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Practical Path of Green Transformation of Rural Tourism to Promote Rural Revitalization under the Perspective of Ecological Civilization Construction

Bing Zhang[1,*]

[1] School of Foreign Languages, Nanyang Institute of Technology, Nanyang, Henan, 473000, China

SUMMARY: *This work looks into the simultaneous development of rural green tourism and rural revitalization with a focus on ecological civilization construction and based on the theory of DSR. Data on rural green tourism and rural revitalization are analyzed empirically for 10 villages situated in the west of Province X during the period from 2020 to 2024. Entropy weight method and coupling coordination degree model are used for the assessment of the comprehensive evaluation index, definition of the level of coupling coordination, and identification of the development trajectory of the two systems. Besides, the construction of the index system associated with the determinants affecting the development and coordination of the two systems and examination of their mutual influence using the geographic detector analysis are provided. The practical approach for developing rural green tourism towards achieving rural revitalization goals is suggested based on the above-mentioned empirical studies. It can be concluded that the comprehensive coordination index of the rural green tourism and rural revitalization system grew from 0.0359 to 0.2101, whereas the coupling coordination degree increased correspondingly from 0.1805 to 0.4583. The development trajectories of these two indices have three distinctive features, which are fast start-up stage, bottleneck stage, and gradual advancement stage. In view of the future development of the two systems, coordination should be made in the following aspects: talent cultivation and innovation in marketing, industry integration and structure optimization, conservation and utilization of resources, and equitable distribution for achieving dual goals of rural tourism greening and rural revitalization.*

KEYWORDS: *DSR analysis framework; rural green tourism; rural revitalization; coupled and coordinated development*

1 Introduction

Rural tourism enjoys widespread recognition worldwide as not only a "sunrise industry" but also a "people-enriching enterprise." As one significant means of solving problems of imbalance and insufficiency in development and satisfying the increasing living demands of the population, it has a high-level strategic significance for rural revival in China [1, 2]. However, as of now, in the face of many practical problems in the development of the rural tourism industry in China, there is no doubt that environmental destruction remains the most urgent issue.

Throughout the development of rural tourism, it is a common occurrence for scenic spots

*zhangbing321321@163.com
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to make a bidirectional choice to pursue profit. Without taking into account the carrying capacity of the rural ecological environment, demolitions and constructions take place on a wide scale, and because of excessive development activities, the rural ecology and scenery are damaged beyond recognition [3, 4]. Furthermore, tourist attractions see more and more tourists exceeding the carrying capacity of their ecological environment and thereby causing disturbances to the existing ecological equilibrium and posing threats to the existence of local biological species [5]. In addition, the automobile exhaust produced by the transportation vehicles driving in tourist attractions, the uncivilized behavior of tourists and the businesses arbitrarily piling, dumping and landfilling of garbage also cause harm to the tourist attractions and their surrounding natural ecological environment, in the long run, the rural tourism will ultimately and gradually lose the strong attraction to the tourists [6-8].

In terms of rural tourism development's influence on ecological environment damage, Literature [9] explored the pressures brought about by the rural tourism development, and found out the imitative and predatory model of resource use. Ecological environment damage brought about by this model and how the constraints it brought upon the sustainable development of rural tourism were discussed. Literature [10] analyzed environmental pollution caused by rapid development of rural tourism, including water pollution, waste production, air pollution, and loss of natural landscape value. The causes of such environmental damage are attributed to poor governance at macro level and lack of environmental consciousness. Serious constraints on the sustainable development of rural tourism imposed by them are pointed out. Literature [11] studied the environmental issues faced in rural tourism development and the necessity of finding a balance between economic development and ecological protection in rural tourism. Possible environmental damages resulting from improper rural tourism development projects and their serious constraints on the sustainable development of the ecological environment and rural heritage were pointed out. Literature [12] discussed the positive influence on communities brought by tourism development, including economic benefit and social benefit. Meanwhile, the environmental damages caused by tourism development, for example the public place congestion, are mentioned. Literature [13] analyzed the potential of rural tourism in creating employment, while examining the impact of its rapid development on the environment, pointing out the need to pay attention to the problem of ecological damage and highlighting the possible negative effects on the lives of local communities. Literature [14] examines the challenges arising from improper waste disposal in rural tourism, analyzes the ecological damage it causes to the environment, and highlights the fact that such problems can undermine the attractiveness of tourism, which in turn threatens the integrity of the natural and cultural heritage of the countryside. Literature [15] examined the ecological pressures faced by small rural tourist islands due to tourist growth, analyzed the threats to fragile ecosystems caused by the intensity of activities by constructing an assessment framework that combines ecological footprints and geographic data, and pointed out that it leads to specific ecological damages, such as a decrease in habitat quality. In addition to this body of literature, another group of scholars has conducted research [16] on the problem of over-tourism within rural tourism destinations in the Czech Republic. Specifically, scholars have focused on the aspects of the problem that are objective, subjective, and temporal, as well as risks and sustainability problems that such intensive development can pose in terms of damaging the ecology of the area around it. In terms of ecological civilization, the realization of sustainability in rural tourism and rejuvenation should be based on the implementation of the green development concept into practice [17]. Utilization of unique features of rural settlements and the role of natural ecological resources along with their utilization and conservation is essential in this regard [18]. Further development of the rural tourism industry contributes to the stimulation of the rural economy and creates additional

job opportunities for rural inhabitants thus addressing the problem of rural unemployment [19, 20]. Furthermore, development is fueled by infrastructure development and the flow of capital in the rural tourism industry [21]. From a macro perspective, the green development of rural tourism positively impacts various aspects of rural life including the economy, culture, society, and ecology [22]. On the micro level, it helps to open additional livelihood opportunities and protect and preserve ethnic culture heritage in rural communities.

