RESEARCH ARTICLE

Research on ecological landscape planning of traditional villages based on circular economy

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Received: October 28, 2024; **accepted:** February 20, 2025.

Traditional villages, as an important part of human cultural and natural heritage, are facing unprecedented challenges and opportunities. With the advancement of science and technology and the development of society, how to achieve the sustainable development of traditional villages, protect their unique ecological landscape, and promote the prosperity of the local economy has become a current research hotspot. This research explored the circular economy mode and the ecological landscape planning methods of traditional villages with a case analysis of Zhifang village, a traditional village located in Jiaxian county, Pingdingshan, Henan, China using the analytic hierarchy process (AHP) to conduct a comprehensive evaluation of the ecological landscape planning. The landscape distribution within the village was assessed using the landscape heterogeneity index. The comprehensive score of the AHP method showed that the ecological landscape planning of this village was excellent, and the landscapes in this village were abundant and evenly distributed. The adoption of the circular economy mode could effectively plan the ecological landscape of traditional villages, offering a valuable reference for protecting ecological landscapes in traditional villages.

Keywords: circular economy, traditional village, ecological landscape, planning.

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Introduction

In the context of intensified global climate changes and the rapidly deteriorating natural environment, the protection and planning of the ecological landscape of traditional villages, the important carriers of inheriting rich cultural and natural heritage, are particularly important [1]. The ecological landscape of traditional villages not only embodies the historical memory and cultural inheritance of villages but also supports the livelihoods and production activities of their inhabitants [2]. As a new economic model, the circular economy emphasizes the conservation, efficient use, and recycling of resources, offering innovative ideas and methods for the ecological landscape planning of traditional villages [3]. However, with the development of society, traditional villages inevitably destroy the environment, resources, and the carrier of cultural inheritance in the process of development [4]. Therefore, it is necessary to use the circular economy mode to realize the sustainable development of villages [5]. When the circular economy model is applied to the ecological landscape planning of villages, it can play a role in the protection and optimization of natural ecological landscapes, the organic

renewal of material cultural landscapes, and the dynamic protection of intangible cultural landscapes.

Traditional villages combined with the circular economy mode need to follow the principles of ecology, integrity, characteristics, and sustainability in the process of ecological landscape planning [6]. The principle of ecology refers to fully considering the status of local buildings and facilities in the planning of a village's ecological landscape, avoiding large-scale demolition and construction, protecting ecological green areas, and minimizing environmental degradation as far as possible on the premise of completing the planning and design objectives. The principle of integrity means that, in the case of a large-scale planned site, the elements of building facilities and color matching in the village should be unified to reflect the coordination of the overall village style. The principle of characteristics refers to extracting characteristic elements, integrating local culture in the design, and deeply dig regional characteristics such as the unique local vegetation. The principle of sustainability means that, in the design process of the village ecological landscape, sustainability and long-term nature should be considered from the perspective of development, local conditions should be adapted, and sufficient redundancy should be left in the planning scheme on the premise of considering future development [7]. Duzgunes *et al*. conducted a study in Salack village located in the Akaabat district of Trabzon, Turkey to identify visually resource-rich landscape areas and ensure the sustainability of resource values through protection [8]. Zhang *et al*. introduced the landscape information chain theory and took Jiabi village in Maoba town, Lichuan, Hubei, China for a case study. By mining local landscape information elements, building landscape information sites, and constructing landscape information corridors, the researchers created a complete landscape information chain dominated by tea culture and integrated with different cultures [9]. Tortora *et al*. evaluated the morphological and vegetative changes in agroforestry land and found that significant alternations had occurred in the local land use of a rural area in Southern Italy [10]. In those previous studies, the protection methods of traditional villages were investigated and analyzed. Some started from the perspective of visual landscape resources, some from the perspective of information reflected by the landscape, and some conducted investigations on local land use.

This research planned the ecological landscape of traditional villages based on the theory of the circular economy mode, enabling the planned villages to achieve sustainable development. The study introduced the circular economy mode and the ecological landscape planning methods of traditional villages with a case analysis of Zhifang village, a traditional village in Jiaxian county, Pingdingshan, Henan, China. this research used the circular economy mode as a theory to guide the ecological landscape planning of traditional villages, providing an effective reference for protecting the ecology of traditional villages.

