

Research Article

Coupling Coordinated Evolution and Forecast of Tourism-Urbanization-Ecological Environment: The Case Study of Chongqing, China

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As an important pioneering city in western China, Chongqing's urbanization and tourism development have brought increasing pressure on the eco-environmental system. This paper presents a comprehensive index system for assessment of the level of tourism based on four aspects: market size, tourism economy, tourism resources, and tourism services. In this paper, we use five indices—economic urbanization, demographic urbanization, social urbanization, spatial urbanization, and cultural urbanization—to establish a comprehensive index system for urbanization. The developed index system also characterizes the eco-environment based on three factors: eco-environmental pressure, eco-environmental response, and eco-environmental state. A coupling coordination degree model (CCDM) focusing on the degree of coupling coordination between tourism, urbanization, and the eco-environment was established using panel data collected from 2000 to 2017 for Chongqing, China. In addition, we used the gray prediction model to predict the degree of coupling coordination of the three systems in Chongqing from 2018 to 2023. The results showed that (1) overall, despite the twists and turns in the middle of the time period, the degree of coupling coordination of the three systems has become increasingly coordinated over time; (2) the three parameters (α -tourism, β -urbanization, and d -eco-environmental) that have been widely used in previous studies had little effect on the coupling coordinated system; and (3) according to the prediction results, the degree of coupling coordination of the three systems will continue to rise slowly, and the cooperation between the three systems will be close to perfect by 2023, which means that the development of one system will greatly drive the other two systems.

1. Introduction

Tourism is an indispensable industry for economic development and has become the main choice for many underdeveloped regions to promote urbanization; its development has always been concerned and supported by the state and society. However, the development of tourism and urbanization will inevitably have an impact on the ecological environment. At present, the development of economic is transforming from rapid development to high-quality development, and the protection of the ecological environment has received unprecedented attention in China. How to coordinate the relationship among tourism,

urbanization, and the ecological environment has become the key towards achieving sustainable development and has attracted social attention. Chongqing is a city with better economic development in underdeveloped western China, especially tourism, but its ability to drive the surrounding cities is insufficient. The spatial layout of the industrial structure needs to be further regulated, and the ecological environment is relatively deteriorating. Therefore, exploring the coordinated development of Chongqing's tourism, urbanization, and ecological environment will help promote the sustainable development of Chongqing and achieve high-quality development. Secondly, Chongqing is an important part of the Belt and Road and the Yangtze River

Economic Belt. Studying the coupling and coordinated development of tourism, urbanization and ecological environment in Chongqing will help promote the sustainable development of the Yangtze River Economic Belt and help the development of the Belt and Road. In addition, Chongqing is a mega city with a population of more than 30 million. Choosing Chongqing as a research object is representative, and it can also provide a case reference for other mega cities in the world (such as Cairo) that are located in underdeveloped areas and have good tourism development.

The possible contributions of this research are to (1) reveal the dynamic trend of coordinated development of tourism, urbanization, and eco-environment in mega city, breaking through the traditional research that is limited to the interaction between systems; (2) explore the impact of model parameters (α -tourism, β -urbanization, and d -ecological environment) change on the degree of coupling and coordination, which can provide reference for other scholars in choosing parameters; (3) predict the degree of coupling and coordination of tourism, urbanization, and ecological environment, hoping to improve the efficiency of government management, provide scientific reference for formulating work plans, and provide references for research in similar fields.

2. Literature Review

At present, a large number of excellent results have been achieved in research on tourism, urbanization, and eco-environment. Mullins (1991) first proposed the concept of tourism-urbanization [1]. Safavi (2012) pointed out that urbanization and tourism coexist, and they share common public services and infrastructure [2]. The interaction between tourism and urbanization has always attracted much attention, but based on different research perspectives, no consistent opinions have been obtained. Sonmez et al. (2012) believe that the development of tourism is conducive to the improvement of urbanization from the perspective of soil utilization [3]. However, Jasenka et al. (2019) pointed out that, in the future, tourism investment will be oriented to private interests and will not be conducive to the development of urbanization [4]. Therefore, the research on the interaction between tourism and urbanization needs more theoretical and empirical studies to supplement and perfection.

The development of tourism is a double-edged sword for the ecological environment. It not only produces negative effects, such as noise pollution and garbage pollution, but also produces positive effects, such as promoting the spread of culture and improving road infrastructure [5]. But how to balance the two? Holden (2009) believes that it is determined by the environmental ethics of the market [6]. From the perspective of sustainable development, Hunter et al. (2002) linked sustainable tourism and ecological footprint and proposed the concept of tourism-ecological footprint [7]. Ozturk et al. (2016) examined the environmental Kuznets curve (EKC) hypothesis by utilizing the ecological footprint as an environment indicator and GDP from tourism as the economic indicator [8]. In recent years, eco-tourism has

been encouraged, and it was found that it is an effective way to promote the development of tourism and protect the environment [9, 10]. The research on the relationship between urbanization and eco-environment began in some western countries where industrialization developed earlier. Howard (1898) first proposed the garden cities [11]. Grossmangm (1995) proposed the environmental Kuznets curve and found that the ecological environment presents an inverted "U" shape with economic growth [12]. That is to say, the early urbanization development will destroy the ecological environment, such as water, air, and soil [13–16]. After that, the urbanization development will protect the ecological environment.

In general, there has been a lot of research on the interaction between tourism, urbanization, and the ecological environment, but in the context of sustainable development, it is not enough to study the relationship between the three. Exploring the coordinated relationship between the three and promoting the three to reach the level of coordinated development as soon as possible is an urgent need for China to achieve high-quality development. However, the research on coupling coordination is concentrated between the two systems [17–20], and there are few studies between the three systems [21–23]. It is worth mentioning that there have been some achievements in concept definition, index system, and model construction. But we also found that there is no uniform rule for the use of the three parameters (α -tourism, β -urbanization, and δ -eco-environmental) in CCDM.

3. Coupling Mechanism

3.1. Concept. "Coupling" was originally a concept used in physics, which refers to the phenomenon that two or more systems or forms of motion affect each other through various interactions [24]. Geographical scholars borrowed this concept and used it to explain a phenomenon or process of complex interactions and adaptations that gradually tend towards coordination. Later, scholars of tourism also used it to study the coordination relationship between tourism and other social development systems or natural subsystems and to develop the concept of tourism coupling [25].

3.2. Coupling Mechanism. The tourism, urbanization, and ecological environment systems all promote and restrict each other while creating a coordinated relationship. The coupling mechanism of the three is shown in Figure 1.

