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Authors: Ying, Han, Chengcai, Tang, and Rui, Zeng

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HAN Ying[1,2], TANG Chengcai[1,2,*], ZENG Rui[1,2]

1. School of Tourism Sciences, Beijing International Studies University, Beijing 100024, China;
2. Research Center of Beijing Tourism Development, Beijing 100024, China

Abstract: In the era of sustainable development, the ecological impact of the development of the tourism industry has attracted extensive attention from all walks of life. Generally considered, tourism ecological security (TES) is an important link to realize the high-quality development of tourism destinations and promote the construction of ecological civilization. Based on keyword discrimination of TES, tourism ecological risk and tourism ecological health, and from the perspective of ecological civilization construction, this paper uses the databases of Web of Science and CNKI as data sources to systematically comb and analyze TES research from the aspects of development process, research methods and research content, and puts forward the prospects for future research on this basis. This analysis found that research in the TES field presents four main characteristics. (1) The phased characteristic of "germination - exploration - development" is significant, and a relatively standard research framework of "evaluation - influencing factors - early warning - regulation" has been formed. (2) The empirical orientation of the research methods is distinct. (3) The development trend is characterized by small-scale dominance and a large-scale surge. (4) The disciplinary integration and practical combination have been continuously strengthened. Combined with the development trends and hot spots of TES, this paper proposes that the direction and goal of deepening TES research in the future should be carried out from the aspects of strengthening research on thresholds, early warning and regulation, improving the application of big data, constructing the synergistic effect mechanisms between tourism and ecology, and realizing the longitudinal deepening and interconnection of scale research.

Key words: tourism; ecological security; tourism ecological security (TES); ecological civilization construction; tourist destination; sustainable development

1 Introduction

In the new era of ecological civilization (Xiao and Zhao, 2017), China has integrated the construction of ecological civilization into political, economic, cultural and social constructions (The CPC Central Committee and the State Council of China, 2012), and strengthened its strategic determination of system construction, which provides a Chinese plan and model for realizing the goal of global sustainable development. As an important way to promote re- gional sustainable development (Li et al., 2020), tourism ecological security (TES) is based on ecological civilization construction, and is also one of the important goals of ecological civilization construction. The two are highly consistent in terms of concept and goal. That is, under the guidance of sustainable development, they are jointly committed to achieving China's ecological revitalization and harmony between man and land, so as to lay a solid foundation for building a global ecological security system and

promoting win-win cooperation in global ecological governance.

Ecological security is an important basis for promoting regional sustainable development, as well as an important content of ecological civilization construction in China. As an important research field in the sustainable development of tourism, TES originated from ecological security research, and has become a main indicator for measuring the environmental impact of tourism (Li, 2018). Scholars have studied TES from different perspectives such as tourism development, human-land relationship, complex ecosystem, etc. Specifically, guided by the specific ecological, economic and social issues, researchers often take the original concept (Lv, 2007), measuring evaluation (Zhang et al., 2008), fragility (Petrosillo et al., 2006), or carrying capacity (Jurado et al., 2012) as the starting point, and conduct the specific research contents such as spatio-temporal pattern and driving mechanism (Yang and Cao, 2021), grading measurement (Weng et al., 2018), sensitive area identification (You et al., 2014a), etc. At the same time, many ecological security constructions of tourist destinations have become the research objects. From the perspective of ecological civilization construction, relevant research has gradually transitioned from a spontaneous and scattered state to a standardized and orderly state, and great progress has been made in the depth and breadth of research. In the future, the tourism industry of China will enter a new stage of comprehensively focusing on ecological security and strengthening the value of tourists' ecological experience.

The rapid development of tourism in recent years has caused increasingly extensive and deep-seated negative harm to destination ecology (Tang et al., 2017; Feng et al., 2019), endangering the security of the ecosystem. Therefore, understanding how to coordinate the conflict between tourism economic growth and ecosystem protection, as well as maintain and improve the ecological security of tourist destinations, have become an important link in the high-quality development of tourist destinations and the hot topics in tourism research (Qin and Cheng, 2019). However, there are few targeted studies on systematically combing TES. Based on the databases of CNKI and Web of Science, this paper systematically summarizes and reviews the existing TES research, and discusses prospects for future research combined with the promotion of global environmental management and practice. This paper aims to sort out the basic theories of TES research and propose the future research directions, in order to provide ideas for improving TES and adhering to tourism sustainable development. At the same time, the purpose of this research is to contribute to an enhanced scientific awareness of the nature and vertical mechanism of TES, standardize and innovate the destination environment and tourism planning, and ensure the coordinated development of socio-economic-natural complex ecosystems.

