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Study on the coupled and coordinated development of tourism, urbanization and ecological environment in shanxi province

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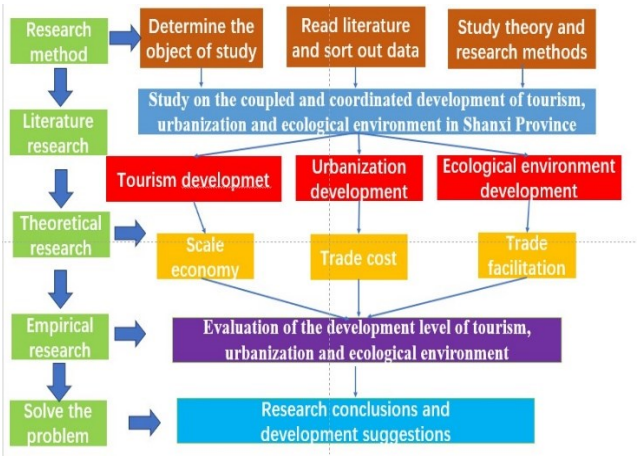
Graphical abstract



Abstract

This paper selects Shanxi Province as the study area and constructs a comprehensive evaluation index system of tourism, urbanization and ecological environment in Shanxi Province. Measurement methods such as polar deviation standardization, entropy value method and coupling coordination degree are adopted to measure the comprehensive development index, coupling degree and coupling coordination degree of tourism development, urbanization level and ecological environment quality in Shanxi Province from 2012 to 2022. The results show that from 2012 to 2022, the comprehensive development level of tourism, urbanization and ecological environment in Shanxi Province continues to rise, and the urbanization level continues to be higher than the tourism and ecological environment development levels, while the system coupling and coordination degrees are low, showing a dysfunctional state. In the future, while vigorously increasing the level of urbanization and developing tourism in Shanxi Province, it is necessary to pay more attention to ecological environmental protection and achieve the coordinated development of tourism, urbanization and ecological environment.

Keywords: Tourism, urbanization, ecological environment, coupled coordination, entropy value method

1. Introduction

Shanxi, also known as “San Jin”, is known as the “Museum of Ancient Chinese Culture” and “Museum of Ancient Chinese Architecture”, and is also one of the birthplaces of Chinese opera art. Shanxi is rich in coal resources, known as the coal town. The province is also home to the Hukou Falls on the Yellow River, Mount Hengshan, one of the Five Great Mountains, Mount Wutai, one of the Four Great Buddhist Sacred Sites, the Yungang Grottoes, one of the Four Great Buddhist Caves, the Pingyao Ancient City, one of the four best-preserved ancient cities in China, and the Guandi Temple in Yuncheng, the ancestor of the martial arts temples, among other places of scenic interest.

In 2023, Shanxi Province realized a GDP of 25698.18 billion yuan, of which the added value of the primary industry was 138.886 billion yuan, the added value of the secondary industry was 1332.969 billion yuan, and the added value of the tertiary industry was 1097.964 billion yuan. By the end of 2023, the total number of 5A-level tourist attractions in Shanxi Province will reach 11, national-level tourist resorts will achieve “zero”, 13,000 kilometers of the three No. 1 tourist highways will be fully completed, the total number of beds available for tourists in the province will reach 1 million, the percentage of overnight tourists will reach 30%, and per capita tourism spending will reach 900 yuan. The added value of tourism and related industries accounted for 3.7% of GDP. While developing the tourism industry, the urbanization process of Shanxi Province is also advancing. As of the end of 2023, the urbanization rate of the resident population in Shanxi Province varied significantly, with Taiyuan leading the rest of the cities by a large margin, reaching 89.23%, and Datong and Yangquan exceeding 70%, while the rest of the cities were lower than the national average level. Overall, the urbanization rate of the resident population in Shanxi Province will be 63.42% in 2023, slightly lower than the national average, ranking 16th among 31 provinces (municipalities and autonomous regions) in China. Shanxi Province is currently vigorously promoting the urbanization of the rural population and building a new pattern of coordinated development of cities and

small towns at all levels. The rapid development of urbanization and tourism has caused a certain impact on the ecological environment, and various contradictions are becoming more and more prominent. Therefore, it is particularly important to coordinate the relationship between the three systems.