Tourism is a highly correlated industry, and the development of tourism will also promote the development of urbanization: (i) the development of tourism, in turn, brings new vitality to the regional economy, which is conducive to investment and the accumulation of economic capital and facilitates urbanization. (ii) Tourism promotes urbanization of the population since the tourism requires numerous employees. According to the calculations of the UMWTO, each additional direct employment in tourism results in an increase of five indirect employment opportunities [25]. (iii) It promotes the development of urban culture by shaping the

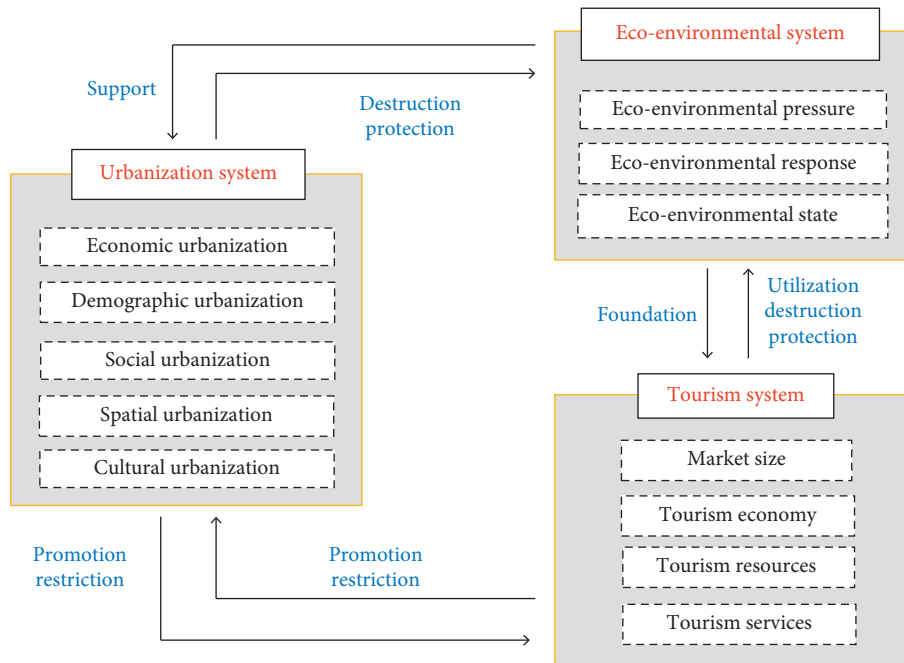


FIGURE 1: Coupling mechanism of tourism, urbanization, and eco-environment system.

unique image and culture of the city and promoting the protection and redevelopment of local traditional culture.

Urbanization has promoted the development of tourism and laid a foundation for the development of tourism: i) urbanization continuously improves the infrastructure and superstructures, promotes the development of interregional and intracity transportation, and provides tourists with food, housing, transportation, shopping, and entertainment [26]. (ii) Urbanization is conducive to promoting the aggregation of related industries, laying a foundation for the construction, extension, and improvement of the tourism industry. (iii) The process of urbanization increases the disposable income of residents, further stimulating the demand for tourism, and is conducive to the upgrading of consumption structure, the improvement of consumption levels, and change in consumption concepts. Conversely, with the rapid development of tourism, the influx of large numbers of people will cause environmental pollution and traffic congestion. In the process of urbanization, unreasonable and unplanned industrial layout and transportation layout will also hinder the development of tourism [27].

Tourism and urbanization must rely on the ecological environment [28]. The ecological environment provides resources for the development of tourism. It can generate income by developing various ecological and human resources, but overexploitation will destroy its character and initial appeal. The ecological environment provides the material foundation for urbanization. However, with the acceleration of urbanization, construction waste, industrial sewage, and dust have harmed freshwater and air resources. Although the development of tourism and urbanization accumulates wealth and provides financial support for the governance of the ecological environment, the damage to the

ecological environment is generally irreversible. Therefore, promoting the coordinated development of the three systems is a principal concern for regional sustainable development.

4. Study Area

Located in the southwest of China, Chongqing is at the junction of the more developed eastern region and the resource-rich western region and has a total area of 82,400 km². Chongqing is an important central city in China (Figure 2). It is an economic, technological, and logistics center on the upper reaches of the Yangtze River, and it is a comprehensive transportation hub for the southwest. It is an important strategic node of the Belt and Road Initiative and the Yangtze River Economic Belt and an inland open highland. Due to these economic and geographical characteristics, Chongqing has an abundance of development opportunities. Such as policy support, import and export trade, and industrial upgrade.

We selected some indicators to show the development process of Chongqing's tourism, urbanization, and ecological environment (Table 1). It can be seen that, from 2000 to 2017, Chongqing's tourism and urbanization have developed rapidly, but at the same time, the emission of pollutants fluctuates, which damages the ecological environment. The key to sustainable development is to develop tourism and urbanization on one hand and protect the ecological environment on the other. Therefore, it is urgent to deepen our understanding of the degree of coupling coordination between tourism, urbanization, and the eco-environment.

