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Article

Rural cultural landscape evaluation system based on analytic hierarchy process: a case study of Hong Fanchi Spring

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ABSTRACT

Based on a combined approach of Analytic Hierarchy Process and fuzzy comprehensive evaluation, this study constructs a rural landscape evaluation system for the Hong Fanchi Spring area in Jinan, China. The research aims to systematically evaluate the cultural landscape quality, identify key factors affecting landscape value, and propose targeted protection strategies. Through literature review, expert interviews (n=18), and the Delphi method, a four-level hierarchical evaluation framework was established with 4 criterion-layer and 14 sub-criterion-layer indicators. Data collected from 389 valid questionnaires across six towns were analyzed using SPSS 27.0. Results revealed an overall cultural landscape evaluation score of 2.77 (on a 5-point scale), indicating below-average quality and considerable room for improvement. Among the four landscape types evaluated, Village Cultural Landscape ranked highest (2.80), followed by Planting Cultural Landscape (2.79), Religious Cultural Landscape (2.77), and Spring Water Cultural Landscape (2.75). The study identified cultural value (weight: 30.61%) and historical value (28.28%) as the most influential indicators, while public recognition (C9) demonstrated the greatest variation across landscape types. Based on these findings, six targeted recommendations are proposed, including classified protection priorities, enhanced community participation, improved legal frameworks, cultural-economic integration, strengthened environmental management, and promotion of sustainable development practices. This evaluation framework provides a reference model for other rural cultural landscape assessments and management strategies.

1. Introduction

Local culture originates in a specific region and gradually forms through long-term human-land interaction and social changes, rooted in collective memory. It fully reflects the complex and profound cultural diversity produced by the interrelationship between humans, nature, and land [1]. Rural cultural landscape, as an important carrier of local culture, is a cultural landscape system composed of both material and non-material cultures along with their landscape environment and perceptual imagery. Therefore, excavating rural cultural resources, strengthening rural cultural landscape construction, and enhancing the value recognition of local culture are effective measures to assist rural flexible governance and promote endogenous rural development.

1.1 Research objectives

This study on the rural cultural landscape of the Hong Fanchi Spring area aims to achieve the following four primary objectives:

- To construct a comprehensive rural cultural landscape evaluation system specifically tailored to the Hong Fanchi Spring area, considering its unique geographical, ecological, and cultural characteristics.
- To determine the weights of evaluation indicators using the Analytic Hierarchy Process (AHP), establishing a scientifically rigorous hierarchical framework that reflects the relative importance of different landscape factors.
- To evaluate the quality of four distinct cultural landscape types in the study area- Spring Water Cultural Landscape, Planting Cultural Landscape, Village Cultural Landscape, and Religious Cultural Landscape- providing a quantitative assessment of their current condition.

Abbreviation

AHP	Analytic Hierarchy Process
CRITIC	Criteria Importance Through Intercriteria Correlation
CR	Consistency Ratio
CSI	Cultural Landscape Satisfaction Index
SPSS	Statistical Package for the Social Sciences
UNESCO	United Nations Educational, Scientific, and Cultural Organization
ICOMOS	International Council on Monuments and Sites
IFLA	International Federation of Landscape Architects

- To propose targeted protection and management strategies based on the evaluation results, addressing the specific challenges and opportunities identified for each landscape type, and contributing to the sustainable development of rural cultural landscapes in the Hong Fanchi Spring area.

These objectives collectively address the need for systematic evaluation, protection, and management of rural cultural landscapes, which serve as important carriers of local culture and play a vital role in rural governance and endogenous development. Current research on rural cultural landscapes mainly focuses on the following aspects:

- Rural landscape evaluation based on cultural perspectives, including evaluation of rural cultural elements in comprehensive rural evaluation systems or establishment of regional rural cultural landscape evaluation systems [2-4].
- Research based on perception and experience perspectives, studying experiencers' satisfaction with rural landscapes or preferences for cultural landscape elements to explore improvement directions for rural cultural landscapes, or using eye-tracking analysis and other methods to obtain objective visual preferences [5-7].
- Research based on planning and protection perspectives, using theories or models such as "source-aggregation" landscape genes to actively protect rural cultural landscapes through constructing rural cultural landscape spatial patterns, cultural landscape heritage corridors, cultural heritage landscape ecological networks, and other measures [8-11].

From the above, existing research mostly focuses on comprehensive evaluations of cultural landscape resource elements, and the proposed measures are mostly based on macro and meso perspectives, with fewer evaluation studies and improvement measures for specific elements. However, new demands arising from current rural governance urgently require dynamic adjustment of evaluation systems and new rural cultural landscapes.