2. Literature review

As a pillar industry of economic development, tourism can promote the development of other related industries, and it is the “sunrise industry” of China’s current development, and the tourism fever is rising throughout the country. As an important carrier of tourism, urbanization is closely related to the development of tourism, and as a new driving force for urbanization, the prosperity of tourism also drives the development of urbanization. Urbanization is the greatest development potential and domestic demand in China at present, and it is also the biggest driving force for the steady and healthy development of social economy during the "13th Five-Year Plan" period and even in the future. In 2016, China's urbanization rate reached 57.35%, and according to the law of "Northam S-shaped curve", it has entered a stage of steady acceleration of urbanization development. However, for a long time, the extensive development of urbanization has caused varying degrees of damage to the ecological environment, including a large consumption of water resources, land resources, minerals, energy, etc., as well as the resulting air pollution, water pollution, and sharp decline in biodiversity. At the same time, along with the rapid development of tourism and urbanization, the living standard of the urban people has been improving, and a large number of people are pouring into the cities and towns, which brings a series of ecological problems such as garbage pollution, water resource pollution, air pollution, and so on, and creates a great pressure on the ecological environment (Ariken *et al*. 2021).

Research on tourism, urbanization and ecological environment mostly focuses on between the two-two systems (Ahmed *et al*. 2020). The first aspect is the tourism-urbanization aspect. Foreign scholars have focused on the concept and characteristics of tourism urbanization, while domestic scholars have focused on the relationship between rural tourism and local urbanization. Under the development pattern of the new era, the interaction effect between rural tourism and local urbanization has emerged, and it is of far-reaching significance to study the coupling and coordination relationship between the two to promote the realization of China's rural revitalization strategy. Cai *et al* (2018) constructed a coordination index between tourism industry and new urbanization, and verified through examples that regional tourism has an important role in promoting the quality of urbanization. Based on the coupling model, Shang *et al* (2018) took the tourism system and urbanization system of Lanzhou city as the research object, and explored the dynamic changes of the coordination degree between the 2 systems in different periods. Ma *et al* (2017) clarified the core driving force of tourism growth from the perspective of industry generation, analyzed the causes and coupling development of the two systems at various stages with Zhangjiajie as an example, and found that there is a medium correlation between the tourism system and the urbanization system, and the degree of coupling coordination reaches the intermediate level of coordination. Taking rural tourism as the basic point, Ren *et al* (2018) proposed a multi-system coordination and improvement interaction mechanism from the synergistic development of new urbanization and rural tourism. Xie *et al* (2021) use the entropy value method and coupling coordination degree and other econometric analysis methods to explore the comprehensive development level and coupling coordination status of tourism and new urbanization in Yichang City, and come up with the development status between the two at different stages.

The second aspect is the tourism industry-ecological environment aspect (Ge *et al*. 2021, Huang *et al*. 2020). The relationship between ecological environmental protection and tourism is a relatively complex one, and the two influence and interconnect with each other in the process of synergistic promotion. At present, there are many evaluation index systems in the academic circles on the coupling and coordinated development of ecological environment and tourism, and the coupling and coordinated development is actually to pursue the synergistic promotion between the two to an ideal extent. However, the current literature is more biased towards the degree of interaction between the two in a certain region or province, and quantitatively studies the degree of coordination between the two, but does not empirically study whether the two can achieve a win-win situation and to what extent and in what combination factors can achieve the synergy between the two from the system level. Zhang *et al* (2017) analyzed the coordinated development relationship between the tourism economy and the ecological environment in the region by using the panel data of the Wanjiang City Belt, and put forward the development countermeasures of industrial integration. Fu *et al* (2019) comprehensively analyzed the tourism industry-ecological environment coupling and coordination relationship in Guizhou Province, and proposed obstacle indicators. Their results showed that the ecological environment construction in Guizhou Province did not have a significant supportive role for tourism development. Liu *et al* (2021) studied the tourism industry and ecological environment in Xinjiang, and proposed to play the leading role of the government in the ecological governance system to help synchronize the development of tourism and ecological environment. In addition, Hu *et al* (2020) studied the relationship between rural tourism and ecological environment from the perspective of rural tourism.

