

Land use scenarios simulation based on the CLUE-S model of the Lijiang River Basin in Guilin, China

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Abstract. The relationship between government policy and land use change is very important, which can provide important information for understanding of land use change and for helping in development of sustainable policy. Returning Farmland to Forest Program is simulated by the CLUE-S model. Land use maps in 1993, 2006, 2010 and 2015 in Lijiang River Basin are interpreted based on remote sensing change from 1993 to 2025 under two scenarios (i.e., Natural Growth Scenarios, Government Intervention Scenarios). In the “Natural Growth Scenarios”, the area of construction land and cultivated land are increased, the others are decreased. In the “Government Intervention Scenarios”, the area of construction land, woodland, cultivated land, and water are increased, the others is in declined. The compared results of two scenarios provide a scientific support for the government policy in the Lijiang River Basin.

1. Introduction

Land-Use and Land-Cover Change (LUCC) is considered a critical research of global environmental change and sustainable development [1]. The government policy has large effects on land use change, which is considered to be the main driving factor [2]. Land use change models are helpful tools for simulating future scene which offer a comprehensively understand of the complex driving forces of economic, policy, physical variables that affect land use/cover[3]. The CLUE-S (Conversion of Land Use and its Effects at Small regional extent) model is developed by Peter H. Verburg [4] and is considered as a powerful tool for simulating land use change and getting scenario analysis. The CLUE-S model is suitable for different regions of the world, such as river basin, urban agglomeration, watershed, hills, the reservoir and others, the CLUE-S model makes a significant contribution to land use change[5].

The purpose of this paper is to establish a chronic record of land use change from 1993 to 2015 in the Lijiang River Basin, based on the Landsat images of 1993, 2006, 2010 and 2015. The CLUE-S model is used to predict the land use change of Lijiang River Basin from 1993 to 2025 under two different scenarios and complete different of land use change under two scenarios.



The primary intention of this study were: (1) to study the tendency of the spatio-temporal distribution of land use change, analyze the degree of land use development, explore the driving factors of land use change, and identify the hotspots of land use change from 1993 to 2025; and (2) to analyze the value of the Returning Farmland to Forest (RFFP) through the difference of land use change between the NS (Natural Growth Scenarios) and GS (Government Intervention Scenarios) in Lijiang River Basin from 1993 to 2025.

2. Materials and Methods

2.1. Study Area

The Lijiang River Basin is located in the Guangxi Zhuang Autonomous Region and the southwest of the Nanling Mountains (Figure 1). The cover area of the Lijiang River Basin is 5306.03 km², and the length of the Lijiang River is 164 km.

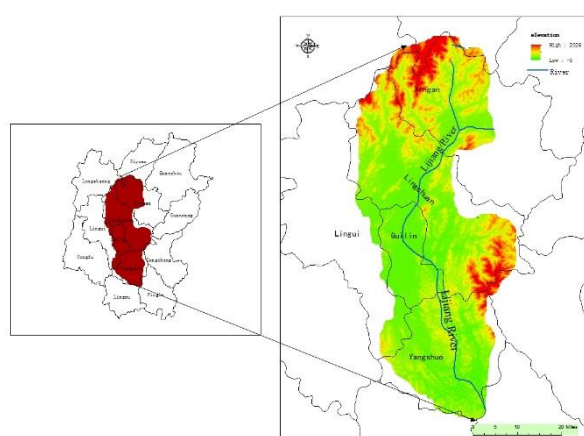


Figure 1. Study area location

2.2. Data and methods

2.2.1. Data. All Landsat images of 1993, 2006, 2010 and 2015 were downloaded from the Earth Resources Observation and Science Center (EROS). In the study, all remote sensing data in WGS84 geodetic datum, Universal Transverse Mercator map projection (UTM, Zone 49N), and is processed by radiation correction and geometric distortion. According to the standards of the second national land survey of the classification system, and considering to local environment, types of land use are divided into five categories, namely construction, shrubland, water, cultivated land, woodland (Table 1). Two scenarios were simulated by CLUE-S model. The Returning Farmland to Forest was carry out in 2002 in the Guangxi Zhuang Autonomous Region. In the following, two different scenarios used for the future land use development are described in more detail (Table 2). In NS scenario, the simulated land use type in 2006 of the Lijiang River Basin that is based on land use type in 1993 by the CLUE-S model. Land use demand for this year 2025 is formulated based on the historical statistics of land use change from 1993 and 2006 by a linear interpolation of total area of each land use type. In GS scenario, land use demand for the year 2025 is formulated based on the historical statistics of land use change from 2010 and 2015 by a linear interpolation of total area of each land use type.

Table 1. The classification of the land use

Land Cover Type	Description
Construction land	Residential areas, industrial land, transportation land
Shrubland	The height of the plants is under 3m, garden plot, constructed green land

Water	Rivers, lakes and reservoirs pits
Cultivated land	Dry field, paddy field
Woodlands	The kinds of forest, such as timber stands, economic forests, etc.

