



# Composite System for the Coupling Degree of Tourism Industry and Regional Ecological Environment: A Case Study of Henan Province, China

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Nat. Env. & Poll. Tech.  
Website: [www.neptjournal.com](http://www.neptjournal.com)

Received: 10-01-2019  
Accepted: 11-02-2019

## Key Words:

Coupling degree  
Tourism industry  
Environment

## ABSTRACT

Tourism is a worldwide industry, but the per capita share of tourism resources in China is relatively small, and the capacity of the tourism environment is limited. Achieving economic growth in tourism and preserving tourism resources and the ecological environment are the premise and guarantee of tourism's sustainable development under the constraints of tourism resources and ecological environment. By calculating the coupling degree of the tourism industry and regional ecological environment, the coupling degree of the regional economy and environment in a particular area can be effectively determined, and a basis for promoting the coordinated development of tourism and ecological environment can be provided. Taking Henan Province as an example, this study establishes a comprehensive evaluation system of the coupling degree between the tourism industry and regional ecological environment system, and uses the coupling model to analyse the coupling status of the two subsystems in Henan Province, and proposes policy suggestions to promote the coupling development of the two subsystems. Results show that the tourism subsystem of Henan Province increased from 0.024 in 2010 to 0.862 in 2016, and the order degree of the ecological subsystem rose from 0.070 in 2010 to 0.770 in 2016. The orderliness of the eco-environment subsystem is less than that of the tourism subsystem, indicating that further improvement of the eco-environment in Henan Province is still possible. The coupling degree of the tourism industry and regional ecological environment showed an increasing trend annually from 0.169 in 2011 to 0.766 in 2016 and exhibited a particularly large increase in 2013. This study's results can provide a theoretical reference for understanding the coordinated development between the tourism industry and regional ecological environment, promoting the coupling between them, and enhancing the sustainable tourism industry of Henan Province.

## INTRODUCTION

With the rapid advancement of social progress and the tourism industry, the eco-environmental problems of tourist destinations have become an endogenous obstacle to the promotion of the tourism industry. Various countries and regions have gradually realized the relationship between the development of tourism and the ecological environment. Tourism is a comprehensive industry. The industrial status and economic role of tourism in the development of the national economy have been gradually strengthened. Tourism also plays an increasingly important role in stimulating the national economy, driving social employment, and promoting the utilization of resources and the environment. China is currently in a process of rapid industrialization and urbanization. The increasing demand for mass and diversified consumption has opened up possibilities for tourism development. The rapid development of tourism has not only produced positive effects, but also changed the ecological environment on which human beings depend to survive. This has caused destructive damages to the environment and affected the sustainable development of tour-

ism. Tourism is a resource-based industry. From the perspective of tourism developers, the development and utilization of tourism resources inevitably change or destroy the original ecological resources. From the perspective of tourists, water pollution, vegetation destruction, and noise pollution caused by excessive tourism activities affect the local ecological environment.

Henan, an important province in central China, has an excellent history and culture and contains numerous tourist attractions. The long history and profound cultural connotations of this province attract Chinese and international tourists. As shown in Fig. 1, the tourism industry in Henan Province has developed rapidly in recent years; particularly, the number of star-rated hotels and the total number of tourist agencies have increased. Although the tourism industry of Henan Province has achieved remarkable progress, compared with the tourism products of other developed tourism provinces, those of Henan Province are not outstanding and fail to form a system and a unique tourism brand. The level of tourism industrialization is low, and the construction of the tourism service infrastructure is imperfect, and

the quality of tourism practitioners does not meet the current demands of high-end tourism. The phenomena of occupying cultivated land, destroying grasslands, and deforestation are also prominent due to the construction of houses, roads, and cableways in several tourist areas in Henan Province. These phenomena destroy the local environment and ecology to a considerable extent and cause a decline in the overall environmental quality of tourist destinations and the deterioration of the life quality of residents in tourist destinations.

