

Coupling Coordination Relationship and Obstacle Factor Diagnosis between Rural Tourism and Rural Human Settlement Environment: A Case Study of Shanxi Province (Postprint)

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Abstract

Based on the construction of evaluation indicator systems for rural tourism and rural human settlements environment, this study employs quantitative methods such as the Analytic Hierarchy Process and the coupling coordination degree model to analyze the coupling coordination relationship between rural tourism and rural human settlements environment in 11 prefecture-level cities of Shanxi Province, and utilizes the obstacle degree model to diagnose the obstacle factors affecting this relationship. The results indicate: (1) Significant regional disparities exist in the levels of rural tourism and rural human settlements environment among various prefecture-level cities, with obvious spatial mismatch between the two. (2) Jinzhong, Linfen, and Yuncheng are classified as the rural tourism-leading type at the moderate coupling coordination level; Jincheng, Changzhi, and Lüliang as the synchronous type at the moderate coupling coordination level; Taiyuan and Yangquan as the rural tourism-lagging type at the moderate coupling coordination level; Xinzhou and Datong as the synchronous type at the barely coupling coordination level; and Shuozhou as the rural tourism-lagging type at the primary coupling coordination level. (3) Infrastructure, public services, and industrial structure constitute the key obstacle factors restricting the coupled and coordinated development of rural tourism and rural human settlements environment in Shanxi Province, with substantial variation in the distribution of obstacles across the seven dimensions, and the key obstacle factors differ among prefecture-level cities. (4) Going forward, Shanxi Province should enhance infrastructure construction, elevate public service levels, and optimize rural tourism supply, while adopting region-specific measures based on the coupling coordination relationships and obstacle factor conditions of each area to promote the sustainable and coordinated development of rural tourism and rural human settlements environment.

Full Text**ARID LAND GEOGRAPHY Vol. 47 No. 1 Jan. 2024****Coupling Coordinative Relationship and Obstacle Factor Diagnosis between Rural Tourism and Rural Human Settlement Environment: A Case Study of Shanxi Province****WANG Guanyao¹, WANG Wei², ZHANG Juanjuan³**¹ Academy of the Yellow River Cultural Ecology/Department of Culture and Tourism, Yuncheng University, Yuncheng 044000, Shanxi, China² School of Culture Industry and Tourism Management, Henan University, Kaifeng 475001, Henan, China³ College of Business, Shanghai University of Finance and Economics, Shanghai 200433, China

Abstract: The coupling coordinative relationships between rural tourism and the rural human settlement environment in 11 prefecture-level cities of Shanxi Province, China, were quantitatively analyzed using an analytic hierarchy process and a coupled coordination model, based on the development of an evaluation indices system for rural tourism and the rural human settlement environment. Obstacle factors of the coupling coordinative relationships were diagnosed using an obstacle-degree model. The results showed that: (1) There were relatively high regional disparities in the levels of rural tourism and the rural human settlement environment in various prefecture-level cities, leading to significant spatial mismatches between the two. (2) Jinzhong, Linfen, and Yuncheng belonged to the rural tourism leading type of moderately coupled coordination level. Jincheng, Changzhi, and Lüliang belonged to the synchronous type of moderately coupled coordination level. Taiyuan and Yangquan belonged to the rural tourism lagging type of moderately coupled coordination level. Xinzhou and Datong belonged to the synchronous type of barely coupled coordination level. Shuozhou belonged to the rural tourism lagging type of primary coupled coordination level. (3) Infrastructure, public services, and industrial institutions were the key obstacle factors restricting the coupling coordinative development of rural tourism and the rural human settlement environment in Shanxi Province. There were significant disparities in the distributions of obstacles among the seven dimensions, and the key obstacle factors varied for each prefecture-level city. (4) In the future, Shanxi Province should strengthen infrastructure construction, improve public service levels, and optimize the supply of rural tourism. Based on the coupling coordinative relationships and the status of obstacle factors in each prefecture-level city, appropriate measures should be taken to promote sustainable and coordinated development of rural tourism and the rural human settlement environment.

