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The Dynamic Analysis of Tourism Industrial Ecologization in Mainland China: Its Status and Evolution

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Abstract

Tourism industrial ecologization (TIE) is one of the effective ways to resolve the conflicts between tourism development and environmental protection, and to achieve tourism sustainability. Therefore, a comprehensive understanding of TIE's status and evolution is the foundation and prerequisite of promoting tourism sustainable development. This study analyzed the structure and interactions among the subsystems of tourism industrial ecosystem, revealed the status and evolution of TIE. The results showed that tourism industrial ecosystem included tourism industrial subsystem (producing pressure), the environment subsystem (consuming the pressure and deteriorating the environment) and the society subsystem (response to the environment). The assessment result showed that the coupling level of tourism industrial ecosystem was in the middle of barely coordination and primary coordination, which meant that the level of TIE was not high. The evolution demonstrated as following: the stress index showed a rapid and massive growth trend, which caused by the negative impacts produced by tourism. And the state index declined, which meant that pressures generated by tourist activities resulted in a deterioration of the environment. The response index was oblique as a "w" type, which marked that the fluctuation was on the rise. Accordingly, optimizing the development of TIE can be remedied through three recommendations.

Keywords

PSR model; Tourism industrial ecologization; Development status; Evolution China

Introduction

The traditional views show that tourism is a low-impact, non-consumptive development option [1] for the economy. What's more, the development of tourism would rarely produce pollution or damage on the environment. However, with the rapid growth of economy, the economic activities increase environmental burden [2-4]. The same as tourism industry, with the prosperity of tourism industry and the trend towards popularization and normality, tourism produced many negative and harmful impacts on the environment [5], such as water pollution [6,7], air pollution [8], solid waste [9]. These negative impacts on the environment seriously threaten the sustainable tourism development [1,10,11]. Thus, it is extremely important and urgent to get rid of those threats and to promote the process of sustainable tourism development.

Pankina et al. [12] argue that it is necessary to form ecological minds for solving environmental problems. Besides, more and more researchers agree that ecologization is not only the basis of achieving sustainability, but also becomes an important demand and global trend [3,13-15], which seeks sustainable development for industries [16]. Ecologization can be defined as an approach, or a way of understanding and taking environmental impacts and preservation into account [17]. In addition, ecologization is a progress of giving ecological substance and content to any possible objects so that resources could last to support an infinite number of human generations [18]. It is the basis for enterprises and industries to achieve the sustainable development [15]. Because of its importance, there are many researchers focused on the relative topics, such as educational ecologization [3,12], ecologization of rural areas [13], ecologization of society [18], economic ecologization [19], trade ecologization [20], industrial ecologization [14,21], and so on. Among these topics, industrial ecologization (IE) is the most popular one.

Industrial ecologization can be used to achieve a real change toward sustainable development in practice [22]. Industrial ecologization refers to a process to achieve higher efficiency and less pollution by constructing industrial ecological system to optimize rationally according to the symbiosis principle of raw material cycle, biology and industry [23]. IE is not only a long term evolution and technological dynamics for tracing the evolution of environmental management [24] but also a way of realizing sustainable development [25]. Meanwhile, it is a development progress that moves forward from dealing with pollution and environmental impacts [26] and a path toward sustainability [27]. Therefore, the main purpose of IE is to evaluate and minimize the environmental impacts [16,28], improve the environmental performance and increase business success of the industries [29-31]. Tourism as one of the economic activities, results in many negative environmental impacts which impede sustainable tourism development. Ming et al. [32] argue that tourism industrial ecologization is the best choice to minimize negative impacts produced by tourism activities, and to realize sustainable tourism development.

Due to the effectiveness for sustainable tourism development, tourism industrial ecologization (TIE) have been explored and discussed. Tourism industrial ecologization is mainly rooted in industrial ecologization. Robert and Nicholas [33], the earliest advocates of industrial ecologization, believe that the development pattern of traditional industrial activities should be transformed into a more comprehensive model of the industrial ecosystem. In this system, it is necessary to optimize energy and material consumption in order to reduce waste production. Thus, identifying the tourism industrial ecologization is crucial to make the tourism ecosystem working effectively. In other words, an efficient tourism industrial ecosystem is the necessary premise of tourism industrial ecologization. There are many comments and researches on tourism industrial ecosystem. Some researchers believe that tourism industrial ecosystem includes the endogenous, exogenous, and symbiotic systems [32]. Some researchers present that the ecological system of tourism industry is composed of "producer", "consumer" and "decomposing person" [34]. Other researchers think that the tourism industrial ecosystem

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consists of tourists, tourist destinations and tourism enterprises [35]. Therefore, it is not clear about the tourism industrial ecosystem for TIE.

