Comprehensive Evaluation of Intensive Land Use Level in Major Cities

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Abstract. This paper takes 69 major cities with geographical features in China as the research object, and analyzes the intensive use of land in different cities, which can be divided into four types: highest level, higher level, general level, lower level and lowest level. The level of urban land intensive use and its economic development level in China can be summarized as the relationship between urban economic development level and corresponding level of its land intensive use. In this paper, the entropy conception, TOPSIS evaluation model and coordination coefficient analysis methods are used to build an evaluation model, analyze the basic level of land intensive use in major cities in China. This paper concludes the methods and models applicable to different cities with different levels of land intensive use.

Keywords: Intensive urban land use; Entropy; TOPSIS model; Coordination factor

1 Introduction

Since the reform and opening up of China, the level of economic and social development in China has been increasing, and the overall situation is becoming more and more perfect. However, while leaps and bounds have been achieved, the problem of rough urban land use has not yet been fundamentally solved, with the phenomenon of "urban villages" being one of the typical manifestations. The accelerating urbanisation process has led to a growing conflict between land resource control and urban expansion; the negative effects of urban overdevelopment cannot be compensated for by the efficiency of intensive urban land use, leading to the formation of the phenomenon of invisible unused land. The negative impact of urban land issues on urban development is becoming increasingly evident and is becoming a 'shortcoming' in the process of urban development. The ability to effectively improve the efficiency of intensive urban land use and to achieve a high level of intensive urban land use is directly related to the success or failure of China's urban development.

In the opening year of the *14th Five-Year Plan*, the article Key Tasks of New Urbanisation and Urban-Rural Integration Development in 2021 has specifically proposed In the opening year of the 1*4th Five-Year Plan*, the article Key Tasks for New Urbanisation and Integrated *Urban-Rural Development* in 2021 specifically sets out the requirement to promote the

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intensive and efficient use of urban construction land, and comprehensively implement the linkage between incremental investment and stock revitalisation and utilisation", which is of great significance in promoting the implementation of the National 14th Five-Year Plan. As a key element in urban construction, land resources will play an important role in this process as a new driving force for urban development, which is also inevitable under the development trend of urban modernisation in China.

2 Research status

In the course of the country's steady promotion of urban modernisation, the issue of intensive urban land use has been of great concern to all sectors of society, and many scholars have conducted a great deal of research on this issue, with many fruitful results. Under the new development trend of the 14th Five-Year Plan, the concept of low-carbon development and ecological civilisation has been further deepened and incorporated as an important element in the study of intensive urban land use, which has led to a new stage of development in this field. Researchers such as Yang Jun have proposed a 're-conceptualisation' of the issue of intensive urban land use, taking into account the requirements of the new era, emphasising that in the new situation, more attention should be paid to achieving a high standard and balance of economic, social and ecological aspects of optimal intensive use. Shi Siqi and others have studied the intensive use of urban land under the concept of low carbon, proposing to incorporate the concepts of intensive and efficient, low carbon and environmental protection into the scope of urban land use evaluation, so as to reflect the intensive use of urban land and further enhance its scientific and comprehensive nature. However, there are certain shortcomings in this study, as the data selected is relatively small and fails to form a general regularity, while the construction of the indicator system needs further supplementation and improvement; Sun Xiaoxiang analyses the barriers and overall evaluation of the level of intensive land use in Suzhou in the past ten years through the PSR model, combining relevant indicators. This study focuses more on the construction of an evaluation system for intensive urban land use, providing a more advanced reference basis for controlling the balance mechanism between urban development and rational land use in the new situation.

From a general point of view, in the new stage of social development, the research on the intensive use of urban land has a strong foundation in terms of theoretical definitions, evaluation criteria, influencing factors and practical applications, but it still needs to be further adjusted and optimised in the light of the current development situation. At the same time, there is a lack of research that meets the development needs of the new situation, and there is a lack of material to support the analysis of the current situation of land resources as a new driving force for urban development.

Based on the above, this study combines relevant data to study and analyses the intensive use of land in major cities in China over the past 15 years, and uses this as a benchmark to classify Chinese cities into classes and form relevant evaluations, as well as to make reasonable suggestions for urban development, so as to provide a reference basis and scientific guidance for the precise control and full use of land resources as a key element of the new driving force for modern urban development, and to form a more adequate theoretical support.

3 Research ideas and model construction

3.1 Research ideas

According to the research objectives of this paper and the current research status of urban land use intensification, this paper now proposes the following research ideas.

