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Coordinated development of environment and tourism in China using grey relational analysis

J. Zhao[1,2*], Sh.M. Li[1]

[1] *School of Economic & Management, Northwest University, 710127, Xi'an, Shaanxi, China.*
[2] *School of History, Culture and Tourism, Huaiyin Normal University, 223300, Huai'an, Jiangsu, China.*

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Coordinated development of tourism and environment is of great significance to the development of human society. The assessment of current development of tourism and environment in China using the theory of grey system established a relationship model for the coordinated development of tourism and environment. Based on the statistics of the development indicators of tourism and environment in China from 2007 to 2015, this paper analyzes the coordinated development of the relationship between them. The analysis results show that the correlation coefficient of tourism and environmental development indicators in China is 0.530, which has the same direction and positive correlation in general. Tourism receipts, domestic tourist arrivals and domestic tourism receipts are the strong correlation tourism development indicators of environmental development. International tourism receipts and international tourist arrivals account for 50% of moderate correlation tourism development indicators of environmental development. Total amount of the wastewater discharge and total number of nature reserve are the strong correlation environmental development indicators of tourism development. This shows that tourism development has an important influence on the environment.

Key words: Environment, Tourism, Coordinated development, Grey relational analysis, China

INTRODUCTION

Tourism has become the world's largest industry. The number of international tourists exceeded 1.2 billion in 2016. Such a large-scale tourism activity may have a substantial impact on the environment. In China, the total tourism revenue in 2016 was 469 trillion yuan, soared by 13.6% compared with the former year. According to the World Tourism Organization (WTO), in 2016, the overall contribution rate of China's tourism industry to the national economy was 11%, and the overall contribution to social employment exceeded 10.26%, which was basically the same as the world average. China has already become an important force in the global tourism economy. Tourism is regarded as environmental protection industry, but in its development process, there are also a series of problems. Tourism development has both positive and negative impacts on the ecological environment of the destination. According to the report of UNWTO, in climate changes caused by human activity, the responsibility of the global tourism industry is expected to reach 7% by the year 2050, tourist transportation, accommodation and other related activities caused by carbon dioxide emissions 1%-3% of total emissions, and accounts for about 5%-14% percent of man-made global warming [1].In order to expand tourist reception, some cities in China sacrifice their ecological environment and promote the development of Tourism. The impacts of tourism activities on the ecological environment are mainly reflected in the atmosphere, water, soil, geological features, plants, animals, microbes, landscapes, etc.

RESEARCH DESIGN

Literature review

In recent years, the rapid development of tourism industry has brought about a lot of negative impacts on environmental development as well as a rapid economic growth. Therefore, many researchers began to study the relationship between tourism and environment, such as tourism and greenhouse gas [2], sustainable tourism and climate change [3-6]. Different cases are selected to study the sustainable development of tourism and environment such as Amazon [7], sub-Saharan Africa [8], and Turkey [9]. With the development of tourism, the negative impact on the environment is constantly emerging, and many scholars focus on the barriers of the coordinated development of them [9,10].

Theoretical analysis

Grey system theory

Grey system theory uses a specific concept of information. It defines situations with no information as "black", those with perfect information as "white", and the situations between these extremes are described as being "grey". It can be used to deal with situations lacking sufficient information or sample data. Grey system theory has been applied in industry, agriculture, physical control, economics, energy and communication areas [11,12]. Grey relational analysis (GRA) is a

*To whom all correspondence should be sent:
E-mail: sylvan_zj@foxmail.com

theoretical method of grey system theory that is one of the most widely adapted models of Grey system theory. It was developed by Julong Deng in 1982 [12].

System theory

According to the viewpoint of system theory, there is a material cycle and interactive restriction between tourism and environment. The two subsystems form a high-level system through the coupling of elements [13]. Tourism activities obtain the necessary resources from the environmental system, and tourism revenue provides financial support for the transformation of environmental system resource elements [14].

Coordinated development theory

The purpose and substance of coordination is to promote the system or organization from unbalanced development to equilibrium, and then to a new imbalance, so as to achieve a new balance. It is a cycle of continuous upgrading processes. In the process of development, we should deal with all kinds of relationships properly, effectively utilize various resources, and establish the active cooperative relationship to achieve the common goals. Coordination of interconnected subsystems or system elements through mutual aid and cooperation optimizes the whole system development to achieve the overall optimization of the system. It is a benign condition to coordinate decision makers' actions consistent with each other, in order to achieve maximum utility.

Grey relational model for the coordinated development of environment and tourism

Tourism development has both positive and negative impacts on the ecological environment of the destination. Combined with the development of tourism and environment, the development of tourism industry increases the economic income, promotes environmental protection work, at the same time bringing a series of negative effects on the environment. The development of tourism and the environment is a unified interaction system. In this system, the tourism and environment interact and associate with each other. The complexity of the relationship between tourism and environment depends not only on their own complexity, but also depends on measuring the efficiency of multi factors, theory incompleteness, different reference systems, quantitative calculation model considering the irrationality of defects as well as data, etc. The relationship between tourism development and environment has the characteristics of incomplete information, diversity of standards and uncertainty, which conforms to the basic characteristics of a grey relational system. Therefore, a grey association model of tourism and environment coordinated development can be established.

