LCM Model

Subjects: Environmental Sciences | Remote Sensing
Contributor: Kongming Li

Cellular Automata-Markov chain (CA-Markov) model is a general method that has been widely used to predict LUCC. However, the process of this treditional model is subjective and stochastic, which makes it's modeling capacity limited. For precisely detecting the LUCC and their driving factors, we introduced the Logistic regression method to integrate with the treditional CA-Markov model (Logistic-CA-Markov model, LCM), to improve the preformance of modeling LUCC. This model would hopefully provide theoretical instructions for future land use planning and management, as well as a new methodology reference for LUCC analysis.

Keywords: LUCC driving factors ; land use prediction ; logistic regression ; CA-Markov model

1. Introduction

Land use and cover has undergone great changes around the world over the past few decades [1], especially in developing countries with increasing populations and rapid urbanization [2]. Land use and cover change (LUCC) on earth's land surface has been proven to be an essential driving factor for a series of regional and global environmental problems [3], such as carbon emission [4,5], climate change [6,7], biodiversity loss [8], ecosystem productivity decrease [9,10], soil and land degradation [11], as well as ecosystem services decline [12]. These environmental issues arouse people's concerns about future developments, leading to the emergency of land changes science, which is regarded as the fundamental content of the global environment change and sustainability research [12,13]. On a global scale, the socioeconomic and political components were considered as the principal factors for LUCC [14]. Previous studies about LUCC mainly focused on its dynamic patterns [3,14], driving factors [15,16,17,18], effects on ecosystems [4,9,10], and dynamic simulation and prediction [14,19,20,21] at different spatiotemporal scales. It is widely thought that the driving mechanism analysis and spatiotemporal pattern prediction for LUCC in the future can help assess the direction and degree of changes in land use and cover, and are critical for sustainable land use and mitigation of global environmental problems regarding LUCC [13,22].

2. Description

Cellular Automata-Markov chain (CA-Markov) model is a general method that has been widely used to predict LUCC in future scenarios, and mainly includes three parts: transition probability produced by Markov chain, transition rules defined by a CA model, and a collection of suitability maps [19,20]. In this model, the production of a suitability maps collection is most crucial and has a great effect on the definition of transition rule in CA and the accuracy of the final modeling results [19]. Previously, Multi-Criteria Evaluation (MCE), a multi-indicator decision-making method with three steps (i.e., indicator selection, parameter setting (score and weight of indicators), and constraint factors), was a common method for creating suitability maps [23,24]. However, in MCE, the indicator selection always depends on researcher's subjective judgement and lack of mathematical analysis, and parameter setting is empirical and often influenced by the calculation method [19]. Therefore, this method is not linked to specific land use and cover changes and is generally a subjective and stochastic procedure to a large extent [19,25].

For improving the performance of the CA-Markov model, some mathematical statistics methods have been used to integrate it with the original CA-Markov, such as artificial neural networks [26], system dynamics [21], analytical hierarchy process [27], multilayer perceptron [28], random forest, as well as logistic regression model [29,30]. Among these models, the logistic regression method has been widely used with the traditional CA-Markov model (Logistic-CA-Markov model, LCM) due to its capacity to take the dynamic process of LUCC into consideration [20]. This is a generalized linear regression model that can well connect the categorical variables and the continuous variables and build potential relationships between them [31]. Cetin and Demirel [32] establish a preliminary framework of LCM for prediction of urban changes in the Istanbul metropolitan area. Fu et al. [19] explored the availability of an integrated LCM in predicting the future LUCC in Hamilton, OH, USA. He et al. [33] predicted the future land use and cover changes in the Beijing-Tianjin-

Hebei metropolitan region using this model. Logistic regression models are also regarded as a reliable way of detecting the driving forces of LUCC and have been extensively applied in relative research. For instance, Arsanjani et al. [34] analyzed the driving factors of the suburban expansion in the metropolitan area of Tehran, Iran. Li et al. [16] detected the driving forces of urban expansion in Shenyang, China from 1997 to 2010.

Arid and semiarid regions accounts for about 40% of earth's land surface [35], which is generally ecologically fragile and vulnerable to environmental changes, most of them distributed in undeveloped areas, such as Northwest China and North Africa [14,36]. The LUCC in arid and semiarid region can not only affect local socioeconomic development and environment protection, but also influence global environmental changes [36]. Gansu Province is a typical arid and semiarid area constrained by a fragile ecological environment and belonging to the most impoverished area in China [37].
