

# Analysis of water resource management in tourism in China using a coupling degree model

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## Abstract

With the rapid development of the tourism industry, the water resource consumption in tourism has largely increased and gets more complicated, making water resource management in tourism more difficult. To achieve sustainable water utilization in tourism, water resource management has to take full account of the local natural, social, and industrial conditions, both satisfying the demands of water resource protection and tourism development. To analyze this coupling relationship, an integrated index system comprised of 15 indices is designed, and a coupling degree model between tourism-related water resource management and local conditions is introduced. The result revealed that tourism-related water resource management is generally congruent with the local conditions in China, and provinces at the very high/low coupling stage presented four clusters. A discussion combining the change of water policies and the water use efficiency of hotels in Beijing revealed that water-saving policies are proven to be necessary for the tourism development. Furthermore, a discussion of the four clusters revealed the advanced experience and deficiency of water policies in substantial tourism areas. The results could provide references for the improvement of water policies in the tourism industry in China.

**Keywords:** China; Coupling degree model; Information entropy weight; Tourism; Water policy; Water resource management

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## Highlights

- An index system and a coupling degree model are introduced to analyze tourism-related water management and local conditions in China.
  - Water management in tourism is generally congruent with the local conditions in China, and their coupling relationship presented a cluster pattern.
  - Water-saving priority is necessary for tourism in China.
  - The provinces on the east coast should take the strictest water management in tourism.
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## 1. Introduction

The tourism industry has been officially identified as a strategic pillar industry in China; its total revenue reached up to 6.63 trillion RMB in 2019, accounting for 6.6% of China's total GDP, while its contributions to employment totaled 79.87 million individuals, or 10% of the total figure for national employment (Ministry of Culture and Tourism of China, 2019). Furthermore, given its potential to contribute to regional economic growth and social development with a reduced industrial base, the tourism industry is considered as a new engine for the development of backward areas in West and Middle China.

Nevertheless, the negative environmental impacts of the tourism industry are becoming increasingly apparent, especially concerning water resources (Chu & Chung, 2016). Studies have proven that water utilization in tourism is significant to the water resource security on the regional level, or rather critical if considering the virtual water (Gossling *et al.*, 2012). In detail, water resources are essential to tourist activities, supporting the tourist's demands of accommodation, entertainment, and recreation. Unfortunately, tourist hotspots are usually water-scarce areas such as mountains, islands, and deserts, while tourism activities are concentrated during sunny periods that are associated with low precipitation, resulting in spatiotemporal dissonance between tourism activities and water resources. These potential contradictions between the water supply and demand may likely exacerbate the water resource risks in the tourist hotspots (Higgins-Desbiolles, 2018).

Accordingly, the Chinese government has introduced water intake quota management to deal with water resource risks. Water intake quota management is the basic water management institution stipulated by the *Water Law* in China, and it has become the foundation of water withdrawal permission, water use planning, and water price reform. As mandated by China's Ministry of Water Resources, provincial administrative bodies have issued their local water intake quota norms of all the industries (Ministry of Water Resources of China, 2013). To truly become the water-saving benchmark for industries, these norms are further required to be congruent with their local natural and social conditions. There has been a lot of studies focusing on formulating a water intake quota in a specific region but lacks a comparison on the national scale (Wang *et al.*, 2014).

An evaluation of the coupling relationship could provide a better understanding of the status of tourism-related water resource management in China. To accurately illustrate the situation of tourism-related water resource management and the local conditions, an integrated index system is designed considering the content and influence factors of water intake quota norms in the tourism industry, and the indices were further weighted by the information entropy method. Then a coupling degree model was applied to quantitatively evaluate the coupling relationship between the tourism-related water resource

management and the local conditions among the provincial-level administrative bodies in mainland China. The purposes of this study include (1) to reveal the status of water resource management in the tourism industry in China; (2) to illustrate the coupling relationship between tourism-related water management and local conditions; (3) to provide references for the improvement of water management in the tourism industry during macro policy-making in China.

## 2. Materials and methods

### 2.1. Water resource management in tourism in China

In light of the rapid development of tourism, the Chinese government has implemented a series of environmental management measures. Within the water sector, water intake quota management has been introduced (Li *et al.*, 2009). Water intake quota refers to the freshwater volume taken per capita, per area, or unit production during a period, and water intake quota management mainly is executed in the form of norms. Water intake quota management aims to guide sensible water utilization on the industry level and cut off the superfluous water utilization. Unlike voluntary water-saving benchmark management in Europe, water intake quota management is mandatory. It is one of the basic water management systems ruled by the *Water Law of the People's Republic of China* (2016), and it has become the basis for the water licenses and water fees of industries (Liu *et al.*, 2019).

The water intake quota management is a kind of integrated water management. Its formulation needs the participation of all the stakeholders, including the municipal water-saving administrations, water-works, scholars, water users, and even the manufacturers of water-saving devices. The water intake quota is determined based on massive investigations. Furthermore, it would go through rounds of modification until it reaches the agreement of all the stakeholders. Once the water intake quota norm is published, the related water users have to comply with it. For example, every year a hotel in Beijing needs to report its number of beds and other information to the municipal water administration, and the municipal water administration would allocate water to the hotel according to the water intake quota and bed number. At the end of the year, the hotel would face a cumulative penalty if it exceeded the allocated water amount; even the large ones would be prohibited from water intake.

The water intake quota should be neither too strict nor too loose, since the former would likely hinder the development of industries, and the latter would just be formalism. To ensure their effectiveness, water intake quota norms are required to be reasonable, advanced, operable, and adapted, as clearly stipulated in the *Technical Guideline of the Stipulation for the Norm of Water Intake* (Ministry of Water Resources of China, 2016), as follows:

- *Reasonable*: water intake quota has to guarantee the basic demand of industries and livelihood, and consider the economic issues, like the affordability of industries and residents.
- *Advanced*: water intake quota should be in line with the water-saving trend, keeping moderately advanced over the present water use efficiency.
- *Operable*: water intake quota should be able to provide references for the water withdrawal permit and water use plan, and it should be easy to understand and provide statistics.
- *Adaptable*: water intake quota should fully consider the local conditions including water resources, economic and social situations, technology, and engineering ability.

