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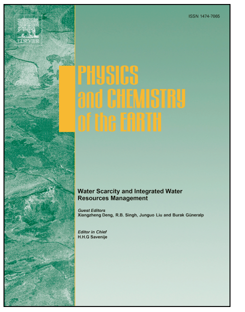

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Evaluation of ecosystem service based on Scenario simulation of land use in Yunnan Province

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Abstract: Climate change and rapid urbanization are important factors restricting future land use. Situational analysis, as an important foundation for the optimization of land use, needs to focus on the impact of climate factors and socio-economic factors. In this paper, the Markov model and the DLS（Simulation of Land System Dynamics）model are combined for the first time, and the land use pattern in 2020 is simulated based on the data of land use in 2000 and 2010 as well as the climate, soil, topography and socio-economic factors of Yunnan Province. In his paper, we took Yunnan Province as the case study area, and selected 12 driving factors by logistic regression method, then the land use demands and layout of Yunnan Province in 2020 has been forecasted and simulated under business as usual (BAU) scenario and farmland protection (FP) scenario and the changes in ecosystem service value has been calculated. The result shows that: (1) after the regression analysis and ROC（Relative Operating Characteristics）test, the 12 factors selected in this paper have a strong ability to explain the land use change in Yunnan Province. (2) Under the two scenarios, the significant reduction of arable land area is a common feature of land use change in Yunnan Province in the future, and its main land use type will be construction land. However, under FP scenario, the current situation where construction land encroach on arable land will be improved. Compared with the change from 2000 to 2010, the trend of arable land, forest land, water area, construction land and unused land will be the same under the two scenarios, whereas the change trend of grassland was opposite. (3) From 2000 to 2020, the value of ecosystem services in Yunnan Province is on the rise, but the ecosystem service value under FP scenario is higher than that of the ecosystem services under BAU scenario. In general, land use in 2020 in Yunnan Province continues the pattern of 2010, but there are also significant spatial differences. Under the BAU scenario, the construction land is mainly in the south of Lijiang City and the northeastern part of Kunming. Under the FP scenario, the new construction land is concentrated near the Lashi dam in northern Yunnan Province, and the high-quality arable land in the valley will be better protected. The research results can provide reference for the optimization of land use pattern in Yunnan Province, and provide scientific basis for land use management and planning. Based on the value of ecosystem services, we should implement the policy of strict protection of arable land, both to ensure food supply and promote the healthy development of ecological environment.

Key words: land use; DLS-Markov model; spatial pattern; ecosystem services; Yunnan Province

1 Introduction

With the development of urbanization and global climate change, the changes of land-use and ecosystem services are active, and urban land has been expanding constantly (Li et al., 2016; Latocha et al., 2016; Lin et al., 2004). For a long time, the contradictions between urbanization, food production and ecological conservation are becoming increasingly underline. Ascertaining the amount of different land use types and spatial distribution as well as ecosystem services value is an important foundation for releasing contradictions mentioned above (Liang et al., 2017; Tolessa et al., 2017).Therefore，taking rational steps to forecast the demands of land use and simulate spatial pattern is particularly important for land use planning, rational use of regional resources and environmental management (Wang et al., 2005; Halmy et al., 2015). Land use models are powerful tools that can be used to analyze the causes of LUCC (Land Use/Cover Change) and to evaluate land use policy (Verburg et al., 2004; Luo et al., 2010). Models can not only support the exploration of future land use changes under different scenario conditions, scenario analysis with land use models can but also support land use planning and policy (Guan et al., 2011). Based on model analysis and the simulation of land use spatial patterns, the driving factors of LUCC can be revealed, clarifying the rate of land use and making possible multiple LUCC scenarios in order to predict future land use demand (Han et al., 2015). The affecting factors in scenario simulation of land use/cover come down to climate, soil, terrain and social economy generally, due to the influence of global climate change and rapid urbanization, climatic and socioeconomic factors have significant effects on structure of land use, so the chosen factors will vary from one simulation aim to another. As for models and methods, researchers have built many models to forecast the quantitative structure of land use as well as optimize spatial pattern, quantitative forecast models include Artificial Neural Network Model (Basse et al., 2014), Regression Model (Weichenthal et al., 2015), System Dynamics Model (He et al., 2011)and Gray Forecast Model (Zeng et al., 2016), and future spatial pattern simulation includes CA Model (Halmy et al., 2015), CLUE Model (Hu et al., 2013), CLUE-S Model (Gibreel et al., 2014) and Agent-Based Model (Bert et al., 2015). All these models have limitations, Artificial Neural Network Model can't work when data is not sufficient, Regression Model is subjective, System Dynamics Model lacks the spatial factor processing ability and Gray Forecast Model can not predict accurately in the long term. And CA model focuses only on the local interaction of the elements, CLUE and CLUE-S Model requires other mathematical methods，and behavior rules are difficult to establish in Agent-Based Model. In the research of LUCC, the application of above models are quite mature, however, theory and method of land system dynamic simulation are still short of systematicness (Jin et al., 2015b). Along with the development of the economy, regional land use competition constantly increase and has characteristics of tendency, Markov model has a strong feasibility in the prediction of land use quantitative structure and an advantage of long-term prediction. Dynamics of Land System Model (DLS) has technical advantages over regional land use pattern simulation, which can synthesize driving factors like climate, soil, terrain and socioeconomic that drive regional land system structure change, and analyze dynamic feedback mechanisms among them quantificationally, simulate and analyze land system structure and succession pattern at the regional and subtle raster scale. Therefore, to overcome the shortcomings of the former models on subjectivity，simplification and imperfection，this paper integrates Markov model and DLS model to analyze the variation characteristics of land use, to forecast the demands of land use and to simulate land use patterns in Yunnan Province in the future. The research results can provide reference for optimizing land use and formulating related policies in Yunnan Province (Li et al., 2002; Liu et al., 2017).