2 Literature statistics

2.1 Keyword discrimination

The industrial attributes of environmental dependence and resource consumption determine the binary contradiction between tourism destination and ecological environment (Pang et al., 2011). The three topics of TES, tourism ecological risk, and tourism ecological health, which specifically characterize the safety, risk, and health of the tourism ecosystem, can accurately describe and reflect the status, threat, and coordination of the ecological environment under the influence of tourism activities. These three are the key factors for analyzing and evaluating the ecological security of tourist destinations and promoting the construction of ecological civilization.

TES refers to the rational development of tourism resources and effective management of the tourism ecological environment within certain ranges of time and space, so that the tourism ecosystem has the relative stability of structure and diversity of functions, and can also provide rich material resources and harmonious environmental space for the development of tourism, as well as maintain the coordinated development of the natural-society-economic complex ecosystem of the tourist destinations (Li et al., 2013). Meanwhile, as ecological risk is the inverse function of ecological security (Xiao et al., 2002), tourism ecological risk refers to the process of describing and evaluating the possibility and magnitude of adverse effects of tourism activities on the ecosystem and its components at a regional scale (Zhong and Li, 2014). In addition, the status of tourism ecological health shows that the tourism ecological system is stable, dynamic and sustainable, i.e., the system can maintain its organizational structure, produce tourism products and services, meet the needs of the sustainable development of tourism destinations, and automatically recover within a period of time after being disturbed by human tourism activities (Zhou et al., 2015c).

This study found that there are highly dialectical relations of the unity of opposites and coordination among these three topics. 1) In terms of causal logic, TES research originates from ecological risks in the tourism development process (Xiao et al., 2002). On this basis, the feedback loop of "identification of tourism ecological risk-improvement of TES" is the driving force for destination ecological civilization construction. Ecological health is one of the development goals of TES, so that the benign evolution of "identification of tourism ecological risk-improvement of ecological security-sustainability of ecological health" is an effective approach to ameliorate the destination environment. 2) In terms of the breadth and depth of the research contents, all three have undergone research process from theory to demonstration. At present, TES has gradually formed the internal logic of "evaluation-influencing factors-early warn-

ing-regulation", while neither tourism ecological risk nor tourism ecological health have formed a clear framework yet. 3) In terms of research level, in 2020, the *National Overall Planning for Major Ecosystem Protection and Restoration Projects* (2021–2035) proposed to focus engineering construction on the development and optimization of a national ecological security barrier system, making ecological security one of the major national strategies. Tourism ecological risk and ecological health are important research issues, with a trend toward multiplicity and practicality. Undeniably, research on TES still shows irreplaceable dominance, and the three topics are important issues for the sustainable development and ecological civilization construction of destinations.

Based on the above considerations, TES is not only the basic research work of ecological health, but also the foothold of ecological risk research. Together with the emphasis and support of national macro policies, TES research clearly has irreplaceable leadership among the three themes. From the current research situation, the TES research system is relatively sound, so it can provide a certain reference for tourism ecological risk and tourism ecological health research. In terms of practical significance, the three themes are all important topics of sustainable development and ecological civilization construction.

2.2 Chinese research statistics

Chinese research was mainly retrieved from the CNKI database. In the specific retrieval process, this paper takes the CSSCI, CSCD and Peking University core journals as the source limitation, setting "ecological security", "ecological risk" and "ecological health" and respectively adding "tourism", "scenic area" and "scenic spot" as the key words. Using these criteria, 316 articles were obtained. After collection and arrangement, this paper excluded repeated and irrelevant articles, and ultimately 228 articles were obtained, which were published from September 2000 to August 2021. Judging from annual publication counts, there are few studies from 2000 to 2004, with 5 or less articles published annually. Since 2005, the number of articles published has increased rapidly, with 19 articles published in 2020. According to Fig. 1, the Chinese research on TES generally presents a trend from slow growth to sharp growth.

2.3 English research statistics

English research was mainly retrieved through the Web of Science database. With "ecological security", "ecological risk", "ecological safety" and "ecological health" and respectively adding "tourism", "scenic spot" as the key words, 263 articles were retrieved. After applying the exclusion criteria above, 114 articles were obtained, which were published from April 2000 to August 2021. Judging from annual publication counts, there are few studies from 2000 to 2005, with only 1 article annually. Since 2006, the number studies began to increase, but with fluctuations. From 2013 to 2021,

the number of relevant articles grew rapidly with 114 articles published, which accounted for 79% of the total number, and the number of articles reached 23 in 2019. According to Fig. 1, the English research on TES generally presents a trend from slow growth to fluctuating growth.
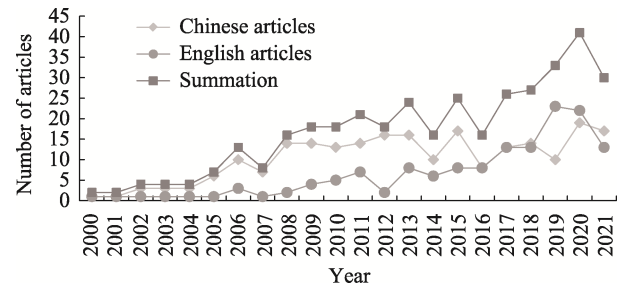

