Land Urbanization Quality in China: Evaluation and Spatial-temporal Variability

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Abstract. Based on the construction of an evaluation index system for land urbanization quality, this paper evaluates and analyzes the variability of spatial-temporal in land urbanization quality during 2005-2015 in China. Results shows that: (1) Among the three aspects of land urbanization quality, sustainable development capacity scores the highest, land urbanization development quality follows, land-population coordinated development is the lowest. (2) The quality of land urbanization in China is generally improving, and the spatial distribution has a "gradient difference", showing a pattern of high east and low west. In conclusion, to improve the quality of land urbanization, all aspects should be considered comprehensively; each region should combine its own conditions to formulate strategies for improving the quality of land urbanization.

1. Introduction
For a long time, China's land urbanization has faced some practical problems such as inefficient utilization of construction land [1], the faster speed of land urbanization than population urbanization [2], and weak sustainable development capabilities, which have raised serious challenges on the sustainable development of land urbanization. Therefore, this paper constructs a comprehensive evaluation index system for land urbanization quality including the development quality of land urbanization itself, the coordinated development of land-population urbanization, and the sustainable development capacity of land urbanization, and comprehensively and dynamic analyzes the spatial-temporal evolution in the quality of land urbanization in China from 2005 to 2015, which is expected to provide a scientific basis for improving the quality of land urbanization, improving land use policies, and protecting scarce cultivated land resources.

2. Method and data
2.1. Method
Under the guidance of the principles of systemicity, scientificity, and operability, and referring to the existing literature [3-6], this paper constructs a three-dimensional evaluation index system firstly, including the development quality of land urbanization, the coordinated development of land-population urbanization and the sustainable development capacity of land urbanization. The specific
indicators are shown in Table 1; then the entropy weight method is used to determine the weight of each indicator; finally, the quality of land urbanization is measured by summation.

| Target | Factor | Index | Direction | Weight |
|--------|--------|-------|-----------|--------|
| Economic quality | Average output value of secondary production | positive | 0.0543 |
| Economic quality | Average output value of tertiary production | positive | 0.0467 |
| Economic quality | Financial revenue per land | positive | 0.0469 |
| Economic quality | Total retail sales of consumer goods per land | positive | 0.0214 |
| Economic quality | Urban population density | positive | 0.0170 |
| Social quality | Urban employment density | positive | 0.0421 |
| Social quality | Urban residential land area per capita | positive | 0.0073 |
| Social quality | Urban traffic road area per capita | positive | 0.0099 |
| Social quality | Per capita electricity consumption | positive | 0.0103 |
| Social quality | SO2 emissions per land | negative | 0.0137 |
| Ecological quality | Discharge of wastewater per land | negative | 0.0177 |
| Ecological quality | solid waste per land | negative | 0.1134 |
| Ecological quality | Energy consumption per land | negative | 0.0240 |
| Ecological quality | Green coverage rate in built-up areas | positive | 0.0013 |
| Ecological quality | Population urbanization rate | positive | 0.0023 |
| Ecological quality | Urban disposable income per capita | positive | 0.0248 |
| Ecological quality | Number of students in colleges and universities | positive | 0.0075 |
| Population urbanization | Medical and health institution beds per thousand people | positive | 0.0167 |
| Coordinated development of land-population urbanization | Number of urban employees participating in basic endowment insurance | positive | 0.0279 |
| Coordinated development of land-population urbanization | Number of urban employees participating in medical insurance | positive | 0.0778 |
| Coordinated development of land-population urbanization | Growth rate of built-up area | negative | 0.0299 |
| Land urbanization | Proportion of construction land in urban land area | positive | 0.0200 |
| Land urbanization | Proportion of land used for public management and public services in construction land | positive | 0.0037 |
| Land urbanization | Proportion of industrial land in construction land | negative | 0.0009 |
| Economic sustainable development | Proportion of residential land in construction land | positive | 0.0009 |
| Economic sustainable development | Fiscal expenditure per land | positive | 0.0481 |
| Economic sustainable development | Investment in fixed assets per land | positive | 0.0158 |
| Economic sustainable development | Foreign direct investment per land | positive | 0.0461 |
| Economic sustainable development | Average price of commercial housing | negative | 0.0264 |
| Social sustainable development | Area of illegally granted land | negative | 0.0904 |
| Social sustainable development | Proportion of the area of construction land leasing by bidding, auction and listing in the total area of land leasing | positive | 0.0359 |
| Ecological sustainable development | Urban sewage treatment capacity | positive | 0.0247 |
| Ecological sustainable development | Urban domestic waste treatment capacity | positive | 0.0241 |
| Ecological sustainable development | Industrial pollution control investment per land | positive | 0.0482 |

