Diagnostic Decision of Tourism Ecological Security Disorder Factors Using DPSIR Model and the Improved TOPSIS Method Based on Data-Driven Decision-Making Models

Changqi Liu, Huan Xu*

School of Geography, Geomatics and Planning, Jiangsu Normal University, Xuzhou, China

*Corresponding author

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Abstract: Data-driven decision models are increasingly applied to development decisions in various industries. At present, the imbalance and inadequacy between high-quality development of tourism and ecological environment protection is increasingly prominent. Therefore, it is particularly important to diagnose the obstacles of tourism ecological security and make the research on tourism ecological security to alleviate the contradiction between tourism industry and ecological environment. In order to construct the data-driven decision-making model of tourism ecological security barriers, this paper adopts the DPSIR model and data-driven TOPSIS model, adopts the Jiangsu province as an example, evaluates the improved TOPSIS mathematical method to realize the diagnostic decision of tourism ecological security barriers, and improves the research method of ecological security of tourism economy. The results show that the tourism space index P3, the growth rate of the number of tourists D6, the population density P2, the tourism traffic pressure P1 and other indicators of the obstacles to the ecological security of the tourism economy in each city are generally ranked first, showing certain spatial heterogeneity.

1. Introduction

In recent years, with the development of economy and society, our country tourism economic development rapidly, marks our country has entered the era of mass tourism, under the premise of ecological civilization construction for cultural tourism and surrounding growing demand, promote the development of cultural tourism, has become one of the main sources of tourism economic development, also enrich the tourism tourism market capacity. How to use mathematical and quantitative analysis methods to ensure a sustainable development state, as well as how to evaluate the ecological security of tourism economy and how to develop in the future, has become one of the important research topics in the academic circle. Tourism ecological security related research mainly involves tourism ecosystem management [1], tourism impact on ecological environment [2] and tourism ecological security regulation [3] and other fields, The specific results have been gradually expanded from the evaluation and research [4], the obstacle factor [5] to the trend prediction [1], the driving mechanism [6], and the maintenance path [7], Research methods include geospatial analysis [8], ecological footprint model [7], coupled coordination model [9], landscape ecology method [10], It involves different spatial scales such as scenic spot level [11], county level [12], municipal [8], provincial [13] and economic belt [14]. The international research on urban agglomeration tourism is mainly manifested in the following three aspects: first, tourism development evaluation, involving tourism economic development [15-17] and the layout of regional tourism, such as the characteristics of tourism efficiency [18, 19], and the characteristics of tourism flow network. Geographic proximity makes urban agglomeration tourism flow changeable and interrelated, exploring the spatial organization distribution and network structure evolution [19-23].

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2. Materials and Methods

2.1. Study Area

2.1.1. General Overview of the Study Area

Jiangsu Province is one part of the integration of "Belt and Road", and its strategic position is very important. (Figure 1) In 2017, Jiangsu province received 747 million domestic and foreign tourists, and achieved a total tourism revenue of 1. 16 trillion yuan, up 9. 6% and 13.6% respectively compared with 2016. The output value of tourism in Jiangsu province accounted for more than 6% of GDP, achieving good revenue from tourism. However, in Jiangsu Province, the ecological environment problems of tourism caused by excessive resource development, extensive utilization and luxury consumption have also increased accordingly. Through the evaluation of tourism economy and ecological security, the influencing factors restricting the ecological security of tourism economy and security are diagnosed and have important reference value for promoting the sustainable development of tourism in Jiangsu Province.

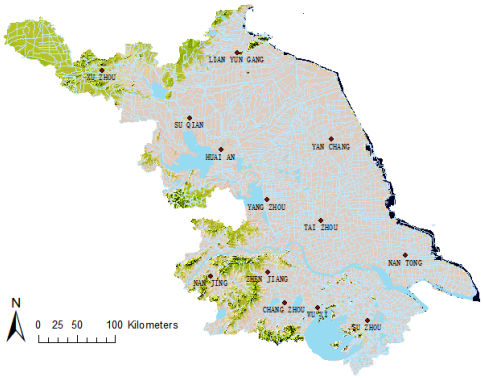

Figure 1 Overview of Jiangsu Province.