2 Case study area

Yunnan (97.31°~106.11°E, 21.8°~29.15°N) covers an area of 380454.36km^2, of which 84% is mountainous, 10% is plateau and 6% is basins, the terrain of this province slopes from the northwest to the southeast, is ladder-like distribution from north to south. Complex topography forming a specific regional climate, in summer, the average temperatures is about 19~22℃; In winter, the average temperature of the coldest month is above 6~8℃. Annual temperature difference is 10~15℃ usually, but the temperature is lower in rainy days. Temperature changes in one day is cold morning, noon heat, especially in spring and autumn, daily temperature difference can be 12~20℃. Most areas receive 1100 millimeters of rainfall a year on average, and it can reach more than 1600mm in some areas in the southern region. Most precipitation is June to August, which accounts for 60% of annual rainfall. The rainfall in the dry season of November–April only accounts for 10~20% of annual rainfall. Yunnan Province is in a period of rapid urbanization development, 2003~2013, the GDP (Gross Domestic Product) growth rate is 3.77%, the growth rate of population is 7.1%, and growth rate of urban population is 63%. During 1996~2010, construction land has occupied 271km^2 arable land, while 78% of which are high quality arable land in intermontane basin, and the contradictions between building land development and arable land protection are becoming increasingly underline (Jin et al., 2015a).