2.2. Data source
This paper uses a panel dataset of 30 provinces or municipalities in China from 2005 to 2015 (Tibet, Taiwan, Hong Kong and Macao are excluded due to data availability) for this analysis. The data used in this paper are collected respectively from "China Statistical Yearbook", “China Energy Statistical Yearbook”, “China Statistical Yearbook of Environment”, “China Land and Resources Statistical Yearbook”, “China Urban Construction Statistical Yearbook” and “China Real Estate Yearbook”. Economic data are all processed at constant prices based on 2005.
3. Results analysis

3.1. Temporal evaluation of land urbanization quality
The results of China's land urbanization quality measurement are shown in Table 2. From the view of overall, the quality of land urbanization showed an overall upward trend from 2005 to 2015, and the score increased from 0.408 to 0.795.

From the view of three dimensions of land urbanization quality, the results are: (1) The quality of land urbanization itself has generally fluctuated and improved. The score increased from 0.244 to 0.266, but its contribution to the quality of land urbanization dropped from 59.74% to 33.48%, indicating that the quality of land urbanization itself has improved, while the contribution to the quality of urbanization was continuously decreasing. (2) The overall quality of the coordinated development of land-population urbanization has improved significantly, from 0.014 to 0.197, and its contribution to the quality of land urbanization has increased from 3.55% to 24.78%, showing a trend of "double improvement" in both values and contributions. The quality of the coordinated development of population urbanization and land urbanization has been continuously improved, which shows the coordination of land urbanization and population urbanization has also been continuously improved. (3) The overall sustainability of the quality of land urbanization has been continuously improved. The score has increased from 0.150 to 0.332, and the contribution to the quality of land urbanization has fluctuated from 36.71% to 41.74%. The ability of sustainable economic development has been continuously strengthened; the ability of sustainable social development has shown an overall trend of improvement, which has made outstanding contributions to the sustainable development of land urbanization; although the ecological quality of land urbanization itself has been declining, the processing capacity of urban sewage and domestic waste has been improved. The continuous strengthening of investment in the treatment of industrial pollution has led to the continuous improvement of the ecological sustainability of land urbanization.

| Year | 2005 | 2007 | 2009 | 2011 | 2013 | 2015 |
|------|------|------|------|------|------|------|
| Land urbanization quality itself | Economic quality | 0.058 | 0.070 | 0.093 | 0.117 | 0.150 | 0.168 |
| | Social quality | 0.017 | 0.032 | 0.044 | 0.055 | 0.069 | 0.081 |
| | Ecological quality | 0.169 | 0.068 | 0.055 | 0.012 | 0.010 | 0.017 |
| | subtotal | 0.244 | 0.169 | 0.192 | 0.184 | 0.230 | 0.266 |
| | Contribution ratio (%) | 59.74 | 50.49 | 36.60 | 33.54 | 32.65 | 33.48 |
| Coordinated development of land-population urbanization | Population urbanization | 0.003 | 0.024 | 0.071 | 0.098 | 0.128 | 0.157 |
| | Land urbanization | 0.011 | 0.032 | 0.037 | 0.020 | 0.038 | 0.040 |
| | subtotal | 0.014 | 0.056 | 0.107 | 0.118 | 0.166 | 0.197 |
| | Contribution ratio (%) | 3.55 | 16.78 | 20.44 | 21.53 | 23.57 | 24.78 |
| Sustainable development capacity | Economic sustainability | 0.042 | 0.050 | 0.066 | 0.081 | 0.098 | 0.109 |
| | Social sustainability | 0.097 | 0.035 | 0.116 | 0.103 | 0.130 | 0.126 |
| | Ecological sustainability | 0.011 | 0.024 | 0.043 | 0.062 | 0.080 | 0.097 |
| | subtotal | 0.150 | 0.110 | 0.225 | 0.246 | 0.308 | 0.332 |
| | Contribution ratio (%) | 36.71 | 32.73 | 42.96 | 44.93 | 43.78 | 41.74 |
| Total | 0.408 | 0.336 | 0.525 | 0.548 | 0.704 | 0.795 |

