

Research Article

Ecological Integrity Evaluation of Organically Evolved Cultural Landscape

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Received 10 June 2022; Revised 27 June 2022; Accepted 18 August 2022; Published 5 September 2022

Academic Editor: Jiafu Su

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When the traditional method is used to evaluate the cultural landscape as a whole, due to the lack of historical and cultural factors, the impact of the ecological environment on the landscape change is not considered. Therefore, it cannot objectively reflect the law of landscape change. Therefore, from the perspective of the combination of cultural landscape composition characteristics and cultural ecological characteristics, this paper puts forward the concept of cultural ecological integrity based on the existing concept of cultural heritage integrity, aiming at the organic evolution of cultural landscape in cultural landscape heritage, and expounded the dynamic sustainability and effectiveness of natural environment and social environment on the process of cultural landscape. Considering the relevant characteristics and different forms of cultural landscape and cultural ecological integrity, according to the concept of cultural ecological integrity, this paper gave the principles and standards of cultural landscape ecological integrity evaluation and put forward the evaluation method of cultural ecological integrity. At the same time, each index in the ecological integrity evaluation model was decomposed and explained. Finally, taking the cultural heritage of Long-men Grottoes as an example, the paper used the cultural and ecological integrity evaluation model proposed in this paper to evaluate the material cultural landscape, intangible cultural landscape, and local traditional dwellings of Long-men Grottoes and made a comparative analysis between the control group and the observation group. The results showed that the cultural landscape ecological integrity evaluation model proposed in this paper can not only objectively evaluate the cultural landscape but also provide a certain theoretical and practical reference for the effective classification, protection and sustainable development, and utilization of the subsequent cultural landscape.

1. Introduction

Cultural landscape usually has the characteristics that nature and culture complement each other, and material and spirit promote each other. It is known from the existing research that the organically evolved cultural landscape comes from the basic needs of society, economy, administration and religion [1]. The research shows that due to the mutual integration and adaptation of landscape and natural environment, various existing cultural landscapes have been formed. For the dynamic cultural landscape existing in the region or widely distributed, for example, the type of cultural landscape with organic evolution, its value lies in the sustainability of the landscape [2]. It has always maintained a positive social role in today's natural and social environment

related to tradition, and is the material evidence of its historical evolution and development.

The cultural ecological integrity of cultural landscape is a reference system and classification reference standard for the evaluation and protection of cultural landscape based on the registration standard of cultural landscape heritage and the evaluation of world cultural heritage issued by the World Heritage Committee (WHC) from the basic standpoint of cultural ecology [3]. In view of the complexity of cultural landscape, cultural ecological integrity effectively considers the natural environment, cultural environment and cultural landscape architecture, which can provide a more comprehensive and dynamic unique perspective for the protection and evaluation of world cultural landscape.

The 2005 edition of the operational guidelines for the implementation of the convention for the protection of the world cultural and natural heritage (hereinafter referred to as the operational guidelines) clearly points out that the authenticity and integrity of the landscape has become an organic part of the outstanding universal value of the world heritage [4, 5]. The analysis of the integrity assessment of relevant cultural landscape heritage shows that people's classification and analysis of the integrity of general cultural heritage can be applied to cultural landscape [6]. However, for the dynamic cultural landscape existing in the region or widely distributed, for example, for the type of cultural landscape with organic evolution, its integrity is more important. Because the existing landscape integrity evaluation is not comprehensive or targeted, this paper proposed to establish a cultural ecological integrity evaluation system of cultural landscape on the basis of ensuring the authenticity of cultural landscape from the perspective of cultural ecology.

2. Related Concepts of Cultural Ecological Integrity of Cultural Landscape

2.1. Characteristics of Cultural Ecological Integrity. The research shows that the cultural ecological integrity of cultural landscape is a landscape attribute formed through continuous evolution and continuation on the basis of the existing operation guidelines on integrity [7]. It reflects the dynamic sustainability and effectiveness of the natural and social environment on the evolution of cultural landscape. Since 1992, experts in cultural landscape and architecture related fields have begun to pay attention to the integrity, emphasizing the integrity, paying attention to the integrity of function, structure and vision, and paying attention to the current situation of static cultural landscape [8, 9]. Therefore, the cultural ecological integrity of cultural landscape should have the following characteristics:

