Research on Measurement and Coupling Coordination of Land Intensive Utilization and New Urbanization

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Abstract. This paper constructs an intensive land use system from the perspective of land input, output and sustainable development, constructs a new urbanization system from the perspectives of ecology, population, economy and society, and applies entropy weight method to 31 provinces, municipalities and autonomous regions. Based on the model of coupling degree and coordinated development degree, this paper divides the types of the two coupled and coordinated development stage by using intensity levels and a new type of urbanization.

1. Introduction

Land intensive utilization is the modern agricultural mode which not only maximizes profits, returns, and agricultural crop yields on smaller land areas, relying on advanced agricultural modern high-tech and management methods and investing in the same elements of production materials and labor force, but also guarantees and pays attention to land maintenance and sustainable development. New-type urbanization refers to the integration of urban and rural areas and the urban-rural integration as its development characteristics. It aims to promote social and economic development and achieve common prosperity. Ultimately, it is an important national development strategy to achieve a harmonious, stable, and sustainable innovation and development trend among population, economy, society, and ecological urbanization.

Research on land intensive use in academic is mostly focused on the evaluation of land intensive use, the relationship between land intensive use and urbanization, and the coordinated development of land intensive use and economy. [1, 2, 3] This paper constructs an evaluation index system for land intensive use and a new urbanization evaluation system. The entropy weighting method was used to measure the weights of various indicators, land intensive use and the intensity of new urbanization development, and to establish a harmonized development stage type of both the coupling degree and the coordinated development degree model division. This will provide a certain reference for clarifying and understanding the status of land intensive utilization and new urbanization in different provinces, municipalities and autonomous regions, and for the relevant land planning departments to formulate policies and regulations according to different provinces, municipalities and autonomous regions.
Table 1. Intensive Utilization of Land and New-type Urbanization Indicator Attributes and Their Weights

| Target layer | Criteria layer | Indicator layer | Attributes | Weights |
|--------------|----------------|-----------------|------------|---------|
| Land input intensity and utility | The number of laborers in the built-up area (Person/km²) | positive | 0.011 |
| | The proportion of urban construction land in urban area (%) | positive | 0.014 |
| | Total crop area sown (Thousand hm²) | positive | 0.027 |
| | Agricultural electricity (Ten thousand kwh) | positive | 0.049 |
| | Total agricultural water use (Billion m³) | positive | 0.032 |
| Land output benefits | Per capita food production (kg) | positive | 0.023 |
| | Unit Land Area Public Finance Revenue (Ten thousand yuan/km²) | positive | 0.080 |
| | Total land area Retail sales of consumer goods (Ten thousand yuan) | positive | 0.041 |
| | Unit land area real estate development investment (Ten thousand yuan) | positive | 0.035 |
| | Unit land area year-end financial institutions Various deposit balances (Ten thousand yuan) | positive | 0.05 |
| Sustainable land development capacity | Green area (hm²) | positive | 0.039 |
| | Fertilizer application amount for agriculture (Ten thousand t) | negative | 0.035 |
| | Industrial SO2 emissions per unit area of land (t/km²) | negative | 0.029 |
| | The amount of industrial wastewater discharged per unit area of land (Ten thousand t/km²) | negative | 0.033 |
| | Industrial land smoke area dust emissions per unit area (t/km²) | negative | 0.042 |
| Eco-urbanization | Every million people own a bus (Vehicle) | negative | 0.005 |
| | Built-up area green coverage area (hm²) | positive | 0.026 |
| | Drainage pipe length (km) | positive | 0.032 |
| Population urbanization | Tertiary industry employee at the end of the year (person) | positive | 0.021 |
| | Number of Basic Pensions, Medical and Unemployment Insurance for Urban Employees (Person) | positive | 0.039 |
| New urbanization development level | Number of college students per 10,000 students (Person) | positive | 0.015 |
| Economic urbanization | Per capita GDP (Yuan) | positive | 0.024 |
| | Total wages of employees on the job (Ten thousand yuan) | positive | 0.043 |
| | Total fixed and liquid assets of industrial enterprises (Ten thousand yuan) | positive | 0.034 |
| | Total output value of foreign-invested enterprises (Ten thousand yuan) | positive | 0.084 |
| Social urbanization | Number of hospitals and hospitals (Pieces) | positive | 0.021 |
| | Internet broadband access users (Ten thousand) | positive | 0.033 |
| | Number of post offices at the end of the year (Pieces) | positive | 0.023 |
| | Mobile phone number of users at the end of the year (Ten thousand) | positive | 0.028 |
| | Real City Road Area at the End of the Year (Ten thousand m²) | positive | 0.029 |
2. Index system and research method