Concerning the relevance of green transformation in rural tourism, Literature [23] explores the meaning of rural green tourism as a type of sustainable tourism, considers the principles and development practice focused on efficient resource usage, and points out the relevance of this green transformation for implementing ideas related to conservation of nature, regional development, and sustainability. Literature [24] examined the characteristics and trends of the green transformation of rural tourism, pointed out that as an emerging form of tourism, it can effectively utilize regional resources and solve rural socio-economic problems, the necessity of using such transformations in terms of improving tourism industry structure and developing rural areas and their sustainable development is also mentioned. Literature [25] focuses on the role of the green transformation of rural tourism in relation to rural economy, stating that since rural green tourism represents an example of small entrepreneurship, it creates jobs and increases the level of income among local population. Based on the analysis of European experiences, Literature [26] pays attention to the need to develop systematic policies and legislation regarding green tourism development and restructuring of agricultural industry. Literature [27] studies the prospects and innovations of rural green tourism transformations, assessing natural ecological and infrastructure conditions and proving that rural green tourism represents one of the important tools to stimulate economic and social development of rural areas. Innovation is necessary for tourism format and service development. The literature [28] talks about the importance of innovation and financial support in making the green transformation of rural tourism possible, risks of lack of necessary funding that hinders the development of the business, and explains that the implementation of innovative investment projects by means of systematic planning and diversification of funding sources is important for enhancing the competitiveness of the businesses and supporting the sustainable development of the green tourism industry. The literature [29] considers the importance of the green transformation of rural tourism from the perspective of creating sustainable economic resilience, as well as mentions that this process lowers the community vulnerability due to economic diversification. At the same time, the process poses some challenges, for example, overuse and limited community involvement in the process. Finally, the literature [30] explores the importance of the green transformation of rural tourism in the context of Europe, considering it as an essential tool for conserving natural resources, stimulating economic growth in the communities and protecting their cultural heritage. The key point that should be made is that it is vital to find a proper balance in these spheres to achieve success.

This research project uses the DSR theory as its theoretical basis and studies the mutual growth of rural green tourism and rural revitalization from three aspects: the driving factors of the coupled development of the two concepts, the current status of the coupled development of the two concepts, and the response adjustments of the coupled development of the two concepts. Evaluation standards for the development of rural green tourism and rural revitalization are defined according to the performance and benefits of the coupled effect between the development of the two concepts. Following the traditional calculation steps of the coupling effect, the comprehensive evaluation indicators, the coupling degrees, and the coupling coordination degrees of the rural green tourism system and rural revitalization system are respectively computed and analyzed. As the geographic location of this study, the western region of Province X is chosen. The weighting factors of each evaluation indicator are

determined by the entropy weight method. Then, the coupling coordination degree model is used to evaluate the development stages of rural green tourism and rural revitalization and judge the status of the coupled and coordinated development of the two concepts. The influencing factors of the coupled and coordinated development of the two concepts are determined, and the degree of impact is quantified through the geographic detection technique. Finally, the constraints affecting the further development of the two concepts are identified, and corresponding measures are put forward.

2 Research on the coupled and coordinated development of rural green tourism and rural revitalization

2.1 Principles and applicability of the DSR framework

The connection between rural green tourism and rural revitalization is based on the interplay of several factors. Meanwhile, the coupling between the above two phenomena involves a systematic process characterized by mutual stimulation and interpenetration of each other. Coupling can not exist without the influence of external factors or pressures on the system, and after certain complex processes within it, the state of coordinated coupling occurs. The purpose of this article is to investigate the coupled development relationship between rural green tourism and rural revitalization based on the DSR analysis method.

2.1.1 Principles of the DSR framework

The prototype for the development of the DSR model is the PSR model, which was developed for environmental issues and which makes it difficult to analyze social issues using this framework relationship. The DSR model was created by the United Nations Commission on Sustainable Development (UNCSD) based on the PSR model, in which pressure was replaced by driver, because driver indicators are applicable to social, economic and institutional domains, and can be used to explain the impact of both positive and negative factors on sustainable development.

The core idea of the DSR model is that the “driving forces” of human socio-economic and other systems exert a driving force on the local development environment and change the “state” of the environment, and that in order to alleviate the pressure to change the development environment and achieve long-term sustainable development, the relevant participating In order to alleviate the pressure of change in the development environment and to realize long-term sustainable development, the relevant participants must make “responsive” changes in the system, management, and inputs.

2.1.2 Applicability of DSR models in coupling studies

Coupling research deals with the states of systems or the interaction of their components, the system in the coupling process needs to go through “conflict-adjustment-coordination” and other coupling phases, the elements within the system have to make corresponding adjustments in order to achieve positive coupling. The analysis of coupling mechanism requires a complete logical structure and research ideas. The advantage of DSR model is to provide a complete idea of the research problem, which can comprehensively analyze several aspects of the problem, rationalize the interrelationship of multiple aspects, and comprehensively analyze and solve the problem. Therefore, DSR model has certain applicability in coupling research.