In compliance with a directive from the Ministry of Water Resources, all provincial-level administrative bodies in mainland China have issued local water intake quota norms for all the industries and domestic residents. Such bodies regulate provinces, autonomous regions, and municipalities directly under the central government, as well as special administrative regions, hereinafter referred to as ‘provinces’ in this paper. Within tourism, water intake quotas are mainly applied in the hotel, restaurant, traffic, shopping mall, and landscaping. However, only the hotel industry is comparable on the national scale. Due to the chaotic classification schemes and units, the other industries could not be properly compared among different provinces, for example, restaurants in some provinces are classified according to their food types (Chinese food, western food, and snack bar), while restaurants in some provinces are classified according to their number of seats or usable area (Wang *et al.*, 2015).

Hotels are classified according to their star rating in almost all the provinces. L/bed/day or m<sup>3</sup>/bed-a is used as the usual unit of measurement. Additionally, the water intake quota norm of the hotel industry is a comprehensive quota, covering all the water utilization that occurred in the hotel, not only including water consumed on the guest floor but also water consumed in catering, landscape maintenance, entertainment, and staff. However, there is an exception, as the unit in the norm of Shanxi province is L/person/day. Furthermore, the water intake quota of Fujian province is too high compared to other provinces, even twice as many as the runner-up, which would disturb the after analysis. Fortunately, the number of hotels in Shanxi only accounts for 1.96% of the total number of hotels in China, and the revenue from tourism in Shanxi only accounts for 1% of the total revenue of tourism in China, while in Fujian, the percentages are 3.38 and 4%, respectively. The absence of these two provinces will not make a significant difference.

Thus, the water intake norm of the hotel industry is selected to represent the water resource management in tourism, and the provinces in mainland China with the exceptions of Shanxi and Fujian provinces are selected as the study area.

## 2.2. Breakdown of water utilization in tourism

There is widespread consensus that water resources are both a necessary and a restrictive condition for the tourism industry (Buckley, 2012). In detail, first water is necessary for tourists’ hygiene and dietary consumption, for maintaining the landscapes and tourist attractions, and for the construction of tourism facilities. Second, tourism activities, such as skiing, golf, and spas, utilize large quantities of water. Third, water bodies are often important landscapes, and waterfront areas can provide a variety of recreational activities, such as swimming, sailing, rowing, diving, and fishing (Hall & Härkönen, 2006). However, the prioritization of tourism development over the protection of water resources is likely to generate water crises, such as receding groundwater and depletion of water resources (LaVanchy, 2017; Gossling, 2002). Furthermore, there tends to be a water competition between tourism and traditional industries in the emerging tourist destinations (Fulazzaky *et al.*, 2017).

The tourism industry is composed of several uncertain sectors, including accommodation, catering, traffic, parks, shopping, and entertainment facilities. These sectors are linked together by meeting the need of tourists. However, they may differ a lot among different types of tourism activities, making it difficult to quantitatively analyze the water use in tourism (Bohdanowicz & Martinac, 2007). What is worse, the quantity of tourism-related water utilization is usually calculated as a component of domestic water utilization and is not considered separately in many cities. So, most tourism water studies

tend to use hotels' water utilization to represent tourism-related water utilization overall. Hoteliers and the government have effectively quantified water utilization within hotels (Deya Tortella & Tirado, 2011). Furthermore, hotels usually encompass many types of tourism-related water utilization, including accommodation, catering, laundry, irrigation of landscape, and entertainment. For now, water utilization in hotels is considered the most important and representative component of water utilization in tourism industries.

Numerous factors influencing water utilization in the tourism industry have been widely analyzed around the world. These factors could be summarized as four categories: water resource endowment, the status of tourism industries, water consumption habits, and water utilization technologies (Tuppen, 2013; Gossling, 2015; Styles *et al.*, 2015; Gabarda-Mallorqui *et al.*, 2017).

Water resource endowment has complex impacts on tourism water use, and water-scarce areas usually have dry and hot weather, which will cause more water consumption in life-supporting and landscape irrigation, but residents in the water-scarce area would likely tend to have higher water-saving consciousness and skills than the water-abundant area.

In the famous and developed tourist destinations, there will be more high-end hotels than emerging ones, which tend to consume more water since there are additional facilities like swimming pools. But the large-scale hotels could enhance the water use efficiency since the scale benefit.

Due to historical reasons, the consumption habits of tourists and residents in developed areas or water-abundant areas tend to be water-intensive and would likely consume more water than the tourists and residents in undeveloped or water-scarce areas.

But developed areas usually have advanced water utilization technologies, which could enhance the water utilization efficiency in tourism. Water utilization technologies include not only the water-saving devices, but also the diverse water supply technologies and gradient water utilization technologies could reduce the cost of fresh water in an integrated way (Lloret *et al.*, 2008; Hardiman & Burgin, 2010; de Sousa *et al.*, 2017).

In sum, there is widespread recognition that: (1) water resources are both a necessary as well as a restrictive condition for the development of tourism and are required in all the sectors of tourism, such as accommodation, catering, traffic, parks, shopping, and entertainment facilities; (2) hotels are the most representative and complete metered component of water utilization in tourism, and have become the focus of the studies of water utilization in tourism; and (3) the factors influencing water utilization in the tourism industry could be summarized as four categories, including water resource endowment, the status of tourism development, consumption habits, and water utilization technologies.

### 2.3. Coupling degree model

The coupling degree model has been widely applied in analyses of the complex relationships among industrial development and natural environments (Liu *et al.*, 2018; Lu *et al.*, 2018; Cheng *et al.*, 2019). Tang used the coupling degree model to evaluate the tourism industry and environment of Heilongjiang Province in China, concluding that this tool is appropriate for analyzing the relationship between tourism and natural resources (Tang, 2015). Other studies have similarly examined the coupling relationship between the tourism industry and environment in other regions (Pang *et al.*, 2011; Yang, 2011).

