

Research Article

Coupling Coordination and Prediction Research of Tourism Industry Development and Ecological Environment in China

Yun Yang,¹ Rong Wang ,² and Junlan Tan³

¹School of Physical and Mathematic Sciences, Nanjing Tech University, Nanjing, Jiangsu, China

²Business School, Nanjing Xiaozhuang University, Nanjing, Jiangsu 211171, China

³School of Hongshan, Nanjing University of Finance and Economics, Nanjing, Jiangsu 210003, China

Correspondence should be addressed to Rong Wang; wxr920@163.com

Received 9 December 2020; Revised 10 February 2021; Accepted 9 March 2021; Published 19 March 2021

Academic Editor: Jose Luis Calvo-Rolle

Copyright © 2021 Yun Yang et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Based on the data relevant to China's tourism industry and ecological environment from 2005 to 2018, the entropy method and the coupling coordination degree model were used to analyze the coupling degree and coupling coordination degree of the tourism industry's development and the ecological environment, and the GM (1.1) gray model was used to predict these values in the future. The model provided predictions and illustrated the trend in the changes in the degree of coordination between the development of China's tourism industry and the ecological environment for the next five years. The results show the following. (1) The coupling degree between China's tourism industry and the ecological environment was between 0.3 and 0.5. It was in the low-level coupling stage in 2005 and 2006 and generally low in 2005–2009, lower than the average level of 0.4204. In 2018, the coupling degree between the development of China's tourism industry and the ecological environment was mainly in a stage of antagonism, reaching a peak of 0.4998 in 2013. The coupling degree declined slightly from 2013 to 2015 and then began to show an upward trend again in 2016. (2) The average coupling coordination level of China's tourism industry development and ecological environment was 0.4266, which is in the medium coupling coordination stage. From 2007 to 2013, it was mainly in the phase of moderate coupling and coordination and high coupling and coordination from 2014 to 2018. (3) From the prediction results, the coupling degree will enter the coupling degree running-in stage in 2021 and the extreme coordination stage in 2023, but the coupling growth level during the running-in period will be significantly lower than the coupling coordination degree. Coordinated development of the two systems will take a long time, and active economic policies need to be adopted to promote their coordinated development.

1. Introduction

China's tourism industry has been developing rapidly since the reform and opening up in the late 1970s, which not only promoted the growth of the national economy but also provided a large number of jobs in society. For many years, tourism, as a typical low-carbon industry, has been highly regarded. However, with the rapid development of mass tourism, problems including disorderly development and blind planning of tourism resources have become increasingly serious [1]. These problems have caused the disorderly distribution of building facilities; the overexploitation of land resources has damaged the ecological environment, to a certain degree, and seriously threatened China's country's

environmental carrying capacity. Tourism, as one of the main functions of modern cities, is an important means to promote regional economic development and urbanization. The quality of a region's ecological environment directly affects the development of the region's tourism economy. The rapid development of the tourism economy also produces a series of negative effects on the regional ecological environment. Balancing the relationship between tourism and the ecological environment to attain the sustainable development of tourism is essential to the promotion of regional economic development.

Coupling and coordination is a term in physics that is used to describe the interaction, mutual influence, mutual promotion, and even coevolution of two or more discrete

subsystems of different natures in an open system based on a certain type of the connection phenomenon [2]. In recent years, with the application of sustainable development and synergy theory in tourism research, scholars around the world have conducted large amounts of research on the relationship between tourism systems and gradually found that the relationship between tourism systems shows symbiotic interactions and coupled development. Many studies have been completed on the coupling and coordination of tourism systems. At present, domestic research on the coupling and coordination of tourism systems has mainly focused on three systems: tourism, economy, and ecological environment. The coupling and coordination degree of the three systems has been quantitatively presented from the perspectives of different scales, and the coupling and coordination of the tourism industry and regional development level and the main driving force have been discussed. In general, large amounts of empirical research have been performed to analyze the coupling and coordination relationship between tourism and the tourism environment. The research is deepening, and the research content is becoming increasingly abundant. However, the prior studies on tourism environment mainly focused on the ecological and economic environments. Services, information, transportation, and other environmental elements have been rarely considered, resulting in a failure to fully analyze the tourism industry and to depict how the tourism industry and the economic, ecological, service, and social environments are coupled. In the context of the current development of tourism, some scholars have begun to pay attention to the relationship between forest ecotourism, ice and snow tourism, and the tourism environment. However, the research on the interactive relationship between tourism and tourism environment is relatively scarce, and the research is not sufficiently thorough. From the perspective of the tourism system, research is lacking on the characteristics of the evolution of the coupling relationship between tourism and the environment [3]. Therefore, in the context of the construction of an ecological civilization, it is practically significant to evaluate the coupling degree and coupling coordination degree of the development of China's tourism industry and the ecological environment. On this basis, predicting the coupling degree and coupling coordination degree of the two in the future will help promote China's tourism. The coordinated development of industry and the ecological environment is essential. In this study, we predicted the future evolution and development trend of the system based on the GM (1.1) gray prediction model. Based on the above, targeted coupling and coordination measures are proposed to provide a certain scientific reference for the attainment of sustainable development and optimal regulation.

The contributions of this paper are as follows. (1) An evaluation index system is constructed for the coupling and coordination of tourism industry development and the ecological environment, and the entropy method combined with expert advice is used to determine the weight of the evaluation index, ensuring the scientific construction of the index system from both subjective and objective

perspectives. (2) The coupling degree and the coupling coordination degree between the tourism industry and the ecological environment are measured using the coupling degree model, and their coupling relationship is determined. (3) The GM (1.1) gray forecast model is used to predict the coupling and coordination relationship between China's tourism industry and the ecological environment. (4) Countermeasures and suggestions are proposed to improve the coordinated development of the tourism industry and the ecological environment on the basis of the aforementioned empirical analysis.

The rest of this article is organized as follows. Section 2 is a literature review that provides an analysis of the previous literature and a theoretical reference for this study. Section 3 introduces the research methods and describes the building of an evaluation index system. Section 4 provides the results and analysis; estimated on the basis of the coupling degree and coupling coordination degree of the tourism industry and the ecological environment, the prediction and analysis for the next five years are carried out. Section 5 outlines the conclusions and recommendations.

2. Literature Review

As one of the common topics explored by social development, coordinating the relationship between the ecological environment and tourism development is a cornerstone for the sustainable development of human society. The tourism industry has typical environmental and resource dependence, and its development and ecological environment are inseparable. According to the research results published by foreign scholars, the relationship between the ecological environment and the tourism industry is extremely close, and the study of the two requires a study of the relationship between the ecological environment and economic activities. Many foreign scholars have studied the relationship between environmental quality and income level based on the Kuznets curve. With the rapid development of tourism in the world after the 1960s, the academic community began to pay attention to the development of the ecological environment. Research in this field both at home and abroad has mainly focused on the following aspects.