2. Research materials and methods

2.1 Research area

The case study area is located in Pingyin County, Jinan, China, specifically the Hong Fanchi Spring Group (Figure), one of Jinan's ten major spring groups. This spring group covers a total area of 383.7 km^2, encompassing 6 towns in Pingyin County. The area has a high concentration of spring water outlets, with an annual spring water discharge of approximately 4 million m^3, accounting for about 3/4 of the total spring water in Pingyin County. Unlike other spring groups, the Hong Fanchi Spring Group's surface water and groundwater form an independent system without recharge areas, so its spring water flow is entirely determined by regional water circulation. Additionally, the streams formed by the convergence of spring water have a more stable water environment compared to large rivers. Three areas (A, B, and C) with densely distributed spring water outlets within the spring group were selected for the study (Figure 1).

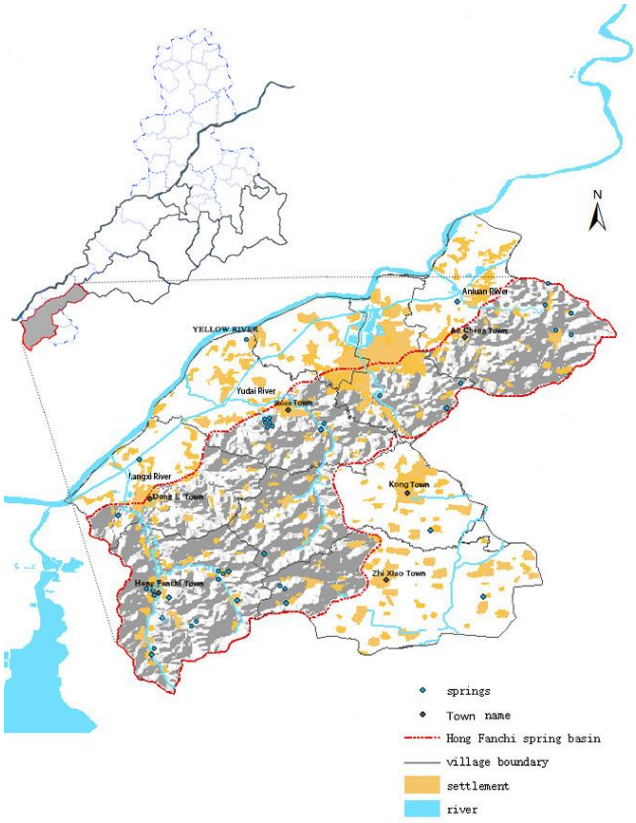

Figure 1. Geographical location and distribution of study areas in Hong Fanchi Spring Group, Pingyin County, Jinan, China

2.2 Data sources

Literature data: Protection regulations, compilation guidelines, and other documents related to landscape protection, traditional village protection, spring water protection, and landscape heritage were categorized and studied to extract relevant considerations and key elements for cultural landscape protection evaluation systems. Additionally, 59 related literature sources (including village landscape protection, rural landscape evaluation, rural cultural landscape evaluation, etc.), including journals and dissertations, were searched as a basis and reference for constructing a cultural landscape protection collaborative development evaluation system.

Interview and questionnaire survey data: Interviews and questionnaire surveys were conducted with experts and residents familiar with the area.

2.3 Methods

2.3.1 Determining evaluation indicators

Through a literature review, common methods for constructing indicator systems were organized and summarized. To ensure the accuracy of the indicator system construction for this research object, the following construction methods and steps were adopted:

(1) Relevant policies, literature materials, and interview data were used as important sources for these indicators. Policy standards include relevant government policies for spring water traditional village protection, construction and development, as well as regulations related to cultural landscape protection and ecological environment protection, which help control the general direction of collaborative evaluation indicators. Literature materials include literature on cultural landscape evaluation system construction, rural landscape evaluation index system construction, and other related topics, and comprehensively and systematically organize and sort out the indicator factors appearing in these literature studies.
(2) Interviews were conducted with cultural landscape managers (6 people), regional economists (2 people), tourism managers (3 people), and village managers (6 people) in the study area (18 people in total). The interview content included the current status of cultural landscape protection management and the value of the Hong Fanchi Spring area. Indicators were extracted and screened from the interview content text.
(3) The Delphi method was used to have experts score the indicators selected in the previous steps, adding weighting to the experts' own subjective influencing factors to make the evaluation system more scientific and reasonable, and finally obtaining the needed indicators.

2.3.2 Constructing the evaluation system

The AHP analysis method was used to determine the weight of indicators and construct the rural cultural landscape evaluation system for the Hong Fanchi Spring Group.