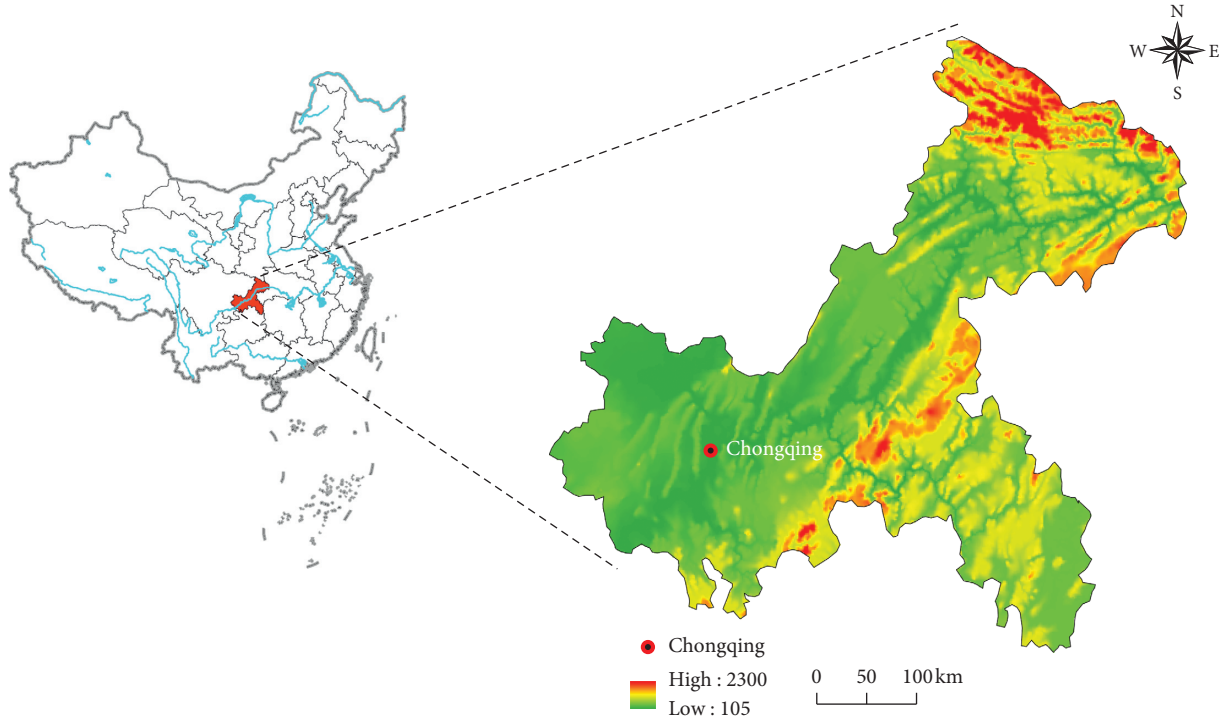


FIGURE 2: Study area in China.

TABLE 1: Development trends of some indicators of tourism, urbanization, and ecological environment.

Systems	Indicator	2000	2010	2017
Tourism system	Number of domestic tourists (10,000 people)	3069.67	16036.57	53871.86
	Number of inbound tourists (10,000 people)	26.61	137.02	358.35
	Number of A-level scenic spots (unit)	32	95	224
Urbanization system	Urban population (10,000 people)	1013.88	1529.55	1970.68
	Urbanization rate (%)	35.6	53	64.1
	Built-up area (km ²)	439.22	1136.53	1573.02
Ecological environment system	Total industrial wastewater discharge (10,000 t)	84344	45180	19303
	Total industrial exhaust emissions (10,000 t)	1907.9	10943.13	9596.76
	Investment in pollution treatment projects completed this year (10,000 yuan)	33524	77502	60702

5. Methods

5.1. Construction of Index Evaluation System. Drawing on the existing research results and comprehensively considering the scientific, representative, available, and comparable principles of index selection, we combined the existing statistical systems and indicators, taking into account Chongqing's tourism, urbanization, and ecological environment. For this study, we selected a total of 54 specific indicators at 12 levels and constructed an evaluation index system for the coordinated development of tourism, urbanization, and the ecological environment in Chongqing as shown in Table 2. Among them, the tourism system consists of four first-level indicators: market size, tourism economy, tourism resources, and tourism services; the urbanization system consists of five first-level indicators: population urbanization, spatial urbanization, economic urbanization, social urbanization, and cultural urbanization; the ecological environment system consists of three first-level indicators:

eco-environmental pressure, eco-environmental response, and eco-environmental state.

5.2. Establishment of Indicator Weights. To make them comparable, the indicators were first standardized as follows [28]:

$$X'_i = \frac{(X_i - \min X_i)}{(\max X_i - \min X_i)} \text{ (Positive index),} \quad (1)$$

$$X'_i = \frac{(\max X_i - X_i)}{(\max X_i - \min X_i)} \text{ (Negative index).}$$

In the formula, X'_i represents the data of the i th index after standardization; X_i represents the original data of the i th index; $\max X_i$, and $\min X_i$ represent the original data of the maximum and minimum values of the i th index in Chongqing. If a certain index is positively correlated with the

TABLE 2: Index system used for evaluating the relationship between tourism, urbanization, and the eco-environment.

Systems	First-level indicator	Second-level indicator	Unit	Weight	Nature	Interpretation	Reference
Tourism system	Market size	Number of domestic tourists	10,000 people	0.110 7	+	Reflects the scale of domestic tourism market	[22, 29]
		Number of inbound tourists	People	0.109 4	+	Reflects the scale of foreign tourism market	[22, 29]
	Tourism economy	Income from domestic tourism	100 million yuan	0.113 1	+	Reflects the tourism economy	[22, 29]
		Income from tourist foreign exchange	10,000 dollars	0.110 0	+	Reflects the tourism economy	[22, 27]
	Tourism resources	Per capita green space	m ²	0.106 2	+	Reflects the per capita greening degree	[21, 27]
		Number of A-level scenic spots	Unit	0.114 2	+	Reflects the richness of tourism resources	[27, 29]
	Tourism services	Number of star hotels	Unit	0.123 5	+	Reflects the number of tourist receptions	[27, 29]
		Number of travel agencies	Unit	0.107 6	+	Reflects the number of tourist receptions	[29-31]
		Travel agency employees	People	0.105 2	+	Reflects the number of travel agency employees	[30]

TABLE 2: Continued.

