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Research on the Coupling Relationship between New Urbanization and Environmental Quality in China

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ABSTRACT
Rapid urban expansion brings social and economic changes, such as increased urban populations and higher standards of living, as well as environmental issues, such as declining air quality and reduced biodiversity. Urbanization is not only the root cause of environmental problems, but also a way to solve environmental problems. Exploring the correlation between urbanization and environmental quality in China can give some scientific arguments for effectively regulating urbanization and achieving a balance between human development and environmental protection. In this paper, the evaluation system of urbanization level is constructed from five aspects of population, land, economy, society and ecology, and the environmental quality evaluation system is constructed by using the PSR model, and the evaluation is carried out using the entropy weight method and the CRITIC method. The coupling model of urbanization and environmental quality is established and regressed from the national and provincial perspectives. At the national level, the level of urbanization, the quality of the environment, and the degree of coupling and coordination continue to increase, and the urbanization process and degree of coupling are good. From a provincial perspective, the level of urbanization and environmental quality varies greatly among provinces, and most of the provinces have lower urbanization scores than environmental quality scores. The degree of coupling coordination varies little, and it is in the development stage from mild incoordination to primary coordination. Based on these conclusions, we put forward a series of policy recommendations to help better achieve sustainable development goals.

Keywords: *Urbanization, Environmental quality, Coupling relationship, Sustainable development*

1. INTRODUCTION

Urbanization is one of the biggest social changes of modern times and has had a profound impact on human social development and living environment [1]. Some of the most obvious features of rapid urbanization in the new era are the large-scale development of urban areas [2]. China's urbanized population has increased from 19% of the total population in 1980 to 59% in 2018, exceeding the world average [3]. In a city, the more concentrated population, the larger scale of land construction and the better economic development represent the higher level of urbanization [4].

Rapid urban growth has brought about changes that have improved the incomes and livelihoods of the inhabitants. It has also caused serious urban and regional environmental problems, such as reduced air quality and reduced biological diversity [5]. Urbanization is not only a source of environmental problems, but also a way to solve them. Urbanization affects the ecology by increasing urban population, energy consumption, and expanding land for construction, while the environment constrains urbanization through livability, competition for capital, and policy. Many scholars have conducted extensive research on this issue, mainly including the interaction, coupling relationship and mechanism of urbanization and ecological environment [6].

China's vast size and uneven levels of economic development have led to differences in urbanization levels and environmental quality. Maintaining the environmental health associated with human activities provides for sustainable urban development and is essential for achieving sustainable socioeconomic development [7]. Therefore, ensuring the coordinated development of urbanization in different regions is an important goal that China needs to achieve.

From the existing literature, the methods of measuring the level of urbanization are the urban population share method, the model method and the index system method [8]. The index system method measures the level of urbanization development by evaluating one or more sets of dimensional indicators. This method combines demographic, land, economic and social factors, making it suitable for the analysis of integrated urbanization [9]. Also, this method can be used for the evaluation of environmental quality.

On this basis, this paper adds environmental urbanization and constructs a comprehensive evaluation system of urbanization. The environmental quality evaluation system includes three aspects: pressure-state-response. Meanwhile, the average weights of entropy value method and CRITIC method are used for evaluation, avoiding the one-sidedness of single method. Finally, the coupling calculation of urbanization and environmental quality was carried out to obtain their mutual relationship. It can provide some scientific suggestions for urbanization and environmental improvement in China.

2. DATA SOURCES AND PROCESSING METHODS

2.1 Data Sources

The survey data used in this study are from China Statistical Yearbook and China Energy Statistical Yearbook. We calculate the relevant data of 30 provinces and cities in China (excluding Tibet, Hong Kong, Macao and Taiwan) from 2007 to 2017.

2.2 Approach

2.2.1 Indicator System

The premise of analyzing the interaction between urbanization and environmental quality is to construct an index system scientifically. Combined with the existing research, this paper makes statistics on frequently appearing indicators, and follows the principles of scientific, generality and usability, and selects indicators to construct a measurement system. According to most urbanization research frameworks, this paper selects 23 indicators and establishes an indicator system including five urbanization subsystems of population, land, economy, society and ecological environment. In terms of environmental quality evaluation system, 10 indicators are selected from three aspects of pressure, state and response. Then the coupling coordination degree model of urbanization and environmental quality is constructed.

