Spatiotemporal Evolution and Multi-scale Obstacle Factor Analysis of the Development Level of Tourism Ecological Resilience in the Yellow River Basin (Postprint)

Authors: Nie Hanyu, Zhang Yanhui, Li Hui, Zheng Yaomin

Date: 2025-06-20T00:00:00+00:00

Abstract

Tourism ecological resilience is a key indicator for measuring the sustainable development capacity of tourism destinations, and enhancing tourism ecological resilience is crucial for promoting the sustainable development of tourism. Based on panel data samples from nine provinces (regions) in the Yellow River Basin from 2000 to 2022, this study employs the entropy-weighted TOPSIS method, Markov chain, and spatial autocorrelation model to analyze the spatio-temporal evolution characteristics of tourism ecological resilience in this region, and further utilizes the obstacle degree model to analyze the obstacle factors affecting the enhancement of tourism ecological resilience. The results show that: (1) From 2000 to 2022, the overall tourism ecological resilience in the Yellow River Basin was at a relatively low level, showing a fluctuating downward trend. (2) A hierarchical spatial structure has basically formed where resilience gradually decreases from downstream to upstream, there exists a significant positive spatial correlation in the development level of tourism ecological resilience among provinces (regions), spatial agglomeration effects are strengthening, mainly manifesting as "high-high"agglomeration and "low-low"agglomeration characteristics. (3) At the obstacle criterion level, the main obstacles are recovery adaptation capacity and innovation evolution capacity, while at the indicator level, the main obstacles are tourism factor agglomeration level, total water resources, tourism R&D expenditure, number of tourism invention patents granted, etc.

Full Text

Preamble

ARID LAND GEOGRAPHY Vol. 48 No. 6 Jun. 2025

Spatio-temporal Evolution and Multi-scale Barrier Factor Analysis

ChinaRxiv 中X

of Tourism Ecological Resilience Development Levels in the Yellow River Basin

NIE Hanyu[1], ZHANG Yanhui[2], LI Hui[3], ZHENG Yaomin[4]

[1] School of Management, Yantai Institute of Science and Technology, Yantai, Shandong 264000, China

[2] School of Business, Beijing Technology and Business University, Beijing, China

[3] School of Management, Tianjin University of Technology, Tianjin 300384, China

[4] School of Business, Beijing Technology and Business University, Beijing, China

Abstract

Tourism ecological resilience serves as a critical indicator for measuring the sustainable development capacity of tourism destinations, and enhancing it is essential for promoting sustainable tourism growth. Based on panel data from nine provinces (autonomous regions) in the Yellow River Basin from 2000 to 2022, this study analyzes the spatiotemporal evolution characteristics of tourism ecological resilience in the region using the entropy-weighted TOPSIS method, Markov chain analysis, and spatial autocorrelation models. Furthermore, a barrier degree model is employed to identify the key factors impeding improvements in tourism ecological resilience. The results reveal: (1) From 2000 to 2022, the overall tourism ecological resilience in the Yellow River Basin remained at a relatively low level, exhibiting a volatile downward trend. (2) A hierarchical spatial structure has essentially formed, with resilience gradually decreasing from downstream to upstream regions. Significant positive spatial correlations exist among provincial-level units, with spatial agglomeration effects strengthening and primarily manifesting as "high-high" and "low-low" clustering patterns. (3) At the criterion layer, recovery adaptability and innovative evolutionary capability constitute the main barriers, while at the indicator layer, tourism factor aggregation level, total water resources, tourism R&D funding, and the number of tourism invention patent authorizations emerge as primary obstacles.