The aim of constructing tourism industrial ecosystem is to apply and manage the tourism industry. With the development and prosperity of Chinese tourism, more and more negative impacts are produced. Obviously, it is necessary to use the tourism industrial ecologization approach to minimize the negative impacts on the environment. It is urgent to explore the ecological pattern for the development of cultural tourism industry [36]. However, it is a pity that few industrial ecologization applications to tourism management have previously been discussed [16]. Thus, here comes the problem, how to apply the tool of tourism industrial ecologization, and how to optimization the development of tourism industry?

According to the analysis on relative literature, there are some research gaps: it is not clear about the tourism industrial ecosystem of TIE. The construction of industrial ecosystem is the essence of industrial ecologization [21]. Therefore, before exploring the TIE, it is necessary to figure out the proper definition of tourism industrial ecosystem; It is unknown that how to apply tourism industrial ecologization to promote the development. There is a lack of research focused on the status and rules of tourism industrial ecologization.

With the rapid development of Chinese tourism industry, there are many negative and harmful impacts on tourism sustainable development in China. Thus, this study aims to comprehensively explore the tourism industrial ecologization of China, and make some suggestions on how to optimize tourism industrial ecologization for tourism sustainable development. According to research gaps mentioned earlier, this paper would construct the tourism industrial ecosystem and dynamic analysis of tourism industrial ecologization. There are three objectives of this paper: to figure out the constructing of tourism industrial ecosystem, which can make a foundation for assessing the tourism industrial ecologization; to figure out the status and development rule of TIE; to make some suggestions on optimizaing the development of tourism industry for promoting the tourism sustainable development. This study makes significant contributions for both theoretical and practical filed. On one hand, this paper tries to find out the construction of tourism industrial ecosystem and dynamic assessment of the TIE, which will significantly enrich the literature on TIE. On the other hand, this paper will shed some lights on the suggestion to optimize the TIE, which will make a practical contribution.

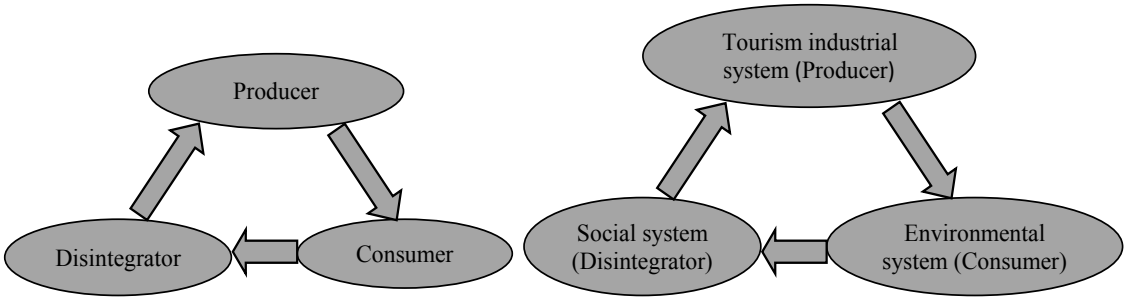
The Construction of Tourism Industrial Ecosystem

The construction of industrial ecosystem is the essence of industrial ecologization [21], and it's the same as TIE. However, there are many different views on tourism industrial ecosystem. Therefore, this paper attempts to understand the essence of the TIE. The natural ecosystems can help us to improve upon the materials and energy efficiency of societies. Farrell suggests that it is helpful to learn from nature ecosystem for industrial ecologization [37]. Obviously, simple nature ecosystem includes the producer, the consumer and the disintegrator. According the roles of simple nature ecosystem, this paper find out who play the relative roles in tourism industrial ecosystem (Figure 1). Therefore, we can infer that the tourism industrial ecosystem included three subsystems, which are tourism industrial system, environmental system and social system.

The system emphasizes the interactions between elements and subsystems. The development level of tourism industrial ecologization depends on the interactions of tourism industrial ecosystem elements. If the coordination of the various subsystems is positive, the system runs smoothly, which will promote the development of tourism industrial ecologization. If it is not positive, it is bad for tourism industrial ecologization. Therefore, this paper will make an effort to figure out how the subsystems of tourism industrial ecosystem interact each other.

The PSR model is fit for analyzing the interactions of subsystems of tourism industrial ecosystem. The pressure-state-response model (PSR) is a framework system developed by OECD and UNEP, which was originally presented by Canadian Statistician Rapport and Friend (1979). The PSR model uses the thought of "cause-effect-response" to reflect the interaction between human activities and the environment [38]. The pressure produced by human economic and social activities has negative impacts on the environment. What is worse, this pressure will change the status of the environment and its quality. Ultimately, the relevant managers will use policies, increasing environmental investment, government management and other methods to respond to the changing status. Industrial ecologization is a progress that moves forward from dealing with pollution and environmental impacts. According to the connotation of PSR model, it is a progress to analyze the cause, clarify the changes and control the impacts [39-41]. Therefore, PSR model was used to analyze the interactions among subsystems of tourism industrial ecosystem (Figure 2).