In the DSR analysis model, the rural green tourism and rural revitalization coupling mechanism can be divided into three main parts, which include coupling driver, coupling state,

and coupling response. The coupling framework under this model is shown in Figure 1 below.

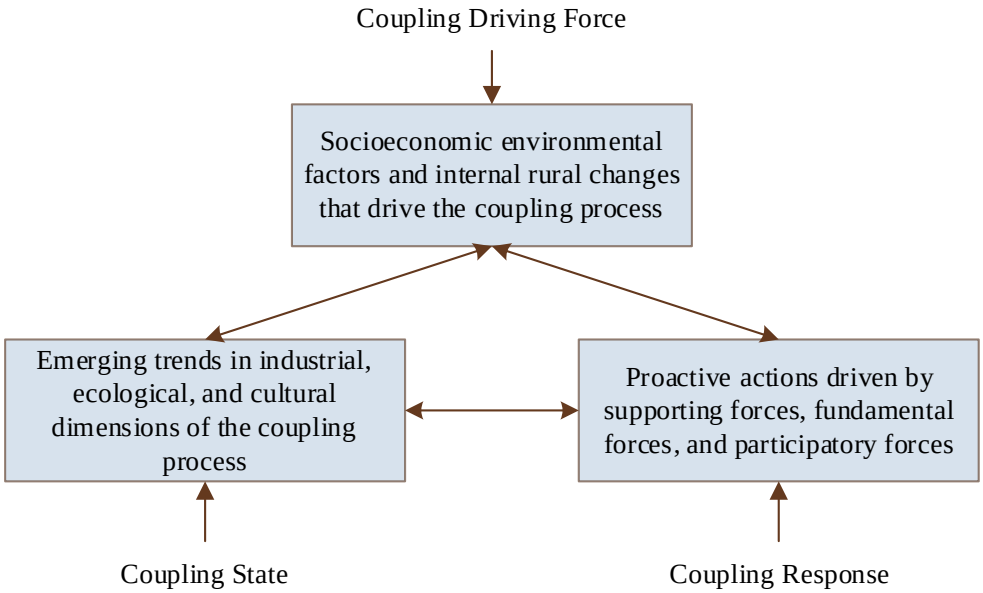

Figure 1: Coupling framework under the DSR model

2.2 Establishment of an evaluation indicator system

In total, eight indicators have been eliminated, four have been modified, and two new indicators have been added after three rounds of consultations with experts. Eventually, the evaluation indicator system of the integration of rural green tourism and rural revitalization is confirmed as indicated in Table 1 below, which includes one target level, two system levels, eight guideline levels, and a total of 26 indicators. The rural green tourism system includes 13 indicators, namely the amount of revenue from green tourism, green tourism revenue as a ratio of GDP, per capita green tourism revenue, types of goods for green tourism, investment in tourism environmental protection, rural environment air quality excellence rate, overall tourist satisfaction, number of heritage sites, number of traditional villages, number of villages with special traits for rural tourism, growth rate of green tourism revenue, per capita income from rural green tourism, and number of indirect jobs from rural green tourism. In addition, the rural revitalization system comprises 13 indicators, including total value of agriculture output, secondary and tertiary industry output value ratio to GDP, comprehensive degree of agricultural mechanization, rural non-agricultural employment, rural forest cover rate, centralized treatment rate of domestic rural garbage, ecological civilization villages count at the county level and higher, fiscal investment in protecting and developing local cultural traits, rural residents cultural and education consumption expenses, number of villages that have their amateur cultural organizations, rural residents' per capita disposable income, rural residents' per capita consumption, and income gap between urban and rural areas.

Table 1: Coupled development evaluation index system

Target layer	System layer	Criterion layer	Index layer (unit)
Evaluation of coupling development of rural green tourism and rural revitalization	Rural green tourism system	Tourism industry	Total revenue of green tourism (billion yuan)
			Green tourism revenue as a share of GDP (%)
			Types of green Tourism Commodities (species)
			Per capita green tourism consumption (Yuan)
		Tourism environment	Investment in environmental protection in tourism (billion yuan)
			Excellent and good rate of rural ambient air quality (%)
			Overall visitor satisfaction (%)
		Tourism culture	Number of Cultural heritage (item)
			Number of traditional villages (n)
			Number of characteristic villages of rural tourism (n)
		Tourism benefits	Green Tourism Revenue Growth rate (%)
			Rural green Tourism per capita income (Yuan)
			Employment Indirectly Driven by Rural Green Tourism (person-time)
	Rural revitalization system	Rural industry	Gross agricultural product (100 million yuan)
			The proportion of gross output value of secondary and tertiary industries in GDP (%)
			The comprehensive level of agricultural mechanization
			The number of rural non-agricultural employment (Ten thousand people)
		Rural ecology	Rural forest coverage rate (%)
			Rural household garbage centralized treatment rate (%)
			The number of ecological civilized villages above the municipal level (n)
		Rural culture	The amount of financial input for the protection and development of local characteristic culture (100 million yuan)
			The amount of consumption expenditure for culture and education of rural residents (Yuan)
			The proportion of villages developing amateur cultural organizations (%)
		Rural affluence	Rural per capita disposable income (Yuan)
			Rural per capita consumption level
			Income gap between urban and rural residents (%)