Taking 69 major cities in China from 2007 to 2021 as the research objects, among the four guideline layers of land input level, land use intensity, economic benefits of land use and ecological benefits of land use, combined with the feasibility analysis of data collection, 12 indicators were selected, including urban fixed asset investment (X_1), population density (X_5), social consumer goods per unit of land Based on this, the index system for evaluating the level of intensive land use in cities was completed; then the data of relevant indicators were collected and collated, and the weights of each indicator were calculated and analysed by the entropy value method to obtain the weights of the target layer; then the results were comprehensively analysed and evaluated by combining the coordination coefficient analysis method and TOPSIS evaluation model. Finally, based on the results, the classification of cities and the summary of the results, combined with the analysis of urban intensive land use model, to derive different types of cities suitable for the use of intensive land use model and the reasons for the selection of the model, and to make relevant recommendations.

3.2 Analysis of urban land intensive use model

1. Introduction to urban land use intensification models

① Road traffic design optimisation and land saving model

This model refers to the internal development potential of urban construction, i.e. starting with urban roads, and optimising the overall road width and cross-section on the premise of ensuring road access, which not only frees up part of the road area, but also improves the road access capacity.

For example, in the Meixi Lake area of Changsha, the principle of "narrow roads and dense network" is followed to form a micro-circulation of traffic roads in the area, which not only improves the capacity of the roads, but also saves land area and further improves the level of intensive use of urban land.

②Land-saving model of sharing public resources

This model refers to the overall planning and layout of industrial land for public services in industrial parks, and the adoption of a "public resource sharing" policy based on standard factory land. The use of this model can save land resources, improve the efficiency of urban land use, and establish unified public service facilities in the industrial park development zone, so that the staff in the park can share public resources. This will not only reduce the waste of land resources caused by repeated construction, thus achieving energy savings, but also reduce construction expenses, increase the level of urban land output and improve the environmental conditions in industrial parks.

③Environmental relocation land saving model

This model refers to the elimination or transfer of some enterprises in the area that originally had high resource input, serious pollution, low production capacity and poor efficiency due to the need for economic development, industrial structure optimisation and upgrading, and green relocation or transfer out of industries with low levels of economic efficiency. According to the requirements of urban planning and economic development, the low-end industries of the enterprises will be withdrawn to the idle land for redevelopment, which will not only allow some of the high-tech industries or high-end service projects to land, but also allow the idle land resources to be fully utilised, thus achieving the purpose of killing multiple birds with one stone.

④ Land-saving model for the transformation and utilisation of abandoned industrial and mining land

This model refers to the process of renovating and reusing abandoned industrial and mining areas on the basis of investigation and restoration, taking into account the actual local situation and applying the concept of ecological protection, in order to improve the level of urban land use intensification in the local area. This will not only improve the efficiency of urban land use, but also improve the local ecological environment, reflecting the development of urban land intensive use model in a modern direction.

A typical example is the treatment of an abandoned mine site in Deqing County, Huzhou, Zhejiang Province, which has been transformed from an abandoned mine pit into a large ecological park integrating leisure and health and agricultural education. It provides a model for ecological restoration of mining areas in China.

⑤ Multi- and high-rise standard factory building land-saving model

This model is based on regional development planning, and in order to provide space for many emerging small and medium-sized enterprises to survive and develop, the construction of multi- and high-rise standard factory buildings is proposed and supported. At the same time, in order to support the development of small and medium-sized enterprises, market operators are introduced to provide assistance such as information and management services to form industrial clusters in the region, thus achieving the objective of intensive use of urban land.

⑥Land-saving model of urban three-dimensional space development

This model refers to the situation where there is a large difference in terrain within an area, the height gap between the current situation of land resources and the planned roads should be considered, and the premise of not changing the current situation of land resources should be combined with all levels: above-ground, surface and underground space, and the land use method of pedestrian and vehicle separation, three-dimensional construction and mixed use should be adopted to highlight the effect of intensive use of urban land more.

For example, the Yali Middle School in Hunan Province has built its car park under the school playground, which not only intensively uses land and improves land use efficiency, but also provides a good reference template for other urban areas[1].

2. Selection of urban land use intensification models

Many scholars in China have long studied the modes of intensive urban land use, among which Zhang Zhihong has discussed the modes of intensive urban land use and analysed three existing modes of intensive urban land use, namely the old city transformation mode, the "retreating two into three" mode and the "urban village" transformation mode. "On this basis, a new model of intensive use of urban land in structural and ecological forms is proposed. Mao Jiangxing and Yan Xiaopei conducted a study on the relationship between urban land use patterns and urban traffic patterns, briefly describing land use patterns such as low-density dispersed patterns and high-density concentrated patterns, and then further elaborating the interrelationship between land use patterns and traffic patterns. Zhang Jie and Yang Chongguang analyse the current situation of land use in the Dongcheng District of Beijing and propose models of land use in the core area of an international metropolis: land use planning model innovation - separation of three rights, land use reserve model innovation - land bank, and Through these models, the level of intensive land use in the Dongcheng District of Beijing can be improved and the contradiction between land resources and land use can be alleviated. Sun Weijie and Hou Xueping studied the intensive land use model of development zones in Guangdong Province. The intensive land use model of local development zones can be divided into three models: intensive location use model, industrial structure optimisation use model and loose and rough use model, etc. Their study pointed out that the rational use of land use model can effectively alleviate the contradiction between land supply and demand. Xu Jianhong explores the land use patterns of the abandoned gold mine in Suichang, Zhejiang province, where the main land use patterns include: the transformation and use pattern of the old abandoned mine, the redevelopment pattern of low-utility land, the comprehensive improvement and diversified use pattern of the abandoned dumps, the cultural landscape reconstruction pattern and the functional land use pattern.

