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Original Research

Determining a Reasonable Speed for Xinjiang's Tourism Development in the '14th Five-Year Plan' under the Green Concept: Analysis from the Perspective of Water Environment Regulation

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Abstract

Taking Xinjiang Autonomous Region as the research area and water environment regulation as the analysis perspective, this paper proposes a method to analyze the reasonable speed of regional tourism development under the green concept. This study analyzes the basic elements of the subsystem of tourism development and water environment regulation, and constructs an evaluation index system. The index is normalized, and the weight of the index is determined through the combination weighting method. The coupling degree of tourism development and water environment regulation in different years is divided into four grades: excellent, good, meduim and poor. This paper also predicts the relevant development indicators of Xinjiang Autonomous Region in 2025, at the end of the 14th Five-Year Plan period. The average coupling degree corresponding to the excellent and good years during the sample years is taken as the threshold value, in order to estimate the reasonable development speed of Xinjiang Autonomous Region's tourism in 2025. The results show that, during the 14th Five-Year Plan period, in order to ensure a good degree of coupling between the development of tourism and the regulation of the water environment in Xinjiang Autonomous Region, the total scale of tourists in Xinjiang Autonomous Region should be controlled within the range of from 257 million to 284 million person-times, and the development speed should be controlled to between 11.56% and 12.93% per year.

Keywords: water environment regulation, tourism development, coupling degree, threshold value, reasonable speed

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Introduction

The Proposal of the CPC Central Committee on Formulating the 14th Five-Year Plan for National Economic and Social Development and the Vision for 2035 recommends that, during the '14th Five-Year Plan' period (2021-2025), China must adhere to the concept that lucid waters and lush mountains are invaluable assets. In addition, the promotion of green and low-carbon development should be accelerated, the environmental quality should continue to improve, the quality and stability of ecosystems should be enhanced, and resource utilization efficiency should be comprehensively improved. China's arid areas are generally characterized by lack of water resources, fragile ecology and lagging economic development. However these areas also have their own particular characteristics in terms of tourism resources. Almost without exception, tourism has become a pillar industry in these places. Tourism in arid areas has played an important role in promoting regional economic development, helping the region to significantly reduce poverty, and ensuring the stability of ethnic groups and local areas. However, tourism developing too rapidly will cause the continuous occupation of the entity water in the region; a threat will therefore be posed to the regional water environment. According to statistics, Xinjiang, a typical arid and semi-arid region in China, received 15.24 million tourists in 2018, generating total tourism revenue of 257.97 billion yuan, which in turn accounted for 20.14 percent of the region's total GDP. In 2018, Xinjiang's tourism-related water consumption reached 2.8 billion cubic meters (m^3), accounting for about 5.10% of the region's total water consumption. Due to the fact that the agricultural water consumption in Xinjiang generally accounts for more than 90% of the region's total water consumption, tourism has become the second largest water consumption industry in Xinjiang after agriculture. Therefore, the potential impact of tourism on the region's water environment cannot be underestimated. In order to implement the requirements of the '14th Five-Year Plan' development strategy formulated by the Chinese government and to comply with the international trend of green and low-carbon economic development, the Xinjiang government must determine a reasonable rate of development of the tourism industry. The decision makers must take into account the healthy and sustainable development of the regional social economy and the carrying capacity of water resources and environment. If tourism develops too slowly, the region's social economy may fail to reach the required level of development. On the other hand, overly-rapid tourism development is likely to break through the carrying capacity of the regional water environment and affect or even destroy the regional ecosystem.

In recent years, the problem of how to formulate development strategies for tourism and other industries based on water resources constraints has attracted great attention, and remarkable progress has been made. (1) In terms of existing research examining the relationship between tourism and water resources, Yao Y.Y. et al. proposed that tele-coupling can alleviate water scarcity and poverty in drylands. The study found that, from 2000 to 2012, the tourism industry's contribution to saving water increased dramatically, through its ongoing expanding market [1]. However, Gössling et al. believed that tourism development has a huge 'multiplier effect' on indirect water resources consumption, which is bound to create huge pressure on water resources [2]. Hadjikakou et al. proposed that, in the foreseeable future, 'water use' will become an important parameter in the evaluation of sustainable tourism. The quality, quantity and availability of water resources will also have an important impact on the development of tourism [3]. Sun Q. et al. focused on studying the impact of tourism on a destination's water environment from the microscopic perspective of scenic spots [4]. Some researchers, based on the demand for the sustainable development of tourist spots, proposed methods to calculate the water resource carrying capacity of tourist spots [5, 6]. Other scholars have also studied the coordinated development relationship between tourism and water resources from the perspective of the tourism water footprint [7-9]. (2) In terms of tourism development and water management policy research, Charara N. et al. proposed increasing the financial attraction of water-saving measures through policy incentives and tax policies [10]. Cervantes-Cocom G. et al. confirmed that water management and environmental education could promote the sustainable development of tourism in Valladolid, Yucatan. The study then recommended the use of energy-saving technology, multiple forms of advertisements that motivate water saving, awareness campaigns for workers and environmental policies [11]. Vila M. et al. advised using the improved Delphi method to identify the key factors that affect the water resource management of tourism destinations, so as to provide a basis for the decision-making related to tourism water demand management [12]. Chan W. et al. proposed water-saving measures for Hong Kong hotels, such as reusing swimming pool water and the installation of flow regulators in rooms, kitchens or laundry rooms [13]. Antakyali D. et al. suggested using a membrane bioreactor for the treatment and detection of hotel sewage in order to realize the circulation mode of water resources [14]. McLennan C.J. et al. believed that water resource management measures have geographical differences. The study found that, among seven influencing factors, the double-flush toilet is the only factor that improves the water use efficiency of hotels in the Asia-Pacific region [15]. Different from the research perspectives of the above-mentioned scholars, Rimba A.B. et al. focused on the impact of population growth, land use, and land cover changes on water quality in tourism-dependent economies [16]. (3) In terms of research on the relationship between water environment regulation and industry development, Xu C.X. et al. determined a reasonable range of regional urbanization development speed. The study constructed an analysis model of the reasonable speed of regional urbanization development under the constraint of the water environment carrying capacity; the comprehensive evaluation value of the water environment carrying capacity was also calculated under different scenarios [17]. Zhang Y. et al. used the LMDI method to study the effect of decomposition factors on industrial wastewater discharge in China. The results show that industrial economic growth is the main driving force behind the increase in industrial wastewater discharge levels [18]. In a study that measured the coupling coordination degree between economic growth quality and ecological environment optimization in the Yangtze River Economic Belt, Li Q. et al. found that foreign direct investment, research and development, and institutional quality promote the coupling and coordinated development of economic growth quality and ecological environment optimization. However, economic growth, industrial upgrading and environmental regulation all reduce the coupling coordination degree [19]. Deng Z.B. et al. analyzed the level of Chinese water ecological civilization construction at national and provincial levels, from 2010 to 2016, in terms of total water resource control, water use efficiency control, comprehensive water environment management, and water management system implementation [20].

Existing studies have made rich achievements in certain aspects of tourism water consumption measurement, the impact of tourism water consumption on the social economy, tourism water-saving policies, etc. However, research on how to analyze the moderate development of tourism based on water environment regulation is still lacking. First, in the analysis of tourism water consumption, the academic focus to date has mainly been based on the pressure of tourism development on regional water resources, but few research results specifically relate to the reasonable development speed of tourism in arid areas. Secondly, the amount of research regarding the combination of water environment regulation subsystems and tourism development subsystems from the perspective of system analysis is still insufficient. Thirdly, no relevant reports have been made that examine how to estimate the reasonable development speed of tourism based on the coupling relationship between tourism development and water environment regulation in tourism development. Based on this research gap, the coupling degree model of tourism development and water environment regulation in Xinjiang is constructed in this paper. Then, this paper calculates a reasonable range of the speed of tourism development in Xinjiang from the perspective of water resources endowment constraints. In this paper, the method of measuring that speed expands the perspective of the international community in studying the development patterns of green and low-carbon economy, and provides a theoretical basis for the realization of 'human-water harmony'. At the same time, the method also provides new ideas for how to achieve green and sustainable development in other industries.

