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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Received: 10 February 2021
Accepted: 5 July 2021

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, medium 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, and the 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 to 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 speed of tourism development under the satisfactory state between water environmental regulation and tourism development. The main research ideas and steps are as follows:

**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.

**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
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...

| 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                      |

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

| Index                                           | Index calculation method/access method | Functions of indexes                                           | Class |
|-------------------------------------------------|----------------------------------------|----------------------------------------------------------------|-------|
| 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 | -     |
| 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       | +     |
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:

\[
\nu_{t_1,t_2} = \left( \frac{Y_{t_2}(t_2)}{Y_{t_1}(t_1)} \right)^{(t_2-t_1)} - 1
\]

(1)

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

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:

\[
Z^\prime_y = \frac{M^0 + (M^* - M^0) \frac{y_j - y_j^{\text{min}}}{y_j^{\text{max}} - y_j^{\text{min}}}}{y_j^{\text{max}} - y_j^{\text{min}}} \text{, efficiency type}
\]

\[
Z_y = M^0 + (M^* - M^0) \frac{y_j^{\text{max}} - y_j}{y_j^{\text{max}} - y_j^{\text{min}}} \text{, cost type}
\]

(2)

Here, \(y_j\) is the j-th index value of the year \(i\); \(Z_y\) represents the j-th index value of the year \(i\) after normalization, and \(y_j^{\text{max}}\) and \(y_j^{\text{min}}\) 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 \(w_j^{(i)}\). 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 \( w_j^{(0)} \).

- 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:

\[
e_j = \frac{S_j}{\bar{x}_j}
\]  

(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 \( \bar{x}_j \) is the mean of the \( j \)-th index.

The objective weight of each index is:

\[
w_j^{(2)} = \frac{e_j}{\sum_{j=1}^{n} e_j}
\]  

(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:

\[
w_j = \frac{w_j^{(0)} w_j^{(2)}}{\sum_{j=1}^{n} w_j^{(0)} w_j^{(2)}}
\]  

(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:

\[
E_i = \frac{\alpha_i^L \cdot \alpha_i^S}{\sqrt{\alpha_i^L + \alpha_i^S}}
\]  

(6)

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

\[
\alpha_i^L = \sum_{j=1}^{8} \omega_j^L \cdot Z_{ij} \quad \alpha_i^S = \sum_{j=9}^{18} \omega_j^S \cdot Z_{ij}
\]  

(7)

...where the weight \( \omega_i^* \) 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: \( x_r \gg x_q \gg x_k \gg x_l \) where ‘\( \gg \)’suggests ‘better’. For example \( x_r \gg x_q \) 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
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 (\(Y_t\)) 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 (\(Y_t\)) 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 of indicators is taken as a decision variable in this study. Also, 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:

\[
\xi_{\text{good}} = \frac{m_{\text{good}}}{\sum_{q=1}^{m_{\text{good}}} E_q} \quad \xi_{\text{excellent}} = \frac{m_{\text{excellent}}}{\sum_{r=1}^{m_{\text{excellent}}} E_r}
\]

where \(E_q\) and \(E_r\), respectively, represent ‘good’ and ‘excellent’ coupling degrees in a certain sample year; \(m_{\text{good}}\) and \(m_{\text{excellent}}\) 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, \(Z_{p}\) is the normalized value of various indicators in the planning year; for example, \(Z_{p}\) is the normalized value of the total number of tourists (\(Y_t\)) 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 of the planning year reach levels of ‘good’ or ‘excellent’, the following discrimination criterion is established:

\[
\xi_{\text{good}} \leq E_p \leq \xi_{\text{excellent}}
\]

The value range of \(Z_{p}\) in the planning year can be obtained by solving Equation (9), which is denoted as: \(Z_{p} \in [Z_{p,1}, Z_{p,2}]\). In this study, Formula (2) is used to calculate the value range of the total number of tourists (\(Y_t\)) in the planning year \(p\) based on \([Z_{p,1}, Z_{p,2}]\), which is denoted as:

\[
Y_{p} \in [Y_{p,1}, Y_{p,2}]
\]