Systems	First-level indicator	Second-level indicator	Unit	Weight	Nature	Interpretation	Reference
Urbanization system		GDP	100 million yuan	0.030 5	+	Reflects the overall degree of economic development	[30]
		Per capita GDP	Yuan	0.030 4	+	Reflects the average degree of economic development	[22, 32]
		Per capita disposable income of urban residents	Yuan	0.030 8	+	Reflects disposable income per capita of urban residents	[21, 22]
	Economic urbanization	The total retail sales of social consumer goods	10,000 yuan	0.031 1	+	Reflects the sales of physical goods in the whole society	[27]
		Added value of the secondary industry	100 million yuan	0.030 5	+	Reflects the increased output value of the secondary industry over the previous year	[27]
		Proportion of secondary industry to GDP	%	0.036 0	—	Reflects the development level of the secondary industry	[21, 22]
		Proportion of output value of tertiary industry to GDP	%	0.029 0	+	Reflects the development level of the tertiary industry	[22, 31]
		Proportion of secondary and tertiary industries to GDP	%	0.030 4	+	Reflects the sum of the output value of the secondary and tertiary industries as a proportion of GDP	[27]
		Added value of the tertiary industry	100 million yuan	0.031 5	+	Reflects the added value of the tertiary industry	[27]
		Proportion of value added of the tertiary industry	%	0.030 2	+	Reflects the proportion of added value of the tertiary industry	[32]
	Population urbanization	Contribution rate of the tertiary industry	%	0.032 1	+	Reflects the contribution rate of the tertiary industry	[23]
		Urbanization rate	%	0.031 0	+	Reflects the proportion of urban population to total population	[30]
		Natural population growth	%	0.035 8	+	Reflects the growth rate of the total population	[23, 30]
Urban population		10,000 people	0.030 8	+	Reflects the urban population	[27, 33]	
Social employment		10,000 people	0.029 4	+	Reflects the social labor force	[30]	
Proportion of employees in the secondary industry		%	0.029 0	+	Reflects the number of employees in the secondary industry	[30]	
Spatial urbanization	Proportion of employees in the tertiary industry	%	0.034 1	+	Reflects the number of employees in the tertiary industry	[21, 22]	
	Urban employment	10,000 people	0.030 1	+	Reflects the urban labor force	[27]	
	Urban registered unemployment rate	%	0.028 6	—	Reflects the urban unemployment rate population	[27]	
	Built-up area	km ²	0.029 8	+	Reflects the degree of city construction	[31, 33]	
	Urban road area	10,000 m ²	0.030 7	+	Reflects urban road construction	[23, 30]	
	Highway mileage	km	0.031 0	+	Reflects the degree of urban highway construction	[27]	
	Engel index of urban households	%	0.035 3	+	Reflects the quality of life for urban residents	[33]	
	Number of medical institutions	Unit	0.028 7	+	Reflects medical security	[23]	
	Number of health technicians	People	0.030 5	+	Reflects the number of medical service personnel	[27]	
	Number of health technicians per 10,000 people	People	0.030 7	+	Reflects the distribution of medical resources	[33]	
	Number of doctors	10,000 people	0.030 9	+	Reflects the number of doctors	[30]	
	Total investment in fixed assets	10,000 yuan	0.030 9	+	Reflects the level of investment in urban construction	[31]	
	Cultural urbanization	Investment in real estate development	10,000 yuan	0.030 0	+	Reflects real estate development	[30]
Number of college students		People	0.030 7	+	Reflects training talent	[32]	
Number of libraries		Unit	0.038 4	+	Reflects the degree of urban civilization	[23]	
Patent grants		10,000 pieces	0.031 1	+	Reflects the development of science and technology	[30]	

TABLE 2: Continued.

Systems	First-level indicator	Second-level indicator	Unit	Weight	Nature	Interpretation	Reference
Ecological environment system	Eco-environmental pressure	Industrial sulfur dioxide emissions	10,000 t	0.087 0	—	Reflects sulfur dioxide emissions (the more emissions, the worse the environment)	[23, 32]
		Total industrial wastewater discharge	10,000 t	0.066 3	—	Reflects the amount of industrial wastewater discharge (the more discharge, the worse the environment)	[32]
		Total industrial exhaust emissions	10,000 t	0.070 2	—	Reflects industrial emissions (the more emissions, the worse the environment)	[21, 23]
		Production of industrial solid waste	10,000 t	0.070 7	—	Reflects the volume of industrial solid waste produced (the more production, the worse the environment)	[33]
		Industrial smoke and dust emissions	10,000 t	0.076 7	—	Reflects industrial smoke emissions (the more emissions, the worse the environment)	[30, 31]
	Eco-environmental response	Investment in pollution treatment projects completed this year	10,000 yuan	0.071 8	+	Reflect the effectiveness of environmental governance	[29]
		Comprehensive utilization rate of industrial solid waste	%	0.071 6	+	Reflects the ability to recycle and reuse industrial solid waste	[30]
		Good air quality days	Day	0.071 1	+	Reflects urban air quality	[30]
		Total water supply	10,000 m ²	0.072 0	+	Reflects urban water supply capacity	[32]
		Total energy consumption	10,000 t	0.069 0	+	Reflects urban energy supply capacity	[30]
Eco-environmental state	Total amount of urban natural gas	10,000 m ²	0.072 1	+	Reflect the city's natural gas supply capacity	[29]	
	Area of nature reserves	100 km ²	0.098 4	+	Reflects urban ecological resources	[29, 33]	
	Ratio of protected area to area of jurisdiction	%	0.103 0	+	Reflects urban greening	[23, 31]	

coordination relationship, $X'_i = (X_i - \min X_i) / (\max X_i - \min X_i)$ is used for standardization, and the nature in Table 1 is "+", indicating a positive effect on coordination; otherwise, $X'_i = (\max X_i - X_i) / (\max X_i - \min X_i)$ is used, and the nature is "-", indicating a negative effect on coordination.

The weight of each indicator is determined by the coefficient of the variation method, which can eliminate the bias. The specific formula is as follows [28]:

$$v_i = \frac{\sigma_i}{\bar{x}_i},$$

$$w_i = \frac{v_i}{\sum_{i=1}^n v_i}. \quad (2)$$

In the formula, w_i represents the weight of the i th index; v_i represents the variation coefficient of the i th index; σ_i represents the standard deviation of the i th index; and \bar{x}_i represents the average number of the i th index.

5.3. Tourism-Urbanization-Eco-Environment Comprehensive Evaluation Model

5.3.1. Comprehensive Development Level of Each System. We referred to the research of Liao et al. (2018) and used the following equation to quantify the comprehensive evaluation function of tourism, urbanization, and the ecological environment systems [26]:

$$U_1 = \sum_{i=1}^n w_i x'_i,$$

$$U_2 = \sum_{j=1}^n w_j y'_j, \quad (3)$$

$$U_3 = \sum_{k=1}^n w_k z'_k.$$

In the formula, U_1 , U_2 , and U_3 represent the comprehensive evaluation function of tourism, urbanization, and ecological environment, respectively; w_i , w_j , and w_k represent the weight of tourism, urbanization, and ecological environment; and x'_i , y'_j , and z'_k represent the dimensionless values.

5.3.2. Coupling Degree Model. Using the model of coupling and coordination developed, a coupling model of Chongqing's tourism, urbanization, and ecological environment was established [22, 27]:

$$C = \left[\frac{U_1 \times U_2 \times U_3}{[(U_1 + U_2 + U_3)/3]^3} \right]^k. \quad (4)$$

In the formula, C is the coupling degree of the system, and $C \in [0, 1]$; the higher the value of C , the better the coordination. k is the adjustment coefficient of the system, and $k=6$ based on previous studies such as the one conducted by Hu et al. (2015) [22].

