

Spatial Mismatch between Tourism Economy and Ecological Environment Systems in Ningxia (Postprint)

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Date: 2022-04-16T00:56:08+00:00

Abstract

To investigate the degree of spatial mismatch between tourism economic development and ecological environment systems and quantitatively analyze their spatial mismatch relationship, this study takes Ningxia as the research object, and based on spatial mismatch theory and models, comprehensively employs the entropy weight method, TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) model, gravity model, and ArcGIS spatial visualization methods to conduct a comprehensive analysis of the spatial mismatch degree between tourism economy and ecological environment systems in the study area from 2011 to 2018. The results show that: from 2011 to 2018, the development level of Ningxia's tourism economy and ecological environment increased from 0.2868 and 0.2395 to 0.4716 and 0.3525, respectively, indicating continuously strengthening tourism economic strength and continuously improving ecological environment quality; from the perspective of center of gravity shift, the tourism economic system center of gravity shifted insignificantly, while the ecological environment showed a shifting trend from south to north, and there existed relatively obvious spatial heterogeneity characteristics between the two; from the perspective of spatial mismatch degree, all prefecture-level cities in the study area exhibited relatively high spatial mismatch degrees, showing a trend of year-by-year increase. Overall, the spatial mismatch between Ningxia's tourism economy and ecological environment systems is primarily caused by differences in tourism location and tourism resources; each prefecture-level city should, based on its own characteristics, leverage resource advantages, tap potential, and achieve the goal of coordinated and sustainable development of regional tourism industry through implementing differentiated spatial correction strategies.

Full Text

Abstract

To investigate the degree of spatial mismatch between tourism economic development and ecological environment systems, and to quantitatively analyze their spatial mismatch relationship, this study takes Ningxia as the research object. Based on spatial mismatch theory and models, we comprehensively employ the entropy weight method, the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) model, the gravity model, and ArcGIS spatial visualization methods to conduct a comprehensive analysis of the spatial mismatch degree between tourism economy and ecological environment systems in the study area from 2011 to 2018. The results indicate that: (1) The development levels of Ningxia's tourism economy and ecological environment increased from 0.2868 and 0.2395 in 2011 to 0.4716 and 0.3525 in 2018, respectively, demonstrating continuously improving tourism economic strength and ecological environmental quality. (2) From the perspective of center of gravity shift, the tourism economic system's center of gravity shows minimal transfer variation, while the ecological environment system exhibits a clear south-to-north transfer trend, with pronounced spatial heterogeneity between the two systems. (3) Regarding spatial mismatch degree, all prefecture-level cities in the study area exhibit relatively high spatial mismatch that shows a 逐年 increasing trend. Overall, the spatial mismatch between Ningxia's tourism economy and ecological environment systems is primarily caused by differences in tourism location and tourism resources. Each city should leverage its unique characteristics, capitalize on resource advantages, and tap development potential to achieve coordinated and sustainable regional tourism industry development through differentiated spatial correction strategies.

Keywords: spatial mismatch; tourism economy; ecological environment; center of gravity; Ningxia

Introduction

Tourism resources and ecological environment constitute the foundation of tourism economic development, while tourism economy provides essential support for tourism resource development, protection, and ecological environmental conservation. The interactive relationship between these elements has become a hot topic in academic research, with widespread recognition that tourism economy and ecological environment are closely interrelated. Current research on tourism spatial interaction relationships primarily focuses on spatial disparities and coupling coordination between tourism resources and tourism economic income. Most studies analyze regional coupling coordination by constructing indicator systems for tourism resources and tourism economy, revealing coordination degrees and spatial differences. However, compared with coupling theory, regional differences in natural conditions, resource endowments, and socio-economic development objectively create spatial heterogeneity

in tourism resources and tourism location, making analysis of regional tourism spatial development mismatch degree and its causes more practically significant. Spatial mismatch theory provides a new perspective for studying the spatial interaction between tourism economy and ecological environment.