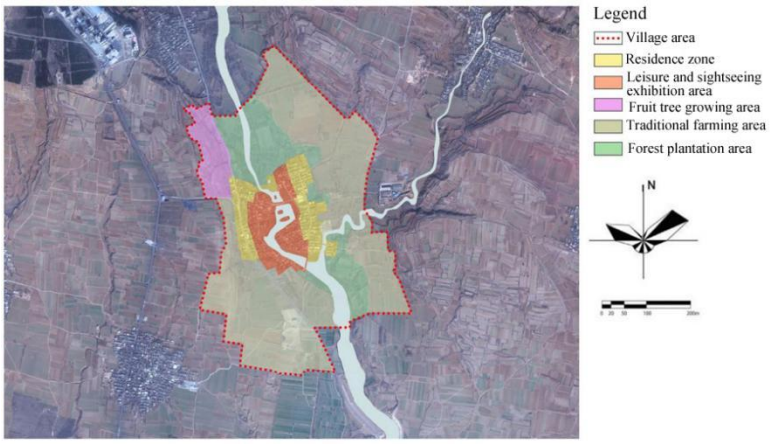
Materials and methods

Case overview

A traditional village, Zhifang village in Huangdao town, Jiaxian county, Pingdingshan, Henan, China, was selected for a specific case analysis. The area is in the northern part of Jiaxian county (113.16°E, 34.03°N), on both sides of Qinglong river with a typical geomantic historical background and regional characteristics in Central China.

Introduction of village planning principles and schemes

The main principles of ecological landscape planning in villages under the circular economy mode needed some targeted adjustments when applying to a specific village. For Zhifang village, the following planning principles were adopted, which included (1) with the consideration for development, protection of the original ecology of Zhifang village should protect not only the integrity of the village layout but also the



The village area industrial layout plan

The overall village planning plan

Figure 1. Landscape planning scheme.

authenticity of the architectural style, while developing ecological tourism resources under the premise of giving priority to protection to achieve a virtuous cycle of resources, (2) respect traditions and ensure dynamic inheritance by respecting the life, production, and folk customs of the traditional village of Zhifang village. It not only protected traditional buildings, environment, and other resources, but also protected the intangible cultural heritage [11], (3) overall protection and environmental coordination by paying attention to the coordination and integration of the regional environment, village pattern, and development style of the village, (4) tailoring measures to the village and highlighting its characteristics by adoption of protection methods such as on-site repair for Zhifang village, (5) highlighting the key points and implementing them at different levels and stages to form the short-term and long-term protection goals, (6) encouraging public participation and respecting for the will of the people. The landscape planning scheme of Zhifang village, which followed the above planning principles, was shown in Figure 1. From the village area industrial layout plan, the agricultural and forestry areas, residential areas, and sightseeing areas were planned from the outside to the inside and from both sides of the Qinglong river to the inside. The agricultural and forestry area ensured local agricultural development, while the residential area guaranteed the daily life of villagers, and the sightseeing area was open to tourists for revenue. In the overall village planning plan, combined

Table 1. Evaluation indicators of ecological landscape in Zhifang village.

Target layer	Criterion layer	Element layer	Indicator layer
The evaluation indicators of ecological landscape in Zhifang village under the circular economy mode	Industrial landscape	Agroforestry landscape	1 Agricultural and forest production landscape
			2 Landscape of agricultural and forestry service facilities
			3 Abundance of agricultural products
		Tourism product landscape	4 Homestay dining
			5 Entertainment ideas
			6 Tourist landscape
	Cultural landscape	Public cultural landscape	7 Public education
			8 Historic buildings
		Cultural event landscape	9 Richness of folk activities
			10 Traditional handicrafts
			11 Degree of public participation
	Ecological landscape	Residents' living environment	12 Architectural features
			13 Infrastructure
			14 Public service facilities
			15 Cleanliness of living environment
		Ecological protection of resources	16 Ecological protection policy
			17 The implementation degree of ecological protection policies

with the industrial layout plan, a lot of village-characteristic architectural sightseeing spots and local characteristic industrial sightseeing spots were set up in the sightseeing areas on both sides of the Qinglong river. These scenic spots could continuously attract tourists, thereby boosting the local economy. To maintain this source of income, the local area would carry out maintenance of the ecological scenic spots.