Table 2. Scenario planning

Situation type	Description of scene	The reason of setting
NS ^a	Be based on the rate change of 1993-2006	The Lijiang River began to urbanization in 1993
GS ^b	Be based on the rate change of 2010-2015	The Lijiang was intervened in 2002

^a NS is Natural growth situation.

^b GS is Government intervention situation.

2.2.2. Methods. Logistic regression analysis is a common method for the research of land use change. The logistic regression model can be written as [6]:

$$\log\left(\frac{P_i}{1-P_i}\right) = \alpha_0 + \alpha_1 x_1 + \alpha_2 x_2 + \cdots + \alpha_n x_n \quad (1)$$

where, P_i is the probability of a cell for the occurrence of the considered land use type; x_n represents the driving factors of each variable; α_0 represents the intercept; α_n represents the coefficient of each variable.

Formula 2 is represents the CLUE-S model prediction principles, and the total probability of a grid cell is calculated for land-use type [7]:

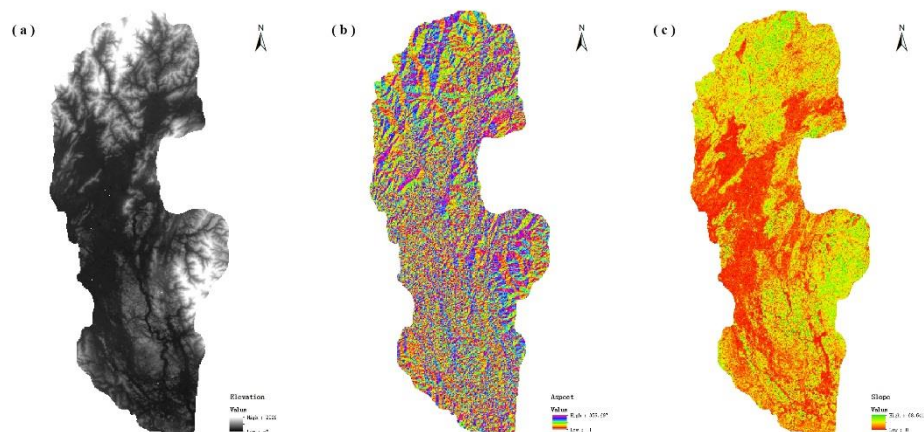
$$TPROP_{i,j} = P_{i,j} + ELAC_j + ITER_j \quad (2)$$

where, $TPROP_{i,j}$ is the probability of a grid cell i for the land use type u ; $P_{i,j}$ is the space distribution probability of the answer of Logistic regression equation; $ELAC_j$ represents the elastic coefficient of land use type j ; $ITER_j$ represents the iteration variable of land use type j .

3. Results

3.1. Driving forces

These driving factors be divided into two categories: natural factors and socio-economic factors, which are used in the logistic regression and the CLUE-S model. The first level is the grid unit, and the second level is the county unit. In this paper, 9 driving factors are chosen, including 6 natural factors (elevation, aspect, slope, distance to railway, distance to road, and distance to river), and 3 socio-economic factors (population, GIP, GOFFAF), Figure 2.



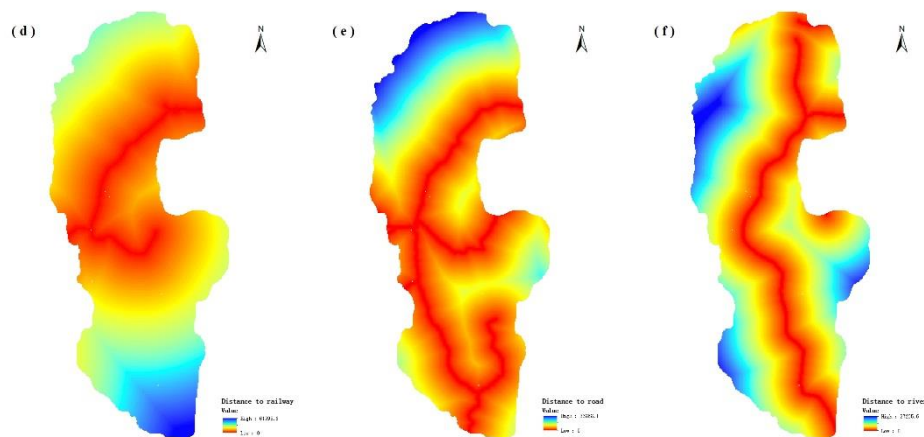


Figure 2. The spatial differentiation of the driving factors in land-use changes (a) Elevation; (b) Aspect; (c) Slope; (d) Distance to railway; (e) Distance to road; (f) Distance to river.

3.2. Regression Analysis of land use

Logistic regression is a critical step in the simulation process, which aims to check up the relationships between location factors and different land use types. In the Natural Growth Scenario (NS), construction has the maximum amount of location factors, which is mainly impacted by elevation and population. In the Government Intervention Scenario (GS), construction has the maximum amount of location factors, which is mainly impacted by elevation and slope. The ROC vales are more than 0.7 for all land use types, which suggests a high degree of spatial similarity between the simulated and real land transition.

