

Study on the Coupling Coordination Development of Urban Land Intensive Use and Urbanization- a Case Study of Jinan City, Shandong Province.

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Abstract: This paper takes Jinan City as the research object to study the coupling and coordinated development of urban intensive use and urbanization, based on the statistical data of Jinan from 2010 to 2019. Firstly, the entropy evaluation method is used to determine the index weights and the multi-factor evaluation model is established to calculate the comprehensive level indexes of land intensive use and urbanization in Jinan. Then the coordination degree model, coupling and coordination development degree model and relative development degree model are constructed to analyze the coordinated development degree of urban land intensive use and urbanization, as well as their coupling coordination relationship. The results are as following. From 2010 to 2019, the comprehensive indexes of urban intensive use and urbanization in Jinan are constantly improving. The coupling coordination degree of land intensive use and urbanization in Jinan has been improved from 0.172 to 0.899, developing from the antagonistic stage to the coordinated stage and constantly tending to high-quality and coordinated development.

1. Introduction

The urban land intensive use is a way of land use to maximize land output and economic benefits per unit area through rational land use planning and layout of urban space^[1]. Urbanization reflects the transformation of economic and social development in a region. Hu Xuwei^[2] thinks that urbanization is the transformation process of a comprehensive system, including population aggregation, economic development and so on. There is a close relationship between urban land intensive use and urbanization. This paper analyzes the current coordinated development situation of urban land intensive use and urbanization through their coupling coordination degrees and whether the land use has positive influence both on land intensive use and urbanization. Based on the establishment of urban land intensive use and urbanization comprehensive level evaluation index system, this paper builds land intensive use and urbanization coupling coordination system, analyzes the coupling coordination relationship and development stages and provides reference for urban land planning and policy-making.

2. Overview of the Study Area and Data Sources

2.1 Overview of the Study Area

Jinan is situated in the middle of Shandong Province, covering an area of 10244 square kilometers. It is located in the junction zone of low hills in central and southern Shandong and alluvial plain in Northwest Shandong. The terrain is high in the South and low in the north, including low mountains and hills, piedmont inclined plain and alluvial plain of the Yellow River. Jinan belongs to the warm temperate continental monsoon climate zone, with an average annual temperature of 13.6 °C and an average annual precipitation of 614 mm. By 2019, the city's permanent resident population is 8.9087 million, with an urbanization rate of 71.21%. The GDP of the whole city is 944.337 billion yuan, an increase of 7.0% over the previous year. The per capita GDP was 106416 yuan, an increase of 5.7%.

2.2 Data Sources

The relevant data of urban land intensive use and urbanization mainly come from China Urban Statistical Yearbook, China Urban Construction Statistical Yearbook, Shandong Province Statistical Yearbook, Jinan Statistical Yearbook from 2011 to 2020 , and refer to Jinan City National Economic and social development statistical bulletin, Shandong Province Urbanization Development report and Jinan City Statistical Yearbook Land use change survey data From 2010 to 2019.

3. Research Methods

3.1 Construction of Evaluation Index Systems

According to the principles of scientificity and operability, systematicness and comprehensiveness, universality and particularity^[3], the index system is established by referring to relevant research results and combining with the actual situation of Jinan City.

This paper constructs the evaluation index system from two aspects of land intensive use and urbanization level. The evaluation of land intensive use is conducted from three aspects: land input level, land use degree and land use efficiency^[4]. The level of land input includes three indicators: the average fixed asset investment, the average financial expenditure and the employment number of the secondary and tertiary industries. The land use degree includes four indicators: per capita road area, per capita construction land area, population density and per capita park green area. The level of land use efficiency includes per capita disposable income of urban residents, total social retail consumer goods, GDP and industrial output value^[5-6].