Based on Formula (1), and taking the year \(m\) in the formula as the base year, this study can then use \(Y_t (t) = Y_{p,1}\) and \(Y_t (t) = Y_{p,2}\) to calculate the lower limit speed (\(v_{m,p}\)) of tourism development in the planning year; \(Y_t (t) = Y_{p,1}\) and \(Y_t (t) = Y_{p,2}\) can be used to calculate the upper limit speed (\\(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 m³. The region’s self-produced water resources amount to 83.27 billion m³, including surface water of 78.86 billion m³ and non-repetitive water of 4.41 billion m³ between surface water and groundwater. However, the water production per unit area is only 53,000 m³ 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 \(Y_p, Y_{10}, Y_{11}, Y_{12}, Y_{13}, Y_{14}, Y_{15}\) and \(Y_{16}\) were derived from China Statistical Yearbook (2003-2017) or relevant local statistical yearbook from 2003 to 2017. The values of \(Y_{10}, Y_{11}, Y_{14}, Y_{15}\) and \(Y_{16}\) 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 \(Y_{13}\) were derived from relevant bulletins about the Chinese economy, society and environment, from 2003 to 2017. In addition, \(Y_{12}\) was calculated according to the ratio of the number of overseas tourists to the total number of tourists; \(Y_{13}\) was computed according to the proportion of tourists staying in 4-star hotels or above to the total number of tourists. Then \(Y_{12}\) 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 | 2131 | 2159 | 2185 | 2209 | 2233 | 2264 | 2298 | 2360 | 2398 | 2445 |
| $Y_2$ (10,000 persons)        | 1029 | 1274 | 1498 | 1697 | 2170 | 2231 | 2134 | 3145 | 4861 | 5206 | 4953 | 6097 | 8102 | 10726|
| $Y_3$ (%)                     | 1.66 | 2.49 | 2.21 | 2.14 | 2.02 | 2.54*| 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 | 5.03 | 4.23 | 3.99 | 4.01 | 4.01 | 4.07 |
| $Y_6$ (108 yuan)              | 91.9 | 115.0| 137.2| 157.6| 203.6| 206.9| 185.8| 305.5| 411.7| 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  |
| $Y_{11}$ (10^6 m³)            | 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|
| $Y_{12}$ (10^6 m³)            | 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|
| $Y_{13}$ (10^6 ton)           | 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 | 91.3 | 91.9 | 91.1 | 97.1 | 97   | 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 |
| $Y_{17}$ (km²)                | 14102| 14102| 14102| 14102| 14102| 14102| 14102| 14102| 14102| 39482| 39482| 39482| 39482| 39482| 39482|
| $Y_{18}$ (%)                  | 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  | 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.
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 \( Y_8 \) 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 \( \omega_j^* \) 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
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:

\[ Y_3(\%): \text{The proportion of foreign tourists fluctuates to a certain extent and is predicted in this paper by the moving average method. The prediction model is} \]
\[ Y_3^\wedge = \frac{1}{n} \sum_{i=1}^{n} y_{p_i} \]  
where \( Y_3^\wedge \) 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(\%): \text{The proportion of high-spending tourists generally conforms to the trend of the 'growth' curve, which is predicted by logistic curve} \]
\[ Y_4^\wedge = c_0 + \frac{c_1}{1 + e^{-c_2 p}}, \text{where} \]
\( Y_4^\wedge \) represents the planning year, \( Y_4^\wedge \) is the predicted value of the index \( Y_4 \) in the planning year.

Then, \( Y_5(10,000 \text{ persons}): \text{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} \]
\[ Y_5^\wedge = \frac{1}{n} \sum_{i=1}^{n} y_{p_i} \]  
where \( Y_5^\wedge \) 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(108 \text{ yuan}): \text{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} \]
\[ Y_6^\wedge = c_0 + c_1 y + c_2 y^2, \text{where} \]
\( Y_6^\wedge \) represents the predicted value of the index \( Y_6 \) in the planning year.

For \( Y_7(\%): \text{This paper calculates this index value based on the predicted values of GDP and the index} \]
\( Y_6 \). The predicted model is \[ Y_7^\wedge = \frac{Y_6^\wedge}{GDP_p}, \text{where} \]
\( Y_7^\wedge \) 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(\text{yuan/person}): \text{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:} \]
\[ Y_8^\wedge = c_0 + c_1 \eta, \text{where} \]
\( Y_8^\wedge \) represents the predicted value of the index \( Y_8 \), and \( \eta \) 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 \( \eta \).

For \( Y_{12}(10^8 \text{m}^3): \text{With reference to the method of measuring the water consumption of the regional tourism industry from the perspective of tourism's total elements} \]
\[ \text{[2, 6], this article decomposes the tourism water footprint into five aspects: catering, accommodation, energy, visiting, and shopping. The prediction model is:} \]
\[ Y_{p12}^\wedge = WF_{cater} + WF_{accom} + WF_{ener} + WF_{visit} + WF_{shop}, \text{where} \]
\( Y_{p12}^\wedge \) 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 \text{ton}): \text{The multi-year average value of the total regional wastewater discharge (since the implementation of the strictest water resources} \]
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:

\[
Y_{13} = \frac{\sum_{k=1}^{k_{max}} Y_{13k}}{n},
\]

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 \( Y_{13k} \) 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

| Class A indexes | \( Y_1 \) (10,000 persons) | \( Y_9 \) (pieces) | \( Y_{10} \) (pieces) | \( Y_{11} \) (10^3 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.
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 $Y_s$.