The third aspect is urbanization-ecological environment aspect (Khan *et al*. 2021, Wang *et al*. 2018). It is generally believed that the coordinated development of urbanization and ecological environment is the core goal of establishing a new type of urbanization. The ecological environment will deteriorate first and then improve with the development of urbanization, and there is an

interactive coupling stress mechanism between the two. Xie *et al* (2021) constructed an evaluation index system of urbanization and ecological environment system in Wuhan, and the results showed that the comprehensive development level of urbanization and ecological environment in Wuhan showed a fluctuating upward trend from 2008 to 2017. Ren *et al* (2020) sorted out the international research progress on urbanization and ecological environment from the perspective of near-remote coupling relationship, and proposed to strengthen the theoretical research on near-remote coupling between urbanization and ecological environment in China. Zhou, Yang *et al* (2020) took the Yangtze River Basin as the research object and explored the coupling relationship between ecological environment and urbanization.

Table1. Indicator selection of tourism-urbanization-ecological environment in Shanxi Province

Level 1 indicators	Level 2 indicators	Level 3 indicators	Causality	Weights	Literature sources
Travel trade	Tourism revenue	International income (billion dollars)	+	0.1315	Yang *et al*. (2020)
		Domestic revenue (billion yuan)	+	0.2537	
	Tourism industry	Total number of travel agencies (unit)	+	0.3137	Cai *et al*. (2018)
		Total number of star-rated hotels (unit)	+	0.3011	
Urbanization	Urbanization of population	Share of urban population (%)	+	0.1262	Zou *et al*.(2020)
		Share of tertiary employment (%)	+	0.1416	
	Economic urbanization	Tertiary sector contribution to the economy (%)	+	0.1837	Ma *et al*. (2017)
		Per capita disposable income of urban residents (yuan)	+	0.1188	
	Social urbanization	Number of museums (unit)	+	0.2216	Ren *et al*. (2018)
		Urban road area per capita (km^2)	+	0.0677	
		Number of standard operating vehicles (unit)	+	0.1404	
Ecological environment	Ecological pressure	Annual sewage discharge (ten thousand tons)	-	0.0623	Xie *et al*. (2021)
		Solid waste emissions (ten thousand tons)	-	0.1178	
		Sulfur dioxide emissions (ten thousand tons)	-	0.1748	
		Soot emission (ten thousand tons)	-	0.0797	
	Ecological state	Green area (hm^2)	+	0.1202	Zheng *et al*. (2020)
		Park area (hm^2)	+	0.1256	
		Number of parks (seat)	+	0.1706	
	Ecological response	Annual sewage treatment volume (ten thousand tons)	+	0.0830	Yu *et al*. (2021)
		Comprehensive utilization of solid waste (ten thousand tons)	+	0.0660	

Note: "+" indicates a desired increase, "-" indicates a desired decrease.

Combing through the literature, it is found that the research on the interrelationship among tourism, urbanization and ecological environment is still imperfect and mostly focused on the underdeveloped southwestern region, with less research on the central region (Yu, 2021). In terms of ecological environment, ecological environment is not only the material basis for the development of tourism, but also an important foundation for the development of local urbanization, and has an important impact on the coordinated development of the two. Taking Shanxi Province as an example, this study constructs a tourism-urbanization-ecological environment coupling model, aiming at exploring the interrelationships among the three, trying to reveal the current status of tourism, urbanization and ecological environment in Shanxi Province, and proposing healthy and sustainable development suggestions to promote the coordinated development of the three, and at the same time, providing reference for the development of tourism in central provinces (Yasmeen *et al*. 2020).

3. Research methodology

3.1. Data sources

The data come from Shanxi Statistical Yearbook 2012-2022, China Statistical Yearbook 2012-2022 and the website of Shanxi Provincial Bureau of Statistics. Among them, the moving average method is used to make up for the years with missing data.