2.3 Processing of Indicators for Rural Green Tourism and Rural Revitalization

2.3.1 The Entropy Weight Method

The methods for evaluating the development quality of rural green tourism and rural revitalization mainly include: weighting method, entropy value method and factor analysis method, of which entropy value method is an evaluation method that does not need to test the results, and presents the characteristics of objectivity and comprehensiveness as a whole, and determines the weight of each indicator by calculating the information entropy of each indicator. In this paper, in order to be able to compare the differences between different years, the entropy value method is appropriately modified by introducing time variables, which makes the calculation results more reasonable. The improved entropy value method model is as follows:

(1) Indicator data of this paper: there are r years, n research objects, and m tertiary indicators located in this system. $x_{\theta ij}$ is the j th indicator data value in area i in the θ th year.

(2) Indicator standardization: Given that the units and scales of each indicator differ, it is necessary to standardize the collected data by removing dimensions, that is, to standardize the indicator data.

Positive indicators:

$$X'_{\theta ij} = \frac{x_{\theta ij} - \min\{x_{\theta ij}\}}{\max\{x_{\theta ij}\} - \min\{x_{\theta ij}\}} \tag{1}$$

Negative indicators:

$$X'_{\theta ij} = \frac{\max\{x_{\theta ij}\} - x_{\theta ij}}{\max\{x_{\theta ij}\} - \min\{x_{\theta ij}\}} \tag{2}$$

(3) Determine the weighting of each indicator:

$$y_{\theta ij} = X'_{\theta ij} \Big/ \sum_{\theta} \sum_{i} X'_{\theta ij} \tag{3}$$

(4) Information entropy of the j th indicator:

$$e_j = -k \sum_{\theta} \sum_{i} y_{\theta ij} \ln(y_{\theta ij}) \tag{4}$$

where $k > 0$ and $k = \ln(rn)$.

(5) Information entropy redundancy of the j th indicator:

$$g_j = 1 - e_j \tag{5}$$

(6) Calculate the weight of each indicator:

$$w_j = g_j \Big/ \sum_{j} g_j \tag{6}$$

2.3.2 Comprehensive evaluation function model

Using the improved entropy weight method described above, the comprehensive evaluation function $f(x)$ of the rural green tourism system and the comprehensive evaluation function $g(y)$ of the rural revitalization system are calculated for rural green tourism and rural revitalization respectively.

$$f(x)=\sum_{i=1}^{13} a_i X_i \tag{7}$$

$$g(y)=\sum_{i=1}^{13} b_i Y_i \tag{8}$$

where a_i and b_i are the weights of the indicators X_i and Y_i respectively.

2.3.3 Tourism Relative Prioritization Model

Relative priority of tourism development means how much ahead or behind the development of rural green tourism in a particular place can be in comparison to other developmental aspects. Rural revitalization has a relatively long process for its implementation as compared to rural green tourism. Moreover, development of rural revitalization during any particular duration stays relatively constant in nature. As opposed to that, development of rural green tourism has the tendency to change due to its unstable nature and therefore, is affected from the outside environment. As a result, high-quality development stage of rural green tourism is either greater than or lesser than the development stage of rural revitalization. The equation can be formulated as follows:

$$p=\frac{y}{x} \tag{9}$$

In this formula, p represents the relative priority of tourism, y refers to the comprehensive evaluation score reflecting the development level of rural green tourism, and x corresponds to the comprehensive evaluation score reflecting the development level of rural revitalization. Drawing on the evaluation outcomes, this paper contends that when $p>1.1$, rural green tourism development is progressing at a comparatively advanced pace; when $0.9\le p\le 1.1$, the development of rural revitalization and rural green tourism maintains a broadly synchronized trajectory; when $p<0.9$, the development of rural green tourism is comparatively lagging.

2.4 Coupling Coordination Degree Model for Rural Green Tourism and Rural Revitalization

2.4.1 Function Functions

Let the variables $U_i\left(i=1,2,3,\ldots,m\right)$ be the ordinal parameters of the coupled system, U_{ij} is used to represent the j th indicator value of the i th ordinal parameter. α_{ij}, β_{ij} serve as the maximum and minimum values within the steady state of the coupled system respectively, and the ordered efficacy coefficient of the coupled system U_{ij} is expressed as follows:

$$U_{ij} = \frac{X_{ij} - \beta_{ij}}{\alpha_{ij} - \beta_{ij}} U_{ij} \text{Has positive effects} \tag{10}$$

$$U_{ij} = \frac{\alpha_{ij} - X_{ij}}{\alpha_{ij} - \beta_{ij}} U_{ij} \text{Has negative effects} \tag{11}$$

In equations (10) and (11), U_{ij} is located between 0 and 1, reflecting the degree of satisfaction that each indicator can reach the target value. Among them, U_{ij} tends to 0 when the more dissatisfied, U_{ij} tends to 1 when the more satisfied. The formula is as follows:

$$U_i = \sum_{i=1}^{m} \lambda_{ij} II_{ij}, \sum_{i=1}^{m} \lambda_{ij} = 1 \tag{12}$$

In Eq. (12), U_i refers to the comprehensive evaluation value of the coupled system in year i, while λ_{ij} corresponds to the weight assigned to each evaluation index within the coupled system.