The result is shown in Figure 2. In particular, the tourism industrial system in Figure 1 plays the role of producer. Its production is the pressure on the environment in the PSR system in Figure 2.



(a) Simple nature ecosystem (b) tourism industrial ecosystem

Figure 1: The consist of tourism industrial ecosystem.

The environmental system plays the role of consumer, who consumes the pressure produced by tourism industry. Then the consumption of environment reflects by the states of environment in Figure 3. The role of disintegrator is social system in Figure 1, whose primary responsibility is to "break down" the "residual state" of the consumer. The "R" refers to response, which aims to ensure the producers to keep function properly. The social response system in Figure 3 is mainly to "decompose" the "state" of environmental system under pressure, which is to respond to the states of the environment.

Thus, the interactions among subsystems of tourism industrial ecosystem will influence the progress and level of industrial ecologization. Besides, the status and development rule of tourism industrial ecosystem can reflect the status and reveal the development rule of TIE. Therefore, the substance of the industrial ecologization development is the same as the development of tourism industrial ecosystem [21]. Thus, the study will clarify the development level of TIE by comprehensively evaluating the work status of interactions among subsystems of tourism industrial ecosystem.

The Indicators and Method for Evaluating TIE

The assess indicators for TIE

The pressure indicators: The pressure indicators mainly refer to the pressure and negative impacts on the environment produced by tourism. And there is a close relationship between tourism capacity and tourism pollution [42]. With the influx of tourists, the original environment of tourist destinations is directly in face of the pollution threat. In addition, the construction of tourism facilities could also present a threat to the destination's environment [43]. Based on these points, the paper mainly made full use of these indicators of tourism development to measure the pressure produced by tourism ecosystem. The pressure produced by tourism includes three parts: the environmental pressure caused by tourists factors (e.g. the number of tourists, tourism practitioners and number of passengers); the comprehensive pressure produced by tourism consumption (e.g. domestic tourism costs and international tourism income); and the pressure caused by tourism activities (e.g. tourism facilities construction and tourism product). The specific pressure system indicators are shown in Table 1.

The state indicators: The state indicators aim to reflect the state of the environment and the environment change in a certain period under the pressure produced by tourism industry. The state not only includes natural environment, but also takes the quality of human life and the state of health into account. The pollution is mainly shown as the destruction of water, air, vegetation and the whole landscape [44]. In addition, water resources per capita, soil erosion

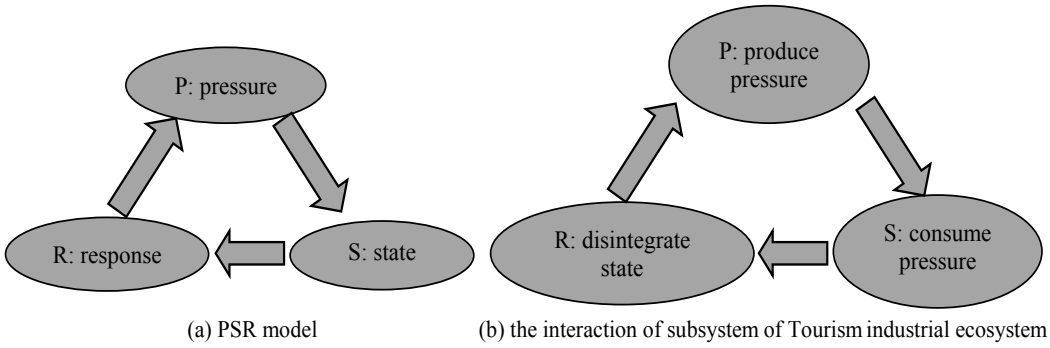


Figure 2: PSR system for Tourism industrial ecosystem.

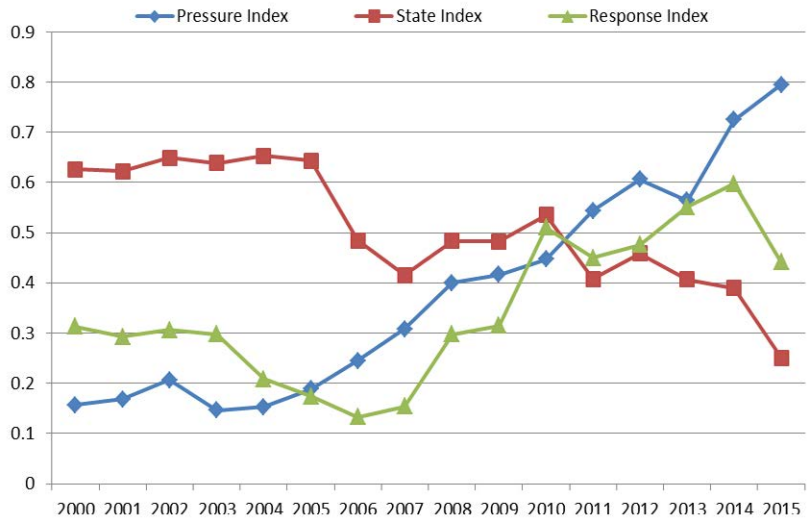


Figure 3: The pressure-status-response index of Tourism industrial ecologization of China.

