

Analysis of Regional Construction Land Development Intensity Pattern Evolution and Influencing Factors –A Case Study of Shaanxi Province (Postprint)

Authors: Wang Bo

Date: 2021-02-13T00:00:00+00:00

Abstract

Regional construction land development intensity is an important indicator that reveals land use efficiency, socio-economic development level, and territorial space development status. Monitoring and governing its changes are important means to optimize territorial space development patterns and achieve regional sustainable development. This study constructs a quantitative model for construction land development intensity, taking Shaanxi Province as an example, to calculate the county-level construction land development intensity index from 2000 to 2015, utilizes spatial autocorrelation analysis methods to reveal its spatial patterns and evolution characteristics, and employs Ordinary Least Squares (OLS) and Geographically Weighted Regression (GWR) models to identify influencing factors of the evolution of construction land development intensity patterns. The results show that: (1) From 2000 to 2015, the overall construction land development intensity in Shaanxi Province showed a growth trend, with significant internal spatial differentiation. High-intensity areas were concentrated in Yulin, Yan' an, Xi' an, Ankang, and other places, while low-intensity areas were concentrated in Xianyang, Baoji, Tongchuan, Shangluo, Weinan, Hanzhong, and other places. (2) The construction land development intensity in Shaanxi Province exhibited obvious spatial agglomeration. Hotspot areas were stably distributed in Xi' an' s municipal districts and surrounding counties, while coldspot areas were distributed in southern Yan' an, Xianyang, Tongchuan, Weinan, Hanzhong, and other partial regions. While county-level construction land development intensity gradually improved, regional development imbalance became increasingly prominent. (3) Fixed asset investment, resident consumption level, fiscal investment level, cultivated land resources, and terrain conditions are the main factors influencing the spatial differentiation of construction land development intensity in Shaanxi Province. However,

the magnitude of their impact varies significantly across different counties, and the influence of individual factors is unstable.

Full Text

Pattern Evolution and Influencing Factors of Regional Construction Land Development Intensity: A Case Study of Shaanxi Province

Bo WANG¹, Xiao-jun HUANG^{1,2,3,4}, Meng-meng LIU¹

(1 College of Urban and Environmental Sciences, Northwest University, Xi' an 710127, Shaanxi, China; 2 Shaanxi Key Laboratory of Earth Surface System and Environmental Carrying Capacity, Xi' an 710127, Shaanxi, China; 3 Shaanxi Yellow River Research Institute, Xi' an 710127, Shaanxi, China; 4 Shaanxi Xi' an Urban Forest Ecosystem Research Station, Xi' an 710127, Shaanxi, China)

Abstract

Regional construction land development intensity is an important indicator that reveals land use efficiency, socio-economic development level, and territorial spatial development status. Monitoring and governing its changes are crucial means for optimizing territorial spatial development patterns and achieving regional sustainable development. This study constructs a quantitative model for construction land development intensity, taking Shaanxi Province as a case study, to calculate the county-level construction land development intensity index for [years missing] years, uses spatial autocorrelation analysis to reveal its spatial pattern and evolution characteristics, and employs Ordinary Least Squares (OLS) and Geographically Weighted Regression (GWR) models to identify influencing factors of the pattern evolution. The results show: (1) The construction land development intensity in Shaanxi Province showed an overall growth trend, with significant internal spatial differentiation. High-intensity areas were concentrated in Yulin, Yan' an, Xi' an, and Ankang, while low-intensity areas were concentrated in Xianyang, Baoji, Tongchuan, Shangluo, Weinan, and Hanzhong. (2) The construction land development intensity exhibited significant spatial agglomeration. Hot spots were stably distributed in Xi' an' s municipal districts and surrounding counties, while cold spots were distributed in southern Yan' an, Xianyang, Tongchuan, Weinan, and parts of Hanzhong. As county-level construction land development intensity gradually increased, regional development imbalance became increasingly prominent. (3) Fixed asset investment, household consumption level, financial input, cultivated land resources, and topographical conditions are the main factors affecting the spatial differentiation of construction land development intensity in Shaanxi Province. However, the degree of impact varies significantly across different counties, and the impact of individual factors exhibits instability.