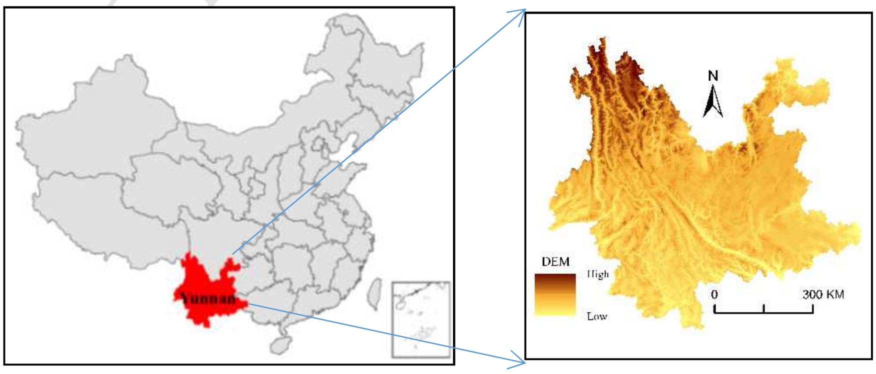

Figure 1: Location of Yunnan province

3 Data and methods

3.1 Data source and processing

The data used in this case study include meteorological data, land use data, topography and landform data and soil data which incorporate soil type. The meteorological data were obtained from China Meteorological Data Sharing Service System and were observed and recorded by the observatory of China Meteorological Administration, which contained annual mean temperature, precipitation and sunshine hour, specifically, sunshine hour was created by using Kriging interpolation after accumulated temperature had been calculated using daily mean temperature data. Land use data set was provided by Data Center for Resources and Environmental Sciences, Chinese Academy of Sciences (RESDC) (http://www.resdc.cn), the primary land use map was extracted from Landsat TM/ETM remote sensing image. To classify the land cover, six classes of land uses/covers were determined accordingly: (1) arable land, (2) woodland, (3) grassland, (4) waters, (5) construction land (including urban and rural, and transportation), and (6) unused land. Topography and landform data mainly included DEM stem from ASTER Global Digital Elevation Model, slope and aspect, the latter two were gained using ArcGIS10.3. Soil data mainly included the organic matter, nitrogen phosphorus and potassium content in soil, soil PH value and the sand, clay, silt content in soil, which was gained from the 2nd national soil survey database. Socioeconomic data was provided by Data Center for Resources and Environmental Sciences, Chinese Academy of Sciences (RESDC) (http://www.resdc.cn), this dataset based on annual demographic data published by National and provincial Bureau of Statistics were gained from population and GDP spatial express model accordingly. The data mentioned above all are Grid format, and the resolution is 1km.

3.2 Statistical methods (for choosing control factors)

Binary logistic regression is a non-linear statistical method of regression analysis for binary dependent variables (Menard, 2004). In the analysis of the correlation between land use type and driving factors, since land use type is a classified variable rather than a continuous variable, the linear regression method is limited by the discontinuous variable and not suitable for solving such problems. Multivariate logistic regression techniques, which based on data sampling, can produce regression coefficients for each independent variable. These coefficients are interpreted by a certain weighting algorithm to generate the probability of change of a particular land use category, thus revealing the role and intensity of each explanatory variable in predicting the probability of occurrence of spatial change，logistic regression method helps to screen out the more significant factors from a number of factors that affect the pattern of land use (Fang et al., 2017). The interpretability of logistic regression results may be tested by means of Relative Operating Characteristics (ROC) (Shu et al., 2014). The area under the curve is between 0.5 and 1, generally speaking, the greater the value is, the more consistent the probability distribution of one land type with the factual land type distribution, and the better the regression equation’s ability to explain the spatial distribution of one land type, the more reliable the subsequent allocation of lad use type;

conversely, if the value is equal to 0.5, it shows that the regression equation has no meaning to the interpretation of land distribution (Pontius and Schneider, 2001).

This paper follows the principle of data availability, factors' spatial diversity and equal focus on natural and socioeconomic factors, and synthesizes predecessor's research results (Overmars et al., 2007; Rahman,2016; Chen et al., 2014; Irwin and Geoghegan 2001), filtering control factors that significantly influence the land use changes from underlying database and has selected 12 land use/cover change control factors by binary logistic regression (Stata) to determine the relationship between each land-use type and the factors influencing it (Lourdes et al., 2011) (Table 1). These included accumulated annually cumulated temperature of daily mean air temperature over 10℃ (ct10), mean annual temperature (ta), mean annual rainfall (rain), elevation (dem), landform (lfm), slope (slope), area proportion of plains (splain), area proportion of stricken area (strike), soil type (soil_type) , distance to road (d_road), distance to city (d_city), residential density (pop) (Figure 2).

Table 1: Results of logistic regression for different land-use types in Yunnan

Factors Driving	Logistic Regression					
	arable land	woodland	grassland	waters	construction land	unused land
ct10	6.88E-07***	5.22E-07***	5.95E-07***	3.05E-06***	4.22E-06***	4.16E-06***
ta	0.0002505***	0.0001881***	0.0002169***	0.0011356***	0.0015727***	0.0017582***
rain	2.62E-06***	1.93E-06***	2.21E-06***	0.0000128***	0.0000165	0.0000165***
dem	0.0000152***	0.0000115***	0.000013***	0.0000682***	0.0000946***	0.0000797***
lfm	0.0004125***	0.0003981***	0.0004946***	0.0014459***	0.0014182***	0.0042987***
slope	9.99E-06***	6.82E-06***	7.50E-06***	0.000041*	0.0000781***	0.0000382**
splain	0.0022622***	0.0017414***	0.0020252***	0.0065473***	0.0079678***	0.0168137***
strike	0.0003437***	0.0002435***	0.0002767***	0.0013582***	0.0017989	0.0013459
soil_type	0.0002214***	0.0001601***	0.0001846***	0.0011547***	0.0016425***	0.0013475***
d_road	0.0001966***	0.0001528	0.0001728***	0.0008061***	0.0008408	0.0014243***
d_city	0.000156***	0.0001207***	0.0001401***	0.0007691***	0.0007876***	0.0016157***
pop	0.0001457***	0.0001141***	0.0001321***	0.0007397***	0.0007423***	0.0016389***
cons	0.0632769	0.0506749	0.0575567	0.2954128	0.3782905	0.4563761
ROC Value	0.6731	0.6373	0.5989	0.7701	0.8794	0.9091

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Furthermore, according to the analysis of significant influence the 12 control factors have on structure of land use, seen from P value, there exists strong correlation between six land use types and especially temperature greater than 10℃, annual temperature, annual rainfall of climate factors and distance to road, distance to city, residential density of socioeconomic factors, of which significance level is extremely high, the same as the correlation between six land use types and factors of terrain and soil factors. In addition, in this study, the ROC values all but one are above 0.63, implying that the logistic regression model effectively represents land cover distribution. Taken together, the selected 12 control factors are representative and comprehensive in that they are strongly correlated with and use structure.

