Evolutionary Characteristics and Influencing Factors of Tourism Ecological Security in the Yellow River Basin: An Analysis Based on the Perspective of Social Network Analysis (Postprint)

Authors: Wei Lirong, Zhanhong Cheng, Ye Shi, Yuyao Zhang, Wang Ziyan, Liqin Niu

Date: 2026-02-27T22:08:31+00:00

Abstract

A deep analysis of the spatial correlation network structure and influencing factors of tourism ecological security in the Yellow River Basin is of great significance for balancing economic benefits and ecological constraints and promoting regional sustainable development. Based on provincial panel data of the Yellow River Basin from 2009 to 2022, this study comprehensively utilizes the entropy method, the modified gravity model, social network analysis, and Quadratic Assignment Procedure (QAP) regression to determine indicator weights, construct a correlation matrix, analyze the spatial correlation characteristics of tourism ecological security across nine provinces and regions, and identify the key elements driving network evolution.

The results indicate that: (1) The tourism ecological security of the nine provinces and regions in the Yellow River Basin exhibits significant trans-administrative boundary characteristics, with inter-regional interdependence showing a continuous strengthening trend. (2) There is obvious spatial heterogeneity in the tourism ecological security network within the basin; the absence of core nodes leads to insufficient regional agglomeration effects and collaborative development. (3) Different provinces belong to different blocks, which determines their distinct functions and positions within the spatial correlation network. (4) Gross Regional Product (GRP), per capita tourism consumption, the added value of the tertiary industry, wastewater discharge, and the utilization rate of solid waste constitute the primary influencing factors of tourism ecological security in the Yellow River Basin.

From the perspective of social network analysis, this study reveals the spatial network structure characteristics of tourism ecological security in the Yellow River Basin from both holistic and local dimensions and analyzes the key influencing factors, providing a new theoretical perspective for the sustainable development of tourism ecological security in the Yellow River Basin.

Full Text

Analysis of the Evolutionary Characteristics and Influencing Factors of Tourism Ecological Security in the Yellow River Basin: A Social Network Analysis Perspective

Wei Lirong[1], Cheng Zhanhong[1], Shi Ye[2], Zhang Yuyao[2], Wang Ziyan[1], Niu Liqin[2]

(1. School of Cultural Tourism, Journalism and Art, Shanxi University of Finance and Economics, Taiyuan 030006, China; 2. School of Resources and Environment, Shanxi University of Finance and Economics, Taiyuan 030006, China)

Abstract

As a vital ecological barrier and economic zone in China, the Yellow River Basin faces the critical challenge of balancing tourism development with ecological preservation. This study investigates the evolutionary characteristics and influencing factors of tourism ecological security (TES) within the Yellow River Basin from the perspective of Social Network Analysis (SNA). Based on provincial panel data from 2009 to 2022, we employ a comprehensive methodological framework—including the entropy weight method, a modified gravity model, SNA, and Quadratic Assignment Procedure (QAP) regression—to analyze the spatial-temporal dynamics of TES. Our findings reveal that while the overall level of tourism ecological security in the basin has shown a gradual upward trend, significant spatial disparities persist. The social network analysis indicates an increasing trend in network density and connectivity, suggesting enhanced regional cooperation. Furthermore, we identify key influencing factors—including regional GDP, per capita tourism consumption, and industrial structure—that drive the evolution of the TES network. This research provides theoretical insights for promoting sustainable tourism and ecological high-quality development in the Yellow River Basin.

Keywords: Tourism Ecological Security; Social Network Analysis; Influencing Factors; Yellow River Basin

1. Introduction

The Yellow River Basin is a core region for China’ s ecological security and socioeconomic development. In recent years, the rapid expansion of the tourism industry has brought significant economic benefits but has also exerted considerable pressure on the fragile ecological environment. Achieving a “win-win” scenario between tourism growth and ecological protection is essential for high-quality development. Tourism Ecological Security (TES) serves as a critical metric for assessing the sustainability of this relationship, reflecting the ability of the ecosystem to maintain its functions amidst tourism-related disturbances.

Existing research on TES has primarily focused on index construction, spatio-temporal evolution [**?**, **?**, **?**], and traditional econometric analysis of influencing factors [**?**, **?**, **?**]. However, these approaches often overlook the complex spatial interactions and network structures between different administrative units. The flow of capital, information, and tourists creates a networked relationship that transcends administrative boundaries. Therefore, applying Social Network Analysis (SNA) provides a novel perspective to understand the structural characteristics and collaborative mechanisms of TES in the Yellow River Basin.