The above-mentioned scholars' studies are relatively outdated and lacking in certain aspects; at the same time, some of the scholars' studies focus on the relationship between a certain aspect of urban development and the intensive use of urban land, which has certain limitations. Therefore, based on the research of various scholars, this paper follows the research principles of scientificity, comprehensiveness and relevance, and then combines the research needs, and selects urban land-intensive utilisation models such as road traffic design optimisation and land-saving model, public resource sharing and land-saving model, environmental relocation and land-saving model, industrial and mining abandoned land transformation and utilisation and land-saving model, multi- and high-rise standard factory building and land-saving model of urban three-dimensional space development. These models are used in conjunction with the findings of the statistical models to make relevant analyses and recommendations.

4 Research design

4.1 Sample selected

For the research on the level of intensive use of urban land, domestic scholars Wu Guoyong established an index system for evaluating the level of intensive use of construction land, and the selected indexes were the added value of one, two, three industries per unit of construction land, land idleness rate, GDP output value per unit of construction land, and the ratio of railway to highway land, etc., to evaluate the level of land use of construction land in various townships in Danzhai County, Guizhou Province; Wei Li and Yan Jun took Yinchuan city as an example, and selected relevant indicators such as urban average fixed asset investment, urban industrial land efficiency, and urban population and construction land growth elasticity coefficient to conduct a comprehensive evaluation of the level of intensive land use in Yinchuan city; Luo Peicong and Dong Furong took residential land in Fuzhou city as an example, and selected indicators such as residential volume ratio, net residential building density, gross population density and green space rate to conduct an evaluation of the level of intensive land use in Fuzhou In a study on the dynamic correlation between urban expansion and urban land use intensification, Hashangchen, Alimujiang Kasmu et chose relevant indicators such as per capita fiscal revenue, per capita road paved area and per capita housing area to evaluate the responsiveness of cities to land use pressure[2]. Shi Xuedong looked at the level of land input, land use The study was conducted by Shi Xuedong on the level of land input, land use, ecological environment quality, land use intensity, land output efficiency, and the development trend of intensive land use, and the relevant indicators were selected to evaluate the level of intensive land use in Yiyang. Mahdianpari, M., Granger, J.E. et use indicators such as land use nature, building density, floor area ratio, distance from urban roads and distance from commercial service centers to evaluate the potential for intensive land use and to study the potential for tapping into the stock of land[3]. Kim Solhee, Kim Taegon, Suh Kyo and Jeon Jeongbae studied energy and environmental performance, selected four indicators, namely input per unit of land, the number of labourers absorbed per unit of land, the average output per unit of land and the degree of land reclamation, to evaluate the level of intensive land use[4]. Hong, J.Y. and Jeon, J.Y. studied relationship between spatiotemporal variability of soundscape and urban morphology in a multifunctional urban area, taking Seoul as a case study[5]. In a word, by using the indicators selected by the above-mentioned scholars as reference, this study takes into account the actual situation of each region based on the relevant domestic literature and follows the principles of scientificity, feasibility and comparability in the selection of indicators. This study measures the level of intensive urban land use with a sample of 69 major cities in China.

4.2 Variablities Instruction

Table 1 Variablities Instruction

Objective	Criterion layer	index	attribute	weight
Level of Intensive use of urban land	Land input level	Urban fixed-asset investment X_1	positive	0.0823
		Urban average road area X_2	positive	0.0740
		Bus per ten thousand X_3	positive	0.0976
	Land use intensity	Employment number X_4	positive	0.1571
		Population density X_5	positive	0.0707
		Urban average construction area X_6	negative	0.0095
	Economic benefits of land use	Urban GDP X_7	positive	0.1625
		Total retail sales of social consumer goods X_8	positive	0.1210

	Ecological benefits of land use	Industry products X_9	positive	0.1706
		Percentage of greenery coverage X_{10}	positive	0.0220
		Harmless treatment rate of domestic garbage X_{11}	positive	0.0146
		Sewage treatment rate X_{12}	positive	0.0180

According to the principles of scientificity, feasibility and comparability, this study builds the indicators system. The variablities are shown in Table 1.

5 Analysis

5.1 Determination of the weighting of indicators by year

The method of constructing the analysis matrix was used to determine the weights of each indicator. The greater the influence of each indicator in the matrix on the target layer, the greater will be the weight calculated by the entropy value method, i.e. the greater the corresponding value of the indicator, the greater will be the weight of that indicator on the target layer.