The coupling degree model is designed based on the coefficient of variation. The coefficient of variation is a dimensionless quantity that positively reflects the dispersion degree of data, as shown in the

following formula:

$$C_v = \frac{S}{\bar{\alpha}} = \frac{\sqrt{\frac{1}{n-1} \sum_{i=1}^n (\alpha_i - \bar{\alpha})^2}}{\frac{1}{n} \sum_{i=1}^n \alpha_i} \quad (1)$$

where  $C_v$  is the coefficient of variation,  $S$  is the norm deviation, and  $\bar{\alpha}$  is the average value. In this study, there are two subsystems, namely tourism-related water resource management subsystem (WM) and local condition subsystem (LC), and  $\alpha$  is the normalized score of subsystems. Let  $\alpha_1 = \text{WM}$  and  $\alpha_2 = \text{LC}$ , then the formula (1) could be written as follows:

$$C_v = \sqrt{1 - \frac{4 \cdot \text{WM} \cdot \text{LC}}{(\text{WM} + \text{LC})^2}} \quad (2)$$

The higher  $C_v$  is, the more discrete WM and LC are, that is to say,  $C_v$  is negatively correlated with the coupling degree between the water resource management subsystem and the local condition subsystem. Thus, the coupling degree model of the tourism-related water management subsystem and the local condition system could be established as the opposite of  $C_v$ :

$$C = \left[ \frac{4 \cdot \text{WM} \cdot \text{LC}}{(\text{WM} + \text{LC})^2} \right]^k \quad (3)$$

where  $C$  is the coupling degree between the tourism-related water management subsystem and the local condition subsystem, and  $k$  is a coefficient, usually  $2 \leq k \leq 5$ .

#### 2.4. Index system and data pre-processing

According to the analysis above, an integrated index system consisting of two subsystems, five aspects, and 15 indices was formulated. In the tourism-related water resource management subsystem, there are five indices: the water intake quota norms of 1–5 star-rated hotels. And in the local conditions system, there are four aspects, namely water resource endowment, status of tourism industry development, consumption habits, and water utilization technologies. The connotations of indices are elaborated in Figure 1.

The up-to-date provincial water intake quotas of hotels were derived from the local water intake quota norms of each province in mainland China (National office of water conversation, 2018). The number of hotels and hotel classes per province and their annual occupancy rates were derived from the *Yearbook of China Tourism Statistics* (Ministry of Culture and Tourism of China, 2019). And other data were mainly obtained from the database *National Data* (National Bureau of Statistic of China, 2020). To enable comparisons at the province level, for each province, all indices were normalized on a 0–1 scale, as follows:

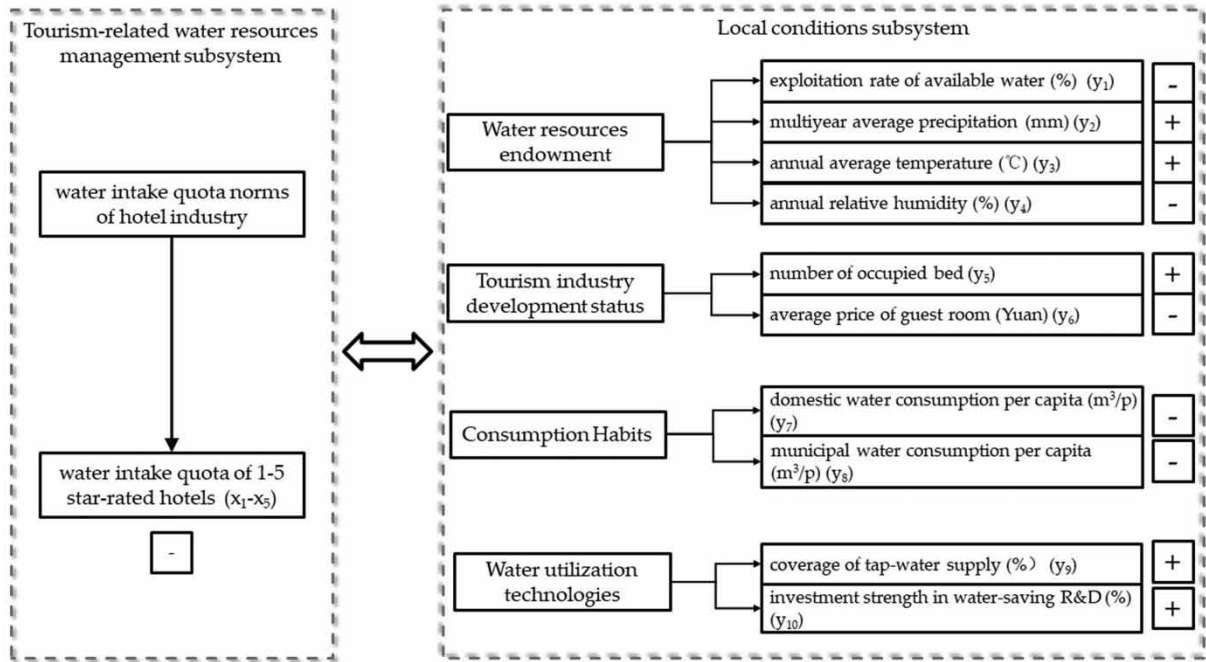


Fig. 1. Index system used for analysis of the relationship between tourism-related water resource management and the local conditions.

For positive indices:

$$x'_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} \quad (4)$$

For negative indices:

$$x'_{ij} = \frac{\max x_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}} \quad (5)$$

where  $x'_{ij}$  and  $x_{ij}$ , respectively, represent the normalized value and original value of index  $j$  in province  $i$ ; and the positive and negative indices have been, respectively, marked + and – in Figure 1, according to their positive or negative contribution to water-saving in tourism.

For each province, the evaluation result of the tourism-related water resource management subsystem and local condition subsystem was calculated by integrating the individual indices as follows:

$$\begin{cases} WM(x) = \sum_{t=1}^p w_t \cdot x'_t \\ LC(y) = \sum_{e=1}^q w_e \cdot y'_e \end{cases} \quad (6)$$

where  $WM(x)$  and  $LC(y)$  are, respectively, the integrated score of tourism-related water resource management subsystem and local condition subsystem. The higher the  $WM(x)$  is, the stricter the tourism-related water resource management is, while the higher  $LC(y)$  is, the less water used by local conditions;  $x'_t$  and  $y'_e$  are the normalized value of  $x_t$  and  $y_e$ , which could be calculated by formulas 4 and 5;  $w_t$  is the weight of indices  $x_t$ , which could be calculated by the amount proportion of  $t$ -star hotel in the whole hotel industry; and  $w_e$  is the weight of indices  $y_e$ , which could be calculated by the information entropy method as follows:

$$\begin{cases} d_j = 1 - \frac{1}{\ln m} \sum_{i=1}^m \frac{x'_{ij}}{\sum_{i=1}^m x'_{ij}} \cdot \ln \frac{x'_{ij}}{\sum_{i=1}^m x'_{ij}} \\ w_j = \frac{d_j}{\sum_{j=1}^n d_j} \end{cases} \quad (7)$$

where  $d_j$  is the entropy redundancy of the index  $j$ , and 0.00001 is substituted for 0 if  $x'_{ij} = 0$ ,  $n$  is the number of indexes, and  $m$  is the number of provinces. The larger  $d_j$  is, the more information index  $j$  contains, and it is supposed to have greater weight.