2.1. Impact of Tourism Industry on the Ecological Environment. Wright and Wall proposed the concept of the environmental impact of tourism and elaborated on the mechanism through which the environment is impacted by tourism activities [4]. Tsaura et al. stated that to achieve sustainable ecotourism development, the relationship among communities, resources, and tourists must be clarified [5]. Mbaiwa noted the negative impact on the development of tourism industry in Africa's Okavango Delta through in-depth research [2]. Based on noise, water, animals, plants, and soil, Stephen studied the impact of the natural environment on the development of the tourism industry and proposed that this impact is not only negative but there is also a certain positive impact [6]. Anisimov et al. conducted a detailed analysis of the long-term development

of the tourism industry using institutional factors and found that a sound environmental protection legal system is the basis for ensuring the healthy development of the tourism industry [7]. Cole stated that tourism development can improve the environmental quality of tourist destinations [8]. Lang analyzed the impact of tourism activities in Haikou on the soil ecological environment, and the results showed that the soil water, organic matter, and total nitrogen contents in tourist-intensive areas are lower than those in tourist-sparse areas [9]. Song analyzed the possible adverse effects of ecotourism on the ecological environment of nature reserves and proposed corresponding countermeasures around standardizing the development of ecotourism and reducing the impact of ecotourism on the ecological environment in nature reserves [10]. Zu, based on relevant data in the Chongqing Statistical Yearbook and through a combination of correlation analysis and multiple linear regression models, analyzed the impact of the development of rural tourism in Chongqing on the ecological environment, finding that Chongqing rural tourism income was positively correlated with the amount of solid waste generated in the tourist area and the proportion of environmental protection funds in the production value. The income from rural tourism in Chongqing was negatively correlated with the rate of good air quality and the per capita forest area [11].

2.2. Coupling and Coordination of the Tourism Industry and the Ecological Environment. In recent years, with the rapid development of China's tourism industry, many domestic scholars have conducted research on industrial coupling and integrated development. Many research results on the coupling mechanism, coupling management, coupling policy, and coupling path of ecological environment and tourism industry have been published, including the in-depth analysis of the interaction mechanism between the ecological environment and tourism economies from the perspective of system theory, resulting in many empirical research and theoretical analysis results [12–16]. Foreign scholars Lacitignola et al. [17, 18] and Petrosillo et al. [19] studied the relationship between the two by establishing an ecotourism system model; domestic scholars have analyzed the coupling of the tourism industry and the ecological environment and studies predicting the coupling and coordination of the two are lacking, for example, Meng, by combining the existing related research results, through the construction of a rural tourism-ecological environment evaluation index system, used the coupling and coordination evaluation model and took Xinchang County as an empirical study to explore the coupling and coordination relationship between the two [20]. Zhang et al. selected Changji Hui Autonomous Prefecture as the research area and used the coupling coordination model and the GM (1.1) prediction model to analyze the coupling and coordination relationship among the three major systems of the economy, tourism, and ecological environments. The results showed that the overall evaluation index of the three major systems from 2007 to 2016 increased. Except for a few years, the

development of the economy and tourism was generally consistent [21]. Zhao et al., using the coupling coordination model to conduct a comprehensive empirical study on the coordinated development of the three major systems in Xinjiang from 2008 to 2017 and using the GM (1.1) gray prediction model, predicted the degree of coupling coordination in the next five years. The structure showed that the degree of coupling coordination demonstrated a trend of rising fluctuations. From the perspective of coordination level, the overall coordination has gradually evolved from primary to intermediate coordination; in the next few years, the coupling of the three major systems in Xinjiang and the degree of coordination generally should show a slight increase, reaching a good level of coordination in 2021 [22]. Zhou regarded the regional economy-eco-environment-tourism industry as a giant open system with extensive connotations, a complex structure, and coupling characteristics. Based on the coupling and coordination model, the evolution of the coupling and coordination of the three major systems in the Yangtze River Economic Belt was analyzed from the time and space dimensions; the GM (1.1) gray model was used to predict the future coupling and coordination of the three major systems in the region. The results showed that from the perspective of time, the coupling coordination degree of the three major systems will maintain stability and fluctuations. The spatial development pattern is roughly high in the east and low in the west. The main constraints of coupling development are different in the east, middle, and west of the country. Except for individual provinces, the degree of coupling and coordination of the large-scale system showed a slight upward trend [23]. Zhang et al., based on the coupling model, calculated the degree of coupling and coordination index between tourism and ecological environment quality in China's coastal regions, analyzed their temporal and spatial patterns and their evolution characteristics, and then used the GM (1.1) prediction model to predict the future level of tourism in China's coastal areas and the coupling degree of the ecological environment based on the gray system theory, hoping to provide the government with decision-making reference [24]. Zhang built a coupling and coordination model between the three systems based on the analysis of the interaction and coupling mechanism of tourism, land use, and ecological environment system and established the coupling relationship between them in the Central Plains Economic Zone. Quantitative evaluation and prediction of the coordination relationship showed that the three experienced a rapid growth trend from 2012 to 2014, and the degree of coordination continued to increase [25].

In summary, domestic and foreign scholars conducted considerable research on the relationship between environment and tourism, including both qualitative and quantitative research results. Compared with foreign countries, Chinese scholars' research started later on these issues. The study of environmental and tourism relations has mainly focused on sustainable tourism development, tourism carrying capacity, and tourism capacity, whereas China has focused on omnidirectional and multiangle analysis. The academic research on coupling coordination degree is

mainly based on the coupling and coordinated development of tourism economy and the environment, and the research scope mostly focused on certain urban agglomerations or a certain province [26–31]; few studies were conducted nationwide using in-scale multiscale analysis, with research lacking on predictive future issues. To this end, we selected the national scope as the research object and introduced the coupling degree and coupling coordination degree model to measure the coupling degree and coupling coordination degree between tourism industry development and the ecological environment in China from 2005 to 2018 and introduced the gray system. The theory predictions are expected to provide a decision-making basis for future sustainable development and provide a reference for the future development of China's tourism industry in coordination with the ecological environment.

3. Methods

3.1. Entropy Method. Existing studies mostly used the expert method and the analytic hierarchy process for determining index weight. Such methods require subjective experience when assigning weight. If different experts are selected, the analysis results will differ. Compared with the subjective weighting method, which has many shortcomings such as more qualitative components and less persuasive power, the entropy method is based on the original index data and mathematically calculates the weight. The entropy method objectively determines the weight of the evaluation index using the size of the observation value information. If there are m systems to be evaluated and n evaluation indices, then the original indicator data matrix can be expressed as

$$X'_{ij} = \frac{X_{ij} - \min(X_{1j}, X_{2j}, \dots, X_{nj})}{\max(X_{1j}, X_{2j}, \dots, X_{nj}) - \min(X_{1j}, X_{2j}, \dots, X_{nj})} + 1, \quad i = 1, 2, \dots, n, j = 1, 2, \dots, m. \quad (1)$$

To calculate the smaller the better indicator,

$$X'_{ij} = \frac{\max(X_{1j}, X_{2j}, \dots, X_{nj}) - X_{ij}}{\max(X_{1j}, X_{2j}, \dots, X_{nj}) - \min(X_{1j}, X_{2j}, \dots, X_{nj})} + 1, \quad i = 1, 2, \dots, n, j = 1, 2, \dots, m. \quad (2)$$

For convenience, the data after non-negative processing are still recorded as X_{ij} .

Step 2. Determine the weight of the indicator: The method of determining the weight of an index based on the entropy weight involves quantifying and comprehensively processing all the information of the unit to be evaluated. The weighting of each factor based on the entropy method can reduce the complexity of the evaluation process. The entropy method was used to

$X = (x_{ij})_{m \times n}$. If the difference between the index values X_{ij} is larger, the comprehensive evaluation effect is better; if the index values are the same, the comprehensive evaluation is invalid.