- (1) Cultural ecological integrity belongs to the cultural landscape of organic evolution: the organic evolution process of cultural landscape is generally closely related to traditional living habits, and is constantly changing with the changes of modern society. Among many cultural landscapes, some cultural landscapes with relevance are called composite landscapes. Their cultural meaning is determined by the relationship between natural factors and human religion, art, history and culture. Most of these complex landscapes are natural scenic spots protected by human beings, such as scenic spots and religious shrines, which have certain characteristics of ecological integrity.
- (2) The cultural ecological integrity of cultural landscape has a certain linear change law of cultural landscape: International Society for Landscape Ecology (ISLE) and American National Geographic Society (ANGS) have conducted in-depth research on cultural landscape on the basis of landscape natural ecology, emphasizing the necessity of integrating cultural landscape and cultural ecology [10]. Some scholars put forward the theory of

cultural continuity from the perspective of anthropology and sociology, holding that different cultures have certain continuity in their own development process. Landscape culture itself has more social culture. It not only involves social ethics, religion, customs and other concepts, but also contains a lot of artistic and cultural content [11, 12]. Therefore, with the continuous change of cultural landscape and environmental conditions, the cultural ecological integrity of cultural landscape can make the landscape culture show a certain linear change law.

- (3) Cultural landscape has certain communication, and the landscape culture of the same culture has regional differences: From the perspective of the development of cultural ecology, cultural ecology mainly studies the interaction and correlation between natural geographical environment and human culture. Cultural ecosystem is a complex of nature, culture and economy [13]. Due to the interaction between culture and ecological environment, within a certain regional scope, the complex natural and social environment usually makes the development of different landscape cultures present a certain diversity, and thus forms regional differences.

As shown in Figure 1, it is the schematic diagram of the discipline relationship of cultural landscape.

2.2. Main Manifestations of Cultural Ecological Integrity. From the perspective of integrity operation guide, the ecological integrity of organic evolutionary cultural landscape is mainly reflected in the following four points:

- (1) Cultural landscape can adapt to the existence of integrity and constantly evolve with the changes of natural or social environment.
- (2) Cultural landscape can provide a certain use function and social value for related fields, can coexist harmoniously with today's social environment and natural environment, and has a certain cultural value.
- (3) In the historical process of the coexistence of single or multiple cultural landscapes of the same type, the changes and development of cultural landscapes can be effectively observed and identified. For example, various forms of relevant historical data can be used for recording and archiving.
- (4) For the cultural heritage to which the cultural landscape belongs, various forms and styles of cultural landscapes that meet the above three characteristics and have the same subordinate cultural types can coexist, thus forming a relatively clear geographical space and reflecting a representative cultural transmission path.

As shown in Figure 2, it is the basic composition of cultural landscape.

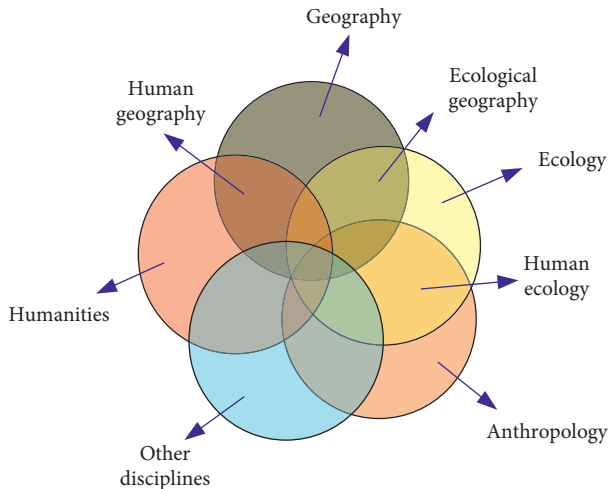


FIGURE 1: Schematic diagram of discipline relationship of cultural landscape.

2.3. *Research Value of Cultural Ecological Integrity.* According to the landscape integrity theory put forward by predecessors, through the improvement of the concept of cultural landscape, it is known that the current cultural landscape is still related to history in terms of function and survival characteristics. At present, the integrity of cultural landscape seen from the visual point of view is only a result and fragment of the historical process. Therefore, in order to accurately understand the changes and authenticity of the heritage, it is crucial to analyze the authenticity of its function and historical structure [14].

Cultural landscape cultural ecological integrity has the significance of single and overall layout in terms of landscape scale and spatial characteristics. The cultural ecological integrity of cultural landscape mainly emphasizes the dynamic change process of the form, field environment and function, land use, life and spiritual belief of cultural landscape. The significance of studying cultural landscape ecological integrity from the perspective of cultural ecology is to fully reflect the social and historical value of cultural landscape integrity [15]. The cultural landscape with good cultural ecological integrity can provide more complete social exchange information for people in the historical process. From the utilization of natural resources to the progress of architectural technology, from the migration of cultural communicators and the spread of culture to the changes of society and the persistence of cultural beliefs are important historical materials.