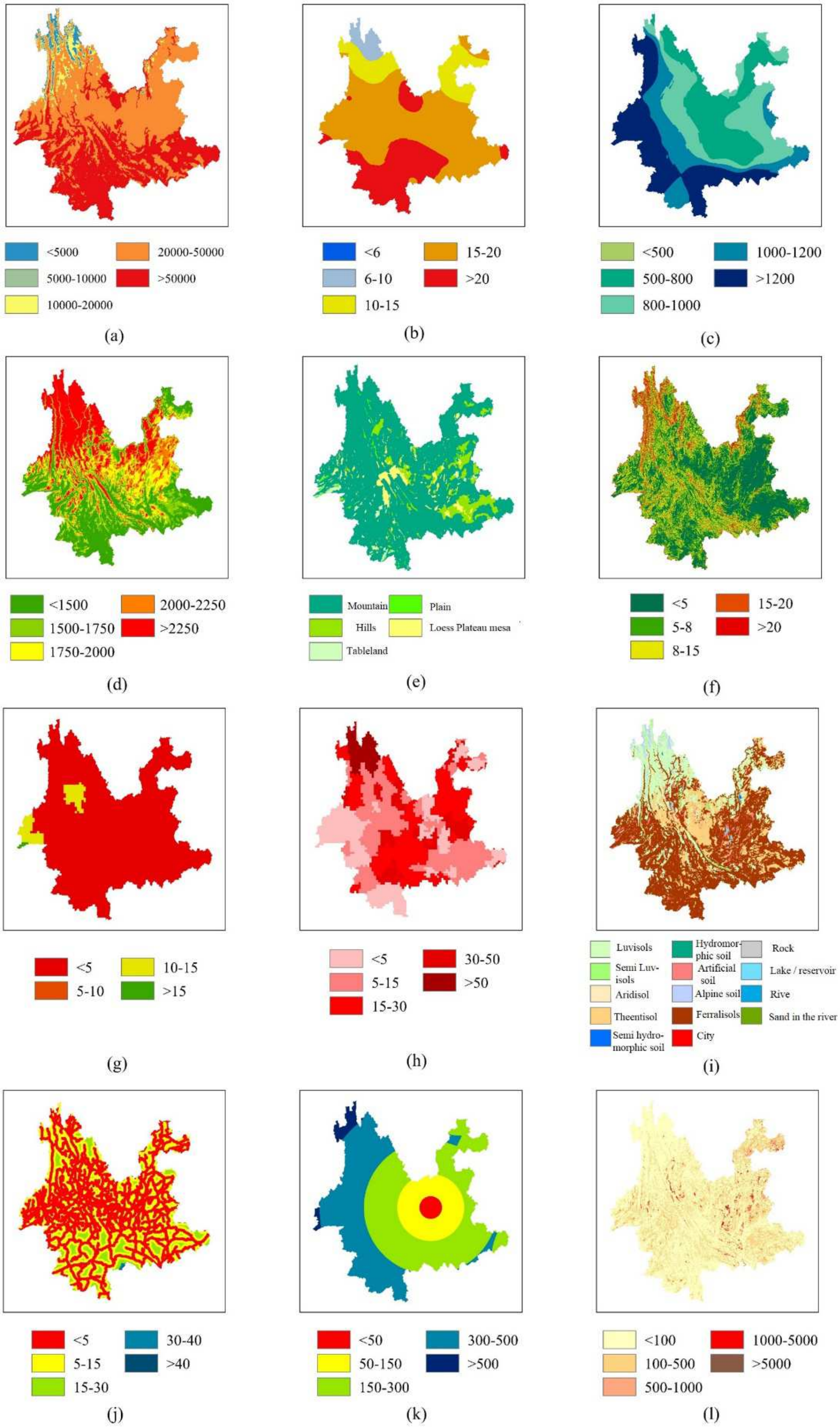

Figure 2: Control factor chart (2010)