2.1.2. Data Source

The data required in this paper from the China tourism statistical Yearbook, China environmental statistics Yearbook, China city statistical Yearbook, Jiangsu province, national economic and social development statistical bulletin, Jiangsu province, Jiangsu province, city statistical Yearbook, environmental bulletin and Jiangsu city tourism bureau statistical survey data.

2.2. Research Methods

2.2.1. Index System Construction to Build Data-Driven Decision-Making Models

The DPSIR model, which has evolved from the PSR model, shows well the interaction between the external environment and human activity. Therefore, the DPSIR (driving force- -pressure- -state- -influence- -response) model is selected to construct the ecological safety evaluation index system of tourism city ecological safety. (Figure 2)

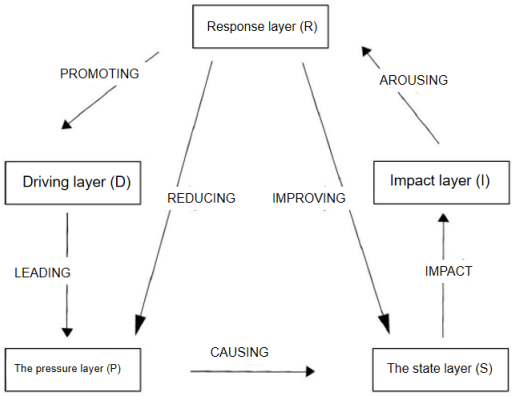

Figure 2. The DPSIR model.

Driving layer (D), as the "starting point" of regional tourism economy ecological security system, is the potential reason for the change of regional tourism economy ecological security. It will increase the investment of regional tourism economy and ecological security level. Tourism consumption will gradually become a common way for residents to improve the quality of life. The increase of per capita disposable income will increase the natural growth rate of population will affect the supply of natural resources and ecological environment quality of the tourist area. Therefore, the driving layer is measured by the per capita GDP, the tertiary industry growth rate, the urbanization rate, the natural population growth rate, the tourism income growth rate and the number of tourist's growth rate.

The pressure layer (P) comes from the driving layer, which is the table cause of the ecological environment safety problems of the regional tourism economy, reflecting the potential damage caused by the regional pollutant discharge. The total amount of wastewater discharge, the total amount of SO2 discharge, household garbage collection and the amount of solid waste production respectively reflect the pressure on the water environment, air environment and land environment of the tourism land, The index value can measure the negative impact of tourism economic and ecological environment; Tourism traffic pressure mainly reflects the pressure caused by tourists on the transportation infrastructure, It is the core reason of the negative impact of tourism industry development on the economy, society and ecology of tourism areas; Tourist space density is the number of tourists within a unit area of a tourist destination, Characterize the ecological security bearing capacity of regional tourism areas; Population density is the number of population per unit of land area, It can reflect the density of population activities in tourist areas; The greater the tourist density index, It reflects that the higher the interference degree of tourists to the life of urban residents, It makes the local people feel resistant to the foreign tourists. Therefore, the pressure layer is measured by tourism traffic pressure, population density, tourism space index, tourist density index, urban industrial wastewater discharge, SO2 discharge, and industrial dust discharge.

The state layer (S) is formed by the pressure and driven impact, reflecting the ecological environment security of regional tourism economy and resource quality. The forest coverage rate reflects the richness of forest resources, and the higher the value is for the ecological security of the tourist destination. As the park green space resources, the days of air quality is the air safety condition of the tourist destination, which reflects the air quality and ecological environment condition of the tourist destination will affect the normal life and the sustainable development of tourism. Therefore, the state layer is measured from the total tourism revenue, the total number of tourists, the density index of tourist attractions, the number of star hotels, the number of travel agencies, the garden green space area, the per capita park green space area, the green coverage rate of the built-up area, and the ratio of days with good air quality.