Fig. 1   Numbers of research papers published from 2000 to 2021

3   Development process

The systematic construction of TES research started with Wu (2005). He formally discussed the dialectical relationship between ecological security and tourism development, turning the field research from scattered and spontaneous to standardized and systematic. The multi-dimensional improvement of TES research began with Fan et al. (2017). Based on the construction of the Third Pole national park group, they pointed out that the construction of national ecological security is closely related to tourism development. In addition, according to the number of TES publications identified by this study (Fig. 1), 2005 and 2017 are also the turning points in academic research. Therefore, the overall research development process of TES can be roughly divided into the germination stage (Before 2004), the exploration stage (2005–2016), and the development stage (After 2017).

3.1   Germination stage (Before 2004)

Since the 1970s, many international conferences, conventions, and organizations have been crucial to the promotion of global environmental protection, such as *The United Nations Conference on the Human Environment*, *Agenda 21*, *Vienna Convention*, *United Nations Framework Convention on Climate Change*, *International Organization for Standardization* (*ISO*), etc. Guided by the trend of worldwide environmental protection, the promulgation of *Regulations on the Administration of Construction Project Environmental Protection* in 1981 marked the formal implementation of an environmental impact assessment system in China. In this context, the research on TES started to sprout. In the germination stage, research activity on TES began to increase with gradually extended topics, which conforms to the development process of academic research from the outside to the inside, but it still possessed significant scattered and spontaneous research characteristics. In general, our analysis of the related research reveals three main charac-

teristics. 1) The characteristic of marginalization is significant. With increased attention, research on the relevant conception is prominent, which shows a slow trend of focalization. In early research, scholars just marginally mentioned ecological security (Jin, 2000) and ecological risk (Burger, 2000), and the research mainly focused on the ecological imbalance pressure (Duffy et al., 2001) caused by tourism activities on tourist destinations. Meanwhile, the focus gradually shifted to theoretical monographic research on the analysis of relationships between ecological security and tourism (Shang and Zhao, 2003). 2) Relevant research is mainly focused on the small-scale. Scholars mostly conducted research from the scale of scenic lake spots (Dong, 2003), while large-scale studies at the national and provincial dimensions were rarely conducted. 3) Most of the research topics are accompanied by eco-tourism, sustainable development, western development, etc., which are characterized by the developments of the times. Since the 1970s, with the implementation of global environmental management practices and China's western development policy, academic research has presented close practice integration and topic extension.

3.2　Exploration stage (2005–2016)

Since 2005, there has been a high incidence of global environmental pollution accidents. Therefore, many international environmental protection organizations had taken a series of measures to further improve the level of environmental management, such as the release of *Millennium Ecosystem Assessment* and *The Sydney Declaration*, as well as the convening of the first *United Nations Environment Assembly*. Overall, international environmental management in the exploration stage shows a significant change from post-coordination to pre-prevention.

Reviewing the exploration stage, TES research presents a trend from rapid growth to fluctuating growth with the characteristics of constantly strengthened standardization and systematization. In general, the research of this stage presents four main characteristics. 1) The core trend of field research is gradually obvious. In this stage, the focus of research topics was becoming more and more prominent, the discussions of scholars mainly centered around three topics: tourism ecological risk (Zhong and Li, 2014), TES (Liu et al., 2009) and tourism ecological health (Zhou et al., 2015d). 2) Field research presents a significant shift from conceptual and theoretical research to empirical research. During this stage, the research perspective gradually shifted from conceptual discrimination (Wu, 2005) to quantitative analysis, in which the research topics were more inclined toward ecosystem security/risk/health evaluation, early warning system construction (You et al., 2014b), dynamic simulation (Wu et al., 2013), etc. 3) The vertical extensibility of research topics is continuously improved, and interdisciplinary characteristics emerge. In this stage, the level of research field was gradually enriched, yet a standardized logic

system had not been formed. In specific research, topics such as the coordination of ecology and economy (Zhou et al., 2015a), identification of sensitive areas (You et al., 2014a), and evaluation criteria (Wang and Wu, 2013) were involved. Relevant research showed the characteristics of interdisciplinary integration, including tourism (He et al., 2018), ecology (Jurado et al., 2012), sociology (Zhou, 2011), chemistry (Ye et al., 2015) and other fields. For example, the research on the division of government and market based on TES emerged. 4) Compared with Chinese research, English research slightly lags behind, but it presents a significant feature of detailed research. Especially, English research characterized by in-depth and detailed analysis was significant, and much of the research had provided a deeper and more detailed theoretical foundation and practical thinking for subsequent research, such as the research of destination vulnerability and resilience assessment (Calgaro et al., 2014), or the integrated index of eco-space importance (Xie et al., 2014).

