness).

$$C_i=\frac{D_i^-}{D_i^+ + D_i^-} \quad (12)$$

1.2.3 Comprehensive sorting and grading standards. Grading standards are shown as Table 4.

Table 4 Grading standards

Judgment criteria	Level definition
$C_i \geqslant 0.65$	I (excellent)
$0.40 \leqslant C_i < 0.65$	II (good)
$C_i < 0.40$	III (general)

2 Recognition and evaluation of landscape gene

2.1 Recognition and extraction of landscape gene

As the only fishing and hunting cultural gene in Xizang, Junba Fishing Village has a strong recognition of the village landscape. Its material genes include traditional cowhide boat making techniques and unique village layout. Tunda Village is built along the Tunba River, forming a unique landscape of watermill fragrance corridor. Its landscape gene is a perfect integration of the "three lives space". Chikang Village is mainly a historical legacy gene of aristocratic manor, while Dadong Village's landscape genes lie in its beautiful pastoral scenery and profound historical and cultural heritage. Jiari Village and Balang Village have relatively complete traditional village architecture and spatial layout genes, with good completeness. The landscape genes of traditional villages in the middle section of the Yarlung Zangbo River should follow the principles of regionalism, scientificity, systematicness and dynamicity. The regionalism should closely fit the unique attribute of "valley+Tibetan culture" in the basin. Scientific indicators need to have clear meanings, easily accessible and quantifiable data. Systematicness should cover material, cultural, ecological, and human settlement landscape genes, ensuring that all dimensions are interrelated and fully reflecting the overall appearance of settlement landscape genes. Dynamicity should fully consider the evolutionary characteristics of landscape genes with the development of the times, such as the adaptation of new buildings and genes in human settlement landscape genes, the adaptation of village cleanliness and genes, the integration of natural landscape genes, the participation of villagers in inheritance, and the completeness of disaster prevention landscape genes. The adaptability of climate genes and the fusion of ecological landscape genes in ecological landscape genes enable the indicator system to reflect the current status of landscape genes and provide targeted directions for subsequent protection and renewal[12-13].

2.2 Construction of rating indicator system[14–15]

A comprehensive evaluation system for the landscape style of traditional villages in the middle section of the Yarlung Zangbo River is built (Table 5).

3 Evaluation results and analysis

3.1 Weight values of evaluation index system

Based on the expert scoring results and the AHP model, the weight values of each index in the landscape assessment system of traditional villages in the middle section of the Yarlung Zangbo River basin are calculated (Table 5).

According to Table 5, the weight sequence of the criterion layer is B1 material landscape gene>B2 cultural landscape gene>B3 ecological landscape gene>B4 human settlement landscape gene. The top 10 indicators in terms of comprehensive weight are integrity of Tibetan cultural landscape preservation (0.061 6), preservation rate of traditional architectural gene (0.060 2), integration degree of culture and tourism of landscape gene (0.058 8), recognition degree of architectural gene (0.056 4), connectivity of Tibetan cultural landscape (0.056 0), spatial integrity of landscape gene inheritance (0.053 2), adaptability degree of natural environment adaptation genes (0.051 3), publicity strength of inheritance (0.050 4), fusion of ecological landscape gene (0.049 4), and protection degree of cultural heritage building gene (0.048 9). This indicates that experts pay special attention to the indicators of architecture, culture, and dynamism in the landscape style evaluation system from the perspective of landscape genes.

3.2 Landscape style evaluation

According to the fuzzy comprehensive evaluation method, combined with multiple factors, a comprehensive judgment on the fuzzy information of the factors is made. For the evaluation of material landscape gene, through fuzzy comprehensive evaluation, evaluation level of C1 is very good, evaluation level of C2–C3 is good, and evaluation level of C4–C9 is average, indicating that the preservation rate of traditional architectural genes is particularly important for the landscape style of traditional settlements, and further protection is needed. C10 is rated as very good. The integrity of Tibetan cultural landscape preservation is an important consideration index of cultural genes. In the process of cultural protection of traditional settlements in the middle section of the Yarlung Zangbo River basin, Tibetan culture is also a cultural tourism. C11–C14 are rated as good. For the evaluation of ecological landscape gene, grades of C15 to C17 are good, while the level of C18 is average. For the evaluation of human habitat landscape gene, the level of C19–C23 is average.

3.3 Comprehensive rating of traditional villages

According to Table 6, the sequence of closeness is Junba Fishing Village>Tunda Village>Jiari Village>Balang Village>Chikang Village>Dadong Village. Junba Fishing Village has a closeness score of 0.836 5, which is level I. Closeness of Tunda Village is 0.650 3, which is level I. Closeness of Jiari Village is 0.506 3, which is level II. Closeness of Balang Village is 0.467 1, which is level II. Closeness of Dadong Village is 0.196 8, which is level III. Closeness of Chikang Village is 0.201 5, which is level III.