(a) more than 10 degrees accumulated temperature (℃)；(b) average temperature(℃)；(c) yearly precipitation(mm)；(d)height(m)；(e) landforms；(f) slope (°)；(g) area proportion of plain area (%)；(h) the proportion of the affected area accounted for the proportion of sown area (%)；(i) soil type；(j) distance to road(km)；(k) distance to city(km)；(l) population density(people/km^2)。

3.3 Markov model

The Markov model is a random process of a state with no aftereffect characteristics, that is to say, a state of the system at some point $t + 1$ is only relevant to the state that is currently known at time t, but is unrelated to the moment before t. This method can reveal the area and ration of one land use type transformed to another effectively. The land use distributions at the beginning (S_t) and at the end (S_{t+1}) of a time period, as well as a transition probability matrix (P_{ij}) representing land use change that occurred during the defined period, are used to construct the Markov model, which is expressed as follows (Sun et al., 2016):

$$S_{t+1} = S_t \times P_{ij} \quad (1)$$

where S_{t+1} and S_t are the land use statuses at the time-points t+1 and t, respectively, and P_{ij} is a transition probability matrix satisfying the following conditions:

$$0 \leq \mathrm{P}_{ij} \leq 1$$

$$\sum_j^n \mathrm{P}_{ij} = 1$$

where i and j are the land use types at the time points t+1 and t, respectively.

3.4 DLS model

Land use modelling is a useful tool to analyze the land use cause, process and result, to recognize the impact of land use system change on ecological environment, and to support the land use planning and policy (He, 2005). Chinese scholar Xiangzheng Deng developed DLS model (Deng et al., 2008;Jin et al., 2017, this model chooses land system as the research object, with regional land use structure change in equilibrium and types of land distribution theory of constraints at grid scale as theory basis, synthesizing natural and socioeconomic factors that driving land system structure to change and analyzing dynamic feedback mechanism between them quantitatively, meanwhile, simulating various types of land evolution patterns. Feedback mechanism is an important part of DLS framework, it aims at determining the statistical connection between land system change and control factors, which can be estimated by using the principle of least squares and it can show the relationship between certain land type exists or not and spatial factors. The estimated equation is:

$$\frac{p_i}{1-p_i} = e^{\beta_0 + \sum_{j=1}^{m} \beta_{1j} C_{ji} + \sum_{j=1}^{n} \beta_{2j} T_{ji} + \sum_{j=1}^{o} \beta_{3j} L_{ji} + \sum_{j=1}^{p} \beta_{4j} I_{ji} + \sum_{j=1}^{q} \beta_{5j} D_{ji} + \sum_{j=1}^{r} \beta_{6j} P_{ji}} \quad (2)$$

In equation (2), $\mathrm{P_i}$ is the probability that one certain land type would appear in where driving factors is given. C、T、L、I、D、P are climate, topography, location, infrastructure, economic and population development, policy changes and other factors. β_0 is a constant term, β_1-β_6 are sub-factors of abovementioned factors.

3.5 DLS-Markov model

This study combines Markov model and DLS model and takes land as a whole to analyze the competition and metastasis relations between different land use types. After determining the future land use quantity structure, it is necessary to allocate this area change to the appropriate area according to the spatial distribution characteristics of the land cover pattern, thus to achieve the spatial simulation of land use change. The Markov model can be used for non-spatial modules due to the lack of spatial variables, and DLS model can be used for spatial modules. We can employ Markov model to predict the land use quantity structure under different scenarios and the prediction results will be an input parameter of the DLS model. Then, the DLS model is used to optimize the regional land use layout. Specific steps are as follows: (1) Extracting land use types from present land-use map in 2010 using ArcGIS10.3, and calculating the proportion of each type of land use area accounted for Yunnan, then original transition probability matrix is established. (2) Generate transition area matrix and transition probability matrix and predict the structure of land use in study area. (3) Prepare main parameters, control factor data, spatial analysis parameters, restricted area code, land demand scenarios and land type binary data six input parameters. (4) Running the model to simulate land use patterns under different scenarios in Yunnan Province for 2020.

Scenario development has become a popular tool because scenarios provide a methodology to describe alternative future environments that might result from today's decisions and they also aid comparison of the potential consequences of different future contexts (Schirpke et al., 2012). In this study, two scenarios are set to simulate space-time change of land use in Yunnan Province for 2020.

Situation 1: BAU (Business As Usual) scenario. The BAU storyline assumed that the current land use trends are maintained (Mehdi et al., 2015), then land use demand in 2020 can be gained based on Markov model.