3.2. Selection of Indicators

Accurately and scientifically selecting evaluation indicators and constructing a reasonable evaluation system are the basic prerequisites for studying the coupling relationship among tourism, urbanization and ecological environment in Shanxi Province. This study draws on the relevant literature and combines the data of Shanxi Province to divide the three systems. In order to eliminate the influence of a single indicator on the results and ensure the availability of data, multiple indicators are used for calculation. The tourism system selects 4 indicators at 2 levels, such as tourism income and tourism

industry. The urbanization system selects 7 indicators at 3 levels, including population, economy and society. The ecological environment system selects 9 indicators at 3 levels, such as state, pressure and response. The final evaluation system of tourism, urbanization and ecological environment is shown in Table 1.

3.3. Standardized processing

Since the scale of each indicator item in the three levels of indicators is different, each indicator is standardized so that comparative calculations can be made between indicators. Finally, a standardized model is established.

$$M_{ij+} = \frac{X - \min(X_{ij})}{\max(X_{ij}) - \min(X_{ij})}, i = 1,2,\cdots,b \quad (1)$$

$$M_{ij-} = \frac{\max(X_{ij}) - X}{\max(X_{ij}) - \min(X_{ij})}, i = 1,2,\cdots,a; \; j = 1,2,\cdots,b \quad (2)$$

Where M_{ij+} is the positive value of the *j*-th indicator in the *i*-th year of the system, M_{ij-} is the negative value of the *j*-th indicator in the *i*-th year of the system. X is the value of the original indicator, min (X_{ij}) is the minimum value of the original indicator, and max (X_{ij}) is the maximum value of the original indicator

3.4. Entropy method indicator assignment

This study refers to the Zahoor's (2022) and applies the entropy method in the objective assignment method to establish the indicator assignment model.

(1) Calculate the weight of the *j-th* indicator.

$$P_{ij} = \frac{M_{ij}}{\sum_{i=1}^{a} M_{ij}} \quad (3)$$

(2) Calculate the information entropy of the *j-th* indicator.

$$A_j = -(\ln a)^{-1} \sum_{i=1}^{a} P_{ij} \times \ln(P_{ij}), \; \ln a > 0 \quad (4)$$

(3) Calculate the coefficient of variation for the *jth* indicator.

$$\theta_j = 1 - A_j \quad (5)$$

(4) Calculate the weight of the *jth* indicator.

$$\partial_j = \frac{\theta_j}{\sum_{j=1}^{b} \theta_j} \quad (6)$$

3.5. Comprehensive development index

After determining the weights of the indicators in the subsystems, a linear weighting method is used to calculate the comprehensive evaluation index of each subsystem.

$$U_i = \sum_{j=1}^{b} \partial_j \times P_{ij} \quad (7)$$

$$H_i = \sum_{j=1+g}^{k} \partial_j \times P_{ij} \quad (8)$$

$$E_i = \sum_{j=1+k}^{b} \partial_j \times P_{ij} \quad (9)$$

In equation U_i, H_i and E_i denote the comprehensive evaluation indices of the three subsystems of tourism, urbanization and ecological environment, respectively.

3.6. Coupling models

Coupling is a phenomenon in which two or more systems interact with each other. It contains two concepts, namely, the degree of coupling and the degree of coupling coordination. The degree of coupling reflects the strength of the interaction between the systems, regardless of the advantages and disadvantages, the degree of coupling coordination reflects the trend of benign coupling, reflecting the state of coupling coordination is good or bad.

(1) Construct the tourism-urbanization-ecological environment coupling model.

$$C = \left(\frac{U_i \times H_i \times E_i}{(U_i + H_i + E_i)^3} \right)^{\frac{1}{3}} \quad (10)$$

Where *C* is the degree of tourism-urbanization-ecological environment coupling.

(2) Construct the tourism-urbanization-ecological environment coupling coordination model.

$$D = \sqrt{C \times T}, \; T = \alpha U_i + \beta H_i + \gamma E_i \quad (11)$$

Where *D* is the degree of coupling coordination, *T* is the comprehensive evaluation index of the subsystems, and the values of the coefficients of the importance of the three subsystems are determined to be α = 0.25, β = 0.40, and γ = 0.35, respectively, according to the research by Zou *et al* (2020).