2. Research Methods and Data Sources

2.1 Construction of the Evaluation Index System

To accurately measure the level of tourism ecological security, this study adopts the Pressure-State-Response (PSR) model and the Driver-Pressure-State-Impact-Response (DPSIR) framework [**?**, **?**]. The index system is detailed in .

2.2 Modified Gravity Model

To quantify the spatial relationships, we utilize a modified gravity model to determine the correlation strength between provinces. The gravitational linkage R_{ij} between province i and province j is calculated as:

$$R_{ij} = K_{ij}\frac{\sqrt{P_iG_i}\cdot\sqrt{P_jG_j}}{D_{ij}^2}, \quad K_{ij} = \frac{G_i}{G_i + G_j}$$

where P represents the tourism population, G represents the tourism ecological security index, D_{ij} is the geographical distance (great-circle distance), and K_{ij} is the contribution coefficient.

2.3 Social Network Analysis (SNA)

We utilize UCINET software to calculate network density and centrality. - **Degree Centrality:** Represents the radiation capacity of each province. -

Closeness Centrality: Represents the information transmission efficiency. - **Betweenness Centrality:** Represents the intermediary role and hub function.

2.4 Quadratic Assignment Procedure (QAP)

Since relational data in social networks often exhibit multicollinearity and autocorrelation, we employ QAP regression to identify the primary influencing factors of the TES spatial correlation network.

3. Results and Analysis

3.1 Overall Network Structure Characteristics

As shown in [Figure 1: see original paper], the network density of tourism ecological security in the Yellow River Basin increased from 0.3056 in 2009 to 0.3472 in 2022, an overall rise of 13.61%. The number of network relationships increased from 22 to 25. This trend indicates that inter-provincial element flows have strengthened and regional collaborative governance is improving. Although a fluctuation occurred in 2020 due to the COVID-19 pandemic, the system demonstrated rapid recovery capacity in the later stages.

[Figure 1: see original paper]

3.2 Individual Node Characteristics

The analysis of individual nodes (Table 2) reveals significant spatial heterogeneity.

1. **Degree Centrality:** Shandong, Inner Mongolia, and Gansu provinces have a higher number of connections, demonstrating significant network control advantages. By 2022, the number of provinces exceeding the annual average rose to six, indicating improved regional resilience.
2. **Closeness Centrality:** Ningxia and Sichuan consistently show higher closeness centrality, acting as critical supports for collaborative governance. In contrast, Shanxi and Henan exhibit lower participation levels.
3. **Betweenness Centrality:** Inner Mongolia plays a critical "bridge" role in resource exchange. Coastal or highly integrated provinces initially dominated, but the network is gradually decentralizing as inland provinces like Shaanxi and Henan increase their intermediary roles.

3.3 Block Model Analysis

Using the CONCOR algorithm, the nine provinces were partitioned into four functional blocks (Table 3):

- **Block I (Bidirectional Spillover):** Shanxi and Henan. These provinces both send and receive relationships, acting as key facilitators of exchange.
- **Block II (Net Spillover):** Gansu, Qinghai, Sichuan, and Ningxia. These western provinces act as primary sources of influence.

- **Block III (Net Receiver):** Inner Mongolia. This region primarily receives connections, acting as a sink for network flows.
- **Block IV (Broker):** Shaanxi and Shandong. These provinces act as intermediaries, coordinating flows between different blocks.

4. Influencing Factors of Tourism Ecological Security

The QAP regression analysis identifies the primary drivers of the TES network. Regional GDP, per capita tourism consumption, the added value of the tertiary industry, and environmental regulation (wastewater discharge and solid waste utilization) are the most significant factors.

Economic development provides the material foundation for ecological investment, while the industrial structure determines the pressure sustained by the ecosystem. The results confirm that the transition toward a high-quality tertiary industry and stricter environmental governance are essential for enhancing the stability of the tourism ecological security network.

5. Conclusion and Recommendations

The tourism ecological security of the Yellow River Basin exhibits significant trans-administrative characteristics and increasing interdependence. However, the absence of a single basin-wide core node has resulted in insufficient regional agglomeration.

To promote high-quality development, we recommend: 1. Strengthening cross-regional coordination and establishing ecological compensation mechanisms. 2. Leveraging the "bridge" functions of broker provinces (Shaanxi and Shandong) to facilitate green technology transfer. 3. Enhancing environmental regulation and promoting the green transformation of the tourism industrial structure in peripheral nodes.

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