As China's tourism industry rapidly develops, spatial mismatch phenomena such as disparities in tourist flow, scenic spots, star-rated hotels, and ecological environmental quality caused by differences in tourism resource endowments, location conditions, and infrastructure have become important issues requiring urgent solutions in regional tourism research. Spatial mismatch theory, which reveals coordination and mismatch degrees between tourism and other industries, is increasingly recognized by tourism scholars. Existing research on tourism spatial mismatch mainly focuses on: tourism resources and income, spatial mismatch measurement of "tourism resources-transportation location-tourist numbers," spatial mismatch patterns and dynamic mechanisms of "foreign investment-inbound business tourism," and spatial mismatch analysis of tourism economy and ecological environment. However, most current studies are qualitative and static, lacking time-series dynamic research, particularly regarding spatiotemporal dynamic evolution characteristics of spatial mismatch.

Ningxia, located in Northwest China, is rich in tourism resources. Since implementing the Inland Open Economy Pilot Zone and provincial-level all-for-one tourism demonstration zone, local governments have strongly supported tourism development, implemented comprehensive open tourism policies, and witnessed rising tourist numbers and growing tourism economic strength. Tourism activities are essentially spatial transfer behaviors that inevitably cause spatial displacement. Long-term mismatched development between tourism economy and ecological environment systems will hinder healthy and sustainable tourism industry development. Therefore, this study takes Ningxia as a case study, comprehensively employing improved TOPSIS model, spatial mismatch model, gravity model, and ArcGIS spatial visualization methods to investigate spatial mismatch between tourism economy and ecological environment systems from 2011 to 2018. The aim is to clarify spatial change trajectories, identify spatial distribution characteristics and mismatch degrees, and provide scientific references and decision-making support for coordinating regional tourism economy-ecological environment relationships and promoting high-quality tourism industry development.

Data and Methods

2.1 Data Sources

This study's data were obtained from the *Ningxia Statistical Yearbook* (2011–2018), *Ningxia Ecological Environment Statistical Bulletin*, corresponding years' Ningxia National Economic and Social Development Statistical Bulletins, land use change data, Ningxia Environment Bulletins and monitoring data, and official data published in government reports and websites. Individual missing

data were interpolated using multiple imputation methods.

2.2 Evaluation Index System Construction

Tourism economy and ecological environment systems are interdependent and mutually reinforcing. The ecological environment forms the foundation for tourism economic system development and tourism ecological security. A sound ecological environment promotes high-quality, sustainable tourism economic development, while tourism economy provides necessary support for ecological environment improvement. Only through coordinated development of ecological environment and tourism economy systems can high-quality tourism industry development be achieved. However, uneven tourism resource distribution leads to unbalanced tourism industry development, and tourism economy development does not completely match ecological environment development, with spatial mismatch phenomena existing in some regions.

To study spatial mismatch between Ningxia's tourism economy and ecological environment systems, this paper selects two macro systems—ecological environment and tourism economy—and constructs an evaluation index system comprising 16 indicators (Table 1), following principles of scientificity, accessibility, and representativeness based on relevant literature.

Table 1 Evaluation index system of spatial dislocation of tourism economy and ecological environment system in Ningxia

System	Subsystem	Indicator	Unit	Weight
Ecological Environment System (A ₁)	Ecological Environment Quality (B ₁)	Forest coverage rate (T ₁)	%	0.089
		Per capita park green area (T ₂)	m ²	0.076
		Built-up area green coverage rate (T ₃)	%	0.082
		Excellent air quality days (T ₄)	days	0.071
	Ecological Environment Pressure (B ₂)	Population density (T ₅)	persons/km ²	0.063
		Per capita forest and grassland area (T ₆)	hm ²	0.058

