Study on the coupling and coordinated development of tourism economy and ecological environment in Guilin city

Cong Wang¹, Rong Wang!*  
¹ College of Tourism & Landscape Architecture, Guilin University of Technology, Guilin, Guangxi ,541006, China  
*Corresponding author’s e-mail: 1464666067@qq.com

Abstract. Correctly figuring out and coordinating the relationship between tourism economy and eco-environment is a crucial issue to approach to regional environmental protection and high-quality tourism development. By introducing an index system, this paper proposes a comprehensive method to evaluate the coupling coordination between tourism economy and eco-environment. The index weight was determined by entropy weight method, and the coupling coordination degree model was established using panel data from 2009 to 2018 in Guilin city. The results present that the overall tourism economic index shows a continuous upward trend, while the eco-environment index had obvious fluctuations; the coupling coordination degree and level continues to grow and had improved from moderate imbalance to primary coordination, respectively. It is trustworthy that there is a bright coupling and coordinated development trend between the tourism economy and the eco-environment in Guilin. With the tourism economy development, an intensive development model dominated by environmental protection and resource conservation should be chosen to promote the coordinated and sustainable development of tourism and the environment.

1. Introduction
The eco-environment is the basis of tourism activities. It is of great significance to maintain or improve the eco-environment of tourist destinations. The continuous development of human tourism activities has a great impact on the change of eco-environment. Therefore, in order to promote the sustainable development of tourism industry, coordinatig the development between tourism industry and eco-environment, has become a hot issue in the academic circles. The relationship between tourism and environment has always been the focus of foreign scholars. It can be traced back to 1920[1-2], and most of them believe that tourism activities may have an impact on the environment[3]. Although the domestic research started late, there still have been rich research results after a period of development. In terms of research scope, scholars have carried out in-depth research from different levels, such as national, administrative and urban agglomeration. In terms of research methods, scholars have introduced a large number of models and quantitative methods based on a large number of studies on the relationship between tourism and environment[4-5]. As well as in research content, early scholars mainly focused on the coordination between regional tourism economy and eco-environment[6-8], while now they pay more attention to the coupling coordination relationship between eco-environment and tourism flow, tourism resources, urbanization, tourism transportation and other aspects[9-11].

As a world-famous scenic tour city, Guilin is presently undergoing rapid tourism development. Recent statistics show that the total number of tourists in Guilin reached 109 million in 2018, with a
total consumption of 139,175 billion yuan. The rapid development of tourism has promoted local tourism economy, whereas it has also brought many tests to the eco-environment. The coordinated development between tourism economy and eco-environment is conducive to maintaining the sustainable development of tourist destinations and improving the comprehensive competitiveness. Therefore, this paper studies the coupling relationship between Guilin’s tourism economy and environment in recent ten years through quantitative methods to understand the interactive relationship between tourism and environmental, so as to provide reference for the sustainable development of Guilin’s tourism industry.

2. Data and methods

2.1 Data sources and index system design

This study follows the principle of index system selection. By referring to the research results of many scholars on the coupling coordination analysis and combining with the specific situation of Guilin, we selected 4 first-level indicators and 20 second-level indicators to construct the evaluation index system (Table 1). The original data was mainly from *Guilin Economic and Social Statistical Yearbook, Guangxi Statistical Yearbook* and *China Environmental Statistical Yearbook* from 2009 to 2018. In order to ensure the authenticity and integrity, this paper also drew on official statistical bulletins.

2.2 Methods

2.2.1 Range normalization.

In order to eliminate the difference in magnitude and dimension between the original data of the index, the data should be dimensionless, using the following equation:

Positive indicator: \( X'_{ij} = \frac{x_{ij} - \text{min}(x_{ij})}{\text{max}(x_{ij}) - \text{min}(x_{ij})} \)  \hspace{1cm} (1)

Negative indicator: \( X'_{ij} = \frac{\text{max}(x_{ij}) - x_{ij}}{\text{max}(x_{ij}) - \text{min}(x_{ij})} \)  \hspace{1cm} (2)

where, \( \text{max}(X_{ij}) \) and \( \text{min}(X_{ij}) \) indicate the maximum and minimum value of index \( j \), \( X'_{ij} \) is the normalized value of \( X_{ij} \).