The results obtained are shown in Table 2.

Table 2 Descriptive analysis of indicator system of 69 major cities (take below cities as examples)

Index	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}
Beijing	50503987.87	8.49	18.14	6151063.33	818.49	114.56	16347.93	5065.09	35804972.85	44.89	94.67	80.72
Tianjin	56977841.27	12.22	10.51	2165568.93	873.92	81.41	11082.33	3682.79	50639480.12	30.72	92.40	64.88
Shijiazhuang	41982335.13	13.45	13.06	882867.73	641.23	63.11	4003.13	11534.40	6350492.98	41.16	96.03	83.16
Taiyuan	34016658.47	11.84	8.30	882829.33	537.26	81.83	2076.73	6331.78	7659783.19	33.00	78.30	65.32
Huhhot	39617732.13	15.39	14.64	337180.47	186.90	145.89	2068.13	3841.94	3718540.14	34.85	90.68	76.07
Shenyang	48649928.13	11.59	10.15	1067399.40	596.82	73.64	5046.60	5249.30	19333555.79	35.48	93.33	71.39
Dalian	46122607.13	12.47	15.59	897144.33	508.89	112.39	5551.00	5906.09	15870444.18	44.52	92.30	87.93
Changchun	41521950.13	14.17	11.60	1094918.33	414.20	99.80	4001.93	2506.67	16723092.39	38.21	88.61	76.88
Harbin	41407461.13	7.48	11.57	1120739.33	245.08	114.79	4145.93	2333.49	10517606.48	29.34	71.50	64.76
Shanghai	70443263.13	9.05	12.54	6317513.33	2195.02	99.10	18772.40	12486.84	69909557.08	34.49	79.67	77.10
Nanjing	49044952.13	18.45	11.59	2102419.33	948.91	113.77	6556.93	5012.09	26354087.71	44.81	91.71	67.27
Hangzhou	48884565.13	11.18	15.44	2702731.33	454.92	88.38	7262.93	6076.51	24400723.04	39.37	99.87	88.77
Ningbo	48380775.13	11.24	16.85	1419114.33	652.42	120.35	5894.33	4479.65	18441176.76	38.33	98.92	74.05
Hefei	84544732.13	21.81	15.60	1743747.33	694.89	143.29	3637.33	10217.89	12419085.50	39.97	96.48	88.82
Fuzhou	41049327.13	12.04	15.89	1653144.33	571.43	100.30	3941.07	9907.04	7636557.63	39.81	97.92	82.48
Xiamen	39033907.13	16.73	18.59	1466770.33	997.69	119.53	2538.73	4808.07	11680250.52	40.90	98.14	87.60
Nanchang	40273678.13	10.64	12.02	1086115.33	682.26	80.42	2751.27	7654.35	10128019.65	47.22	98.57	79.57
Jinan	43587730.13	17.58	12.27	1212579.33	783.88	92.13	4462.00	4769.48	12800076.19	38.45	94.79	81.90

Qingdao	49583540.13	18.45	16.46	1359320.33	731.65	87.08	6631.07	6069.68	18824278.76	41.15	100.00	86.74
Zhengzhou	43217732.13	10.28	13.37	1790102.33	963.61	88.66	5068.07	12914.93	10800261.31	36.48	90.68	82.45

Firstly, the weights of each indicator in the indicator layer to the target layer are determined, and on the basis of data pre-processing, the data of each year of the 12 indicators are obtained by normalization, and further calculated according to the entropy value method, the results of the weights of each indicator in the indicator layer to the target layer are constructed into the following analysis matrix.

	Y_1	Y_2	Y_3	Y_4	Y_5	…
X_1	a_{11}	a_{12}	a_{13}	a_{14}	a_{15}	…
X_2	a_{21}	a_{22}	a_{23}	a_{24}	a_{25}	…
X_3	a_{31}	a_{32}	a_{33}	a_{34}	a_{35}	…
X_4	a_{41}	a_{42}	a_{43}	a_{44}	a_{45}	…
X_5	a_{51}	a_{52}	a_{53}	a_{54}	a_{55}	…
⋮	⋮	⋮	⋮	⋮	⋮	

where Xi denotes the indicator in each indicator layer and Yj denotes the year.

The results obtained are shown in Table 3.