Situation 2: FP (Farmland Protection) scenario. Assuming that arable land is strictly protected, according to Overall Planning of Land Use in Yunnan Province (2006~2020), the strictest farmland protection system will be implemented and arable land scale will be enlarged. In this situation, arable land protection would be strengthened, and construction land occupying arable land would be strictly controlled, so the rate that arable land occupied was cut in half, and arable land increases at a constant rate the same as 2000~2010.

4 Results and analysis

4.1 Analysis of land use characteristics

4.1.1 Analysis of the state of current land use

Using land use data in 2000 and 2010, the number of land use types of Yunnan Province in 2000 and 2010 can be obtained (Table 2). The table shows that land use in Yunnan Province had changed dramatically from 2000 to 2010, and land use pattern changed greatly. In the aspect of quantity, apart from woodland, grassland and construction land, the number of other three land use types all dropped; In the aspect of land use structure changes, the proportion of arable land decreased from 18.06% to 17.77%, there was a slight increase in construction land, the proportion of which increased 0.08%, relatively speaking, grassland and waters changed little, the proportion of woodland remained higher than 57%, the total area increased to 684.77km^2 in 10 years, and the proportion of which increased by 0.18%.

Table 2: Area of different land use types in Yunnan Province, 2000, 2010

Statistics Type	2000 Area/km^2	2000 Percentage %	2010 Area/km^2	2010 Percentage %
arable land	68717.42	18.06	67616.73	17.77
woodland	217065.65	57.05	217750.42	57.23
grassland	87719.56	23.06	87892.21	23.10
waters	2826.73	0.74	2775.76	0.73
construction land	2026.27	0.53	2335.23	0.61
unused land	2098.73	0.55	2084.01	0.55

4.1.2 Analysis of land use structure spatial transition

Using ArcGIS10.3, land use transition area matrix and transition probability matrix can be gained (Table 3), during the period2000~2010, the ratio that other land use types transformed into construction land, arable land was the highest, the others were waters, grassland, woodland and unused land in turn, however, the ratio that construction land transformed into other land use types was decreasing by the order of arable land, woodland, grassland, waters and unused land. The number of arable land of Yunnan is 68717.42 km^2 in 2000, and construction land is 2026.27 km^2. The areas that arable land transformed into construction land was 1209.42 km^2, which is greater than the areas that construction land transformed into arable land, 441.93 km^2. This mainly because in the background of rapid urbanization，a larger number of arable land had been occupied. The mutual convention between woodland and grassland was obvious, which indicated that deforestation was still there while measures had been taken to protect woodland and grassland.

4.2 Analysis of simulation of land use scenarios

4.2.1 Analysis of land use structure prediction

According to the preceding settings, areas of each land use type under two different scenarios in 2020 are figured out (Table 4).

Table 3: Land use transition probability matrix in Yunnan, 2000~2010 (unit: %)

	Land use type	2010					
		arable land	woodland	grassland	waters	construction land	unused land
2000	arable land	39.35	38.26	19.65	0.90	1.76	0.09
	woodland	11.65	72.30	15.44	0.22	0.15	0.25
	grassland	15.51	37.85	45.23	0.51	0.36	0.54
	waters	21.83	19.56	15.49	41.04	1.73	0.28
	construction land	49.50	14.66	11.15	2.57	21.81	0.20
	unused land	3.00	22.87	25.97	0.52	0.14	47.31

Table 4: Land area and changing rate in two scenarios

	scenario	arable land	woodland	grassland	waters	construction land	unused land
Land use structure in 2020（km^2）	BAU	67433.27	217923.84	87883.36	2756.44	2381.82	2075.63
	FP	67529.49	217841.32	87867.56	2761.11	2375.96	2078.92
land use changing rate in 2020（%）	BAU	-0.27	0.08	-0.01	-0.70	2.00	-0.40
	FP	-0.13	0.04	-0.03	-0.53	1.74	-0.24

According to table 4, under these two different scenarios, during 2010-2020, arable land area would reduce continuously, but the decrease rate is lower compared with 2000~2010; woodland would increase continuously at a lower rate; construction land would increase continuously, but compared with the period 2000~2010, growth in construction land slows down, however, it remains the fastest-growing among the six land use types. And construction land was mainly converted from arable land, so construction land was increasingly expanding by massively occupying arable land, which reflects that Yunnan would remain the rapid process of urbanization, and the number of each land use type would be in a unbalanced dynamic transformation state in the future; unused land area would reduce continuously, in the development of the economic society, it would be exploited and used gradually and starting new fields for urban construction and economic development. In a word, land use change is still active in Yunnan Province in the future.