3.3　Development stage (After 2017)

Since 2017, global environmental management has shifted from conceptual and holistic governance to specific and breakthrough rectification. The promotion of numerous international measures reflects the pertinence of global resource conservation and environmental governance, such as the establishment of the ecological civilization system in China, the proposal of carbon neutralization and carbon peak (Tang et al., 2021) and the UN's call for "zero pollution earth". Overall, international environmental governance presents the remarkable characteristics of systematization and breakthrough in this stage.

In the development stage, TES research shows a surging trend in quantity, and it has gradually become an important research direction and topic of sustainable tourism development with the significant characteristics of multidimensional promotion. In general, the research in this stage presents four main characteristics. 1) Pattern research gradually formed, with innovation in some cases. In this stage, the research content gradually tended toward the internal logic of "evaluation-influencing factors-early warning-regulation". On this basis, the research framework system was gradually completed, and the research context of each branch topic has gradually taken shape. Meanwhile, driven by climate change, international environmental management has taken on a brand-new look. Scholars actively combine practices to explore innovative topics, such as the dynamic evaluation of TES (Xu et al., 2021), spatio-temporal patterns and spatial effects (Li et al., 2017), etc., which shows the characteristics of the new times. 2) The professional and scientific nature is more significant. In this stage, related research places more emphasis on the interaction between tourism system and ecosystem. By constructing the logical framework of TES assessment for dynamic evolution, early warning and regulation, relevant research has gradually realized the mul-

ti-faceted systematic practice of human response, ecological restoration, early warning and regulation in the changing process of TES. 3) The research scale is diversified, and large-scale research has increased significantly. The research tends to cover diverse scales, such as national and provincial (Xu et al., 2021), city and county (He et al., 2020), river basins (Yin and Zheng, 2017), scenic spots (Bao and Liu, 2017), etc. Overall, large-scale research shows an obviously surging trend. 4) Academic dialogues in the TES field have become more frequent, which is manifested in the increasing frequency of international publications on Chinese research (Ruan et al., 2019; Shi et al., 2020). On the one hand, this shows that the international vision of TES research is becoming wider and wider. On the other hand, it shows that the barriers to academic dialogue and communication in the field are gradually decreasing, and less information asymmetry means deeper thinking and more efficient practical measures.

4 Research method & content of TES

Covering the economy, society, environment and other aspects of tourism destinations, TES is a complex social-economic-natural compound ecosystem with various ele-ments that interact and influence each other (Xu and Liu, 2018).

4.1 Research method

TES research initially focused on phenomenon description analysis and relationship speculation, and gradually evolved into the comprehensive application of field research, statistical measurement and geospatial research methods. English research mostly adopts the interview method, field research and the geospatial analysis method. In the early stage of Chinese research, qualitative methods of phenomenon description and law extraction were adopted. In recent years, the method system presents significant empirical characteristics, with various method systems introduced gradually, such as statistical measurement and the geospatial research method. Specifically, scholars comprehensively apply various analytical methods like the modeling, index, fuzzy evaluation and spatial analysis methods to discuss the evaluation and quantification of TES with the support of remote sensing and GIS technology (Yan et al., 2012). The specific research methods used by scholars on various hot research topics are listed in Table 1.

Table 1 Partial listing of research methods for TES

Topic	Method	Key factors	Literature
Evaluation of TES	Analytic hierarchy processing	Developing the evaluation index system	Dong et al., 2016
	The entropy weight method	Determining index weights	Jun et al., 2019
	Technique for Order Preference by Similarity to an Ideal Solution	Scientifically evaluating the state of TES	Zhou et al., 2015b
	Fuzzy set pair analysis	Clearly showing the whole and partial structures	Tang et al., 2018
	Ecological footprint	Revealing the complementary relationships between tourism and ecology of destination	Shi et al., 2020
Influencing factors of TES	Factor analysis	Multivariate induction and analysis of influencing factors	Wang et al., 2008
	Grounded theory	Qualitatively generating research theory	Zheng et al., 2015b
	Grey relation analysis	Effectively indicating the correlation degree of each influencing factor	Tang et al., 2018
	Obstacle factors analysis	Measuring the negative impact of each indicator	Xu et al., 2021
Early warning of TES	Matter-element analysis	Solving the problem of incompatibility between individual indicators	You et al., 2014b
	Fuzzy comprehension evaluation method	Comprehensively evaluating early warning status	Wu et al., 2005
	Grey model (1,1)	Starting early warning based on time series data	Chen et al., 2017
	System dynamics	Conducting early warning through process and structure level analysis	Rodríguez-Izquierdo et al., 2019
	Radical basis function	Improving the accuracy of early warning through model analysis	Zhou et al., 2016