Key words: rural tourism; rural human settlement environment; coupling coordinative relationship; obstacle degree; Shanxi Province

Since the 19th National Congress of the Communist Party of China made the major strategic decision to implement the rural revitalization strategy, governments at all levels and various sectors of society have increasingly emphasized the development of rural tourism and the improvement of rural human settlement environments. Developing rural tourism in suitable areas is an important pathway to achieving rural revitalization and also helps improve rural human settlement environments. Meanwhile, promoting the improvement of rural human settlement environments is a key link in achieving rural revitalization and provides a favorable development environment for rural tourism. The 2022 No. 1 Central Document continued to emphasize the implementation of high-quality rural leisure tourism projects and the advancement of rural human settlement environment improvement. Against this backdrop, promoting the sustainable and coordinated development of rural tourism and rural human settlement environments has become an objective requirement for facilitating high-quality rural tourism development, improving rural human settlement environments, and achieving rural revitalization.

Rural tourism and rural human settlement environments are hot topics in academic research, with numerous studies yielding fruitful results. However, current research on the relationship between the two remains limited. Existing literature focuses on three main aspects: (1) The driving effects and mechanisms of tourism on rural human settlement environments. Li Bohua et al. [?] argued that tourism development can promote the improvement of traditional village human settlement environments from economic, socio-cultural, and residential perspectives. Chen Xinxin et al. [?] suggested that tourism development can strengthen the driving effects of population, capital, land, and policy on the transformation and development of traditional village human settlement environments. Yang Xingzhu et al. [?] found that rural human settlement environments in southern Anhui tourism areas are significantly influenced by tourism resources and tourism economy. Li Bohua et al. [?] divided the evolution process of human settlement environments in scenic area-edge rural tourism destinations into four stages: invasion, competition, response, and regulation. (2) The supporting effects and mechanisms of rural human settlement environments on rural tourism. Li Chuangxin [?] and Feng Nan [?] noted that rural human settlement environments provide ecological resources, human resources, and service facilities for rural tourism development. Zheng Yi et al. [?] argued that improving rural human settlement environments can expand rural tourism demand and supply, thereby promoting rural tourism development. Lin Enhui et al. [?] found based on agricultural census data that the supporting effects of rural human settlement environments on rural tourism are strongly influenced by transportation conditions and rural collective economic levels. (3) Thoughts and strategies for the coordinated development of rural tourism and rural human settlement environments. Cui Xin [?] proposed, based on the all-for-one tourism concept, using rural tourism to guide rural human settlement environment improvement and using rural human settlement environments as the foundation for identifying rural tourism characteristics. Lu Shuying [?] and Wang Cheng [?] argued that a

balance should be found between tourism development and resource protection to improve the suitability of rural human settlement environments, promoting coordinated development according to local conditions. Fang Falin et al. [?] suggested strategies such as optimizing the ecological environment, upgrading agricultural landscapes, and developing rural tourism culture to enhance rural tourism attractiveness.

Overall, existing research has three main limitations: in terms of research content, studies focus on one-way relationships rather than bidirectional interactions; in terms of research scale, micro-scale case studies of single tourism destinations dominate, with less attention to regional differences and formation mechanisms at the macro scale; and in terms of research methods, qualitative approaches prevail, with insufficient application of quantitative methods and models. Therefore, this paper constructs an evaluation indices system for rural tourism and rural human settlement environments, comprehensively applies the analytic hierarchy process, coupling coordination model, and obstacle-degree model to quantitatively analyze the coupling coordinative relationships and obstacle factors between rural tourism and rural human settlement environments in 11 prefecture-level cities of Shanxi Province. The study identifies priorities for promoting sustainable and coordinated development, aiming to provide theoretical support and practical guidance for deepening academic research and advancing high-quality rural tourism development and rural human settlement environment improvement.