Based on the actual situation of Jinan, the urbanization level evaluation system is constructed from four aspects of population, economy, society and spatial urbanization^[7-9]. At the level of population urbanization, the urbanization rate of permanent residents and the proportion of employment number in secondary and tertiary industries are selected to reflect it. The level of economic urbanization includes per capita GDP, per capita gross industrial output value and total retail sales of social consumer goods. The level of social urbanization includes the number of buses and heating area per 10000 people. The spatial urbanization layer includes the green space coverage rate of built-up area and the proportion of urban built-up land area in urban area.

3.2 Calculate the Comprehensive Indexes of Land Intensive Use and Urbanization

1). Standardization of indexes

In this paper, range standardization method is used to standardize the original data. The formulas are as follows.

$$\text{Positive indicators: } X_{ij}' = \frac{X_{ij} - X_{ij\min}}{X_{ij\max} - X_{ij\min}}$$

$$\text{Negative index: } X_{ij}' = \frac{X_{ij\max} - X_{ij}}{X_{ij\max} - X_{ij\min}}$$

X_{ij}' is a certain index after standardization.

2). Determine the weights of indexes

There are subjective and objective evaluation methods to determine the index weights. The subjective evaluation methods include AHP, Delphi method, fuzzy comprehensive evaluation method and so on. The objective evaluation methods mainly include entropy weight method, variation coefficient method and so on. In this paper, the entropy method of objective evaluation method is selected to determine the weights. The smaller the entropy, the higher the order degree; otherwise, the lower the order degree.

(1). Calculate the proportion of index P_{ij}

$$P_{ij} = \frac{X_{ij}'}{\sum_{i=1}^m X_{ij}'} \quad (i = 1, 2, 3, \dots, m, j = 1, 2, 3, \dots, n)$$

(2). Calculate the information entropy e_j of indexes

$$e_j = -k \sum_{i=1}^m (P_{ij} \times \ln P_{ij}) \quad (i=1,2,3,\dots,m; j=1,2,3,\dots,n)$$

The constant $k = 1/\ln m$ ($k > 0$, m is the number of evaluation units.)

(3). Calculate the redundancy d_j of the index j

$$d_j = 1 - e_j \quad (j=1,2,3,\dots,n)$$

(4). Calculate the weight values W_j of the index j

$$W_j = \frac{d_j}{\sum_{j=1}^m d_j} \quad (j=1,2,3,\dots,n)$$

3). Determine the comprehensive indexes

Based on the values P_{ij} and W_j , use multi-factor evaluation model to determine the comprehensive indexes. The formula is as following.

$$F_i = \sum_{j=1}^m X_{ij} \cdot W_j \quad (i=1,2,3,\dots,m; j=1,2,3,\dots,n)$$

Obtain the comprehensive indexes of urban land intensive use and urbanization, and represent them by L_i and U_i , respectively.

3.3 Establish Evaluation Models

3.3.1 Coupling Coordination Degree Model

According to the comprehensive indexes of urban land intensive use and urbanization level, the coupling coordination degree model is established. Refer to the relevant papers and establish the coupling coordination degree model. The formula is as following.

$$C = \left\{ \frac{L_i + U_i}{[(L_i + U_i)/2]^2} \right\}^{\frac{1}{2}}$$

C ($0 \leq C \leq 1$) is coupling coefficient. The closer C is to 1, the more coordinated the two subsystems are. The closer C is to 0, the more out of tune the two subsystems are. L_i is the comprehensive index of land intensive use at a certain time. U_i is the comprehensive index of urbanization level at a certain time.

3.3.2 Coupling Coordination Development Degree Model

The degree of coupling coordination can only describe the degree of coordinated development between two systems, but it can not determine whether the two systems promote each other at a higher level or are related at a lower level. Therefore, the coupling coordinated development degree model is introduced to reflect the coordinated development level among systems. The formulas are as follows.

$$D = \sqrt{CT} \quad (0 \leq D \leq 1)$$

$$T = \alpha L_i + \beta U_i$$

T is the comprehensive coordination index of land intensive use and urbanization. D is the land intensive use subsystem and urbanization subsystem coupling coordination degree. And the larger the numerical value is, the better the coupling coordination effect is. α and β are the undetermined coefficients. $\alpha + \beta = 1$. Take $\alpha = 0.5$, $\beta = 0.5$ as the undetermined coefficients.