### 3. Results

#### 3.1. Weights

The weights of indices in the tourism-related water resource management subsystem are shown in [Figure 2](#). The weights of the same star-level hotel are different among provinces, since they are calculated by the proportion of the total hotels in every single province. In most provinces, the 3-star hotel has the largest weight, and it is popular with tourists since its cost-effective. Notably, the high-end luxury 5-star hotel is more popular in the provinces with developed tourism, for example, Beijing, the capital of China, Hainan, a famous tropical island, and Shaanxi, a famous historic tourism destination in China.

The weights of indices in the local condition subsystem are shown in [Table 1](#). Tourism industry development status has the largest weight, which means it is the most important factor influencing the water management in tourism, followed by water resource endowment and water utilization technologies. On the index level, the average price of guest room has the greatest effect on local conditions, the number of occupied beds and investment strength in water-saving research & development followed.

#### 3.2. Results of the subsystems

The integrated scores of tourism-related water resource management are calculated according to formula (6) and divided into five ranks using the Jenks Natural Breaks ([Figure 3\(a\)](#)). The higher score represented stricter water intake quota norms, which means that hotels are requested to use less water per bed. Apparently, most provinces concentrated above rank III, with only three provinces belonging to rank II and two provinces (Guangdong and Hainan) belonging to rank I. That is to say, compared to

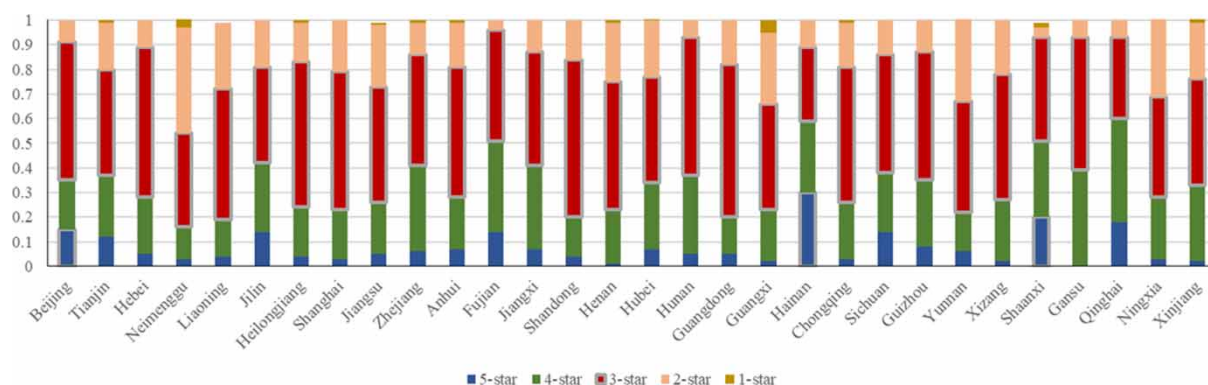


Fig. 2. Weights of indices of the tourism-related water management subsystem.

Table 1. Weights of indices of the local condition subsystem.

Aspect	Weight	Indices	Entropy redundancy ( $d_j$ )	Weight ( $w_j$ )
Water resource endowment	0.29	Exploitation rate of available water	0.07	0.12
		Multiyear average precipitation	0.04	0.06
		Annual average temperature	0.04	0.06
		Annual relative humidity	0.03	0.05
		Number of occupied beds	0.09	0.15
Industry development status	0.37	Average price of guest room	0.14	0.22
		Domestic water consumption per capita	0.02	0.04
Consumption tendency	0.16	Municipal water consumption per capita	0.08	0.13
		Coverage of tap-water supply	0.03	0.04
Water utilization technologies	0.18	Investment strength in water-saving R&D	0.09	0.14

the provinces with the loosest water intake quota, most provinces take much stricter quotas. Furthermore, the provinces below rank III are all concentrated in southern China, while the provinces in northern China mostly belong to ranks IV and V, showing quotas tend to be stricter in northern China than in southern China.

Similarly, the integrated scores of local conditions are calculated and divided into five ranks (Figure 3(b)). The higher score represented the province that tends to be more efficient in water use in tourism, no matter whether passively or voluntarily. The provinces concentrated in rank III, which means that most provinces just have medium conditions for water-saving comparing to the provinces which have advanced water-saving technologies or urgent water-saving demand. Notably, the provinces that belong to rank V are all on the east coast of China, including Beijing, Shandong, Shanghai, Zhejiang, and Guangdong.

### 3.3. Results of the coupling degree

Finally, the coupling degree of tourism-related water management subsystem and local condition subsystem is calculated according to formula (3). Then, it is divided into five stages by combining Jenks Natural Breaks and the classification schemes in previous studies. As shown in Figure 4, 21 provinces are at or above the high coupling level, reflecting that the tourism-related water management is

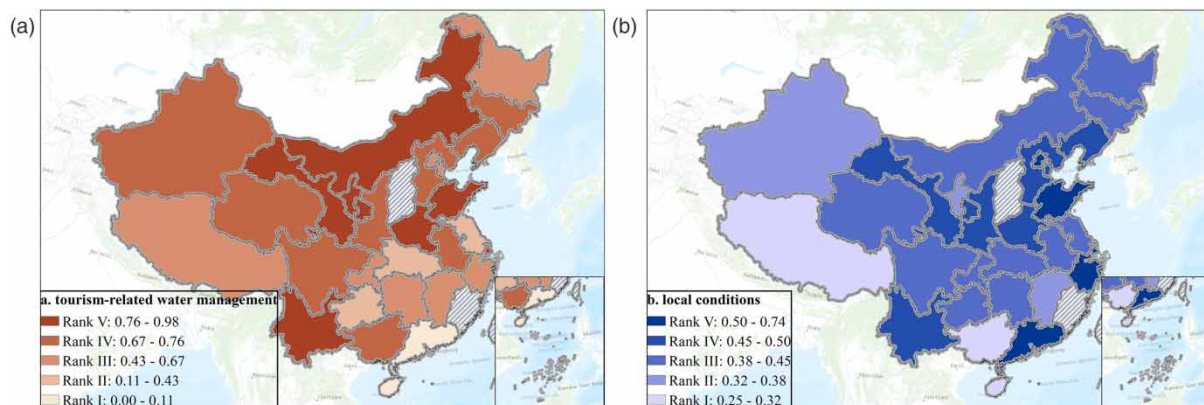


Fig. 3. Integrated score of tourism-related water management subsystem (a) and local condition subsystem (b).