3. Study on Cultural Ecological Integrity Evaluation of Cultural Landscape

3.1. *Standards to be Followed for Cultural Ecological Integrity Evaluation.* Cultural ecological integrity based on cultural landscape is a concept put forward from the perspective of cultural ecology, which can reflect the ecological characteristics of cultural landscape. Therefore, according to the integrity of traditional cultural landscape heritage and

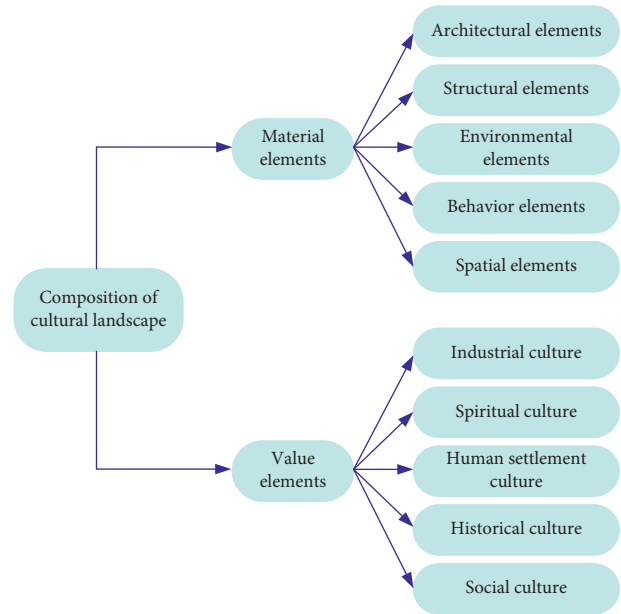


FIGURE 2: Basic composition of cultural landscape.

modern cultural ecology, the evaluation criteria of modern cultural ecological integrity can be obtained, as shown in Table 1.

According to the evaluation requirements in Table 1, after a certain historical period, the traditional cultural landscape heritage evaluation mainly focuses on the evaluation criteria of relative static and existing status. On this basis, a new evaluation standard can be formed from the perspective of modern cultural ecology, that is, pay more attention to the relationship between modern culture, landscape and architecture in the evaluation process. For example, landscape culture plays an important role in modern cultural ecology [16]. Therefore, from the perspective of traditional cultural landscape and modern cultural ecology, we can put forward the ecological evaluation standards of cultural landscape.

- (1) Reference of evaluation criteria: due to the lack of research on the existing evaluation methods or systems for the ecological integrity of cultural landscapes at home and abroad, on the basis of the existing concept of cultural heritage integrity, we can refer to the existing evaluation systems for the integrity and authenticity of cultural landscapes, which mainly include empirical evaluation, single factor evaluation and comprehensive factor grading and quantification from the theoretical basis and technical means. Then, combined with the existing views and research methods of cultural ecology, further improve the evaluation criteria of cultural landscape ecological integrity.
- (2) The scientificity of the evaluation criteria: in the process of evaluating the ecological integrity of cultural landscape, the established evaluation index system should not only fully reflect the internal mechanism of the ecological integrity of

TABLE 1: Integration of traditional cultural landscape integrity and modern cultural ecology.

Integrity of traditional cultural landscape heritage	Evaluation concept of modern cultural ecology
Landscape elements and their composition	Integration of modern culture and ecosystem
Landscape material and technology	Dynamic regulation of constituent elements
Traditional cultural landscape and its heritage	Tolerance of modern culture
Complementarity of traditional cultural heritage	Stratification of modern cultural system

the research object, but also systematically describe the connotation and target expectation of the evaluation object and its resources on the basis of relevant cultural landscape system theories.

- (3) The dominance of evaluation indicators: the selected evaluation indicators should be representative and typical. When designing the cultural landscape integrity evaluation system, we should not only carefully screen and demonstrate the relevant indicators, but also reflect the importance of different indicators through weighted processing. In addition, the structure of the evaluation index system should be clear and concise.
- (4) Guidance of evaluation criteria: the purpose of evaluating the ecological integrity of cultural landscape is to better protect the existing cultural landscape and achieve its sustainable development. Therefore, the establishment of corresponding index points in the evaluation index system can not only provide guidance for the relevant government departments to manage cultural landscape, but also provide scientific reference for the protection, development and utilization of cultural landscape resources.