Entropy is mainly used to measure uncertainty in the field of information theory. The size of the entropy depends on the amount of information: the larger the amount of information, the less the uncertainty and the lower the entropy value; conversely, the larger the amount of information, the higher the entropy value. Combined with the entropy property, we can judge the disorder degree and randomness of a certain scheme and the degree of dispersion of a certain index. This means that we can calculate the weight of each index based on the information entropy, which provides an important basis for comprehensive multi-index evaluation work. When using the entropy method to determine the weight of each index, it is necessary to standardize the data in advance. This reduces the bias of results due to subjective factors. The specific steps are as follows:

Step 1. Data standardization processing: The entropy method can skip the standardization process without any dimension influence. The principle is finding the proportion of a certain indicator in different schemes in the same indicator. If there are negative data, it needs to be non-negative to process the data. The data should be translated to ensure that the logarithm of the entropy is meaningful.

The bigger the better indicator is calculated as follows:

study the determination of the index weights. First, based on the selected evaluation indicators, an $n \times m$ raw data matrix can be obtained as follows:

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix}_{n \times m}, \quad (3)$$

where n is the number of systems and m is the evaluation index.

Secondly, the same trend is used to process the target index, and a positive matrix is obtained. After the evaluation, because the above indicators have advantages and disadvantages, to ensure that all indicators are high-quality indicators, the low-quality index should be processed by the inverse method. The corresponding matrix is obtained:

$$Y = \begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ y_{n1} & y_{n2} & \cdots & y_{nm} \end{bmatrix}_{n \times m}. \quad (4)$$

The matrix is normalized as follows:

$$z_{ij} = \frac{y_{ij}}{\sum_{i=1}^n y_{ij}}, \quad j = 1, 2, \dots, m, \quad (5)$$

where z_{ij} is the element in the normalized matrix.

When calculating the entropy weight of the evaluation index, the calculation formula is as follows:

$$H(x_j) = -k \sum_{i=1}^n z_{ij} \ln z_{ij}, \quad j = 1, 2, \dots, m, \quad (6)$$

where k is the adjustment factor, $k = 1/\ln n$, and z_{ij} is the normalized value of the j th indicator of the first evaluation unit. The result of converting the entropy value of the evaluation index into the weight value is as follows:

$$d_j = \frac{1 - H(x_j)}{m - \sum_{j=1}^m H(x_j)}, \quad j = 1, 2, \dots, m, \quad (7)$$

where $0 \leq d_j \leq 1$, $\sum_{j=1}^m d_j = 1$.

3.2. Coupling Coordination Degree Evaluation Method

3.2.1. Coupling Theory. The relationship between different systems or elements and the degree of influence, that is, the degree of coupling, is a concept in physics. The degree of coordination and the interaction between different systems or elements is called coordination, which reflects the sustainable development between various systems or elements. The coupling coordination degree is used to define the degree of coordination and mutual influence between different systems or elements, which is a visual representation of the degree of correlation between systems, and between the systems, reflecting the degree of coordination. The tourism industry development-ecological environment system is particularly complex, including environmental, social, and economic factors. The development of the tourism industry, especially its sustainable development, is inseparable from the support of a healthy ecological environment. As an important part of the ecological environment, the tourism industry enriches the ecological environment, and the two factors jointly form a coupling system in which the two factors coordinate and influence each other. The tourism industry has achieved its own

development relying on the natural elements of the ecological environment (such as rivers, vegetation, and soil). The tourism industry is an economic activity through which humans develop and use natural resources. Knowledge of environmental protection and reducing environmental stress features is required.

The degree of coupling selected for this study is the degree of correlation between the different indicators of the development of the tourism industry and the ecological environment and the degree of influence of those indicators. The degree of coupling coordination is defined as the degree of coordinated development of the two subsystems. An evaluation index system should be constructed to determine the degree of coupling and coupling coordination between the two factors to understand the degree of coordination, the degree of influence, and the level of mutual integration.

3.2.2. Coupling Degree Model. According to the capacity coupling system model in physics, the coupling degree model of tourism industry development and ecological environment can be constructed:

$$C_m = \left\{ \frac{u_1 u_2 \cdots u_m}{\prod (u_i + u_j)} \right\}^{1/m}, \quad (8)$$

$$C = \left[\frac{u_1 u_2}{(u_1 + u_2/2)^2} \right]^2.$$

The value range of C is $C \in [0, 1]$. When $C=0$, the coupling degree between the tourism industry and ecological environment is the lowest, reflecting that almost no correlation between the two systems, and the coupling system tends to develop in a disorderly manner. When $C=1$, the coupling degree between the tourism industry and the ecological environment is the largest, indicating that the two subsystems are in the stage of amphoteric resonance coupling, tending to orderly development. In the comparative analysis of the coupling degree of provinces (regions and cities) in the country, the coupling degree model alone cannot reflect the degree of coordination between the tourism industry and the ecological environment in all provinces and cities. Given this problem, we constructed a coupling degree model to contrast and analyze the coupling and coordination of urban tourism industry development and the ecological environment in different provinces and cities and to clarify the differences in the coupling coordination degree of these provinces, combined with the comparative analysis results based on the coupling coordination degree model for tourism industry development and ecological environment systems. The degree of coordination between the internal indicators was calculated as follows:

$$D = \sqrt{C \cdot T}, \quad (9)$$

$$T = \alpha u_1 + \beta u_2,$$

where D represents the degree of coupling coordination, T is the comprehensive coordination index of the two subsystems of tourism industry development and ecological

environment, and α and β represent the importance of the tourism industry subsystem and the ecological environment subsystem, respectively, for analyzing the coupling of the subsystems. When the relationship is the same, the two are just as important. Therefore, referencing previous research experience, both α and β were assigned a value of 0.5. On the basis of previous studies, we divided the coupling degree and coupling coordination degree of tourism industry development and ecological environment into four grades. The standards and types are shown in Table 1.

3.3. GM (1.1) Gray Prediction Method. The tourism industry development and the eco-environment systems are quite large, involving two major systems. They contain many indicators and have a limited sample size. The entire coupling trend cannot be predicted by ordinary linear or nonlinear models, which have high uncertainty. Therefore, by comparing the difference with other research methods, we thought that the GM (1.1) gray forecasting method would be more suitable. The GM (1.1) gray forecasting method can be used to solve systems with incomplete information, such as series forecasting and catastrophe forecasting. The GM (1.1) gray forecasting model is superior to traditional time series forecasting methods when solving problems with small samples or incomplete data and can maintain higher accuracy when predicting future situations. As such, we built a tourism and ecological environment evaluation index system based on the entropy method and used the GM (1.1) model to predict future changes, aiming to improve the coordinated development of tourism and the ecological environment and reasonably recommend policy measures based on the predicted results, providing a reference basis for government decision-making. The modeling method and specific steps of the GM (1.1) gray forecasting method are as follows.

Step 1. Data processing. First, the original time series is processed using data to reduce the randomness of the original time series, and the processed time series is named a generated column.

Let $X^{(0)} = \{X^{(0)}(1), X^{(0)}(2), X^{(0)}(3), \dots, X^{(0)}(n)\}$ be the raw data of an indicator to be predicted and calculate the level ratio of the series $\lambda(t) = X^{(0)}(t-1)/X^{(0)}(t)$, $t = 2, 3, \dots, n$. The GM (1.1) model prediction is valid when most of the levels are added in the $(e^{(-2/n+1)}, e^{(2/n+1)})$ interval. Otherwise, the data need to be reprocessed. For example, the data are opened, logarithmically processed, and smoothed. The preprocessed data are smoothed using three-point smoothing, which can be processed as follows:

$$\begin{aligned} X^{(0)}(t) &= \frac{[X^{(0)}(t-1) + 2X^{(0)}(t) + X^{(0)}(t+1)]}{4}, \\ X^{(0)}(1) &= \frac{[3X^{(0)}(1) + X^{(0)}(2)]}{4}, \\ X^{(0)}(n) &= \frac{[X^{(0)}(n-1) + 3X^{(0)}(n)]}{4}. \end{aligned} \quad (10)$$

Completing the preprocessing accumulates the generated processing data. In this process, the first data of the column are generated, that is, the data of the original sequence; then, the second data of the original sequence are added to the first data of the original sequence to obtain the generated sequence. The second data are then looped continuously to obtain the complete generated column.