2.4.2 Coupling model

The coupling degree between rural green tourism and rural revitalization is computed as follows:

$$C = \left[\frac{U_1 * U_2}{(U_1 + U_2)^2} \right]^{\frac{1}{2}} \tag{13}$$

Here C denotes the coupling degree of the two systems, while U_1 and U_2 represent the comprehensive evaluation indices of rural green tourism and rural revitalization respectively. The value of the coupling degree falls between 0 and 1. The closer C is to 1, the greater the orderliness of the system, indicating a benign coupling state; the closer C is to 0, the greater the degree of disorder within the system.

2.4.3 Coupling coherence model

The coupling coordination degree model for rural green tourism and rural revitalization is constructed using the following formula:

$$D = \sqrt{C * F}, \quad F = \alpha U_1 + \beta U_2 \tag{14}$$

In Eq. (14), D denotes the coupling coordination degree, C represents the coupling degree, and F is the coordination index. α and β are coefficients to be determined.

2.4.4 Coupling harmonization evaluation level criteria

After a large number of experts and scholars research, construct the evaluation standard of coupling coordination level, determine the value range of D always $0 \le D \le 1$. When D is equal to 0, the systems are independent of each other, the systems do not affect each other, the coupling degree is minimum and in a disordered state. When D is greater than 0 and ≤ 0.29,

it indicates that the coupling coordinated development level of the system is low, with only a minor degree of influence between the two systems, and both systems remain in the primary stage. When $0.3 \le D \le 0.69$, it indicates that the development level of the two systems is undergoing rapid advancement, a certain degree of mutual influence exists between them, and they have entered the medium coupling stage. When $0.7 \le D \le 1.0$, it indicates that the two systems have reached the optimal coupling point, with each system actively reinforcing the other, and together they have attained the high coupling stage. The criteria for classifying coupling coordination levels are presented in Table 2.

Table 2: Criteria for classifying coupling coordination levels

Serial number	Interval	Grade	Development level
1	[0,0.1)	Extreme disorder	Primary stage
2	[0.1,0.2)	Severe disorder	
3	[0.2,0.3)	Moderate disorder	
4	[0.3,0.4)	Mild disorder	Intermediate stage
5	[0.4,0.5)	Near disorder	
6	[0.5,0.6)	Barely coordination	
7	[0.6,0.7)	Primary coordination	
8	[0.7,0.8)	Intermediate coordination	Advanced stage
9	[0.8,0.9)	Good coordination	
10	[0.9,1]	High quality coordination	

3 Mechanisms Through Which Rural Green Tourism Drives Rural Revitalization

3.1 Introduction to the Study Area

The geographical landform of the western part of Province X is mainly mountains and hills, and the formation of the village spatial distribution shows the characteristics of points, lines, and surfaces due to the impact of the natural geography such as mountains and rivers. In addition to its unique natural geographic landscape, the western part of Province X has a rich history and culture and a large variety of unique ethnic cultures retained up to now. All of the above factors create solid foundations for the sustainable development of rural green tourism in this area. The development of rural green tourism in Province X has a long history, starting from the beginning of the 1990s, from the original scattered to an integral comprehensive development trend. During this process, the quantity of rural green tourism spots has continued to increase, models of development have constantly been innovated, rural green tourism products have been diversified, and the development trend continues to maintain advantages. This paper aims at the analysis of rural green tourism and rural revitalization of 10 villages in the western region of Province X during the years 2020-2024.

3.2 Descriptive statistics of evaluation indicators

Following mean-based standardization procedures applied to all indicators, the resulting normalized values for both rural green tourism indicators and rural revitalization indicators spanning the period from 2020 to 2024 are presented in Table 3 below. Within this table, the rural green tourism indicators are designated A1 through A13, while the rural revitalization

system indicators are labeled B1 through B13. A review of the tabulated data reveals that indicators belonging to both systems exhibit a consistent year-on-year upward trend, with this pattern becoming particularly pronounced across the years from 2022 to 2024. The growth rate of key indicators, including total green tourism income and per capita green tourism consumption, noticeably accelerates in the latter portion of the study period, with total green tourism income increasing from 0.0045 in 2020 to 0.3821 in 2024, and per capita green tourism consumption increasing from 0.0011 in 2020 to 0.2467 in 2024, which reflects the increasing scale of the green tourism economy and the significant enhancement of investment.