3.2. Main Methods of Cultural Ecological Integrity Evaluation. The main methods of cultural ecological integrity evaluation include the comprehensive analysis method of qualitative and quantitative treatment for multifactor, multilevel and multi-index problems [17]. In order to make the cultural landscape ecological integrity evaluation model accurately and objectively reflect the evolution law of landscape objects, this paper fully draws on the experience of domestic and foreign scholars in the integrity and authenticity evaluation of cultural landscape heritage, and the proposed landscape evaluation method can not only describe the evolution characteristics of cultural landscape, but also reflect the value of cultural landscape. At the same time, based on the existing evaluation methods of predecessors, the evaluation system of cultural landscape and cultural ecological integrity is established by using sampling survey method, fuzzy evaluation method, principal component analysis method and analytic hierarchy process [18]. As shown in Figure 3, it is a schematic diagram of the research process of cultural landscape ecological integrity.

3.3. Construction of Cultural Ecological Integrity Evaluation Index System. When constructing the evaluation index system of cultural ecological integrity, this paper mainly analyzes the structure and constituent factors of cultural landscape according to the existing cultural ecological integrity standards of cultural landscape and the requirements of future protection and sustainable development, so as to make it related to the cultural ecology of cultural landscape [19]. In this paper, analytic hierarchy process (AHP) is mainly used to construct the evaluation index system of cultural ecological integrity, as shown in Figure 4.

In the cultural ecological integrity evaluation index system, the determination of each index weight is mainly based on analytic hierarchy process, including the construction of hierarchical structure model and the establishment of pairwise comparison matrix [20]. Using the paired comparison method, the paired comparison matrix is established from 1 to 9 comparison scales to the lowest level. The meaning of pairwise comparison matrix is shown in Table 2.

For the calculation of the weight vector, if the maximum eigenvalue of matrix A is λ_{\max} , the corresponding eigenvector is $w = (w_1 \ w_2 \ \dots \ w_n)^T$, then $a_{ij} = (w_i/w_j)$, where $i, j = 1, 2, \dots, n$, as follows

$$A = \begin{bmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \dots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & \frac{w_2}{w_2} & & \frac{w_2}{w_n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \dots & \frac{w_n}{w_n} \end{bmatrix}. \quad (1)$$

For consistency inspection, calculate the consistency index CI first, shown as follows:

$$CI = \frac{\lambda_{\max} - n}{n - 1}. \quad (2)$$

Then, the average random consistency index RI is searched correspondingly. For $n = 1, 2, \dots, 9$, the consistency ratio CR can be calculated by the ratio of CI to RI . When $CR < 0.1$, it is considered that the consistency of the judgment matrix is acceptable, otherwise the judgment matrix should be properly modified. As shown in Table 3, it is the average random consistency index RI value.

Finally, calculate the combination weight vector and check the consistency of the combination results, as shown in Table 4.

The combination consistency test is similar to the above method, and the calculation formula is

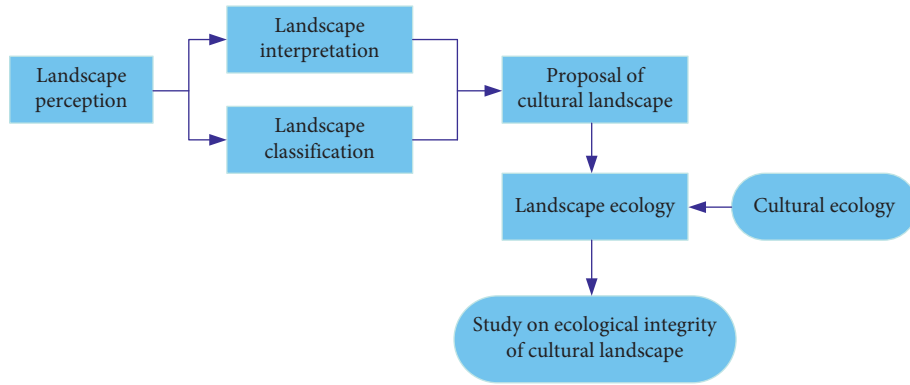


FIGURE 3: Schematic diagram of cultural landscape ecological integrity research process.