Table 3 Weight of indicators in each year from 2007 to 2021

INDEX \ YEAR	2007	2008	2009	2010	2011	2012	2013	2014
X_1	0.1454	0.1362	0.0808	0.0900	0.0927	0.0976	0.0920	0.0951
X_2	0.1141	0.0878	0.1263	0.0836	0.0886	0.0775	0.0589	0.0578
X_3	0.0572	0.1076	0.1084	0.0692	0.0614	0.0532	0.1135	0.1218
X_4	0.1421	0.1306	0.1350	0.1484	0.1556	0.1639	0.1510	0.1474
X_5	0.0636	0.0585	0.0604	0.0662	0.0688	0.0718	0.0664	0.0672
X_6	0.0061	0.0053	0.0054	0.0054	0.0068	0.0069	0.0095	0.0081
X_7	0.1141	0.1273	0.1415	0.1651	0.1761	0.1827	0.1655	0.1625
X_8	0.0938	0.0957	0.1060	0.1302	0.1155	0.1168	0.1291	0.1242
X_9	0.1746	0.1600	0.1780	0.1702	0.1669	0.1811	0.1646	0.1594
X_{10}	0.0376	0.0289	0.0108	0.0193	0.0341	0.0148	0.0193	0.0166
X_{11}	0.0207	0.0236	0.0181	0.0208	0.0157	0.016	0.0186	0.0295

X_{12}	0.0307	0.0385	0.0292	0.0316	0.0179	0.0177	0.0115	0.0105

INDEX \ YEAR	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Average**
X_1	0.0993	0.0711	0.1031	0.1077	0.0081	0.0075	0.0077	0.0823
X_2	0.0569	0.0643	0.0753	0.0612	0.0509	0.0595	0.0477	0.0740
X_3	0.1220	0.1152	0.0759	0.1090	0.1185	0.1170	0.1144	0.0976
X_4	0.1523	0.1586	0.1525	0.1514	0.1850	0.1876	0.1952	0.1571
X_5	0.0700	0.0728	0.0707	0.0698	0.0853	0.0843	0.0853	0.0707
X_6	0.0098	0.0118	0.0127	0.0151	0.0106	0.0158	0.0135	0.0095
X_7	0.1637	0.1641	0.1516	0.1547	0.1878	0.1889	0.1925	0.1625
X_8	0.1277	0.1407	0.1162	0.1352	0.1382	0.1293	0.1163	0.1210
X_9	0.1595	0.1638	0.1636	0.1614	0.1839	0.1808	0.1905	0.1706
X_{10}	0.0202	0.0195	0.0614	0.0102	0.0138	0.0123	0.0113	0.0220
X_{11}	0.0082	0.0086	0.0089	0.0062	0.0070	0.0081	0.0095	0.0146
X_{12}	0.0105	0.0093	0.0081	0.0182	0.0111	0.0089	0.0161	0.0181

Then, by analysing the weights of each indicator in the matrix and the level to which it belongs, the results calculated by the entropy method are summed up to obtain the weights of the level of land input, the intensity of land use, the economic efficiency of land use and the ecological efficiency of land use on the level of intensive urban land use in each year.

Table 4 Weights of criterion layer from 2007 to 2021

	Land input level	Land use intensity	Economic benefits of land use	Ecological benefits of land use
2007	0.4588	0.0697	0.3825	0.0890
2008	0.4622	0.0638	0.3830	0.0910
2009	0.4505	0.0658	0.4255	0.0581
2010	0.3912	0.0716	0.4655	0.0717
2011	0.3983	0.0756	0.4585	0.0677
2012	0.3922	0.0787	0.4806	0.0485
2013	0.4154	0.0759	0.4592	0.0494
2014	0.4221	0.0753	0.4461	0.0566
2015	0.4305	0.0798	0.4509	0.0389
2016	0.4092	0.0846	0.4686	0.0374
2017	0.4068	0.0834	0.4314	0.0784
2018	0.4293	0.0849	0.4513	0.0346
2019	0.3625	0.0959	0.5099	0.0319
2020	0.3716	0.1001	0.4990	0.0293
2021	0.3650	0.0988	0.4993	0.0369

By analyzing the calculation results of the entropy method in Tables 3 and 4 above, it can be concluded that the four indicators of gross industrial product (X_9), urban GDP (X_7), number of employees (X_4), and total retail sales of social consumer goods per unit of land (X_8) have greater weights, so they have a considerable influence on the intensive use of urban land, and their corresponding criterion layers, i.e., land use The corresponding criterion layer, i.e. the economic benefits of land use, has a greater weight; however, indicators such as the green coverage rate of built-up areas (X_10), the harmless treatment rate of domestic waste (X_11) and the sewage treatment rate (X_12), which are in the criterion layer, i.e. the ecological benefits of land use, have a smaller weight and thus have a smaller impact on the intensive use of urban land. The analysis of the weight values of the matrix in this study shows that the weights calculated using the entropy value method are the same as for the different levels of land use intensification, with indicators such as gross industrial product (X_9) and urban GDP (X_7) having considerable importance for urban land use intensification, which reflects that the results obtained using the entropy value method are more accurate and realistic.

