ISSN: 2688-8645

Research Progress of Land Use Land Change Spatial Simulation Prediction

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Abstract

Land use Land change is mainly driven by human activities, is an important part of the changing environment, and is also a direct reflection of the impact of human activities on the changing environment. By analyzing the research progress in three aspects of land use change characteristics, driving mechanism and simulation prediction, this paper obtains the key research direction of subsequent land use related research, and provides scientific support for the development of land engineering industry.

Keywords

Land Use; Spatial Simulation; Driving Mechanism; Research Progress.

1. Introduction

The IPCC Special Report on Climate Change and Land proposed that the occurrence of extreme climate events under global warming has a serious impact on land use, and the change of land use has aggravated the occurrence of extreme climate events. In 2024, the No. 1 document of Shaanxi Provincial Party Committee was released, proposing to "optimize the spatial layout of cultivated land, garden land, forest land, and grassland, with a net increase of 200,000 mu of stable cultivated land throughout the year" and implement the strictest cultivated land protection system. In September 2024, the General Office of the CPC Central Committee and The General Office of the State Council proposed in the Opinions on Strengthening the Protection of Cultivated Land and Improving the Balance of Cultivated Land Quality, that in the process of implementing cultivated land protection, it is necessary to respect the law, guide the situation, and adapt to local conditions. Based on this, the paper analyzed the spatio-temporal change trend of land use pattern in Shaanxi Province from multiple perspectives, clarified the driving mechanism of the change, and scientifically and accurately predicted the future change under the influence of changing environment, so as to better implement the cultivated land protection system and provide theoretical basis and scientific support for the formulation of related policies of land and resources planning in Shaanxi Province. It has important scientific significance and application value to the planning and management of land resources in Shaanxi Province and the sustainable development of regional social economy.

Land use is an important indicator reflecting the complex interaction between human society and natural environment. Land use change is mainly driven by human activities and is an important part of the changing environment, as well as a direct reflection of the impact of human activities on the changing environment [1]. In recent decades, changes in land use

ISSN: 2688-8645

brought about by human activities in the process of urbanization construction and response to soil and water conservation policies and measures have brought new challenges to climate, biodiversity, ecosystem, food security and social economy, etc. The main manifestations of land use change are urban expansion and wetland loss [2-3]. At present, researches related to land use change are mainly divided into two categories: one is to study the changes of land use caused by historical human activities and its driving mechanism; the other is to predict the future distribution of land use. The core content of research on land use change under changing environment lies in the characteristics of land use change in time and space, the analysis of land use change driving mechanism and the simulation and prediction of future land use, in order to answer the questions of "when and how land use changes", "why land use changes" and "how will land use change in the future".

2. Research Progress of Land Use Change Characteristics

It is of great significance for sustainable land management and future land planning process to analyze the characteristics and mechanism of land use change in the historical period in order to better understand the spatio-temporal change of land use. As for the characteristics of land use temporal and spatial change, the current relevant studies mainly analyze the quantitative change and spatial transformation of land use by calculating the transfer area and direction of different land use types, and analyze the land use change patterns by calculating information entropy, equilibrium degree and fractal dimension. In the study of land use temporal and spatial change, the commonly used methods include transfer matrix, intensity analysis and change trajectory analysis. The transition matrix and intensity analysis mainly focus on the analysis of land use change at adjacent time points, while the change trajectory analysis method can extend it to multiple time points.

As for the land use transfer matrix, it can directly and clearly see the quantity change and conversion direction of different land use types at two adjacent time points, and the application process is relatively simple, but it is limited to the analysis of land use change between the two time point scales. For the intensity analysis, it analyzes the intensity of land use change and the stability of each land use type from three aspects: interval level, land class level and transition level on the basis of the transfer matrix and combined with the top-down research framework. Meanwhile, it can analyze land use change at multiple time point scales, but only at adjacent time points. As for the change trajectory analysis method, it is mainly a method to identify the spatio-temporal change process of land use through the change of the number and spatial position of pixels or patterns of land use data, which can be well applied to the analysis process of land use change at multiple time points and is not restricted by adjacent time points. Therefore, the change trajectory method has been widely used in the research of spatial-temporal change characteristics of land use. Liu et al. used the above three methods to evaluate the spatio-temporal variation characteristics of ecology-production-living land in Wujiang Basin of China [4]. For the above three methods, especially the change trajectory analysis method, it has been proved to be more effective in clarifying the nuances in the process of land use change [5].