Keywords: construction land; development intensity; pattern; influencing fac-

tors; Shaanxi Province

1.1 Study Area Overview

Shaanxi Province is located in northwestern China, covering a land area of [missing value]. The province had a permanent population of [missing value] in [year] and governs [missing value] counties (county-level cities and municipal districts). Based on differences in natural geographical characteristics, Shaanxi Province can be divided into three major regions (Fig. [Figure 1: see original paper]): the Loess Plateau region in northern Shaanxi, the Guanzhong Plain region in central Shaanxi, and the Qinling-Bashan mountainous region in southern Shaanxi.

In recent years, with rapid socio-economic development, the scale of construction land in Shaanxi Province has continuously expanded. From [year] to [year], the province's construction land area increased from 7,831 km² to 13,775 km², with an average annual growth rate of 4.77%. However, alongside large-scale development of construction land, numerous problems have emerged, including disordered expansion and extensive utilization of construction land, idling of rural residential land, overload of resources and environment in ecologically fragile areas, and serious ecological problems such as soil erosion and environmental pollution caused by overdevelopment. How to optimize the territorial spatial development model, promote rational utilization of construction land, and achieve coordinated development of socio-economy and ecological environment has become an important practical issue facing Shaanxi Province.

1.2 Data Sources

The land use data used in this study were obtained from the Resource and Environment Science Data Center of the Chinese Academy of Sciences (<http://www.resdc.cn>), specifically the land use remote sensing monitoring data for [years]. According to its classification system, construction land includes urban land, rural residential land, and other construction land. Terrain slope data were sourced from the National Earth System Science Data Sharing Platform (<http://www.geodata.cn>). Socio-economic data were obtained from the *Shaanxi Statistical Yearbook*, *Shaanxi Regional Statistical Yearbook*, and statistical yearbooks of various cities. This study uses [number] county-level units (counties, county-level cities, and municipal districts) in Shaanxi Province as the research units. For comparative analysis, administrative divisions from previous years were adjusted according to the provincial administrative division standards.

2.1 Construction Land Development Intensity Model

Construction land development intensity is a comprehensive index that reflects the level of construction land utilization and the carrying capacity of population and socio-economic elements within a certain region. Based on this, this study selects construction land proportion, population carrying capacity, and

economic development intensity to comprehensively characterize construction land development intensity. The calculation formula is as follows:

Where, construction land proportion (CLP) reflects the scale of regional construction land development, expressed as the ratio of construction land area to total regional area; population carrying capacity (PCS) reflects the population carrying capacity of regional construction land, expressed as the ratio of total population to construction land area; economic development intensity (EDI) reflects the economic output capacity of regional construction land, expressed as the ratio of secondary and tertiary industry output value to construction land area; α , β , and γ are the weights of construction land proportion, population carrying capacity, and economic development intensity, respectively. Since CLP, PCS, and EDI are all positive indicators, the original data were first processed using positive standardization. The standardization formula is:

$$Y_{ij} = (X_{ij} - X_{jmin}) / (X_{jmax} - X_{jmin})$$

Where: X_{ij} , X_{jmax} , X_{jmin} , and Y_{ij} are the original value, maximum value, minimum value, and standardized value of the j -th indicator for the i -th research object, respectively. The entropy method was then used to determine the weight values of α , β , and γ as [missing values], respectively. Finally, the construction land development intensity values were calculated comprehensively.

2.2 Spatial Autocorrelation

Spatial autocorrelation includes global autocorrelation and local autocorrelation. Global autocorrelation commonly uses Moran's I index to describe the spatial relationship and spatial differences of a phenomenon across the entire region, with a value range of $[-1, 1]$. When Moran's $I < 0$, it indicates negative spatial correlation; when Moran's $I > 0$, it indicates positive spatial correlation; when Moran's $I = 0$, it indicates random distribution. Local spatial autocorrelation can reflect the local association between the attribute value of a spatial unit and its adjacent spatial units, identifying the specific spatial locations where agglomeration occurs. The Getis-Ord G_i^* statistic is commonly used to identify high-value clusters or hot spots and low-value clusters or cold spots of spatial object attribute values.