Keywords: tourism ecosystem; tourism ecological resilience; spatiotemporal evolution; barrier factor; Yellow River Basin

1. Introduction

The vigorous growth of tourism has a positive driving effect on local economic development, yet excessive tourism expansion often leads to ecological damage and weakened ecosystem service functions. In this context, exploring new pathways for sustainable tourism development while unleashing tourism' s economic potential, and enhancing the adaptive and restorative capacities of tourism destination ecosystems, is crucial. The 20th National Congress of the Communist

Party of China explicitly proposed the vision of building "livable, resilient, and smart cities," bringing the concept of "resilience" into public view. Resilience refers to a system' s capacity to effectively absorb and adapt to external disturbances while maintaining its core characteristics and key functions. Resilience theory undoubtedly provides a valuable theoretical framework for investigating the recovery mechanisms and reconstruction pathways of tourism ecosystems after disturbances.

The concept of "resilience" originated in mechanical engineering, referring to a system' s ability to return to its original state after experiencing pressure. Through continuous scholarly exploration, it has undergone an evolutionary progression from "engineering resilience" to "ecological resilience" and then to "evolutionary resilience." Engineering resilience focuses on recovery and adaptation, while ecological resilience emphasizes maintaining stability. Evolutionary resilience, however, posits that ecosystems can strengthen their sustainability through structural self-adjustment and flexible responses to external shocks. This concept aligns more closely with the complexity and dynamic evolution of tourism ecosystems. Therefore, this study selects evolutionary resilience as its theoretical foundation.

Based on evolutionary resilience theory and drawing upon the research framework of Li Zhiyuan et al., this study constructs a DPSIR model comprising three dimensions: defense and resistance capacity, recovery and adaptation capacity, and innovation and evolution capacity. Tourism ecological resilience is defined as the triple-capability system demonstrated by tourism ecosystems when facing challenges such as disorderly tourism development, ecological degradation, and external emergencies. The first capability involves defense and resistance to withstand and mitigate these shocks; the second encompasses recovery and adaptation to restore basic functions and balance after damage; and the third represents innovative evolution, which drives the ecosystem toward higher-level, more sustainable states through strategies such as optimization, adjustment, and transformation.

Scholars have conducted extensive explorations across multiple dimensions, including conceptual definition, theoretical modeling, evaluation indicator construction, influencing factors, and optimization pathways. However, several limitations persist: First, existing models such as DPSIR fail to fully capture the dynamic and innovative nature of ecosystems. Second, previous research has predominantly focused on static evaluation or single-time-point comparisons, with limited in-depth analysis of temporal dynamics and spatial distribution patterns. Third, studies identifying influencing factors have suffered from narrow perspectives and methodological constraints, making it difficult to reveal interactions across economic, social, cultural, and ecological scales. Addressing these gaps, this study examines tourism ecological resilience in the Yellow River Basin, constructing a comprehensive evaluation indicator system based on "defense and resistance capacity-recovery and adaptation capacity-innovation and evolution capacity." Using the entropy-weighted TOPSIS method, Markov chain analysis, and spatial autocorrelation models, we analyze the spatiotemporal evolution characteristics from 2000 to 2022, and employ a barrier degree model to identify the primary obstacles to resilience enhancement, thereby providing theoretical support and practical guidance for the green transformation and sustainable development of tourism in the Yellow River Basin.

---

2. Data and Methods

2.1 Data Sources

Data sources for this study are categorized as follows: Per capita GDP, proportion of fiscal expenditure to GDP, tourism revenue as a share of GDP, number of travel agencies and star-rated hotels, per capita tourism consumption expenditure, tourism reception volume, tourism revenue growth rate, tourism reception growth rate, solid waste comprehensive utilization rate, domestic garbage harmless treatment rate (I_{15}), and sewage treatment rate (I_{16}) were obtained from the *China Statistical Yearbook* (2001-2023). Forest coverage rate (R_9), nature reserve area as a proportion of jurisdictional area (R_{10}), and total water resources (R_{11}) were sourced from the *China Forestry Statistical Yearbook* (2001-2023) and *China Water Resources Bulletin* (2001-2023). Per capita road area (R_6), number of medical institution beds per capita (R_7), internet penetration rate (R_8), urban park green space area (R_{12}), and environmental pollution control investment as a proportion of GDP (I_{13}) were derived from the *China Statistical Yearbook* (2001-2023). Tourism factor aggregation level (D_1), tourist density index (D_4), tourism space index (D_5), tourism employment proportion (R_5), wastewater discharge (D_6), exhaust emissions (D_7), carbon emissions (D_8), number of tourism invention patent authorizations (I_{14}), and number of tourism college students (I_{17}) were calculated from data in the *China Tourism Statistical Yearbook*, *China Cultural Heritage and Tourism Statistical Yearbook*, and *China Transportation Statistical Yearbook* (2001-2023). Additional data were supplemented from provincial statistical yearbooks and bulletins for the nine provinces (autonomous regions) in the Yellow River Basin. Missing data were interpolated using linear interpolation.