2.3.3 Questionnaire survey and analysis

Questionnaire questions were set based on the indicators, and questionnaire surveys were distributed to collect original data for evaluation results, which were then analyzed using SPSS tools.

3. Results and discussion

3.1 Screening and determining evaluation indicators

First, indicators were screened by analyzing relevant laws and regulations: "Operational Guidelines for the Implementation of the World Heritage Convention," "Rural Landscape Resource Evaluation Standards," "Traditional Village Evaluation and Recognition Index System," "Jinan Spring Water Landscape Selection Rules," "Jinan Spring Water Protection Regulations," "Jinan Spring-City Cultural Landscape Protection Management Measures," "China Historical and Cultural Famous Towns (Villages) Evaluation Index System" (Building Village [2007] 360).

Second, 59 related literature sources (including village landscape protection, rural landscape evaluation, rural cultural landscape evaluation, etc.), including journals and dissertations, were searched. The evaluation system construction content in the above literature was analyzed, and indicator systems similar to this paper's evaluation system were selected for in-depth analysis to build an indicator factor database. Based on the indicator factor database, the specific indicator factors that appeared and their frequencies were counted as important references for indicator factor screening. (Table 1 and Table 2). The frequency analysis of indicator factors from the literature review is presented in Figure 2.
Finally, interviews were conducted with cultural landscape managers (6 people), regional economists (2 people), tourism managers (3 people), and village managers (6 people) in the study area. After completing the collection and organization of the interview texts, professional qualitative data analysis software, Maxqda, was used to systematically code them. Through rigorous coding rules and processes, appropriate codes were assigned to various types of information in the texts, and the statistics function of Maxqda software was used to analyze the frequency of all generated codes, in order to clearly understand the proportion and frequency of various themes, concepts, or phenomena in the interview content, as a reference basis for indicator factor screening. The results of the qualitative analysis of interview data using Maxqda software are visualized in Figure 3, showing the classification and frequency of indicator factors extracted from the interviews."

The preliminary evaluation indicators (Table 2) were organized from related institutional documents, literature, and interview screening factors, and made into a scoring table. The Delphi method was used for the final screening of indicators. The Delphi method is a consulting decision-making technique proposed by the American Rand Corporation in 1964 that can be widely applied in various fields. By objectively aggregating the opinions of multiple experts, it can make probabilistic estimates for a large number of non-technical factors that cannot be quantified. Regional cultural landscape managers (11 people) were invited to complete the scoring. After collecting the data, the mean, standard deviation, coefficient of variation, etc. of the scoring results were calculated, indicators with low importance were eliminated, the coordination coefficient was calculated (Kendall's Wa, test, p=0.000), and inappropriate indicators were modified or deleted. After multiple rounds of scoring until expert opinions were unified, the final indicators were determined [12]. This study used a 5-point Likert scale, with scores of 1-5 representing: not important, not very important, moderately important, quite important, very important.

Finally, 4 indicator classifications B for the Hong Fanchi Spring Domain cultural landscape were obtained: Value, Protection and Management Level, Social Impact, Environmental Impact; and 14 evaluation indicators C: Cultural Value, Historical Value, Economic Value, Social Value, Legal Perfection, Management Degree, Protection Management Effect, Recognition, Participation, Educational Function, Tourism Development, Ecological Environmental Quality, Sustainability, Environmental Aesthetics.

3.2 Establishing the evaluation system

The Analytic Hierarchy Process divides the research problem into goal layer, criterion layer, and structure layer. This study adopts the AHP ladder hierarchical structure model.
Goal layer: A = Hong Fanchi Spring Group Cultural Landscape Comprehensive Evaluation;
Criterion layer: Bn = {Value, Protection and Management Level, Social Impact, Environmental Impact};
Sub-criterion layer: Cn = {C1, C2, C3, ...C14} = {Cultural Value, Historical Value, Economic Value, Social Value, Legal Protection, Protection Degree, Protection Effect, Protection Policy Perfection, Public Recognition, Public Participation, Social Education Impact, Ecological Environment, Sustainability, Environmental Aesthetics};
Plan layer: Dn = {D1, D2, D3, D4} = {Spring Water Cultural Landscape}, {Planting Cultural Landscape}, {Traditional Village Cultural Landscape}, and {Religious Cultural Landscape} (Figure 4).