Assuming that X is a sequence set, when it has numerical proximity, quantity comparability, and nonnegative properties, the sequence set is called grey incidence sequence set:

$$X=\begin{Bmatrix} x \mid i \in N, N=\{0,1,2.....m\}, m \geq 2, x_i=(x_i(1), x_i(2), x_i(3), ...x_i(n)), \\ x_i(k) \in X, k \in K, K=\{1,2,.....n\}, n \geq 3 \end{Bmatrix}$$

where γ(x0(k), xi(k)) are the Grey correlation coefficients of X_i to X_0; γ (x_0, x_i) are the Grey correlation coefficients of X_i *to* X_0。

Based on the relationship between tourism and environmental development, the following empirical analysis model was established:

The natural sequence *X (t), Y (t)*, that is:

$$X_i(t_k)=\{X_i(t_1), X_i(t_2), ...X_i(t_k)\}$$

$$Y_j(t_k)=\{Y_j(t_1), Y_j(t_2), ...Y_j(t_k)\}$$

$$i, j, t=\{1,2,.....n\}$$

Then there is the correlation coefficient $\gamma_{ij}(t)$ of X(t) and *Y(t)* at time *t*.

$$\gamma_{ij}=\frac{1}{1+\left|\frac{\triangle x(t)}{\partial_{x_i}}-\frac{\triangle y(t)}{\partial_{y_j}}\right|} \; p.s.: t \in T$$

$$\triangle x(t)=x(t+1)-x(t)$$

$$\triangle y(t)=y(t+1)-y(t)$$

∂_{x_i} , ∂_{y_j} are the standard deviations of x_i and y_j.

Indicators and model selection

Basis for the index selection

Based on the research results of domestic and foreign scholars, combining the basic characteristics of China's environment and tourism, and considering the availability of data, the following ten environmental and tourism development indicators are selected. The values of x_i and y_j are derived from the corresponding index values of each year in Table 1.

Data selection

For this study, researchers evaluated data from the China tourism statistics bulletin and National Environmental Statistics Bulletin (China). As the impact of tourism on the environment has an obvious lag which, according to expert estimations, is 3-4 years, the index of tourism development selected the period from 2007 to 2011, the environment development index selected the period from 2011 to 2015, which is a lag of four years. The specific indicators and data as shown in Table 2 and 3.

Table 1. Grey correlation index of tourism and environment in China

Tourism development indicators	Variables	Environmental development indicators	Variables
Tourism receipts (trillion RMB)	$x_1(t)$	Total amount of the wastewater discharge （100 million tons）	$y_1(t)$
Domestic tourist arrivals (billion people)	$x_2(t)$	Total amount of SO_2 in the exhaust emission （10 thousand tons）	$y_2(t)$
Domestic tourism receipts(trillion RMB)	$x_3(t)$	Industrial solid waste production （100 million tons ）	$y_3(t)$
International tourism receipts (billion USD)	$x_4(t)$	Total number of nature reserves（number）	$y_4(t)$
International tourist arrivals (100 million people)	$x_5(t)$	Total investment in environmental pollution control (100 million RMB)	$y_5(t)$

Table 2. Tourism development indicators data table (2007-2011)

Tourism development indicators	Variables	2007	2008	2009	2010	2011
Tourism receipts (trillion RMB)	$x_1(t)$	1.096	1.160	1.290	1.570	2.250
Domestic tourist arrivals (billion people)	$x_2(t)$	1.610	1.712	1.902	2.103	2.641
Domestic tourism receipts(trillion RMB)	$x_3(t)$	0.777	0.875	1.018	1.258	1.931
International tourism receipts (billion USD)	$x_4(t)$	41.919	40.843	39.675	45.814	48.464
International tourist arrivals (100 million people)	$x_5(t)$	1.319	1.300	1.260	1.340	1.350

Table 3. Environmental development indicators data table (2011-2015)

Environmental development indicators	Variables	2011	2012	2013	2014	2015
Total amount of the wastewater discharge (billion tons)	$y_1(t)$	65.92	68.48	69.54	71.62	73.53
Total amount of SO_2 in the exhaust emission(million tons)	$y_2(t)$	22.18	21.18	20.44	19.74	18.59
Industrial solid waste production (billion tons)	$y_3(t)$	3.23	3.29	3.28	3.26	3.27
Total number of nature reserves (number)	$y_4(t)$	2640	2669	2697	2729	2740
Total investment in environmental pollution control (billion RMB)	$y_5(t)$	602.62	825.36	903.72	957.55	880.63

According to the model of the empirical analysis of the coordinated development of tourism and environment, set at *T = 1, T = 2, T = 3, T = 4, T = 5* time series, using the formula listed in front. Calculate the grey relational degree of the environmental development index to tourism development index as shown in Table 4.