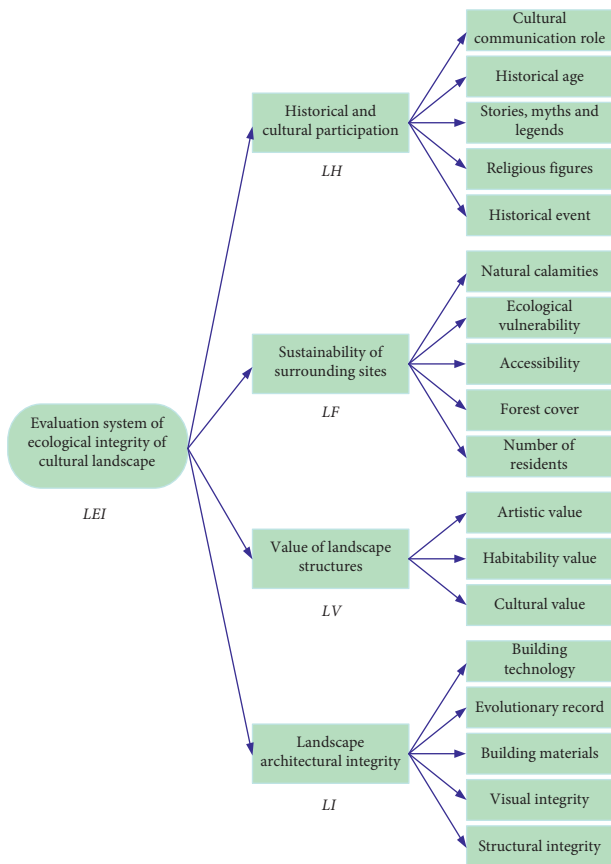


FIGURE 4: Evaluation index system of ecological integrity of cultural landscape.

$$b_i = \sum_{j=1}^m b_{ij} a_j, \quad i = 1, 2, \dots, n, \quad (3)$$

$$CR = \frac{\sum_{j=1}^m CI(j) a_j}{\sum_{j=1}^m RI(j) a_j}$$

When $CR < 0.1$, it is considered that the consistency of the judgment matrix is acceptable; otherwise, the judgment matrix should be properly modified.

4. Cultural Ecological Integrity Evaluation Model and Index Description

In the target layer of the evaluation index system, it mainly reflects the comprehensive index of cultural landscape ecological integrity evaluation by integrating different evaluation factors, which is expressed by the comprehensive index A of cultural landscape ecological integrity, and its evaluation index is expressed by LEI . It consists of four indicators, among which, the landscape history and cultural participation are represented by B_1 , the indicator is named LH , the sustainability of surrounding sites is represented by B_2 , the indicator is named LF , the landscape structure value is represented by B_3 , the indicator is named LV , and the landscape architectural integrity is represented by B_4 , the indicator is named LI . For the cultural ecological integrity evaluation of cultural landscape, descriptive indicators and evaluation indicators are selected to reflect the ecological integrity of the landscape in time and space respectively.

The ratio of standard layer and factor layer represents the evaluation weight of each index, which is marked as p_i^h , p_i^f , p_i^v and p_i^i respectively. The standard value can be comprehensively determined and recorded as f according to the evaluation and scoring of experts in relevant research and cultural landscape related fields [21, 22]. Each index evaluation model of the ecological integrity evaluation standard layer can be expressed as follows:

$$LH = \sum_{i=1}^5 p_i^h f_i^h \sum_{i=1}^5 p_i^h = 1,$$

$$LF = \sum_{i=1}^5 p_i^f f_i^f \sum_{i=1}^5 p_i^f = 1, \quad (4)$$

$$LV = \sum_{i=1}^3 p_i^v f_i^v \sum_{i=1}^3 p_i^v = 1,$$

$$LI = \sum_{i=1}^5 p_i^i f_i^i \sum_{i=1}^5 p_i^i = 1.$$

Using the participation of landscape culture, regional sustainability, and the integrity of landscape architecture structure and value, we can build a comprehensive evaluation system of cultural ecological integrity of cultural

TABLE 2: Significance of pairwise comparison matrix.

Scale	Meaning
1	When the two factors are compared, they are of the same importance
3	When two factors are compared, the former is slightly more important than the latter
5	When two factors are compared, the former is obviously more important than the latter
7	When two factors are compared, the former is more important than the latter
9	When two factors are compared, the former is much more important than the latter
2, 4, 6, 8	Represents the intermediate value of the above judgment

TABLE 3: Average random consistency index value.

n	1	2	act	4	5	6	7	8	9	10	11	12
RI	0	0	0.51	0.87	1.14	1.26	1.33	1.42	1.47	1.48	1.53	1.56

TABLE 4: Calculation of combined weight vector.

A	A_1	A_2	...	A_m	Total sorting weight of layer B
B	B_1	B_2	...	B_m	
B_1	b_{11}	b_{12}	...	b_{1m}	$\sum_{j=1}^m b_{1j}a_j$
B_2	b_{21}	b_{22}	...	b_{2m}	$\sum_{j=1}^m b_{2j}a_j$
...
B_n	b_{n1}	b_{n2}	...	b_{nm}	$\sum_{j=1}^m b_{nj}a_j$

TABLE 5: Detailed rules for the evaluation of cultural ecological integrity from the perspective of historical and cultural participation.