2.2 Methodology

2.2.1 Entropy-weighted TOPSIS Method This study combines entropy weighting with the TOPSIS method. Entropy weighting determines objective weights by measuring the information entropy of evaluation indicators, effectively avoiding subjective interference inherent in traditional methods. Using panel data to calculate entropy weights enables objective assessment of tourism ecological resilience development levels across different regions and time periods in the Yellow River Basin. The TOPSIS method can intuitively demonstrate the relative advantages and disadvantages of tourism ecological resilience among regions. Specific calculation procedures follow references [21].

2.2.2 Markov Chain Markov chain is a mathematical statistical model describing random processes of system state changes over time. In analyzing tourism ecological resilience development levels in the Yellow River Basin, Markov chains can examine transition probabilities and pathways between different resilience states over time, as well as how these states evolve. Specific calculation procedures follow references [22].

2.2.3 Spatial Autocorrelation Model Spatial autocorrelation models are important tools for measuring spatial autocorrelation, enabling better understanding of spatial data distribution patterns and revealing spatial dependence and heterogeneity of geographic phenomena. In this study, the global Moran' s I reflects the overall spatial agglomeration degree of tourism ecological resilience levels across the entire region, while the local Moran' s I further reveals local spatial agglomeration patterns and outliers. Specific calculation procedures follow references [24].

2.2.4 Barrier Degree Model The barrier degree model identifies major obstacle factors affecting system development and quantifies their impact. In analyzing tourism ecological resilience development levels in the Yellow River Basin, this model constructs barrier degrees to identify multi-scale obstacle factors hindering resilience enhancement and ranks them accordingly. Specific calculation procedures follow references [25].

---

3. Results

3.1 Temporal Evolution of Tourism Ecological Resilience in the Yellow River Basin

To visualize the dynamic trends of tourism ecological resilience development levels in the Yellow River Basin, we quantified and analyzed the development levels from 2000 to 2022 using the entropy-weighted TOPSIS method. Figure 2 and Figure 3 illustrate the development levels and trends for nine provinces (autonomous regions) and three basin segments (upstream: Qinghai, Sichuan, Gansu, Ningxia, Inner Mongolia; midstream: Shaanxi, Shanxi; downstream: Henan, Shandong) as defined by the Yellow River Conservancy Commission.

From 2000 to 2022, tourism ecological resilience in the Yellow River Basin exhibited a volatile downward trend, with provincial resilience indices ranging from [0.135, 0.735] and an average of 0.365, indicating relatively low overall development levels and reflecting severe ecological challenges in the basin. The study period witnessed cyclical fluctuations with a significant change in 2020, showing a pattern of "initial rise, subsequent decline, then rise again followed by decline." Notably, the sharp decline in 2020 was primarily attributable to the COVID-19 pandemic' s sudden impact. This dynamic trajectory demonstrates the high sensitivity and unique response mechanisms of the Yellow River Basin's tourism ecosystem to internal and external environmental changes.

At the sub-basin level, tourism ecological resilience distribution showed significant gradient differences, with downstream > midstream > upstream. Specifically, the average resilience values were 0.452 for downstream, 0.338 for midstream, and 0.305 for upstream regions. The downstream region significantly outperformed midstream and upstream areas due to its status as the most economically developed area in the basin, with mature tourism resources and product development and greater emphasis on ecological governance and environmental protection.