### EARLIER STUDIES

Since the beginning of the 20th century, foreign scholars have been conducting preliminary explorations of the relationship between the tourism economy and the ecological environment. They focused on the impact of tourism on the environment, eco-tourism, sustainable tourism development, and tourism and ecological environment coupling. Coupled development of tourism ecology is a new product of the integration of ecological theory and tourism theory. Scholars and experts generally accept the viewpoint that the degree of tourism ecology coupling can represent the dynamic relationship between tourism and the regional ecological environment system. Butler (1991) believed that with the increasing popularity of sustainable development, tourism was regarded as an activity that could easily develop along appropriate routes. However, the lack of understanding of the complexity of tourism results in the disregard for the pollution caused by tourism to the environment. Morrison et al. (1991) believed that although tourism has been widely promoted as a tool for economic development, it may have adverse social and environmental impacts on host communities. Bithas (1997) calculated and studied an ecosystem and its environmental-economic interaction. Sun et al. (1998) examined the relationship between tourism and the environment and between tourism activities and environmental factors and investigated the mechanism of their interaction. Madan et al. (2000) posited that due to the influx of tourists, a huge demand for accommodation, hotels, and other related infrastructure and facilities emerged in tourist destinations, and this demand placed considerable pressure on the natural environment. Hunter (2002) stated that tourism was one of the largest industries in the world. The development of tourism may have an extensive impact on the local environment; therefore, sustainable development of tourism destinations is an important issue. Mbaiwa (2003) believed that tourism in the Okavango Delta provided employment opportunities for local communities, but tourism had begun to exert negative impacts on the region, such as the destruction of the region's ecology due to driving beyond the prescribed lanes, noise pollution, and poor

waste management. Li et al. (2012) proved that in an urban centre, a certain spatial coupling existed between the areas with high ecological vulnerability and those with intensive tourism activities. The impact of tourism activities on the reservoir ecological environment cannot be ignored. Yuan et al. (2014) analysed the interactive relationship among tourism, the ecosystem, and the regional economy in the process of development and concluded that this interactive relationship was mutually influential and restrictive. Zhao et al. (2014) reported that the impact of tourism on the water environment had become a popular topic in ecotourism research. The relationship between tourism activities and the water environment in Liupanshan Ecotourism Area in China was analysed. Amir et al. (2015) believed that the tourism industry had a negative impact on the regional environment; however, if tourism could develop harmoniously with the environment to a certain extent, then the tourism industry would achieve sustainable development. Budeanu et al. (2016) discussed the relationship between tourism development and environmental coupling development to achieve sustainability. Law et al. (2016) constructed the concept of green economy from the perspective of tourism and proposed a model for transforming the concept of green economy into the participation process of tourism stakeholders; the model was validated in a case study of Bali, Indonesia. Dvarkas (2017) believed that although the development of tourism could provide economic benefits to a region, the increasing number of tourists had a long-term impact on the ecological situation. Carrillo et al. (2017) studied the sustainability of Spanish regional tourism by building a comprehensive index and using multi-criteria decision-making technology to synthesize and weigh the simple indexes considered. Fadafan et al. (2018) stated that ecosystems are sensitive and vulnerable. He developed and applied a non-compensatory framework to analyse the impact of tourism development on land use. Tamayo et al. (2018) analysed the impact of tourism development on the ecological environment of Philippine coral reefs .

Existing literature shows that the impact of tourism on the ecological environment is a controversial issue. The positive and negative impacts of tourism on the environment are closely related to the research and evaluation system of the ecological environment and the evaluation methods of the tourism environment. Therefore, taking Henan Province as an example, this study calculates the coupling value of tourism and the regional ecological environment composite system in 2010-2016 by using the coupling model then proposes concrete measures to change the situation wherein tourism economic growth lags behind that of the ecological environment. Therefore, protection of the tourism environment can be promoted, and ecology can be

actively developed in the process of tourism development. Suggestions for tourism and other aspects are also provided in this study.