2.2.2 Entropy method.

Entropy weight method can ensure the objectivity and scientificity of data analysis. The calculation method is as follows:

\[ H_j = -k \left( \sum_{i=1}^{m} p_{ij} \ln p_{ij} \right), \quad k = \frac{1}{\ln m} \]  \hspace{1cm} (3)

where, \( m \) is the number of years, and \( p_{ij} \) is the proportion of \( j \) index in the \( i \)-th year, which is stipulated as follows:

\[ p_{ij} = \frac{1 + X'_{ij}}{\sum_{j=1}^{m} (1 + X'_{ij})}, \quad W_j = \frac{1 - H_j}{\sum_{j=1}^{m} (1 - H_j)} \]  \hspace{1cm} (4)

Table 1. Index system used for evaluation of the relationship between tourism economy and ecological environment and the index weights.

| Subsystem     | First-class Index | Second-class Index                                      | Entropy Weight | Index Type |
|---------------|-------------------|--------------------------------------------------------|----------------|------------|
| Tourism       | Economy           | Total tourism incomes (100 million yuan)                | 0.0545         | +          |
|               |                   | Earnings from domestic tourism (100 million yuan)       | 0.0549         | +          |
|               |                   | Foreign exchange earnings from international tourism (100 million yuan) | 0.0524         | +          |
|               |                   | Tertiary industry income (100 million yuan)             | 0.0504         | +          |
|               |                   | Proportion of total earnings from tourism in GDP (%)    | 0.0554         | +          |
2.2.3 Coupling coordination degree model.

(1) Comprehensive Evaluation Index. The comprehensive index evaluation formulas of tourism economy and eco-environment system are respectively as follows:

\[ F(x) = \sum_{i=1}^{m} a_i x_i' \]  
\[ G(x) = \sum_{i=1}^{n} b_i y_i' \]  

where, \( x_i' \) and \( y_i' \) are the standardized value of tourism economy and eco-environment system respectively; \( a_i \) and \( b_i \) are the weight of them respectively.

(2) The coupling degree. With reference to the coupling degree coordination model in physics, the formula for calculating the coupling degree of tourism economy and eco-environment system is constructed:

\[ C = \frac{F(x) \times G(x)}{\sqrt{F(x)^2 + G(x)^2}} \]  

where, \( C \) represents the degree of coupling between tourism and the environment. The closer the value is to 1, the better the degree of coupling between the two systems.

(3) The coupling coordination degree. Coupling coordination degree can reflect the overall coordinated development level of tourism economy and eco-environment system, and measure the development synergy between the two systems. The calculation formula is as follows:

\[ T = \alpha F(x) + \beta G(x), \quad D = \sqrt{C \times T} \]  

Where, \( T \) is the comprehensive evaluation index of tourism economy and eco-environment; \( \alpha \) and \( \beta \) represent the contribution of the two systems. Considering their equal importance status, and \( \alpha + \beta = 1 \), both are chosen as 0.5.

(4) Evaluation criteria of coupling coordination degree. In order to judge the development of coupling of tourism economy and eco-environment, by combining the existing research results, a rating standard for coupling coordination degree is constructed, as shown in Table 2.

| D  | Development Stages                  | D  | Development Stages                  |
|----|-------------------------------------|----|-------------------------------------|
| 0-0.10 | Extremely dysfunctional recession | 0.50-0.60 | Barely coordinated development |
| 0.10-0.20 | Severely dysfunctional recession | 0.60-0.70 | Primary coordinated development |
| 0.20-0.30 | Moderately dysfunctional recession | 0.70-0.80 | Intermediate Coordinated Development |
| 0.30-0.40 | Mild dysfunctional recession | 0.80-0.90 | Well-coordinated development |
| 0.40-0.50 | On the verge of imbalanced recession | 0.90-1.00 | Quality coordinated development |
3. Results

3.1 Results of subsystem comprehensive level

According to the entropy method to determine the weight of each index (Table 1), the comprehensive level index of tourism economy and eco-environment of Guilin from 2009 to 2018 was obtained (Table 3). According to the data, the tourism economic index had increased from 0.0355 in 2009 to 0.4932 in 2018, the overall development level had continued to increase. This showed that Guilin's tourism economy generally maintains a good development trend, and it can give full play to its own climate and resource advantages, and vigorously promote the high-quality development of tourism.