At the provincial level, Henan (0.489) and Shandong (0.415) had the highest average resilience, followed by Sichuan (0.389) and Shaanxi (0.342), while Shanxi (0.285), Inner Mongolia (0.283), Ningxia (0.236), Qinghai (0.234), and Gansu (0.232) ranked lowest. This distribution pattern is closely related to economic development levels, tourism resource development depth and breadth, ecological protection strategies, and policy orientations.

3.2 Spatial Evolution of Tourism Ecological Resilience Development Types

To compare spatial evolution patterns, we employed ArcGIS 10.8 software with the Jenks natural breaks classification method to categorize provincial resilience levels into four types: low resilience (index < 0.25), relatively low resilience (0.25-0.35), medium resilience (0.35-0.45), and high resilience (> 0.45) for the years 2000, 2008, 2016, and 2022.

The spatial distribution of tourism ecological resilience in the Yellow River Basin changed significantly during the study period. By 2022, a hierarchical spatial structure had essentially formed, with resilience gradually decreasing from downstream to upstream. Specifically, in 2000, no provinces exhibited high resilience; low and relatively low resilience types dominated, with most provinces showing medium resilience, forming a stepped geographic distribution. By 2008, high-resilience provinces increased to two (Inner Mongolia and Ningxia), while the remaining seven provinces showed medium resilience. By 2016, only Henan exhibited high resilience, with medium resilience provinces decreasing to two (Sichuan and Shandong), relatively low resilience increasing to four (Qinghai, Inner Mongolia, Shaanxi, Shanxi), and low resilience remaining at two (Gansu, Ningxia). By 2022, high-resilience provinces increased to two (Henan, Shandong), while medium and relatively low resilience types decreased to one (Sichuan) and three (Qinghai, Inner Mongolia, Shaanxi) respectively, and low resilience provinces increased to three (Gansu, Ningxia, Shanxi). This pattern reflects a development stage where economic growth was prioritized over ecological protection, with resilience enhancement not yet a widespread focus.

3.3 Dynamic Evolution of Tourism Ecological Resilience Development Levels

To analyze dynamic transitions between different resilience levels, we constructed a Markov chain model for the period 2000–2022. The state transition probability matrix reveals that diagonal elements represent the probability of maintaining the same resilience level, while off-diagonal elements quantify potential transitions between levels.

Upstream Region: Low-resilience areas showed high stability (0.857 probability of remaining low) with limited upward mobility. Relatively low-resilience areas had moderate stability (0.625) but faced regression risks (0.250). Medium-resilience areas showed general stability (0.444) with multidirectional transition possibilities. High-resilience areas demonstrated high stability (0.667) with only downward risk to medium level (0.333).

Midstream Region: Low-resilience areas were relatively stable (0.667) with high probability of transitioning to relatively low level (0.333). Relatively low-resilience areas showed stability (0.500) with regression risk (0.250) and moderate upward potential (0.250). Medium-resilience areas had high stability (0.667) with significant upward potential to high level (0.333) but small regression risk (0.222). High-resilience areas were extremely stable (1.000).

Downstream Region: Low-resilience areas were relatively stable (0.667) with higher probability of transitioning to relatively low level (0.333) than to medium level (0.167). Relatively low-resilience areas had stability (0.500) with regression risk (0.250) and moderate upward potential (0.250). Medium-resilience areas showed high stability (0.750) with significant upward potential (0.250) but small regression risk (0.083). High-resilience areas were extremely stable (0.800) with only minor downward risk (0.200).

In summary, upstream regions showed overall stability with low-resilience areas difficult to upgrade and high-resilience areas relatively stable but facing transition risks. Midstream regions exhibited clear upward and downward transitions, with low-resilience areas prone to downward movement and medium-resilience areas showing multidirectional transitions. Downstream regions demonstrated overall stability, though low-resilience areas faced upgrade difficulties while medium-resilience areas showed strong upward potential and high-resilience areas maintained extreme stability.