### BRIEF INTRODUCTION TO THE TOURISM-ECOLOGY COUPLING MODEL

Coupling is a concept in physics in which two or more systems or motion forms influence each other through various interactions. From the perspective of coupling, coupling and its effect and the degree of coupling refer to the dynamic evolution process of multiple systems and their coupling elements from disorder to order on the basis of a virtuous cycle. The degree of coupling shows the movement of the order and structure of the system when it reaches a critical region, which determines the trend of the system from disorder to order. The key to the mechanism of the system from disorder to order is the coupling between the order parameters in the system, and the coupling degree is a measure that reflects the coupling effect. Therefore, this study defines the tourism-ecological coupling degree as the degree of interaction between the tourism industry and the ecological environment system through its own coupling factors, which can be used as an index to reflect the strength of the role of the tourism industry and regional ecological environment system.

**Determination of order parameters:** Considering scientific and practical principles, the selected order parameter must be able to represent the variables of tourism industry status to serve as the order parameter index. In consideration of data availability, we choose four indicators to evaluate the tourism system. These four indicators are the numbers of Chinese tourists, international tourists, star-rated hotels, and employees of the hotel and catering industry. The index system of the ecological environment includes six indicators, namely, industrial wastewater discharge, industrial smoke and dust discharge, forest coverage, industrial solid waste production, comprehensive utilization rate of industrial solid waste, and investment in environmental pollution control. The data used in this study are from Henan Statistical Yearbook, China Environmental Statistical Yearbook, and China Tourism Statistical Yearbook. The investigation period is from 2010 to 2016.

**Order degree of the system:** Considering subsystems  $S_j, j \in [1, k]$ , we set the order parameter variables in the development process as  $e_j = (e_{j1}, e_{j2}, \dots, e_{jn})$  and  $n \geq 1, \beta_{ji} \leq e_{ji} \leq \alpha_{ji}, i \in [1, n]$ . For generality, we assume that  $e_{j1}, e_{j2}, \dots, e_{jn}$  increases. The higher the order degree of the system is, the smaller the value is. The larger the value of  $e_{j1+1}, e_{j1+2}, \dots, e_{jn}$  is, the lower the order degree of

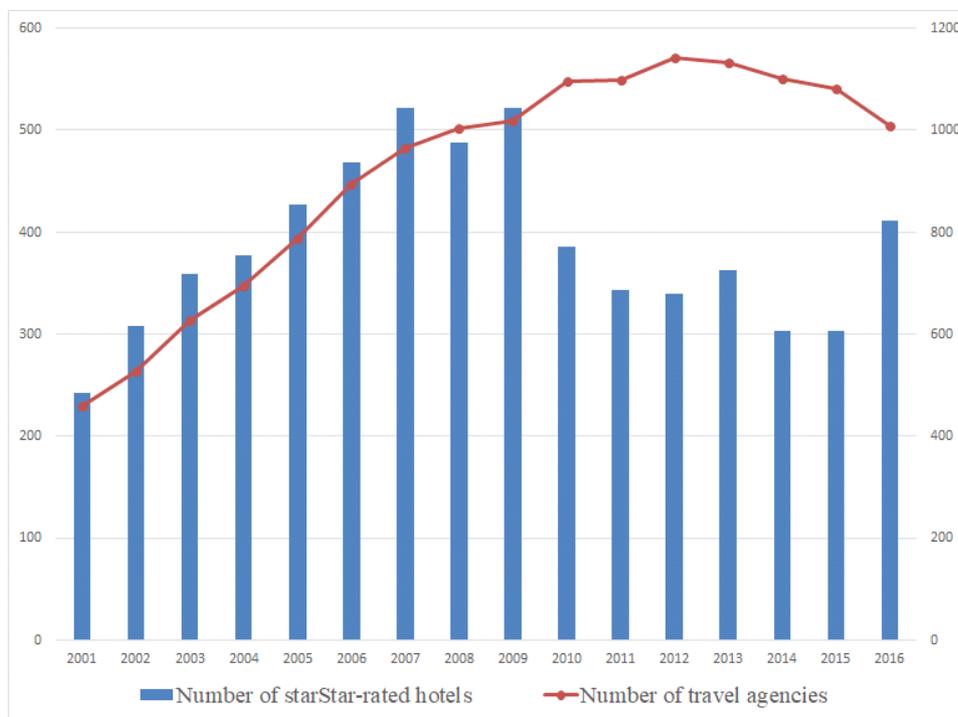


Fig. 1: Number of star-rated hotels and travel agencies in Henan Province from 2001-2016. (Data from the China Tourism Statistics Yearbook)