According to $X^{(1)}(k) = \sum_{n=1}^k X^{(0)}(n)$, we obtain a new series:

$$X^{(1)} = \{X^{(1)}(1), X^{(1)}(2), X^{(1)}(3), \dots, X^{(1)}(n)\} \quad (11)$$

The degree of randomness of this series is considerably weakened, and the stationarity is considerably increased, which can be described by the following:

$$\frac{dX^{(1)}}{dt} + aX^{(1)} = u, \quad (12)$$

where a represents the development gray number and u is the endogenous control gray number.

Step 2. Model solving. Set $Y_n = [X^{(0)}(2), X^{(0)}(3), \dots, X^{(0)}(n)]^T$, where \hat{a} is the parameter vector to be evaluated, $\hat{a} = \begin{pmatrix} a \\ u \end{pmatrix}$:

$$B = \begin{bmatrix} -\frac{1}{2}(X^{(1)}(1) + X^{(1)}(2)) & 1 \\ -\frac{1}{2}(X^{(1)}(2) + X^{(1)}(3)) & 1 \\ \dots & \dots \\ -\frac{1}{2}(X^{(1)}(n-1) + X^{(1)}(n)) & 1 \end{bmatrix}. \quad (13)$$

Then, the model can be expressed as follows:

$$Y_n = B\hat{a}. \quad (14)$$

From the least squares method, we obtain the following:

$$\hat{a} = (B^T B)^{-1} B^T Y_n. \quad (15)$$

Solving this differential equation yields a discrete time response function for gray prediction as follows:

$$\hat{X}^{(1)}(t+1) = \left[X^{(0)}(1) - \frac{u}{a} \right] e^{-at} + \frac{u}{a}, \quad t = 0, 1, 2, \dots, n-1, \quad (16)$$

where $\hat{X}^{(1)}(t+1)$ is the resulting accumulated predicted value, and the predicted value is restored as follows:

$$\hat{X}^{(0)}(t+1) = \hat{X}^{(1)}(t+1) - \hat{X}^{(1)}(t). \quad (17)$$

If the data are preprocessed, they must be transformed to reflect the actual predicted value.

TABLE 1: Classification of coupling degree and coupling coordination degree.

C value interval	Coupling type	D value interval	Coupling coordination type
$0 < C \leq 0.3$	Low	$0 < D \leq 0.3$	Low
$0.3 < C \leq 0.5$	Antagonistic	$0.3 < D \leq 0.5$	Moderate
$0.5 < C \leq 0.8$	Run-in	$0.5 < D \leq 0.8$	High
$0.8 < C < 1$	High	$0.8 < D < 1$	Extreme

Step 3. Through the error test of the gray prediction model in Table 2, the accuracy of the result is judged according to the P value and the C value.

4. Results and Discussion

4.1. *Evaluation Index System Construction.* From the above analysis, a coupling relationship exists between the tourism economy and the ecological environment, and the two show the characteristics of mutual influence, mutual restriction, and common development. Therefore, constructing an appropriate evaluation index system would provide the basis for evaluating the coordination degree of economic tourism development and the ecological environment. However, no unified measurement standard exists for the relevant indicators of economic development and resource environmental evaluation [32], and the tourism economy and ecological environment system involve a wide range of indicators, making it impossible to evaluate each one. Therefore, the evaluation index system in this article was constructed based on the research results of Chen [33] and Feng [34] and according to the statistical data collected in this study, following the overall correspondence, appropriate proportions, prominent focus, the principle of the combination of the total and average indexes, data availability, and comparability. The index system in this study was constructed as follows:

- (1) *Subjective Screening.* The subjective component of the indicator system was mainly using questionnaires. Questionnaires were issued to 20 experts, business managers, government officials, and university teachers in the field of tourism and ecological environment, and the recovery rate and efficiency were 100%. Then, the fuzzy comprehensive evaluation method was used to analyze the results of the questionnaire.
- (2) *Statistical Screening.* The screened indicators were determined and analyzed, and the coefficient of difference of the remaining 30 indicators was calculated. The boundary value of the coefficient of the difference was set to 0.05, and any index with the coefficient of difference less than this value was removed.
- (3) *Index Weights.* The deterministic evaluation index weights were established based on the entropy weight method, which is a method used to quantify and comprehensively process the information of all units to be evaluated. We used the entropy method to determine the index weights.

TABLE 2: Gray forecast accuracy test level standard.

Model accuracy level	P	C
1 pole (excellent)	$0.95 \leq P$	$C \leq 0.35$
2 poles (good)	$0.80 \leq P < 0.95$	$0.80 < C \leq 0.5$
3 poles (qualified)	$0.70 \leq P < 0.8$	$0.5 < C \leq 0.65$
4 poles (failed)	$P < 0.70$	$0.65 < C$

In summary, we divided the indicators into two major systems as follows: the tourism industry system or the ecological environment system. The former includes economic benefits and infrastructure systems, and the latter is subdivided into four subsystems: social, service, ecological, and economic environments (Table 3). To prevent subjective factors from affecting the index weight calculation results, the weights of all indicators were confirmed based on the entropy weighting method to ensure scientific evaluation results.

4.2. *Data Source.* The raw tourism industry development and ecological environment data were derived from the annual China Tourism Statistics Yearbook and the statistical yearbooks and statistical bulletins of various provinces and cities; there are no raw data indicators in the statistical yearbooks, which were mainly calculated based on the original data from 2005 to 2018.

4.3. *Results of Coupling Degree and Coordination Degree Measurement.* According to the abovementioned established tourism industry and ecological environment evaluation index system, based on the coupling degree and coupling coordination degree model, the coupling and coordination degrees in 2005–2018 were calculated.

4.3.1. *Analysis of Coupling Degree Results.* From the calculation results in Table 4, the coupling degree between China’s tourism industry and the ecological environment was between 0.3 and 0.5. According to the above classification of coupling degrees, the coupling degree between China’s tourism industry and the ecological environment was in an antagonistic stage. Early 2005 and 2006 were in the low-level coupling stage, indicating that the degree of coupling was gradually increasing, but the overall level of coupling during 2005–2009 was low, lower than the average level of 0.4204, and the coupling degrees after 2009 were higher than average. In 2013, the coupling degree between the two reached the highest point, 0.4998, which is very low in the running-in phase of the coupling type. In 2018, the coupling degree between the tourism industry and the ecological environment was 0.4825, which is 1.95 times that of 2005. From the calculation results of the coupling degree,

TABLE 3: Coupling evaluation index system of the tourism industry and the ecological environment.