2.3 Spatial Heterogeneity of Influencing Factors Based on OLS and GWR Models

Traditional linear regression models (OLS) do not consider spatial pattern elements and only perform overall regression calculations for all samples and parameters. In contrast, Geographically Weighted Regression (GWR) models can estimate the influence of different regions and reflect the spatial distribution differences of parameters, allowing parameters to vary with spatial location, making the results more realistic. The GWR model is as follows:

$$y_i = \beta_0(u_i, v_i) + \sum \beta_p(u_i, v_i)x_{ip} + \epsilon_i$$

Where: y_i is the dependent variable; (u_i, v_i) are the spatial coordinates of the i -th sample; $\beta_0(u_i, v_i)$ is the intercept term of the regression model; $\beta_p(u_i, v_i)$ is the regression coefficient of the p -th independent variable; p is the number of independent variables; ϵ_i ($i = 1, 2, \dots, n$) is the independently distributed random error term.

The weights in the model are set as a function of the distance between observation points. Bandwidth greatly affects model accuracy. Methods for determining bandwidth include the Akaike Information Criterion (AIC) method and cross-validation (CV) method. The AIC method takes into account differences in degrees of freedom among different models. Therefore, this study uses a Gaussian function to determine weights and adopts the AIC method to determine the optimal bandwidth.

Construction land development intensity is a measure of land use level and degree in the process of human socio-economic activities, and is therefore jointly influenced by various factors including population, society, economy, and resources. Based on principles of scientificity, objectivity, and accessibility, this study selects driving factors affecting construction land development intensity from aspects of economic development, population size, investment and consumption, resource endowment, natural conditions, and government regulation (Table).

3.1.1 Overall Pattern Change

The construction land proportion, population carrying capacity, and economic development intensity of each county were calculated separately, and the results were substituted into formula ([missing]) to calculate the county-level construction land development intensity in Shaanxi Province. The natural breaks method was used to classify it into high-intensity areas, sub-high-intensity areas, sub-low-intensity areas, and low-intensity areas, thereby analyzing the spatial pattern evolution characteristics of the three dimensions and construction land development intensity from 2000 to 2015.

From the perspective of construction land proportion (Fig. [Figure 2: see original paper]), all counties showed significant growth, with the provincial average construction land proportion increasing from 6.67% to 8.89%. The spatial distribution showed significant imbalance, with high-value areas mainly concentrated in the Guanzhong region. Among them, the main urban area of Xi'an had the highest construction land proportion, followed by Xianyang's municipal districts; construction land proportions in northern Shaanxi and southern Shaanxi were relatively low.

From the perspective of population carrying capacity (Fig. [Figure 3: see original paper]), all counties experienced significant declines, with the provincial average population carrying capacity decreasing from 4.59×10^2 to 0.60×10^2 . Areas with high population carrying capacity in Shaanxi were concentrated in northern and southern Shaanxi, while the Guanzhong region

had relatively low levels. Additionally, from 2000 to 2015, due to the increase in county-level construction land scale, high-value areas of population carrying capacity decreased significantly, with the most pronounced declines in Yulin and Ankang.

From the perspective of economic development intensity (Fig. [Figure 4: see original paper]), all counties showed significant growth, with the provincial average economic development intensity increasing from [missing value] to [missing value]. The spatial differentiation of county-level economic development intensity was significant, with high-value areas mainly concentrated in Yulin, northern Yan' an, Ankang, and the municipal districts of Xi' an, Xianyang, and Baoji. Most counties in Guanzhong had relatively low economic development intensity. Additionally, from 2000 to 2015, the number of high-value areas of economic development intensity in southern Shaanxi increased significantly.