the system is. The smaller the value is, the higher the order degree of the system is. The complex system of the tourism industry and regional ecological environment includes tourism and regional ecological environment systems, and the order parameter in the development process of the tourism system is  $e_1 = (e_{11}, e_{12}, \dots, e_{1n})$ . According to the concept of system order degree, we define the order degree of order parameter  $e_{1j}$  components as follows:

$$u_1(e_{1i}) = \begin{cases} \frac{e_{1i} - \beta_{1i}}{\alpha_{1i} - \beta_{1i}} & (i = 1, 2, \dots, l) \\ \frac{\alpha_{1i} - e_{1i}}{\alpha_{1i} - \beta_{1i}} & (i = l + 1, l + 2, \dots, n) \end{cases} \quad \dots(1)$$

Where,  $\alpha_{1i}$  and  $\beta_{1i}$  belong to the maximum and minimum of the first index of the tourism industry system, respectively. According to this definition, after normalization treatment,  $u_1(e_{1i}) \in [0, 1]$ . When the value is large, the contribution of  $e_{1i}$  to the orderly tourism industry system is also large. The total contribution of ordinal parameters to the orderliness of the tourism system can generally be achieved by an integrated method  $u_1(e_{1i})$ . The commonly used methods are geometric average and linear weighted. The geometric average method is expressed as:

$$u_1(e_1) = \sqrt[n]{\prod_{i=1}^n u_1(e_{1i})} \quad \dots(2)$$

The linear weighting method proceeds as:

$$u_1(e_1) = \sum_{i=1}^n \omega_{u1}(e_{1i}), \quad (\omega \geq 0, \sum_{i=1}^n \omega = 1) \quad \dots(3)$$

Where,  $\omega$  is the weight of each index.

In the order degree of the tourism system  $u_1(e_1) \in [0, 1]$ , when  $u_1(e_1)$  is large, the contribution of the order parameters  $e_1$  to the order of the tourism system and the order degree of the tourism system are high and vice versa. The order parameters are set in the development process of the regional ecological environment system as  $e_2 = (e_{21}, e_{22}, \dots, e_{2i})$ . According to the calculation method of the order degree of the tourism system, the order degree of the component of regional ecological environment parameters  $e_{2i}$  can be obtained as  $u_2(e_{2i}), u_2(e_{2i}) \in [0, 1]$ .

**Coupling degree of the system:** At initial time  $t_0$ , the order degree of the tourism system is set as  $u_1^0(e_1)$  and that of the regional ecological environment system is set as  $u_2^0(e_2)$ . When the system evolves to time  $t_1$ , the order degree of the tourism system is set as  $u_1^1(e_1)$  and that of the regional ecological environment system is  $u_2^1(e_2)$ . If  $u_1^1(e_1) \geq u_1^0(e_1), u_2^1(e_2) \geq u_2^0(e_2)$  can be true at the same time, then the tourism and regional ecological environment systems can be regarded as coupled development, and the coupling degree model is as follows:

pling degree model is as follows:

$$c = sig(\bullet) \sqrt{|u_1^1(e_1) - u_1^0(e_1)| |u_2^1(e_2) - u_2^0(e_2)|} \quad \dots(4)$$

In which:

$$sig(\bullet) = \begin{cases} 1, u_1^1(e_1) \geq u_1^0(e_1) \text{ and } u_2^1(e_2) \geq u_2^0(e_2) \\ -1, u_1^1(e_1) < u_1^0(e_1) \text{ or } u_2^1(e_2) < u_2^0(e_2) \end{cases} \quad \dots(5)$$

As indicated in Formulas (4) and (5), a high degree of coupling can only be realized when the tourism and regional ecological environment systems are in an orderly state. If the orderly degree of one subsystem considerably increases but that of the other subsystem slightly increases or decreases, then the entire tourism industry-regional ecological environment will be affected. Achieving a good coupling state is impossible for a composite system.