Table 3: Descriptive statistical results of evaluation indicators

Criterion layer	Index layer	2020	2021	2022	2023	2024
Tourism industry	A1	0.0045	0.0723	0.1456	0.2381	0.3821
	A2	0.0011	0.0321	0.0678	0.1567	0.2467
	A3	0.0032	0.0587	0.1123	0.2134	0.3456
	A4	0.0011	0.0456	0.0892	0.1789	0.2987
Tourism environment	A5	0.0023	0.0634	0.1278	0.2543	0.4123
	A6	0.0045	0.0923	0.1654	0.3123	0.5234
	A7	0.0067	0.0745	0.1432	0.2789	0.3005
Tourism culture	A8	0.0009	0.0211	0.0567	0.1345	0.2534
	A9	0.0012	0.0389	0.0823	0.1678	0.3421
	A10	0.0006	0.0312	0.0756	0.1834	0.2746
Tourism benefits	A11	0.0023	0.0432	0.0789	0.1567	0.2765
	A12	0.0034	0.0612	0.1189	0.2376	0.4321
	A13	0.0011	0.0398	0.0823	0.1678	0.3567
Rural industry	B1	0.0045	0.0934	0.1823	0.3245	0.5123
	B2	0.0002	0.0156	0.0423	0.1234	0.2876
	B3	0.0023	0.0654	0.1245	0.2678	0.4234
	B4	0.0012	0.0432	0.0876	0.1897	0.3987
Rural ecology	B5	0.0034	0.0723	0.1389	0.2678	0.4567
	B6	0.0056	0.0623	0.1245	0.2456	0.3876
	B7	0.0008	0.0189	0.0512	0.1123	0.3421
Rural culture	B8	0.0023	0.0718	0.1367	0.2789	0.4654
	B9	0.0011	0.0478	0.0934	0.2012	0.3765
	B10	0.0008	0.0123	0.0345	0.0987	0.2987
Rural affluence	B11	0.0045	0.0956	0.1823	0.3018	0.5271
	B12	0.0032	0.0812	0.1546	0.2673	0.4027
	B13	0.0234	0.0234	0.0558	0.1125	0.2673

3.3 Coupled evaluation level analysis

3.3.1 Entropy method for determining indicator weights

Following the methodology outlined in section 2.3.1, the computed results are displayed in Table 4 below. Within the set of indicators comprising the rural green tourism system, the two indicators carrying the greatest weight are the share of green tourism income relative to GDP and the total volume of green tourism income, recording values of 0.1647 and 0.1338 respectively. These figures underscore the considerable significance that both indicators hold within the overall evaluation framework. Turning to the rural revitalization system, the per capita disposable income of rural residents and the gross agricultural output value are assigned

weights of 0.1136 and 0.1117 respectively.

Table 4: Results of weight calculation

Criterion layer	Index layer	Information entropy value	Information utility value	Weight coefficient
Tourism industry	A1	0.8352	0.1648	0.1338
	A2	0.8215	0.1785	0.1647
	A3	0.8634	0.1366	0.0624
	A4	0.8951	0.1049	0.0373
Tourism environment	A5	0.8421	0.1579	0.1162
	A6	0.9126	0.0874	0.0621
	A7	0.8743	0.1257	0.0225
Tourism culture	A8	0.9012	0.0988	0.1103
	A9	0.8873	0.1127	0.0857
	A10	0.8694	0.1306	0.0357
Tourism benefits	A11	0.9134	0.0866	0.0943
	A12	0.8456	0.1544	0.0523
	A13	0.8721	0.1279	0.0227
Rural industry	B1	0.8145	0.1855	0.1117
	B2	0.9287	0.0713	0.0283
	B3	0.8312	0.1688	0.0981
	B4	0.8567	0.1433	0.0772
Rural ecology	B5	0.8198	0.1802	0.1073
	B6	0.8392	0.1608	0.0915
	B7	0.8943	0.1057	0.0465
Rural culture	B8	0.8276	0.1724	0.1011
	B9	0.8623	0.1377	0.0727
	B10	0.9156	0.0844	0.0291
Rural affluence	B11	0.8123	0.1877	0.1136
	B12	0.8432	0.1568	0.0883
	B13	0.9278	0.0722	0.0346

3.3.2 Composite score analysis

In regard to the comprehensive scores assessment of rural green tourism and rural revitalization, the two indexes are both independently developed and interrelated with each other. In order to effectively express the relationship between them in an accurate way, it is essential to perform a comprehensive assessment analysis on the two indexes separately. The calculation of comprehensive evaluation index is hence carried out with a weighted calculation method. This comprehensive score assessment can be seen in Table 5. As shown in the table, the comprehensive level index of rural green tourism always stays behind the index of rural revitalization within the timeframe from 2020 to 2024, which means that rural revitalization has proceeded faster in the research area than rural green tourism industry.

Table 5: Results of composite score calculation

Year	f(x)	g(y)	Comparison of comprehensive scores between the two systems
2020	0.0208	0.0509	f(x)<g(y)
2021	0.1315	0.1595	f(x)<g(y)
2022	0.1009	0.1626	f(x)<g(y)
2023	0.1301	0.1852	f(x)<g(y)
2024	0.2054	0.2147	f(x)<g(y)

3.3.3 Coupling harmonization analysis

Through the application of the coupling measurement model, the state of coupled development between the rural green tourism system and the rural revitalization system within the study area is examined, with the computational results presented in Table 6 and the corresponding variations in the comprehensive coordination index alongside the growth rate of coupling coordination degree illustrated in Figure 2. The comprehensive coordination index registers a progressive rise from 0.0359 in 2020 to 0.2101 in 2024, reflecting a gradual elevation in the overall development level of both systems over this period. With respect to the coupling coordination degree, a consistent upward trend is observed, with the recorded value climbing from 0.1805 in 2020 to 0.4583 in 2024. With regard to this growth, coupled development evolves from a state of "serious dissonance" to a condition of "borderline dissonance." Coupled with the growth rate changes shown in Figure 2, the trends of growth rate changes for both the comprehensive coordination index and the coupling coordination degree reveal the existence of stage features. For example, relatively high growth rates (3.0529 and 1.1086) are observed during 2020-2021, indicating a period of rapid initiation of the coupled development process. Growth rates begin to decrease and even become negative in some cases during 2021-2022, meaning that coupled development faces temporary bottlenecks which may result from industry homogenization or increased environmental pressures, etc. During 2022-2024, growth rates start to recover and stabilize, suggesting that sound development trajectories have been attained by means of adjustments to the development approach.