From the perspective of construction land development intensity (Fig. [Figure 5: see original paper]), county-level construction land development intensity in Shaanxi Province showed a growth trend, with the provincial average development intensity increasing from [missing value] to [missing value]. In terms of spatial distribution, high-intensity areas were mainly distributed in the main urban area of Xi' an, Qingjian, Zizhou, Jiaxian, and Wuqi counties in Yulin, Zichang, Yanchang, and Zhidan counties in Yan' an, and Xunyang, Hanyin, Baihe, and Ziyang counties in Ankang. Low-intensity areas were mainly distributed in northern Yulin, southern Yan' an, and some counties under the jurisdiction of Xianyang, Baoji, Tongchuan, Weinan, and Hanzhong.

Specifically, in 2000, [number] counties in Shaanxi Province had construction land development intensity at low or sub-low levels, while [number] counties were at high or sub-high levels. By 2015, the number of low or sub-low intensity counties decreased to [number], while high or sub-high intensity counties increased to [number]. During this period, county-level construction land development intensity improved significantly, with the most prominent changes in counties surrounding Xi' an and in southern Yulin and northern Yan' an. By 2015, county development intensity continued to grow, but except for some changes in parts of Yulin and Ankang, the overall pattern changed little. The number of low or sub-low intensity counties stabilized at around [number], while high or sub-high intensity counties numbered around [number]. This indicates that the overall county-level construction land development intensity in Shaanxi Province remains at a relatively low level, with a small proportion of high-development-intensity counties. Additionally, from the perspective of specific county units, urban municipal districts in the Guanzhong region generally have higher development intensity than the counties they govern, while this pattern is not obvious in northern and southern Shaanxi. The reason may be that urban municipal districts in northern and southern Shaanxi have lower construction land utilization efficiency, and their population carrying capacity and economic development intensity are even lower than some counties, resulting in lower construction land development intensity than some counties.

3.1.2 Spatial Relationship Change

Global Spatial Relationship The global Moran' s I index was calculated for each time period. The results show that the Moran' s I indices for construction land development intensity in Shaanxi Province for the three time periods were [missing values], all passing significance tests (Z-values greater than the critical value), indicating that construction land development intensity in Shaanxi Province exhibits significant spatial agglomeration. Meanwhile, the Moran' s I index gradually increased from 2000 to 2015, indicating that the overall spatial agglomeration characteristic strengthened year by year.

Local Spatial Relationship The Getis-Ord G_i^* index was calculated for construction land development intensity in Shaanxi Province for the three years, and the natural breaks method was used to classify it into cold spots, sub-cold spots, sub-hot spots, and hot spots. The results show that hot spots of construction land development intensity remained stably distributed in Xi' an' s municipal districts and surrounding counties from 2000 to 2015. Sub-hot spots were distributed in southern Yulin, northern Yan' an, and parts of Ankang. Cold spots were distributed in southern Yan' an, Xianyang, Tongchuan, Weinan, and parts of Hanzhong. Sub-cold spots were distributed in northern Yulin, Baoji, and Shangluo. Sub-hot spots and cold spots showed a trend of first increasing then decreasing, while sub-cold spots showed a trend of first decreasing then increasing, indicating that regional development imbalance first intensified then moderated. Overall, the hot-cold spot pattern shows that northern Shaanxi, southern Shaanxi, and Guanzhong each have their own high-value areas while low-value areas are contiguously distributed, which basically matches the global change and spatial heterogeneity trend of construction land development intensity.

3.2.1 Influencing Factor Identification Based on OLS Model

The OLS model was first used to identify influencing factors of construction land development intensity in Shaanxi Province from 2000 to 2015. The results show (Table) that the adjusted R^2 values were all above [missing value], meaning the model could explain [missing value]% of sample changes. Among them, per-area fixed asset investment, per capita retail sales of consumer goods, proportion of fiscal expenditure to GDP, per capita cultivated land area, and terrain relief degree passed significance tests ($P < 0.05$), indicating they are the main factors affecting construction land development intensity in Shaanxi Province.