5.2 Analysis of changes in indicator weights at the guideline level by year

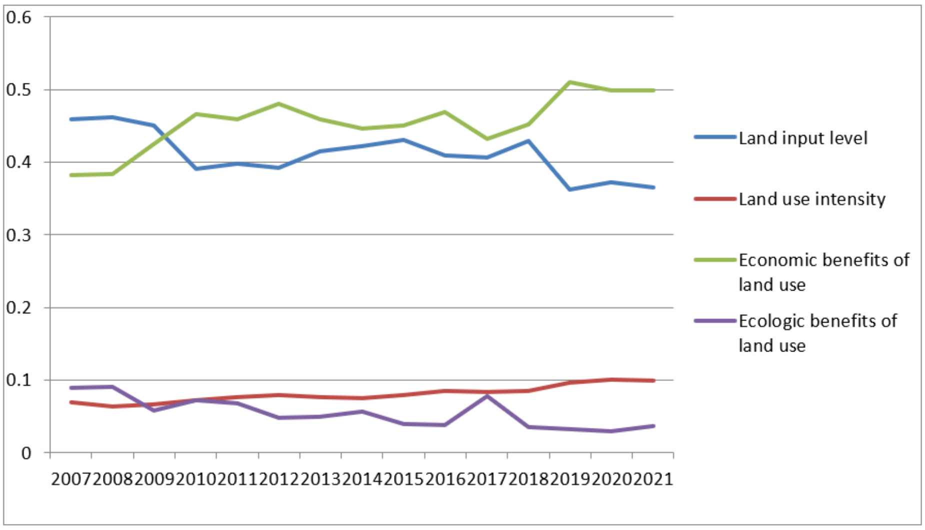

Figure 1 Line graph of indicator weights at the criterion level

As can be seen from the Figure 1, during the 15-year period from 2007 to 2021, the influence of the two target layers of land input level and economic efficiency of land use on the level of intensive urban land use is more significant, with their weights fluctuating in the range of 0.4-0.5, and the former has an overall decreasing trend, while the latter has an overall increasing trend; while the two target layers of land use intensity and ecological efficiency of land use have a smaller weight, basically below 0.1, and have a limited influence on the level of intensive urban land use. The weights of the two target layers are relatively small, basically below 0.1, and have limited influence on the level of intensive urban land use, and the target layer of land use intensity basically shows an upward trend, while the target layer of ecological benefits of land use basically shows a downward trend.

In terms of the internal linkage between the target layers, there is an inverse relationship between the level of land input and the economic efficiency of land use, the intensity of land use and the ecological efficiency of land use. The higher the level of land input, the lower the ratio of output to input, i.e. the lower the economic benefit. The higher the intensity of land use, the more difficult it is to protect the ecology of the land, and the lower the ecological benefit.

5.3 Coordination analysis

To facilitate the quantitative description of the coordination among the four subsystems of land input level, land use intensity, economic benefits of land use, and ecological benefits of land use in each city, this paper uses the coordination coefficient to evaluate the coordination relationship among the four subsystems.

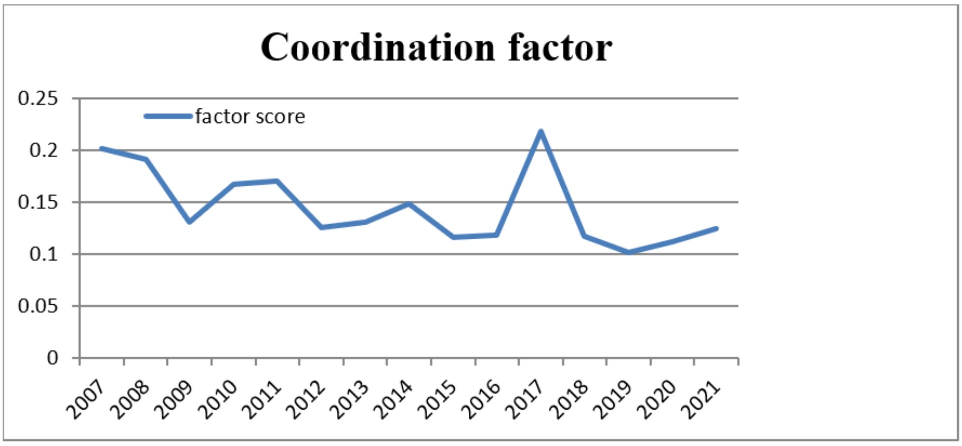

Figure 2 Line graph of the coordination factor

As can be seen from the Figure 2, during the 15 years from 2007 to 2021, the coordination coefficient fluctuated in the range of 0.1-0.2 and basically remained at a low level. The reason for this lies in the unbalanced development of China's regions. In recent years, instead of narrowing the gap between the economic development of the three major regions, namely the east, the middle and the west, there has been a tendency to widen. The eastern coastal region has taken the lead in development and has formed a more complete industrial system and national economic system, while the vast central and western regions have developed more slowly, thus making the problem of unbalanced regional economic development in China more and more prominent, thus affecting the balance between various subsystems.