4.2.2 Analysis of scenario simulation

The present study used Kappa index to evaluate the overall simulation accuracy (Wang et al., 2012), the simulated land-use map for 2010 were compared with the actual map. The Kappa index were found to be 0.7719 for 2000, which indicated that the simulation results are credible.

Using DLS-Markov model, maps of simulation under two different scenarios were obtained (Figure 3), comprehensively, land use pattern of Yunnan Province for 2020 extents the pattern for 2010, arable land spreads across intermountain basin and river valley areas on the plateau, and mainly distribute in south-east of the province. Forestry has a wide coverage in the province, and is mainly distributed by topography and mountains. Grassland is mainly distributed in the east and west region. Construction land is mainly distributed in the east-central part of the province, and in Kunming and the surrounding area, it covers a vast area.

In the BAU situation, the land use pattern would extends its current changing trends until 2020 in Yunnan province, woodland and arable land would maintain a trend of increase while grassland, waters and unused land would maintain a trend of decrease. Main areas with reduced arable land are in the valley to the Lantsang River in Southern Yunnan and to the Yuanjiang in Southeastern Yunnan. Near the Mount Ailao are main areas with reduced Woodland and grassland. In southern Lijiang and northern Kunming, construction land is markedly expanded, and expansion happens in the original construction land preferentially. Reduced arable land was mainly transformed to construction.

In the FP situation, the rate of decline in arable land is cut down obviously, and the rate of conversion from arable land to construction land also had been slowed down, the proportion of returning farmland to grasslands and to lakes declined. Main areas with reduced Arable Land are the Yuanjiang River in Southern Yunnan, the west of Mount Gaoligong abutting Burma and the north of Lijiang River abutting Sichuan Province. Construction land is markedly expanded in northern Yunnan Province’s Lashi Dam. Construction land expansion has been brought under effective control and the rate of construction expansion of arable land had declined obviously .

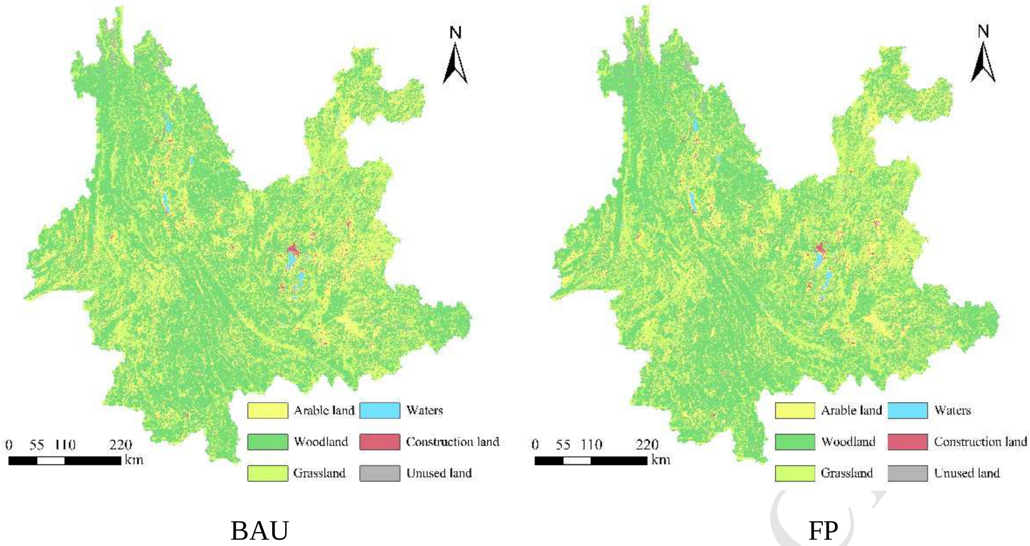

Figure 3: Two scenarios of land use simulation of Yunnan Province in 2020

4.3 Analysis of ecosystem services value

According to MA(The Millennium Ecosystem Assessment), ecosystem services are the benefits people obtain from ecosystems，these include provisioning, regulating, and cultural services that directly affect people and supporting services needed to maintain the other services. Ecosystems have value because they maintain life on Earth and the services needed to satisfy human material and nonmaterial need. The changes in these services can have a profound impact on human well-being through the impact of security, the basic material conditions needed to maintain high quality of life, health and social and cultural relationships. (Liu et al., 2017; Alessandra et al., 2017). At present, it is an important principle to balance the interests of ecosystem services because of the great demand for human ecosystem services. Therefore, the objectives of ecosystem management and the actions taken to do so should not only take into account the impact of changes in ecosystems on human beings, but also the importance of the intrinsic value of human species and ecosystems.