Table 6: Results of coupling development calculations

Year	f(x)	g(y)	C	F	D	Grade
2020	0.0208	0.0509	0.9076	0.0359	0.1805	Severe disorder
2021	0.1315	0.1595	0.9954	0.1455	0.3806	Mild disorder
2022	0.1009	0.1626	0.9722	0.1318	0.3580	Mild disorder
2023	0.1301	0.1852	0.9846	0.1577	0.3940	Mild disorder
2024	0.2054	0.2147	0.9998	0.2101	0.4583	Near disorder

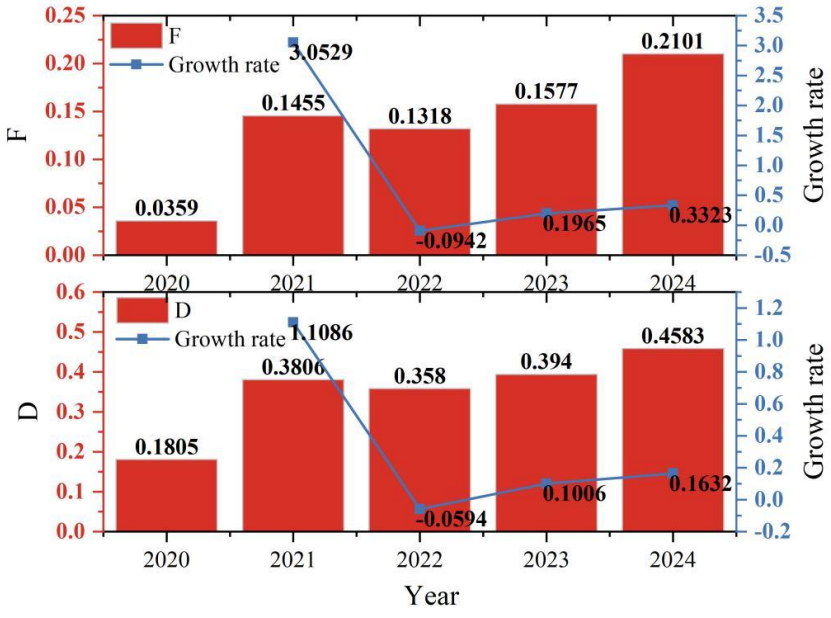

Figure 2: Results of growth rate changes

3.4 Analysis of factors affecting coupling coordination

3.4.1 Selection of Indicators for Drivers of Coupled and Coordinated Development

Green tourism is an innovative industry that exhibits extensive coverage and significant externalities. With the particular characteristics of rural areas, the development of green tourism in rural areas faces the effect of various factors. The implementation of the strategy of revitalizing rural areas not only covers economic aspects like economic development of the villages and improvement of the well-being of villagers, but also includes other aspects such as rural infrastructure construction, ecological environment protection, rural cultural heritages conservation, and improvement of the spiritual lives of villagers. Thus, the development of the two rural systems, namely green tourism system and rural revitalization system, is influenced by multiple factors together.

By summarizing the existing studies, it is found that the economic environment, policy conditions, industrial structure, resource endowment, scientific and technological progress, and transportation conditions affect the coupled and coordinated development of rural green tourism and rural revitalization in the region. Based on the principles of objectivity, scientificity and data availability, this paper constructs an indicator system of influencing factors from eight aspects, such as regional economic foundation, tourism resource endowment, tourism market demand, regional industrial structure, tourism reception capacity, government organization capacity, population resource endowment, and regional informatization level, as shown in Table 7. Drawing on the geographic detector, this study examines the driving role that individual factors play in the coupled and coordinated development of the two systems, as well as the aggregate degree of influence each factor exerts under conditions of interaction. The aim is to arrive at a precise understanding of the forces propelling the coupled and coordinated development of the rural green tourism and rural revitalization systems across ethnic and non-ethnic villages alike, while simultaneously laying the groundwork for the timely identification of problems arising throughout the developmental process and the formulation of targeted countermeasures in response.

Table 7: Index system of influencing factors

	Influencing factors	Characteristic indicators	Unit
C1	Regional economic foundation	Total income of district (village)	Ten thousand yuan
C2	Tourism resource endowment	Number of surrounding scenic spots	Number
C3	Tourism market demand	Annual tourist reception	Ten thousand people
C4	Regional industrial structure	Tourism accounts for the proportion of local GDP	%
C5	Tourism reception capacity	Average years of education for village cadres	Year
C6	Government organizational capacity	The proportion of households engaged in tourism services	%
C7	Population resource endowment	Proportion of permanent residents in districts (villages)	%
C8	Regional information level	Internet penetration	%

3.4.2 Impact Factor Detection Results

Green tourism constitutes an innovative industry characterized by broad sectoral coverage and substantial external effects. Given the distinctive conditions inherent to rural environments, the advancement of green tourism in such settings is subject to the influence of a wide array of contributing factors. The rural revitalization strategy, in its scope, extends well beyond purely economic concerns such as village-level economic growth and improvements to residents' material well-being. It encompasses a broader set of dimensions, including the construction of rural infrastructure, the protection of ecological environments, the preservation of rural cultural heritage, and the enrichment of villagers' spiritual and cultural lives. As a result, the developmental trajectories of the two interconnected rural systems, namely the rural green tourism system and the rural revitalization system, are jointly shaped by multiple interacting forces.