System	Subsystem	Indicator	Unit	Weight
Tourism Economy System (A ₂)	Ecological Environment Protection (B ₃)	Industrial wastewater discharge (T ₇)	10 ⁴ t	0.069
		Urban domestic waste clearance (T ₈)	10 ⁴ t	0.065
		Agricultural fertilizer use per unit area (T ₉)	kg/hm ²	0.061
		Per capita afforestation area (T ₁₀)	hm ²	0.072
		Industrial wastewater discharge standard rate (T ₁₁)	%	0.078
		Domestic waste harmless treatment rate (T ₁₂)	%	0.074
		Industrial solid waste comprehensive utilization rate (T ₁₃)	%	0.066
		Environmental protection investment proportion (T ₁₄)	%	0.076
	Tourism Economic Income (B ₄)	Domestic tourism revenue (T ₁₅)	10 ⁸ yuan	0.085
		International tourism revenue (T ₁₆)	10 ⁸ USD	0.091
		Per capita tourism revenue (T ₁₇)	yuan	0.079
		Tourism revenue as proportion of GDP (T ₁₈)	%	0.087

System	Subsystem	Indicator	Unit	Weight
	Tourist Reception (B ₅)	Domestic tourist arrivals (T ₁₉)	10 ⁴ persons	0.083
		Inbound tourist arrivals (T ₂₀)	10 ⁴ persons	0.088
		Domestic tourists as proportion of regional total (T ₂₁)	%	0.081
		Inbound tourists as proportion of regional total (T ₂₂)	%	0.086
	Tourism Development Rate (B ₆)	Total tourist growth rate (T ₂₃)	%	0.077
		Total tourism revenue growth rate (T ₂₄)	%	0.073

2.3 Improved TOPSIS Evaluation Model

The TOPSIS method is a commonly used multi-objective decision analysis technique that evaluates objects by measuring their proximity to positive and negative ideal solutions, objectively reflecting their relative merits. This study employs an improved TOPSIS model to calculate comprehensive development levels of tourism economy and ecological environment systems in the study area.

The model calculation process is as follows:

1) Standardization of evaluation indicators

For positive indicators:

$$Y_{ij} = \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)}$$

For negative indicators:

$$Y_{ij} = \frac{\max(x_j) - x_{ij}}{\max(x_j) - \min(x_j)}$$

where Y_{ij} is the standardized value of indicator j in year i ; $\max(x_j)$ and $\min(x_j)$ are the maximum and minimum values of indicator j , respectively; and x_{ij} is the original value.

2) Determination of indicator weights

This study adopts the more objective entropy weight method to determine indicator weights, effectively avoiding subjective influences. The calculation formulas are:

$$e_j = -\frac{1}{\ln(8)} \sum_{i=1}^8 z_{ij} \ln(z_{ij})$$

$$w_j = \frac{1 - e_j}{\sum_{j=1}^{25} (1 - e_j)}$$

where w_j is the weight of indicator j ; e_j is the entropy value of indicator j ; $z_{ij} = Y_{ij} / \sum_{j=1}^{25} Y_{ij}$ is the standardized value; and when $z_{ij} = 0$, $z_{ij} \ln(z_{ij}) = 0$.

3) Construction of weighted evaluation matrix

$$T = (T_{ij})_{8 \times 25}, \quad T_{ij} = w_j \times Y_{ij}$$

where T is the weighted evaluation matrix; Y_{ij} is the standardized value; w_j is the indicator weight; and T_{ij} is the normalized decision matrix element.

4) Determination of positive and negative ideal solutions

$$T_i^+ = (\max T_{ij} \mid i = 1, 2, \dots, 8)$$

$$T_i^- = (\min T_{ij} \mid i = 1, 2, \dots, 8)$$

where T_i^+ and T_i^- represent the positive and negative ideal solutions, respectively.

5) Calculation of distances to ideal solutions

$$D_i^+ = \sqrt{\sum_{j=1}^{25} (T_{ij} - T_i^+)^2}$$

$$D_i^- = \sqrt{\sum_{j=1}^{25} (T_{ij} - T_i^-)^2}$$

where D_i^+ and D_i^- are the distances from the evaluation object in year i to the positive and negative ideal solutions, respectively.

6) Calculation of closeness coefficient (C_i)

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-}$$

where $C_i \in [0, 1]$. A larger C_i value indicates higher comprehensive development levels of tourism economy and ecological environment systems, and vice versa.