1.1 Study Area Overview

Shanxi Province features diverse landforms and profound cultural heritage, making it a well-known tourism resource province in China. Rural areas in Shanxi concentrate 70% of the province's tourism resources. Currently, Shanxi has 39 national key rural tourism villages, 450 national forest villages, 619 traditional Chinese villages, 300 provincial rural tourism demonstration villages, and 235 tourism poverty alleviation demonstration villages. In 2020, rural leisure tourism in Shanxi received over 70 million visitors, generating revenue of 8.21 billion yuan, making it a strong driver of tourism development. However, Shanxi is also an important coal industrial base where economic development lags, ecological environments need improvement, and rural agricultural development faces numerous challenges, urgently requiring the advancement of rural human settlement environment improvement.

Since 2019, ecological protection and high-quality development of the Yellow River Basin have become national strategies. The "Outline of the Yellow River Basin Ecological Protection and High-Quality Development Plan" emphasizes creating a Yellow River cultural tourism belt with international influence. In December 2019, Shanxi was approved by the Ministry of Culture and Tourism as one of the second batch of provincial-level national all-for-one tourism demonstration zone creation units. Planning documents such as the "Shanxi Province 14th Five-Year Plan for Culture and Tourism Development" and the "Shanxi

Province All-for-One Tourism Development Plan Outline” have clarified strategic deployments and work priorities for promoting rural tourism development, emphasizing the importance of advancing rural human settlement environment improvement for rural tourism development. Against this backdrop, the timing is ripe for promoting coordinated development between rural tourism and rural human settlement environments in Shanxi Province.

1.2 Theoretical Basis

Coupling refers to the phenomenon of interaction and mutual influence among multiple systems or various elements within a system [?]. Coordination refers to the benign interconnection where multiple systems or various elements cooperate harmoniously and consistently [?]. There exists a significant bidirectional interaction between rural tourism and rural human settlement environments (Fig. [Figure 1: see original paper]). On the one hand, rural tourism development can drive the improvement of rural human settlement environments from perspectives such as resource base, industrial institutions, and market demand. On the other hand, rural human settlement environments can provide favorable development conditions for rural tourism from aspects including economic development, public services, infrastructure, and ecological environment. The coupling coordinative relationship between the two affects both rural tourism development and rural human settlement environment improvement. The higher the level of rural tourism development, the better the condition of rural human settlement environments, and the more optimal their coupling coordinative relationship, the more conducive it is to sustainable and coordinated development. Simultaneously, this coupling coordinative relationship is constrained and influenced by factors in rural tourism (resource base, industrial institutions, market demand) and in rural human settlement environments (economic development, public services, infrastructure, ecological environment). Relative disadvantages in any one or more of these factors may become obstacle factors in their coupling coordinative relationship, thereby hindering sustainable and coordinated development.

1.3.1 Construction of the Index System

Based on theoretical analysis of the coupling coordinative mechanism between rural tourism and rural human settlement environments, and drawing on existing research on rural tourism evaluation and rural human settlement environment evaluation [?, ?, ?, ?], we initially constructed an evaluation indices system for rural tourism and rural human settlement environments. We then consulted eight senior experts engaged in tourism and rural research, and based on their feedback, finally determined four dimensions for evaluating rural tourism development level (resource base, industrial institutions, market demand) and four dimensions for evaluating rural human settlement environment conditions (economic development, public services, infrastructure, ecological environment). We selected 11 rural tourism evaluation indices and 13 rural human settlement en-

vironment evaluation indices (Table).

1.3.2 Measurement of Coupling Coordinative Relationships

(1) Dimensionless processing. To eliminate the influence of index dimensions and measurement scales, we first applied a utility function to process indices dimensionlessly:

$$u_{ij} = \begin{cases} \frac{x_{ij}-\beta_i}{\alpha_i-\beta_i} & \text{(for positive indicators)} \\ \frac{\alpha_i-x_{ij}}{\alpha_i-\beta_i} & \text{(for negative indicators)} \end{cases}$$

where u_{ij} is the utility coefficient of index i in region j (i.e., the value after dimensionless processing), with a value range of $[0, 1]$. A smaller u_{ij} value indicates lower contribution of the index, and vice versa. x_{ij} is the initial value of index i in region j ; α_i and β_i are the upper and lower limit values of index i , respectively. To avoid u_{ij} values of 0, we enlarged the maximum value of each index by 10% as the upper limit and reduced the minimum value by 10% as the lower limit.

