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Spatiotemporal Evolution Analysis of Land Use Types in the Greater Xi' an Area: Postprint

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Abstract

Through multiple methods, this study analyzes the evolution characteristics of land use types, spatial variation features, and their influencing factors in the Greater Xi' an region, aiming to provide a scientific basis for the optimized development of land use in Greater Xi' an. With the support of GIS and RS technologies, three periods (1996, 2006, and 2016) of LANDSAT TM (OLI) remote sensing images of the region were interpreted. Using a land use transfer matrix and land use change models, a quantitative analysis was conducted on the spatiotemporal dynamic changes of land use types and land cover in Greater Xi' an since 1996. The results indicate: (1) Over the past 20 years, the area of construction land in Greater Xi' an has continuously increased, while the areas of cultivated land and forestry land have generally decreased, grassland has slightly increased, water bodies have slightly shrunk, and frequent conversions among various land use types have occurred. (2) The comprehensive degree of land use is relatively high and continuously strengthening, with the land use structure tending toward equilibrium. (3) In terms of spatial variation, regional differences in land use change are significant, and the speed of centroid shifts for construction land, cultivated land, and forestry land exhibits a phased characteristic of being initially rapid and subsequently slow. (4) Based on a comprehensive review of relevant literature, the primary driving factor of land use change in the Greater Xi' an region is policy-related factors. This paper, for the first time, proposes the evolution patterns of land use in the Greater Xi' an region from a spatiotemporal change perspective, and these results can provide a scientific basis for land optimization during the development process of Greater Xi' an.

Full Text

Abstract

The evolution, spatial variation, and influencing factors of land use types in the greater Xi' an area have been sufficiently quantified. In order to provide a scientific basis for the optimal use and development of land in the greater Xi' an area, we analyzed and interpreted regional remote sensing images from the Landsat Thematic Mapper and Operational Land Imager from 1996, 2006, and 2016. We adopted a land use transfer matrix and land use change model to conduct quantitative analysis of the spatial and temporal changes in land use and land cover since 1996. We supported these tools with GIS and RS technologies. We found that the area of developed land in the greater Xi' an area, Shaanxi Province, China has increased over the past 20 years, while cultivated and forested land has decreased. Grassland has increased slightly, while the water area has shrunk slightly. We noted frequent classification changes. The comprehensive degree of land use was high and constantly strengthened over time, and the land use structure tended to be balanced. We identified significant regional differences in land use change, and the transfer speeds of the centers of gravity of construction land, arable land, and forestry land show the characteristics of the stages of speed before slowness. The driving factors of land use change in the greater Xi' an area were mainly policy factors. This paper proposes the land use evolution rule of the Greater Xi' an area for the first time from the angle of time and space change. Our results should provide a scientific basis for land use optimization as the greater Xi' an area continues to develop and grow.

Keywords: greater Xi' an area; type of land use; time and space change; land use change model

1 Data and Methods

1.1 Data Sources

We obtained Landsat TM (2016 OLI) remote sensing images from three periods (May 11, 1996; April 26, 2006; and May 2, 2016) with a spatial resolution of 30 m × 30 m from the Geospatial Data Cloud platform (http://www.gscloud.cn/). The images cover path/row 126/36, 126/37, and 127/37.

1.2 Socioeconomic Data

Socioeconomic data including population and GDP statistics were obtained from the Shaanxi Statistical Yearbook (http://www.shaanxitj.gov.cn/) and the China Yearbook Online (http://www.yearbookchina.com/).

2 Methods

2.1 Land Use Classification

We classified land use into five categories based on the National Standard of "Classification of Current Land Use Status" (GB/T 21010-2007) [8]: cultivated land, forest land, grassland, water bodies, and construction land. We performed supervised classification using the maximum likelihood method and validated the results with ground survey data. The overall classification accuracies for the three periods were 85.8%, 88%, and 87%, respectively, with Kappa coefficients of 0.8412, 0.8563, and 0.8491, meeting the required standards for land use change analysis.