System	Subsystem	Evaluation index	Nature	Weight
Tourism industry	Economy	Number of tourists (10,000 people)	+	0.1621
		Tourism income growth rate (%)	+	0.0522
		Tourism industry profits and taxes (10,000 yuan)	+	0.0913
		Tourism income as a percentage of GDP (%)	+	0.0765
		Proportion of tourism practitioners (%)	+	0.1012
	Infrastructure	Number of tourist attractions	+	0.1822
		Tourist advisory service center	+	0.1141
		Tourism industry proportion of tertiary industry	+	0.0912
		Tourism infrastructure investment (10,000 yuan)	+	0.1292
		Ecological environment	Economy	GDP per capita (yuan/person)
Total import and export (USD 10,000)	+			0.0121
Per capita disposable income (yuan/person)	+			0.0681
Total retail sales of per capita social consumer goods (yuan/person)	+			0.0231
The ratio of three production to GDP (%)	+			0.0455
Average wage level of urban workers (yuan/person)	+			0.0512
Per capita park green area (m ² /person)	+			0.0121
Pollution-free treatment rate of domestic garbage (%)	+			0.0123
Proportion of natural reserves in the jurisdiction (%)	+			0.0612
Ecology	Industrial wastewater discharge (10,000 tons)			-
	Industrial carbon dioxide emissions (10,000 tons)		-	0.0887
	Industrial soot emissions (10,000 tons)		-	0.0888
	Green coverage rate in built-up areas (%)		+	0.0561
	Railway density km/million km ²		+	0.0762
	Service		Internet penetration rate (%)	+
Grade road density (km/km ²)			+	0.0231
Mobile phone penetration rate (ministry/100 people)			+	0.0581
Population urbanization rate (%)			+	0.0486
Society	Average number of students per 10,000 persons		+	0.0561
	Urban population density (person/km ²)		+	0.0181
	Electricity consumption per capita (kwh)	+	0.0266	

TABLE 4: Value and grade of coupling degree of the tourism industry and ecological environment.

Year	Tourism industry composite index U_1	Eco-environmental comprehensive index U_2	Comprehensive coordination index T	Coupling degree C	Coupling coordination degree D	Coupling level	Coupling coordination level	Coupling coordination characteristics
2005	0.0311	0.4419	0.2365	0.2478	0.2421	Low	Low	Tourism industry relatively lagging
2006	0.0349	0.4971	0.2660	0.2476	0.2566	Low	Low n	Tourism industry relatively lagging
2007	0.0721	0.5812	0.3267	0.3133	0.3199	Antagonistic	Moderate	Tourism industry relatively lagging
2008	0.0912	0.6533	0.3723	0.3279	0.3494	Antagonistic	Moderate	Tourism industry relatively lagging
2009	0.1523	0.7512	0.4518	0.3744	0.4112	Antagonistic	Moderate	Tourism industry relatively lagging

TABLE 4: Continued.

Year	Tourism industry composite index U_1	Eco-environmental comprehensive index U_2	Comprehensive coordination index T	Coupling degree C	Coupling coordination degree D	Coupling level	Coupling coordination level	Coupling coordination characteristics
2010	0.2533	0.5632	0.4083	0.4626	0.4346	Antagonistic	Moderate	Tourism industry relatively lagging
2011	0.3209	0.4834	0.4022	0.4897	0.4438	Antagonistic	Moderate	Tourism industry relatively lagging
2012	0.4311	0.4612	0.4462	0.4997	0.4722	Antagonistic	Moderate	Tourism industry relatively lagging
2013	0.4634	0.4312	0.4473	0.4998	0.4728	Antagonistic	Moderate	Ecological environment relatively lagging
2014	0.5871	0.4287	0.5079	0.4939	0.5008	Antagonistic	High	Ecological environment relatively lagging
2015	0.6523	0.3903	0.5213	0.4840	0.5023	Antagonistic	High	Ecological environment relatively lagging
2016	0.6809	0.3912	0.5361	0.4814	0.5080	Antagonistic	High	Ecological environment relatively lagging
2017	0.7101	0.4096	0.5599	0.4817	0.5193	Antagonistic	High	Ecological environment relatively lagging
2018	0.7623	0.4455	0.6039	0.4825	0.5398	Antagonistic	High	Ecological environment relatively lagging
Average value	0.3745	0.4949	0.4347	0.4204	0.4266	Antagonistic	Moderate	Tourism industry relatively lagging

the coupling degree between China’s tourism industry and ecological environment during 2005–2018 was poor, being in a state of mutual competition for a long time. The two interacted less, mainly due to the lack of development of the tourism industry at the time and the ecological environment was not a focus. The 18th National Congress of the Communist Party of China introduced the overall layout of the five-in-one, incorporating ecological civilization. As a result, environmental protection received more attention; the interactive relationship between tourism industry development and the ecological environment has become the focus of academia. From the measurement results of the coupling degree, the coupling degree increased significantly after the 18th National Congress of the Communist Party of China,

reaching its peak in 2013. The coupling degree declined slightly from 2013 to 2015 and then began to show an upward trend in 2016, but the rate of increase tended to stabilize the growth trend.

From the line chart of Figure 1, the coupling degree has rose for a long time since 2005, and the fluctuation range was not stable. The rising speed in 2005–2012 was the fastest during the rapid development stage, showing that the tourism industry developed rapidly during the period of rapid economic growth. The policy measures implemented to stabilize the growth of the structure promoted the rapid improvement in the coupling between the two. During the period of 2013–2018, although the growth rate was not high, it was steady, indicating that China had paid more attention

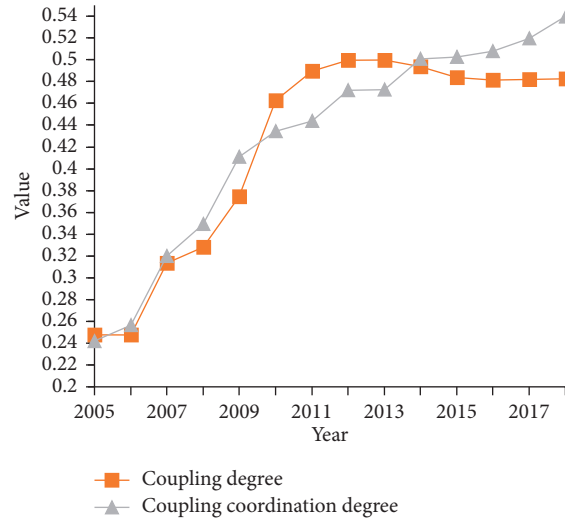


FIGURE 1: Coupling degree and coupling coordination degree of China's tourism industry development and the ecological environment in 2005–2018.

to quality improvement during the transition from the high-speed to the high-quality growth stage, so the coupling degree between the two continuously improved.

4.3.2. Analysis of Coupling Coordination Degree Results.

Table 4 shows that the coupling degree between China's tourism industry development and ecological environment was not high. The average level during the whole sample period was 0.4266, which is the moderate coupling and coordination stage. Low coupling was found in 2005 and 2006, indicating that the development of the tourism industry and the ecological environment was basically in disorder. The main reason for this finding is that the early economic development was lagging. The main driver of the country's development was industry, with tertiary industry developing slowly along with people's disposable income. Most of people's income was used for daily consumption, and the lagging concept of tourism restricted the development of the tourism industry. Therefore, the tourism industry was relatively lagging, and the relationship with the ecological environment was not obvious. In 2007–2013, the degree of coupling further improved because China's investment in the tourism industry and the quality of the ecological environment were increasing. The interaction between the two produced a preliminary link. The concept further improved, and the requirements for the ecological environment have been increasingly raised. Therefore, as the development of the tourism industry became concerned with the protection of the environment, the coupling and coordination of the two improved significantly, and in 2013, the tourism industry lagged behind. The ecological environment is relatively lagging behind because the national civilization has strengthened the construction of ecological civilization since the 18th National Congress, paying more attention to the protection of the ecological environment. The coupling and coordination degree of the two further improved; 2014–2018 demonstrated high coupling and

coordination, and the coupling degree of the two reached a peak. The coupling coordination degree in 2018 reached 0.5398, which is 2023 times that of 2005. The coupling coordination degree considerably improved in recent years. The emergence of a series of new forms of tourism such as ecotourism, recreation and tourism, and health tourism has tied tourism and the ecological environment together, and the people's ecological concept has been continuously enhanced, so ecological environmental protection has been viewed as an opportunity to promote the tourism industry. Reforms and upgrading have accelerated the integration and development of the two, and the coupling and coordination between the two have achieved remarkable results.