5.3.3. Coupling Coordination Degree Model. The coupling degree can only indicate the strength of the mutual influence of the systems but can indicate neither whether the systems promote each other nor the level of mutual promotion. Therefore, this article introduces the coupling coordination degree model to reflect the overall level of coordination between tourism, urbanization, and the ecological environment. This was calculated as follows [22]:

$$D = \sqrt{C \times T},$$

$$T = \alpha U_1 + \beta U_2 + \delta U_3. \quad (5)$$

In the formula, D represents the degree of coupling coordination; T represents the comprehensive index of tourism, urbanization, and ecological environment; and α , β , and δ represent the weights. Some studies have used different weight values. Hu et al. (2015) held that although tourism and urbanization promote each other, the relationship is not symmetrical, with the ecological environment playing an important role in the development of tourism and urbanization; for this reason, Hu et al. (2015) assigned the following weight values: $\alpha = 0.2$, $\beta = 0.4$, and $\delta = 0.4$ [22]. Gao et al. (2016) took into account the different contribution rates of the three major systems, taking $\alpha = 0.35$, $\beta = 0.3$, and $\delta = 0.35$ [23], while Wang (2018) argued that tourism and urbanization promote each other, with the ecological environment as the basis for the development of tourism and urbanization so that $\alpha = 0.3$, $\beta = 0.3$, and $\delta = 0.4$ [28]. Zhou et al. (2016) held that tourism and urbanization are integrated and thus assigned equal importance to each such that $\alpha = 0.4$, $\beta = 0.4$, and $\delta = 0.2$ [30]. Finally, Deng et al. (2018) conducted a comprehensive analysis using expert scoring and a thorough inspection and decided to take $\alpha = 0.25$, $\beta = 0.4$, and $\delta = 0.35$ [21]. In this article, we calculate different values and compare them in Section 6.3. Using the existing research results, combined with the research focus of this paper, the degree of coupling coordination of tourism, urbanization, and ecological environment was divided into 6 levels (Table 3) [21, 34].

5.4. Gray GM (1,1) Prediction. The gray system theory was first proposed in China in 1982. The gray model is a mathematical method based on the gray system theory, and it can find the inherent rules from a series of data. The gray model mainly predicts the data in the singular sequence. The specific implementation steps are as follows [26]:

- (1) Establish the original sequence and sort the n actual observations: $X_0 = \{x_0(1), x_0(2), \dots, x_0(n)\}$. Then, the original sequence is accumulated to obtain a new sequence: $X_1 = \{x_1(1), x_1(2), \dots, x_1(n)\}$. The new sequence is fitted by a first-order differential equation, and the corresponding differential equation of the gray model is obtained [26]:

$$\frac{dX_1}{dt} + \alpha X_1 = \mu, \quad (6)$$

TABLE 3: Coordinated development level evaluation criteria.

Coordination state	D value	Description	Types
Serious imbalance	$0 < D \leq 0.2$	The nexus between the three systems is extremely poor	Imbalance decay type
Imbalance	$0.2 < D \leq 0.4$	The interaction between the three systems is weak	
Endangered	$0.4 < D \leq 0.5$	The interaction between the three systems is slightly increased	Intermediate transition type
Little coordination	$0.5 < D \leq 0.6$	The relationship between the three systems is slightly coordinated	
Coordination	$0.6 < D \leq 0.8$	The relationship between the three systems is coordinated	Coordination promotion type
Good coordination	$0.8 < D \leq 1$	The coordination between the three systems is extremely good	

where α is the development coefficient and μ is the gray effect.

- (2) Let \hat{a} be the parameter vector and $\hat{a} = (a/\mu)$, which can be solved using least squares: $\hat{a} = (B^T \times B)^{-1} \times B^T \times Y_n$. After solving equation (6), the prediction model is as follows [33]:

$$X_1(k+1) = \left[x_0(1) - \frac{\mu}{a} \right] e^{-ak} + \frac{\mu}{a}, \quad (k = 1, 2, \dots, n). \tag{7}$$

- (3) Finally, the accuracy test is performed, and the accuracy level is shown in Table 4. If both P and C are within the permitted range, this model can be used for prediction [35].

5.5. *Data Sources.* The data used in this paper was obtained from relevant websites such as *The Chongqing Statistical Yearbook (2000-2017)* [36] and the official website of the National Bureau of Statistics of People’s Republic of China [37]. Missing data were supplemented by the difference method, which strives for completeness and accuracy of the data.

6. Results

6.1. *Analysis of The Comprehensive Evaluation Index.* The comprehensive evaluation index of Chongqing’s tourism, urbanization, and ecological environment systems is shown in Figure 3. The fluctuation trends of tourism and urbanization are relatively consistent. The ecological environment showed a trend of rising-fluctuating-rising steadily; it was lower than that of the other two systems for the first time in 2013.

The development trend of tourism in Chongqing can be roughly divided into 4 stages: a low-level and steady growth stage from 2000 to 2008 followed by a fast-rising stage from 2008 to 2013, when its value exceeded the comprehensive index of urbanization; from 2013 to 2016, the comprehensive index of tourism was significantly higher than others, but its growth trend slowed down; and from 2016 to 2017, there was a sharp increase. Chongqing’s tourism development has been mainly constrained by the amount of consumers’ disposable income. Due to the development of social economy, more and more people travel, and thus tourism has become a pillar industry for Chongqing that has further stimulated the development of its tourism industry.

The increase in urbanization in Chongqing can be roughly divided into three phases: from 2000 to 2008, the

comprehensive index of urbanization was in a volatile growth stage with a relatively slow increase; from 2008 to 2016, the comprehensive index of urbanization was in a stage of steady and rapid growth; and from 2016 to 2017, the comprehensive index of urbanization showed a significant downward trend. This change may be explained by the fact that, in the earlier period, the large-scale influx of workers into the city fueled the economic development and accelerated urbanization. Subsequently, the rapid development of real estate accelerated land urbanization. The downward trend is mainly related to municipal government policies and the quality of urbanization. For example, *the Special Work Plan for Chongqing to Rectify and Regulate the Intermediary Behavior of Real Estate Development and Sales* maintains the balance between supply and demand for real estate and limits real estate speculation [38], while *the Chongqing City Fine Management Standard* is committed towards improving the quality of life of Chongqing residents [39].

The development trend of Chongqing’s ecological environment is also roughly divided into three stages: from 2000 to 2008, the comprehensive index of ecological environment showed a rising trend, while it showed large fluctuations from 2008 to 2013, with no obvious upward trend; in 2014, the volatility period ended, and a new rising trend began. Before 2008, the increase in tourism and urbanization had not exceeded the carrying capacity of the ecological environment; however, from 2008 to 2013, the government and entrepreneurs were unaware of the importance of the ecological environment, and thus the ecological environment was severely damaged while developing the economy. After 2013, there was increasing concern regarding environmental pollution in Chongqing, and as a result, environmental governance was strengthened leading to an increase from 3–4 points to 8.5–9 points on *the District and County Economic and Social Development Performance Evaluation Index System*, which is higher than the GDP (gross domestic product) growth evaluation score.