Evaluation and analysis of the planning scheme

This research adopted the analytic hierarchy process (AHP) method to evaluate and analyze the ecological landscape planning scheme under the circular economy mode of Zhifang village. Starting from land production, life, ecology, and other functions, the criterion layers of evaluation indicators were evaluated from the perspectives of local industry, culture, and ecology [12], including the industrial, cultural, and ecological landscapes. The criterion of each criterion layer was subdivided into various elements. The industrial landscape criterion was subdivided into the agroforestry landscape and tourism product landscape. The cultural landscape criterion was subdivided into the public cultural landscape and cultural event landscape [13], while the ecological landscape was subdivided into residents' living environment and ecological protection of resources. Each element had its measurement indicators (Table 1). After the hierarchical indicators were divided, 30 experts were invited to compare and score the importance of the indicators in pairs starting from the indicator layer at the bottom, and then a judgment matrix was constructed [14]. When scoring, the importance was ranked from low to high with scores of 1, 3, 5, 7, and 9, respectively. The median value was taken if a score was between two adjacent scores. The judgment matrix was used to compute the weight of each indicator. The consistency test was employed to adjust the weight in the calculation process, which was expressed as follows.

$$\begin{cases} CI = \frac{\lambda_{max}}{n-1} \\ CR = \frac{CI}{RI} \end{cases} \quad (1)$$

where CI was the consistency indicator. CR was the consistency ratio. RI was the average random consistency index. λ_{max} was the maximum feature value of the judgment matrix. n was the order of the judgment matrix. When the CR of the judgment matrix was smaller than 0.1, it meant that it passed the consistency test and could continue to be used for weight calculation. After the indicator weights were

Table 2. Evaluation results of the AHP method.

Target layer	Criterion layer	Weight	Element layer	Weight	Indicator layer	Weight	Score
Evaluation index of ecological landscape in Zhifang Village under the circular economy mode	Industrial landscape	0.332	Agroforestry landscape	0.489	1. Agricultural and forest production landscape	0.331	8.5
					2. Landscape of agricultural and forestry service facilities	0.322	8.3
					3. Abundance of agricultural products	0.347	7.2
			Tourism product landscape	0.511	4. Homestay dining	0.357	8.4
					5. Entertainment ideas	0.297	7.3
					6. Tourist landscape	0.346	8.3
	Cultural landscape	0.287	Public cultural landscape	0.512	7. Public education	0.433	7.6
					8. Historic buildings	0.567	8.7
			Cultural event landscape	0.488	9. Richness of folk activities	0.333	6.6
					10. Traditional handicrafts	0.357	6.4
					11. Degree of public participation	0.310	7.8
	Ecological landscape	0.381	Residents' living environment	0.477	12. Architectural features	0.311	9.3
					13. Infrastructure	0.248	7.4
					14. Public service facilities	0.192	7.6
					15. Cleanliness of living environment	0.249	8.5
			Ecological protection of resources	0.523	16. Ecological protection policy	0.477	8.9
					17. The implementation degree of ecological protection policies	0.523	8.8

obtained, 30 experts were invited to score the ecological landscape of Zhifang village from the perspective of the constructed indicators before finally, an overall score was obtained. In addition to the AHP method, this study also adopted the landscape heterogeneity index to assess the ecological landscape of this village [15], which included landscape diversity index (*H*), landscape dominance index (*D*), landscape evenness index (*E*), patch density index (*PD*), and landscape richness index (R_r) calculated as follows.

$$\begin{cases} H = -\sum_{i=1}^{n} P_i \log_2 P_i \\ D = H_{\max} + \sum_{i=1}^{n} P_i \log_2 P_i \\ E = \frac{H}{H_{\max}} \times 100\% \\ PD_i = \frac{N_i}{A_i} \\ R_r = \frac{N_i}{N} \times 100\% \end{cases} \quad (2)$$

where P_i was the proportion of the area of the i -th category of landscape in the total area. H_{max} was the maximum diversity index when the proportion of each landscape area in the total area was the same. N_i was the number of patches with the i -th category of landscape. A_i was the total area of patches with the i -th category of landscape. N was the total number of patches.