Material and Methods

This paper aims to obtain the reasonable development rate of tourism under the satisfactory coupling state between water environmental regulation and tourism development. The main research ideas and steps are as follows:

Step 1: Construct the evaluation index system. During this stage, this paper respectively analyzes the basic elements of the tourism development subsystem and the water environment regulation subsystem. Then the evaluation index system of each subsystem is constructed.

Step 2: Standardize all indicators and determine the weights. During this stage, the efficiency and cost indexes are respectively standardized, in order to determine the weight of each index.

Step 3: Construct the coupling degree evaluation model. During this stage, this paper firstly calculates the tourism development index and water environment regulation evaluation index, respectively. Then measurements are made of the coupling degrees of regional tourism development and water environment regulation in the recent years. Finally, based on the calculation results, the coupling degrees of recent years are divided into four grades: excellent, good, medium and poor.

Step 4: Determine the reasonable range of regional tourism development speed. To determine the reasonable speed range, this paper firstly needs to forecast the development indicators related to the 14th Five-Year Plan. Then, the coupling threshold of tourism development and water environment regulation is set.

Step 1: Construction of the Evaluation Index System

Subsystem Construction and Element Analysis

In this paper, tourism development and water environment regulation are taken as two subsystems. The subsystem of tourism development is used to describe the process of the continuous optimization of the regional tourism industry, the increasing number of tourists and the continuous growth of tourism revenue. The subsystem of water environment regulation is used to describe the strength of the government's water environment regulation policy in a certain period and a certain region. This paper adopts the composite index method to construct the evaluation index of water environment regulation intensity from the aspects of policy and regulation elements, water quantity elements, water quality elements and ecological

Table 1. The basic elements and the description of the tourism development subsystem and water environment regulation subsystem..

Subsystem	Basic elements	Components
Tourism development	Elements about residents and visitors	Including the total number of local residents, the total number of tourists, the structure of tourists and so on
	Elements about tourism income	Including total regional tourism revenue, tourism revenue in GDP, etc.
Water environment regulation	Elements related to policy and regulations	Number of newly-issued environmental protection policies and regulations, and the cumulative number of environmental protection policies and regulations
	Water quantity elements	Including the total amount of regional water resources, regional tourism industry water consumption, etc.
	Water quality elements	Including the intensity of waste water discharge in the tourism industry and the intensity of regional sewage treatment
	Elements related to ecological environment	Including the area of wetland, forest cover and so on

environment elements. The basic elements of the tourism development subsystem and the water environment regulation subsystem are presented in Table 1.

Evaluation Index System Construction

The issue of how to optimally develop tourism under the constraints of water environment regulations involves complex social relations in many fields. The number of tourists, the components of tourists and tourism income are important indicators that reflect the development level of tourism. Meanwhile, water supply, water use, wastewater discharge and wastewater disposal are important indicators that reflect the state of the water environment. Combined with the element analysis in Table 1, the intensity evaluation index systems of the tourism development subsystem and the water environment regulation subsystem are constructed, as shown in Table 2.

The level of tourism development depends on the total number of tourists, the total tourism consumption, the development of tourism products, the employment

Table 2. Tourism development and water environment evaluation index systems.

	Index		Index calculation method/access method	Functions of indexes	Class
Tourism development	Elements pertaining to residents and visitors	Total number of local residents Y_1 (10,000 persons)	National/local statistical yearbooks	Analyzing the relationship between water environment carrying capacity and total population	-
		Total number of tourists Y_2 (10,000 persons)	National/local statistical yearbooks	Analyzing the impact of tourism development speed on water environment	-
		Ratio of overseas tourists Y_3 (%)	Number of foreign tourists/total number of tourists	Analyzing the impact of tourists from different areas on water quantity and quality	-
		Percentage of high-spending tourists Y_4 (%)	The proportion of tourists staying in hotels of 4 stars and above to the total number of tourists	Analyzing the impact of different levels of tourists on the water environment	-
		Number of tourism employees Y_5 (10,000 persons)	Number of employees in the catering industry + number of employees in star-rated hotels	Analyzing the impact of practitioners on water consumption and quality	-
	Elements of tourism income	Total regional tourism revenue Y_6 (million yuan)	National/local statistical yearbooks	Analyzing the ability of regional tourism to control the water environment	+
		Ratio of total tourism revenue in GDP Y_7 (%)	Total tourism revenue/ total GDP	Analyzing the status of tourism in local economic development	+
		Per capita tourism consumption Y_8 (yuan/person)	National/local statistical yearbooks	Reflecting the contribution of tourists to the local economy	+

Table 2. Continued.

Water environment regulations	Elements of policy and regulations	Number of newly-issued environmental protection policies and regulations Y_9 (pieces)	Related legal websites	Reflecting the strength of regional environmental protection policies	+
		Accumulated number of environmental protection policies and regulations Y_{10} (pieces)	Related legal websites	Reflecting the strength of regional environmental protection policies	+
	Water element	Total regional annual water supply Y_{11} (billion m^3)	National/local water resources bulletins	Reflecting regional water supply capacity	+
		Water consumption of regional tourism industry Y_{12} (billion m^3)	Conversion based on field surveys, sample surveys, payment information, etc.	Reflecting the relationship between the number of tourists, tourism income and other indicators and total water consumption	-
	Water quality factors	Total regional wastewater discharge Y_{13} (billion tons)	National/local water bulletins	Reflecting the intensity of regional sewage discharge	-
		Ratio of wastewater discharge from tertiary industry Y_{14} (%)	National/local water bulletins	Reflecting the wastewater discharge intensity of the tertiary industry in the region	-
		River chief proportion of Class I – III rivers Y_{15} (%)	National/local water bulletins	Reflecting the proportion of high-quality waters in the region	+
		Sewage centralized treatment rate Y_{16} (%)	National economic, social and environmental bulletins	Reflecting the sewage treatment situation in the region	+
	Elements of the ecological environment	Wetland area Y_{17} (km^2)	National/local statistical yearbooks	Reflecting the regional ecological environment	+
		Forest coverage Y_{18} (%)	National/local statistical yearbooks	Reflecting the ecological function of the area to improve the water environment	+

status of the tourism industry, and so on. This article utilizes the change in the total number of tourists to reflect the speed of the development of the tourism industry. The specific formula is as follows:

$$v_{t_1,t_2} = \left(Y_2(t_2)/Y_2(t_1)\right)^{1/(t_2-t_1)} - 1 \tag{1}$$

In Formula (1), v_{t_1}, v_{t_2} represents the average tourism development speed from year t_1 to year t_2; $Y_2(t_1)$ and $Y_2(t_2)$, respectively, reflect the total number of tourists in year t_1 and t_1.

Step 2: Standardization of Indicators and Determination of Weights

Standardization of Indicators

This paper standardizes the indicators by using the interval number method. Finally, the indicators are standardized to the score interval [M^0, M^*]. The normalized formula is:

$$\begin{cases} Z_{ij} = M^0 + (M^* - M^0)\dfrac{y_{ij} - y_j^{\min}}{y_j^{\max} - y_j^{\min}}, & \text{efficiency type} \\ Z_{ij} = M^0 + (M^* - M^0)\dfrac{y_j^{\max} - y_{ij}}{y_j^{\max} - y_j^{\min}}, & \text{cost type} \end{cases} \tag{2}$$

Here, y_{ij} is the j-th index value of the year *i*; Z_{ij} represents the j-th index value of the year *i* after normalization, and $y_j^{\max}$ and $y_j^{\min}$ are, respectively, the maximum and minimum values under the same index in different years.