The impact of fixed asset investment on construction land development intensity is manifested in that the more capital invested per unit of construction land area, the more obvious the agglomeration effect of population and industry, which strengthens the population carrying capacity and economic output benefits of construction land, thereby promoting the enhancement of construction land development intensity. However, the carrying capacity and output benefits of construction land have upper limits. When the population number

and economic benefits per unit of construction land reach their peaks, development intensity cannot continue to increase even with further investment.

Consumption, as one of the main drivers of economic growth, also has an important impact on construction land development intensity. The continuous rise in household consumption capacity and upgrading of consumption structure create strong demand for residential, commercial, and leisure spaces, meaning more construction land is used to undertake production activities, thus greatly promoting urban construction land development intensity.

Local government fiscal expenditure on infrastructure, enterprise transformation, and social services will increase construction land scale or intensity to a certain extent. Therefore, areas with greater financial input often have stronger construction land proportion, population carrying capacity, and economic development intensity, and thus higher construction land development intensity.

Per capita cultivated land area and terrain relief degree are negatively correlated with construction land development intensity. Cultivated land is the main source of construction land expansion. If regional cultivated land resources are limited, it will inevitably lead to increased construction land development intensity. Conversely, if regional cultivated land resources are abundant, it is prone to disorderly expansion and inefficient utilization of construction land. Similarly, terrain relief degree determines the development conditions and utilization potential of construction land, thereby exerting varying degrees of constraint on construction land development intensity.

3.2.2 Spatial Heterogeneity Analysis of Influencing Factors Based on GWR Model

To further explore the spatial differentiation of influencing factors, the four significant influencing factors identified by the OLS model were used in GWR models for spatial visualization of regression coefficients, obtaining the spatial distribution of influencing factors of construction land development intensity in Shaanxi Province from 2000 to 2015. The results show (Table) that the adjusted R^2 values were [missing values], showing improvement over the OLS model. The Akaike Information Criterion (AICc) values were [missing values], smaller than the OLS model, indicating better GWR model fit. Combined with the spatial distribution of regression coefficients for each explanatory variable:

Per-area Fixed Asset Investment The regression coefficient between per-area fixed asset investment and construction land development intensity first increased then decreased from 2000 to 2015, indicating that the impact of fixed asset investment on construction land development intensity first strengthened then weakened. From the spatial distribution of regression coefficients (Fig. [Figure 7: see original paper]), the spatial distribution changed little from 2000 to 2005, generally showing a gradual increase from northern to southern Shaanxi. In contrast, 2010 showed significant changes, with low-value areas shifting from northern Shaanxi to Baoji in the Guanzhong region, while northern Shaanxi

transformed from low-value to sub-high-value areas, and medium-value areas in Guanzhong extended northward, generally showing a gradual increase from northwest to southeast. The reason for the changed spatial pattern in 2010 is that during this period, northern Shaanxi vigorously developed Yan'an New City and the Yulin-Hengshan integration construction, with fixed asset investment bringing urban expansion and further infrastructure expansion, enhancing both construction land scale and development intensity.

Per Capita Retail Sales of Consumer Goods Household consumption level is positively correlated with construction land development intensity, with relatively high regression coefficients, indicating that household consumption level has a significant impact on construction land development intensity. From the spatial distribution of regression coefficients (Fig. [Figure 8: see original paper]), high-value areas were concentrated in southern Shaanxi and Yan'an in northern Shaanxi in 2000, forming high and sub-high value areas, while medium-value areas formed in the Guanzhong region. Overall, the regression coefficients showed no consistent pattern in spatial distribution from 2000 to 2015, indicating that the impact of household consumption level on construction land development intensity varied significantly across different years.