From the line chart of China's tourism industry and ecological environment coupling degree (Figure 1), the coupling coordination degree shows a growth trend; the overall level is continuously improving with both rapid and stable growth stages. During 2012 and 2013 to 2018, the postcoupling coordination degree of the 18th National Congress of the Communist Party of China increased steadily, reflecting that the coordination between the development of China's tourism industry and the ecological environment has continuously improved. In the past few years, there have been calls for a beautiful China, quality tourism, and other policy guidance. The coordination and efficiency of the two have risen steadily, presenting a development trend.

In summary, the coupling degree and coupling coordination degree of China's tourism industry development and ecological environment are generally increasing; this rising trend is related to the implementation of China's economic policy. To determine whether the degree of coupling and coupling coordination between the two stages of development will maintain steady growth and whether the integration stage and extreme coupling coordination become the focus of social attention, we further used the GM (1.1) gray prediction model. It is predicted that the coupling degree and coupling coordination degree between China's tourism industry development and ecological environment

TABLE 5: Error test based on the GM (1.1) gray prediction model.

Year	Coupling degree C value				Coupling coordination D value				
	Observation value	Fitting value	Relative error (%)	Relative error	Observation value	Fitting value	Relative error (%)	Relative error (%)	
2005	0.2478	0.2698	-0.022	-8.8781	0.2421	0.2466	-0.0045	-0.0186	
2006	0.2476	0.2602	-0.0126	-5.0889	0.2566	0.2432	0.0134	0.0522	
2007	0.3133	0.3012	0.0121	3.8621	0.3199	0.2891	0.0308	0.0963	
2008	0.3279	0.3121	0.0158	4.8185	0.3494	0.3045	0.0449	0.1285	
2009	0.3744	0.3534	0.021	5.6090	0.4112	0.4118	-0.0006	-0.0015	
2010	0.4626	0.4521	0.0105	2.2698	0.4346	0.4393	-0.0047	-0.0108	
2011	0.4897	0.4834	0.0063	1.2865	0.4438	0.4521	-0.0083	-0.0187	
2012	0.4997	0.4823	0.0174	3.4821	0.4722	0.4788	-0.0066	-0.0140	
2013	0.4998	0.4882	0.0116	2.3209	0.4728	0.4823	-0.0095	-0.0200	
2014	0.4939	0.4833	0.0106	2.1462	0.5008	0.5021	-0.0013	-0.0030	
2015	0.484	0.4856	-0.0016	-0.3306	0.5023	0.4902	0.0121	0.0241	
2016	0.4814	0.4888	-0.0074	-1.5372	0.508	0.4899	0.0181	0.0356	
2017	0.4817	0.4904	-0.0087	-1.8061	0.5193	0.4833	0.036	0.0693	
2018	0.4825	0.4912	-0.0087	-1.8031	0.5398	0.5325	0.0073	0.0135	
Test value		$C = 0.2561; P = 0.9677$				$C = 0.1521; P = 0.9876$			

TABLE 6: Predicted values.

Year	Coupling degree C value	Coupling coordination D value
2019	0.4621	0.5521
2020	0.4901	0.6129
2021	0.5123	0.6712
2022	0.5212	0.7421
2023	0.5688	0.8018
2024	0.5839	0.8109

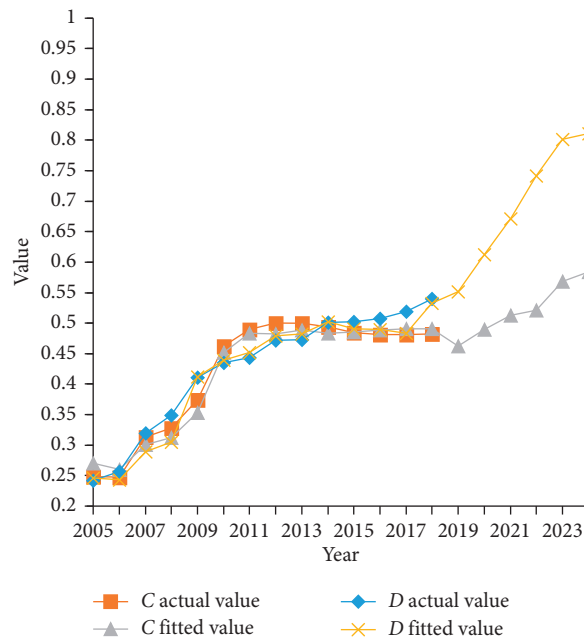


FIGURE 2: Trends in the predictive indicators.

in the next five years will provide theoretical reference for the implementation of policies.

4.4. Prediction and Analysis of Coupling Coordination Degree between China's Tourism Industry Development and the Ecological Environment. In 2018, Xi Jinping's ecological civilization thought was formally established. New development concepts, ecological civilization, and beautiful China were enshrined in the Constitution, and more emphasis was placed on the protection of the ecological environment. The report of the 19th National Congress proposed that ecological civilization construction will be the cornerstone of China's sustainable development, the key to which is the improvement in ecological efficiency. In the high-quality development stage, China's tourism industry development and the ecological environment are in a critical period of transformation. To understand the changing trends of the two in the next five years, we adopted the GM (1,1) gray prediction model. The degree of coupling and coupling coordination was dynamically simulated. After verification by the model, the coupling degree fit $C = 0.2561$ and $P = 0.9677$ and the coupling coordination fit $C = 0.1521$ and $P = 0.9876$ (Table 5). According to the accuracy level of the previous model, $0.95 \leq P$ and $C \leq 0.35$, which are excellent for prediction. That is, the coupling degree of tourism industry development and the ecological environment can be predicted in China from 2019 to 2024. The prediction results are provided in Table 6 and Figure 2, which show that the degree of coupling will increase steadily from 2019 to 2024, the coupling degree is reached as of 2021, and the growth rate will significantly improve. In addition, the predicted value of coupling coordination degree also increases significantly. In 2023, it enters the extreme coordination stage, and the synergistic development effect of the two will significantly improve. Generally, the coupling degree of China's tourism industry development and the ecological environment in the five-year period will rise and the coupling level and coordination level will increase by one level, but from Figure 2, the degree of coupling and coupling coordination can be improved. The development of the tourism industry and the coordination of the ecological environment will still take a long time, so it is necessary to adopt positive economic policies to promote the coordinated development of the two. In the next part of this paper, we provide suggestions for the coordinated development of the two.