Table 1: PSR framework of evaluation index system for TIE.

Target Layer	Benchmark Layer	Indicator layer	The meanings of indicators	Weight
Tourism industrial ecologization	Pressure system	Domestic tourism costs	the comprehensive pressure produced by tourism consumption	0.1970
		international tourism income		0.1573
		number of tourists	the pressure caused by personnel factors	0.1368
		number of passengers		0.1390
		tourism practitioners		0.1552
		number of travel agencies	pressure caused by tourism activities, as tourism facilities construction, production	0.0718
		number of catering corporates		0.1004
		number of hotels		0.0425
	State system	water resources per capita	change of water resource	0.0906
		the ratio of forest cover	forest harvesting, biological invasion, biodiversity and so on	0.2235
		Park green area per capita	occupation status of Green space	0.1113
		total energy consumption in the wholesale, retail and residential and catering industries	energy consumption	0.1133
		water pollution	environmental load condition	0.1339
		population mortality	population Health Load Status	0.3214
	Response system	investment in environmental pollution control	finance response	0.2211
		investment in prevention and control of geological hazards		0.3710
		afforestation Area	behavior response	0.0874
		the area of nature reserve occupies the proportion of area		0.0422
		proportion of total export trade of primary products	ecosystem productivity response	0.2783

Source: Organized by the authors based on the Chinese Tourism Statistical Yearbook and the annual China Environment Statistics Yearbooks.

ratio and pollution load degree are usually included in the ecological construction effectiveness evaluation system [45]. Accordingly, water resources change status (referred by water resources per capita), forest harvesting, biological invasion, biodiversity and other conditions (referred by forest cover), green space occupancy status (referred by Park green area per capita), energy consumption status (referred by total energy consumption in the wholesale, retail and residential, and catering industries), environmental load (referred by water pollution) and population health load (referred by population mortality) are selected to measure the state.

The response indicators: The response indicators mainly refer to the measurement taken by the government, the society, the enterprises, etc., which aims to mitigate, recover and prevent the negative effects produced by tourism industry. Since we focused on a macroscopic view, the response indicators were chosen only from the angle of government and social aspects. During the emergency response of water pollution accidents, the wealth and material resources should be allocated. Similarly, the response indicators to the state of the natural environment could be analysed from finance response (referred by pollution control and investment in prevention and control of geological hazards), behaviour response (referred by afforestation area and the area of nature reserve occupies the proportion of area), and ecosystem productivity response (referred by proportion of total export trade of primary products).

The assess method of TIE

Data sources and processing: The purpose of the study is to explore the status and evolution of the tourism industrial ecologization of China from 2000 to 2015. The data of pressure indicators is from the Chinese Tourism Statistical Yearbook (from 2001 to 2016), then the data of state indicators and response indicators are derived from the annual China Environment Statistics Yearbook (from 2001to 2016).

After obtaining the data, the mean-value method was used to supple the missing data. In order to complete the standardized processing, extreme difference method was applied in this study. Positive indicators were used in formula (1) and the negative indicators were used in formula (2). X_{ij} represents the number of j years of the index i, Max x_i represents the maximum value of the index i in all years, and Min x_i represents the minimum value of the index i in all years.

$$X'_{ij} = (X_{ij} - \min X_i) / (\max X_i - \min X_i) \quad (1)$$

$$X'_{ij} = (\max X_{ij} - X_{ij}) / (\max X_i - \min X_i) \quad (2)$$

The weight of indicators: The weight of indicators directly influences the result of TIE evaluation. Thus, it is necessary to calculate the weight of each index by objective method. And entropy method is an important method for comprehensive evaluation for multiple indicators, which can objectively weight the indicators based on the information provided by indexes. Therefore, in order to reduce the influence of subjective factors, this study calculated the weight of each indicator by using the entropy method [46], and the results are shown in Table 1.