Table 1. Relevant regulatory documents and their indicator classifications

Name	Related Indicator Classifications	Year	Issuing Unit
Heritage Convention	Skills and human wisdom, historical, cultural, scientific and artistic value, etc.	1972	UNESCO
World Cultural Heritage Protection Management Measures	Historical significance, artistic value, protection status, authenticity and integrity, management and sustainable development	2006	Ministry of Culture and Tourism of the People's Republic of China
Traditional Village Evaluation and Recognition Index System	Three major categories of evaluation indicators: traditional buildings, village site selection and layout, intangible cultural heritage; 20 indicators	2012	Ministry of Housing and Urban-Rural Development of China
Jinan Spring Water Landscape Selection Rules	Historical and cultural nature, landmark nature, publicity, sustainability, appreciation, scientific research, and utilization value	2013	Jinan Spring Water Festival Promotion Committee Office
China Historical and Cultural Famous Towns (Villages) Evaluation Index System	Two major categories of indicators: value characteristics and protection measures, specifically composed of 10 middle categories and 17 small categories of indicators, covering historical longevity, cultural relic value, influence of historical events and famous people, scale of historical buildings, typicality of historical traditional buildings, historical environmental elements, scale of historical streets (waterways), etc.	2017	Ministry of Housing and Urban-Rural Development and National Cultural Heritage Administration
Jinan Spring-City Cultural Landscape Protection Management Measures	Spring water culture, Confucian culture, folk culture, traditional Chinese medicine culture, religious culture, natural ecology, environmental landscape, protection, and utilization	2020	Jinan Municipal Government Departments
Rural Landscape Resource Evaluation Standards (T/CHSLA 50012-2022)	Three major categories of primary indicators: natural landscape resources, cultural landscape resources, agricultural landscape resources; seven categories of secondary indicators: biological landscape, non-biological landscape, overall natural landscape, historical and cultural landscape, rural settlement landscape, agricultural production landscape, agricultural cultural landscape, and 22 specific indicators	2022	Chinese Society of Landscape Architecture

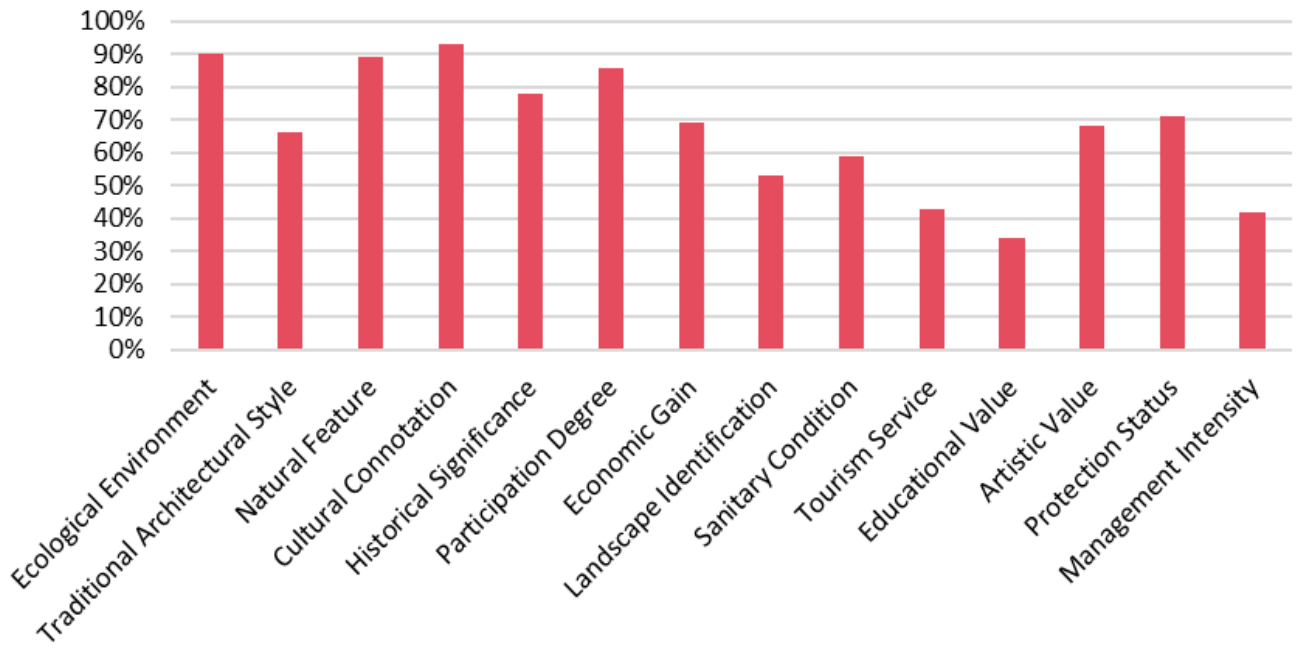

Figure 2. Frequency distribution of evaluation indicators in the reviewed literature