6.2. *Analysis of the Coupling Degree.* The development trend of the coupling degree between Chongqing’s tourism, urbanization, and ecological environment is shown in Figure 4. Among them, U_1-U_2 indicate the development trend of Chongqing’s tourism-urbanization system; U_1-U_3 indicate the development trend of Chongqing’s *tourism-ecological environment system*; U_2-U_3 indicate the development trend of Chongqing’s urbanization-ecological environment system; and $U_1-U_2-U_3$ indicate the development trend of

TABLE 4: Gray prediction accuracy inspection level standards.

P	C	Model accuracy level	P	C	Model accuracy level
>0.95	<0.35	First grade	>0.80	<0.50	Second grade
>0.70	<0.65	Third grade	<0.70	>0.65	Fourth grade

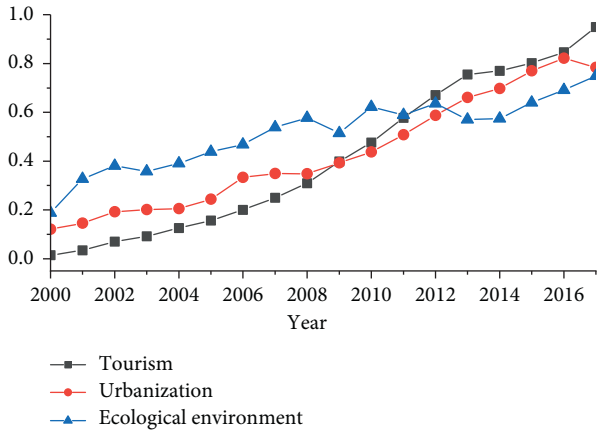


FIGURE 3: The comprehensive evaluation index of tourism, urbanization, and the eco-environment in Chongqing.

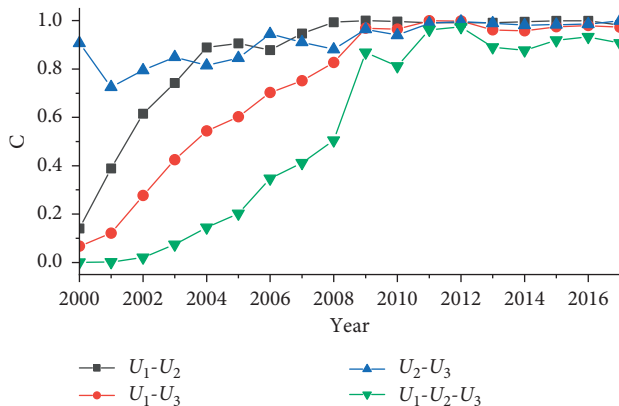


FIGURE 4: The coupling degree of tourism, urbanization, and the eco-environment in Chongqing.

Chongqing’s tourism-urbanization-ecological environment system.

The coupling degree of the tourism-urbanization system is divided into three phases: a rapid growth phase from 2000 to 2004, indicating a closer relationship between Chongqing’s tourism and urbanization, with the mutual promotion between tourism development and urbanization gradually becoming more significant. A period of gentle growth followed from 2004 to 2008, but an anomaly occurred in 2006, possibly because the rapid increase in urbanization did not have a corresponding positive effect on tourism. The period from 2008 to 2017 was stable, which is related to Chongqing’s efforts to build a global tourism city, and indicated a close relationship between tourism and urbanization.

The coupling degree of the tourism-ecological environment system can be divided into two phases: a rapid growth phase from 2000 to 2009, where we see a change from low-level coupling to high-level coupling, and a period with a high coupling level from 2009 to 2017. At the beginning of the first phase, tourism development is lagging and thus did not have a large impact on the ecological environment. The two systems seem to have little correlation. With the development of tourism, there was a greater impact on the ecological environment. There were small fluctuations in the second phase from 2009 to 2017, but there was still a high degree of coupling. The symbiotic relationship between tourism and the ecological environment is more obvious; a positive development in either system will have a positive impact on the other.

The coupling degree between urbanization and the ecological environment can also be divided into two stages: before 2012, there was a period of significant fluctuation, but the two systems were in the coupling stage, while after 2012, the coupling degree of the two systems showed a gentle upward trend. Development of urbanization has always been associated with the ecological environment. The early development of urbanization severely damaged the ecological environment; however, in 2012, the 18th National Congress of the Communist Party of China was held, and government policy shifted towards new type and ecological urbanization, which recognizes that urbanization and the ecological environment are inseparable, and as a result, these two systems have become increasingly coordinated.

The coupling degree of the three systems can be divided into two phases. From 2000 to 2009, it showed a steady upward trend and increased rapidly from low-level coupling to the running-in phase. Low-level coupling was mainly caused by the lagging development of tourism and urbanization and the low degree of coupling between the tourism-urbanization and tourism-ecological environment systems. After 2009, the coupling degree of the three fluctuated, but they were all still in a high-level coupling stage. Due to the destruction of the ecological environment, the coordination degree of the three fluctuated; however, after 2012, environmental governance was strengthened, and the fluctuation of the three has slowed down since then.

6.3. Analysis of the Degree of Coupling Coordination. To test the influence of tourism, urbanization, and the ecological environment on the degree of coupling coordination, this study analyzed five cases with different parameters for tourism, urbanization, and the ecological environment. The degree of coupling coordination among the three are shown in Figure 5. The comparison of the five cases of coupling results revealed that the overall trends were consistent, despite slight differences (Figure 6). These findings indicate that the degree of coupling coordination is not greatly affected by the weight of the three parameters (α -tourism, β -urbanization, and d -eco-environmental). Therefore, this article primarily focused on the general trends of the results.

According to Table 2, the degree of coupling coordination of Chongqing’s tourism, urbanization, and the

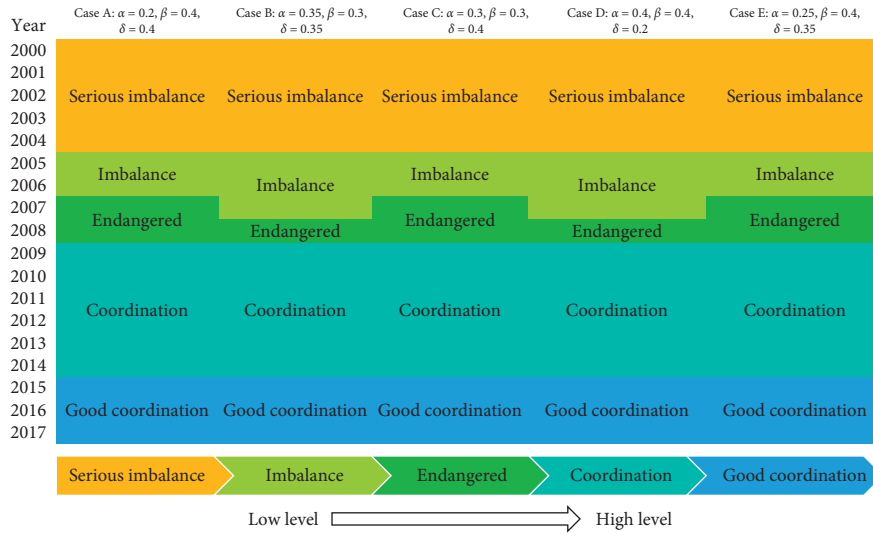


FIGURE 5: Comparison of the degree of coupling coordination under different parameters.