Impact layer (I) is reflecting the development intensity of tourism economy and resources in tourism areas. Per capita tourism income is a common indicator to describe the development of the tourism industry in the tourism development system, indicating the benefits brought by the tourism industry. The proportion of tourism in GDP reflects the impact of tourism development on the local economy and increasing the local government support for the industry; tourism economic density refers to the percentage of tourism income in its land area in a certain period, reflecting the interaction between land bearing and tourism industry. Therefore, the influence layer is measured by the proportion of the tertiary industry, the tourism income index and the per capita consumption of tourism.

Response layer (R) is a positive and effective response measure taken by tourism economic and ecological security and affected by various stresses, which can reflect the environmental governance level of pollution prevention and control in tourism areas. The proportion of environmental investment in GDP reflects the positive response in ecological protection and preventing environmental pollution; and household garbage disposal rate are the important ways to solve the pollution problem and restore the original ecological security and stability, reflecting the maintenance of tourism economy. Therefore, the response level is measured by the number of college students per 10,000 students, the proportion of financial expenditure to GDP, the proportion of urban maintenance and construction funds.

On the premise of following the principles of quantifiable, scientific and systematic, the dynamic evolution law of the ecological security of tourism economy in Jiangsu Province and its obstacles are analyzed, so as to provide a reference for decision-making for the rational development and utilization of regional tourism resources and guarantee the ecological security of regional tourism economy. (Table 1)

Table 1. Evaluation index system of tourism economic and ecological security pattern in Jiangsu Province

The standard layer	Elements layer	order number	Index layer
Driving force D	Economic elements	D1	GDP / yuan per capita
		D2	Tertiary industry growth rate /%
	Social elements	D3	Urbanization rate /%
		D4	Natural population growth rate /%
	Tourism elements	D5	Tourism revenue growth rate /%
		D6	Tourism growth rate /%
Pressure P	Tourism traffic	P1	Travel traffic pressure /%
	Tourism society	P2	Population density (person / km2)
		P3	Travel Space Index / (1 m 0 / km2)
		P4	Tourist density index /%
	Ecological condition	P5	Discharge of urban industrial wastewater / ten thousand tons
		P6	SO2 emissions / 10 thousand tons
		P7	Industrial soot emissions / ten thousand tons
State S	Economic quality	S1	Total tourism revenue / 100 million yuan
		S2	Total number of visitors / ten thousand visits
	Sightseeing resource	S3	Density index of tourist attractions /%
	Tourism facilities	S4	Star-rated hotels / number
		S5	Travel agency number /
	Ecological condition	S6	Garden green area / hm2
		S7	Green area per capita / m2
		S8	Green coverage rate of the built-up area /%
		S9	Days ratio of good air quality: /%
Influence I	Tourism economy	I1	The tertiary industry accounted for /%
		I2	Tourism revenue index /%
	Tourist market	I3	Travel per capita consumption / (yuan / person-time)
Respond R	Social response	R1	The number of college students per ten thousand students in school
	Economic regulation	R2	Fiscal expenditure accounted for GDP /%
		R3	Expenditure on urban maintenance and construction funds accounted for /%
	Comprehensive ecological improvement	R4	Industrial solid waste utilization rate /%
		R5	Centralized treatment rate of urban sewage treatment plant /%
		R6	The harmless rate of household waste /%

2.2.2. Comprehensive Evaluation Model

2.2.2.1. Unstructured Quantification of the Index Data

Due to the differences in the magnitude and order of magnitude, the extreme method was used to standardize the original index data. The specific calculation and public announcement is as follows:

Positive action indicator:

$$x'_{ij} = (x_{ij} - x_{jmin})/(x_{jmax} - x_{jmin}) \quad (1)$$

Negative action index:

$$x'_{ij} = (x_{jmax} - x_{ij})/(x_{jmax} - x_{jmin}) \quad (2)$$

In formula: $x'_{ij}$is the standardized value of raw data;x_{ij} is the original value of item j index of the i year; x_{jmin} is the minimum value of item j index; and the x_{jmax} is maximum value of item j index.

2.2.2.2. Entropy Method for Weight

The index method is more objective to determine the index weight by entropy value. The smaller the information entropy of the index, the greater the information provided, the greater the impact on the comprehensive evaluation, and thus the greater the weight, and vice versa.