5. Conclusions and Recommendations

5.1. Conclusions. Forty years since the reform and opening up, the vigorous development of China's tourism industry has enhanced the public's awareness of ecological environmental protection and provided an important driving force for environmental protection. However, the blind development of tourism resources in recent years has created problems for the ecological environment and its sustainable development. This paper introduced the coupling coordination model and measured the coupling degree and

coupling coordination degree of China's tourism industry development and the ecological environment in 2005–2018, comparing tourism industry and ecology from two dimensions: time series evolution and prediction. The spatial and temporal evolution of the coupling degree between the two major systems was analyzed to provide policy reference for the sustainable development of tourism and the ecological environment. The main conclusions are as follows:

- (1) The coupling degree between China's tourism industry and the ecological environment was between 0.3 and 0.5. It was in the low-level coupling stage in 2005 and 2006 and was generally low in 2005–2009, below the average level of 0.4204. From 2007 to 2018, the coupling degree between the development of China's tourism industry and the ecological environment was mainly in the antagonistic stage, and the coupling degree was not high. It peaked at 0.4998 in 2013, which was close to the value in the running-in period. The coupling degree declined slightly from 2013 to 2015 and then showed an upward trend again, but the rate of increase slowed, tending to a steady growth trend.
- (2) China's tourism industry development and ecological environment coupling coordination degree was not high. The average level during the whole sample period was 0.4266, which is the moderate coupling coordination stage. In 2005 and 2006, it was in the low coupling coordination stage. In 2013, it was mainly in the moderate coupling coordination stage and 2014–2018 were in the high coupling coordination stage. The coupling coordination degree considerably improved, the closeness of the two deepened, and the interaction response increased. The degree of coupling coordination also showed a rising trend first and then slowing. The benefits of coupling coordination steadily increased, and the fluctuation range of coupling coordination degree was slightly larger than coupling degree.
- (3) Judging from the prediction results of the degree of coupling and coordination, it will steadily increase from 2019 to 2024, entering the stage of running-in in 2021, with the growth rate increasing significantly. In addition, the predicted value of the degree of coupling coordination will significantly increase. In 2023, it will enter the stage of extreme coordination, and the coordinated development effect of the two will be significantly improved. However, the coupling growth level during the running-in period will be significantly lower than the coupling coordination degree. The coordinated development of the two will still require a long time, so it is necessary to adopt active economic policies to promote the coordinated development of the two areas.

5.2. Recommendations. Through the calculation of the coupling coordination degree and the prediction of the future, we found that the coordinated development of the

two will still require a long time, so it is necessary to adopt active economic policies to promote the coordinated development of the two areas:

- (1) *Strengthening Ecological Environment Management.* Strengthening the level of ecological environment governance can create favorable conditions for the implementation of relevant policies and benefit the tourism industry. The growth of the tourism industry is also important to the balance of the ecosystem. Given the current tourism and environment situation in the country, the coordination and coordination are insufficient and there is still much room for improvement in terms of coordination and synchronization. In the future, all localities should increase the intensity of reforming regional ecological civilization systems, pay attention to the coupling and coordination between tourism industry development and ecological environment management, and incorporate them into the system [35]. In the comprehensive project management system, especially in planning regional tourism, we must adhere to the idea of macrocoordination, promote work in stages, strive to achieve major results, and eliminate some factors that hinder the development of regional tourism systems and tourism industry [36].
- (2) The tourism industry development is ahead, and the ecological environment is lagging behind. In some places, the development of the tourism industry is pursued in the form of sacrificing ecological resources so that the degree of coupling and coordination between the two is declining. For regions that do not pay attention to the construction of an ecological civilization, it is necessary to promote the concept of the ecological civilization and guide and encourage them to launch green tourism products. Considering the carrying capacity of the ecological environment, the model of coupling and coordination between the development of the tourism industry and the construction of ecological civilization must be explored, innovating the tourism + format [37] and coordinating the relationship between the tourism industry and the ecological environment, making the tourism industry in this region develop in a sustainable direction [38].
- (3) *Types of Advanced Ecological Environment Development and Lagging Development of the Tourism Industry.* It is necessary to slightly support the tourism industry to realize the value of ecological environment resources to the maximum extent, concentrating on improving the quality of the tourism industry and maximizing the value of the tourism industry. During the period of economic restructuring in China, the development of the tourism industry has faced many challenges. The regional tourism industries can be actively cultivated with tailor-made tourism products, such as cultural

blocks, forest towns, beautiful towns and villages, and county-level tourism, to strive to become a national tourism demonstration unit and to build a tourism-based infrastructure to build the tourism industry. A new format cluster could be created for the development of the regional tourism industry [39].

- (4) *Strengthen the Role of the Government in Macroeconomic Regulation and Control.* The coordinated development of the eco-environment and tourism industry depends on the government's macroeconomic regulation and control. Therefore, a tourism industry and eco-environment coordination policy committee should be set up to conduct decision-making work [40]. Professionals should develop supporting facilities for the relationship and coordinated development of the two. The strategy is adjusting the relationship between the various aspects so that the degree of coupling and coordination between the two can be improved.

5.3. Research Limitations. We studied the coupling and coordination relationship between the development of the tourism industry and the ecological environment. Although some valuable conclusions were obtained, there are still certain shortcomings, which are mainly reflected in the following aspects:

- (1) The tourism industry and the ecological environment are huge systems, and the many evaluation indicators cannot all be listed. They can only be determined by referring to the research results of previous scholars and the indicator screening method adopted in this article. Therefore, incomplete research indicators may cause differences in results.
- (2) The prediction of the degree of coupling between the two systems in this article reflects the future change trend, which is expected to provide the government with a reference for decision-making. However, due to China's large area and the large differences between regions, the degree of coupling may differ in different regions. Due to space limitations, we did not study specific regional differences. Therefore, the research in this article only reflects the overall change trend in China as a whole and does not reflect the change trend of specific regions in China. We will further study regional differences in the future, focusing on specific areas.
- (3) In terms of research method selection, many research methods are available in this field. We combined the research methods and content used by most scholars and chose a relatively suitable method for research. It was impossible to explore the application of other methods. In future studies, we will explore more research methods in this field.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