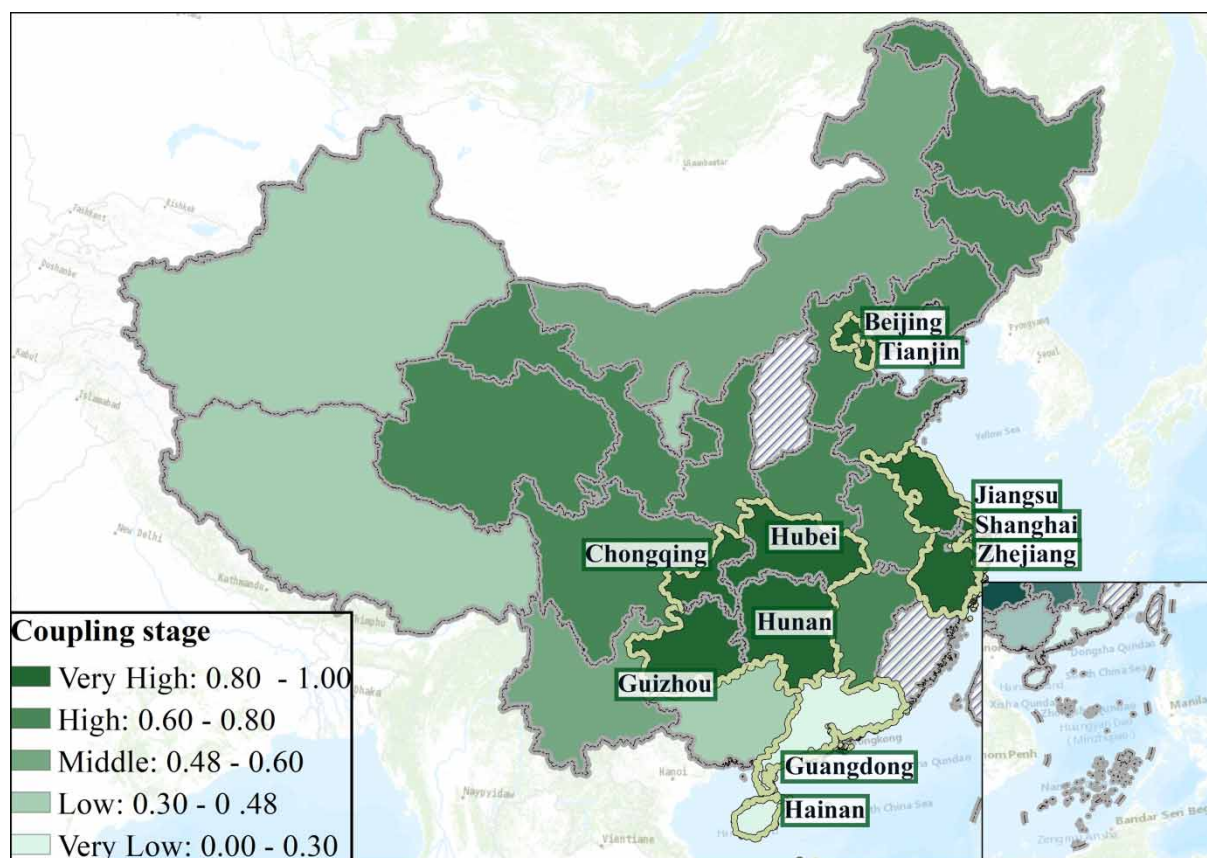


Fig. 4. Coupling degree of tourism-related water management and local condition subsystems.

congruent with the local conditions in most provinces in China. While only six provinces are at or below low coupling level, it is noteworthy that the low coupling stage and very low coupling stage mean that the water intake quotas are relatively incongruent with the local conditions, rather than absolutely incongruent with the local conditions.

The provinces at the very high and very low coupling stage presented a significant cluster spatial pattern. The very high coupling stage provinces formed three clusters: Beijing, Tianjin at north China, Zhejiang, Shanghai, and Jiangsu in east China, Chongqing, Sichuan, Hunan, and Hubei at southwest-middle China; and the very low coupling stage provinces formed 1 cluster: Guangdong, Hainan at south China.

#### 4. Discussion

Water management in tourism has begun to draw attention in recent years, and water policies have shifted to water-saving priority in China. As early as 1999, the Ministry of Water Resources of China began to deploy the water intake quota management on the national scale. And in rapid sequence, the legal status of water intake quota management was consolidated by the *Water Law* and the *Regulation of Water Intake Permit and Water Fee*. However, the water intake quota in tourism did not respond positively at the provincial scale. Until the year 2013, the water intake quota management was repeatedly emphasized by the Ministry of Water Resources of China, and provinces in China began to pay attention to draw up and normalize water intake quotas (Figure 5). And the temporal and spatial influences of water intake quota management both appeared.