2.4 Spatial Mismatch Model

Spatial mismatch, evolved from Kain's spatial mismatch hypothesis, primarily represents the uncoordinated development state of two or more elements in space. Based on spatial mismatch theory, this study introduces a spatial mismatch evaluation model:

$$T_i = \frac{A_i}{B_i} - \frac{A}{B}$$

where T_i is the spatial mismatch index of city i ; A and B are the comprehensive development levels of ecological environment and tourism economy systems for Ningxia in corresponding years; A_i is city i 's ecological environment system development level; and B_i is city i 's tourism economy system development level.

The T_i value can be positive or negative. When $T_i < 0$, it indicates that the city's tourism economic development is below the expected target; when $T_i = 0$, it shows consistency with the expected target; when $T_i > 0$, it indicates that tourism economic development exceeds the expected target.

Following the spatial mismatch classification grades from Liu Zhanfu et al. and Hu Yao, and based on Ningxia's specific conditions, we classify the absolute value of spatial mismatch index into three mismatch levels (Table 2) to characterize the spatial mismatch degree between tourism economy and ecological environment systems in Ningxia. When $|T_i| \in [10, \infty)$, it indicates a high mismatch area; when $|T_i| \in [5, 10)$, a medium mismatch area; and when $|T_i| \in [0, 5)$, a low mismatch area.

Table 2 Division standard of spatial dislocation degree of Ningxia tourism economy and ecological environment system

Mismatch Level	Absolute Value Range	Characteristics
Low mismatch	$[0, 5)$	Coordinated development
Medium mismatch	$[5, 10)$	Moderate imbalance
High mismatch	$[10, \infty)$	Severe imbalance

2.5 Gravity Model

The gravity model, based on mechanics principles, calculates the coordinate of a region's overall equilibrium center point and is widely applied in population flow

centers, employment centers, and economic development centers. This study utilizes the gravity model to reveal spatial distribution patterns of Ningxia's tourism economy and ecological environment system centers. If the two centers coincide, it indicates consistent regional tourism economy and ecological environment development; if they deviate, it signals spatial mismatch between tourism economy and ecological environment systems requiring correction.

The specific calculation formulas are:

$$X_s = \frac{\sum_{i=1}^n X_i S_i}{\sum_{i=1}^n S_i}, \quad Y_s = \frac{\sum_{i=1}^n Y_i S_i}{\sum_{i=1}^n S_i}$$

where (X_s, Y_s) represents the longitude and latitude of Ningxia's tourism economy system center; (X_i, Y_i) are the longitude and latitude of city i 's administrative center; S_i is city i 's tourism economy index; and n is the total number of prefecture-level cities in Ningxia ($n = 5$).

Similarly, the gravity model can calculate the longitude and latitude of Ningxia's ecological environment system center (X_e, Y_e) to characterize the center trajectory evolution of tourism economy and ecological environment systems.

Results

3.1 Comprehensive Evaluation of Tourism Economy and Ecological Environment Systems

Using the improved TOPSIS method, we obtained comprehensive development levels of Ningxia's tourism economy and ecological environment systems (Figure 1). To characterize their comprehensive evolution features, we selected 2011, 2014, and 2018 as time sections and used ArcGIS visualization to produce development level classification maps.

Figure 1 Comprehensive evaluation level of tourism economy and ecological environment system in Ningxia

During the study period, Ningxia's ecological environment system development level showed a 逐年 increasing trend, rising from 0.2395 to 0.3525 with an average annual growth rate of 5.90%, indicating continuously improving ecological environment quality. Particularly after the 2016 all-for-one tourism strategy, Ningxia's ecological environment quality showed significant growth, primarily due to increased ecological conservation and restoration efforts, continuous environmental governance, and emphasis on low-carbon tourism transformation and intensive development, which significantly improved the tourism ecological environment.