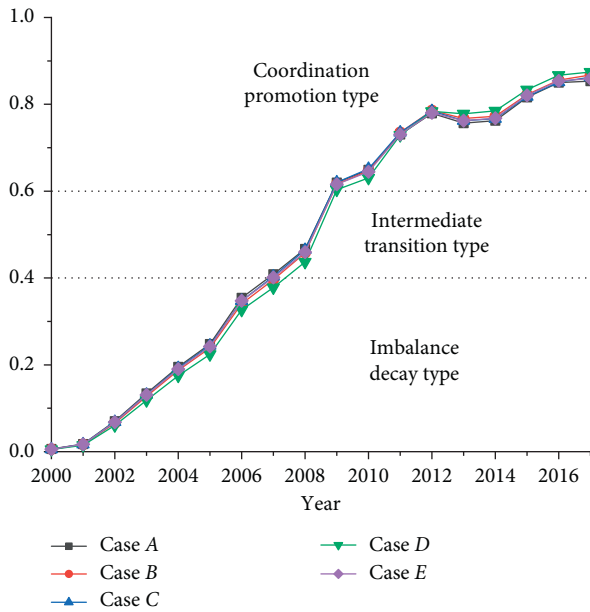


FIGURE 6: Development of the degree of coupling coordination under different parameters.

ecological environment from 2000 to 2017 can be divided into three types; from 2000 to 2007, $D < 0.4$, which is an imbalance decay type; from 2007 to 2009, $0.4 < D \leq 0.6$, which is an intermediate transition type; and from 2009 to 2017, $0.6 < D < 1$, which is a coordinated promotion type.

According to the fluctuation curve of the degree of coupling coordination, it can be roughly divided into three stages:

- (1) A steady upward trend from 2000 to 2012. The early degree of coupling coordination is low, mainly because of the lagging development of tourism and urbanization, and the coupling degree of the three is at a low-level coupling stage. From 2008 to 2009, the sharp increase in the curve was related to the

accelerated recovery of the economy and the accelerated development of the tourism industry after the subprime mortgage crisis.

- (2) From 2012 to 2013, there was a slight decrease since, despite the better development of tourism and urbanization in Chongqing, the ecological environment had been severely damaged, which has affected the degree of coupling coordination among the three. Among the comprehensive evaluation indexes of the ecological environment system, the coupling degree of the three systems and the degree of coupling coordination of the three declined in 2013, indicating that the overall degree of coupling coordination is consistent with the coupling degree between the systems.
- (3) From 2013 to 2017, there was a steady upward trend, a result of the fact that Chongqing's tourism, urbanization, and the ecological environment had developed rapidly, and the coupling degree between three systems had improved to reach a high level of coupling. Any significant development of one of the three will have an equal promotion effect on the others.

6.4. Predictive Analysis. The weights of tourism, urbanization, and the ecological environment have no significant impact on the degree of coupling coordination among the three. However, Chongqing's ecological environment plays an important role in both the development of tourism and urbanization; urbanization is the foundation of tourism development, and the tourism industry is vulnerable. In general, the ecological environment and urbanization development are more important than tourism. Therefore, we selected the following weight calculation results for prediction: $\alpha = 0.2, \beta = 0.4$, and $\delta = 0.4$. Based on the degree of coupling coordination of tourism, urbanization, and the ecological environment in Chongqing from 2011 to 2017, the

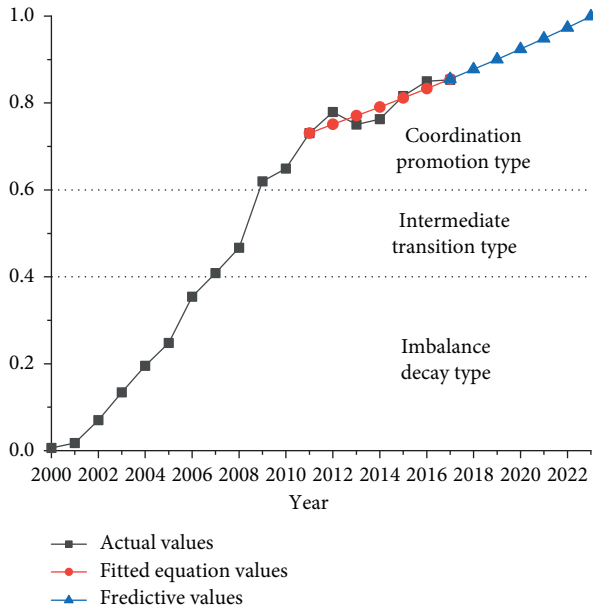


FIGURE 7: Forecast of the degree of coupling coordination.

prediction model of the degree of coupling coordination was obtained: $X_1'(K+1) = 28.5244e^{0.02598K} - 27.7936$. We then tested the accuracy of the prediction model and found that $C = 0.40$ and $P = 0.86$. Referring to Table 4, the accuracy level is between the first and second levels and can be used for predicting the trend in the degree of coupling coordination. The prediction results from 2018 to 2023 are shown in Figure 7.

The results predict that, in the future, the degree of coupling coordination will show a trend of steady growth, but the growth rate will gradually slow down. If there are no emergencies, the degree of coupling and coordination of tourism, urbanization, and ecological environment will always be in a coordination promotion type, and the three systems will achieve a positive mutual promotion effect and reach a state of coordination.

7. Conclusion and Discussions

Taking Chongqing as an example, this paper studies the dynamic changes of the degree of coupling coordination of tourism, urbanization, and eco-environment of a megacity in underdeveloped areas. The main findings are summarized below.