4.2 Research content

The multiple characteristics of research topics in the TES field are remarkable, showing a trend of change from theoretical discrimination to empirical research, and from focused research to progressive research. The security of various resource elements in tourism destinations, such as the security of land, forests, and biology, has become the re-search theme of scholars. Most of them use specific case sites as the starting point to analyze their ecological security status in detail, involving the evaluation, early warning and regulation of specific tourism ecological issues. The potential ecological risks under the distribution of heavy metals in typical tourist destinations, the division of labor between the government and the market from the perspective of ecological security, and the popularization of TES science have

gradually come into the research fields of scholars, which also represent a positive response to global environmental management and multidisciplinary research.

4.2.1 Evaluation of TES

TES evaluation is a specific method to diagnose the TES for the ecological environment of tourist attractions by conducting comprehensive qualitative and quantitative assessments (Wu, 2017). Current research methods are mostly transplanted or borrowed from adjacent disciplines. Although there are great differences in research perspectives, contents and conclusions in various contexts between China and the West, theoretical and empirical research on the evaluation of TES presents significant localization characteristics. Overall, the characteristics of TES evaluation research are shown in Table 2.

(1) Theoretical framework of TES evaluation

At present, there are many discussions on ecological security evaluation and the construction of its index system. As shown in Table 3, a theoretical framework of the index system that is applicable to different scenarios has been formed, such as compound ecosystem theory, ecological environment pressure state, ecological environment resilience theory and ecological environment management construction. These index systems have considered the pressure of human activities on the ecological environment, the change of resource status, and the resilience of ecosystem restoration capacity in different situations from different perspectives. After comprehensive evaluation, optimization and regulation are carried out to maintain the coordination and unity of social benefits and ecological security. In general, the establishment standards of the TES index system are diverse and the contents are gradually systematized, which can provide some guidance for relevant practice. However, this system still needs to be further strengthened in the aspects of dynamic evaluation, circular evaluation, suitability for local conditions and multidisciplinary systematic evaluation.

Table 2 Characteristics of TES evaluation research

Perspective	Characteristic	Implication	Literature
Compound |ecosystem	Focus on system analysis and status evaluation	Exploring the interaction within the multi-dimensional system and analyzing it from the dimensions of economy, society and ecological environment	Qin et al., 2019
Subject research	Focus on interdisciplinary research	Presenting the complex characteristics of multi-disciplinary intersections such as tourism, ecology, geography, economics, management and so on	Xu et al., 2021
Practical demanding	Focus on tourism development model	Taking realistic hot issues as starting points, including tourism ecological risk, stakeholders, environmental capacity, carrying capacity and so on	Ruan et al., 2019; Lu et al., 2019

Table 3 Theoretical framework of the TES evaluation index system

Applicable scenario	Evaluation model	Element layer composition	Literature
Compound ecosystem theory	PSR-SEE	Pressure-State-Response-Society-Economy-Environment	Li et al., 2017
Eco-environmental stress state	PSR	Pressure-State-Response	He et al., 2018
	DPSIR	Driver-Pressure-State-Impact-Response	Ruan et al., 2019
	DPSIR-EES	Driver-Pressure-State-Impact-Response-Economy-Environment-Society	Shi et al., 2021
Eco-environment resilience theory	CSAED	Carrying-Supporting-Attraction-Evolution-Developing	Zhou et al., 2016
	VOR	Vigor-Organization structure-Restoring force-Service function-Community crowd health and education level	Zhou et al., 2015c
	Ecological footprint	Tourism ecological footprint-Tourism land carrying capacity	Shi et al., 2020
Eco-environment management and construction	TQR	Threat-Quality-Regulation	Xu and Liu, 2018
	PSC	Pressure-State-Control	You et al., 2014b
	IRDS	Institutional environment-Regulatory and construction acts-Disturbance activation-Security state	Zheng and Zhang, 2015b
	System dynamics model	Environment-Population-Tourism Resources	Wu et al., 2013