Evaluation criteria	Evaluation factor	Evaluation weight (p_i^h)	Description of evaluation indicators (f_i^h)
Historical and cultural participation (B_1)	Cultural communication role	0.30	Assign values according to the level of cultural transmission, and refer to the size of cultural radiation area
	Historical age	0.18	The buildings of different ages are divided into five categories, including contemporary buildings, modern buildings, near ancient buildings, middle ancient buildings and ancient buildings
	Stories, myths and legends	0.13	Determined according to the size and amount of landscape influence
	Religious figures	0.18	Determined according to the size and amount of landscape influence
	Historical event	0.21	Determined according to the size and amount of landscape influence

landscape. Through the organic integration of the above four landscape cultural attributes, the comprehensive evaluation of cultural ecological integrity can be realized. Because these cultural attributes are independent of each other and have the same status for the comprehensive evaluation of cultural ecological integrity, the weights of these four factors are equal [23]. The relationship between the comprehensive evaluation index of cultural landscape ecological integrity and each evaluation index can be expressed as follows:

$$LEI = \sqrt[4]{LH * LF * LV * LI}. \quad (5)$$

In each index classification of the evaluation index system, landscape architecture, ecological environment, and cultural environment are the three subsystems of

cultural landscape, which integrate the dynamic and open ideas of cultural landscape. In the cultural landscape ecological integrity evaluation system, the standard layer B_1 means to evaluate the historical and cultural participation, so as to dynamically describe the integrity of the cultural environment from the time dimension, as shown in Table 5.

After experts in the field of urban and rural planning and landscape ecology assess the ecological integrity of cultural landscape, the average value of relevant indicators of urban and rural planning and landscape design is determined [24]. The research goal of this paper is to evaluate the cultural ecological integrity on the basis of analyzing the organic evolutionary characteristics of cultural ecological integrity. Therefore, this paper mainly establishes the cultural ecological

TABLE 6: Evaluation rules of cultural ecological integrity from the perspective of space opening.

Evaluation criteria	Evaluation factor	Evaluation weight (p_i^f)	Description of evaluation indicators (f_i^f)
Sustainability of surrounding sites (B_2)	Natural calamities	0.18	Taking the occurrence frequency of earthquakes with magnitude greater than 4 as the characteristic of dominant disasters, the lower the frequency, the higher the corresponding index value. Similar evaluation methods shall be adopted for other related natural disasters
	Ecological vulnerability	0.15	The ecological stability of cultural landscape is evaluated from the five ecosystems of cold and drought, grassland, agriculture and animal husbandry, farming and forest, so as to ensure the ecological integrity of the whole cultural landscape
	Accessibility	0.38	The evaluation standard of accessibility index is mainly based on the sustainable impact of traffic on cultural landscape, taking it as a reference, taking advanced modern traffic as the highest level, simple modern traffic as the second level, human and animal power buffer as the third level, and human and animal power as the fourth level directly
	Forest cover	0.1	Based on forest coverage
	Number of residents	0.19	Determined according to the size and amount of landscape influence

TABLE 7: Evaluation rules of cultural ecological integrity from the perspective of landscape structure and cultural value.

Evaluation criteria	Evaluation factor	Evaluation weight (p_i^v)	Description of evaluation indicators (f_i^v)
Value of landscape structures (B_3)	Artistic value	0.3	Evaluation and assignment by relevant experts from the qualitative aspect
	Habitability value	0.24	Evaluate the residential function from the perspectives of heating, heat preservation, storage, and sanitation
	Cultural value	0.46	Evaluation and assignment by relevant experts from the qualitative aspect

TABLE 8: Evaluation rules of cultural ecological integrity from the perspective of landscape structure itself.

Evaluation criteria	Evaluation factor	Evaluation weight (p_i^i)	Description of evaluation indicators (f_i^i)
Landscape architectural integrity (B_4)	Building technology	0.16	Qualitative rating shall be carried out according to the content of traditional building technology used in cultural landscape from high to low
	Evolutionary record	0.24	The grading evaluation shall be conducted according to whether there are site selection literature records, landscape construction process records, repair records, destruction records and the number of recorded items
	Building materials	0.16	The landscape structure materials are evaluated according to the sensitivity. The stone has the lowest sensitivity, the highest relative integrity, the soil is in the middle, the wood is the lowest, and the stone soil mixture and stone wood mixture take the middle value in turn
	Visual integrity	0.24	Rating based on visual effects of existing landscape structures
	Structural integrity	0.2	The evaluation shall be conducted according to the following conditions: no major renovation, multiple improvements, complete reconstruction, remains of the site and the site of the site

integrity evaluation system from the perspective of cultural ecology, without involving the specific index weight value.