Calculating the index of TIE: The formula of the TIE index was concluded in the study, which is shown as formula (3). W_{ij} refers to the weight of j index of the system I, p_{ij} represents the value of the j index of i system, and B_i refers to the weight of i system. The three systems were regarded equally important in this study, that is, the weight of each system was taken as 1/3. If the value of the TIE index is closer to 1, the higher level of TIE is, the better status of TIE is and the stronger ability of sustainable tourism development achieves. If the value of the TIE index is closer to 0, it indicates that the ecological level of tourism industry and the ability of tourism sustainable development are both bad.

$$TIE = \sum_{i=1}^{n} B_i \sum_{i=1}^{n} W_{ij} P_{ij} \quad (3)$$

Coupling coordination degree of PSR System analysis

Coupling means that two or more than two systems affect each other through various interactions. Besides, the coupling degree is the system or element interacted and affected each other [47]. The coupling degree is used to measure the degree of harmony among systems and internal elements in the process of development, which can reflect the trend of system from disorder to order [47,48]. When the subsystems or the internal elements of the system are properly fit, promoting each other, which means the system coupled well. Whether the coupling degree of coordination is good, it can reflect that two or more systems promote each other or not. The ultimate goal of TIE does not only realize the effective interaction among the systems, but also form the coupling optimization among the systems. Thus, the study brought the coupling coordination degree to analyze the coupling relationship among the pressure systems, the state systems and the response systems of tourism industry to reveal the evolution and the status of tourism industry.

This study cited the principle of multi system coupling coordination in synergetic theory, and constructed the multiple-system coupling coordination function on the basis of coupling degree model, which was calculated by formula (4).

$$D = (C \times T)^{1/2}, T = a_1 \times t_1 + a_2 \times t_2 ... + a_m \times t_m \quad (4)$$

t_1, t_2, and t_m represent each system of coordinated coupling model, and a_1, a_2, a_m refer to the weight of each system respectively. D refers to the coordination coupling degree and C is the coupling degree. C could be calculated through formula (5). In formula (5), m refers to the number of systems, and in this study m is 3.

$$C = m[t_1 \times t_2 \times t_3 ... \times t_m)(\prod_{i \neq j, i, j=1,2...m} (t_1 + t_2 + ...t_m)]^{1/m} \quad (5)$$

The Dynamic Analysis of TIE

This paper explored the status and evolution of tourism industrial ecologization, which can help us to make some suggestions for promoting the development of TIE and sustainable tourism.

The progress of TIE evolution

The pressure index: According to the weight of each indicator and data, this study calculated the index of the pressure produced by tourism industry. Its evolution was shown in Figure 3. In general, the pressure index increased 63.75% from 2000 to 2015, showing a rapid and substantial growth trend, which meant that with the development of tourism gradually increasing, the pressure produced by tourism production and activities increased rapidly.

Specifically, it is in the variable period in China (from 2000 to 2003), which Chinese tourism industry was initially developed. Under this background, tourism income, hotels, travel agencies and other tourism facilities were gradually increased from 2000 to 2002. With the promotion of tourism activities, the pressure produced by tourism activities increased. However, "SARS" spread throughout China in 2003, which greatly affected the development of tourism activities. During the "SARS" period, the number of travelers decreased dramatically. Besides, hotels, travel agencies have closed down to rectify. In addition, Chinese tourism industry temporarily turned into the "dormant" state. Therefore, the pressure of its production also appeared the decline performance.

China is in the "continuous pressurization period" from 2004 to 2011, and after "SARS" period, the tourism industry renewed. Tourism revenue increased year by year in this period. Furthermore, the tourism facilities were updating and getting well-equipped. And the pressure produced by tourism activities had a growth of 42.12% during this period. It should be pointed out that there were some natural disasters in 2008 in China, such as Wenchuan earthquake and snowstorm of the southern China, which slowed down the growth of tourism activities during 2008 and 2010.

It is also a "variable period" from 2012 to 2015 in China. In 2013, the pressure of tourism activities declined, which was mainly due to the promulgation of the "Chinese Tourism law". It limits the largest number of tourist to a destination. Thus, the "blowout" state of the scenic spot has eased, and its corresponding pressure has also decreased.

The state index: Overall, the state index of the TIE is declining, which indicates that the Chinese environment is deteriorating. This is mainly manifested by the decrease of water resources per capita, the total energy consumption of the hospitality industry (e.g. wholesale, retail, lodging and catering) and the increasing of water pollution emission. In particular, the index of state decreased 37.56% from 2000 to 2015 and the average annual decline rate was about 68.34%. It is in the "state rapid decline period" from 2004 to 2007. During this period, the average annual decline rate was 10.66%, which was mainly induced by the tourism industry experienced "SARS" period. Then, after a brief "dormancy", tourism industry in China began to revive, and accommodation, catering, energy consumption and water pollution emissions surged.