Results and discussion

The AHP method was employed to assess the ecological landscape planning of Zhifang village. The scores for the hierarchical indicators were presented in Table 2, and the ranking of the indicator weights was shown in Figure 2. The overall rating for the ecological landscape planning of Zhifang village under the circular economy mode was 8.11, which indicated that the local ecological landscape planning was excellent. In the ranking of evaluation indicators

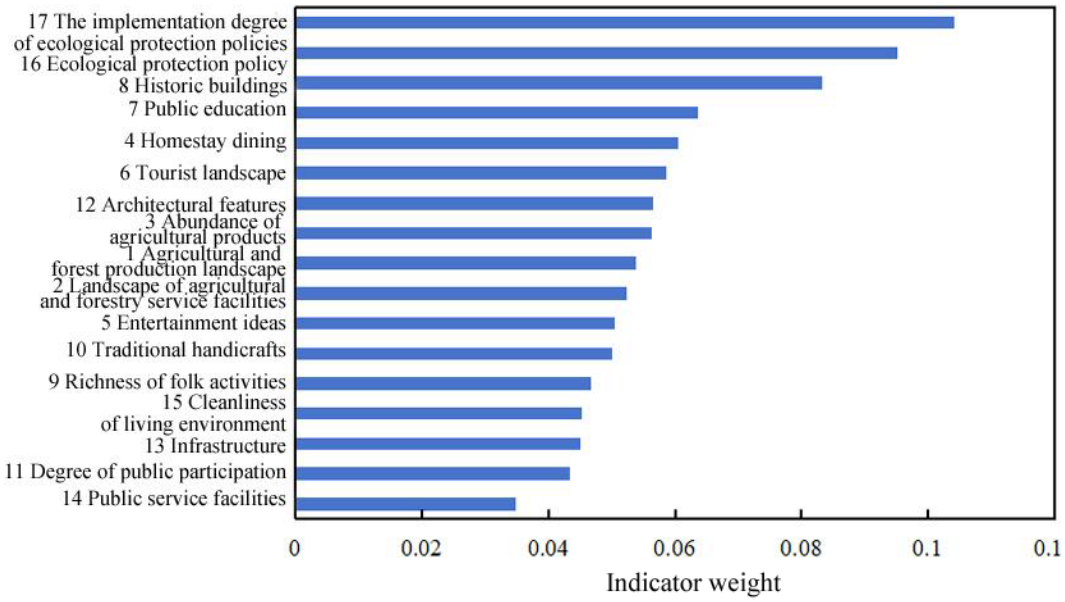


Figure 2. Weight ranking of evaluation indicators.

Table 3. Ecological landscape heterogeneity in Zhifang village.

Landscape type	H	D	E	H_{max}	PD_i /km²	R_r
Residence zone	2.21	0.53	0.51	2.83	0.153	0.153
Leisure and sightseeing exhibition area					0.168	0.142
Fruit tree growing area					0.147	0.139
Traditional farming area					0.166	0.151
Forest plantation area					0.187	0.143
Rivers					0.212	0.138
Roads					0.125	0.134

by weight, the implementation degree of ecological protection policies had the highest weight followed by ecological protection policies, while public service facilities had the lowest weight. The ecological landscape planning and construction of a village was a large-scale project. Particularly during project construction, various projects must be coordinated, and a supportive policy is needed to ensure that the project progresses in the right direction and, more importantly, to ensure that this policy is effectively implemented. In addition, the landscape heterogeneity index was used in this study. The results showed that the diversity index of the ecological landscape planning in Zhifang village was 2.21. Regarding the diversity index, it was important to note that, when there was only one landscape in the area, the diversity index was 0. However, when there were two or more landscapes present, and the proportion of each landscape was equal, the diversity index reached its maximum value. The maximum diversity index of the ecological landscape in this village was 2.83. The actual diversity index of Zhifang village was lower than the maximum diversity index, but it was close. The dominance index and evenness index of the ecological landscape in the village were 0.53 and 0.51, respectively (Table 3). A higher dominance index indicated a greater disparity in the proportion of different landscapes within the region. The evenness was the opposite. The landscape distribution in the

village was relatively uniform. In addition, the patch density and landscape richness index of each landscape also showed the uniformity of landscape distribution.

Conclusion

This research introduced the circular economy mode and the ecological landscape planning methods of traditional villages and presented a case study of Zhifang village. In the analysis process, the AHP method was adopted to comprehensively evaluate the ecological landscape planning of Zhifang village, while the landscape distribution within the village was assessed using landscape heterogeneity indexes. The comprehensive score assigned by the AHP for the ecological landscape planning of the village was 8.11, indicating that the local ecological landscape planning was excellent. In the ranking of evaluation indicators by weight, the implementation degree of ecological protection policies had the highest weight followed by ecological protection policies, while public service facilities had the lowest weight. The diversity index for ecological landscape planning in Zhifang village was 2.21, the dominance index was 0.53, and the evenness index was 0.51. The patch density and landscape richness of each landscape were also relatively similar.

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