The comprehensive evaluation index of eco-environment increased from 0.1301 in 2009 to 0.3438 in 2018. Overall, its development level had been improved. However, it can be found from Figure 1 that Guilin's eco-environmental index showed some fluctuations from 2009 to 2018. Guilin’s eco-environmental index declined in 2011 and 2014. In 2011, the eco-environmental index was relatively low at 0.1562. The main reason was that the quality of ecological resources was threatened in the rapid economic development. Data such as the coverage area of forestation of developed area, the days of air quality equal to or above grade B had suddenly dropped; and people’s concept of environmental protection had not kept up with the development speed of social economy. The proportion of fiscal expenditure on energy conservation and environmental protection was relatively small, the speed of eco-environment protection did not match the speed of economic development.

By comparing the index size of tourism economy and eco-environment (Table 3), it can be divided into two stages: the development of tourism economy in 2009-2016 was relatively backward, while that in 2017-2018 was the opposite. Before 2016, the favorable eco-environment provided opportunities for the development of the tourism economy. The slow development of tourism had not broken the ultimate carrying capacity of ecological resources. After 2016, with the rapid development of tourism economy, the pressure on eco-environment has been increasing, leading to the obvious lag of eco-environment development. However, it can be seen from the temporal change of the T value (Table 3), excepted that the value of individual years had slightly decreased, the overall trend was rising.

Table 3. Coupling results of tourism economy and ecological environment system.

| Year | F(x) | G(x) | T   | C   | D   | Coordination level                        |
|------|------|------|-----|-----|-----|-------------------------------------------|
| 2009 | 0.0355 | 0.1301 | 0.0828 | 0.8204 | 0.2605 | Moderately dysfunctional recession         |
| 2010 | 0.0532 | 0.1781 | 0.1157 | 0.8418 | 0.3120 | Mild dysfunctional recession               |
| 2011 | 0.0930 | 0.1562 | 0.1246 | 0.9673 | 0.3471 | Mild dysfunctional recession               |
| 2012 | 0.1343 | 0.2346 | 0.1845 | 0.9623 | 0.4213 | On the verge of imbalanced recession       |
| 2013 | 0.1545 | 0.2589 | 0.2067 | 0.9676 | 0.4472 | On the verge of imbalanced recession       |
| 2014 | 0.1947 | 0.2114 | 0.2031 | 0.9992 | 0.4504 | On the verge of imbalanced recession       |
| 2015 | 0.2393 | 0.2610 | 0.2502 | 0.9991 | 0.4999 | On the verge of imbalanced recession       |
| 2016 | 0.2684 | 0.2993 | 0.2838 | 0.9985 | 0.5324 | Barely coordinated development             |
| 2017 | 0.3617 | 0.3337 | 0.3477 | 0.9992 | 0.5894 | Barely coordinated development             |
| 2018 | 0.4932 | 0.3438 | 0.4185 | 0.9839 | 0.6417 | Primary coordinated development            |

3.2 Results of the degree of coupling coordination

According to Table 3 and Figure 1, the coupling degree has been above 0.8 in recent ten years, indicating that Guilin's tourism economy and eco-environment have always been in a high-level coupling stage. From 2010 to 2011, the coupling degree increased greatly, mainly because the comprehensive level of eco-environment declined significantly, tourism economy was rising steadily, the coupling degree of the two systems was improved. The coupling levels in some years were similar, but their actual meanings were different, and their comprehensive development levels were different. For example, the coupling values of 2014 and 2017 were both 0.9992, but the tourism economy index in 2014 was 0.1947, which was lower than the 2017 tourism economic index of 0.3477.

Judging from the coupling coordination value, the overall rising speed was relatively stable, but the
values were all below 0.7, and the coupling coordination level was relatively low. Specifically, from 2009 to 2016, the coupling coordination degree increased greatly from 0.2605 to 0.5324. In 2016, tourism economy and ecological environment entered a stage of barely coordinated development. The main reasons were: the better development of tourism industry had promoted the improvement of tourism economy. In 2016, Guilin’s total tourism revenue reached 63.731 billion yuan, accounting for over 30% of GDP. At the same time, Guilin had strengthened eco-environment protection, industrial exhaust emissions had dropped significantly, the number of days with good air throughout the year had increased, so the environment had improved significantly. From 2017 to 2018, the coupling coordination degree was above 0.5 and below 0.7, with little fluctuation. It showed that the degree of coordination between tourism economy and eco-environment was constantly improving. According to the comprehensive level development index, the tourism economic index grew faster and far exceeded the eco-environment, and the growth trend of the eco-environment index was relatively flat, indicating that there was a certain contradiction between the development of tourism economy and the carrying capacity of eco-environment system. The rapid development of tourism brought pressure to eco-environment. The faster the economic grew, the greater the challenge eco-environment faced. At this stage, the two systems were in a phase of consistency, so the change trend was relatively flat.