Proportion of Fiscal Expenditure to GDP The regression coefficient of the proportion of fiscal expenditure to GDP showed a decreasing trend from 2000 to 2015, indicating that the impact of fiscal input on construction land development intensity weakened. From the spatial distribution of regression coefficients (Fig. [Figure 9: see original paper]), the distribution pattern did not change significantly from 2000 to 2005, but sub-low-value areas in southern Shaanxi gradually decreased. In 2010, northern Shaanxi experienced major changes, with regression coefficients of all grades distributed, indicating significant differences in the impact of fiscal input across northern Shaanxi. In 2015, high-value areas almost covered the entire northern Shaanxi region, while low-value areas in southern Shaanxi further decreased. Overall, the regression coefficients of the proportion of fiscal expenditure to GDP showed a decreasing trend from north to south. Combined with the spatial distribution of construction land development intensity, high and medium-intensity development areas overlap with low and sub-high value areas of regression coefficients, indicating that high-intensity development areas have low sensitivity to government fiscal input, while low-intensity areas have high sensitivity.

Per Capita Cultivated Land Area The absolute value of the regression coefficient for per capita cultivated land area gradually increased and then decreased in 2015, indicating that against the background of incremental expansion of construction land, the year-by-year reduction of cultivated land resources enhanced the impact on construction land development intensity, while under the background of improved efficiency in stock utilization of construction land, the impact of cultivated land resources on construction land development intensity gradually weakened. From the spatial distribution of regression coefficients (Fig. [Figure 10: see original paper]), high-value areas were distributed in the

Guanzhong Plain in 2000, with low-value areas in northern Shaanxi and southern Shaanxi. In 2005, high-value areas shifted to Baoji, forming a pattern increasing from northeast to southwest. In 2010, the changes were significant, with northern Shaanxi becoming high-value areas and southern Shaanxi becoming low-value areas, forming a pattern increasing from south to north. In 2015, high-value areas were concentrated in northern Yulin, with medium and low-value areas spreading to the southeast, forming a pattern increasing from southeast to northwest. Combined with the spatial distribution of construction land development intensity, areas with high absolute regression coefficient values correspond to high-intensity development areas, while areas with low absolute values correspond to low-intensity areas, reflecting to some extent the opposition between per capita cultivated land area and construction land development. High-intensity development areas are more constrained by cultivated land resources, and the reduction of per capita cultivated land area forces continuous enhancement of construction land development intensity.

Terrain Conditions From the distribution of regression coefficients across periods (Fig. [Figure 11: see original paper]), low-value areas were concentrated in southern Yulin and northern Yan'an in 2000, with high-value areas concentrated in Yulin, similar to the 2005 distribution pattern. In 2010, sub-high-value areas decreased significantly, with low-value areas shifting from northern Shaanxi to Baoji and Hanzhong. In 2015, high-value areas increased significantly, concentrated in parts of Shangluo and Ankang in southern Shaanxi, while low-value areas returned to northern Shaanxi. Overall, the regression coefficients showed a pattern of increasing from northwest to southeast in 2015. Combined with the spatial distribution of construction land development intensity, areas with small absolute regression coefficient values correspond to high-intensity development areas in southern Shaanxi, while areas with large absolute values correspond to high-intensity areas in northern Shaanxi, indicating that terrain conditions have a greater impact on construction land development intensity in northern Shaanxi than in southern Shaanxi. The reason is that southern Shaanxi's Qinling-Bashan mountainous region focuses on ecological protection, where development is restricted, and steep mountainous areas are difficult to develop. In contrast, northern Shaanxi's Loess Plateau region has active socio-economic activities but is significantly affected by terrain conditions, with construction land mostly concentrated in relatively flat areas such as mountain valleys and gullies.

5 Discussion

From 2000 to 2015, construction land development intensity in Shaanxi Province showed an overall growth trend, but internal spatial differentiation was significant. High-intensity development areas were distributed in the main urban area of Xi'an; Qingjian, Zizhou, Jiaxian, and Wuqi counties in Yulin; Zichang, Yan-chang, and Zhidan counties in Yan'an; and Xunyang, Hanyin, Baihe, and Ziyang counties in Ankang. Low-intensity areas were mainly distributed in northern

Yulin, southern Yan' an, and some counties under the jurisdiction of Xianyang, Baoji, Tongchuan, Weinan, and Hanzhong.