5.4 Results

The TOPSIS evaluation model was used to score the cities by year and aggregated to find the means, resulting in the final evaluation results shown in Table 5.

Table 5 Average score of main cities

city	score	city	score	**city**	score
Shenzhen	0.6854	Wuxi	0.2438	Nanchang	0.1599
Shanghai	0.6612	Changsha	0.2428	Wenzhou	0.1535
Beijing	0.5310	Zhengzhou	0.2311	Tangshan	0.1512
Guangzhou	0.4419	Ningbo	0.2250	Harbin	0.1424
Chengdu	0.4044	Shenyang	0.2110	Kunming	0.1389
Tianjin	0.4041	Dalian	0.2048	Yantai	0.1348
Chongqing	0.3572	Shijiazhuang	0.2017	Xuzhou	0.1304
Hangzhou	0.2973	Fuzhou	0.1940	Quanzhou	0.1283
Wuhan	0.2954	Xian	0.1849	Luoyang	0.1215
Hefei	0.2863	Jinan	0.1809	Tiayuan	0.1196
Nanjing	0.2760	Xiamen	0.1753	Jining	0.1141
Qingdao	0.2496	Changchun	0.1644	Yangzhou	0.1131
city	score	city	score	city	score
Baotou	0，1072	Yinchuan	0.0843	Guilin	0.0626
Huizhou	0.1057	Pingdingshan	0.0817	Anqing	0.0561
Huhhot	0.1021	Xiangyang	0.0779	Changed	0.0537
Qinhuangdao	0.1019	Jiujiang	0.0764	Ganzhou	0.0499
Xining	0.1010	Bengbu	0.0756	Zunyi	0.0473
Nanning	0.0988	Beihai	0.0722	Mudanjiang	0.0463
Urmuqi	0.0985	Yueyang	0.0714	Nanchong	0.0461
Jinghua	0.0943	Zhanjiang	0.0696	Dandong	0.0454
Lanzhou	0.0908	Haikou	0.0672	Luzhou	0.0453
Guiyang	0.0906	Jilin	0.0657	Sanya	0.0430
Yichang	0.0853	Jinzhou	0.0633	Shaoguan	0.0349

Based on the results obtained, the cities were ranked and classified according to their scores. The cities were given five categories. The distribution of scores is shown in Figure 3.

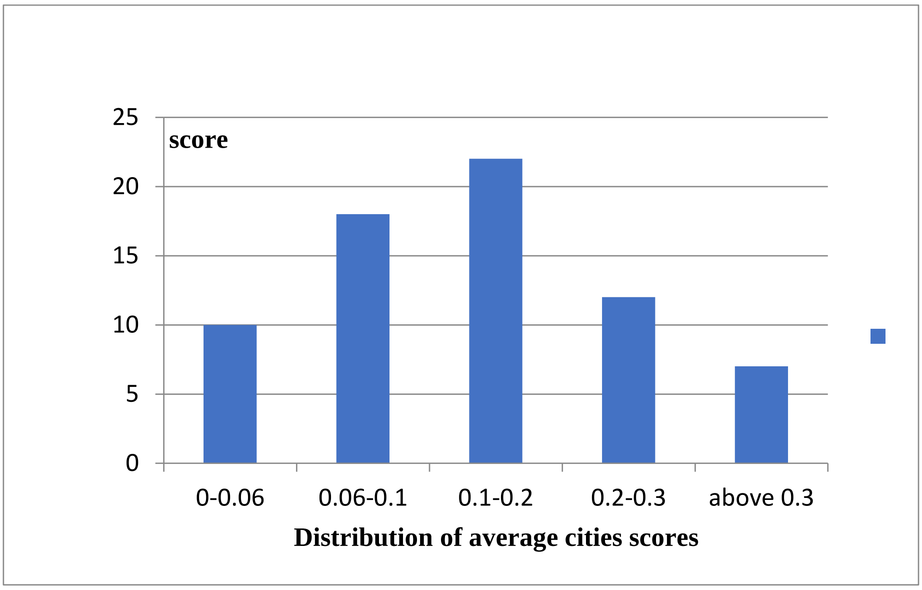

Figure 3 Distribution of mean city scores

Category 1 cities are those with a score of 0.3 or above and a high level of intensive urban land use, including seven cities including Shenzhen, Shanghai, Beijing, Guangzhou, Chengdu, Tianjin and Chongqing. All of these cities are national center cities and are ahead of their time in terms of urban development, leading the country in all aspects. In terms of land use, the available land resources in these cities are relatively scarce in relation to their development needs, and this mismatch between resources and demand emerged early in the cities' rapid early development and is an important constraint to urban development. These cities have in the past focused on maximising the use of land through efficient land use intensification, thereby reducing the negative impact of land scarcity on urban development, and in the process have accumulated rich experience in urban land use intensification and have developed effective methods of urban land use intensification that are appropriate to local development, demonstrating a high level of urban land use intensification in the present.