(2) Index system of TES evaluation

The evaluation index system of TES should reflect not only the security status of various elements within the system, but also the interactions and influences of human activities (Walz, 2000). Therefore, the construction of a complete evaluation index system is the basis of TES research (Zhou et al., 2015a). As shown in Table 3, the establishment of the TES index system has a multi-level theoretical background, but there is still no highly recognized index system. From the theoretical perspective, on the one hand, the reason may lie in the complexity of the TES system. As affected by data, the evaluation study cannot cover all elements and the lack of a complete and clear outline in structure leads to the appearance of fragmented characteristics (Zheng and Zhang, 2015a). On the other hand, although the measurement accuracy of evaluation methods keeps improving, it is easy to

split the interactions between indicators in the measurement process, resulting in "either/or" measurement results (Weng et al., 2018). From the practical level, with the increasing research scale, the relationships between obstacle factors and the ecological security state become more and more ambiguous, and there are large communication gaps between stakeholders and policy makers (Svarstad et al., 2008), leading to certain practical obstacles in the construction of the index system.

(3) Threshold of TES evaluation

The TES threshold indicates the TES evaluation index standard, which is used to qualitatively evaluate the level of TES. A good TES situation reflects a coordinated and stable situation of economic-social-natural system in tourist destinations (Wang and Chen, 2021). The determination of the ecological security threshold is a highly exploratory work, which can generally be selected through the national, industrial or local standards, environmental background standards, and analogy standards (Wang et al., 2013). By analogy to TES, this leads to the subjectivity and arbitrariness of the threshold to a certain extent. In addition, with the social progress, environmental improvement and technological development of destinations, the threshold value can easily change accordingly. Therefore, comparing the relative TES status of various regions can better reflect the ecological environment of the tourist destination (Jin and Zhuang, 2004). On the other hand, the threshold standards that can be widely used in resource and environmental assessment are mainly generated from practical operation and real demand, underscoring the complex and changeable problem-solving process (Guo et al., 2015). Therefore, it is understandable that there is no unified TES threshold and grading standard. In the existing studies, according to the specific disciplinary background and practical needs, scholars have comprehensively classified the TES into either 5 levels (Wang and Chen, 2021), 7 levels (Zhou et al., 2015b), or differentiation (Xu and Liu, 2018) thresholds, which can provide a certain reference for local TES evaluation.

4.2.2 Influencing factors of TES

Exploring the influencing factors of TES is an urgent problem for the sustainable development of tourism destinations. In the early stage, the academic community tended to evaluate the factors affecting multi-scale ecological security / ecological risk (El Sherbiny et al., 2006). In the most recent ten years, this aspect gradually transformed into the influencing factors of TES, which is mainly conducted from a systematic perspective based on diversified models or index systems. During the analysis process of specific influencing factors, scholars mainly use grey correlation analysis (Tang et al., 2018), obstacle degree analysis (Xu et al., 2021), striction factor analysis (Zhang et al., 2020), geographical detector (Ruan et al., 2019) and other quantitative methods to obtain their conclusions. In related studies, restrictive, sensitive and barrier factors are all research elements of influencing factors. In addition, a few scholars have qualitatively summarized the evaluation indicators or impact factors of destination applicability by referring to previous research results (Liu et al., 2009).

Influencing factors are the basis for analyzing the mechanism of TES. However, few studies are currently involved in the exploration of impact mechanisms (Ruan et al., 2019), which leads to the lack of a fully formed unified research method framework system. Therefore, one important direction for the future research on influencing factors of TES will be determining how to strengthen the exploration of the influencing mechanism while innovating research methods and evaluation indicators.

4.2.3 Early warning system of TES

Early warning of ecological security is the process of measuring the degree of deviation of the tourism ecological environment from the warning line and generating relevant early warning signals (Li, 2016). Foresight and warning are the distinguishing characteristics (You et al., 2014b). The construction of the current early warning index system is the core of dynamic early warning research on TES (Yang and Cao, 2020). In recent years, the longitudinal extension of early warning research on TES has been continuously strengthened, and various research contents have emerged endlessly, such as relevant principles (Li, 2016), systems (Bahraminejad et al., 2018), methods (Zhou et al., 2016), models (Xu et al., 2017), etc. At the same time, trend prediction is an important part of TES early warning. Scholars mostly use the gray GM(1, 1) model (Xu et al., 2017) to conduct research, and occasionally introduce the RBF neural network model, although its universality still needs further verification (Zhou et al., 2016).