Determination of Index Weight

Aiming at the sub-systems of tourism development and water environment regulation, the weight of different indexes is calculated by the combination weight method.

– Determine the subjective weight $w_j^{(1)}$. This paper firstly uses the AHP method to establish a hierarchical structure model. Then the 5-scale method is utilized to determine the subjective weight $w_j^{(1)}$.

– Determine the objective weight $w_j^{(2)}$. Under the variation coefficient method, due to the dimensional difference of each index, the coefficient of variation of each index is used to measure the degree of difference in the value of each index in this study.

$$e_j = \frac{S_j}{\overline{x}_j} \tag{3}$$

Here, e_j is the coefficient of variation of the j-th index; S_j represents the standard deviation of the j-th index, and $\overline{x}_j$ is the mean of the j-th index.

The objective weight of each index is:

$$w_j^{(2)} = \frac{e_j}{\sum_{j=1}^{n} e_j} \tag{4}$$

– Determine the combination weight. In this study, W_j (j = 1, 2, ..., n) is taken as the combination weight; then, the calculation formula is as follows:

$$w_j = \frac{w_j^{(1)} w_j^{(2)}}{\sum_{j=1}^{n} w_j^{(1)} w_j^{(2)}} \tag{5}$$

Step 3: Construction of Coupling Degree Evaluation Model

Evaluation Model of Coupling Degree between Tourism Development and Water

Environment Regulation

If the evaluation value of the coupling degree between regional tourism development and water environment regulation in the level year i is recorded as E_i(j = 1, 2, ..., m), then the calculation formula is as follows:

$$E_i = \sqrt{\frac{\alpha_i^L \cdot \alpha_i^S}{\alpha_i^L + \alpha_i^S}} \tag{6}$$

...where α_i^L is the tourism development index of the program x_i, and α_i^S represents the water environment assessment index of the program x_i. The following formula is used to calculate the two indexes:

$$\alpha_i^L = \sum_{j=1}^{8} \omega_j^* \cdot Z_{ij} \quad \alpha_i^S = \sum_{j=9}^{18} \omega_j^* \cdot Z_{ij} , \tag{7}$$

...where the weight w_j^* is calculated according to Formula (5).

Coupling Degree Grade Division

In this study, the sample years of regional tourism development are recorded as 1,2,...,m, namely, the total current development years are m years. The coupling degrees between tourism development and water environment regulation in different years in the sample period are calculated according to Formula (6) and are classified into four grades: excellent, good, medium and poor. The specific meaning of each grade is shown in Table 3.

All indicators of the two sub-systems of tourism development and water environment regulation in year i are combined into program x_i. The respective sets composed of years with excellent, good, medium and poor coupling degrees are denoted as $D_{excellent}$, D_{good}, D_{medium} and D_{poor}. If $r \in D_{excellent}$, $q \in D_{good}$, $k \in D_{medium}$, $l \in D_{poor}$ it is reasonable to believe that: $x_r \succ x_q \succ x_k \succ x_l$, where '$\succ$'suggests 'better'. For example $x_r \succ x_q$ indicates that the coupling degree of 'tourism development subsystem-water environment regulation subsystem' in year r is better than that in year q.

Step 4: Reasonable Range of Regional Tourism Development Speed

Forecast of Relevant Development Indicators for the Planning Year

According to the available data, the evaluation indexes are divided into two categories. Specifically, they are Class A indexes, whose predicted values or development trend information can be directly obtained from relevant national or local planning reports, and

Table 3. Symbolic meaning of decision-maker's impression rating.

Grade	The value of E_i	Symbolic meaning
Excellent	$E_i \geq \theta_1$	The tourism industry has been fully developed in this year under the constraints of water environment regulations in the year *i*.
Good	$\theta_1 < E_i \leq \theta_2$	The tourism industry has achieved good development under the restriction of water environment regulations in the year *i*.
Medium	$\theta_2 < E_i \leq \theta_3$	The development speed of tourism in the year *i* is faster or slower under the restriction of water environment regulation.
Poor	$E_i \leq \theta_3$	The tourism industry develops too fast or too slowly under the constraints of water environment regulations in the year *i*.

Table 4. Class A and B indexes.

Class A indexes	Y_1, Y_9, Y_{10}, Y_{11}, Y_{14}, Y_{15}, Y_{16}, Y_{17}, Y_{18}
Class B indexes	Y_3, Y_4, Y_5, Y_6, Y_7, Y_8, Y_{12}, Y_{13}

Class B indexes, whose predicted values or development trend information are generally impossible to obtain from planning reports and which need to be forecast with reasonable methods.

This study takes the total number of tourists (Y_2) as a decision variable. The specific division of Class A and Class B indexes is shown in Table 4.

Estimation of Reasonable Speed of Tourism Development

The total number of tourists (Y_2) in the planning year is taken as a decision variable in this study. Also, on the basis of predicting the other indicators that year, the set threshold is used to calculate the reasonable value range of the total number of tourists (Y_2) in the planning year. Then, the reasonable speed of tourism development is estimated.

According to the annual average of 'good' coupling degrees and that of 'excellent' degrees during the sample years, the coupling degree threshold between the 'good' level and the 'excellent' level of the planning year are set, and the calculation formula is as follows:

$$\xi_{good} = \sum_{q=1}^{m_{good}} E_q \big/ m_{good} \quad ; \quad \xi_{excellent} = \sum_{r=1}^{m_{excellent}} E_r \big/ m_{excellent} \tag{8}$$

...where E_q and E_r, respectively, represent 'good' and 'excellent' coupling degrees in a certain sample year; m_{good} and $m_{excellent}$ are the number of years in which 'good' and 'excellent' coupling degrees occur, respectively.

In this study the coupling degree of the planning year p is denoted as E_p. Also, Z_{pj} represents the normalized value of various indicators in the planning year; for example, Z_{p2} is the normalized value of the total number of tourists (Y_2) in the planning year, which is a variable to be estimated. In order to make the coupling degree of 'tourism development subsystem-water environment regulation subsystem' in the planning year reach levels of 'good' or 'excellent', the following discrimination criterion is established:

$$\xi_{good} \le E_p \le \xi_{excellent} \tag{9}$$

The value range of Z_{p2} in the planning year can be obtained by solving Equation (9), which is denoted as: $Z_{p2} \in [\underline{Z}_{p2}, \overline{Z}_{p2}]$.

In this study, Formula (2) is used to calculate the value range of the total number of tourists (Y_2) in the planning year p based on $[\underline{Z}_{p2}, \overline{Z}_{p2}]$, which is denoted as: $Y_{p2} \in [\underline{Y}_{p2}, \overline{Y}_{p2}]$.

Based on Formula (1), and taking the year m in the formula as the base year, this study can then use $Y_2(t_1) = y_{m2}$ and $Y_2(t_1) = \underline{Y}_{p2}$ to calculate the lower limit speed ($\underline{v}_{m,p}$) of tourism development in the planning year; $Y_2(t_1) = y_{m2}$ and $Y_2(t_2) = \overline{Y}_{p2}$ can be used to calculate the upper limit speed ($\overline{v}_{m,p}$).