Table 4. Grey relational degree of environmental development index $y_1(t)$~$y5(t)$ to tourism development index $x_1(t)$~$x5(t)$.

r_{ij}	$y_1(t)$	$y_2(t)$	$y_3(t)$	$y_4(t)$	$y_5(t)$
$x_1(t)$	0.718	0.440	0.348	0.643	0.563
$x_2(t)$	0.715	0.428	0.418	0.668	0.628
$x_3(t)$	0.717	0.436	0.419	0.642	0.587
$x_4(t)$	0.604	0.531	0.454	0.527	0.411
$x_5(t)$	0.460	0.526	0.466	0.529	0.371
AVG	0.643	0.472	0.421	0.602	0.512

Correlation strength with $0 < r \leqq 0.35$ is a weak correlation, with $0.35 < r \leqq 0.65$ is a moderate correlation, and with $0.65 < r \leqq 1.0$ is a strong correlation. The established correlation between tourism and environment development is shown in Table 5, 6 and 7.

Table 5. Strong correlation between environmental development indicators and tourism development indicators.

Environmental development indicators	Strong correlation
$y_1(t)$	$x_1(t)$, $x_2(t)$, $x_3(t)$
$y_2(t)$	
$y_3(t)$	
$y_4(t)$	$x_2(t)$
$y_5(t)$	

Table 6. Moderate correlation between environmental development indicators and tourism development indicators.

Environmental development indicators	Moderate correlation
$y_1(t)$	$x_4(t)$, $x_5(t)$
$y_2(t)$	$x_1(t)$, $x_2(t)$, $x_3(t)$, $x_4(t)$, $x_5(t)$
$y_3(t)$	$x_2(t)$, $x_3(t)$, $x_4(t)$, $x_5(t)$
$y_4(t)$	$x_1(t)$, $x_3(t)$, $x_4(t)$, $x_5(t)$
$y_5(t)$	$x_1(t)$, $x_2(t)$, $x_3(t)$, $x_4(t)$, $x_5(t)$

Table 7. Weak correlation between environmental development indicators and tourism development indicators

Environmental development indicators	Weak correlation
$y_1(t)$	
$y_2(t)$	
$y_3(t)$	$x_1(t)$
$y_4(t)$	
$y_5(t)$	

RESULTS AND DISCUSSION

According to table 4, it can be calculated the average (R) of Grey relational degree of environmental development index to tourism development index in China from 2007 to 2015 is 0.530(R=0.530), showing a moderate correlation. The percentages of strong correlation, moderate correlation, and weak correlation respectively is 16%, 80% and 4%. The domestic tourist arrivals ($x_2(t)$) appear twice in strong correlation index of environmental development, accounting for 50% in the strong correlation factors. That is, the domestic tourist arrivals are the main factor affecting the development of China's environment, to attach importance to it.

From the analysis of the relationships between tourism development indicators and environmental development indicators in China, the following three conclusions can be drawn:

(1) Tourism receipts ($x_1(t)$), number of domestic tourist arrivals ($x_2(t)$) and domestic tourism receipts ($x_3(t)$) are the strong correlation indicators of environmental development. Tourism receipts ($x_1(t)$) positive impact on the environment development is to provide more financial support for environmental protection and development; at the same time, long tourists staying time, diverse tourism demands, may have a negative impact on the environment. Number of domestic tourist arrivals ($x_2(t)$) is the majority of the number of tourist arrivals. The concept and behavior of domestic tourists have a great impact on the environment. Domestic tourism receipts ($x_3(t)$) is a major component of tourism receipts. Tourism revenue can be used to improve and upgrade the local environment.

(2) Moderate correlation indicators of environmental development contain tourism receipts ($x_1(t)$), number of domestic tourist arrivals ($x_2(t)$), domestic tourism receipts ($x_3(t)$), international tourism receipts ($x_4(t)$) and international tourist arrivals ($x_5(t)$). International tourism receipts ($x_4(t)$) and international tourist arrivals ($x_5(t)$) occupy 50%, and the rest indicators share the other half. The Tibetan people in Bitahai Nature Reserve in Yunnan Province (China) use to stop some foreign tourists from damaging the environment and telling them the importance of environmental protection.

(3) Total amount of wastewater discharge ($y_1(t)$) and total number of nature reserves ($y_4(t)$) are the strong correlation environmental development indicators of tourism development. Air pollution is one of the three main factors that influences British tourists coming to China. Animal food safety is also an important factor for international tourists. Reduction of the discharge of wastewater and increase in the number of natural reserves will greatly promote the development of tourism.

CONCLUSION

The results of the research show that tourism receipts, domestic tourist arrivals and domestic tourism receipts are the strong correlation indicators of environmental development. Tourists with different environmental awareness have different impact on the environmental. Raise tourist awareness of conservation. Elevate the cultural qualities of domestic tourists. When tourism activities have a negative impact on the environment, the number of tourists can be controlled by raising the ticket price, although tourism revenue will temporarily decline, but in the long run, the local environmental protection can promote the tourism industry. The amount of tourism revenue will be used for environmental protection and ecological improvement, and the environmental protection fund shall be no less than 10% of the income from scenic spot. It was significant to promote the coordination of tourism and environment in China.

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