The second group of cities scored in the 0.2-0.3 range, with a high level of intensive urban land use. 12 cities, including Nanjing and Hangzhou, scored in the 0.2-0.3 range. Most of these cities are new first-tier cities, with advantages in location, history and policy, and are more attractive to development factors such as capital, material and population. However, the existing land planning and construction in these cities has basically been implemented, and re-planning or optimisation on this basis will cause a lot of additional costs, which is the main factor affecting or restricting their further improvement of urban land use efficiency.

The third group of cities scores in the 0.1-0.2 range, with an average level of intensive urban land use, including 22 cities in Luoyang and Nanchang. The majority of cities in China are in this category, and the low economic efficiency of land in this category is the main reason for their relatively low level of intensive urban land use compared to the second category.

The fourth category of cities scores in the 0.06-0.1 range, with a low level of intensive urban land use, and includes 18 cities including Guilin and Beihai. Although these cities have a large regional area, the actual available land area is relatively small. In addition, they lack advanced industries as support and guarantee for urban development, and their local development is underdeveloped, making the level of intensive urban land use low.

The fifth category of cities scores below 0.06, with a low level of intensive urban land use, and includes 10 cities within Nanchong and Ganzhou. The development of cities in this category is constrained by many factors and is generally at a low level. Their land resources are relatively abundant for the development needs of the cities, but the rough use of land and the low efficiency of local industries generally result in the inefficient intensive use of urban land.

6 Conclusions and Recommendations

The analysis of the land-intensive use of 69 major cities shows that the majority of cities in China have an evaluation score in the middle level (within the range of 0.1-0.2), and the number of cities decreases from one level to the other. In order to improve the level of intensive land use in each city and to explore the potential of new land dynamics to drive urban development, the following recommendations are provided for each category of cities based on the classification of the results and the integration of the corresponding solutions.

1. Cities in the first category are generally at a more developed level, and can mainly adopt the environmental protection relocation grounding model and the urban three-dimensional space development land-saving model. At a specific level, the city can work to improve the efficiency of intensive land use, relocate or eliminate industries with low ecological and economic efficiency, and integrate and redistribute some low-efficiency land. At the same time, urban construction can be moderately extended to the periphery to alleviate the contradiction between land and development, expand the influence of developed cities and drive the surrounding areas to form a regional efficient development. In addition, these cities have basically reached saturation in the development of two-dimensional land resources, and further pursuit of the development of three-dimensional spatial areas and efficient use is a practical and feasible way to mention the level of intensive land use.

2. The second category of cities is saturated with the use of land resources and can mainly adopt the public resource sharing and land saving model and the environmental relocation model. This will facilitate the transformation of land resources into key elements of public services, consolidate facilities with similar uses into dedicated areas to avoid unnecessary pressure on land due to repeated construction, and accelerate the renewal of industries and related facilities on the premise of ensuring ecological and environmental protection, gradually improving the efficiency and economic benefits of intensive land use in the process of replacing the old with the new. In this way, the efficiency of land use can be improved, while at the same time the ecological environment can be maintained and improved, so that the city can become more attractive in the process of steady progress.

3.The level of land use intensification in the third category of cities is general and universal, and can be improved in more ways than in the first two categories to maximise the effectiveness of the new land dynamics for the modernisation process. The main approaches that can be adopted are the land-saving model for the transformation and use of abandoned industrial and mining land and the land-saving model for multi- and high-rise standard factory buildings.

4. For cities in the fourth category, the current lack of geographically available land resources is the greatest constraint to improving the intensive use of land. In terms of improving the efficiency of land use at the two-dimensional territorial level, the cities can adopt the land-saving model of urban three-dimensional spatial development to expand the available space in the city, combine the land-saving model of road traffic design optimization and the land-saving model of industrial and mining abandoned land transformation, and focus on finding new forms of industries suitable for the local development according to local conditions, so as to include more land in the region to achieve the maximum development and use of land. At the same time, the pursuit of a higher level of intensive use must not be left behind. For land that has already been put to use, synergies can be made with more developed regions to carry out industrial transformation and upgrading while ensuring the ecological benefits of the land, so that advanced industries can be used to stimulate the vigorous momentum of land resources for development.

5. The fifth category of cities is still in its infancy in terms of the process of urban modernisation and development. Land resources have little influence on urban development, so they can flexibly adopt the various models in this paper in response to the requirements of urban modernisation, further improve land-use planning at the overall level, and raise the level of intensive urban land use, taking into account urban conditions. We can implement the concept of sustainable development at a time when the cost of ecological construction is low at the primary stage. In addition, the concept of sustainable development is implemented at a time when the cost of ecological construction is low. In addition, the concept of sustainable development is implemented at a time when the cost of ecological construction is low.

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