Overview of the Study Area and Data Sources

Overview of the Study Area

Xinjiang, China is located at 73°40'~96°23'E and 34°25'~49°10'N; this is an arid inland climate region with rare precipitation and intense evaporation. The average annual precipitation in Xinjiang is 154.5 mm, which is only 25% of the national average precipitation depth. According to the results of National Water Resources Comprehensive Planning, Xinjiang has an average annual total precipitation of 254.4 billion m^3. The region's self-produced water resources amount to 83.27 billion m^3, including surface water of 78.86 billion m^3 and non-repetitive water of 4.41 billion m^3 between surface water and groundwater. However, the water production per unit area is only 53,000 m^3 per square kilometer.

According to China Tourism Statistics Yearbook (2017), there are 369 A-level scenic spots in Xinjiang, including 11 5A-level scenic spots and 88 4A-level scenic spots. In recent years, Xinjiang's tourism industry has developed rapidly. In 2017, Xinjiang received 107.25 million tourists (unit: person-times), creating a total tourism revenue of 182.12 billion yuan, which only accounted for 16.74% of the total regional GDP. However, in 2018, the scale of tourists reached 150.24 million person-times, and the total tourism revenue increased significantly to 257.97 billion yuan, accounting for 20.14% of the total regional GDP.

Data Sources

The sample period in this study is from 2003 to 2017 (the sample years). The basic data collected that pertain to the sample years are shown in Table 5.

In Table 5, the values of Y_1, Y_2, Y_6, Y_8, Y_{17} and Y_{18} were derived from China Statistical Yearbook (2003-2017) or relevant local statistical yearbook from 2003 to 2017. The values of Y_9, Y_{10}, Y_{13}, Y_{14} and Y_{15} were obtained from China Water Resources Bulletin (2003-2017) or relevant local water resources bulletins from 2003 to 2017. The index values of Y_{12} and Y_{16} were derived from relevant bulletins about the Chinese economy, society and environment, from 2003 to 2017. In addition, Y_3 was calculated according to the ratio of the number of overseas tourists to the total number of tourists; Y_4 was computed according to the proportion of tourists staying in 4-star hotels or above to the total number of tourists. Then Y_5 was calculated based on the sum of the

Table 5. Evaluation index values from 2003 to 2017.

Index/unit	Year														
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Y_1 (10,000 persons)	1934	1963	2010	2050	2095	2131	2159	2185	2209	2233	2264	2298	2360	2398	2445
Y_2 (10,000 persons)	1029	1274	1498	1697	2170	2231	2134	3145	3962	4861	5206	4953	6097	8102	10726
Y_3 (%)	1.66	2.49	2.21	2.14	2.02	2.54*	2.82*	3.39	3.34	3.08	3.01	3.03	2.76	2.47	2.19
Y_4 (%)	15.27	15.30*	15.56	18.58	21.94	22.96	21.40	26.88	29.70	30.34	32.10	34.95	40.18	39.59	39.64
Y_5 (10,000 persons)	3.78	3.36	3.52	3.94	4.50	4.55	4.46	4.30	4.54	5.03	4.23	3.99	4.01	4.01	4.07
Y_6 (10^8yuan)	91.9	115.0	137.2	157.6	203.6	206.9	185.8	305.5	441.7	578.1	676.0	652.3	1025.1	1399.5	1821.2
Y_7 (%)	4.87	5.20	5.27	5.18	5.78	4.92	4.13	5.15	6.68	7.13	8.01	7.03	10.99	14.50	16.74
Y_8 (yuan/person)	893	903	915	929	938	927	871	971	1115	1189	1299	1317	1681	1727	1698
Y_9 (pieces)	12	20	58	47	68	72	61	76	98	84	74	80	86	21	40
Y_{10} (pieces)	12	32	90	137	205	277	338	414	512	596	670	750	836	857	897
Y_{11} (10^8m^3)	494.4	497.1	508.5	513.4	517.7	528.2	530.9	535.1	523.5	590.1	588.0	581.8	577.2	565.4	552.3
Y_{12} (10^8m^3)	4.33	4.90	5.46	5.98	6.88	7.03	6.93	8.88	11.13	14.35	14.77	14.88	18.01	21.11	27.89
Y_{13} (10^8ton)	8.47	8.02	7.17	7.56	8.04	8.31	8.50	11.59	10.35	10.32	10.83	10.83	10.78	11.13	10.13
Y_{14} (%)	14	12.7	13	11.9	11	9.7	9.8	13.4	4.6	6.9	9.1	12.2	10.8	10.8	11*
Y_{15} (%)	86.9	72.2	87.5	86.3	92.4	97.4	96.8	98.6	98.7	91.3	91.9	91.1	97.1	97	97*
Y_{16} (%)	62*	63.59	62.18	72.13	59.71	66.98	69.7	71.9	75	82.4	86.7	85.2	82.1	84.3	88.3
Y_{17} (km^2)	14102	14102	14102	14102	14102	14102	14102	14102	14102	14102	39482	39482	39482	39482	39482
Y_{18} (%)	2.9	2.9	2.9	2.9	2.9	2.9	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2

Note: The meanings of each index code are the same as those in Table 2; ‘*’ indicates the missing statistical data supplemented by the author based on the changing law of the data.

Table 6. The results of w_j^*.

Tourism development indexes	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8		
w_j^*	0.064	0.267	0.076	0.091	0.069	0.196	0.084	0.153		
Water environment regulation indexes	Y_9	Y_{10}	Y_{11}	Y_{12}	Y_{13}	Y_{14}	Y_{15}	Y_{16}	Y_{17}	Y_{18}
w_j^*	0.088	0.043	0.191	0.160	0.176	0.153	0.060	0.053	0.040	0.036

Note: The meanings of each index code are the same as those in Table 2.

Table 7. Coupling degree from 2003 to 2017.

	Year														
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Coupling degree	19.64	19.48	19.64	19.68	19.53	19.59	19.67	19.29	19.89	19.86	20.20	19.90	20.39	20.43	20.19
Grade	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Poor	Good	Good	Excellent	Good	Excellent	Excellent	Good

number of employees in the catering industry and the number of employees in star-rated hotels; Y_7 was based on the ratio of Xinjiang's total tourism revenue to its GDP, and Y_{11} was obtained through conversion based on field surveys, sample surveys, water fee payment information, etc.

Results and Discussion

Index Normalization Processing and Weight Calculation

This paper takes $M^0 = 60$ and $M^* = 100$, and normalizes the index value based on Formula (2). In view of the paper's length, the calculation process is omitted. The combination weight method is adopted to calculate the value of ω_j^* according to Formula (5). The results are shown in Table 6.

Calculation of the Coupling Degree between Tourism Development and Water Environment Regulation in Xinjiang during Sample Years

Based on Formula (6), this paper calculates the coupling degree between tourism development and water environment regulation in Xinjiang during the sample years. According to expert advice and combining the characteristics of tourism development in Xinjiang, this article firstly sets the coupling degree classification standard. Then the coupling degrees of different sample years are divided into four grades: excellent, good, medium and poor. See Table 7 for details.

According to Table 7, the scatter plots of the coupling degrees of different years are drawn; the coupling degrees of each year are also classified, based on the set classification standard (see Fig. 1).

As shown in Fig. 1, from 2003 to 2017, the coupling degree between tourism development and water environment regulation in Xinjiang generally showed a 'positive' trend. Specifically, the coupling degrees were 'medium' from 2003 to 2009, 'poor' in 2010, 'good' in 2011, 2012, 2014 and 2017, and 'excellent' in 2013, 2015 and 2016.

Estimation of the Reasonable Speed of Tourism Development in Xinjiang during the 14th Five-Year Plan

Forecast of Related Development Indicators in the Planning Year

This study takes 2017 as the base year, and regards 2025, the end of the 14th Five-Year Plan, as the planning year.