2.1. Intensive Utilization of Land and Construction of New Urbanization Index System
When selecting indicators, this paper ensures that the indicators can fully and objectively reflect the actual development of 31 provinces, municipalities, and autonomous regions in mainland China, and constructs an evaluation index system for land intensive utilization and new urbanization as shown in Table 1.

2.2. Intensive Utilization of Land and Measurement of New Urbanization Level
Firstly this paper constructs a 30*31 judgment data matrix, of which 30 are 30 horizontal intensive land use and new urbanization evaluation indicators and 31 are the vertical portraits of 31 provinces, cities, and autonomous regions of China's mainland. The entropy method is used to measure the judgment matrix. The steps for calculating the entropy method are as follows:

(1) The proportional swap of land intensive use and new urbanization indicators: \( Q_{ij} = x_j \sum_{i=1}^{n} x_i \);

(2) The information entropy of intensive land use and new urbanization indicators: \( e_j = -k \sum_{i=1}^{n} Q_{ij} \ln Q_{ij} \);

(3) The redundancy of land intensive use and new urbanization indicators: \( d_j = 1 - e_j \);

(4) The weight of land intensive use and new urbanization indicators: \( w_j = d_j \sum_{i=1}^{m} d_j \);

(5) The intensity of intensive land use and Intensive use of land and new urbanization: \( W_i = \sum_{j=1}^{n} (w_j \times X_{ij}) \);

Explanation: \( m \) is the number of land intensive utilization and new urbanization evaluation indicators; \( n \) is the number of provinces, municipalities and autonomous regions; \( k \) is adjustment factor, \( k \) is calculated as \( k = 1/\ln n \); \( X_{ij} \) is the standardized value of the jth index of the ith province, municipality and autonomous region \( x_{ij} \) is the initial value of the jth index of the th province and municipality, The \( X_{ij} \) calculation method is: when \( x_{ij} \) is positive, \( X_{ij} = \frac{x_{ij} - x_{ij, min}}{x_{ij, max} - x_{ij, min}} \); when \( x_{ij} \) is negative, \( X_{ij} = \frac{x_{ij, max} - x_{ij}}{x_{ij, max} - x_{ij, min}} \).

2.3. The Division of Coordinated Stages of Intensive Land Use and New Urbanization
This paper constructs an evaluation model of the degree of coupling and coordinated development of land intensive utilization and new urbanization applicable to this paper, where the formula for coupling as follows:

\[ C = \left[ \left( W_1 * W_2 \right) / \left( W_1 + W_2 \right) \right]^{3/2} \]

\( W_1 \) and \( W_2 \) are the integrated intensity of land intensive utilization and new urbanization development in 31 provinces, municipalities and autonomous regions respectively, \( C \) is the degree of coupling between the two. \( C \) standard is as follows: \( C \in [0,0.3) \) belongs to low level coupling; \( C \in [0.3,0.5) \) belongs to antagonistic coupling; \( C \in [0.5,0.8) \) belongs to running-in coupling; \( C \in [0.8,1.0] \) belongs to high level coupling.

At the same time, in order to avoid that the average level of intensive land use and new-type urbanization from a certain province is relatively low, but the degree of coupling is higher, which does not meet the objective reality, this paper introduces the degree of coordinated development based on the
coupling degree formula, and truly measures and reflects the coordinated development status and trend of the two. The formula for harmonizing the degree of development is as follows:

$$D = \sqrt{C*T}$$

$$T = \alpha U_1 + \beta U_2$$

$D$ is the degree of coordinated development between the two, $T$ is Comprehensive coordination coefficient. $\alpha$ and $\beta$ are the contribution coefficients of land intensive use and new urbanization. This article believes that the two are in equal status and are of a very important degree and influence each other, promote each other, and contain each other.