B_2 is mainly used to evaluate the ecological environment integrity of spatial open regulation, as shown in Table 6. It can describe the spatial open regulation of ecological environment integrity from five aspects, namely accessibility,

number of residents, ecological vulnerability, forest coverage, and natural disasters.

B_3 is mainly used to evaluate the integrity of landscape structure and cultural value, as shown in Table 7. Among them, functionality refers to the functional value of human settlements, which mainly evaluates the ecological integrity

TABLE 9: Index classification and comprehensive evaluation standard of cultural ecological integrity.

Integrity grading assignment HL	Incomplete	Inferior	Secondary	Superior	Advanced
Assignment	1	3	5	7	9
Grading standard	[1, 2]	(2, 4]	(4, 6]	(6, 8]	(8, 9]
f_1^h	Contemporary	Modern	Paleozoic	Medieval	Ancient
f_2^h	No	Few	Some	Multi	Several important
f_3^h	Pure	Individual	General	Important	Important nodes
f_4^h	No	Small	Many	Wide	Wide and numerous
f_5^h	No	Few	Some	Important	Many and influential
f_1^f	Inaccessible	Direct entry	Buffer entry	Simple	Advanced
f_2^f	<10	10~100	100~1000	1000~5000	>5000
f_3^f	Cold arid	Grassland	Husbandry	Farming	Forest
f_4^f	<0.1	0.1-0.2	0.2-0.4	0.4-0.6	>0.6
f_5^f	Frequently	Multiple	Episodic	Less	No record
f_1^v	No	Unsuitable	Poor suitability	Basically suitable	Suitable
f_2^v	—	—	—	—	—
f_3^v	—	—	—	—	—
f_1^i	No	Any record	Any two	Any three	Four or more
f_2^i	Timber	Earth	Stone wood mixture	Stone soil mixture	Stone
f_3^i	Fully modern	Modern and traditional	Traditional and modern	Traditional technology	Traditional architectural
f_4^i	Relic land	Remains of the site	Complete reconstruction	Repaired	No major renovation
f_5^i	Dilapidated	Damage	Relatively complete	Basically complete	Complete



FIGURE 5: Some cultural landscapes of Long-men Grottoes. (a) Remote landscape, (b) exterior view of Grottoes, (c) Giant Buddha, and (d) Plank road.

TABLE 10: Evaluation results of physical cultural heritage integrity.

Site cultural landscape integrity (100%)						Total
Quantitative assessment (60%)			Qualitative assessment (40%)			
Historical time (10%)	Degree of scarcity (10%)	Landscape scale (30%)	Landscape richness (10%)	Artistic value (25%)	Scientific value (15%)	
5%	7%	8%	5%	12%	6%	43%

TABLE 11: Evaluation results of intangible cultural heritage integrity.

Integrity of intangible cultural landscape (100%)						Total
Quantitative assessment (60%)			Qualitative assessment (40%)			
Historical time (10%)	Degree of scarcity (10%)	Landscape scale (30%)	Landscape richness (10%)	Artistic value (25%)	Scientific value (15%)	
3%	2%	5%	4%	8%	4%	26%

from the aspects of heating, insulation, storage, and sanitation. The other two items need to be qualitatively assessed according to relevant experts. B_4 is mainly used to evaluate the integrity of the landscape structure itself, as shown in Table 8.

To evaluate the cultural ecological integrity of cultural landscape from the perspective of cultural ecology, because it involves the natural field, cultural ecological characteristics and cultural factors of cultural landscape, it is necessary to consider the comprehensive evaluation of time, space and perceptual activities. Referring to the cultural landscape evaluation index system, the index adopts a five-level standard combining qualitative and quantitative.

Since the evaluation grading values of LH , LF , LV , and LI are all between 1 and 9, expressed as $LH \in [1, 9]$, $LF \in [1, 9]$, $LV \in [1, 9]$, and $LI \in [1, 9]$, we can know $LEI \in [1, 9]$ from formula (5). Therefore, LEI can be divided into $[1, 2]$, $(2, 4]$, $(4, 6]$, $(6, 8]$, and $(8, 9]$ five ecological integrity, which respectively correspond to the incomplete, low integrity, medium integrity, excellent integrity, and high integrity of cultural ecological integrity of cultural landscape. Different types of cultural landscape can be refined into different evaluation data for targeted classification research. As shown in Table 9, the evaluation index classification and evaluation criteria of cultural landscape ecological integrity are described.