The weights are calculated as follows:

$$p_{ij} = \frac{(x'_{ij}+1)}{\sum_{i=1}^{n}(x'_{ij}+1)} \quad (3)$$

$$e_j = -\frac{1}{\ln m}\sum_{j=1}^{n} p_{ij}\ \ln p_{ij} \quad (4)$$

$$\omega_j = \frac{(1-e_j)}{\sum_{j=1}^{n}(1-e_j)} \quad (5)$$

In formula: p_{ij} is the weight of the i year in the j index. The original expression is: $p_{ij} = \frac{x'_{ij}}{\sum_{i=1}^{n} x'_{ij}}$, but when$p_{ij}$ = 1 , ln$p_{ij}$is meaningless, it is corrected to formula (3) as p_{ij} . e_j is the entropy of item j indicator; m is the number of years; n is the number of indicators; ω_j is the weight value of item j indicator. Therefore, the weight of each subsystem and the weight of each individual index ω_j under the subsystem ω_k are obtained respectively.

2.2.2.3. Ecological Security Evaluation Index

The weighted comprehensive method is used to comprehensively evaluate the ecological security of tourism economy in Jiangsu Province. The function formula is:

$$E_i = \sum_{k=1}^{3} \omega_k \cdot \sum_{j=1}^{n} \omega_j x'_{ij} \quad (6)$$

In formula: E_i is the comprehensive evaluation index of tourism economic and ecological security in the year of i; k represents the number of subsystems; then $\sum_{j=1}^{n} \omega_j x'_{ij}$ is the index of each subsystem. The E_i closer to 1, the better the ecological security situation of the tourism economy is.

2.2.3. Disorder Degree Model to Diagnostic Decision of Tourism Ecological Security Based on Data-Driven Decision-Making Models

In addition to evaluating the ecological security level of tourism economy, it is also very necessary to analyze and diagnose the main obstacle factors affecting the ecological security of tourism economy. The obstacle factor diagnosis is made by introducing three indicators: factor contribution degree (U_j), indicator deviation degree (I_{ij}) and obstacle degree (M_{ij},N_{kj}). The specific formula is as follows:

$$U_j = \omega_k \cdot \omega_j \quad (7)$$

$$I_{ij} = 1 - x'_{ij} \quad (8)$$

$$M_{ij} = \frac{U_j \cdot I_{ij}}{\sum U_j \cdot I_{ij}} \times 100\% \quad (9)$$

$$N_{kj} = \sum M_{ij} \quad (10)$$

Formula: U_j indicates the weight of item j index to the total target; I_{ij} represents the gap between item j index and the tourism economic ecological security target, set as the difference between the single index and 100%; M_{ij} indicates the obstacles of the i year; and N_{kj} indicates the standard indicators to the tourism economic ecological security.

3. Results and Discussion

3.1. Analysis of the Ecological Security Pattern of Tourism Economy in Jiangsu Province

3.1.1. Comprehensive Index of Tourism Economy and Ecological Security of Jiangsu Province

Through DPSIR and entropy right TOPSIS model calculated the 13 cities of Jiangsu province tourism economic ecological security index (Table 2), for intuitive represent tourism economic ecological security in Jiangsu province, 13 cities of Jiangsu province tourism economic ecological security comprehensive index divided by natural breakpoint import Arc GIS after visual analysis, draw the tourism economic ecological security index spatial distribution diagram (Figure 3).

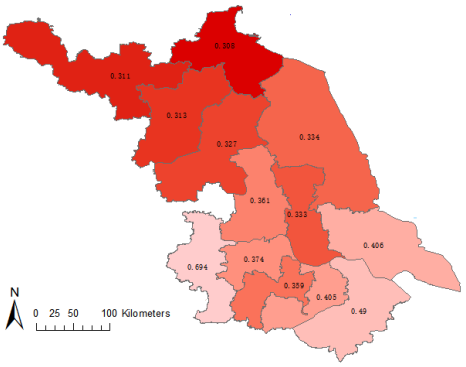

Figure 3 The ecological security index of tourism economy in Jiangsu Province

Table 2. The Ecological Security Index of Tourism Economy of Jiangsu Province

The ecological security index of tourism economy		
City name	Index value	ranking
Nanjing City	0.694	1
Wuxi City	0.405	4
Xuzhou City	0.311	12
Changzhou City	0.359	7
Suzhou City	0.49	2
Nantong City	0.406	3
Lianyungang City	0.308	13
Huai'an City	0.327	10
Yancheng	0.334	8
Yangzhou City	0.361	6
Zhenjiang City	0.374	5
Taizhou City	0.333	9
Suqian city	0.313	11