3. Intensive Utilization of Land and the Development Level

This article categorizes 31 provinces, cities and autonomous regions in mainland China according to their geographical locations: Western China, Central China, Northeast China, Eastern China, etc. According to Table 2, presently, the new urbanization in the eastern region is ahead of the intensive use of land, the new urbanization in the western region is relatively balanced with the development of land intensive use, while the new urbanization in the central and northeast regions lags behind the development of intensive land use. The rank of land intensive utilization is as follows: Eastern Region (0.151) > Central Region (0.142) > Northeast Region (0.111) > Western Region (0.063). The order of new urbanization intensity is as follows: Eastern Region (0.184) > Central Region (0.115) > Northeastern Region (0.099) > Western Region (0.063).

3.1. Intensive use of land

The intensity of land input in the western region is ahead of the sustainable use of land, but the land output benefits lag behind; The intensity of land input in the central region is balanced with sustainable land use, and both are ahead of the land output benefits; Northeast China has the most balanced development in terms of land input, land output, and sustainable land use. In the eastern region, land input intensity lags behind sustainable land use, and land output benefits are the highest (Table 2). The order of land input intensity is as follows: Central (0.056) > Eastern (0.037) = Northeast (0.037) > Western (0.026), the order of land output benefits is as follows: Eastern (0.062) > Northeast (0.036) > Central (0.029) > Western (0.015), the order of sustainable land use is as follows: Central (0.057) > Eastern (0.052) > Northeast (0.038) > Western (0.022).