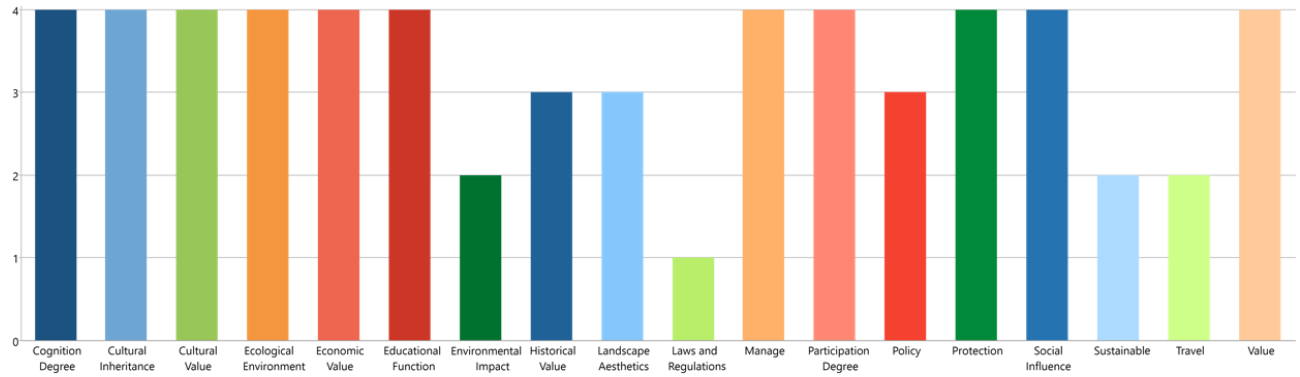

Figure 3. Classification of indicator factors extracted from interview coding analysis

Table 2. Preliminary evaluation indicator system

Target Layer (A)	Criterion Layer (Bn)	Sub-criterion Layer (Cn)	Indicator Nature	Plan Layer (Dn)
Hong Fanchi Spring Landscape Comprehensive Evaluation System A	Value	Cultural Value	Qualitative	
		Historical Value	Qualitative	
		Social Value	Qualitative	Spring Water Cultural Landscape
		Economic Value	Quantitative	
	Protection Management Level	Management Effect	Quantitative	
		Legal Perfection	Quantitative	Planting Cultural Landscape
		Management Degree	Quantitative	
		Protection Funding Investment	Quantitative	
	Social Impact	Landscape Recognition	Quantitative	
		Public Participation	Quantitative	Village Cultural Landscape
		Social Belonging	Qualitative	
		Educational Function	Quantitative	
		Tourism Development	Quantitative	
	Environmental Impact	Landscape Source Configuration	Quantitative	
		Environmental Quality	Quantitative	Religious Cultural Landscape
		Sustainability	Quantitative	
		Aesthetic Effect	Qualitative	

3.3 AHP method weight determination

Eleven regional cultural landscape managers were invited to establish judgment matrices for each layer of indicators in the cultural landscape indicator element assessment and make pairwise comparisons. After passing the consistency test, the subjective weights of each indicator were obtained. The above personnel were then invited again to score the importance of the evaluation indicators, and the CRITIC method was used to obtain the objective weights of each indicator. Finally, the final weights of each indicator were obtained by combining both weights. The specific calculation steps are as follows:

Since the rural cultural landscape evaluation system is determined by multiple factors, with hierarchical relationships and different levels of importance between different factors, the Analytic Hierarchy Process was chosen as an effective method for analyzing the Hong Fanchi Spring Group rural cultural landscape evaluation system. The basic idea of hierarchical analysis is to decompose complex problems into constituent factors and group these factors according to dominant relationships through analysis of the factors and related relationships contained in complex systems, thus objectively forming a multi-level ordered recursive hierarchical structure. The Analytic Hierarchy Process is suitable for the research object of this paper, and through the construction of comparison matrices and weight calculation, the influence of artificial factors is minimized. The Analytic Hierarchy Process was used to determine the indicator weights. The hierarchical model of the Hong Fanchi Spring Group rural cultural landscape was constructed; the Delphi method was used for expert assignment, and the 1-9 scale method (Table 3) was used to construct 2×2 judgment matrices between indicators at each level; eigenvalues for each layer were calculated; weights for factors at each layer were derived; and consistency tests were performed. The consistency ratio index (CR) of the judgment matrix, if CR ≤ 0.1, means the judgment matrix passed the test and achieved satisfactory consistency; otherwise, the matrix needs to be readjusted to pass the test [13].