### EMPIRICAL RESEARCH

Through the standardization of the original data, the calculation is conducted according to Formulas (1) to (4), and the settlement results are shown in Fig. 2. As shown in the figure, the subsystems of tourism and the ecological environment in Henan Province from 2010 to 2016 showed an overall steady upward trend. Among the subsystems, the rising trend was evident (from 0.024 in 2010 to 0.862 in 2016). In recent years, cities in Henan Province have focused on strengthening the development of the tourism industry, using the regional economy to drive the development of tourism-related industries, conducting in-depth excavations, and developing local tourism resources to increase the attractiveness of tourism. This can effectively promote the orderly development of the tourism subsystem itself. The orderliness of the ecological environment subsystem in Henan Province increased from 0.070 in 2010 to 0.770 in 2016, and the environment was effectively improved. However, the orderliness of the ecological environment subsystem in 2016 was lower than that of the tourism subsystem, which indicates that further improvement of the ecological environment in Henan Province is still needed, and it cannot effectively support Henan Province. The gradual improvement of the orderliness of eco-environmental subsystems shows that Henan Province has attached great importance to the eco-environment in recent years and strengthened the protection of the eco-environment, which has produced good results. The eco-environment has been effectively protected through the continuous improvement and maintenance of eco-environment development. With the acceleration of the urban process, sustained and rapid development of tourism economy, and change in tourism consumer demand, the pressure on

the ecological environment increases. Henan Province should further formulate policies for the development of tourism, and protect the ecological environment well, and promote the further improvement of the orderliness of the ecological environment subsystem.

On the basis of the order degree of tourism and eco-environment subsystems, the coupling degree of tourism-regional eco-environment complex system is calculated according to Formula (5), as shown in Table 1.

As shown in Table 1, the coupling degree of tourism and ecological environment in Henan Province from 2011 to 2016 showed an upward trend from 0.169 in 2011 to 0.766 in 2016. A particularly large increase was noted in 2013. In recent years, Henan Province has increased the protection and improvement of the ecological environment and focused on building an environment-friendly eco-tourism system while enhancing the economic growth of tourism and the ecological environment. By planning, integrating, and modifying the natural landscape and beautifying the ecological environment, Henan Province has produced various tourism products and designed distinctive tourism projects to reduce the destruction of the ecological environment, and beautify the natural landscape, and promote the quality of the tourist ecological environment and tourism.

## POLICY RECOMMENDATIONS

### **Strengthen the assessment of the tourism environment and conduct real-time monitoring of the tourism environment:**

The assessment of the environmental effects of tourism development should be strengthened, and protection of the ecological environment should be controlled at the source. Understanding the development of tourism projects is necessary to protect the ecological environment of tourist cities and scenic spots. In addition, the evaluation of the positive and negative effects and the extent of development projects on natural and man-made environments must be strengthened from all aspects; then, it can be used as an important basis for departmental decision making to strictly prohibit the development of projects that seriously damage the ecological environment. Simultaneously, the carrying capacity of the tourism ecological environment should be scientifically determined, and the development plan of tourism resources should be rationally formulated, and the eco-

logical protection of tourism resources should be reinforced, thereby avoiding human-caused damage to tourism resources. Moreover, a monitoring mechanism of the tourism environment should be established to control pollution in time. It is necessary to establish and improve the ecological management and monitor institutions of tourist cities and scenic spots, and formulate a scientific index system for ecological protection, and improve the professional and technical team for ecological protection. Lastly, advanced technical means should be used for monitoring and governance, and the ecological environment monitoring of tourist cities and scenic spots should be strengthened.