From the perspective of each city's ecological environment comprehensive evaluation values, all cities showed varying growth rates. The largest increase occurred

in Shizuishan City (average annual growth rate of 6.49%), followed by Zhongwei City (6.12%) and Guyuan City (5.45%), while Wuzhong City had the lowest growth rate at only 5.03%. Shizuishan previously focused on energy-based economic development, which significantly impacted the ecological environment. In recent years, with the implementation of Helan Mountain ecological restoration projects, the city's development orientation has shifted, with mining and related enterprises gradually withdrawing and ecological restoration accelerating. Guyuan City and Zhongwei's Haiyuan County, located in the Liupan Mountain poverty area, experienced large-scale ecological migration during the 12th Five-Year Plan period, with ecological restoration and recovery accelerating in relocation areas. Wuzhong City, situated in central Ningxia's arid belt and the central area of the Yellow River urban belt, has faster urbanization than other non-capital cities and accommodates many poverty alleviation relocation villages from southern Ningxia's concentrated contiguous poverty areas, resulting in slower ecological environment improvement.

Figure 2 Development level of ecological environment system in Ningxia from 2011 to 2018

The tourism economy system showed a rapid overall growth trend during the study period, increasing from 0.2868 to 0.4716 with an average annual growth rate of 8.05%, indicating continuously strengthening tourism economic strength (Figure 3). Significant differences existed among cities: Yinchuan City had the highest tourism economic development level (average 0.4512), followed by Wuzhong City (0.3124) and Zhongwei City (0.2987), while Guyuan City had the lowest (0.2415). As Ningxia's political center and a region rich in tourism resources, Yinchuan possesses 4A-level and above scenic spots, relatively concentrated tourism resources that facilitate multiple tourist choices, well-developed infrastructure, high service levels, and diversified, regionally distinctive tourism product structures that create favorable conditions for shopping tourism, greatly promoting rapid regional tourism economic development. Wuzhong City and Zhongwei City, located along the Yellow River, possess favorable cultural and natural tourism resources but suffer from slow resource development due to geographical constraints, small-scale scenic spots, lagging infrastructure, and single tourism product structures, severely hindering tourism economic development. Guyuan City, located in the Liupan Mountain area with backward economic development and limited transportation, faces difficulties in tourism resource development due to capital and technology constraints, has scattered existing scenic spots, lagging infrastructure, and primarily local tourists engaged in sightseeing with low consumption capacity. Regional poverty and ecological fragility are the main factors restricting tourism industry development.

Figure 3 Development level of tourism economic system in Ningxia from 2011 to 2018

3.2 Center of Gravity Trajectory Evolution Analysis

Based on comprehensive evaluation indices of Ningxia' s tourism economy and ecological environment systems, we calculated center of gravity changes at different stages using the gravity model (Table 3). To ensure temporal continuity, we selected 2011–2013, 2014–2015, and 2016–2018 as time slices, dividing the center migration trajectory into three stages.

Table 3 Trajectory of the spatial gravity center of tourism economy and ecological environment system in Ningxia from 2011 to 2018

Stage	Tourism Economy System Center	Ecological Environment System Center
2011–2013	106.042°E→106.041°E, 37.774°N→37.774°N 106.041°E→106.041°E, 37.774°N→37.762°N 2014–2015	

The results show that during 2011–2018, Ningxia' s tourism economy system center experienced relatively small longitude changes, fluctuating around 106°E, while its latitude center shifted from north to south. The ecological environment system center showed minimal longitude change, basically stable around 106°E, but its latitude center shifted from south to north. From stage 1 (starting point) to stage 3 (ending point), the overall migration direction of the tourism economy system center was northward, while the ecological environment system center also migrated northward. The primary reason for the ecological environment system' s latitude shift from south to north is that the comprehensive development level of the northern region' s ecological environment system has improved faster than the southern region in recent years. Although the southern mountainous area has always ranked at the forefront of Ningxia with good ecological foundations, the northern plain region has 逐年 improved its ecological environment restoration capacity, especially after 2016 when Ningxia issued ecological protection redlines, clarified ecological protection boundaries, and intensified ecological governance in key areas like Helan Mountain and the Yellow River basin.

From the relative positions of the tourism economy and ecological environment system centers (Figure 4), the study period reveals obvious spatial heterogeneity characteristics between the two systems, with the gap between their longitudes and latitudes 逐年 increasing. The tourism economy center shifted southward while the ecological environment center moved northward, with migration directions fluctuating across different years. The tourism economy system showed a “north-south-north” migration route, while the ecological environment system displayed a “south-north” route, further confirming the persistent spatial mismatch between tourism economy and ecological environment systems.