TABLE 12: Damage assessment results of traditional dwellings around Long-men Grottoes.

Extent of damage (%)	Number	Proportion (%)
≥85%	18	41
75%–85%	11	25
60%–75%	8	18
45%–60%	5	11
≤45%	2	5

5. Application and Analysis of Evaluation Model

In order to verify the scientificity and effectiveness of the cultural landscape and cultural ecological integrity evaluation system proposed in this paper, this paper takes the Long-men Grottoes landscape in Luo-yang City, Henan Province as an example for investigation and analysis. Long-men Grottoes are located in the southern suburbs of Luo-yang, Henan Province, China. Here, the two mountains stand against each other, the Yi-river flows in the middle, and the scenery is beautiful. As shown in Figure 5, it is the landscape of some Long-men Grottoes.

In order to evaluate the application effect of the cultural landscape ecological integrity evaluation model proposed in this paper, taking the material cultural landscape, intangible cultural landscape and local traditional dwellings of Long-men Grottoes as samples, 10 places were randomly selected as the control group and the observation group. Among them, the control group used the traditional empirical evaluation method, and the observation group used the cultural landscape ecological integrity evaluation model proposed in this paper.

For the physical cultural heritage and intangible cultural heritage, the evaluation is mainly conducted from the quantitative and qualitative perspectives. Quantitative indicators account for 60%, mainly including historical time (10%), scarcity (10%), landscape scale (30%), and landscape richness (10%). Qualitative indicators account for 40%, mainly including artistic value (25%) and scientific value (15%). As shown in Table 10, the evaluation results of the ecological integrity of the physical cultural heritage are shown, and Table 11 is the evaluation results of the ecological integrity of the intangible cultural heritage.

In addition, this paper uses the cultural landscape ecological integrity evaluation model to evaluate the damage of traditional dwellings around Long-men Grottoes, as shown in Table 12.

In order to analyze the evaluation effect of the cultural landscape and cultural ecological integrity evaluation system proposed in this paper on the Long-men Grottoes site, the two groups of experimental objects were compared from three aspects: the material cultural landscape of Long-men Grottoes: the intangible cultural landscape and the local traditional dwellings. As shown in Figure 6, from the score results of the two groups, the total score of the observation group is higher than that of the control group, and the scores of various indicators of the observation group are also higher than that of the control

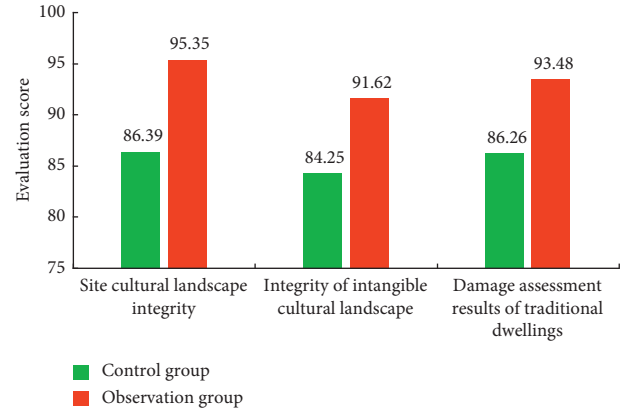


FIGURE 6: Comparison of actual operation effect between the two groups.

group. Through comparative experiments, we know that the cultural landscape ecological integrity evaluation model proposed in this paper can objectively reflect the evolution process of cultural heritage.

6. Conclusion

In view of the fact that the existing cultural landscape integrity evaluation system was not perfect enough to objectively reflect the evolution law of cultural landscape, this paper proposed a cultural ecological integrity evaluation model of cultural landscape based on the organic evolution characteristics of cultural landscape in cultural landscape heritage. Through the elaboration of ecological integrity and ecological integrity evaluation methods, the evaluation system and methods of cultural landscape ecological integrity were given theoretically. The cultural ecological integrity evaluation system not only fully considered the characteristics of the organic evolutionary cultural landscape but also objectively reflected the particularity and complexity of the cultural landscape. Through the application and analysis of examples, the results showed that the cultural landscape ecological integrity evaluation system proposed in this paper had important research significance for the protection, sustainable utilization, and development of organic evolutionary cultural landscape. In addition, this study can not only provide some theoretical reference and practical guidance for the effective classification of different organic evolutionary cultural landscapes but also provide a basis for the retrospective study of organic evolutionary cultural landscapes.

Data Availability

The labeled dataset used to support the findings of this study is available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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