According to the environment evolution, it could be classified by four stages: (1) Stationary period (2000-2004). During this period, the impact of tourism activities on the environment was stable, which was mainly caused by the slow development of tourism activities (2) Deterioration period (2005-2007). During this stage, environmental deterioration was mainly caused by the rapid development of tourism activities. The environmental problems during this stage were mainly manifested in the decrease of water resources per capita, the increasing of energy consumption and water pollution emissions. (3) Temporary turnaround period (2008-2010). The turnaround of environment was mainly because of the natural disasters (e.g. Wenchuan earthquake, snowstorm) in 2008. Under this background, environmental governance, disasters prevention and investment funds increased. Therefore, the state of environment could be alleviated. (4) Continued deterioration period (2011-2015). With the normalization and popularization of tourism activities, the environmental pressure increased rapidly, which resulted in the state of environment deteriorating continuously. On the whole, the tourist activities produce a huge environmental pressure. However, the environment becomes a consumer under this kind of pressure which leads to deteriorating of environment status. According to the status of the environment state, most Chinese tourism destinations belong to the resource waste and the environmental pollution type industry [49].

The response index: As shown in Figure 2, the index of TIE response is skewed a "w" type distribution, which demonstrates an obvious fluctuation trend. During 2000 and 2015, the response system displayed a phased upgrade. (1) The "slow ascension period" (2000-2003). With the development of national ecological construction in 1999, the area of afforestation and nature reserve were improved, so the response index showed a slow rising performance. (2) The significant improve period (2007-2010). The Wenchuan Earthquake, the Southern of China Snow disaster in 2008 and other natural disasters resulted in an investment on disaster prevention, ecological construction and pollution treatment. Thus, not only the ecological

construction effect was remarkable, but also the response system has been significantly improved. (3) The continuous promotion period (2011-2014). During this period, the response system was further improved, which was mainly in the financial and behaviour response to further strengthen. Among them, it showed a clear downward trend, which was mainly because of the reduction of investment in environmental pollution control in 2015.

It is not worth much that response system scored a brief decline during 2003 and 2006, which was mainly because the surge in imports of food (e.g. grains, wheat, and rice) during 2003 and 2005. Correspondingly, the cultivated area was also increased, which leads to a decrease of forestation area and eventually resulted in a brief decline of the response system.

The index of TIE: According to the formula (3), we calculated the index of TIE and the result was shown as Figure 4.

Generally speaking, the index of TIE is rising, which indicates that the TIE level of China is increasing greatly from 2000 to 2015. The TIE index of China grows from 36.52% to 49.54%, which is consistent with the results of the effect of ecological construction of China (1953-2008) [45]. Specifically, the TIE process of China can be divided into four stages according to Figure 4.

Slow development period (2000-2003). At this stage, Chinese tourism industry has been preliminarily developed. Gradually, its pressure on the environment has increased. With the development of national ecological construction started from 1999, the government responded to the pressure of the tourism activities and decomposed the environmental deterioration. Therefore, the TIE level of China developed slowly.

Short period of degeneration (2004-2006). After "SARS", the tourism activities renewed. With the pressure of tourism activities growing continually, the environment was gradually deteriorated. However, the afforestation area of the response effectiveness was decreased due to the increasing arable land, which resulted in the response system not responding to the pressure produced by tourism activities and the deterioration of the environment. Therefore, the index of TIE was briefly degraded.

Stage 3: Significant improvement period (2007-2010). In 2008, Snow Disaster in Southern China, Wenchuan earthquake and other natural disasters occurred successively in China, which promoted the investment of disaster prevention. Besides, China advocated promoting energy conservation and environmental protection of tourism agencies, hotels and other tourism enterprises in 2009, which aims to reduce energy consumption and ensure a reasonable determination of scenic spots' carrying capacity. With the promotion of these policies, the level of TIE in China was obviously improved.

Stage 4: Continuous promotion period (2011-2014). In 2013, "Tourism Law" was formally promulgated in China. It required that the scenic spots must ensure the largest tourist capacity and avoid the environmental damage caused by overload. In 2014, China added other policies, which focused on resource energy conservation and tourism environmental protection. Therefore, the developed TIE level of China had been increasing continuously. It is noticeable that the corresponding index of TIE had a certain decline due to the obvious weakening of the response index in 2015.

Analysis on coupling of Tourism industrial ecosystem

According to formula (4) and (5), the study calculated the TIE coupling degree (C) and TIE coupling degree (D) of China from 2000 to 2015. And the results were shown in Figure 5.

In general, the coupling degree of the system did not change obviously, which fluctuated at the level of 0.6. According to the classification grade of the coupling degree [50], the development TIE level of coupling degree was between the barely coordination and the primary coordination, which demonstrated that the work effectiveness of system was not efficient.