3.1.2. Classification of Tourism Economy and Ecological Security Levels in Jiangsu Province

After calculating the comprehensive index of tourism economy and ecological security in the 13 cities of Jiangsu Province, it is necessary to classify the level of tourism economy and ecological

security according to the relevant standards. According to the relevant existing literature research, there is no unified standard for the grade evaluation of tourism economy and ecological security. Therefore, on the basis of reference to the existing literature and the comprehensive index of tourism economy and ecological security of 13 cities in Jiangsu Province, the grade standard of tourism economy and ecological security can be divided as shown in the three tables as follows (Table 3):

Table 3. Classification of Tourism Economy and ecological security levels in Jiangsu Province.

Span	(0,0.25]	(0.25,0.35]	(0.35,0.45]	(0.45,0.55]	(0.55,0.65]	(0.65,0.75]	(0.75,1]
Security classification	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7
Safe state	The deterioration level	Risk level	Sensitive level	Critical security level	General safety level	Compare security levels	Very secure

3.2. Analysis of the Overall Characteristics of Tourism Economy and Ecological Security in Jiangsu Province

From the spatial point of view, the economically developed Ningzhenyang urban agglomeration, the Suzhou-Xi-Changzhou-Taihu urban agglomeration and the Nantong city with a good ecological environment have a high safety factor, roughly showing the spatial difference of "high in the south and low in the north". The internal development of Nanjing and Suzhou is 0.694 and 0.405 respectively. With the prominent "dual-core" characteristics, the average ecological safety coefficient of tourism economy in 13 cities is 0.4157, and the only 3.5 cities are lower than the average value. (Figure 4).

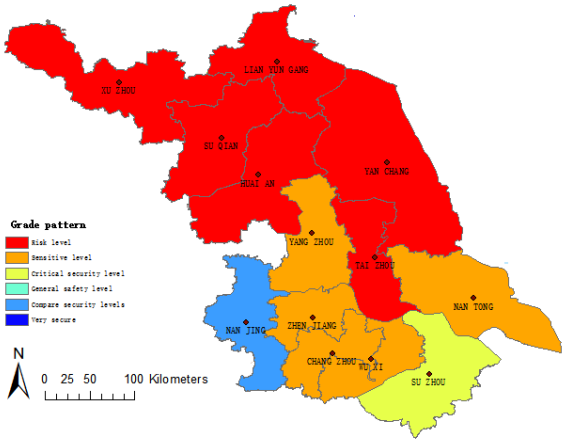

Figure 4 Grade pattern of tourism economy and ecological security in Jiangsu Province.

3.3. Diagnostic decision of Tourism Ecological Security Disorder Factors Based on Data-Driven Decision-Making Models

Application of tourism economic ecological security obstacle factor diagnosis model of Jiangsu province city tourism economic ecological security obstacle factor diagnosis, due to the index layer influence factors, for the further tourism economic ecological security factors, through the model calculation ranking years ranked the top five obstacle factor, for the diagnosis of the main obstacle factor (Table 4).