To avoid pseudo-regression cases, this paper conducted and passed a unit root test on the panel data of thirty provinces using EViews software. Since the dimensionality of each indicator is inconsistent, it is necessary to normalize each indicator. Considering the information entropy and the comparative strength and conflict of the data, we use the entropy weight method and CRITIC method to calculate the weights of each indicator and average them respectively based on the Stata software programming. Finally, all indicators are weighted and summed to obtain the urbanization level and environmental quality. The results of the selection of specific indicators and the calculation of weights are shown in Table 1.

2.2.2 Entropy Method

The entropy weight method uses the entropy in thermodynamics to describe the disorder of the system. In general, the greater the entropy, the greater the uncertainty, and vice versa. Therefore, we can judge the uncertainty of an event, that is, the size of randomness, by calculating the entropy value, so as to test the validity of the indicator. Generally speaking, the greater the entropy value, the greater the randomness, the greater the degree of dispersion, and the easier it is to mutate, and the greater the impact of the corresponding indicators on the overall model judgment results. In practical research, we can obtain the corresponding weight by calculating the degree of variation of the indicators, so that quantitative comparison and analysis can be carried out intuitively.

2.2.3 CRITIC Method

The CRITIC method is an objective weighting method proposed by Diakoulaki, which aims to determine the relative importance target weights in MCDM problems. The developed method is based on an analytical study of the evaluation matrix to extract all the information contained in the evaluation criteria, the derived weights contain the contrasts and conflicts contained in the decision problem structure. CRITIC is a more direct method and requires less computational effort [10].

2.2.4 Coupling Development Model

Coupling is often used to indicate the interaction between different indicators in a given system. When the indicators of a system cooperate well, the coupling can be considered benign. Otherwise, this is vicious coupling. The coupling model of urbanization and environmental quality is expressed as follows:

$$C=\sqrt{\left(U_1\times U_2\right)/\left[\left(U_1+U_2\right)/2\right]^2} \tag{1}$$

where C is the coupling degree between urbanization and ecological quality, and $C\in[0,1]$. When C is close to 0, it means that the correlation of the system is small and there is no coordination relationship. When C is close to 1, the opposite is true. U1 is the urbanization level and U2 is the ecological quality level.

Based on the coupling model, the coupling coordination degree model can better demonstrate the degree of coupling coordination between the level of urbanization and the quality of the ecological environment. The model is as follows:

Table1. Evaluation indicators of urbanization level and environmental quality

Evaluation Content	Evaluation Index	Unit	Attribute	Entropy weight	CRITIC weight	Average weight
population urbanization	Proportion of urban population	%	X1+	0.0271	0.0420	0.0345
	urban population density	person/km^2	X2+	0.0325	0.0691	0.0508
	population growth rate	%	X3+	0.0239	0.0672	0.0456
	The proportion of people in higher education	%	X4+	0.0542	0.0296	0.0419
	Proportion of employed persons in urban units to urban persons	%	X5+	0.0297	0.0358	0.0328
land urbanization	Proportion of urban construction land	%	X6+	0.0312	0.0641	0.0476
	Construction area per capita	m^2	X7+	0.0926	0.0380	0.0653
	Length of urban drainage pipes per capita	m	X8+	0.0619	0.0399	0.0509
	Urban road area per capita	m^2	X9+	0.0232	0.0512	0.0372
economy urbanization	Per capital GDP	Yuan	X10+	0.0452	0.0337	0.0395
	Consumption level of urban residents	Yuan	X11+	0.0550	0.0310	0.0430
	General government revenue per capita	10^{8}Yuan	X12+	0.1463	0.0466	0.0965
	Urban fixed asset investment per capita	10^{8}Yuan	X13+	0.0460	0.0530	0.0495
	The proportion of the tertiary industry	%	X14+	0.0480	0.0528	0.0504
society urbanization	Public transport per 10,000 people	/	X15+	0.0395	0.0332	0.0363
	The number of health technicians per 10,000 people	/	X16+	0.0303	0.0268	0.0286
	Number of city road lights	/	X17+	0.0723	0.0391	0.0557
	Urban water penetration rate	%	X18+	0.0054	0.0358	0.0206
	Urban gas penetration rate	%	X19+	0.0112	0.0440	0.0276
ecology urbanization	Proportion of urban green space	%	X20+	0.0427	0.0347	0.0387
	Public toilets for every 10,000 people	/	X21+	0.0444	0.0506	0.0475
	Per capita park green space	m^2	X22+	0.0265	0.0466	0.0365
	Green coverage in built-up areas	%	X23+	0.0108	0.0353	0.0230
ecosystem pressure	Domestic waste emission intensity	kg/10^4 Yuan	y1-	0.0094	0.0687	0.0390
	CO2 emission intensity	kg/10^{4}Yuan	y2-	0.0214	0.0974	0.0594
	so2 emission intensity	kg/10^{4}Yuan	y3-	0.0077	0.0677	0.0377
	Wastewater discharge intensity	kg/10^{4}Yuan	y4-	0.0065	0.0617	0.0341
ecosystem condition	per capita water resources	m^3	y5+	0.2693	0.0984	0.1839
	Forest cover rate	%	y6+	0.1091	0.1604	0.1348
	Harmless treatment rate of domestic waste	%	y7+	0.0295	0.1133	0.0714
ecosystem response	total afforestation area	10^4 hectares	y8+	0.1823	0.1245	0.1534
	Proportion of local financial environmental protection expenditure	%	y9+	0.0621	0.1381	0.1001
	forestry investment	10^{4}Yuan	y10+	0.3026	0.0697	0.1862