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

Fig. 2h). The change trend and fitting lines of $Y_{13}$. 
The coupling degree is ‘good’, this paper obtains \( \tilde{\xi}_{\text{good}} = \sum_{q=1}^{m_{\text{good}}} E_q / m_{\text{good}} = 19.96 \). When considering the ‘excellent’ coupling degree, this paper obtains \( \tilde{\xi}_{\text{excellent}} = \sum_{r=1}^{m_{\text{excellent}}} E_r / m_{\text{excellent}} = 20.34 \).

(2) Establishing criteria: 19.96 \( \leq \tilde{E} \leq 20.34 \).

(3) Calculation of reasonable speed range: Based on Formula (2), this paper calculates that the value range of \( Y_y \) in 2025 will be \( [Y_{y1}, Y_{y2}] = [25720, 28380] \). 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 \( [2572, 283.8] \) (Unit: million person-times).

Taking 2017 as the base year, in Formula (1), this article firstly takes \( Y_y(t_1) = Y_{y11} = 10725 \) and \( Y_y(t_2) = Y_{y21} = 25720, \) to calculate the lower limit speed of tourism development in the planning year and then gets \( v_{n,p} = 11.56\% \). Second, taking \( Y_y(t_1) = Y_{y12} = 10725 \) and \( Y_y(t_2) = Y_{y22} = 28380, \) this paper then gets \( v_{n,p} = 12.93\% \). 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

| Prediction index | Prediction model | Description | Results |
|------------------|------------------|-------------|---------|
| \( Y_y(\%) \)   | \( \hat{Y}_{y1} = \hat{\sum}_{j=1}^{n_{\text{r}}} \hat{y}_{j1} / \eta \) | 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 |
| \( Y_y(\%) \)   | \( \hat{Y}_{y2} = \hat{\sum}_{j=1}^{n_{\text{r}}} \hat{y}_{j2} / \eta \) | \( K = 0.01, a = 0.066, b = 0.899. \) Taking 2003 as the first year, then \( p = 23. \) At the confidence level of 0.05, the calculated result \( \chi^2 = 5.169 < \chi^2_{0.05} \) indicates that the predicted value has passed the test. | 63.69 |
| \( Y_y(10,000 \text{ persons}) \) | \( \hat{Y}_{y3} = \hat{\sum}_{j=1}^{n_{\text{r}}} \hat{y}_{j3} / \eta \) | 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 |
| \( Y_y(10^4 \text{ yuan}) \) | \( \hat{Y}_{y4} = 293.5947 - 102.0070 \times p + 12.7695 \times p^2 \) | 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, \( \bar{R}^2 = 0.95 \) indicates that the model fitting degree is good. | 4703 |
| \( Y_y(\text{yuan/person}) \) | \( \hat{Y}_{y5} = \hat{\sum}_{j=1}^{n_{\text{r}}} \hat{y}_{j5} / \text{GDP}_p \) | The GDP value in 2018 was 1,280,939 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 |
| \( Y_y(\text{yuan/person}) \) | \( \hat{Y}_{y6} = 446.9827 + 0.0333 \times \eta \) | The t-test values of the coefficients are 5.6131 and 9.6282 respectively, which are significant at the 1% confidence level; \( \bar{R}^2 = 0.88 \) 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 \( \eta, \) which shows a parabolic growth trend in line with the year. After fitting this study gets \( \eta = 63582 \) (yuan) in 2025. | 2562 |
| \( Y_{i2}(10^3 \text{ m}^3) \) | \( \hat{Y}_{i2} = WF_{\text{water}} + WF_{\text{avout}} + WF_{\text{water}} + WF_{\text{water}} + WF_{\text{shop}} \) | 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 |
| \( Y_{i3}(10^3 \text{ ton}) \) | \( \hat{Y}_{i3} = \hat{\sum}_{j=1}^{n_{\text{r}}} \hat{y}_{j3} / \eta \) | 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.
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 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

This research was funded by Major Projects of the National Social Science Fund of the People’s Republic of China (17ZDA064).

Conflict of Interest

The authors declare no conflict of interest.

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