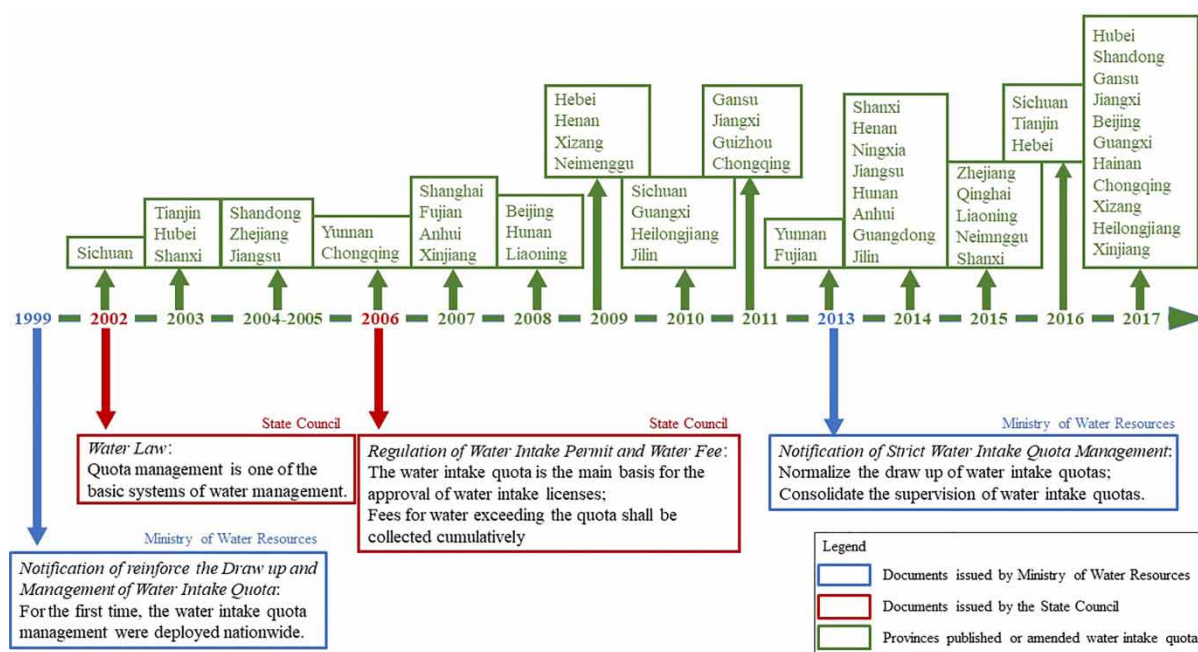


Fig. 5. The development course of water intake quota management in China.

#### 4.1. Temporal variation

The efficiency of water use in tourism has been largely improved, in the early 21st century the annual water consumption per tourist in China once had the highest value ( $349 \text{ m}^3/\text{bed}\cdot\text{a}$ ) around the world in Becken's study (Becken, 2014), but now has decreased to  $223 \text{ m}^3/\text{bed}\cdot\text{a}$  (4-star and 5-star hotel),  $165 \text{ m}^3/\text{bed}\cdot\text{a}$  (3-star hotel) and  $85 \text{ m}^3/\text{bed}\cdot\text{a}$  (1-star and 2-star hotel), while in southern China, the numbers have decreased to  $350 \text{ m}^3/\text{bed}\cdot\text{a}$  (4-star and 5-star hotel),  $256 \text{ m}^3/\text{bed}\cdot\text{a}$  (3-star hotel), and  $180 \text{ m}^3/\text{bed}\cdot\text{a}$  (1-star and 2-star hotel) (Ministry of Water Resources of China, 2019).

Fortunately, we got the water consumption data of 349 hotels in the years 2007 and 2017 in Beijing, accounting for 66% of the total number of hotels in Beijing. In 2008, Beijing first implemented water intake quota management in the hotel industry. And during this decade, the water intake quota management had been well carried out. As a result, the water consumption per bed of the samples has been largely improved (Table 2). The 4-star and 5-star hotels are often large and high-end, and their average water consumption per bed had decreased  $83.4 \text{ m}^3/(\text{bed}\cdot\text{a})$ , 28% down on the year 2007; 3-star hotels are the medium level, and their average water consumption per bed had decreased  $11.9 \text{ m}^3/(\text{bed}\cdot\text{a})$ , 5.8% down; 1-star and 2-star hotels are small and budget hotels, and their average water consumption per bed had decreased  $22 \text{ m}^3/(\text{bed}\cdot\text{a})$ , 15.8% down.

Obviously, the water intake quota management achieved different results among different level hotels. The large and high-end hotels performed best, since they have more water-use sections which have water-saving potential, such as gardens, staff bathrooms, and central air-conditioning, as well as well-trained staff for water-saving. Small and budget hotels performed much better than the expectation, since they modified water-saving devices, outsourced the laundry, and generally found their own ways to save water. The medium hotels appeared to be negativist, according to our field interview; they seem to be indifferent to water-saving, since they just feel that the current water intake quota could satisfy their water demand.

#### 4.2. Spatial variation

As mentioned in Results of the coupling degree, the coupling degree of the tourism industry and water intake management presented four clusters on the provincial scale. The four clusters could represent more than half of the tourism industry in China, and the number of hotels in these clusters accounts for 50.21% of the total number of hotels in China, while the revenue of tourism accounts for 62.31% of the total revenue of tourism in China. Moreover, the coupling relationship between tourism-related water management and local conditions is significantly different among the clusters mentioned above. Thus, considering the ranks of tourism-related water management, the aspects in the local condition subsystem (Figure 6, divided by Jenks Natural Breaks), the regional water-saving

Table 2. Comparison of average water consumption per bed of hotel samples between 2005 and 2015.

	1 star and 2 star		3 star		4 star and 5 star	
	2005	2017	2005	2017	2005	2017
Average water intake per bed ( $\text{m}^3/(\text{bed}\cdot\text{a})$ )	139.0	117.0	203.5	191.6	297.7	214.3