3.2. New urbanization development level

The development of social urbanization in the western, central and northeast regions is all ahead of the economic urbanization, the next rank is the development of ecological urbanization, and population urbanization is the most lagging behind. The development of economic urbanization in the eastern region ranks first, social urbanization temporarily ranks second, and both eco-urbanization and population urbanization are relatively weak and relatively balanced. (Table 2) The order of ecological urbanization is as follows: Eastern (0.027) > Central (0.020) > Northeast (0.017) > Western (0.011), the order of population urbanization is as follows: East (0.028) > Central (0.016) > Northeast (0.014) > West (0.010). The order of economic urbanization is as follows: East (0.075) = Middle (0.032) = Northeast (0.032) > West (0.015). The order of social urbanization is as follows: East (0.054) > Central (0.047) > Northeast (0.036) > West (0.027).
| Western Region | Land input intensity | Land output benefits | Sustainable land | Comprehensive intensive use | order | Intensive use of land | New urbanization development level |
|---------------|---------------------|----------------------|-----------------|---------------------------|-------|----------------------|---------------------------------|
| Guangxi       | 0.034               | 0.011                | 0.031           | 0.075                     | 22    | 0.015                | 0.010                           |
| Ningxia       | 0.007               | 0.011                | 0.013           | 0.031                     | 30    | 0.006                | 0.003                           |
| Xinjiang      | 0.075               | 0.015                | 0.015           | 0.105                     | 14    | 0.004                | 0.009                           |
| Xizang        | 0.004               | 0.004                | 0.004           | 0.012                     | 31    | 0.001                | 0.006                           |
| Inner Mongolia| 0.036               | 0.026                | 0.035           | 0.098                     | 18    | 0.015                | 0.008                           |
| Chongqing     | 0.015               | 0.021                | 0.019           | 0.055                     | 26    | 0.019                | 0.025                           |
| Sichuan       | 0.035               | 0.021                | 0.030           | 0.086                     | 20    | 0.024                | 0.023                           |
| Guizhou       | 0.019               | 0.020                | 0.030           | 0.068                     | 23    | 0.010                | 0.005                           |
| Yunnan        | 0.028               | 0.015                | 0.022           | 0.064                     | 25    | 0.010                | 0.008                           |
| Gansu         | 0.028               | 0.009                | 0.011           | 0.048                     | 27    | 0.009                | 0.006                           |
| Qinghai       | 0.004               | 0.012                | 0.030           | 0.046                     | 28    | 0.002                | 0.001                           |
| Shanxi        | 0.023               | 0.017                | 0.027           | 0.067                     | 24    | 0.013                | 0.015                           |
| Average       | 0.026               | 0.015                | 0.022           | 0.063                     |       | 0.011                | 0.010                           |
| Central Region| Hunan               | 0.084               | 0.029           | 0.067                     | 180   | 0.019                | 0.017                           |
| Henan         | 0.079               | 0.045                | 0.093           | 0.217                     | 3     | 0.022                | 0.023                           |
| Jiangxi       | 0.032               | 0.023                | 0.046           | 0.101                     | 17    | 0.016                | 0.011                           |
| Shanxi        | 0.065               | 0.022                | 0.056           | 0.142                     | 9     | 0.012                | 0.012                           |
| Hubei         | 0.040               | 0.029                | 0.040           | 0.108                     | 12    | 0.021                | 0.019                           |
| Anhui         | 0.039               | 0.025                | 0.042           | 0.106                     | 13    | 0.027                | 0.014                           |
| Average       | 0.056               | 0.029                | 0.057           | 0.142                     |       | 0.020                | 0.016                           |
| Northeast area| Heilongjiang        | 0.057               | 0.027           | 0.020                     | 104   | 0.015                | 0.012                           |
| Jilin         | 0.024               | 0.032                | 0.030           | 0.085                     | 21    | 0.014                | 0.010                           |
| Liaoning      | 0.031               | 0.050                | 0.063           | 0.144                     | 8     | 0.023                | 0.020                           |
| Average       | 0.037               | 0.036                | 0.038           | 0.111                     |       | 0.017                | 0.014                           |
| East area     | Beijing             | 0.022               | 0.092           | 0.126                     | 126   | 0.019                | 0.031                           |
| Tianjin       | 0.021               | 0.043                | 0.023           | 0.088                     | 19    | 0.017                | 0.014                           |
| Shanghai      | 0.026               | 0.207                | 0.058           | 0.292                     | 1     | 0.020                | 0.025                           |
| Zhejiang      | 0.027               | 0.045                | 0.046           | 0.119                     | 11    | 0.027                | 0.032                           |
| Guangdong     | 0.064               | 0.046                | 0.069           | 0.179                     | 5     | 0.051                | 0.061                           |
| Jiangsu       | 0.049               | 0.044                | 0.069           | 0.163                     | 7     | 0.053                | 0.034                           |
| Shandong      | 0.067               | 0.030                | 0.067           | 0.164                     | 6     | 0.044                | 0.038                           |
| Hebei         | 0.061               | 0.053                | 0.125           | 0.239                     | 2     | 0.018                | 0.018                           |
| Fujian        | 0.022               | 0.034                | 0.046           | 0.101                     | 16    | 0.014                | 0.013                           |
| Hainan        | 0.009               | 0.022                | 0.005           | 0.037                     | 29    | 0.005                | 0.016                           |
| Average       | 0.037               | 0.062                | 0.052           | 0.151                     |       | 0.027                | 0.028                           |
4. The Coupling of Land Intensive Use and New Urbanization
According to Table 3, the degree of coupling between land intensive use and new urbanization in 31 provinces, cities and autonomous regions in China is between 0.3 and 0.5, which is affiliated with antagonistic coupling levels. In order to further distinguish antagonistic differences within these provinces, municipalities and autonomous regions, this article further divides them into the following parts within the interval of antagonistic coupling: (1) High-grade antagonistic coupling (C between 0.49-0.5); (2) Low-grade antagonistic coupling (C between 0.46-0.47); (3) Medium-grade antagonistic coupling (C between 0.47-0.48); (4) Low-grade antagonistic coupling (C between 0.46-0.47); (5) Low-grade antagonistic coupling (C less than 0.46). At present, the land intensive use and the new urbanization in the northeastern and central regions are both coupled at a high level of antagonism, the eastern region is a medium and high grade antagonistic coupling, and the western region has the lowest degree of coupling, manifested as intermediate-grade antagonistic coupling. The land intensive use and new urbanization in most provinces, municipalities and autonomous regions are at a high level of antagonism coupled level, However, there are also some cases of “false high-level coupling” in Ningxia and Gansu (low intensity of land intensive use and new urbanization), Therefore, this paper introduces the harmonized development degree D to divide the coordinated development of land intensive use and new-type urbanization, so as to make up for the deficiency of “false high-level coupling”.