Table 3. Scale values for the judgment matrix

Quantitative Value	Meaning (Indicator i compared to indicator j)	Quantitative Value	Meaning (Indicator i compared to indicator j)
1	Indicator i and j are equally important	1	Indicator i and j are equally important
3	Indicator i is slightly more important than j	1/3	Indicator i is slightly less important than j
5	Indicator i is clearly more important than j	1/5	Indicator i is clearly less important than j
7	Indicator i is much more important than j	1/7	Indicator i is much less important than j
9	Indicator i is absolutely more important than j	1/8	Indicator i is absolutely less important than j
2, 4, 6, 8 (1/2, 1/4, 1/6, 1/8)	Intermediate values between adjacent levels		

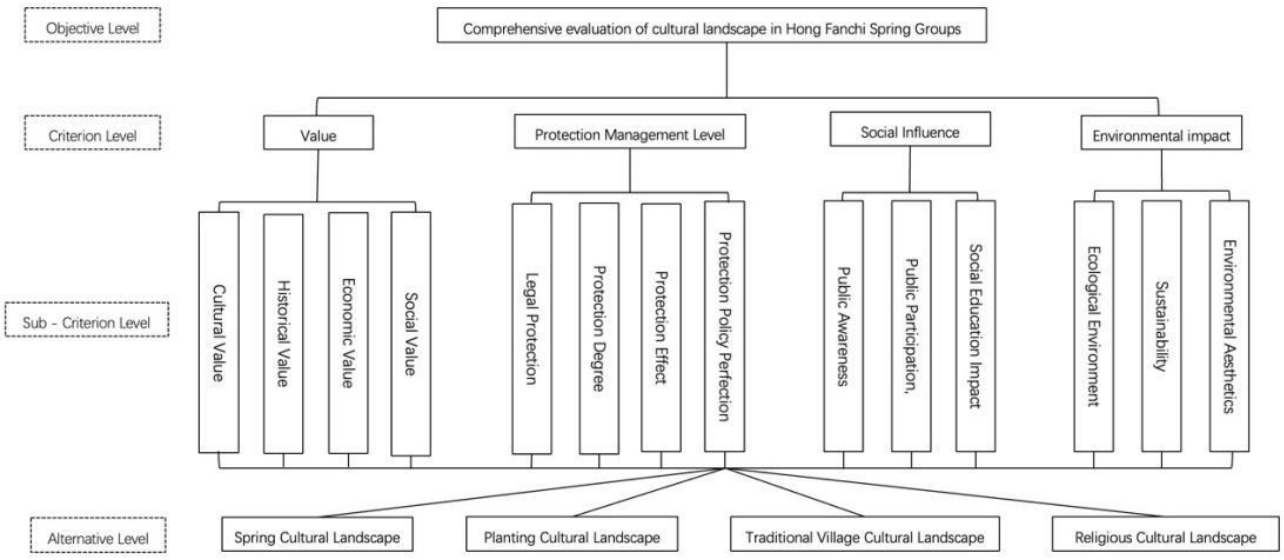

Figure 4. Hierarchical structure model of the Hong Fanchi Spring Group cultural landscape evaluation system

Fuzzy mathematics was used to evaluate scores. Through field research, expert opinion reference, and resident interview surveys, fuzzy mathematics was used to score qualitative indicators as excellent, good, medium, poor, and very poor, represented as 5, 4, 3, 2, 1, respectively. For quantifiable indicators, the data normalization method was used, and ultimately, the weights of each indicator were derived (Table 4).

Table 4. Weights of evaluation indicators

Goal Layer	Criterion Layer	Weight	Indicator Layer	Weight
Hong Fanchi Spring Group Cultural Landscape Comprehensive Evaluation	Value	30.88%	C1 Cultural Value	30.61%
			C2 Historical Value	28.28%
			C3 Economic Value	19.90%
			C4 Social Value	21.20%
	Protection and Management Level	24.48%	C5 Legal Protection	28.94%
			C6 Protection Degree	28.45%
			C7 Protection Effect	21.20%
			C8 Protection Policy Perfection	21.41%
	Social Impact	23.24%	C9 Public Recognition	35.81%
			C10 Public Participation	37.40%
			C11 Social Education Impact	26.80%
	Environmental Impact	21.40%	C12 Ecological Environment	42.84%
			C13 Sustainability	32.66%
			C14 Environmental Aesthetics	24.50%

3.4 Comprehensive evaluation results

Questionnaires were designed based on the indicators, and surveys were conducted in 6 villages and towns within the Hong Fanchi Spring area. As shown in Table 5, population size factors of each village and town were fully considered to ensure a relatively balanced number of participants from each village and town, maximizing the reduction of sample bias caused by population differences, thereby ensuring the scientific and reasonable nature of the research data.