3.4 Spatial Agglomeration of Tourism Ecological Resilience Development Levels

To further understand spatial agglomeration characteristics, we analyzed Moran' s I indices. The global Moran' s I values for 2000–2022 all passed significance tests at the 1% level, with positive values revealing significant positive spatial correlations among provincial tourism ecological resilience levels. Z-values exceeded critical thresholds, indicating pronounced spatial agglomeration effects.

Temporally, the global Moran' s I showed a fluctuating upward trend from 0.247 to 0.314, demonstrating continuously strengthening spatial agglomeration.

Building on the global analysis, we created local Moran scatter plots for four key time points (2000, 2008, 2016, 2022) to visualize local spatial associations and dynamic evolution. Provinces predominantly clustered in the first and third quadrants, showing significant spatial agglomeration and heterogeneity, mainly manifesting as "high-high" and "low-low" patterns. Notably, third-quadrant provinces were significantly more numerous, indicating a tendency toward "low-low" agglomeration in the basin.

At the provincial level, Henan and Shandong consistently showed "high-high" agglomeration, indicating high resilience levels and positive spillover effects. Sichuan exhibited persistent "high-low" agglomeration, reflecting high local resilience but low surrounding levels. Gansu, Ningxia, and Inner Mongolia consistently showed "low-low" agglomeration, indicating substantial room for improvement. Shanxi degraded from "high-high" to "low-high" agglomeration, while Qinghai regressed from "low-high" to "low-low" agglomeration, reflecting increasing challenges in tourism ecological resilience for both provinces and their neighbors.

3.5 Obstacle Factors in Tourism Ecological Resilience Development

3.5.1 Criterion Layer Analysis Analysis of criterion-layer obstacle factors across nine provinces revealed that innovative evolutionary capability exhibited the highest barrier degree, representing the primary constraint on improving tourism ecological resilience in the Yellow River Basin. Recovery and adaptation capacity also constituted a significant barrier, while defense and resistance capacity showed relatively lower barrier degrees, reflecting certain stability in withstanding internal and external shocks. Future resilience enhancement strategies should focus on regulating and optimizing these two core criterion layers.

3.5.2 Indicator Layer Analysis **(1) Provincial-level obstacle factors:** To identify key indicator-layer obstacles, we applied the barrier degree model. Tourism factor aggregation level (D_1) emerged as the dominant obstacle factor across the basin, appearing 24 times among top-five barriers, followed by total water resources (R_{11}) and tourism R&D funding (I_{13}). For upstream regions, I_{13}, D_1, and R_{11} were the primary obstacles during 2000–2022. For midstream regions, D_1 replaced I_{13} as the top obstacle. For downstream regions, I_{13}, D_1, and R_{11} remained primary obstacles. Overall, D_1 is the main barrier hindering provincial tourism ecosystem resilience improvement.

(2) Sub-basin obstacle factors: Building on provincial analysis, we further identified obstacles for upstream, midstream, and downstream regions. Upstream regions were primarily constrained by I_{13}, D_1, and R_{11}. Midstream regions faced D_1, I_{13}, and R_{11} as main obstacles. Downstream regions were hindered by I_{13}, D_1, and R_{11}. These findings highlight consistent obstacles across scales while revealing regional variations in barrier intensity.

---

4. Discussion and Conclusions

4.1 Discussion

This study comprehensively analyzed the spatiotemporal evolution characteristics and obstacle factors of tourism ecological resilience in the Yellow River Basin from 2000 to 2022 using entropy-weighted TOPSIS, Markov chains, spatial autocorrelation models, and barrier degree models. The research contributes to existing literature in three key aspects: First, based on evolutionary resilience theory, we constructed a multi-dimensional evaluation indicator system encompassing defense and resistance capacity, recovery and adaptation capacity, and innovation and evolution capacity. Second, we employed diverse computational methods to comprehensively understand spatiotemporal evolution trends. Third, from a refined analysis perspective, we conducted hierarchical obstacle factor identification at both criterion and indicator layers, while considering spatial scale differences by analyzing barriers at both provincial and sub-basin scales. This multi-scale approach helps capture characteristics and differences across geographic spaces, providing scientific evidence for targeted regional sustainable tourism strategies and ecological conservation planning.