3.3.3 Relative Development Degree Model

In order to get the relative development state between the two subsystems, the relative development degree model is used to measure. The formula is as following.

$$E_i = L_i / U_i$$

E_i is the coefficient of relative development degree.

4. Results and Analysis

4.1 Analysis on Comprehensive Evaluation Scores of Urban Land Intensive Use and Urbanization Level

From 2010 to 2019, the comprehensive index of land intensive use in Jinan shows an overall upward trend, indicating that the level of land intensive use in Jinan City is constantly improving. From 2010 to 2018, the land intensive use index of Jinan City increased from 0.044 to 0.912, with a large growth rate. It can be seen that the government has taken measures to effectively improve the land intensive use of Jinan City. Combined with the index level analysis, the improvement of land intensity is mainly due to the increase of fixed asset investment and social retail consumer goods, which leads to the improvement of land investment level, utilization degree and utilization efficiency.

From 2010 to 2019, the urbanization level index of Jinan City has been rising, from 0.02 in 2010 to 0.973 in 2019, with a large growth rate. The rapid increase in the proportion of non-agricultural population and urban built-up land in urban area promotes the urbanization of population, society, economy and space in Jinan. The changes of the comprehensive index of land intensive use and urbanization in Jinan in the past 10 years are shown in Figure 1.

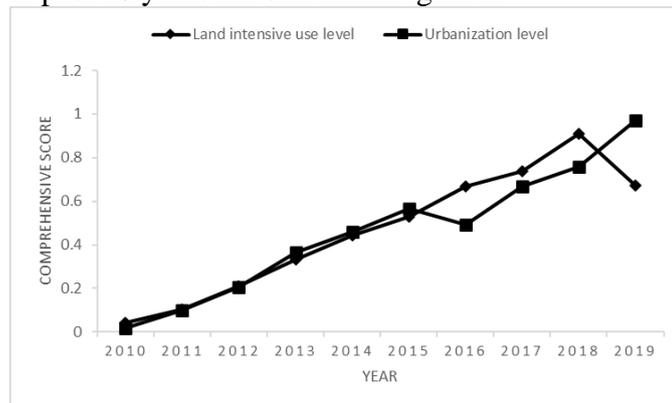


Fig.1 Changes of the Comprehensive Indexes of Land Intensive Use and Urbanization in Jinan City

4.2 Analysis on Coupling Coordination Development of Urban Land Intensive Use and Urbanization

The change of coupling degree, coupling coordination degree and relative development degree coefficient of land intensive use and urbanization level in Jinan City from 2010 to 2019 is shown in Figure 2. According to the classification standard of coupling coordination degree, the coupling coordination degree is divided into coupling coordination degree grades, as shown in Table 1. According to the relevant development coefficient, the coupling and coordinated development types of land intensive use and urbanization in Jinan City are obtained, as shown in Table 1.

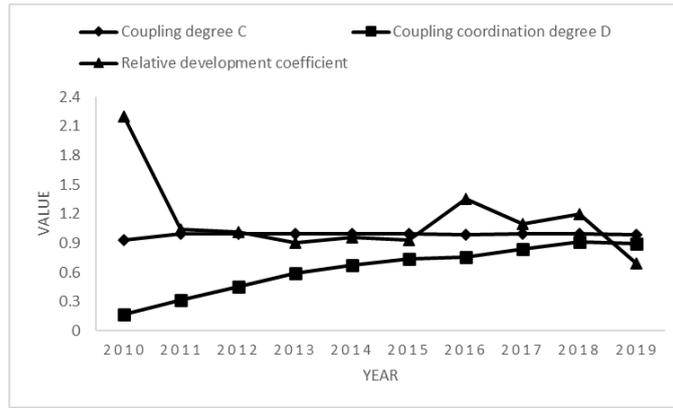


Fig.2 Coupling Degree, Coupling Coordination Degree and Relative Development Degree Coefficient of Land Intensive Use and Urbanization Level in Jinan City from 2010 to 2019