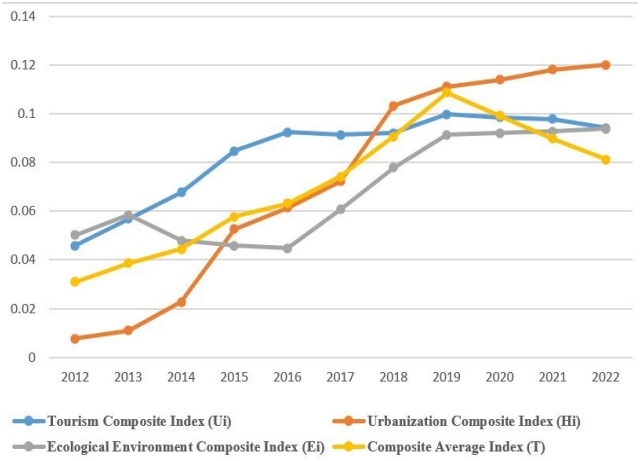


Figure 1. Comprehensive development curve of tourism-urbanization-ecological environment in Shanxi province

(3) Coupling coordination evaluation criteria. In order to facilitate the comparison of the differences between tourism-urbanization-ecological environment in Shanxi Province, the coupling degree and coupling coordination degree are graded by drawing on literature and literature, as shown in Table 2. Meanwhile, the system development characteristics are specified based on the size of the integrated development index of tourism-urbanization-

ecological environment subsystem: $U_i > H_i > E_i$ or $U_i > E_i > H_i$. Tourism ahead of its time $H_i > U_i > E_i$ or $H_i > E_i > U_i$, urbanization overruns; $E_i > H_i > U_i$ or $E_i > U_i > H_i$, ecology ahead of its time.

4. Empirical analysis

4.1. Evaluation of tourism-urbanization-ecological environment development

The entropy method was used to calculate the development index of three subsystems in Shandong Province from 2009 to 2022 (tourism index U_i, urbanization index H_i, and ecological environment index E_i), and then the tourism-urbanization-ecology was calculated. The comprehensive environmental evaluation index T (Table 3), and the weights of each evaluation index are shown in Table 1. At the same time, according to the calculated comprehensive evaluation index, the comprehensive development curve of tourism-urbanization-ecological environment in Shandong Province from 2009 to 2019 was drawn (see Figure 1).

As shown in Table 3, the evaluation indices of the three major subsystems of tourism, urbanization and ecological environment in Shanxi Province have increased year by year in recent years, with the tourism index increasing from 0.0459 in 2012 to 0.0942 in 2022, the urbanization index increasing from 0.0076 in 2012 to 0.1201 in 2022, and the ecological environment index increasing from 0.0503 in 2012 to 0.0933 in 2022. Meanwhile, the comprehensive evaluation index rises from 0.0309 in 2012 to 0.0812 in 2022. The comprehensive development curve of tourism, urbanization and ecological environment in Shanxi Province shows that the evaluation indices of tourism, urbanization and ecological environment sub-systems are all on a slow rising trend.

Table 2. Coupling and coupling harmonization levels coupling harmonization degree

Degree of coupling coordination	Coupling coordination level	Coupling level
(0, 0.1]	Extreme disorder	Low coupling
(0.1, 0.2]	Severe disorder	
(0.2, 0.3]	Moderate disorder	
(0.3, 0.4]	Mild disorder	Antagonism
(0.4, 0.5]	On the verge of becoming dysfunctional	
(0.5, 0.6]	Sue for harmonization	Running-in
(0.6, 0.7]	Mildly coordinated	
(0.7, 0.8]	Intermediate level coordination	
(0.8, 0.9]	Good coordination	High coupling
(0.9, 1.0]	Quality coordination	

Table 3. Comprehensive evaluation index and characteristics of tourism-urbanization-ecological environment in Shanxi Province