Despite these contributions, limitations remain: First, as an emerging research field, the theoretical framework and indicator system for tourism ecological resilience require further refinement. Although our indicators consider tourism ecosystem characteristics and draw from existing research, the system needs optimization and supplementation. Future studies should explore additional dimensions and indicators to more comprehensively reflect resilience characteristics. Second, limited by data availability, this research focused on the provincial scale; prefecture-level city analysis was not included due to challenges in data accessibility, consistency, and completeness. As tourism and ecological databases improve, future research can refine the spatial scale for more detailed analysis.

4.2 Conclusions

(1) Temporal dimension: During the study period, tourism ecological resilience in the Yellow River Basin remained at a relatively low level overall, showing a volatile downward trend. Sub-basin analysis revealed significant gradient differences, with downstream > midstream > upstream. Temporal evolution showed heterogeneous characteristics across resilience levels: low-resilience areas exhibited strong solidification tendencies, relatively low-resilience areas faced multiple constraints despite potential for improvement, medium-resilience areas represented critical transition stages, and high-resilience areas demonstrated stable, positive development trajectories.

(2) Spatial dimension: The spatial distribution of tourism ecological resilience changed significantly, forming a hierarchical structure decreasing from downstream to upstream by 2022. Spatial agglomeration analysis revealed significant positive spatial correlations among provinces, with pronounced agglomeration effects mainly manifesting as "high-high" and "low-low" clustering patterns.

(3) Obstacle factor analysis: At the criterion layer, recovery and adaptation capacity and innovation and evolution capacity were the primary obstacles. At the indicator layer, tourism factor aggregation level (D_1), total water resources (R_{11}), tourism R&D funding (I_{13}), and number of tourism invention patent authorizations (I_{14}) were identified as key barrier factors.

References

[1] Wang Zhaofeng, Liu Qingfang. The evolution and influencing factors of spatial network structure of China' s provincial tourism efficiency[J]. *Scientia Geographica Sinica*, 2021, 41(3): 397-406.

[2] Wang Songmao, Niu Jinlan. Co-evolution of tourism economy and urban ecological resilience in Shandong Province[J]. *Acta Geographica Sinica*, 2023, 78(10): 2591-2608.

[3] Holling C S. Resilience and stability of ecological systems[J]. *Annual Review of Ecology & Systematics*, 1973, 4(1): 1-23.

[4] Li Y, Shi Y, Qureshi S, et al. Applying the concept of spatial resilience to socio-ecological systems in the urban wetland interface[J]. *Ecological Indicators*, 2014, 42(1): 135-146.

[5] Ma L, Tao T, Li Z, et al. Study on spatial divergence of rural resilience and optimal governance paths in oasis: The case of Yongchang County in the Hexi Corridor of China[J]. *Environment, Development and Sustainability*, 2024, 26(2): 4603-4627.

[6] Yuan Y, Bai Z, Zhang J, et al. Increasing urban ecological resilience based on ecological security pattern: A case study in a resource-based city[J]. *Ecological Engineering*, 2022, 175(5): 1064-1075.

[7] Yang Xiuping, Jia Yunting, Weng Gangmin, et al. A study on system dynamics of the resilience of urban tourism environment system: A case study of Lanzhou City[J]. *Tourism Science*, 2020, 34(2): 23-40.

[8] Li Zhiyuan, Xia Zancai. Synergy effect and spatial characteristics analysis of tourism ecological resilience and efficiency in the Yangtze River Economic Belt[J]. *Journal of Nanjing Normal University (Natural Science Edition)*, 2021, 44(4): 33-42.

[9] Cochrane J. The sphere of tourism resilience[J]. *Tourism Recreation Research*, 2010, 35(2): 173-185.

[10] Li Zhiyuan, Feng Xuegang, He Jing, et al. Spatial correlation network structure and driving factors of tourism ecological resilience in China[J]. *Geographical Research*, 2024, 43(5): 1146-1165.