### **Strengthen the government's leading role in tourism development and comprehensively improve the level of tourism management:**

The government should give full play to the function of macro-control, and formulate proper and feasible policies, and improve the corresponding laws and regulations. The advantages of the government should be utilized to conduct considerable market research, and forecast the tourism demand situation of various places, and adopt reasonable diversion measures to balance the tourism demand of hot and cold spots. Therefore, the occurrence of events that will damage the tourism image of Henan Province, when the tourism booms burst, can be avoided. When the demand for tourism is predicted to exceed the supply of tourism, the price can be raised, and additional fees other than the usual can be charged to effectively control the consumption of resources. Illegal operators who damage the image of the tourism market must be punished according to the law to ensure the orderly development of the tourism industry. Tourism is a highly cooperative development industry that requires government departments to play a good coupling function, do a good job of coupling between various relevant departments, and comprehensively improve the management level, thereby ensuring the smooth development of tourism, reducing unnecessary resource consumption, and promoting the sustainable development of tourism.

### **Implement taxing on the tourism environment and focus on the long-term benefits of tourism development:**

The increasingly serious environmental problems appear to be caused by limited environmental capacity and accumulation of environmental pollution. However, these problems are in fact caused by people's obsession to satisfy immedi-

Table 1: Coupling degree of tourism and regional eco-environmental composite system in Henan Province from 2011-2016.

Year	2011	2012	2013	2014	2015	2016
Coupling degree of tourism and regional eco-environmental composite system	0.169	0.250	0.408	0.504	0.636	0.766

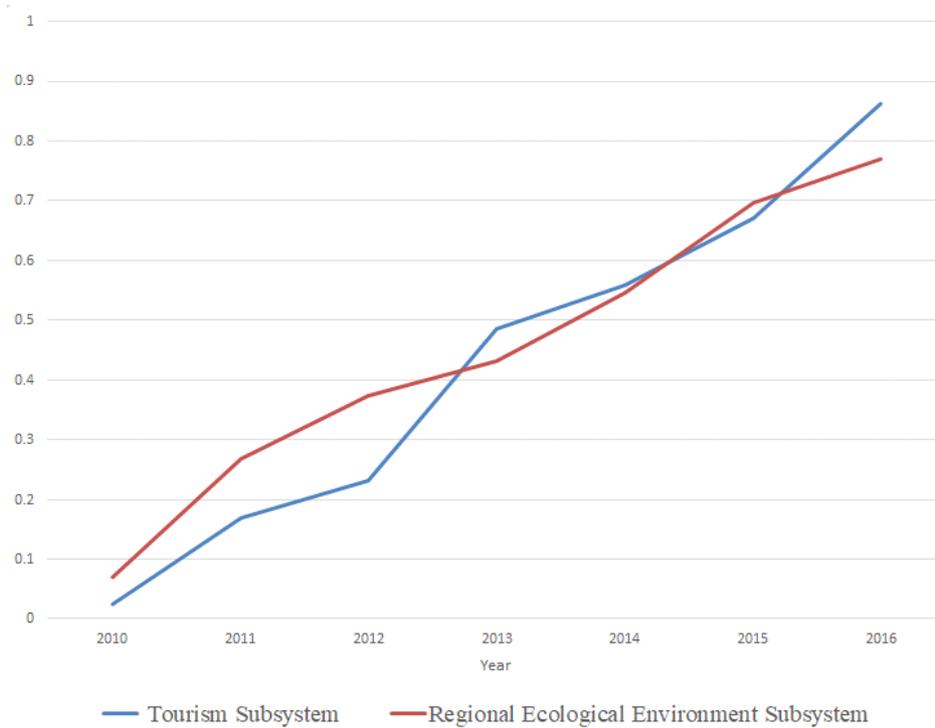


Fig. 2: Orderliness of tourism and eco-environment subsystems.

ate vested interests while ignoring the future development potential and the advancement of contemporary and future generations. Therefore, when environmental tax is used as a means to solve environmental problems, we can not only focus on the present, short-term, and contemporary efficiency and fairness, but also realize that the environmental resources we have do not belong to the contemporary people but are borrowed from future generations. Therefore, time factor, discounting time, and compound interest should be respectively considered when allocating environmental resources, and measuring the value of environmental resources, and calculating the benefits of environmental protection to realize the intergenerational equity of environmental benefits. Environmental tax may slow down economic development in the short run, but the intergenerational equity of the environment helps promote the long-term stability of economic benefits. The implementation of environmental tax is particularly important and focuses on the principle of long-term interests.