Table 1 Evaluation of Coupling and Coordinated Development of Land Intensive Use and Urbanization in Jinan City

Year	Coupling degree C	Coupling coordination degree D	Coupling coordination Classification	Relative development degree coefficient	Types of coupling and coordinated development
2010	0.927	0.172	Severe disorder	2.201	Urbanization lags behind
2011	1	0.318	Mild disorder	1.044	Synchronization
2012	1	0.455	Near disorder	1.015	Synchronization
2013	0.999	0.59	Barely coordination	0.904	Synchronization
2014	1	0.672	Primary coordination	0.960	Synchronization
2015	0.999	0.74	Intermediate coordination	0.934	Synchronization
2016	0.989	0.759	Intermediate coordination	1.356	Urbanization lags behind
2017	0.999	0.838	Good coordination	1.101	Synchronization
2018	0.996	0.912	High quality coordination	1.201	Urbanization lags behind
2019	0.983	0.899	Good coordination	0.690	Land intensive use lags behind

According to the research of relevant scholars^[10] and the actual situation of Jinan City, the coupling and coordinated development stages of urban land intensive use and urbanization are divided into three stages: antagonistic stage, running-in stage and coordinated stage. When the coupling coordinated development is in the antagonistic stage, the relationship between them is out of balance, including the extreme imbalance, serious imbalance, moderate imbalance and mild imbalance. When the coupling coordinated development is in the running-in stage, the types include near imbalance, barely coordination and primary coordination. When the coupling coordinated development is in the coordination stage, the types include intermediate coordination, good coordination and high-quality coordination. It can be seen that the coupling and coordinated development of Jinan City is in the antagonistic stage from 2010 to 2011, in the running in stage from 2012 to 2014, and in the coordinated development stage from 2015 to 2019. It can be seen that the coupling and coordinated development level of Jinan City is constantly improving, and gradually tends to be high-quality and coordinated development.

From the perspective of relative development coefficient, when $E_i > 1$, the coupling coordination type of land intensive use level and urbanization is urbanization lag; when $E_i \approx 1$, land intensive

use level and urbanization are synchronized; when $E_i < 1$, land intensive use level lags^[11-12]. According to the following standards, when $0 < E_i \leq 0.8$, the intensive use of urban land lags behind the development level of urbanization, and the extensive use of urban land; when $0.8 \leq E_i \leq 1.2$, the intensive use of urban land and urbanization are at the same level; when $E_i \geq 1.2$, the urbanization lags behind the intensive use of land. The results show that the intensive use of urban land and urbanization in Jinan is mostly synchronous, which indicates the continuous development urbanization and the intensive use of urban land. The optimization of the two systems can better promote each other and promote the sustainable development of the city.

5. Conclusion

In this paper, the index systems of urban land intensive use and urbanization are established and the comprehensive levels of land intensive use and urbanization of Jinan City are scored. Based on the comprehensive scores, the coupling coordination scheduling, coupling coordination development degree and relative development degree models are used to study the coupling coordination development of land intensive use and urbanization, and the coupling coordination degree score is determined according to the coupling coordination development standard. Then through the analysis of relative development degree, the relationship between land intensive use and urbanization level is obtained. The results show that the coupling coordination of land intensive use and urbanization in Jinan City has been continuously improved. At present, it is in the stage of coordinated development and tends to be high-quality coordinated development. The two types of development are roughly synchronous. Different measures should be taken in different development stages to regulate and control the intensive land use and urbanization development.

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