- [1] X. Y. Wang, X. J. Lu, and W. L. Zhu, "Analysis and evaluation of factors affecting the tourism development of major tourist cities in my country," *Economic Geography*, vol. 40, no. 5, pp. 201–212, 2020.
- [2] J. E. Mbaiwa, "The socio-economic and environmental impacts of tourism development on the Okavango delta, north-western Botswana," *Journal of Arid Environments*, vol. 54, no. 2, pp. 447–467, 2003.
- [3] M. Nuo, "Research on the coordinated development of ecological environment and economic coupling in inner Mongolia," *Economic Management Digest*, vol. 19, pp. 13–14, 2020.
- [4] G. Wall and C. Wright, *The Environment A Impact of Outdoor Recreation*, University of Waterloo, Waterloo, ON, Canada, 1977.
- [5] S.-H. Tsaur, Y.-C. Lin, and J.-H. Lin, "Evaluating ecotourism sustainability from the integrated perspective of resource, community and tourism," *Tourism Management*, vol. 27, no. 4, pp. 640–653, 2006.
- [6] L. J. S. Stephen, "Geography of tourism and resort development : charles A. Stansfield Jr. national council for geographic education," *Annals of Tourism Research*, vol. 23, no. 1, pp. 239–240, 1996.
- [7] A. P. Anisimov and A. Y. Ryzhenkov, "Specially protected nature territories and the development of ecological tourism," *Environmental Policy & Law*, vol. 1, pp. 325–333, 2013.
- [8] D. N. Cole, "Backcountry impact management: lessons from research," *Trends*, vol. 31, no. 3, pp. 10–14, 1994.
- [9] L. Chen, "The impact of tourism activities in Haikou on the soil ecological environment," *Journal of Shandong Agricultural University (Natural Science Edition)*, vol. 51, no. 4, pp. 46–49, 2020.
- [10] S. Huang, "The impact of ecotourism on the ecological environment of nature reserves and countermeasures," *Agricultural Technology Services*, vol. 10, pp. 111–113, 2020.
- [11] Z. Zou, "Analysis of the impact of the development of tourism economy on the ecological environment under the background of rural revitalization: taking Chongqing as an example," *Forestry Economics*, vol. 41, no. 6, pp. 73–77, 2019.
- [12] R. Z. Shi, *Study on the Coupling and Coordination Relationship between Tourism Economy and Ecological Environment in Hainan Province*, Hainan University, Haikou, China, 2015.
- [13] Q. Y. Wang, *Study on the Coordination Degree of Tourism Economy and Ecological Environment in Wuhan*, Central China Normal University, Wuhan, China, 2015.
- [14] X. X. Zou, F. J. Du, and K. M. Xiong, "Coupling research on ecological agriculture and community tourism system in Karst rocky desertification area—taking Yangchang cave in Qingzhen as an example," *China Karst*, vol. 1, pp. 406–412, 2009.
- [15] F. Cui, "Research on the coordinated development of tourism economy and ecological environment in Shanghai," *China Population Resources and Environment*, vol. 18, no. 5, pp. 64–69, 2008.
- [16] S. T. Qi and Y. J. Xie, "Study on the coupling relationship between tourism economy and ecological environment in sub-provincial cities," *City Tourism*, vol. 20, no. 1, pp. 91–97, 2013.
- [17] D. Lactignola, I. Petrosillo, and M. Catdlil, "Modelling socio-ecological tourism-based systems for sustainability," *Ecological Modelling*, vol. 206, no. 1, pp. 191–204, 2007.
- [18] D. Lactignola, I. Petrosillo, and G. Zurini, "Time dependent regimes of A tourism -based social -ecological system: period-doubling route to chaos," *Ecological Complexity*, vol. 7, no. 1, pp. 44–54, 2010.
- [19] I. Petrosillo, G. Zurlini, and E. Grato, "Indicating fragility of socio-ecological tourism-based systems," *Ecological Indicators*, vol. 6, no. 1, pp. 104–113, 2006.
- [20] T. X. Zaccarelli, "Research on the coupling and coordination of rural tourism and ecological environment and its ecological development," *Jiangsu Agricultural Sciences*, vol. 47, no. 11, pp. 30–35, 2019.
- [21] Z. Z. Zhang, Y. E. Cao, and P. P. Zhao, "A preliminary study on the coordinated development of economy-tourism-ecological environment coupling in Changji Hui Autonomous Prefecture," *Journal of Northwest Normal University (Natural Science Edition)*, vol. 56, no. 3, pp. 95–101+126, 2020.
- [22] H. L. Zhao, Z. P. Yang, F. Han, H. Shi, C. R. Wang, and J. J. Guo, "Analysis and prediction of the coupling situation of Xinjiang tourism industry-economic development-ecological environment," *Arid Land Geography*, vol. 192, no. 4, pp. 291–299, 2020.
- [23] C. Zhou, "Analysis and prediction of the coordinated development of regional economy-ecological environment-tourism industry coupling—taking provinces and cities along the Yangtze River Economic Belt as examples," *Economic Geography*, vol. 36, no. 3, pp. 86–193, 2016.
- [24] G. H. Zhang, Z. Z. Liu, and X. Y. Wang, "Analysis and prediction of coupling degree of tourism and ecological environment in China's coastal areas," *Journal of Ecoenvironment*, vol. 5, pp. 792–800, 2013.
- [25] J. Zhang, "Coupling analysis and prediction of tourism-land use-ecological environment coupling degree in the central plains economic zone," *Tourism Forum*, vol. 5, pp. 39–44, 2014.
- [26] D. H. Liu and Y. C. Yang, "Research on coordination degree of regional economy-tourism-ecological environment—taking Anhui province as an example," *Resources and Environment in the Yangtze Basin*, vol. 20, no. 7, pp. 892–896, 2011.
- [27] M. M. Pan, Y. Z. Cai, and S. H. Jiang, "Research on coupling and coordinated development of regional economy, tourism and eco-environment system—taking Xinjiang as an example," *Xinjiang Agricultural Reclamation Economy*, vol. 1, pp. 21–27, 2014.
- [28] X. J. Huang and Q. Zhou, "Preliminary study on the coupling development of ecological economy and ecological environment in Poyang lake—from the perspective of ecotourism construction," *Enterprise Economy*, vol. 4, pp. 16–20, 2015.
- [29] Q. S. Hu, X. R. He, and H. Guo, "Research on the coordinated development of tourism-ecological environment coupling in Changsha city," *Journal of Natural Science of Hunan Normal University*, vol. 41, no. 4, pp. 9–15, 2018.
- [30] Y. P. Zhang, H. Wahaha, and J. H. Dang, "Analysis of the coordinated development of tourism economy ecological

- environment in Turpan,” *Human Geography*, vol. 4, pp. 140–145, 2014.
- [31] C. Zhou, X. G. Feng, and R. Tang, “Analysis and prediction of coupling development of regional economy-ecological environment-tourism industry—taking provinces and cities along the Yangtze river economic belt as an example,” *Economic Geography*, vol. 36, no. 3, pp. 186–193, 2016.
- [32] M. H. Yang, M. M. Cao, and M. Lei, “Analysis of the coordinated evolution of economic development and resource environment in Shaanxi province,” *Human Geography*, vol. 3, pp. 125–128, 2009.
- [33] C. Y. Chen, S. G. Duan, L. Li, and X. Xiao, “Research on the coupling and coordination relationship between tourism economy and ecological environment in five Northwestern provinces,” *Forestry Economics*, vol. 42, no. 6, pp. 75–85, 2020.
- [34] F. Cui Feng, “Research on the coordinated development degree of tourism economy and ecological environment in Shanghai,” *China Population Resources and Environment*, vol. 5, pp. 64–69.
- [35] G. Khatwani and P. R. Srivastava, “Impact of information technology on information search channel selection for consumers,” *Journal of Organizational and End User Computing*, vol. 30, no. 3, pp. 63–80, 2018.
- [36] S. J. Li and M. X. Li, “Research on the coupling relationship between tourism economy and ecological environment in China’s coastal cities,” *Business Research*, vol. 62, no. 2, pp. 185–192, 2016.
- [37] L. Fabisiak, “Web service usability analysis based on user Preferences,” *Journal of Organizational and End User Computing*, vol. 30, no. 4, pp. 1–13, 2018.
- [38] J. Bao, “Research on the coordinated development of tourism and ecological environment—taking Huangshan city of Anhui province as an example,” *Journal of Anhui University (Philosophy and Social Sciences)*, vol. 37, no. 2, pp. 150–156, 2013.
- [39] X. Q. Gao, J. R. Lei, and Y. F. Ma, “Research on coordination degree of inbound tourism flow and regional economy in Gansu province,” *Journal of Lanzhou University of Arts and Science (Social Science Edition)*, vol. 2, pp. 43–49, 2019.
- [40] A. Shahri, M. Hosseini, K. Phalp, J. Taylor, and R. Ali, “How to engineer Gamification,” *Journal of Organizational and End User Computing*, vol. 31, no. 1, pp. 39–60, 2019.