Figure 1. Coupling coordination degree evolution curve of tourism economy and ecological environment systems.

4. Conclusions
(1) Based on the analysis of each subsystem of Guilin's tourism economy and eco-environment, it is clear that the tourism economy system generally presented a continuous upward trend, while eco-environment system had obvious fluctuations. The development of tourism economy was inconsistent with eco-environment. After 2017, eco-environment index was lower than that of tourism economy. It can be seen that the basic environment quality of Guilin was fine, which had a strong carrying capacity for the development of tourism economic activities. However, the rapid development of tourism economy put pressure on eco-environment, which limited the sustainable development of the region.

(2) According to the sequential variation in the coupling coordination degree of Guilin's tourism economy and eco-environment, the coupling degree value was above 0.8, showing an overall upward
trend, in contrast the coupling coordination degree value was relatively small, mainly between 0.2 and 0.6. It illustrated that the holistic coordination degree was still at a low to medium level. The overgrowth of tourism economy had brought negative impact to eco-environment, which imposed great restrictions on the further enhancement of the coupling coordination degree of the two systems.

(3) From the development type of the coupling coordination degree between tourism economy and eco-environment, Guilin gradually changed from the eco-environment leading development to the tourism economy leading development, indicating that Guilin had a good eco-environment foundation, which greatly promoted the development of tourism economy. However, the overly extensive development of tourism economy had caused excessive damage to the ecological environment.

On the whole, the correlation between tourism economy and eco-environment is gradually increasing, and the coupling and coordinated development of the two systems has a good development trend. While developing tourism economy, Guilin should take into account its superior ecological environment, and limit the development of the tourism economy within the carrying capacity of regional eco-environment. Therefore, the development of tourism and economy need to take an intensive development model dominated by protecting environment and conserving resources to promote the sustainable development of eco-environment and tourism economy in tourist destination.

Acknowledgments
This work is supported by doctoral research project of Guilin University of Technology: Historical Geography Research of Guilin Traditional Gardens.

References
[1] Lutz, H J. (1945) Soil condition of public grounds in public forest parks. Journal of Forestry, 43(43): 122–127.
[2] Liu, R. Y. (1997) Impacts of outdoor recreation on natural vegetation. Chinese Forestry Science Quarterly, (29): 35–58.
[3] Gossling, S. (2002) Global environmental consequences of tourism. Global Environmental Change-human and Policy Dimensions, 12(4): 283–302.
[4] Zhang, Y.F.; Zhu, H.Y.; Liu, F. (2013) Relationship on tourism environments, consumption habits and participation willingness of low-carbon tourism: taking the Wulingyuan natural heritage site as an example. Tourism Tribune, 28(06):56–64.
[5] Li, W., Han, P.J., Zhao, X.Y. (2018) Sustainable development of tourism in a vulnerable ecological region: an emergy analysis of the Gannan Tibetan Autonomous Prefecture. Acta Ecologica Sinica, 2018,38(16):5894–5903.
[6] Fang, Y.L., Huang, Z.F., Duan, Z.X., Wang, K. (2013) Coupling and coordinating about Chinese tourism developing and eco-environment. Economic Geography, 33(12):195–201.
[7] Xie, Y.J. (2013) Research on coupling relation between tourism economy and ecological environment of China's sub-provincial cities. Urban Development Studies, 20(01):91–97.
[8] Liu, D.H., Yang, D.C. (2011) Coupling coordinative degree of regional economy-tourism-ecological environment—a case study of Anhui province. Resources and Environment in the Yangtze Basin, 20(07):892–896.
[9] Ma, Y., Li, L.X., Ren J. (2017) Coordination development research among the tourism economy-traffic condition-ecological environment in Shengnongjia forest district. Economic Geography, 37(10):215–220.
[10] Yang, X.P., Zhang, D.C., Yuan, P.P., Zhang, X.B. (2020) Study on coupling coordination degree of tourism-ecological environment-urbanization system—taking the Ningxia Hui Autonomous Region for an example. Mathematics in Practice and Theory, 50(02): 35–47.
[11] Cheng, H., Xu, Q., Guo, Y.Q. (2019) Temporal and spatial evolution of the coupling coordinated development between tourism resources development and ecological environment in China. Economic Geography, 39(07): 233–240.