[Figure 2: see original paper]

2.2 Land Use Dynamic Degree Model

We calculated the single land use dynamic degree to quantify the change rate of each land use type [9]. The formula is:

$$S_{ij} = \frac{A_{ij} - A_{ij0}}{A_{ij0}} \times \frac{1}{T} \times 100\%$$

where S_{ij} represents the dynamic degree of land use type i during period j; A_{ij} and A_{ij0} represent the area of land use type i at the end and beginning of period j, respectively; and T represents the study period length in years.

2.3 Land Use Degree Model

We calculated the comprehensive land use degree index using the following formula [12]:

$$L = 100 \times \sum_{i=1}^{n} a_i \times r_i$$

where L is the comprehensive land use degree index; a_i is the area percentage of land use type i; r_i is the land use degree grading index of type i; and n is the number of land use types. The grading indices for cultivated land, forest land, grassland, water bodies, and construction land were 3, 2, 2, 1, and 4, respectively .

3 Results and Analysis

3.1 Land Use Classification Results

The land use classification results for 1996, 2006, and 2016 show significant spatiotemporal changes in the greater Xi' an area [Figure 2: see original paper].

Construction land expanded rapidly, primarily converting from cultivated land around urban centers.

3.2 Land Use Change Analysis

The land use transfer matrix analysis reveals that cultivated land was the main source of new construction land. Between 1996-2006, approximately 3.17 km^2/year of cultivated land was converted to construction land, while between 2006-2016, this rate increased to 12.05 km^2/year .

3.3 Spatiotemporal Characteristics

3.3.1 Temporal Change Characteristics The comprehensive land use degree index increased from 270.2416 in 1996 to 279.0229 in 2006 and further to 291.5465 in 2016, indicating intensifying human disturbance and land use development . The land use dynamic degree analysis shows that construction land had the highest annual growth rate, particularly during 2006-2016.

3.3.2 Spatial Pattern Evolution We analyzed the spatial patterns using the gravity center model. The gravity centers of construction land, cultivated land, and forest land all shifted during the study period . The construction land gravity center moved 1.58 km toward the northeast between 2006-2016, reflecting the development of the Xi' an-Xianyang New Area. The cultivated land gravity center shifted 0.77 km toward the northwest, while forest land gravity center moved 0.3 km toward the southwest [Figure 8: see original paper].

[Figure 8: see original paper]

3.4 Driving Factors Analysis

3.4.1 Policy Factors Policy factors were the primary drivers of land use change in the greater Xi' an area. The establishment of the Xi' an-Xianyang New Area in 2014 and the implementation of the "Great Xi' an" development strategy significantly accelerated urban expansion and construction land growth [7]. The "Grain for Green" program also influenced conversions between cultivated land and forest/grassland.

3.4.2 Socioeconomic Factors Population growth and economic development were secondary drivers. The permanent population of Xi'an increased from 6.48 million in 1996 to 8.71 million in 2016, while GDP grew from 41.5 billion yuan to 625.7 billion yuan. These changes drove demand for construction land and infrastructure development [11, 15-17]. The correlation coefficient between GDP growth and construction land expansion was 0.92 ($p < 0.01$), indicating a strong positive relationship.

4 Conclusions

(1) From 1996 to 2016, construction land in the greater Xi' an area expanded continuously, primarily at the expense of cultivated land. The area of forest land decreased, while grassland and water bodies showed minor fluctuations.

(2) The comprehensive land use degree index increased steadily, reflecting intensifying human activities and land development. The land use structure tended toward equilibrium, but regional differences remained significant.

(3) The gravity centers of construction land, cultivated land, and forest land all shifted during the study period, with construction land showing the most pronounced movement toward the northeast, consistent with the development direction of the Xi' an-Xianyang New Area.

(4) Policy factors, particularly the "Great Xi'an"development strategy and the establishment of the Xi'an-Xianyang New Area, were the dominant drivers of land use change. Socioeconomic factors such as population growth and economic development played secondary but important roles.