(2) Weight assignment and subsystem evaluation score calculation. To minimize human bias in measurement results, we applied the entropy weighting method for objective weighting and used linear weighting to measure rural tourism and rural human settlement environment evaluation scores:

$$R_j = \sum_{i=1}^n \omega_i u_{ij}, \quad \sum_{i=1}^n \omega_i = 1$$

where R_j represents the evaluation scores of rural tourism and rural human settlement environments, and ω_i is the weight of index i .

(3) Measurement of coupling coordinative levels. We used a coupling coordinative degree model to measure the coupling coordinative level between rural tourism and rural human settlement environments. According to relevant research [?, ?], coupling coordinative degree can be divided into coupling degree and coordinative degree. Coupling degree reflects the relative strength among subsystems (i.e., coordination level), while coordinative degree reflects the overall coupling coordinative level of the system. Therefore, the coupling degree and coordinative degree between rural tourism and rural human settlement environments are expressed as:

$$C = \sqrt{\frac{R_{1j} \cdot R_{2j}}{\left(\frac{R_{1j} + R_{2j}}{2}\right)^2}}$$

$$D = \sqrt{C \cdot (\alpha R_{1j} + \beta R_{2j})}$$

where C and D are the coupling degree and coordinative degree, respectively, both with value ranges of $[0, 1]$. A larger C value indicates higher coordination level between rural tourism and rural human settlement environments, while a larger D value indicates higher coupling coordinative level. α and β are undetermined coefficients representing the relative importance of rural tourism and rural human settlement environments. Since rural tourism heavily depends on the development environment provided by rural human settlement environments, and improvements in rural human settlement environments can substantially promote rural tourism development, while the driving effect of rural tourism on rural human settlement environment improvement is relatively weak—confirmed by expert feedback—we set $\alpha = 0.4$ and $\beta = 0.6$ following relevant research [?].

(4) Classification of coupling coordinative relationship types. Drawing on relevant research [?], we classified the coupling coordinative relationships into five levels based on coordinative degree value intervals: primary ($0.0 \sim 0.2$), barely ($0.2 \sim 0.4$), moderate ($0.4 \sim 0.6$), good ($0.6 \sim 0.8$), and premium or coupled coordination level ($0.8 \sim 1.0$). On this basis, we used the leading degree L value ($L = R_{1j} - R_{2j}$) to reflect the leading degree of region j 's rural tourism over its rural human settlement environment. Using the natural breaks classification method, we divided L values into three intervals from largest to smallest, representing rural tourism leading, synchronous, and lagging conditions relative to rural human settlement environments. This classification method theoretically yields 15 basic types ($5 \text{ levels} \times 3 \text{ relative development conditions}$), capable of reflecting both the coupling coordinative relationship level and the relative development status of the two systems.

1.3.3 Diagnosis of Obstacle Factors

To identify key obstacle factors limiting the coupling coordinative development of rural tourism and rural human settlement environments, we applied an obstacle-degree model to analyze the obstacle degree of each dimension at the criterion level on their coupling coordinative levels:

$$Q_{ij} = \frac{(1 - u_{ij}) \times \omega_i}{\sum_{i=1}^n (1 - u_{ij}) \times \omega_i} \times 100\%$$

where Q_{ij} is the obstacle degree of factor i in region j , with a value range of $[0, 100\%]$. A larger value indicates a higher obstacle degree of that factor on coupling coordinative levels. u_{ij} is the dimensionless processed index value, and ω_i is the contribution degree of factor i . Given that the index system involves many dimensions, we did not adopt the equal-interval classification standard used by scholars [?]. Instead, drawing on classification standards for location entropy and destination preference indices [?, ?], and considering the dimensional characteristics of the index system, we used the mean obstacle degree of seven dimensions (14.29%) as the boundary to divide obstacle degree

values into four levels: extremely weak ($0 \sim 7.14\%$), weak ($7.14\% \sim 14.29\%$), strong ($14.29\% \sim 28.57\%$), and extremely strong ($> 28.57\%$).