3.2. Spatial evaluation of land urbanization quality
With the help of ArcGIS software, the Jenks natural break method is used to divide the land urbanization quality value into three categories from low to high: low quality (≥0.340), medium quality (0.34~0.43) and high quality (>0.43), and Table 3 lists the land urbanization quality of each province in 2005, 2010 and 2015.
From 2005 to 2015, the land urbanization quality in various provinces has a "gradient difference", and the overall characteristic is marked by a gradual decline trend from east to west. (1) In terms of development level of land urbanization quality, Jiangsu, Shanghai and Zhejiang have always been in the ranks of high quality, while Ningxia, Qinghai, Guizhou and Guangxi have always been at a low level. (2) In terms of development speed, the three provinces with the fastest speed of quality improvement are Yunnan, Shanxi and Guizhou, with growth rates above 26%, the three provinces with the fastest decline in land urbanization quality are Qinghai, Hainan and Gansu, with a decline rate of more than 20%.

Table 3 The land urbanization quality in each province

| province     | 2005 | 2010 | 2015 |
|--------------|------|------|------|
| East         |      |      |      |
| Beijing      | 0.4  | 0.4  | 0.4  |
| Tianjin      | 0.4  | 0.49 | 0.4  |
| Hebei        | 0.4  | 0.38 | 0.3  |
| Shanghai     | 0.56 | 0.53 | 0.55 |
| Jiangsu      | 0.47 | 0.51 | 0.51 |
| Zhejiang     | 0.49 | 0.48 | 0.49 |
| Fujian       | 0.43 | 0.43 | 0.46 |
| Shandong     | 0.38 | 0.41 | 0.41 |
| Guangdong    | 0.41 | 0.45 | 0.46 |
| Hainan       | 0.44 | 0.36 | 0.35 |
| North east   |      |      |      |
| Liaoning     | 0.4  | 0.3  | 0.3  |
| Heilongjiang | 0.3  | 0.4  | 0.4  |
| Inner Mongoria | 0.3 | 0.3  | 0.3  |
| Guangxi      | 0.3  | 0.3  | 0.3  |
| Chongqing    | 0.3  | 0.3  | 0.3  |
| Sichuan      | 0.36 | 0.40 | 0.39 |
| Guizhou      | 0.26 | 0.29 | 0.32 |
| Yunnan       | 0.26 | 0.38 | 0.34 |
| Shaanxi      | 0.37 | 0.41 | 0.41 |
| Gansu        | 0.41 | 0.32 | 0.33 |
| Qinghai      | 0.32 | 0.28 | 0.25 |
| Ningxia      | 0.25 | 0.27 | 0.29 |
| Xinjiang     | 0.27 | 0.35 | 0.32 |
| Middle       |      |      |      |
| Shanxi       | 0.29 | 0.34 | 0.38 |
| Anhui        | 0.37 | 0.38 | 0.40 |
| Jiangxi      | 0.41 | 0.43 | 0.42 |
| Henan        | 0.44 | 0.41 | 0.43 |
| Hubei        | 0.35 | 0.38 | 0.39 |
| Hunan        | 0.41 | 0.41 | 0.47 |

4. Conclusions
Based on the construction of a land urbanization quality evaluation index system, this paper measures and analyzes the spatial-temporal characteristics of land urbanization quality in China from 2005 to 2015. The conclusions are as follows: (1) From the three dimensions of land urbanization quality: First, the sustainable development ability of land urbanization has improved rapidly, but the social sustainable development ability has been improved slowly; second, the development quality of land urbanization itself has not changed much, but its ecological quality has declined significantly; third, the scores of coordinated development of land-population urbanization is the lowest, but which increases gradually. In particular, the coordination quality of population urbanization to land urbanization has improved significantly, while the support ability of land urbanization to population urbanization is insufficient. (2) Although the land urbanization quality in China has fluctuated and improved as a whole, there is a significant spatial distribution pattern of high east and low west. Therefore, each region should formulate strategies to improve the quality of land urbanization in accordance with local conditions.

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