This study quantifies the spatiotemporal evolution of land use in the greater Xi' an area and identifies its primary driving mechanisms, providing a scientific basis for sustainable land use planning and policy-making in the region.

References

[1] LI Fengxia, SHI Hui, FENG Xiaogang, et al. Study of land use dynamic evolution and driving factors in Xi' an [J]. Bulletin of Surveying and Mapping, 2015, (12): 41-45.

[2] WANG Xiaofeng, FU Bojie, SU Changhong, et al. Spatio-temporal characteristics and driving forces of built-up land in Xi' an, China [J]. Acta Ecologica Sinica, 2015, 35(21): 7139-7149.

[3] SUN Kai, YANG Yanzheng, ZHAO Pengxiang, et al. Spatial temporal evolution of landscape pattern in Xi' an based on 3S technology [J]. Journal of Northwest Forestry University, 2015, 30(2): 180-185.

[4] ZHOU Zixiang, LI Jing, HAN Yanfei. Evaluation and effect of LUCC on NPP in Guanzhong-Tianshui economic zone [J]. Arid Land Geography, 2013, 36(6): 1058-1066.

[5] LI Hui, ZHOU Weibo, MA Cong, et al. Effects of urbanization on regional precipitation and river hydrological process in Xi' an City [J]. Arid Land Geography, 2017, 40(2): 322-331.

[6] ZHANG Leqin, CHEN Suping, WANG Wenqin, et al. Review and prospect on driving force research of construction land expansion in the context of rapid urbanization [J]. Arid Land Geography, 2013, 36(1): 164-175.

[7] Xi' an Municipal People' s Government. National economic and social development plan of Xi' an (Xi' an Xixian New Area) (2017-2021) [EB/OL]. http://www.xa.gov.cn/ptl/def/def/index_1121_6774_ci_trid_2786338.html.

[8] CHEN Baiming, ZHOU Jiyuan. Interpretation of the national standard of "classification of land use status quo" [J]. Journal of Natural Resources, 2007, 22(6): 994-1003.

[9] TANG Huajun, WU Wenbin, YANG Peng, et al. Recent progresses of land use and land cover change (LUCC) models [J]. Acta Geographica Sinica, 2009, 64(4): 456-468.

[10] ZHUANG Dafang, LIU Jiyuan. Spatial and temporal evolution of land use types in the greater Xi' an area [J]. Journal of Natural Resources, 1997, 12(2): 105-111.

[11] TAO Wenfang. Spatial pattern and driving factors of urbanization in the Xi' an-Xianyang region, northwest China [D]. Yangling: Northwest A&F University, 2010.

[12] BING Guanglu, SHI Peiji, JU Linghua. Analysis of land use changes and driving factors in ecologically fragile areas: A case study of Zhangye City [J]. Arid Zone Research, 2010, 27(2): 169-175.

[13] ZHANG Guangfeng. Land use/cover change and its evaluation and analysis of ecosystem service value [D]. Jinan: Shandong Normal University, 2014.

[14] YANG Yong. LUCC and ecological safety assessment in Xianyang City [D]. Xi' an: Shaanxi Normal University, 2007.

[15] YANG Lina. Study on the dynamics of land-use change and driving force in Xianyang City [D]. Xi' an: Northwest University, 2009.

[16] ZHOU Zixiang, LI Jing, HAN Yanfei. Evaluation and effect of LUCC on NPP in Guanzhong-Tianshui economic zone [J]. Arid Land Geography, 2013, 36(6): 1058-1066.

[17] YANG Yong. LUCC and ecological safety assessment in Xianyang City [D]. Xi' an: Shaanxi Normal University, 2007.

[18] ZHOU Zixiang, LI Jing, HAN Yanfei. Evaluation and effect of LUCC on NPP in Guanzhong-Tianshui economic zone [J]. Arid Land Geography, 2013, 36(6): 1058-1066.

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