Table 8: Results of interaction detection of influencing factors

	C1	C2	C3	C4	C5	C6	C7	C8
C1	0.6553							
C2	0.7561	0.6717						
C3	0.9275	0.9473	0.7912					
C4	0.9917	0.9925	0.9536	0.3277				
C5	0.7635	0.7442	0.9506	0.8553	0.5008			
C6	0.8947	0.9415	0.8817	0.9746	0.9514	0.8715		
C7	0.9922	0.9902	0.9824	0.8415	0.6635	0.9712	0.6022	
C8	0.8836	0.8845	0.9902	0.9734	0.8945	0.9904	0.9823	0.8351

4 Practical Path of Green Transformation of Rural Tourism to Promote Rural Revitalization

For further promoting green transformation in rural tourism industry and maximizing the driving effect in rural revitalization, a feasible path needs to be formed in the following three aspects.

In terms of attracting professional talent and renewing the marketing approaches for rural green tourism, both governmental bodies and private enterprises should place emphasis on recruiting individuals with specialized expertise in tourism-related fields, encompassing planners, designers, marketing professionals, and others willing to direct their efforts toward rural settings. Concurrently, the integration of big data, artificial intelligence, and new media platforms can be leveraged to build an intelligent, region-wide marketing system capable of substantially raising market visibility. Drawing on the findings of the impact factor analysis, dedicated effort is needed to excavate and transform tourism resource endowments, converting inherent natural and cultural advantages into tangible market competitiveness through the incubation of cultural intellectual properties and the organization of distinctive events. Alongside these measures, the cultivation and development of locally rooted talent warrants equal attention.

With regard to fostering the coordinated growth of rural green tourism in conjunction with other rural industries, the active promotion of "tourism+" and "+tourism" development models offers a potent mechanism for driving sound and accelerated economic progress across the region. Guided by the principle of industrial integration, deliberate effort must be directed

toward extending the tourism industrial chain so as to forge meaningful connections between tourism activities and the primary, secondary, and tertiary sectors of the rural economy. Given the documented interrelationship between regional industrial structure and tourism resource endowment, targeted optimization of the industrial composition is warranted to guard against homogenized competition among localities. Industrial complementarities, including the integration of agriculture with tourism and the fusion of cultural activities with tourism, among others, enable the sharing of resources and the superimposition of economic benefits, ultimately elevating the overall degree of systemic coupling.

In pursuing a sustainable exploitation of rural landscape and rural resources, the principle of "protection-first" needs to be firmly followed while the boundary of tourism development and environmental conservation should be scientifically determined. Tourism environment and rural ecological environment indicators have been given much weight in the model, and the growth rate of their relevant indicators between 2022 and 2024 has proven quite significant. In this regard, it can be said that the quality of ecological environment would play a supporting role in the coordinated development of the two models. Therefore, efforts need to be taken to further improve the rural natural environment and human environment by improving rural public facilities and continuously enhancing village improvement and sanitation activities.

In terms of comprehensively releasing the dividends of tourism and realizing the sharing of the fruits by all people, the synergistic effect of economic foundation, industrial structure and tourism resource endowment has a decisive influence on the degree of coupling coordination. Therefore, villagers should be encouraged to participate directly in tourism operation and management, and develop cooperative societies, joint-stock cooperative systems and other forms of organization, so that they can take the main position in the industrial chain. At the same time, through the equalization of public services and the improvement of social security, rural tourism becomes a happy industry that benefits all residents.

5 Conclusion

This paper proposes an evaluation index system based on the coupling coordination degree and applies the entropy weight method along with the coupling coordination degree model and other relevant analysis methods to analyze the weighting of evaluation indicators, composite evaluation values, coordination levels, and developmental paths in 10 villages of the western region of Province X during the period of 2020 to 2024.

During the whole research period, the composite evaluation value of rural revitalization is always higher than that of rural green tourism. It indicates that there exists a certain amount of underdevelopment potential in rural green tourism in the region. The coupling degree between rural green tourism and rural revitalization has been steadily increasing, and the coordination level has been evolving from its original serious disharmony (0.1805) to the threshold value of disharmony (0.4583). However, high-quality coupling in the region has not been achieved yet, and it needs to continue moving towards a higher-level coupling stage. The interaction levels among different factors in the region in this research are rather strong. For instance, the interaction levels between the regional economic base and the regional industrial structure, the regional economic base and the population resource endowment, the tourism resource endowment and the population resource endowment, the tourism resource endowment and the regional industrial structure, the tourism market demand and the regional informatization level, and the governmental organizational capability and the regional informatization level have surpassed 0.99.

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About the Author

Bing Zhang (1980-), holds a Doctor's degree from Shinawatra University, lecturer of School of Foreign Language, Nanyang Institute of Technology, and has published one paper.

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