Figure 4 Trajectory of the spatial gravity center of tourism economy and ecological environment system in Ningxia from 2011 to 2018

3.3 Spatial Mismatch Analysis

Spatial mismatch reflects the deviation degree of tourism economy and ecological environment system elements in space. Based on comprehensive evaluation indices, we constructed a spatial mismatch evaluation model to measure the mismatch degree between the two systems. To quantify spatial mismatch degrees across Ningxia's prefecture-level cities, we calculated spatial mismatch indices for 2011-2018 (Table 4) and classified them into high, medium, and low mismatch areas based on absolute values (Table 5). Larger absolute values indicate more significant mismatch, while smaller values indicate less mismatch.

Table 4 Spatial mismatch index of tourism economy and ecological environment system in Ningxia from 2011 to 2018

Year	Yinchuan	Shizuishan	Wuzhong	Zhongwei	Guyuan
2011	-2.35	3.12	4.21	5.67	6.89
2012	-3.01	3.89	4.98	6.23	7.45
2013	-3.67	4.56	5.67	6.89	8.01
2014	-4.23	5.12	6.34	7.45	8.67
2015	-4.89	5.78	7.01	8.12	9.23
2016	-5.56	6.45	7.67	8.78	9.89
2017	-6.12	7.01	8.34	9.34	10.56
2018	-6.78	7.67	8.98	9.89	11.23

Table 5 Spatial mismatch level of tourism economy and ecological environment system in Ningxia from 2011 to 2018

Year	High Mismatch Area	Medium Mismatch Area	Low Mismatch Area
2011	Zhongwei, Guyuan	Shizuishan, Wuzhong	Yinchuan
2012	Zhongwei, Guyuan	Shizuishan, Wuzhong	Yinchuan
2013	Zhongwei, Guyuan	Shizuishan, Wuzhong	Yinchuan
2014	Shizuishan, Wuzhong, Zhongwei, Guyuan	—	Yinchuan
2015	Shizuishan, Wuzhong, Zhongwei, Guyuan	—	Yinchuan
2016	All five cities	—	—
2017	All five cities	—	—
2018	All five cities	—	—

The results reveal strong heterogeneity in spatial mismatch degrees across the study area, with an overall increasing trend. From the perspective of positive/negative mismatch relationships, Yinchuan City consistently shows negative spatial mismatch, indicating that as the capital city, its actual tourism economic development level exceeds expected levels, with ecological environment advantages fully utilized but ecological environment improvement lagging behind rapid tourism economic growth. The other four cities all show positive

spatial mismatch with 逐年 increasing indices, indicating their actual development levels fall short of expected targets, ecological environment potential is not fully realized, and tourism economic development has considerable room for growth.

Overall, all five cities exhibit upward trends in spatial mismatch indices, and the situation remains concerning, indicating more significant non-coordination between the two systems. Targeted measures should be adopted to improve mismatch degrees and promote coordinated, sustainable development.

To better characterize the spatial distribution pattern of spatial mismatch, we produced distribution maps using ArcGIS visualization (Figure 5). The distribution shows that medium-high mismatch areas accounted for the largest proportion and increased 逐年 during 2011–2018, followed by medium mismatch areas which showed a decreasing trend, while low mismatch areas were absent until all cities developed into high mismatch areas by 2018.

Figure 5 Spatial distribution pattern of spatial mismatch level of tourism economy and ecological environment system in Ningxia

Although all Ningxia cities are currently in high mismatch areas, different development states and mismatch causes exist due to regional differences. Yinchuan City belongs to negative high mismatch, particularly shifting to high mismatch after 2016, indicating severe imbalance between tourism economic development and ecological environment development, with high tourism development intensity and severe mismatch between tourism economy and ecological environment systems. This stems from Yinchuan's superior location as Ningxia's transportation hub, concentrated tourism resources, complete infrastructure, and strong tourism brand effects, which accelerate tourism industry development but also increase ecological pressure, causing imbalance.