$$T = \alpha U_1 + \beta U_2 \qquad (2)$$

$$D = \left(C * T\right)^{\frac{1}{2}} \qquad (3)$$

where T is the overall effect between U1 and U2. a and b represent the weight coefficients of urbanization and environmental quality, both taking 0.5. D represents the degree of coupling coordination between U1 and U2, ranging from 0 to 1. Different degrees of coupling coordination represent different types of development degrees, and this paper classifies the degrees of coupling coordination of urbanization and environmental quality, as shown in Table 2.

Table2. Coupling coordination degree classification

D Value	Classes
0≤D<0.2	Extreme incoordination
0.2≤D<0.4	Mild incoordination

0.4≤D<0.6	Primary coordination
0.6≤D<0.8	Good coordination
0.8≤D<0.1	Superior coordination

The higher the degree of coordination between urbanization and environmental quality, the more coordinated their development, that is, urbanization and the environment can promote each other and develop together [11].

3. EMPIRICAL ANALYSIS AND DISCUSSION

3.1 Analysis on the Coupling Coordination Relationship between National Urbanization and Environmental Quality

The urbanization level and environmental quality are evaluated using the entropy weight method and the CRITIC method from the national level, and are substituted into the coupling coordination model for calculation. The results are shown in Figure 1. From the national level, China ' s urbanization level and ecological environment quality are constantly improving. China's urbanization level increased from 0.22(2007) to 0.40(2017), with rapid development of urbanization level. The ecological environment quality level increased from 0.28(2007) to 0.41(2017), and the ecological environment quality developed rapidly. In terms of the degree of coupling and coordination, it can be seen from the figure that from 2007 to 2017, the degree of coupling and coordination development in China has increased year by year, from 0.50 in 2007 to 0.63 in 2017, from a slight imbalance to a good degree of coordination. Overall, China's urbanization process is generally well developed, and the degree of coupling with the environment has gradually improved.

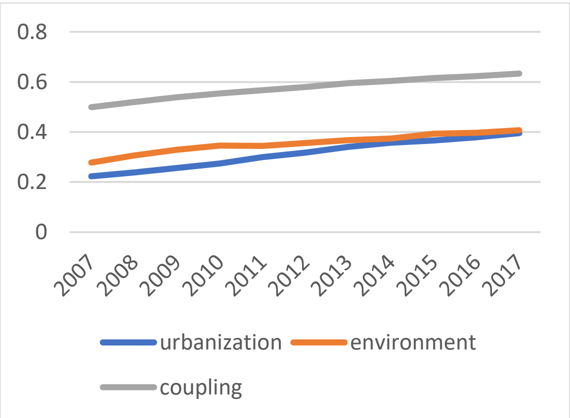

Figure 1 China's urbanization level, environmental quality and coupling results

3.2 Analysis on Coupling Coordination Relationship between Urbanization and Environmental Quality in Different Provinces

We use the entropy weight method and CRITIC method to evaluate the level of urbanization and environmental quality at the provincial level, and substitute it into the coupling coordination model for calculation. The results are shown in Table 3.