Class A indexes were obtained through relevant national or local planning reports; the forecast results are shown in Table 8. In accordance with the principle

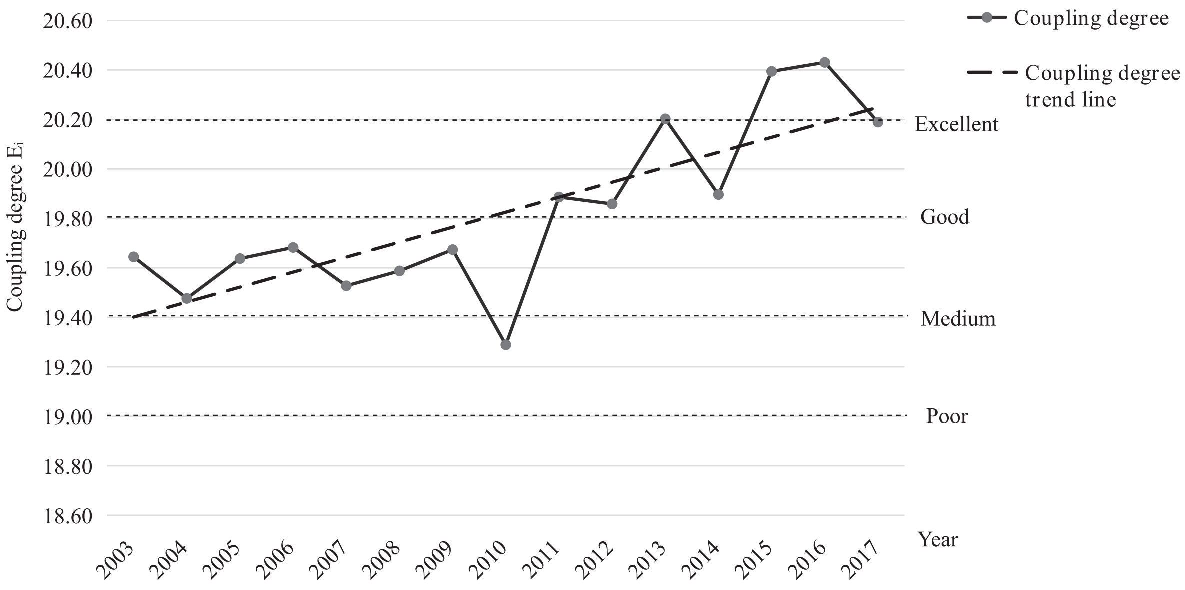

Fig. 1. Coupling degree from 2003 to 2017.

that the intensity of government environmental regulation during the 14th Five-Year Plan period will continue to maintain the intensity of control exerted during the 13th Five-Year Plan period, this study assumes that the number of newly-issued environmental protection policies and regulations during the 14th Five-Year Plan period will be the average number of those issued from 2014 to 2018.

The prediction methods for Class B indicators are as follows:

Y_3 (%): The proportion of foreign tourists fluctuates to a certain extent and is predicted in this paper by the moving average method. The prediction model is $\hat{y}_{p3} = \sum_{j=k}^{k+n-1} y_{j3} / n$, where $\hat{y}_{p3}$ represents the predicted value of the index (Y_3) in the planning year, and n represents the number of moving average periods.

Next, Y_4 (%): The proportion of high-spending tourists generally conforms to the trend of the 'growth' curve, which is predicted by logistic curve $\hat{y}_{p4} = 1/\left(k + ab^p\right)$ ($a > 0$, $0 < b < 1$). Here, p represents the planning year; $\hat{y}_{p4}$ is the predicted value of the index (Y_4) in the planning year.

Then, Y_5 (10,000 persons): Although the change in the number of employees in the tourism industry shows certain volatility, it is generally relatively stable. This article predicts the value of that number using the moving average method. The prediction model is $\hat{y}_{p5} = \sum_{j=k}^{k+n-1} y_{j5} / n$, where $\hat{y}_{p5}$ represents the predicted value of the index (Y_5) in the planning year, and n represents the number of moving average periods.

For Y_6 (10^8 yuan): As shown in the scatter diagram (see Fig. 2d), the total tourism revenue of Xinjiang shows a parabolic growth trend. This article predicts this index based on the equation $\hat{y}_{p6} = c_0 + c_1 p + c_2 p^2$, where $\hat{y}_{p6}$ represents the predicted value of the index (Y_6) in the planning year.

For Y_7 (%): This paper calculates this index value based on the predicted values of GDP and the index (Y_6). The predicted model is $\hat{y}_{p7} = \hat{y}_{p6} / \mathrm{GDP}_p$, where $\hat{y}_{p7}$ represents the predicted value of the index (Y_7) in the planning year, and GDP_p represents the predicted GDP of Xinjiang in the same year.

For Y_8 (yuan/person): Because there is a correlation between per capita tourism consumption and the income level of tourists, this article predicts this index with the causal model: $\hat{y}_{p8} = c_0 + c_1\eta$, where $\hat{y}_{p8}$ represents the predicted value of the index (Y_8), and η represents the average income level of tourists. Also, the weighted average of the disposable income of tourists from different sources is taken in this paper as the value of index η.

For Y_{12} ($10^8 m^3$): With reference to the method of measuring the water consumption of the regional tourism industry from the perspective of tourism's total elements [2, 6], this article decomposes the tourism water footprint into five aspects: catering, accommodation, energy, visiting, and shopping. The prediction model is: $\hat{y}_{p12} = WF_{cater} + WF_{accom} + WF_{ener} + WF_{visit} + WF_{shop}$, where $\hat{y}_{p12}$ represents the predicted value of the index Y_{12}, WF_{cater} represents the catering water footprint, WF_{accom} represents the accommodation water footprint, WF_{ener} represents the energy water footprint, WF_{visit} represents the visiting water footprint, and WF_{shop} represents the shopping water footprint.

For Y_{13} (10^8 ton): The multi-year average value of the total regional wastewater discharge (since the implementation of the strictest water resources

Table 8. Prediction results of Class A indexes in 2025.

Class A indexes	Y_1 (10,000 persons)	Y_9 (pieces)	Y_{10} (pieces)	Y_{11} ($10^8 m^3$)	Y_{14} (%)	Y_{15} (%)	Y_{16} (%)	Y_{17} (km^2)	Y_{18} (%)
Prediction	2623	52	1293	650*	11.2	98*	91*	39482	5.6

Note: Each index code has the same meaning as those in Table 2. Source: Outline of the 13th Five-Year Plan for National Economic and Social Development of Xinjiang Uygur Autonomous Region, the 13th Five-Year Plan for Environmental Protection of Xinjiang Uygur Autonomous Region, etc.; '*' indicates that the value is extrapolated based on the planning data for 2020.

management system) is taken as the value of the index (Y_{13}) in this paper. In addition, the model used to calculate this index is as follows: $\hat{y}_{p13} = \sum_{j=k}^{k+n-1} y_{j13}/n$, where k represents the year when the most stringent water resources management system was initially implemented, n represents the number of years since 2012, and $\hat{y}_{p13}$ represents the predicted value of the index (Y_{13}).

The change trend and fitting lines of Class B indexes are shown in Fig. 2(a-h); the specific prediction model and prediction results are shown in Table 9.