**Strengthen the legislation of the tourism environment and raise public awareness of tourism environmental protection:** Local governments should formulate local laws and regulations to protect the tourism ecological environment. According to relevant laws and regulations, tourism administration departments should formulate local laws and regu-

lations on tourism development and ecological environment protection, and gradually set up ecological law enforcement teams, and publicize the ecological legal system. These departments should also punish acts of destroying the ecological environment to promote ecological protection into the track of the legal system. Furthermore, the government should improve people's understanding of eco-environmental protection in tourist cities and scenic spots. The government should also use new and traditional media to disseminate knowledge on human beings, the environment, and development to the public as well as legal and technological knowledge on environmental protection so as to increase public awareness of environmental protection. Tourist environmental protection education in tourism can enhance tourists' awareness of environmental protection. Moreover, it can reduce the damage to the ecological environment by tourists by setting up corresponding explanations of the ecological environment landscape, and reminding tourists to focus on environmental hygiene signs, and facilitating an environment-coupled waste collection system.

**Speed up the transformation and upgrading of the tourism industry and improve the mechanism of tourism ecological compensation:** The supply of tourism products should be optimized (changed from sightseeing to experi-

ential tourism) to realize the transformation and upgrading of tourism, and tourism products with minimal pollution and improved experience, such as rural, agricultural, ecological, cultural, and medical tourism, should be vigorously developed. Well-known tourist attractions are cultivated and diverted during holidays to prevent a large number of tourists from pouring into the same scenic area and exceeding the carrying capacity of the scenic area. Henan Province has rich cultural connotations in the development of tourism derivatives. We should fully tap this culture and develop cultural derivatives, such as tourism performances and tourist souvenirs. The effective development of tourism activities cannot be separated from the guidance of tourism policies and the norms of tourism laws and regulations. Tourism is a comprehensive industry involving various industries; therefore, additional laws and regulations are needed to clarify the responsibilities of all parties. In addition, the construction of the tourism legal system should be perfected, and acts that destroy the ecological environment in the process of tourism development and tourism management should be punished, and the behaviours of people should be effectively standardized to create a good tourism environment. Lessons should also be drawn from the ecological compensation experience of other provinces, and the eco-environmental defenders of tourism should be compensated by means of taxation, financial subsidies, and policy support. Only in this way can the tourism industry consider ecological, social, and economic benefits and achieve sustainable development.

## CONCLUSIONS

With the rapid development of the tourism industry of China in recent years, tourism has become an important part of national life and one of the basic driving points of national economic development. However, the development of tourism activities cannot be separated from the dependence on resources. The unbalanced level of energy consumption and environmental protection in the tourism industry has become an important factor that affects the coordinated development of tourism and the ecosystem. Taking Henan Province as an example, this study constructs a comprehensive evaluation system for the coupling degree between the tourism industry and regional ecological environment system and uses the coupling model to analyse the coupling status of the tourism industry and regional ecological environment system in Henan Province. The results show that the orderliness of the eco-environment subsystem in Henan Province is less than that of the tourism subsystem, indicating that further improvement of the eco-environment is still required. The coupling degree between tourism and the ecological environment increased from 0.169 in 2011 to 0.766 in 2016, and a particularly large increase occurred in 2013.

This study also proposes policy suggestions, such as strengthening tourism environment assessment, reinforcing the leading role of the government in tourism development, implementing tourism environment tax collection, strengthening tourism environment legislation, and accelerating the transformation and upgrading of the tourism industry. In the future, we can continue to study the determination of the factors that affect the tourism ecological environment, the construction of an index system for the carrying capacity of the ecotourism environment, and the establishment of a sustainable development model for the ecotourism area. Quality evaluation of the tourism ecological environment and application of high technology in the management of the tourism environment are also worth investigating.

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