In contrast, Shizuishan, Wuzhong, Zhongwei, and Guyuan cities all show positive mismatch with 逐年 increasing indices, indicating severe imbalance between tourism economic development and ecological environment development, with tourism economic development lagging behind Yinchuan. Under the autonomous region's ecological priority strategy and national environmental protection policies, these cities' ecological environment quality has continuously improved, but tourism economic development is constrained by capital and technology, resulting in slow tourism resource and product development and lack of sustained momentum. Consequently, the mismatch between tourism economic development and ecological environment development has become increasingly prominent. Such regions should achieve tourism industry transformation and upgrading by combining multicultural elements with ecological environment, tap potential, and adopt differentiated spatial correction strategies to achieve coordinated and sustainable regional tourism development, thereby enhancing industrial competitiveness.

Discussion

Analysis of common influencing factors reveals that spatial mismatch between Ningxia's tourism economic development and ecological environment systems mainly results from differences in tourism location and tourism resources across prefecture-level cities. The northern plain region is a traditional tourism hotspot with well-known, abundant tourism resources, particularly Yinchuan City with the highest tourism economic development level and obvious capital location advantages, showing negative index levels. Guyuan City, located in the southern loess hilly region with high vegetation coverage and abundant rainfall, has an ecological environment superior to the northern region. Particularly through returning farmland to forest and grassland policies, its ecological environment development level has 逐年 surpassed the northern region, with the most obvious ecological location advantages in the autonomous region. Although its tourism economic development is catching up, it remains relatively backward regionally, resulting in the highest positive mismatch index.

Overall, Ningxia should be treated as a key region for resolving overall spatial mismatch coordination. On one hand, Ningxia's tourism industry development should prioritize tourism economy-ecological environment coordination; on the other hand, spatial mismatch degrees should be reduced based on different cities' mismatch causes to achieve coordinated and balanced development between tourism economy and ecological environment systems. Meanwhile, each city should leverage its unique characteristics, capitalize on resource advantages, tap potential, and adopt differentiated spatial correction strategies to achieve coordinated and sustainable regional tourism development.

It is worth noting that spatial mismatch formation results from multi-factor coupling influences. Therefore, exploring spatial mismatch degrees, clarifying interactions among mismatch formation factors, identifying dominant influencing factors, and investigating formation mechanisms are important for optimizing spatial mismatch phenomena. This study only discusses spatial mismatch degrees between tourism economic development and ecological environment systems without analyzing influencing factors and driving mechanisms. Given Ningxia's obvious regional economic development and ecological environment differences, indicator selection may not comprehensively cover the entire region. Additionally, the selected time interval (2011–2018) cannot precisely reveal spatiotemporal mismatch patterns and their regularities across Ningxia's cities. Future research should expand data quantity and improve data completeness.

Conclusions

This study constructs an evaluation index system for spatial mismatch between Ningxia's ecological environment and tourism economy systems. Using improved TOPSIS model, we calculated comprehensive development levels from 2011–2018, revealing that both tourism economic development level and ecological environment development level show 逐年 increasing trends, indicating

continuously strengthening tourism economic strength and improving ecological environment quality. From each city's perspective, all cities demonstrate varying growth rates, but significant internal differences exist.

The gravity model reveals that the ecological environment center's longitude changed minimally, basically stable around 106°E, while its latitude shifted significantly from south to north. From the relative positions of tourism economic and ecological environment system centers, obvious spatial heterogeneity characteristics exist during the study period, particularly with 逐年 increasing gaps in longitude and latitude. The tourism economy center shifted southward while the ecological environment center moved northward, with migration directions fluctuating across years. The tourism economy system showed a "north-south-north" migration route, while the ecological environment system displayed a "south-north" route, further confirming persistent spatial mismatch.

Spatial mismatch index calculations show significant variation across cities. Except for Yinchuan City's negative mismatch increase, Shizuishan, Wuzhong, Zhongwei, and Guyuan cities all show positive mismatch increases. The absolute values of mismatch indices further demonstrate severe overall imbalance between Ningxia's tourism economic development and ecological environment systems, with all cities becoming high mismatch areas by 2018.

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