Table 5. Questionnaire reliability and validity analysis

Reliability Analysis			
Cronbach's α coefficient	Standardized Cronbach's α coefficient	Variables	Sample size
0.865	0.866	63	400
KMO and Bartlett's Test			
KMO Measure of Sampling Adequacy	0.965		
Bartlett's Test of Sphericity	Approx. Chi-Square	19150.018	
	df	1953	
	p	0.000[a]	
Note: [a] significant at the 0.1% level (p < 0.001)			

Four hundred questionnaires were distributed, 389 were recovered, and after questionnaire validity testing and reliability analysis, the questionnaire data were good. The reliability and validity analysis of the questionnaire survey is presented in Table 6, confirming the quality of the collected data. After summarizing and organizing the questionnaire data, it was imported into SPSS 27.0 software, and the evaluation scores for the Hong Fanchi Spring Group cultural landscape were calculated according to the calculation process listed above. The calculation process is as follows:

First, the evaluation score for each tertiary indicator needs to be obtained through the mean of that indicator's score, and the overall evaluation score is the sum of the evaluation scores of each tertiary indicator multiplied by its weight, as per the following formula:

$$CSI_1 = \sum_{i=1}^{n} w_{ij} r_i \quad (1)$$

CSI1 represents the overall evaluation value of the Hong Fanchi Spring Group cultural landscape, wij represents the average score of the jth indicator of the ith type of cultural landscape, ri represents the average score of the ith indicator, and n represents the number of indicators.

Next, the calculation method for secondary indicator evaluation scores: The weight of each tertiary indicator under each secondary indicator is divided by the total weight of tertiary indicators in that dimension, then multiplied by the mean corresponding to each tertiary indicator, and finally the values obtained for each dimension are summed, as per the following formula:

$$CSI_2 = \sum_{i=1}^{n} \frac{w_i r_i}{\sum_{i=1}^{n} w_i} \quad (2)$$

CSI2 represents the evaluation score of each secondary indicator, wi represents the weight of the ith indicator, ri represents the average score of the ith indicator, and n represents the number of indicators.

Table 6 presents the evaluation indices for each cultural landscape type, providing a comprehensive comparison of their performance across all evaluation indicators. The evaluation indices for each indicator were obtained and ranked according to the size of the index. The comprehensive

evaluation results for all four cultural landscape types are summarized in Table 7, which shows their overall evaluation values and rankings.

According to the content shown in Table 7, the overall evaluation value of the Hong Fanchi Spring Domain cultural landscape is 2.77. Based on the evaluation standards defined earlier, its overall evaluation is below the average level, which is not ideal. This indicates that currently, surveyors' satisfaction with the local cultural landscape is relatively low, and there is still a certain gap between the overall situation of the regional cultural landscape and expectations.

Table 6. Evaluation indices for each cultural landscape type

	Spring Water Cultural Landscape	Planting Cultural Landscape	Village Cultural Landscape	Religious Cultural Landscape
B1	0.8118	0.8317	0.8147	0.8150
C1	0.7966	0.8288	0.8127	0.8012
C2	0.7445	0.7558	0.7487	0.7424
C3	0.5154	0.5353	0.5219	0.5264
C4	0.5724	0.5735	0.5549	0.5692
B2	0.6805	0.6858	0.6801	0.6831
C5	0.7901	0.8016	0.8147	0.8024
C6	0.7973	0.8101	0.7689	0.8030
C7	0.5936	0.5963	0.5867	0.5899
C8	0.5989	0.5936	0.6080	0.5952
B3	0.6151	0.6451	0.6685	0.6292
C9	0.9203	1.0134	1.1629	0.9588
C10	1.0201	1.0650	1.0107	1.0369
C11	0.7062	0.6975	0.7028	0.7115
B4	0.6386	0.6416	0.6350	0.645
C12	1.4608	1.4844	1.4651	1.4694
C13	0.8745	0.8475	0.8491	0.8802
C14	0.6486	0.6664	0.6529	0.6627

Table 7. Overall evaluation values and rankings of cultural landscape types in Hong Fanchi Spring Domain

Type	Comprehensive Evaluation Value	Ranking
Spring Water Cultural Landscape	2.75	4
Planting Cultural Landscape	2.79	2
Village Cultural Landscape	2.80	1
Religious Cultural Landscape	2.77	3

According to the comprehensive evaluation results of the Hong Fanchi Spring Domain cultural landscape, the performance of various types of cultural landscapes is as follows:

Village cultural landscape received the highest comprehensive evaluation value (2.80), ranking first among all categories, indicating that village cultural landscape performs particularly well in cultural value, historical value, social participation, and environmental impact aspects, especially in the recognition indicator (C9) of social impact where it scored significantly high (1.1629). Additionally, it also performed well in educational function and participation aspects, showing the positive role of this type of landscape in local residents' cultural identity and social cohesion.