Reasonable Speed of Tourism Development

(1) Threshold determination: Taking the average value of the coupling degrees in all cases where

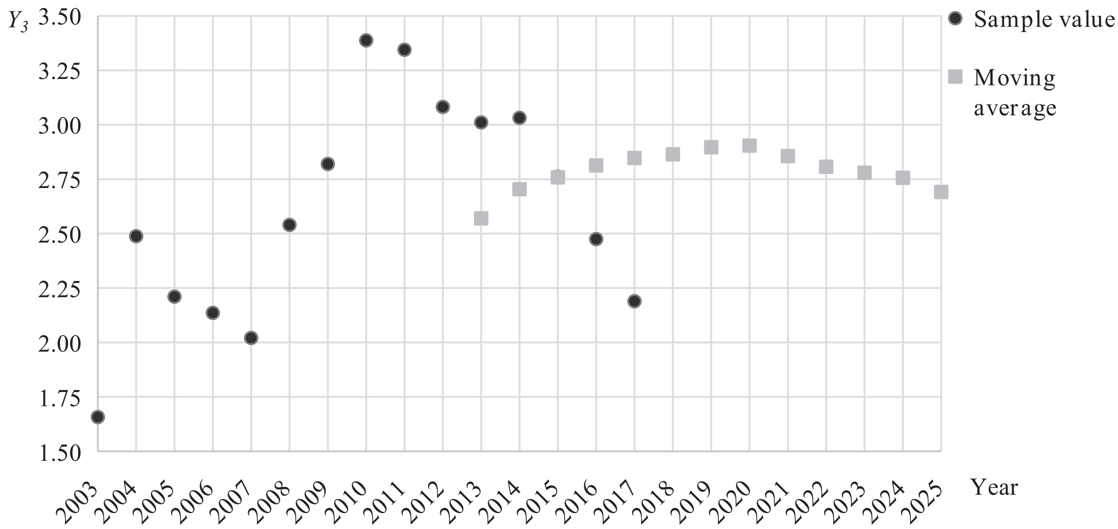

Fig. 2a). The change trend and fitting lines of Y_3.

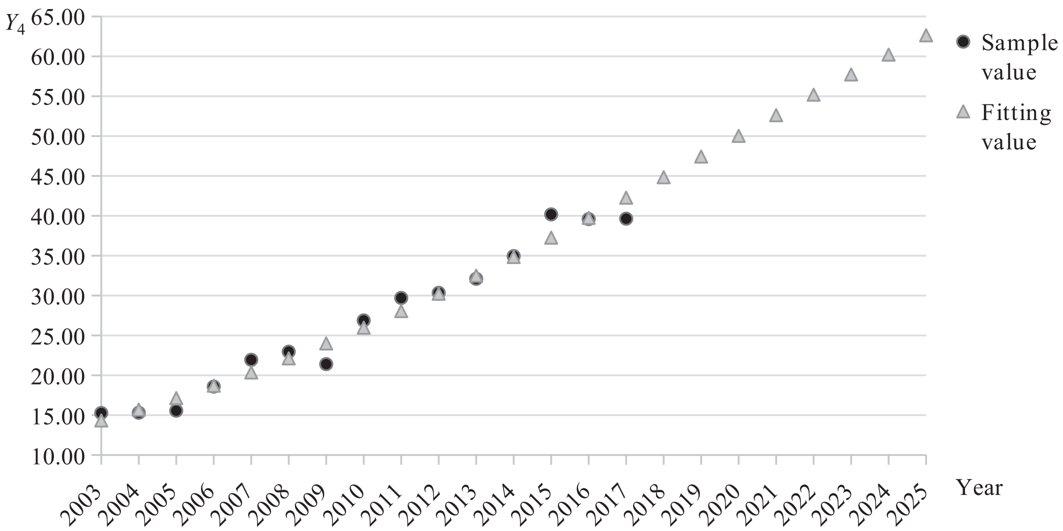

Fig. 2b). The change trend and fitting lines of Y_4.

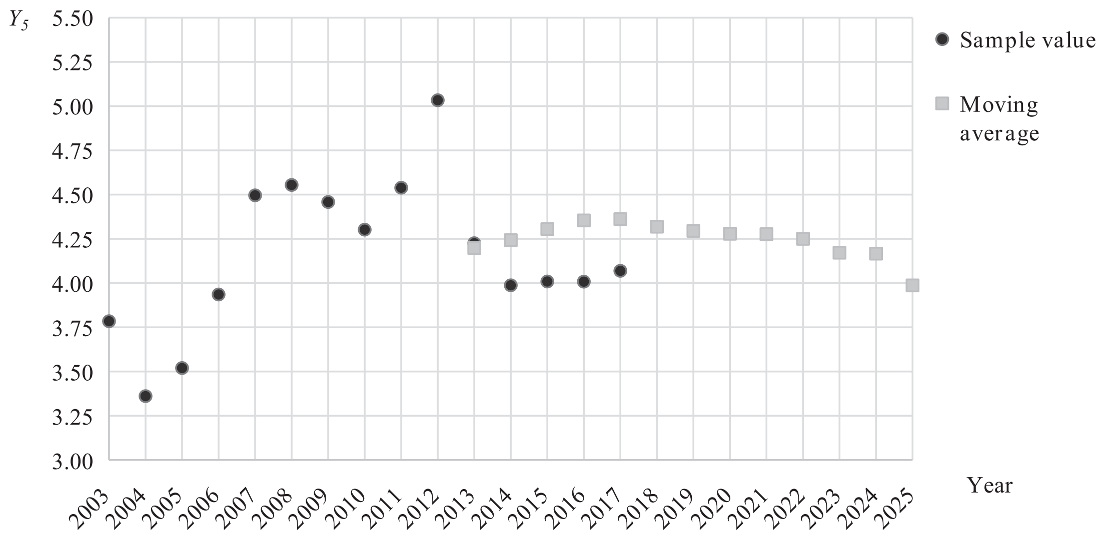

Fig. 2c). The change trend and fitting lines of Y_5.

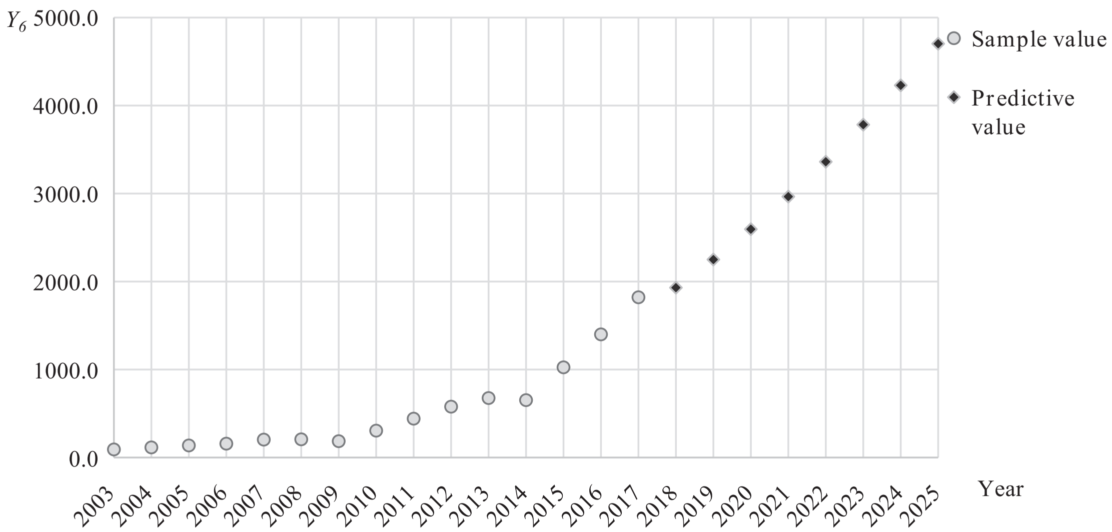

Fig. 2d). The change trend and fitting lines of Y_6.