Previous studies on construction land development intensity mostly used the proportion of regional construction land area to total regional area to represent development intensity. This calculation method only considers land use function and construction land scale, while neglecting the comprehensiveness of construction land as a carrier of human production activities and differences in its utilization efficiency and carrying capacity. This study treats construction land development intensity as a comprehensive index of regional land use degree and its population carrying capacity and economic output intensity, enabling comprehensive evaluation of construction land development intensity from the perspectives of scale, efficiency, and carrying capacity. Based on multi-temporal land use remote sensing monitoring data, analyzing the spatio-temporal evolution characteristics of county-level construction land development intensity in Shaanxi Province not only achieves long-term evaluation of regional construction land development intensity but also serves as an effective means for dynamic monitoring of territorial spatial development and identification of human activity intensity patterns. The spatial heterogeneity analysis of influencing factors based on OLS and GWR models reveals the spatial differences in the degree of influence of population, society, economy, resources, and environment on construction land development intensity, which is significant for deeply exploring the driving and constraining factors of construction land development intensity in different regions, formulating targeted territorial spatial development strategies, and rationally guiding regional development and construction activities.

Currently, all regions across the country are vigorously carrying out territorial spatial planning, and resource-environment carrying capacity evaluation and territorial spatial development suitability evaluation are the foundation of territorial spatial planning. The research content and conclusions of this paper have certain reference significance for scientifically understanding territorial spatial development status, conducting “double evaluations” and territorial spatial planning, and optimizing territorial spatial development patterns. Based on the research results, future construction land control in Shaanxi Province can be carried out from two aspects: (1) Strengthen control over construction land in high-intensity development counties, reasonably determine urban growth boundaries, strictly control the amount of new construction land, increase the utilization and development of stock land, and avoid resource-environment carrying capacity imbalance caused by expanded development intensity. (2) For counties with low development intensity, increase fixed asset investment and fiscal expenditure to achieve population and industry agglomeration, promote economic development of small and medium-sized towns through industrial support and talent introduction policies; meanwhile, avoid blind expansion, reasonably delineate ecological protection red lines, and promote urbanization while ensuring ecological environmental quality.

This study still needs further improvement and deepening. For example, local

government land development and management policies often have important impacts on regional construction land development, but this indicator is difficult to quantify directly and can only be represented through proxy indicators such as fixed asset investment and fiscal expenditure. The authors will further address this in future research.

References

- [1] LYU Xiao, HUANG Xianjin. Research progress and prospect of construction land expansion[J]. *Geography and Geo-Information Science*, 2013(6): 55-62.
- [2] ZHANG Miao, GAN Chenlin, CHEN Yinrong. Carbon emission efficiency and optimization of low carbon for construction land development intensity in China according to provincial panel data[J]. *Resources Science*, 2016, 38(2): 265-275.
- [3] XU Y, TANG H, WANG B, et al. Effects of land use intensity on ecosystem services and human well being: A case study in Huailai County, China[J]. *Environmental Earth Sciences*, 2016, 75(5): [missing].
- [4] HUANG X, HUANG X J, LIU M M, et al. Spatial temporal dynamics and driving forces of land development intensity in the western China from 2000 to 2015[J]. *Chinese Geographical Science*, 2020, 30(1): 16-29.
- [5] ZHAO Yali, LIU Youzhao. Diffidence and influencing factors of urban land development intensity across 222 cities in China[J]. *Resources Science*, 2013, 35(2): 380-387.
- [6] ZHANG Peng, ZHANG Xujia, LIU Yong, et al. Diversity of urban spatial efficiency based on the land development intensity in Changchun City[J]. *Scientia Geographica Sinica*, 2018, 38(6): 895-902.
- [7] WANG Zhongcheng, LI Jinlian. Study on the intensity of land development in the central city[J]. *Jiangsu Urban Planning*, 2008, (12): 17-21.
- [8] WANG Haoyu. The study on evaluation of matching degree between construction land development strength and ecological environment capacity in Xinjiang[D]. Urumqi: Xinjiang Agricultural University, 2016.
- [9] VA D, ORLITOVÁ E. Spatial relationship between human population density, land use intensity and biodiversity in the Czech Republic[J]. *Landscape Ecology*, 2012, 27(9): 1279-1290.
- [10] MACCHI L, GRAU H R, ZELAYA P V, et al. Trade offs between land use intensity and avian biodiversity in the dry Chaco of Argentina: A tale of two gradients[J]. *Agriculture Ecosystems & Environment*, 2013, 174(174): 11-20.
- [11] LIU Yanjun, LIU Jing, HE Cui, et al. Evolution of the coupling relationship between regional development strength and resource environment level in China[J]. *Geographical Research*, 2013, 32(3): 507-517.