Generally speaking, the early warning research of TES is still in the exploratory stage, with significant regional characteristics, and the systematic theoretical and methodological framework is not yet sound. In terms of research methods, quantitative methods are mainly used, such as the comprehensive index method (Zhang and Qiu, 2014), fuzzy comprehensive evaluation method (Wu et al., 2005), matter-element model (You et al., 2014b), etc. In terms of warning objects, small-scale studies such as scenic spots are still the main focus, and there are few early-warning studies on large-scale objects such as national or provincial areas (Liu et al., 2012; Xu et al., 2017). In terms of research content, there are few studies on trend prediction, and there are certain limitations in hierarchical and dynamic early warning. Considering the subjective and objective limitations of ecological security early warning, as well as the multi-level, multi-dimensional and dynamic characteristics of early warning (Shen et al., 2010), it is particularly important to construct a scientific and appropriate early warning system of TES.

4.2.4 Regulation of TES

The regulation of TES is an inevitable choice from the end

ecological governance to the front ecological management in the tourism environment (Dong et al., 2016). It is also an important bridge between alleviating the interference of tourism activities and enhancing the ecosystem service function. Based on the determination of ecological thresholds, the evaluation of ecological security, the discrimination of spatial patterns, and the coupling of tourism geographic factors and ecological processes, etc., the regulation of destination TES is accompanied through the whole process of TES research (Peng et al., 2018). At present, the research perspectives of TES regulation are diverse, showing significant policy compatibility and practical relevance. From the perspectives of land development (Xu et al., 2021), regional economy (Wang and Chen, 2021), and landscape security (You et al., 2014a), scholars have discussed topics such as spatial pattern evolution (Tang et al., 2018), obstacle factor diagnosis (Xu et al., 2021), driving mechanism analysis (Yang and Cao, 2021), dynamic simulation (Wu et al., 2013), etc. On the whole, despite the large volume and wide scope of TES regulation studies, the focus attribute of the topics is relatively poor. Most of the related studies rely on TES evaluation, early warning system and analysis of influencing factors, showing significant regional characteristics on the basis of strong scale dependence.

5 Conclusions and prospects

5.1 Conclusions

Overall, TES research presents four main characteristics.

(1) The phased characteristics are significant, and a relatively standard research framework has been formed. Through literature review, it is found that TES research at home and abroad has significant phased characteristics in terms of the number of publications and research topics, presenting distinct stages of germination, exploration and development. Currently, TES research presents a relatively standardized research framework of "evaluation - influencing factors - early warning - regulation". Chinese studies started earlier, while foreign studies have developed rapidly in recent years.

(2) The empirical orientation of the research methods is distinct. In recent years, TES research has constantly drawn on the theories and methods of ecology, management, economics, etc., mainly focusing on the aspects of evaluation, influencing factors, early warning and regulation, discussing scientific issues of how to evaluate, what the trend is, and how to manage or prevent the ecological problems, and ultimately showing empirical and in-depth characteristics. However, due to many obstacles in theory and practice, a unified index system and evaluation method has not yet been established.

(3) The development trend is characterized by small-scale dominance and a large-scale surge. At present, small-scale research focuses on the ecological security issues of typical tourist destinations, which will provide references for the same type of TES governance. Meanwhile, large-scale research, accompanied by the implementation of national policies, focuses on regional TES issues, so as to provide ideas for targeted regional regulation measures. Limited by various unstable factors such as chaotic ecological security thresholds, differences in data availability and changeable state evolution, there are some shortcomings in the accuracy of TES research at different scales. Meanwhile, many subjective and objective factors will affect the scientific nature of TES research on different scales, such as the universality of research methods, the interpretation level of evaluation results, and the perspectives of early warning and regulation.

(4) The disciplinary integration and practical combination have been continuously strengthened. The TES research process basically forms two paths. One is based on the theory of ecological security, which is presented as the deep logical contemplation of the relationship between ecological security and ecotourism, so that the characteristics of the multidisciplinary integration of TES research have been strengthened. The second path is to focus on the empirical perspective and carry out diversified level research on scale, theme and theory under the dual guidance of environmental management policy and destination ecological practice. In contrast, English research is relatively lagging, and it needs to be strengthened in two aspects: boundary definition and TES focus. Although Chinese research has a large base, it still needs more in-depth exploration in both research entry points and topic depth.

5.2 Prospects

Combined with the current practice and development of TES, future research can focus on four main areas.

(1) Strengthen research on thresholds, early warning and regulation. A highly recognized index system, threshold standards and research methods have not yet been established. There are also several deficiencies in the existing research, such as: the establishment of the index system structure and the selection of indicators are highly subjective; the threshold and grading standards of evaluation and early warning have not been unified yet; the introduction of research methods in different disciplines lacks evaluation criteria, and the universality needs to be verified; the methods and standard application of early warning research lack necessary validation, etc. One suggestion is to optimize the early warning and regulation model of TES by using big data mining algorithms and visualization, combined with a scientific time series model. According to the national ecological security red line standard, the bottom line and threshold of TES should be determined. At the same time, future research should simulate different development scenarios based on diversified ecological data, so as to put forward an optimization plan of TES regulation.