First, the comprehensive evaluation indicators of the tourism and urbanization systems in Chongqing generally showed a steady upward trend. Before 2008, the comprehensive evaluation index of urbanization was always higher than that of tourism, because tourism demand always lags behind the demand for economic growth. As the development of urbanization accumulates wealth and stimulates the development of tourism, the comprehensive development index of tourism is always higher than that of urbanization after 2008. After 2012, the comprehensive evaluation index of urbanization and ecological environment is lower than that of tourism, and Chongqing has become a city with

advanced tourism development. From the evaluation index of eco-environment, Chongqing has a good ecological environment. However, from 2008 to 2013, there were fluctuations; this is mainly due to the double pressure from the economy and tourism that has destroyed the ecological environment. After 2013, although urbanization and tourism are still developing rapidly, the comprehensive evaluation index of eco-environment has shown a steady upward trend. This is because people's awareness of environmental protection has increased, and the government has implemented environmental protection policies.

Second, the coupling degree value of U_2-U_3 was relatively large. This indicates that there is always significant interaction between the development of urbanization and eco-environment in Chongqing. The coupling degree of U_1-U_2 , U_1-U_3 , and $U_1-U_2-U_3$ generally showed an upward trend over time. In the early years, the economy of Chongqing is backward, and economic growth is the main task of Chongqing's development. The government has not paid much attention to the development of tourism, and people lack tourism demand, resulting in a low degree of interaction between tourism, urbanization, and the ecological environment. Therefore, the coupling degree of tourism, urbanization, and ecological environment is extremely low.

Third, the degree of coupling coordination of tourism, urbanization, and the ecological environment has shown a shift from an imbalance decay type to an intermediate transition type to a coordination promotion type. Before 2008, it was mainly tourism and urbanization that restricted the coordinated development of the three. The degree of coupling coordination was less than 0.4, which was an imbalance decay type. Since then, the economic effects of tourism have gradually emerged. On one hand, Chongqing has built numerous projects to attract tourists; on the other hand, people's demand for tourism has increased. Therefore, the rapid development of tourism has promoted the coordinated development of the three in Chongqing. We found that the three parameters (α -tourism, β -urbanization, and δ -eco-environmental) have had little effect on the degree of coupling coordination. It may be because the comprehensive evaluation indexes of tourism, urbanization, and ecological environment are extremely close, leading to similar calculation results. The prediction results show that, from 2018 to 2023, the degree of coupling coordination between tourism, urbanization, and the eco-environment in Chongqing as well as the interconnectedness of the three systems is increasing.

7.1. Theoretical Implications. First, the CCDM is established, and the coupling degree between the three systems of tourism, urbanization, and ecological environment is quantitatively studied. The similar approaches can be extended to more interacting systems to carry out coupling coordination research aimed at understanding the status quo and finding ways to promote the development of more systems. In addition, we have compared the influence of different parameters (α -tourism, β -urbanization, and δ -eco-

environmental) on the coordination results, which can provide reference for other scholars in choosing parameters.

Second, we used the gray prediction model to predict the degree of coupling and coordination of Chongqing's future tourism, urbanization, and ecological environment. The above method can be applied to the prediction research of coupling coordination degree in different regions and different systems. In addition, similar methods can also be applied to more systems for predictive research aimed at grasping the future development direction of the system and providing scientific basis for the formulation of policies and work plans.

7.2. Practical Implications. Before 2008, due to the low levels of tourism, there was little interaction between tourism, urbanization, and the ecological environment in Chongqing, and the degree of coupling coordination of the three systems was an imbalance decay type. Later, the Chongqing Tourism Development Committee had issued a series of tourism implementation plans and special plans such as *The Twelfth Five-Year Plan* for Chongqing's Tourism Development, which provided a strong foundation for the development of tourism. Since then, Chongqing has successfully created a number of boutique tourist attractions such as Nanshan's Golden Foshan and Liyang Taohuayuan, and Chongqing is now a trending Internet topic. It can be seen that the development of Chongqing's tourism is closely related to government support. Therefore, in the future, Chongqing may strengthen and reform tourism regulations. In addition, Chongqing should continue to develop the market for senior citizens and primary and middle school students, while innovatively increasing Chongqing's tourism profile. In the era of big data, Chongqing should also accelerate the integration of tourism and the Internet.

From 2008 to 2013, the comprehensive evaluation indicators of tourism and urbanization increased, but the comprehensive evaluation indicators of the ecological environment showed large fluctuations, which shows that the development of tourism and urbanization has had an adverse impact on the ecological environment. Once the ecological environment is destroyed, it is difficult to repair. In the future, Chongqing's development of tourism and urbanization must make the protection of the ecological environment a priority. Chongqing should continue to reform environmental protection systems and strengthen the construction of environmental protection through investment in both talent and capital, while continuing to accelerate the elimination of high-energy-consuming and high-polluting enterprises, vigorously developing ecological industries, and actively promoting ecological restoration including increasing forest coverage.

As urbanization, tourism, and the eco-environment become increasingly interconnected, the coupling and coordination of the three systems also increase. The urbanization of Chongqing should take into account the overall context and shift to high-quality development. This will not only enhance economic development, but also enhance cultural urbanization and reduce damage to the ecological

environment. Historically, the primary problem for urban development has been traffic reduction, and Chongqing is no exception. Its unique geographical location is an important advantage and a main factor in Chongqing's rapid development. In the future, Chongqing should continue to take advantage of the transportation hub in the southwest to solve the country's traffic problem. This will further promote the development of tourism, especially rural leisure tourism. In addition, talent training is an indispensable key factor in urbanization. Thus, Chongqing should further invest in talent to enhance Chongqing's sustainable development.

7.3. Limitation. Given the fact that our study was intended to explore the coordination relationship between tourism, urbanization, and the eco-environment in Chongqing, the design of the indicator systems was based on the comprehensive consideration of the development of tourism, urbanization, and eco-environment in Chongqing. Although it provides a new research indicator system in similar regions, the indicator systems may not be applicable to other countries and different regions. Future research should update the indicator systems and the coordination state criteria to meet the needs of various regions and periods. In addition, the coupling and coordination of space should be considered, and the factors that affect its coupling and coordination should be further analyzed.

Data Availability

The data used in this article are from relevant websites such as The Chongqing Statistical Yearbook (2000–2017) and the official website of the National Bureau of Statistics of People's Republic of China. The missing data were supplemented by the difference method, which strives for completeness and accuracy of the data. Should readers need data, it can be provided separately.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

The study was designed by L.L. (Liuxin Li), Q.Y. (Qing Yang), and X.X. (Xinli Xie); the data from yearbooks and professional websites were retrieved by Q.Y. and C.S. (ChangchengSun); L.L. and Q.Y. wrote the manuscript; F.Z. (Fengtai Zhang) and X.X. provided important ideas and suggestions.

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