[11] Zhang Aoxiang, Miao Chenglin, Chen Zhengyan. Urban ecological resilience, social networks and its influencing factors in the Yellow River Basin[J/OL]. *Arid Land Geography*. [2025-01-04]. http://kns.cnki.net/kcms/detail/65.1103.x.20240524.1707.001.html.

[12] Guo Xiangyang, Ming Qingzhong, Yang Chunyu, et al. Spatiotemporal evolution of tourism ecosystem resilience in karst ecologically fragile areas and its multi-scale obstacle factors: A case study of Guizhou[J]. *Economic Geography*, 2023, 43(10): 190-200, 230.

[13] Fang Yelin, Wu Yanni, Wang Qiuyue, et al. Evaluation and influencing factors of tourism economic resilience based on DPSIR model: A case study of the Yangtze River Delta urban agglomeration[J]. *Journal of Nanjing Normal University (Natural Science Edition)*, 2024, 47(2): 26-34.

[14] Wang Zhaofeng, Chen Qingqing. Spatio-temporal pattern evolution and trend prediction of tourism ecological security in the Yangtze River Economic Belt since 1998[J]. *Acta Ecologica Sinica*, 2021, 41(1): 320-332.

[15] Ren Hongjie, Li Huishang. Spatial and temporal evolution characteristics and influencing factors of rural ecological resilience in China[J]. *Arid Land Geography*, 2024, 47(11): 1915-1923.

[16] Folke C, Carpenter S R, Walker B, et al. Resilience thinking: Integrating resilience, adaptability and transformability[J]. *Ecology and Society*, 2010, 15(4): 152-167.

[17] Zhang Mingdou, Ren Yanting, Zhou Liang. Spatiotemporal evolution characteristics and influencing factors of urban ecological resilience in the Yellow River Basin[J]. *Arid Land Geography*, 2024, 47(3): 445-454.

[18] Fang Yelin, Wang Qiuyue, Huang Zhenfang, et al. Spatial and temporal evolution of tourism economic resilience and mechanism of impact in China[J]. *Progress in Geography*, 2023, 42(3): 417-427.

[19] Pike A, Dawley S, Tomaney J. Resilience, adaptation and adaptability[J]. *Cambridge Journal of Regions, Economy and Society*, 2010, 3(1): 59-70.

[20] Niu Yafei, Chen Tian. Research on tourism eco-environment system: The cornerstone of eco-tourism research[J]. *Tourism Tribune*, 2004, 19(4): 5-6.

[21] Li Bo, Qin Huan, Yu Jianhui, et al. Evaluation and pattern evolution of provincial tourism resources competitiveness in China[J]. *Economic Geography*, 2019, 39(9): 232-240.

[22] Wang Shaojian, Gao Shuang, Huang Yongyuan, et al. Spatio-temporal evolution and trend prediction of urban carbon emission performance in China based on super-efficiency SBM model[J]. *Acta Geographica Sinica*, 2020, 75(6): 1316-1330.

[23] Li Wenlong, Qi Jianling, Zhang Hongyu, et al. Evaluation of agricultural high-quality development level, regional difference and spatial correlation analysis in China[J]. *Journal of Yunnan Agricultural University (Social Science Edition)*, 2024, 18(1): 1-8.

[24] Liu Honghong, Liu Shufang. Spatiotemporal evolution and obstacle identification of complex ecosystem resilience in the Qilian Mountain area[J]. *Arid Land Geography*, 2024, 47(2): 237-247.

[25] Zhao Mingliang, Liu Fangyi, Wang Huan, et al. Foreign direct investment, environmental regulation and urban green total factor productivity of the Yellow River Basin[J]. *Economic Geography*, 2020, 40(4): 38-47.

[26] Li Kaifeng, Li Zihao. Measurement of green total factor productivity in the Yellow River Basin[J]. *Statistics & Decision*, 2022, 38(4): 98-101.

Note: Figure translations are in progress. See original paper for figures.