1.4 Data Sources and Description

Data used in this study were obtained from: (1) Statistical materials published by authoritative departments, including the *Shanxi Statistical Yearbook*, statistical yearbooks of various prefecture-level cities, and national economic and social development statistical bulletins. (2) Lists of rural tourism destinations and tourist attractions, including: the list of national key rural tourism villages published on the official website of the Ministry of Culture and Tourism; the list of national forest villages published on the official website of the National Forestry and Grassland Administration; the list of traditional Chinese villages published on the Traditional Villages website; and the lists of provincial rural tourism demonstration villages, tourism poverty alleviation demonstration villages, and tourist attractions published by the Shanxi Provincial Department of Culture and Tourism. Additionally, since rural tourism development was strongly affected by COVID-19 after 2019, all statistical indicators in this study used 2019 data.

2.1 Development Levels of Rural Tourism and Rural Human Settlement Environments

Based on the above methods, we calculated the comprehensive scores and dimensional scores of rural tourism and rural human settlement environments for various prefecture-level cities in Shanxi Province (Table). Regarding comprehensive scores for rural tourism, regional disparities in Shanxi Province were significant, with the highest score in Jinzhong being 104 times the lowest in Shuozhou. Specifically, Jinzhong, Linfen, Yuncheng, and Taiyuan had comprehensive scores between 0.385 and 0.522, indicating relatively high rural tourism levels; Changzhi, Jincheng, and Lüliang scored between 0.229 and 0.295, indicating medium levels; and Datong, Yangquan, and Shuozhou scored between 0.005 and 0.027, indicating relatively low levels.

Regarding comprehensive scores for rural human settlement environments, regional disparities were also notable, with the highest in Taiyuan being 3.4 times the lowest in Xinzhou. Taiyuan, Yangquan, Shuozhou, and Jinzhong scored between 0.474 and 0.773, indicating relatively high levels; Jincheng, Linfen, Changzhi, and Yuncheng scored between 0.377 and 0.427, indicating medium levels; and Lüliang, Datong, and Xinzhou scored between 0.229 and 0.295, indicating relatively low levels.

Evidently, prefecture-level cities with higher rural tourism levels are concentrated in central and southern Shanxi, while those with higher rural human settlement environment levels are concentrated in central and northern Shanxi, showing obvious spatial mismatch. Moreover, large gaps exist in dimensional

scores across the eight dimensions, suggesting that key obstacle factors for coupling coordinative relationships may vary by region.

2.2 Coupling Coordinative Relationships between Rural Tourism and Rural Human Settlement Environments

Based on the above methods, we calculated the coupling degree and coordinative degree of rural tourism and rural human settlement environments for various prefecture-level cities (Fig. [Figure 2: see original paper]), and classified leading degrees into three intervals using natural breaks: $-0.503 \sim -0.164$ (lagging), $-0.163 \sim 0.157$ (synchronous), and $0.158 \sim 0.263$ (leading). We then determined each city's coupling coordinative relationship type (Fig. [Figure 2: see original paper]). All prefecture-level cities showed medium-low coupling degrees and coordinative degrees, indicating considerable room for improvement—likely influenced by Shanxi's relatively lagging socio-economic level. The coupling coordinative relationships distributed across five basic types.

2.2.1 Moderate Coupling Coordination Level—Rural Tourism Leading Type

This type includes Jinzhong, Linfen, and Yuncheng. These regions exhibit moderate coupling coordination levels, with rural tourism levels significantly leading rural human settlement environment levels. Their coupling degrees range 0.480–0.530, coordinative degrees 0.484–0.489, and leading degrees 0.246–0.263, ranking relatively high provincially. However, rural human settlement environments clearly constrain rural tourism development. Therefore, these cities should vigorously improve rural human settlement environments to create better development conditions for rural tourism.