Moreover, the reasons for the uncoordinated of TIE during 2000 and 2014 were analyzed in this paper. The results were shown as Table 2. It was found that the main reasons for the system uncoordinated were as follows: (1) when $\Delta R > \Delta P + \Delta S$, the main performance was that pressure increased and the state deteriorated, but there was an excessive response, such as year 2000, 2002 and 2009. (2) When $\Delta P > \Delta S + \Delta R$, the main performance was that the state deteriorated and the response increased, but the pressure increased too. There was

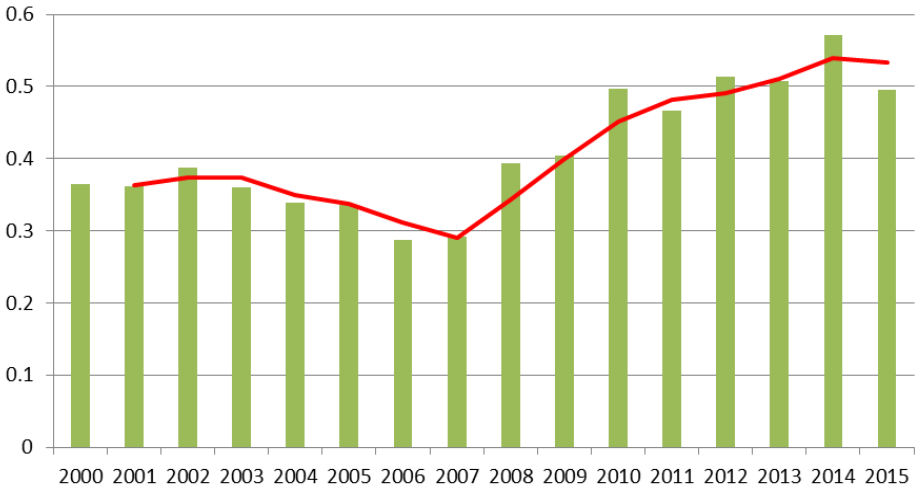


Figure 4: Composite index of Tourism industrial ecologization of China from 2000 to 2015.

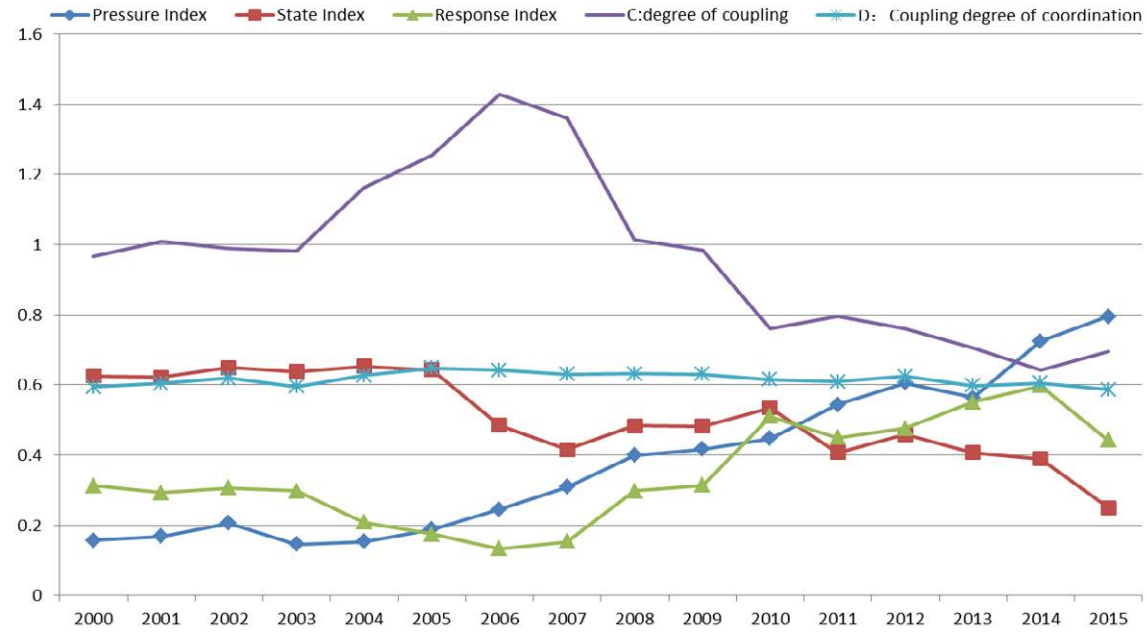


Figure 5: The PSR system coordination of TIE of China.

Table 2: The reasons for the situation of no coordination of TIE of China from 2000 to 2015.