3. Research Progress of Land Use Driving Mechanism

As for the driving mechanism of land use change process, the factors affecting land use change mainly include natural environment, economic and social development level, land management policy decision-making and so on. Since some driving factors cannot be quantified in the analysis process, it is necessary to obtain quantifiable driving factors before analyzing the driving mechanism of land use change, and there is no collinearity problem between driving factors. Effective driving factors are the key to analyzing the scale effects of land use change and

ISSN: 2688-8645

driving forces. At present, correlation analysis, regression analysis and principal component analysis are commonly used to discuss the influence of different driving factors on land use change, and the more commonly used methods include grey correlation analysis and Logistic model. As for Logistic model, due to the nonlinear relationship between driving factors and land use change, it can well analyze the relationship between multiple independent variables and single dependent variable as a nonlinear regression model. The above statistical correlation method can only analyze the relationship between driving factors and land use change from a single driving factor, but land use change is a complicated and spatially heterogeneous process, and the proposed geographical detector method just solves this problem. Geographical detector can not only analyze the impact of a single driving factor on land use change, but also the impact of the interaction of two driving factors on land use change [6].

4. Research Progress of Land Use Simulation and Prediction

Based on the analysis of the characteristics and driving mechanism of land use change in the historical period, the model is used to simulate and forecast the future land use. In the process of predicting the future land use distribution, it is divided into two aspects: the quantity prediction and the spatial distribution prediction of each land use type. For land use quantity prediction, there are Markov chain model, system dynamics model, grey prediction model and so on. For the prediction of land use spatial distribution, the widely used models include cellular automata model, small-scale land use change and effect model, land use change simulation scenario model [7], patch-based land use change simulation model, etc. In the process of simulation and prediction of future land use data, quantitative prediction model and spatial distribution prediction model are usually coupled [8] to combine the advantages of multiple models in the process of land use prediction, so as to obtain more reliable future land use distribution.

In the coupled model, the simulation result of the spatial model is relatively important. For different spatial prediction models, the simulation performance is different in different regions. Jiang Xiaofang et al. compared the simulation performance of FLUS model, CLUE-S model and PLUS model in Ganlingao area in the middle reaches of Heihe River Basin, and the results showed that the PLUS model had the best simulation performance under the same size grid scale. In the same comparison and analysis of FLUS model, CLUE-S model and PLUS model, it is found in the land use simulation results of Changshu City and Haikou City that the simulation results of FLUS model and CLUE-S model are more stable, while the simulation results of PLUS model are prone to deviation [9]. Wang Duanrui et al. found that compared with CA-Markov model, CLUE-S model has higher simulation accuracy in northeast China. Lin and Peng compare and analyze the simulation performance of CA-Markov model, FLUS model and PLUS model in Fuxian Lake Basin, and the results show that the PLUS model can predict the land-use change in the basin more accurately [10]. To sum up, the selection of future land use simulation models in different regions and different basins needs to be judged according to the comparison and analysis of simulation results of multiple models in the region. Currently, CA-Markov model, FLUS model and PLUS model are widely used.

5. Conclusion

When conducting research related to the optimization of land use spatial pattern, it is first necessary to analyze the changes caused by current human activities, such as the analysis of the characteristics of land use change and its driving mechanism, so as to select the impact factors affecting future changes according to the results of historical characteristic changes and attribution analysis, and simulate future land use change based on the possible future changes. In order to better cope with the future land use change, in order to put forward the land use

ISSN: 2688-8645

planning policy in line with the future development trend. It is very important to analyze the evolution law and driving mechanism of land use in Shaanxi Province in the historical period to make effective spatial planning and management of land resources. By analyzing its evolution trend and driving mechanism, we can more scientifically grasp the changes of land use in Shaanxi Province in the historical period, which is the basis for sustainable management of land resources, and also provides a reference for predicting future dynamic changes, and is a strong guarantee for implementing the cultivated land protection system.

Acknowledgments

Thanks for Research on the Scientific Research Item of Shaanxi Provincial Land Engineering Construction Group (DJNY2024-22).

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