2.2.2 Moderate Coupling Coordination Level—Synchronous Type

This type includes Jincheng, Changzhi, and Lüliang. These regions exhibit moderate coupling coordination levels, with rural tourism and rural human settlement environment levels developing basically synchronously. Their coupling degrees range 0.492–0.499, coordinative degrees 0.412–0.475, and leading degrees $-0.060 \sim 0.140$, ranking in the middle provincially. Therefore, these cities should give equal emphasis to rural tourism development and rural human settlement environment improvement to advance toward higher coupling coordination levels.

2.2.3 Moderate Coupling Coordination Level—Rural Tourism Lagging Type

This type includes Taiyuan and Yangquan. These regions exhibit moderate coupling coordination levels, with rural tourism levels significantly lagging behind rural human settlement environment levels. Their coupling degrees range 0.412–0.496, coordinative degrees 0.419–0.593, and leading degrees $-0.433 \sim -0.419$,

ranking high and medium provincially. Rural human settlement environments provide substantial development space for rural tourism. Therefore, these cities should leverage their excellent rural human settlement environments to promote rural tourism development.

2.2.4 Barely Coupling Coordination Level—Synchronous Type

This type includes Xinzhou and Datong. These regions exhibit barely coupling coordination levels, with rural tourism and rural human settlement environment levels developing basically synchronously. Their coupling degrees range 0.483–0.495, coordinative degrees 0.373–0.375, and leading degrees $-0.078 \sim 0.157$, ranking 9th and 10th provincially, indicating relatively low coupling coordination levels with basically synchronous development. Therefore, these cities should give equal emphasis to both systems to promote progress toward higher coupling coordination levels.

2.2.5 Primary Coupling Coordination Level—Rural Tourism Lagging Type

This type includes only Shuozhou. This region exhibits a primary coupling coordination level, with rural tourism levels significantly lagging behind rural human settlement environment levels. Shuozhou's coupling degree, coordinative degree, and leading degree are 0.246, 0.189, and -0.164 , respectively, ranking last provincially due to its extremely low rural tourism level that substantially lags its rural human settlement environment. Therefore, Shuozhou should leverage its relatively good rural human settlement environment to promote rural tourism development.

2.3 Obstacle Factors in Coupling Coordinative Relationships

Using the above methods, we calculated the obstacle degrees of each dimension at the criterion level on the coupling coordinative levels of rural tourism and rural human settlement environments in various prefecture-level cities (Table). From the mean obstacle degree of each dimension, the seven dimensions averaged 11.11%–17.88%, ranking as: infrastructure (R_4), public services (R_3), industrial institutions (R_2), economic development (R_5), resource base (R_1), market demand (R_6), and ecological environment (R_7). The obstacle degree means of infrastructure, public services, and industrial institutions reached the “strong” level, while the other four dimensions were at the “weak” level, indicating that infrastructure, public services, and industrial institutions are key obstacle factors restricting the coupling coordinative development of rural tourism and rural human settlement environments in Shanxi Province. Therefore, priority should be given to strengthening infrastructure construction, improving public service levels, and optimizing rural tourism supply, while also optimizing their spatial layout.