Year	U_i	H_i	E_i	T	Development characteristics
2012	0.0459	0.0076	0.0503	0.0309	Ecology ahead of its time
2013	0.0569	0.0109	0.0584	0.0386	Ecology ahead of its time
2014	0.0678	0.0228	0.0479	0.0445	Tourism ahead of its time
2015	0.0847	0.0527	0.0458	0.0578	Tourism ahead of its time
2016	0.0924	0.0615	0.0447	0.0632	Tourism ahead of its time
2017	0.0914	0.0722	0.0608	0.0742	Tourism ahead of its time
2018	0.0921	0.1033	0.0778	0.0906	Urbanization ahead of time
2019	0.0998	0.1111	0.0913	0.1088	Urbanization ahead of time
2020	0.0986	0.1139	0.0921	0.0992	Urbanization ahead of time
2021	0.0978	0.1181	0.0928	0.0898	Urbanization ahead of time
2022	0.0942	0.1201	0.0938	0.0812	Urbanization ahead of time

4.1.1. Evaluation of the level of tourism development

As canbe seen from Figure 1, the overall development level of the tourism industry shows an upward trend and can be divided into 3 phases, which are the growth phase from 2012-2016, the flat phase from 2016-2019, and the decrease phase from 2019-2022 due to the impact of epidemics. International revenues, domestic revenues and the number of travel agencies all showed growth from 2016-2019, with international revenues increasing from $4.73 billion per year to $6.76 billion per year, domestic revenues increasing from 601.37 billion yuan per year to 750.42 billion yuan per year, and the number of travel agencies increasing from 2,001 to 2,116 in this four-year period.

Although the above three indicators have improved, the overall level of development of the tourism industry has shown signs of slowing down, which is mainly due to the decline in the number of star-rated hotels year by year, the main reason for this situation is that hotels, as an important link in the tourism industry, the quality of service is often neglected. During this period, the government has actively responded to the country's call for the upgrading of the hotel management services, and has rigorously reorganized the hotel service industry, and for the hotels that do not meet the standards. It is worth noting that due to environmental protection requirements, the government has increased its efforts to rectify environmentally unfavorable scenic spots, which has limited the scale of tourism in some of the tourist

attractions, and in turn has had a certain impact on the tourism industry.

4.1.2. Evaluation of urbanization development level

As can be seen from Figure 1, during the 11-year period from 2012 to 2022, the urbanization level of Shanxi Province has increased year by year and exceeded the tourism index and the ecological environment index in 2018, and the growth level of its urbanization index has reached an average annual rate of 43.07%, which is much higher than the average annual growth rate of the tourism index and the ecological environment index, and the annual growth rate of the tourism index and the ecological environment index is 61.51% in 2019.According to the *Shanxi Provincial Statistical Yearbook 2019*, the urbanization level was 61.51% in 2019.The urbanization index of Shanxi Province further increased after 2014, when Shanxi Province issued the *New Urbanization Plan of Shanxi Province (2014-2020)*, which put forward the objectives of urbanization of counties and promotion of ecological civilization construction to further enhance the urbanization level of the province. Although the urbanization index shows an increase, the urbanization index is not high, only rising from 0.0076 in 2012 to 0.1201 in 2022, due to the following factors. Firstly, the urbanization level is not high due to the high proportion of employment in the primary industry in Shanxi Province. Secondly, the lack of strong support in the central and western regions, and the fact that there is only a single core city of Taiyuan, which is not sufficient to support the urbanization process in the central and western regions, and it is also not enough to drive the province's urbanization level to increase.

The development of urbanization has brought about rapid economic development. During the 11-year period from 2012 to 2022, the contribution rate of the tertiary industry to the economy has increased from 40.1% to 78.4%, the disposable income of urban residents has reached RMB 34,329. The construction of culture has been outstanding, with the number of museums increasing from 108 to 441. The travel for urban residents has become more convenient, with the area of urban roads increasing from 20.9% to 20.9% per capita. The area of urban roads has increased from 20.9 km^2 to 25.3 km^2, and the number of urban public transportation stations has increased from 27,531 to 64,046.