Year	Changes	description	Year	Changes	description
2000	ΔR>ΔP+ΔS	excessive response	2008	ΔS>ΔP+ΔR	environmental degradation
2001	ΔP>ΔS+ΔR	surged pressure	2009	ΔR>ΔP+ΔS	excessive response
2002	ΔR>ΔP+ΔS	excessive response	2010	ΔP>ΔS+ΔR	surged pressure
2003	ΔS>ΔP+ΔR	environmental degradation	2011	ΔP>ΔS+ΔR	surged pressure
2004	ΔP>ΔS+ΔR	surged pressure	2012	ΔR>ΔP+ΔS	excessive response
2005	ΔP>ΔS+ΔR	surged pressure	2013	ΔS>ΔP+ΔR	environmental degradation
2006	ΔP>ΔS+ΔR	surged pressure	2014	ΔS>ΔP+ΔR	environmental degradation
2007	ΔP>ΔS+ΔR	surged pressure			

Tips: P represents for pressure, S represents for State, R represents for Response.

a surge of pressure, such as year 2004, 2005, 2006 and 2007. (3) When ΔS>ΔP+ΔR, the deterioration of state was beyond the pressure of the reduction and the response increasing, which was environmental degradation, such as year 2008.

Conclusion and Management Implications

Conclusion

The traditional research showed that tourism is "smokeless industry" and pollution-free industry [1]. With the development of tourism, the negative impacts produced by tourism are becoming more and more obvious. According to the relevant studies, industrial ecologization is an important trend of tourism industry. Moreover, Tourism industrial ecologization is the best choice and method to achieve tourism sustainable development. Based on the ecological system of natural system, the study presented a PSR system for evaluating the level of tourism industrial ecologization. In addition, the study selected the relevant data of China from 2000 to 2015, and used an entropy method to determine the weight of each index, evaluated the level of TIE, and dynamically analyzed the system coordination of TIE. Correspondingly, the findings could be concluded as follows:

The construction of tourism industrial ecosystem is the essence of tourism industrial ecologization. This paper learned from the nature ecosystem and constructed tourism industrial ecosystem. The three subsystems, tourism industry, environment and society, consist of tourism industrial ecosystem. Besides, this paper used PSR model to analyze the interaction of three subsystems of tourism industrial ecosystem. The tourism industry plays the producer role, and it produces pressure on environment. The environment plays the consumer role, and it consumes the pressure. Besides, the society plays a role of disintegrator and makes response to the deteriorating environment. The positive interaction of these three subsystems promotes the development of TIE.

The study tested the coordinated coupling degree of tourism industrial ecosystem. The index of TIE has not changed obviously. In addition, it fluctuated at the level of 0.6, which was between barely coordination and primary coordination. Furthermore, systematic uncoordinated conditions are caused by the three situations (excessive response, surged pressure and environmental degradation). It should be noticed that surged pressure is the most common reason.

The study evaluated the status and disclosed the evolution of tourism industrial ecologization. Overall, the index of TIE is rising,

which indicates that the level of tourism industrial ecologization is increasing gradually from 2000 to 2015. The pressure index increased by 63.75% during 2000 to 2015, which showed a rapid and substantial grow trend. With the gradual development of tourism, the pressure caused by tourism production and activities increased. The index of state of tourism industrial ecologization is declining, which indicates that environment of China is deteriorating. Besides, the index of response of tourism industrial ecologization was skewed "w" type distribution, which showed an obvious fluctuation trend.

Management implications

According to the dynamic analysis of development of tourism industrial ecologization, this paper put forward some suggestions to optimize the development of tourism industry:

From the national aspect, strengthening policy guidance and adding legal construction are necessary. In 2009, 2013 and 2014, a series of policies and laws were advocated and executed, which had an important impact on the status and evolution of tourism industrial ecologization. Therefore, China should speed up the development of policies which support industries and enterprises, and promote tourists and other aspects. China should make efforts to turn tourism industry into an environmental friendly industry.

From the industrial aspect, it is necessary to promote eco-tourism and pay attention to the energy resource conservation and ecological environmental protection. The pressure of tourism industrial ecologization shows an obvious rising trend. However, the promotion of eco-tourism model can effectively alleviate the pressure. In order to promote the eco-tourism model, it is necessary to ensure that the number of tourists is controlled under the reasonable capacity for the environment. Besides, tourism industry should encourage enterprises to establish green tourism enterprises, low-carbon tourism enterprises, etc.

From the technical aspect, it is crucial to pay attention to the state of environment and the time to respond. The pressure produced by tourism activities on environment may have lag effect, so we should dynamically focus on the change of environment. Moreover, when we make responses to the pressure and environment status, it should be reasonable, moderate and efficient. Therefore, it is important to strengthen the evaluation and monitor of the status of tourism industrial ecologization. Meanwhile, we should use policy to regulate the relationship among the elements of tourism industrial ecologization.

Limitations and further research

There are also some suggestions for the future research. First, a mixed method (e.g. subjective and objective methods) could be used to measure weight of indexes. Second, System Dynamics could be used to analyze the interactions of tourism industrial ecologization, which can comprehensively explain the various influencing factors how to affect the development of tourism industrial ecologization.

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