- [12] SHEN Chunzhu, TAN Qichuan, WANG Danyang, et al. Research on land development intensity based on carrying capacity of resources and environment and suitability of development and construction: A case study of Jiangsu[J]. Resources and Environment in the Yangtze Basin, 2019, 28(6): 1276-1286.
- [13] CHEN Yi, HUANG Xianjin, CHEN Zhigang, et al. The spatial balance degree evaluation of construction land in China[J]. Scientia Geographica Sinica, 2012, 32(12): 1424-1429.
- [14] WANG Jing, XIAO Haifeng. Optimization of the distribution of cotton production in Xinjiang under the view of cultivated land ecological security[J]. Arid Land Geography, 2018, 41(4): 833-843.
- [15] WEI Siyi, JU Xiang, XUN Wenhui. Spatial temporal coupling relationship between land development intensity and carrying capacity of regional resources and environment: A case study in Shenyang economic region[J]. China Land Science, 2018, 32(7): 58-65.
- [16] BIAN Fengming, LIU Yantong, ZHAO Ling. The spatial balance degree evaluation on land use in Jilin Province[J]. China Land Science, 2015, 29(12): 74-80.
- [17] WANG Quanxi, SUN Pengju, LIU Xuelu, et al. Spatial temporal differentiation and situation of spatial coordination degree on land use in Gansu Province[J]. Arid Land Geography, 2020, 43(1): 271-279.
- [18] JIN Gui, DENG Xiangzheng, CHEN Dongdong, et al. Trends and spatial patterns of land conversions in the north China Plain[J]. Resources Science, 2016, 38(8): 1515-1524.
- [19] XU Zijun, WANG Xiyuan, SHI Qingdong, et al. Analysis and application of spatial relationship of nutrient accumulation in economic forests in Xinjiang based on spatial statistical theory[J]. Arid Land Geography, 2017, 40(6): 1227-1234.
- [20] WANG Xixi, SHEN Xiaoyan, XU Jianbin, et al. Spatial correlation analysis of the influencing factors and the relationship between passenger volume and cargo volume in the Bohai Rim[J]. Economic Geography, 2018, 38(2): 133-139.
- [21] ZHANG Jingke, CHEN Yi, HUANG Xianjin. Assessment of the equilibrium degree and limitation degree of Yangtze River economic belt' s land development[J]. Resources and Environment in the Yangtze Basin, 2017, 26(12): 1945-1953.
- [22] TAN Shukui, LIU Qi, LI Yanan. Spatial temporal characteristics of spatial balance degrees on land use in China[J]. China Land Science, 2017, 31(11): 40-46.
- [23] CAO Xiaoshu, XU Jianbin. Spatial heterogeneity analysis of regional economic development and driving factors in China' s provincial border counties[J]. Acta Geographica Sinica, 2018, 73(6): 81-91.

[24] WANG Hongliang. Research on construction land use intensity in urbanization: A case study in Inner Mongolia[D]. Beijing: China Agricultural University, 2017.

[25] LIU Yanjun, YU Huisheng, LIU Degang, et al. Spatial differentiation mechanisms of the pattern evolution of construction land development intensity in northeast China[J]. Acta Geographica Sinica, 2018, 73(5): 818-831.

Note: Figure translations are in progress. See original paper for figures.

Source: ChinaXiv –Machine translation. Verify with original.