From Table 4: from the perspective of similarity analysis, according to the barriers ranking can be concluded, tourism space index P3, tourist growth D6, population density P2, tourism traffic pressure P1 index on municipal tourism economy of ecological security barriers generally ranking near the top, plus regional construction development in Jiangsu province larger intensity of the importance of the ecological environment is not high limit the ecological security level of tourism economy in Jiangsu province. From the perspective of heterogeneity, the obstacle factors are different, including urban and rural construction intensity, flat terrain, dense population, and population density P2 is the main obstacle factor in Suzhou and Wuxi; in the northern Jiangsu, the urban and rural level and

infrastructure construction is low, the harmless rate of domestic waste R6 and industrial solid waste utilization rate R4 are the main obstacle factor in Huaian and Lianyungang; in the central region, the high economic level and the urbanization process are fast, making the distribution of obstacle factors in this region is scattered. In addition, from the perspective of DPSIR, the factors with higher barriers are basically concentrated in the pressure system, while the obstacle factors in some cities come from the driving force system and the pressure system, while the obstacle effect affecting the system and the response system is relatively weak.

Table 4 Diagnosis of ecological security barriers in tourism economy of Jiangsu Province.

Diagnostic object	Project	The top five indicators are ranked				
		1	2	3	4	5
Nanjing City	Obstruction factor	R3	S6	R2	I1	R1
	Disorder%	11.90553421	11.90195888	10.41109566	9.710684214	9.283215762
Wuxi City	Obstruction factor	D6	P 2	S6	D4	D5
	Disorder%	9.932487655	8.094114626	7.480487963	6.161398581	6.093277677
Xuzhou Citey	Obstruction factor	D6	P3	S6	P2	P1
	Disorder%	9.426734404	9.223565007	7.452718252	7.122681948	6.926125729
Changzhou City	Obstruction factor	P3	D6	S6	D5	P1
	Disorder%	8.803050377	8.752569464	8.279874601	6.478253054	5.705574131
Suzhou City	Obstruction factor	D6	P 2	S6	P 3	D4
	Disorder%	10.54025484	8.880659712	7.939247301	6.889987988	6.482048014
Nantong City	Obstruction factor	P3	D6	P2	D4	P1
	Disorder%	12.97281841	11.29885834	10.94036677	8.648382003	6.679719553
Lianyungang City	Obstruction factor	P3	R 6	R 4	P1	R3
	Disorder%	12.31380489	10.21132887	7.154180085	6.529394059	6.493880323
Huai'an City	Obstruction factor	R 6	P3	R4	P2	D 6
	Disorder%	10.98188256	10.76031507	8.295349724	7.678793454	5.956067387
Yancheng	Obstruction factor	P3	D6	P2	P1	D4
	Disorder%	10.71852246	10.66235947	10.23783486	9.865549961	5.783986331
Yangzhou City	Obstruction factor	P3	D6	P1	D4	D5
	Disorder%	11.20630189	9.699742629	8.197664531	6.405584603	5.322364149
Zhenjiang City	Obstruction factor	P3	D6	P1	P7	S1
	Disorder%	11.27970667	9.126511974	6.846495806	5.935536568	5.739756953
Taizhou City	Obstruction factor	P3	D6	P2	P1	D4
	Disorder%	12.97878927	10.36132964	10.08413386	7.961664367	6.444065556
Suqian city	Obstruction factor	P3	D6	P2	P1	D4
	Disorder%	10.99689794	10.58474418	9.184070041	8.950372983	7.275869056

4. Conclusion and Policy Enlightenment

Tourism economic ecological security in Jiangsu province presents obvious regional differentiation, tourism economic ecological security system is affected by the economic, social, natural and other factors is more significant. In the development of tourism in Jiangsu province should also balance the comprehensive benefits of tourism economic ecological security, give full consideration to the coordinated development of regional tourism economic ecological security. In view of the obvious differences in the obstacle factors in the north, central and southern regions of Jiangsu Province, we should increase the financial input in ecological environment in combination with the local social and economic conditions, formulate targeted regulations and policies, and strengthen the research and detection of the coordinated and stable development state of tourism development and ecological environment in Jiangsu Province. Jiangsu tourism resources are rich in, but the old development mode, path dependence phenomenon is serious, leading to the lack of brand effect of tourism resources in Jiangsu province, attractive, the future should be economic development and ecological environment as the goal, from the "resource extensive type" development mode to "resource intensive" development mode, implementation on the premise of ensuring ecological

environment rationalization of tourism resources utilization, improve the quality of regional economic development.

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