4.1.3. Evaluation of ecological environment development level

As can be seen from Figure 1, the ecological environment evaluation index has the same overall rising trend as the urbanization index and tourism index, but at the same time there is a fluctuation phenomenon, and the ecological environment index fell to a low of 0.0447 in 2016. Analysis of the data found that sulfur dioxide emissions, as a negative indicator, increased by 18.3% year-on-year in 2016, reaching 3.83 million tons, with the highest emissions of all years. Solid waste increased by 21.8 per cent year-on-year to 195.33 million tons, again at the highest rate. Meanwhile, the urbanization index and tourism index showed an upward trend from 2012 to 2016, indicating that the development of tourism and urbanization in Shanxi province sacrificed the ecological environment and developed in a rough form during these eight years. After 2016, the ecological environment index showed an upward trend again, and Shanxi province issued the Interim Measures for Ecological Compensation for Environmental Air Quality in Shanxi Province and Interim Measures for Ecological Compensation for Environmental Air Quality in Shanxi Province (2014-2020). And it is proposed to improve the ecological carrying capacity and accelerate the repayment of the outstanding debt brought about by rapid economic development.

4.1.4. Analysis of the comprehensive development level of tourism-urbanization-ecological environment

The comprehensive development level of tourism-urbanization-ecological environment in Shanxi Province shows an upward trend, and the urbanization index rises rapidly, driving the development of the whole system. In 2012-2013, the ecological environment index is greater than the urbanization index and the tourism index, presenting the ecological environment as being ahead of the curve. In 2014-2017, the tourism index is is greater than the urbanization index and the ecological environment index, presenting tourism overrun. In 2018-2022, the urbanization index is greater than the tourism index and the ecological environment index, presenting urbanization overrun. The tourism index and urbanization index show an increase at the same time, indicating a positive relationship between these two systems. However, after 2015, the ecological environment index is consistently lower than the other two subsystem indices, showing an inverted U-shape, indicating that the development of urbanization and tourism has caused a certain degree of damage to the development of the ecological environment, and the three subsystems show an imbalance phenomenon.

4.2. Analysis of tourism-urbanization-ecological environment coupling coordination

Using the coupling coordination formula and the entropy value method to calculate the weight of each subsystem, the coupling relationship of tourism-urbanization-ecological environment system in Shanxi Province is further calculated, as shown in Table 4. According to Table 4, the change curve of tourism-urbanization-ecological environment coupling coordination in Shanxi Province is drawn (see Figure 2). From Table 4 and Figure 2, it can be seen that from 2012 to 2022, the coupling degree of tourism-urbanization-ecological environment in Shanxi Province first rises and then stabilizes, and the coupling degree shows a gradual increase, and the coordination among the three sub-systems gradually increases. However, the coupling degree will no longer rise when it reaches the antagonistic stage, and the coupling coordination degree has only developed to the moderate dysfunction stage, without entering the coordinated development stage. It can be divided into the following four stages. In 2012, the tourism-urbanization-ecological

environment system of Shanxi Province was in a state of low coupling and extreme dysfunction, because the urbanization index was much lower than the tourism index and the ecological environment index, which may be due to the slowing down of the urbanization process caused by the economic crisis. In 2013, the tourism-urbanization-ecological environment system of Shanxi Province was in a state of low coupling and severe dysfunction, mainly due to the fact that due to the weakening of the impact of the economic crisis, the urbanization process gradually recovers. In 2014-2019, the tourism-urbanization-ecological environment system in Shanxi province showed an antagonistic severe dysfunctional state, with further increase in the urbanization index and pollutant emissions, which further curbed the development of the ecological environment. Although tourism revenue and the number of travel agencies are increasing, the number of star-rated hotels decreases due to the government's increased control, so the coupling coordination index is low. In 2020-2022, Shanxi Province's tourism-urbanization-ecological environment system shows antagonistic moderate dysfunction due to the impact of the epidemic, and although the indicators of the various subsystems are rising, they have not yet reached a coordinated state, and still has great development space.