(2) Improve the application of big data. TES research in-

volves multiple disciplines. In addition to traditional environmental, economic, social, and ecological indicators, technical indicators such as land use are also introduced, but wetland and atmospheric indicators are rarely introduced. The accuracy, type, and time nodes of the data collected by different disciplines are also different. Integrating these multi-source and heterogeneous data into TES research is the key difficulty of current research. For example, the current ecological data statistics in China are obviously lagging behind the socio-economic data, and there are great differences in the statistical caliber in different years, resulting in the poor comparability. Therefore, it will be necessary to improve the application of big data in the field research of TES in the future, that is, to realize real-time, traceable and predictable dynamic evaluation, early warning and regulation, in order to promote the controllability and dataization of tourism in ecological civilization construction.

(3) Construct the synergistic effect mechanism between tourism and ecology. At the theoretical level, the hot issues in current tourism ecology research are how to coordinate the relationship between tourism development and ecological protection, as well as reasonably maintain and improve TES (Zhou et al., 2015a). For a long time, TES research has focused on geography and ecology. In the future, it will be necessary to measure the value and contribution of TES to the destination economy/society/culture, tourism consumption, tourism production, and the impact on the overall strategic layout, in order to explore the synergy between tourism and ecology in a wide range, and achieve high-quality development in the field. At the practical level, one important direction will be to strengthen the construction of the policy system of TES and boost the strategic layout of ecological civilization. China's ecological security policy system includes ecological space management policy, environmental pollution prevention policy, ecological risk control policy, incentive policy and performance appraisal policy (Cheng et al., 2019). However, the current TES research is not closely related to the national ecological civilization construction strategy or the national land ecological security policy, and it fails to provide forward-looking guidance for policy formulation. Therefore, it is necessary to carry out forward-looking evaluation on the mechanism and effects of various policies, in order to sort out and strengthen the construction of the TES policy system.

(4) Realize the longitudinal deepening and interconnection of scale research. Firstly, based on accurate data, small-scale TES research makes it easier to obtain scientific and reasonable conclusions. While ensuring its accuracy, future research should strengthen horizontal comparative studies and improve the typical case study, so as to provide a basis for micro-destination TES research and practice. Secondly, large-scale TES research has stronger data availability, and in-depth research from the macro perspective can provide a reference for national strategies and regional co-

ordination of tourism ecological measures. Based on the improved data accuracy by the big data algorithm, future research should further strengthen the collaborative research between tourism and the regional economy, society and culture, so as to realize the strategic guidance of TES research for practice, and take this as a breakthrough to realize the space-time linkage in the dynamic evolution of TES. In order to promote field dialogue and better realize the ecological civilization construction, a major trend in the future will be to realize the interconnection of TES research results at different scales through data mining and processing algorithms. Last but not least, boosting tourists' green consumption (Tang et al., 2022a) and promoting area's green development (Tang et al., 2022b) are of great significance to maintain and improve the ecological security of tourism destinations. This is also an important measure to realize the ecological security and ecological civilization construction of tourism destinations from the micro level, which is beneficial to the longitudinal deepening and interconnection of scale research.

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生态文明建设视角下旅游生态安全研究综述

韩 莹 [1,2]，唐承财 [1,2]，曾 睿 [1,2]

1. 北京第二外国语学院旅游科学学院，北京 100024；
2. 北京旅游发展研究基地，北京 100024

摘 要：可持续发展时代下，旅游产业发展的生态影响受到了社会各界的广泛关注。普遍认为，旅游生态安全是实现旅游目的地高质量发展、推动生态文明建设的重因素。本文以生态文明建设为视角，在对旅游生态安全、旅游生态健康、旅游生态风险辨析的基础上，以 Web of Science 和中国知网等数据库为数据源，从发展历程、研究方法、研究内容等方面对旅游生态安全相关研究进行系统梳理分析并提出未来研究展望。研究发现，旅游生态安全领域研究呈现以下特点：（1）"萌芽–探索–发展"的阶段化特征显著，已形成较为规范的"评价–影响因素–预警–调控"定式研究框架；（2）研究方法的实证取向鲜明；（3）发展态势表现为小尺度为主、大尺度激增；（4）学科融合性不断加强，呈现紧密的实践结合性。结合旅游生态安全发展的趋势和热点，本文提出了未来旅游生态安全研究深化的方向和目标应从强化阈值与预警及调控研究、完善大数据应用、构建旅游与生态协同效应机理、实现尺度纵深及互联研究等方面展开。

关键词：旅游业；生态安全；旅游生态安全；生态文明建设；旅游地；可持续发展