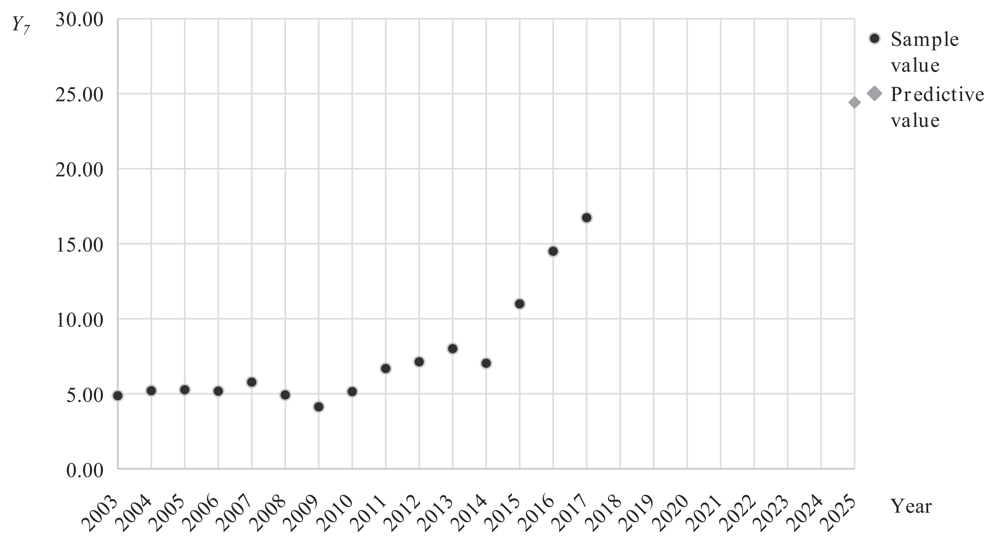

Fig. 2e). The change trend and fitting lines of Y_7.

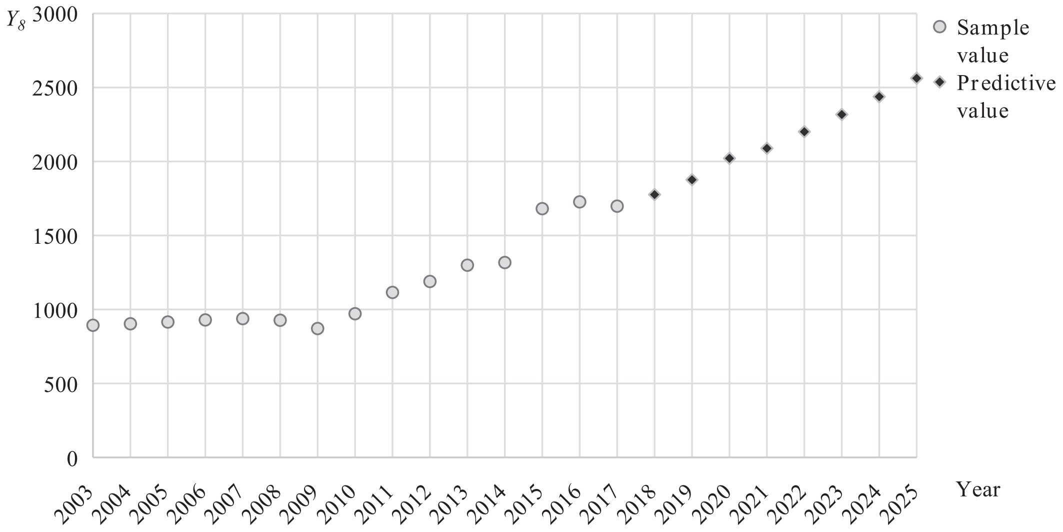

Fig. 2f). The change trend and fitting lines of Y_8.

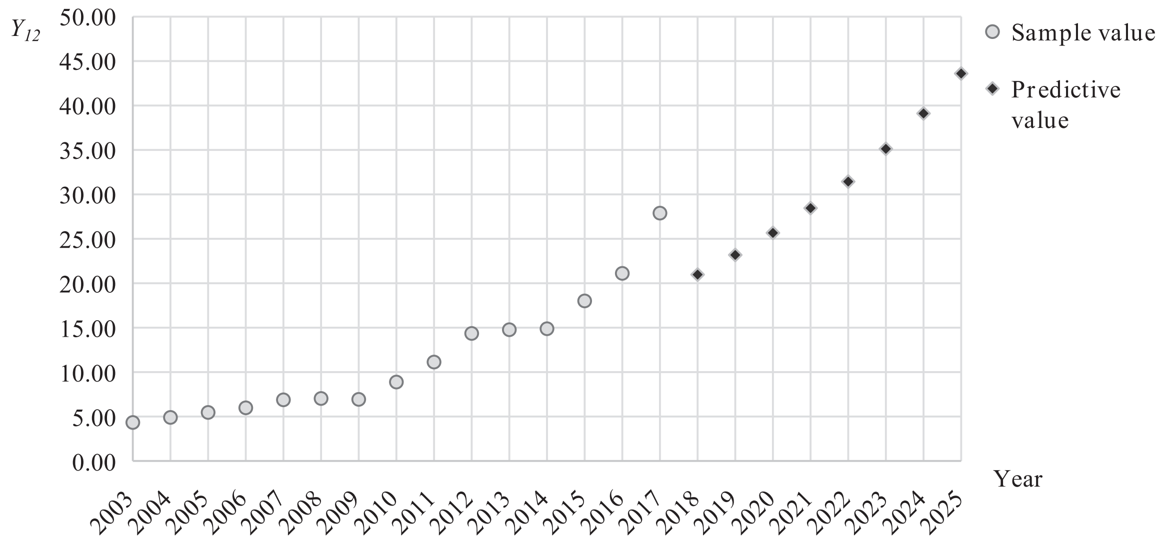

Fig. 2g). The change trend and fitting lines of Y_{12}.

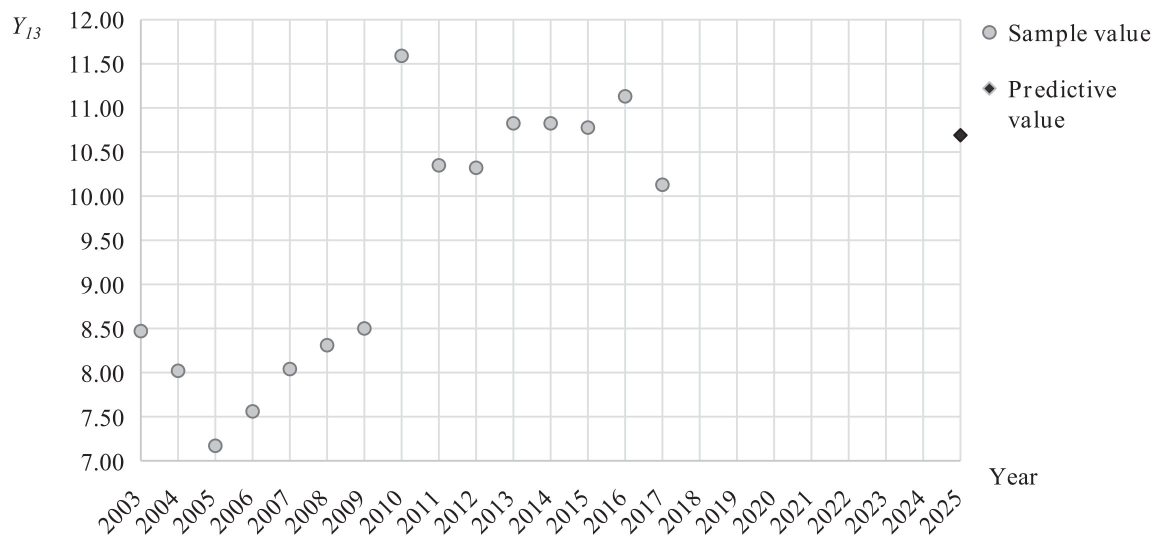

Fig. 2h). The change trend and fitting lines of Y_{13}.