3.3. Land use scenario simulation in Lijiang River Basin

Combining with NS and GS, the forecast of land use in 2025 is respectively simulation by CLUE-S model. Figure 3 is revealed a trend of land use map in the 2025. Under the county-level of Land use types, Natural Growth Situation is different from Government Intervention Situation (Figure 3). Under the county-level of land use types, the results under the NS are different from those obtained under the GS (Figure 4).

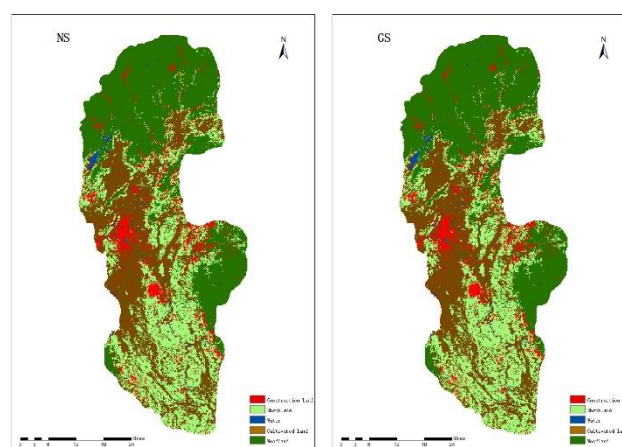


Figure 3. Simulated scenarios of land use in 2025

NS is defined as a continuation of interpolation result that linear interpolation of total area of each land use type from 1993 to 2006. The results show that during 1993-2025, the area of construction land and cultivated land have a positive trend, which is mainly at the expense of woodland, agricultural and shrubland.

GS is defined as a government intervention scenario and thus, as expected, results in the most pronounced land use pattern changes with a strong trend toward regularity during 1993-2025.

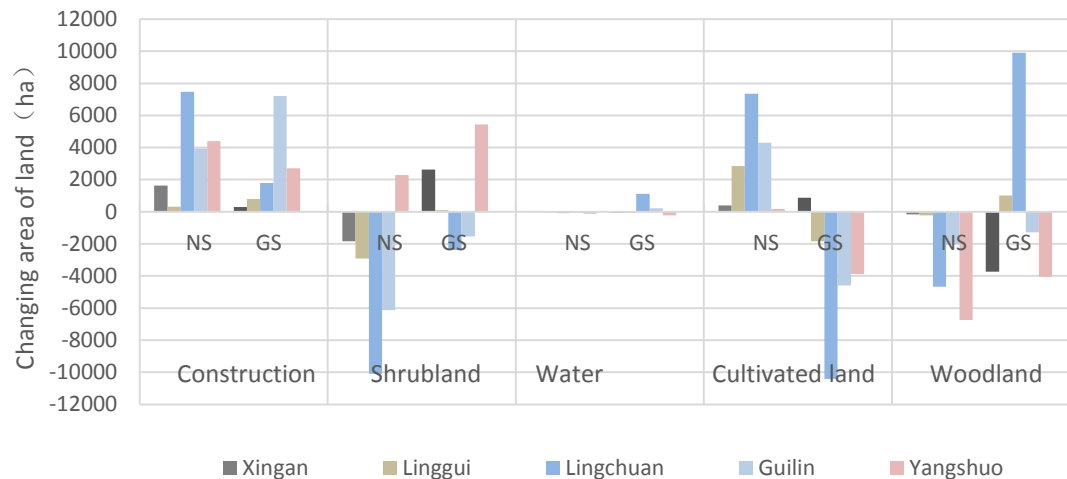


Figure 4. Land use change at the county-level in different scenarios

4. Conclusions

We used Landsat remote sensing image as data source and constructed CLUE-S model, simulated land use change from 1993 to 2025 under two scenarios (i.e., natural increase, government intervention). We explored the future characters of land use change and analyzed the driving factors of possible social. In the natural increase scenarios, by using the based data of the land use in 1993, we simulated land use change in 2025; in the government intervention scenarios, by using the based data of the land use in 2006, we simulated the trend of land use change in 2025. We analyzed the future characters of land use change by the CLUE-S model under two situations. The result of simulation produced a good Kappa coefficient above 0.85, and ROC values more than 80%. The research revealed the future possible trends of land use change and provided a sound basis for further analyses of the possible impact on the land use degree in the Lijiang River Basin. The spatial patterns of land use were obviously different during two decade. We found that woodland and water areas decreased in the NS but slightly increased in the GS, respectively. The hotspot for GS was a controlled, organized development of construction land, however, the construction of NS was ruleless, unplanned expansion. The RFFP of Lijiang River Basin program had been most successful payment. Under the correct leadership of the state forestry administration, the Lijiang River Basin was completed the various project and obtained the obvious result. By identifying the hotspots of land use change, we found that governmental intervention such as RFFP could protect ecological environment and improve the awareness of environmental protection.

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Acknowledgments

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