Table 4. Tourism-urbanization-ecological environment coupling and coordination rank in Shanxi Province

Particular year	*C*	*D*	Coupling level	Level of coordination
2012	0.258	0.092	Low coupling	Extreme disorder
2013	0.260	0.101	Low coupling	Severe disorder
2014	0.305	0.115	Antagonistic phase	Severe disorder
2015	0.320	0.137	Antagonistic phase	Severe disorder
2016	0.319	0.143	Antagonistic phase	Severe disorder
2017	0.329	0.155	Antagonistic phase	Severe disorder
2018	0.332	0.174	Antagonistic phase	Severe disorder
2019	0.329	0.190	Antagonistic phase	Severe disorder
2020	0.326	0.205	Antagonistic phase	Moderate disorder
2021	0.328	0.216	Antagonistic phase	Moderate disorder
2022	0.329	0.233	Antagonistic phase	Moderate disorder

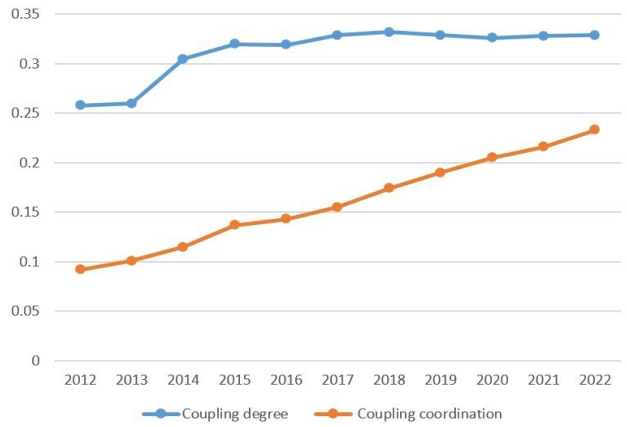


Figure 2. Change curve of tourism-urbanization-ecological environment coupling coordination in Shanxi province

5. Summary and recommendations

5.1. Summary

The development index, coupling degree and coupling coordination degree of the three subsystems of tourism, urbanization and ecological environment in Shanxi province from 2012 to 2022 show a good upward trend as a whole. The development level of urbanization continues to rise, the development level of tourism rises slowly, and the level of ecological environment shows a decline in the first period and a continuous rise in the later period. Overall, the ecological environment development level lags behind the urbanization and tourism development level, and the system coupling degree continues to be larger than the coupling coordination degree, reflecting the feature that high coupling may not be high coordination. Compared with other provinces, the degree of tourism-urbanization-ecological environment coupling and coupling coordination in Shanxi Province are generally low, and the overall coordination of the system needs to be further improved.

5.2. Recommendations

A high-quality ecological environment is fundamental to the sustainable development of society, and the pursuit of rapid urbanization and over-exploitation of tourism resources will have a negative impact on the ecological environment. Efforts to improve the quality of the ecological environment is the top priority for the current development of Shanxi Province, to promote eco-tourism and eco-urbanization, to gradually improve the ecological protection mechanism and to enhance the ecological carrying capacity. As a complex material system, the ecological environment is characterized by diversity, hierarchy and wholeness, so it is necessary to consider the formulation of policies for ecological protection in different areas of Shanxi Province, such as the western plains, the central mountains and the eastern hills.

At present, the domestic tourism market is gradually hot, and the tourism industry in Shanxi Province is relying on the rapid development of the urbanization process. And cities and counties at all levels should seize the opportunity to optimize the structure of the tourism industry, improve the quality of tourism development, and achieve the high-quality development of the tourism industry, and make local backbone culture and tourism enterprises bigger and stronger. At the same time, we will speed up the intelligent construction of the culture and

tourism industry, making full use of emerging technologies such as 5G and artificial intelligence to create intelligent scenic spots and hotels. The government has increased eco-tourism publicity, giving full play to the advantages of eco-tourism resources and avoiding over-exploitation and endangering the ecological environment.

Villages and towns should promote the decision-making and deployment of urbanisation in depth, consolidate the foundation, accelerate the coordinated development of new industrial parks and urbanization, and further realise the benign interaction between population aggregation, industrial upgrading and town development. At the same time, they should grasp the important role of tourism and other tertiary industries in the process of urbanization, strive to increase the proportion of the employed population in the tourism industry, and provide a solid carrier for the development of tourism. The people focus on ecological construction, advocate ecological livability and sustainable development of towns, actively change the mode of economic growth, advocate a green economy, and rely on high technology to reduce the emission of pollutants such as wastewater, exhaust gas and solid waste, and improve the utilisation rate of resources.

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