Table 3. The Coupling and Coordination Stage Types of Land Intensive Use and New Urbanization Development

| Coupling C | Coupling level | Coefficient T | D    | Development stage | Order |
|------------|----------------|---------------|------|-------------------|-------|
| Guangxi    | 0.500          | High grade    | 0.078| 0.198             | High Imbalance | 21    |
| Ningxia    | 0.498          | High grade    | 0.029| 0.120             | High Imbalance | 29    |
| Xinjiang   | 0.398          | Low Level     | 0.065| 0.161             | High Imbalance | 27    |
| Xizang     | 0.483          | Medium and high grade | 0.009| 0.067             | Low imbalance | 31    |
| Inner Mongolia | 0.497       | High grade    | 0.088| 0.210             | Medium imbalance | 19    |
| Chongqing  | 0.481          | Medium and high grade | 0.075| 0.190             | High Imbalance | 23    |
| Sichuan    | 0.475          | Medium level  | 0.125| 0.244             | Medium imbalance | 11    |
| Guizhou    | 0.496          | High grade    | 0.060| 0.173             | High Imbalance | 24    |
| Yunnan     | 0.496          | High grade    | 0.057| 0.168             | High Imbalance | 25    |
| Gansu      | 0.495          | High grade    | 0.056| 0.166             | High Imbalance | 26    |
| Qinghai    | 0.327          | Low Level     | 0.026| 0.093             | Low imbalance  | 30    |
| Shanxi     | 0.491          | High grade    | 0.082| 0.201             | Medium imbalance | 20    |
| Average    | 0.470          | Medium level  | 0.063| 0.166             | High Imbalance | 20    |
| Hunan      | 0.485          | Medium and high grade | 0.145| 0.265             | Medium imbalance | 9     |
| Henan      | 0.492          | High grade    | 0.185| 0.302             | Low imbalance  | 5     |
| Jiangxi    | 0.498          | High grade    | 0.093| 0.215             | Medium imbalance | 17    |
| Shanxi     | 0.486          | Medium and high grade | 0.115| 0.237             | Medium imbalance | 14    |
| Hubei      | 0.498          | High grade    | 0.117| 0.242             | Medium imbalance | 12    |
5. Conclusion

(1) In terms of land intensive use, western land investment is ahead of sustainable land use but land output lags behind relatively; Land input in the central region is balanced with sustainable land use, and both are ahead of land output; And northeast China has the most balanced land input, output, and sustainable use.

(2) In terms of new urbanization, the development of social urbanization in the west, central region and northeast are all ahead of the economic urbanization, ecological urbanization is the second, and population urbanization is the most lagging behind. And in eastern region, economic urbanization ranks first, social urbanization temporarily ranks second, ecological urbanization and population urbanization are relatively weak and relatively balanced.

(3) The pattern of spatial differentiation between land intensive use and new-type urbanization is not balanced, showing a situation of “lower in the east, higher in the north” and a downward trend in the east to west direction. The whole western part of the country except Xinjiang is in the low-value zone of land intensive use, especially in Ningxia, Gansu, Qinghai and Tibet. The high value of land intensive use is concentrated in the south with Hunan and Guangdong as the core and the east with Shanghai, Jiangsu, Shandong, Henan, Shanxi, Hebei, Beijing, and Liaoning as the core.

(4) The intensive use of land in the northeast and central areas is coupled with high-grade urbanization at a high level of antagonism, coupled with the middle-to-high-grade antagonistic coupling in the east and intermediate-grade antagonistic coupling in the west. Most provinces, municipalities, and
autonomous regions are at a high level of antagonism coupled, but there are "false high-level couplings" conditions in Ningxia and Gansu. Besides, the land intensive use and new-type urbanization in the east, central and northeast regions are moderately disordered, and the west is highly disordered.

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