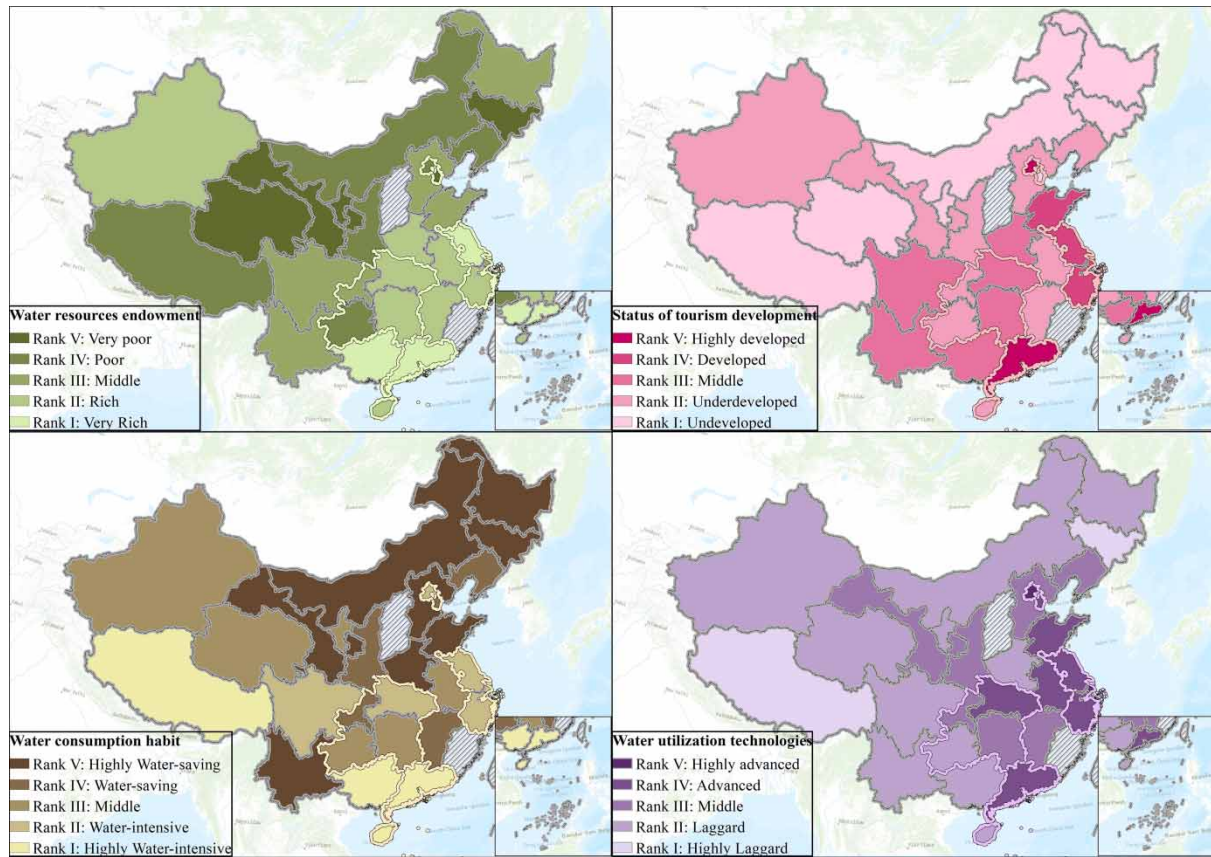


Fig. 6. Ranks of aspects in the local condition subsystem.

plans (National Development and Reform Commission, 2017), and regional development strategies (Fang *et al.*, 2017), features of the clusters could be summarized as follows.

**4.2.1. Capital circle cluster.** The capital circle cluster includes Beijing and Tianjin municipality. The ranks of tourism-related water management are both III, and the ranks of the four aspects of local conditions are on average ‘IV-V-III-V’, representing that in this cluster the tourism-related water management tends to be strict, while water resource endowment is poor, tourism highly developed, consumption habits tended to be water-saving, and water utilization technologies are highly advanced.

Beijing and Tianjin are the core metropolis of capital circle urban agglomeration. They are the most popular tourist destinations in China, and their tourist services usually are high-end and luxury, needing a large volume of water resources to support them. However, they are facing a serious water shortage, and water resources had been over-exploited for a long time (Liu *et al.*, 2016). The huge demand for water resources for industry development and a serious water shortage had caused the serious conflict between water supply and demand. Necessarily, strict water management is required to handle the conflict. Responsively, a series of strict water management has been taken in Beijing and Tianjin, both

administratively and economically. For example, an enterprise that violates the water intake quota norm would probably face a progressive fine and even water withdrawal prohibition.

However, these strict water managements are not groundless, and plenty of supporting measures have been adopted. The measures ranged from diverse water supply to water-use devices. Recycled water and rainwater have been widely used in the irrigation of landscape, toilet flushing, and car washing, while water recycling systems are promoted on building, community, and municipal levels. The water-intensive industries are replaced with water-saving ones, and high water cost commodities are imported from water-rich regions. The highly efficient water-saving technologies and devices were strongly promoted. The water-saving consciousness and skill of the employees who directly use water in enterprises had also been well instilled (Bao & He, 2017).

In general, the water resource management in Beijing and Tianjin tends to be strict owing to the serious conflict of water supply and demand, and an integrated water management system had been adopted to support the strict water policies. Although the absolute value of water intake norms is not low in this cluster on the national scale, they are strict enough considering the water demand of the high-end tourism industries.

*4.2.2. Yangtze River Delta cluster.* Yangtze River Delta cluster includes Shanghai municipality, Jiangsu, and Zhejiang province. The ranks of tourism-related water management are ‘II-III-IV’, and on average could be considered as III, while the ranks of local conditions are on average ‘II-IV-II-V’, representing that in this cluster the water management tends to be strict, while the water resource endowment is rich, tourism highly developed, consumption habits tend to be water-intensive, and water utilization technologies are highly advanced.

This cluster strongly coincided with the Yangtze River Delta urban agglomeration, which is the most developed urban agglomeration in China. They are the most popular tourist destinations in China, and their tourist services are also high-end and luxurious; fortunately, abundant water resources supported tourism development. The major problem in the Yangtze River Delta is water pollution, as the abundant water resources are abused; as shown in previous studies, there is an obvious inverse correlation between water resource endowment and its utilization efficiency (Li et al., 2009). Moreover, the water quality and water environment have been impacted, and the further development of tourism would likely be limited (Chen et al., 2018). The strict water management could not only help enhance the water utilization efficiency to support the further development of tourism, but also relieve the water pollution issues by reducing the wastewater discharge.

In general, water resource management in the Yangtze River Delta tends to be strict owing to the water pollution issues and the water demand for tourism development. The rich water resource endowment provided sufficient conditions for industries in the past, while, on the other hand, they led to water-intensive consumption habits and low water utilization habits. Thus, some water-saving measures are also required, such as seawater desalination, high-end water-saving technologies, and water recycling.