Table 3. Evaluation and coupling results of urbanization level and environmental quality

Region	Urb level	Env quality	D value
Beijing	0.4662	0.3564	0.4514
Zhejiang	0.4075	0.3835	0.4446
Fujian	0.3235	0.4413	0.4347
Guangdong	0.3630	0.3773	0.4302
Jiangxi	0.3151	0.4264	0.4281
Shaanxi	0.3355	0.3955	0.4268
Jiangsu	0.4431	0.2939	0.4248
Inner Mongolia	0.3003	0.4189	0.4211
Qinghai	0.2954	0.4173	0.4190
Guangxi	0.2325	0.5096	0.4149
Yunnan	0.2445	0.4837	0.4147
Hunan	0.2724	0.4265	0.4128
Shandong	0.3609	0.3187	0.4118
Hainan	0.2965	0.3849	0.4110
Sichuan	0.2603	0.4252	0.4079
Chongqing	0.2631	0.3915	0.4006
Hebei	0.2988	0.3431	0.4001
Heilongjiang	0.3045	0.3361	0.3999
Tianjin	0.4353	0.2344	0.3996
Xinjiang	0.3612	0.2776	0.3979
Hubei	0.2817	0.3510	0.3965
Henan	0.2993	0.3134	0.3913
Shanghai	0.4104	0.2250	0.3898
Liaoning	0.2834	0.3145	0.3864
Anhui	0.2852	0.3082	0.3850
Shanxi	0.2598	0.3050	0.3752
Jilin	0.2505	0.3154	0.3749
Guizhou	0.2081	0.3723	0.3731
Ningxia	0.3051	0.2241	0.3616
Gansu	0.2397	0.2644	0.3548

As can be seen from Table 2, the level of urbanization varies greatly among Chinese provinces and cities. Judging from the average urbanization level from 2007 to 2017, the urbanization level in Beijing is the highest at

0.47, and the lowest in Guizhou is 0.21, a difference of 0.26. On the other hand, the urbanization process varies greatly between provinces and cities. From 2007 to 2017, the urbanization level of Jiangsu Province increased by 0.26, while that of Liaoning Province increased by only 0.07.

There are also large differences in the quality of the environment. Judging from the average level of environmental quality from 2007 to 2017, Guangxi's environmental quality was the best at 0.51, and Ningxia was the worst at 0.22, a difference of 0.29. On the other hand, the environmental quality of different provinces and cities varies greatly. The added value of Guangxi was 0.32, and the added value of Qinghai was only 0.05.

The coupling degree gap between provinces and cities is small, the maximum coupling degree in Beijing is 0.45, and the minimum coupling degree in Gansu Province is 0.35, both of which are in the mild dissonance and primary coordination stages.

4. CONCLUSIONS

In recent centuries, urbanization has had a huge impact on human life and the ecological environment. A comprehensive understanding of the harmonious relationship between urbanization and environmental quality is important for achieving sustainable development of urban agglomerations [12]. This paper constructs a coordinated development model of urbanization and environmental quality, and evaluates and analyzes the urbanization level and environmental quality of 30 provinces in China. The conclusions drawn from the study are as follows.

First of all, from the national level, China 's urbanization level, ecological environment quality, coupling and coordinated development have increased year by year, and the overall urbanization process is good.

Secondly, the level of urbanization varies widely among different provinces and cities in China. The urbanization level of Beijing is the highest at 0.47, and the urbanization evaluation index of Guizhou Province, which has the lowest urbanization level, is 0.21. The urbanization level varies greatly. In terms of development speed, the added value of urbanization level in most provinces is above 0.15, and the overall development momentum is relatively strong.

Thirdly, the environmental quality of each province and city varies greatly, with the difference of 0.29 between the highest rated Guangxi and the lowest rated Ningxia. In the long run, the environmental quality of each province and city continues to grow. The level of urbanization in most areas lags far behind the quality of the environment, and the level of urbanization does not match the development level of the ecological environment.

Finally, the coupling gap between provinces and cities is relatively small. In general, the coupling coordination between urbanization and environment in various provinces and cities has developed from a slight imbalance to a primary coupling stage, which means that at this stage, the level of urbanization in most areas has entered a stage of rapid development, and urbanization and environmental quality will interact with each other. That is to say, the development of urbanization at this stage may bring positive and negative externalities to the ecological environment.

Based on these conclusions, some suggestions are made for the urbanization process in China.

(1) China needs to focus on the balanced development of urbanization in provinces and cities and narrow the differences in the urbanization process. Provinces with higher urbanization levels such as Beijing and Jiangsu should play a regional leading role and strengthen cooperation with neighboring provinces with lower urbanization levels in terms of economy and technology.

(2) Provinces such as Guizhou and Guangxi have lower urbanization levels but higher environmental quality. These provinces can promote urbanization by appropriately accelerating economic construction and urban land use, etc.

(3) The coupling and coordination degree of urbanization level and environmental quality in each province has not yet reached a good level. In particular, provinces such as Gansu and Ningxia have a low level of environmental quality and coupled coordination, and these provinces should be cautious in promoting urbanization and pay attention to improving environmental quality. We should avoid causing irreversible damage to the environment and affecting the goal of sustainable development.

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