Planting a cultural landscape follows closely with a comprehensive evaluation value of 2.79, ranking second. Planting a cultural landscape performs excellently in cultural value and historical value (0.8288 and 0.8016, respectively), demonstrating its high cultural connotation and historical significance. At the same time, it also has certain advantages in tourism development (C11) and ecological environmental quality, possessing strong dual functions of ecology and economy.

Religious cultural landscape has a comprehensive evaluation of 2.77, ranking third, with an overall evaluation slightly lower than village and planting cultural landscapes, but scoring high in economic value (C10) (1.0369), highlighting the potential of religious cultural landscape in economic development. It also has a strong appeal in the social impact aspect, with a high educational function and cultural dissemination power. The Spring Water cultural landscape has a comprehensive evaluation of 2.75, ranking fourth. Although its overall performance is relatively low, it still performs well in the environmental aesthetics (C14) indicator (0.6486), indicating high visual aesthetics and environmental quality. Additionally, it also has a certain foundation in ecological sustainability and natural protection, serving as an important carrier for eco-tourism and natural education. In summary, in the Hong Fanchi Spring Domain cultural landscape, the village and planting landscapes stand out in overall performance. It is recommended to prioritize these two types of landscapes in future protection and development processes to achieve the dual goals of cultural protection and regional sustainable development. At the same time, attention should be paid to the economic potential and environmental aesthetic value of religious and spring water cultural landscapes to enhance the balance and comprehensiveness of overall regional development.

4. Conclusion

Starting from the purpose of improving rural cultural landscape protection and management, this study takes the Jinan Hong Fanchi Spring Group as the research object, collects rural cultural landscape evaluation indicators, uses the AHP method to determine indicator weights, and classifies and grades four types of cultural landscape elements for evaluation. The evaluation results prove that there is great room for future improvement and development of the Jinan Hong Fanchi Spring Group rural cultural landscape, and management and protection need to be strengthened. Based on the analysis results, corresponding protection management strategy recommendations are proposed:

(1) Classified implementation, highlighting priorities: According to the comprehensive evaluation results, priority should be given to protecting the village and planting cultural landscapes, developing differentiated protection measures, and strengthening the display and inheritance of their cultural and historical values. Specific measures include establishing cultural exhibition centers, traditional skills inheritance bases, as well as compiling village cultural directories and agricultural cultural heritage archives.

(2) Strengthening community participation and recognition: Enhance public recognition and participation in cultural landscapes, encourage local communities to actively participate in management and protection. Various forms of mass cultural activities, such as cultural landscape lectures,

study tours, and local festival activities, should be conducted to enhance the public's sense of belonging and responsibility for local culture.

(3) Improving legal and management systems: Regarding management level and legal perfection (such as C5, C6), it is recommended to improve relevant laws and regulations and enhance the professionalism and execution of protected area management institutions. Local legislation should be promoted to incorporate cultural landscape protection into urban and rural development planning, and establish sound protection assessment and supervision mechanisms.

(4) Promoting the integration of culture and economic development: Utilize the economic value potential of religious cultural landscapes to develop related cultural tourism products and activities, promote cultural industry development, and achieve win-win results for cultural protection and economic growth. Examples include developing religious cultural tourism routes, building cultural creative product centers, and guiding the integration of intangible cultural heritage crafts with religious culture.

(5) Strengthening environmental management and aesthetic protection: Based on the environmental aesthetic advantages of spring water cultural landscapes, strengthen ecological environmental governance and aesthetic maintenance, and promote the organic integration of ecology and culture. Spring water ecological protection zones should be established, and ecological restoration projects should be combined with aesthetic landscape design to enhance the overall viewing experience.

(6) Promoting sustainable development: Strengthen the sustainable management of landscape resources, combined with ecological environmental quality and sustainability (such as C12, C13), and promote green and low-carbon development paths. Landscape ecological monitoring systems should be established, green technologies and materials should be promoted, and sustainable tourism and community low-carbon lifestyles should be guided.

Ethical issue

The authors are aware of and comply with best practices in publication ethics, specifically with regard to authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests, and compliance with policies on research ethics. The authors adhere to publication requirements that the submitted work is original and has not been published elsewhere.

Data availability statement

Datasets analyzed during the current study are available and can be provided upon a reasonable request from the corresponding author.

Conflict of interest

The authors declare no potential conflict of interest.

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