Table 9. Prediction model and results of Class B indexes.

Prediction index	Prediction model	Description	Results
Y_3 (%)	$\hat{y}_{p3} = \sum_{j=k}^{k+n-1} y_{j3} / n$	Taking n = 10, the relative error from 2013 to 2017 is 1.38%, and the predictive value is adjusted according to the relative error.	2.69
Y_4 (%)	$\hat{y}_{p4} = 1/\left(0.01 + 0.066*0.899^p\right)$	K = 0.01, a = 0.066, b = 0.899. Taking 2003 as the first year, then p = 23. At the confidence level of 0.05, the calculated result χ^2=5.1691<$\chi^2_{0.05}$ indicates that the predicted value has passed the test.	63.69
Y_5 (10,000 persons)	$\hat{y}_{p5} = \sum_{j=k}^{k+n-1} y_{j5} / n$	Taking n = 10, the relative error from 2013 to 2017 is 4.72%, and the predicted value is adjusted according to the relative error.	3.99
Y_6 (10^8 yuan)	$\hat{y}_{p6} = 293.5947 - 102.0070 \times p + 12.7695 \times p^2$	Taking p = 23; the t-test values of each coefficient are 2.9664, -3.5835 and 7.3812, respectively, which are significant at 1% confidence level. Also, $\overline{R^2} = 0.95$ indicates that the model fitting degree is good.	4703
Y_7 (%)	$\hat{y}_{p7} = \hat{y}_{p6} / \mathrm{GDP}_p$	The GDP value in 2018 was 1280.939 billion yuan. Based on this, the GDP in 2025 will be 1,926 billion yuan in accordance with an average annual growth rate of 6%.	24.42
Y_8 (yuan/person)	$\hat{y}_{p8} = 446.9827 + 0.0333 \times \eta$	The t-test values of the coefficients are 5.6131 and 9.6282 respectively, which are significant at the 1% confidence level; $\overline{R^2} = 0.88$ indicates that the model fitting degree is good. In the sample period, the weighted average of the per capita disposable income of tourists from China, Japan, Singapore, the United States, Britain, Germany, and France is taken as the value of η, which shows a parabolic growth trend in line with the year. After fitting this study gets η = 63582 (yuan) in 2025.	2562
Y_{12} (10^8 m^3)	$\hat{y}_{p11} = WF_{cater} + WF_{accom} + WF_{ener} + WF_{visit} + WF_{shop}$	Combining the characteristics of the index data of each sub-account, it is predicted that the results of each water footprint account in 2025 will be 14.60, 3.75, 19.86, 1.91, and 3.48 million m^3.	43.60
Y_{13} (10^8 ton)	$\hat{y}_{p13} = \sum_{j=k}^{k+n-1} y_{j13} / n$	Corresponding to 2012, this study takes k = 10; n = 6 is taken in accordance with the period from 2012 to 2017.	10.69

Note: The meaning of each index code is the same as in Table 2.

the coupling degree is 'good', this paper obtains $\xi_{good} = \sum_{q=1}^{m_{good}} E_q / m_{good}$=19.96. When considering the 'excellent' coupling degree, this paper obtains $\xi_{excellent} = \sum_{r=1}^{m_{excellent}} E_r / m_{excellent}$=20.34.

(2) Establishing criteria: 19.96≤E_p≤20.34 .

(3) Calculation of reasonable speed range: Based on Formula (2), this paper calculates that the value range of Y_2 in 2025 will be $[\underline{Y}_{p2}, \overline{Y}_{p2}]$ = [25720, 28380] . That is, to ensure that the coupling degree between tourism development and water environment regulation in Xinjiang reaches the 'excellent' and 'good' levels, the total scale of tourists should be controlled in the interval [257.2, 283.8](Unit: million person-times).

Taking 2017 as the base year, in Formula (1), this article firstly takes Y_2 (t_1) = y_{m2} = 10725 and Y_2 (t_1) = $\underline{Y}_{p2}$ = 25720, to calculate the lower limit speed of tourism development in the planning year and then gets $\underline{v}_{m,p}$ = 11.56%. Secondly, taking Y_2 (t_1) = y_{m2} = 10725 and Y_2 (t_1) = $\overline{Y}_{p2}$ = 28380 , this paper then gets $\overline{v}_{m,p}$ = 12.93%. That is, in order to ensure that the coupling degree reaches the 'excellent' and 'good' levels in 2025, the average annual development speed of Xinjiang's tourism industry during the 14th Five-Year Plan period should be controlled within the interval [11.56%, 12.93%], or at around 12.25%.

Conclusions

(1) By the end of the 14th Five-Year Plan, in order to ensure that the tourism development and water environment regulations in Xinjiang can maintain a

satisfactory coupling relationship, the average annual development speed of the tourism should be controlled within the range of between 11.56% and 12.93%, or at around 12.25%. Corresponding to this level of control, the total number of tourists should be controlled to between 257.2 and 283.8 million person-times. On the one hand, once the average annual development speed of the tourism industry exceeds the upper limit of 12.93%, the excessive development of the tourism could conceivably break through the carrying capacity of the water environment, thereby reducing the coupling relationship between tourism development and water environment regulations. On the other hand, if the development speed is slower than the lower limit of 11.56%, the failure of tourism to reach the required level of development may affect the contribution of tourism development to the regional social economy.

(2) Among the sample years, the total number of tourists in Xinjiang in 2003 was only 10.291 million person-times. However, by 2018, the total number of tourists in Xinjiang reached 150.24 million person-times, showing an average annual growth rate of 19.57%. According to the results calculated in this paper, it is required that, from 2019 to 2025, the development speed of the tourism industry should be controlled within the interval of between 11.56% and 12.93%, so as to ensure that the development of tourism and the water environment can maintain a good coupling relationship. This finding shows that, under the concept of green development, Xinjiang's tourism industry needs to moderately control the development speed of tourism, to reduce the possible negative impacts on water resources and the environment, so as to achieve 'human-water harmony'.

(3) From the perspective of the tourism development subsystem, it is possible to strive for greater development space for the tourism industry. This can be done by increasing the total regional tourism income and per capita tourism consumption. According to the calculations in this paper, if the region's total tourism income increases by 10%, the tourism development speed can be increased by 1%. If per capita tourism consumption is increased by 10%, the tourism development speed can be increased by 0.7%.

(4) From the perspective of the water environment regulation subsystem, it is possible to strive for greater development space for the development of the tourism industry. This could be done by increasing the total annual water supply in the region, controlling the water consumption of the regional tourism industry, and reducing the total discharge of wastewater in the region. According to the results, if the total annual water supply in the region increases by 10%, the tourism development speed can be increased by 0.5%. If the regional tourism industry water consumption is reduced by 10%, the tourism development speed can be increased by 0.1%. If the total regional wastewater discharge is reduced by 10%, the development speed of the tourism industry can be increased by 0.2%.

Based on the above research, it is suggested that, when formulating its tourism development plan corresponding to the '14th Five-Year Plan' Xinjiang should control the average annual tourism development speed at around 12.25% in order to ensure a good coupling relationship between tourism development and the regional water environment. At the same time, during the '14th Five-Year Plan' period, Xinjiang should strive to increase the region's total tourism revenue, control the water consumption of the regional tourism industry, and reduce the total amount of regional wastewater discharge. These steps will help to promote the healthy and sustainable development of the tourism industry.

Acknowledgments

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Conflict of Interest

The authors declare no conflict of interest.

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