Regarding the distribution of obstacle degrees across dimensions, resource base shows an extremely strong obstacle degree for Taiyuan and a strong obstacle degree for Shuozhou, indicating these cities should focus on rural tourism product innovation and quality improvement. Industrial institutions show strong obstacle degrees for all cities except Taiyuan and Datong, suggesting these regions should cultivate rural tourism enterprises and optimize supply. Market demand shows strong obstacle degrees for Yangquan, Shuozhou, Changzhi, and Jincheng, indicating these cities should strengthen rural tourism marketing and expand/upgrade demand. Economic development shows strong obstacle degrees for Lüliang, Datong, Xinzhou, Linfen, Jincheng, and Changzhi, suggesting these cities should promote rural economic development and increase farmers' income. Public services show strong obstacle degrees for all cities except Taiyuan, indicating these regions should strengthen rural public service facility construction and improve service quality. Infrastructure shows strong obstacle degrees for all cities except Taiyuan and Yangquan, suggesting these regions should advance rural infrastructure construction and improve production/living conditions. Ecological environment shows extremely strong obstacle degrees for Taiyuan and Yuncheng, and a strong obstacle degree for Jinzhong, indicating these cities should strengthen rural ecological environment protection and promote green industrial development.

3 Discussion

Developing rural tourism and promoting rural human settlement environment improvement have become important missions. Existing research has confirmed that rural tourism can drive human settlement environment improvement [?, ?, ?], while rural human settlement environments can support rural tourism development [?, ?, ?, ?]. This study selected Shanxi Province to further examine their coupling coordinative relationships and obstacle factors, finding that infrastructure, public services, and industrial institutions are the most critical obstacle factors. This conclusion shares some similarities with studies on constraints in one-way relationships [?, ?]. The significant regional disparities in coupling coordinative relationships and varying obstacle factors across regions can support the development approaches proposed by Lu Shuying [?] and Wang Cheng [?].

Compared with existing research, this study's main contribution lies in directly focusing on the bidirectional interaction between the two systems, examining the mechanisms, measurement, and obstacle factors of their coupling coordinative relationships. In establishing classification standards for coupling coordinative relationship types, we combined coordinative degree with leading degree to reflect both the coordination level and relative development status, enabling more precise differentiation of various relationship types. When establishing obstacle degree classification standards, we adjusted existing standards according to the study area's actual conditions and the index system's dimensional characteristics, enhancing applicability.

The coupling coordinative relationship between rural tourism and rural human settlement environments is a systematic issue involving multiple stakeholders and elements. Due to data availability limitations, this study selected 24 indices to examine the issue, though some unconsidered factors (e.g., policy systems, social security) also directly or indirectly affect their coupling coordinative relationships. Additionally, since indices related to rural tourism resource bases are difficult to obtain as time-series data, this study conducted analysis based on cross-sectional data. Theoretically, time-series data would more accurately reflect their coupling coordinative relationships and obstacle factors.

4 Conclusions

- (1) Regarding development levels, significant regional disparities exist in both rural tourism levels and rural human settlement environment levels across prefecture-level cities, with obvious spatial mismatches. Cities with higher rural tourism levels concentrate in central and southern Shanxi, while those with higher rural human settlement environment levels concentrate in central and northern Shanxi. Large gaps also exist in dimensional scores across the eight dimensions.
- (2) Regarding coupling coordinative relationships, all prefecture-level cities show medium-low coupling degrees and coordinative degrees, with considerable room for improvement. Jinzhong, Linfen, and Yuncheng are the rural tourism leading type of moderate coupling coordination level. Jincheng, Changzhi, and Lüliang are the synchronous type of moderate coupling coordination level. Taiyuan and Yangquan are the rural tourism lagging type of moderate coupling coordination level. Xinzhou and Datong are the synchronous type of barely coupling coordination level. Shuozhou is the rural tourism lagging type of primary coupling coordination level.
- (3) Regarding obstacle factors, infrastructure, public services, and industrial institutions are the key obstacle factors restricting the coupling coordinative development of rural tourism and rural human settlement environments in Shanxi Province. Significant disparities exist in obstacle distributions across the seven dimensions, with key obstacle factors varying by prefecture-level city.
- (4) Regarding priorities for promoting sustainable and coordinated development, Shanxi Province should prioritize strengthening infrastructure construction, improving public service levels, and optimizing rural tourism supply. Measures should be tailored to each region's coupling coordinative relationship and obstacle factor status to promote sustainable and coordinated development of rural tourism and rural human settlement environments.

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

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