4 Conclusions

This study mainly uses analytic hierarchy process to build a comprehensive evaluation system for the landscape style of traditional villages in the middle section of the Yarlung Zangbo River, and the weight and comprehensive ranking are calculated. Using the fuzzy evaluation method, a 5-level evaluation of 23 indicators is

Table 5 Weight value of landscape style evaluation index system in the middle section of the Yarlung Zangbo River basin

Target layer	Criterion layer	Weight	Indicator layer	Indicator name	Self weight (criterion layer)	Comprehensive weight (global)
Comprehensive evaluation of the landscape style of traditional villages in the middle section of the Yarlung Zangbo River basinA	B1 material landscape gene	0.38	C1	Preservation rate of traditional architectural genes	0.158 4	0.060 2
			C2	Identification of architectural genes	0.148 5	0.056 4
			C3	Protection degree of cultural heritage architecture genes	0.128 7	0.048 9
			C4	Integrity of street and alley landscape genes	0.118 8	0.045 1
			C5	Genetic adaptability of settlement layout	0.108 9	0.041 4
			C6	Landscape genes of public space	0.099 0	0.037 6
			C7	Activity of intangible cultural heritage landscape gene	0.089 1	0.033 9
			C8	Inheritance of traditional cultural landscape genes	0.079 2	0.030 1
			C9	Integrity of festival landscape genes	0.069 3	0.026 3
	B2 cultural landscape gene	0.28	C10	Integrity of Tibetan cultural landscape preservation	0.220 0	0.061 6
			C11	Connectivity of Tibetan cultural landscape	0.200 0	0.056 0
			C12	Spatial integrity of landscape gene inheritance	0.190 0	0.053 2
			C13	Publicity efforts of inheritance	0.180 0	0.050 4
			C14	Integration degree of culture and tourism of landscape genes	0.210 0	0.058 8
	B3 ecological landscape gene	0.19	C15	Adaptability of natural environment adaptation genes	0.270 0	0.051 3
			C16	Land use landscape genes	0.250 0	0.047 5
			C17	Fusion of ecological landscape gene	0.260 0	0.049 4
			C18	Climate adaptation genes	0.220 0	0.041 8
	B4 human settlement landscape gene	0.15	C19	Adaptation of new buildings to genes	0.220 0	0.033 0
			C20	Adaptation of village cleanliness to genes	0.210 0	0.031 5
			C21	Fusion degree of natural landscape genes	0.200 0	0.030 0
			C22	Participation of villagers in inheritance	0.190 0	0.028 5
			C23	Completeness of disaster prevention landscape genes	0.180 0	0.027 0

Table 6 Comprehensive rating of traditional typical villages

No.	Village name	Distance from the positive ideal solution D_i^-	Distance from the negative ideal solution D_i^+	Closeness Ci (overall score)	Rating level
1	Junba Fishing Village	0.032 6	0.164 8	0.836 5	I
2	Tunda Village	0.068 9	0.128 5	0.650 3	I
3	Jiari Village	0.097 4	0.099 9	0.506 3	II
4	Balang Village	0.105 2	0.092 1	0.467 1	II
5	Chikang Village	0.172 3	0.043 6	0.201 5	III
6	Dadong Village	0.158 7	0.038 6	0.196 8	III

conducted, of which the "very good" evaluation indicators are C1 and C10, the "good" evaluation indicators are C2, C3, C11–C17, and the rest are general. The evaluation level of "very good" accounts for 8.7%, the evaluation level of "good" accounts for 39.1%, and the evaluation level of "general" accounts for 52.2%. Using the TOPSIS method (closeness) for comprehensive scoring, Junba Fishing Village and Tunda Village are classified as level I, Jiari Village and Balang Village are classified as level II, and Dadong Village and Chikang Village are classified as level III. Given the different landscape features of the six villages, it should deeply explore the unique cultural DNA in each village on the plateau that distinguishes from others, and safeguard the material carriers, such as protecting the landscape pattern, traditional buildings, public spaces, etc. It should scientifically distinguish and moderately develop the traditional village landscape, avoid homogenization, and prevent damage to the traditional village landscape. For example, the architectural layout of Jiari Village has a high spatial density. From the perspective of protection, it is recommended to develop the tourism industry appropriately and reasonably. In future practice, it needs to continuously optimize the evaluation index system to enhance the scientific nature of research and its practical guidance value, thereby providing more accurate decision-making basis for the scientific planning and construction of plateau rural landscapes.

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