*4.2.3. Upper-middle Yangtze River cluster.* Upper-middle Yangtze River cluster includes Chongqing municipality, Hubei, Hunan, and Guizhou province. The ranks of tourism-related water management are ‘III-III-II-II’, on average could be considered as rank II, and the ranks of local conditions are on average ‘II-II-III-III’, representing that in this cluster the water management tends to be loose, while water resource endowment is rich, but the tourism is underdeveloped, while consumption tendency and water utilization technologies are medium.

This cluster is located at the upper and middle reach of the Yangtze River and contains parts of the southwest and middle China urban agglomeration. This cluster is the emerging region in China, tourism industries are undergoing rapid development, the abundant water resources provided sufficient conditions and have not been fully exploited, while water pollution issues are under control (Huang et al., 2016; Zhou et al., 2019).

The water management in this cluster tends to be loose owing to its well water quantity and quality. The major objective of water management in this cluster is keeping the harmonious relationship between humans and water during the fast development of tourism.

**4.2.4. South China cluster.** South China cluster includes Guangdong and Hainan province. This cluster contains the only very low coupling stage in China, and apparently, they are located at the southernmost point in China. The ranks of tourism-related water management are both I, and the ranks of local conditions are on average ‘I-V-I-V’, representing that in this cluster the water management is extremely loose, while water resource endowment is very rich, tourism is highly developed, consumption habits tend to be highly water-intensive, and water utilization technologies are highly advanced.

The water resource endowment and tourism development in this cluster are even better than the Yangtze River Delta cluster; however, the water pollution is heavier than the latter as well. The natural water bodies were heavily polluted by the manufacturing industries. What is worse, the consumption habits in this cluster are highly water-intensive, produced wastewater eutrophication. Even the urban potable water is mostly unqualified, and the coliform bacteria, Fe, and N-NH<sub>3</sub> heavily exceeded water quality standards. But tourism needs high-quality water and freshwater bodies, the polluted lakes and rivers would probably disable the development of tourism. Although the local government has noticed this situation, it seems that effective water management has not been practiced (Luo et al., 2010; Dong et al., 2020).

In general, water management in this cluster is focused on ensuring tourism development but failed to control water pollutions. The water intake quota norms are too loose to inspire industries to improve their water utilization efficiency.

### 4.3. Summary

Given the above, the coupling degree model accurately reflected the complex coupling relation between water management and local conditions in China and revealed the merit and deficiency of tourism-related water resource management in China. The provinces in water-scarce areas tend to take more strict water policies than the ones in water-abundant areas, since they have to develop tourism with limited water supply. In the water-abundant areas, the major water issue is water pollution. The traditional water-intensive water consumption habits usually caused the abuse of water resources and then created water pollution. Strict water intake norms in the water-abundant are still necessary, since they could help release water pollution issues by reducing wastewater discharge.

## 5. Conclusions

Water resource management in China has undergone a change from focusing on the water supply to water-saving, and now it is widely recognized that sensible water management should satisfy both the

development demands of industries and the protection of water resources. Especially in the fast-developing tourism industry, the water consumption rapidly increased, and the content of water utilization became more and more complex. To be sensible, the tourism-related water resource management is required to be congruent with the local conditions.

In this study, a coupling degree model was introduced to describe the coupling relationship between tourism-related water management and local conditions. According to the results, tourism-related water management is generally congruent with the local conditions in most provinces in China. Compared to the few provinces below the low coupling level, most provinces tend to take strict water management, which could be regarded as carrying out the current ‘Water-saving Priority’ policy in China. Water-saving has proven to be necessary for tourism in China, no matter whether in the water-scarce regions or the water-abundant regions. In water-scarce regions, water-saving management could help to control the amount of tourism-related water consumption, relieving the water shortage crisis. In water-abundant regions, water-saving management could help to reduce the wastewater discharge and abate water pollution issues, and then support the further development of tourism. Otherwise, the serious water pollution issues would likely impact the availability of water resources and the sustainable development of tourism, just as Guangdong and Hainan provinces.

The tourism-related water management of the provinces on the east coast of China would be of interest to the areas with substantial tourism. They should take the strictest water management in tourism, comprehensively considering the water resource endowment, the developing water demand of tourism, the water consumption habits, and water utilization abilities. With regard to the water management, to be more specific, the water intake quotas were strictly and sensibly formulated with the participation of all the stakeholders, including the municipal administrations, waterworks, water users, and the manufacturers of water-saving devices. And the water intake quotas have become the basis for the water fees and water licenses of enterprises. On the other hand, the municipal administrations took many support measures, such as promoting water meters and high-efficient water-saving devices, diverse water supply, and gradient water use. Furthermore, with the progress of water management ideas, the virtual water trade has been put into practice. More and more tourism enterprises chose to shift their commodities and services to water-abundant areas, such as hotels choosing to outsource laundry to the large-scale laundry companies instead of their on-site small laundry room. In general, the highly advanced water utilization technologies and water management ideas provided strong support to the strict water management in these provinces.

However, there are some inadequacies in this study. First, the studied industry is limited to the hotel, since the water intake norms of other industries in tourism are too chaotic and their classification schemes are not unified, but with the amendment of water intake norms, there is a hope that the classification schemes will be unified and more industries would be included in the analysis. Second, disturbed by the unit and outlier, Shanxi and Fujian province are excluded from this study, although their absence is non-signature for the national analysis, so they should amend their water intake norms to achieve the consistency required by the guidelines. Third, limited by the data available and the ability of authors, the water quality issues are neglected in the index system, and the water utilization efficiency of the tourism industry is characterized by the public service industry and domestic water utilization efficiency. At last, the coupling degree model presented the relative relation rather than absolute status, for example, the coupling degree of Hainan is 0, which presented that the coupling relationship of Hainan is the worst, but its water intake quota management is not related to the local conditions at all.

Thus, in future studies, more industries and provinces should be dynamically included in the coupling degree model, and the water intake norms of catering, landscape, shopping mall, park, and even car-

washing should be amended to unify their classification and measurement schemes, as well as the other water resource management measures such as wastewater discharge, water recycling, and water reregulation. Moreover, the indices should be improved with the water quality and environment issues, as well as more precisely describe the water utilization efficiency of the tourism industry.

## Data availability statement

All relevant data are available from <https://data.stats.gov.cn/>.

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