Price is a reference signal for policymakers to make decision-making measures, and ecosystem services that lack the market environment are not only inefficiently configured, but also cause unsustainable attitudes and behaviors of the public to ecosystems. In this case, the ecosystem service value assessment has become a decision-making tool that provides guidance to the development of relevant decisions by quantifying the importance of ecosystem services to social well-being, thereby enhancing the protection of ecosystems and improving Sustainable use of ecosystem services (Liu et al., 2017; JOSHUA FARLEY, 2008).

Land-use change has a significant impact on the world's ecosystems. In general, changes in land use or land management will increase the provision and value of some services but decrease others (Jin et al., 2017;Polasky et al, 2011).

Therefore, by assessing the value of ecosystem services under different land use conditions, it will help to play the guiding role of price mechanism, promote the rational use

On the foundation of the above research, estimating the ecosystem services value of the research area in 2000,2010 2020 by reference to the chart of ecosystem services of land ecosystem unit area in China, which was established by Xie Gao Di and so on (Xie et al., 2003; Jin et al., 2015c). The farmland, woodland, waters, unused land consulted the category and value of the ecosystem of farm, forest, wetland, waters and desert respectively (the value of construction land is zero), obtained a calculation of the ecosystem service value of each year in Yunnan Province.

Table 5: The ecosystem service value of each year in Yunnan Province

Year	2000	2010	2020	
			BAU	FP
Ecosystem services value	5340.85	5345.55	5346.62	5345.78

Through the analysis on the table, the ecosystem services value of Yunnan province during 2000 to 2020 showed an increasing trend, the ecosystem services value under BAU scenario increased by 0.11% while the ecosystem services value under FP scenario increased by 0.09%. And the ecosystem services value under BAU scenario was higher than the urbanization, which meant more ecological land translated to constructive land resulting in the decrease of ecosystem services value.

5 Conclusion and discussion

Land use change is the result of the interaction between man and land. Dynamic simulation model based on high resolution spatial data is an effective tool to clarify land use change mechanism, process and trend. Based on the data of land use in Yunnan Province in 2000 and 2010, this paper uses the Markov model and DLS model to simulate the spatial distribution of land use in Yunnan Province in 2020 under business as usual scenario and farmland protection scenario and further calculates the value of its ecosystem services. The results show that the rapid expansion of construction land in two scenarios is the main feature of future land use change in Yunnan Province. However, compared with 2000~2010, the construction land expansion slowed down the occupation of arable land and woodland.

During the period 2000~2010, land use change is comparatively active, Construction land expanded rapidly by occupying large amounts of arable land, woodland increased a little while waters and unused land decreased. 2010~2020, in BAU and FP situation, woodland and grassland are still the main land use types in Yunnan Province, although construction land expansion pace would slow down, the acceleration rate of construction land is higher than the rate of other 5 land use types change.

In BAU situation, construction land keep occupying arable land in dam area, which boosts the growth of regional economy for the cost of base construction is low, but reduction of arable land would threaten food production. The conversion from grassland and waters to construction land and unused land would worsen the environment. In FP situation, regional food safety is ranked at the top, high quality arable land is protected by taking into account ecological security and economic development.

The ecosystem services value of Yunnan province during 2000 to 2020 showed an increasing trend and the ecosystem services value under BAU scenario was higher than under the FP scenario. This shows that the land use development model adopted by arable land protection is more conducive to protecting the ecological environment and promoting sustainable development. Therefore, in the future development, we must adhere to the red line of arable land, strictly limit the construction land occupied arable land.

After having selected factors on climate and socioeconomic with strong representation and terrain and soil factors to analyze land use change characteristics, this paper takes advantage of both the merits of the Markov model and DLS model to predict and simulate land use pattern in 2020 in Yunnan Province. Quantitatively analyzing change characteristics of land use at subtle raster level opens up new ways for the study of land system structure changes and ecosystem value evaluation. However, only two periods of land use maps were used in this study and we assumed that land use change rates are relatively stable, so the simulation precision may be limited, in follow-up study, multi-temporal data should be used for analysis and simulation. And the calculation of the value of ecosystem services is based on the average value of ecosystem services in China from Xie Gaodi, which can’t fully reflect the regional differences of ecosystems. In the future, we need to consider the spatial heterogeneity of ecosystem service value and calculate the value of ecosystem services in line with the regional characteristics of the study area.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Highlights

- This paper set under business as usual (BAU) and farmland protection（FP）two scenarios.
- This study simulated land use patterns of Yunnan Province for the year 2020 under BAU and FP scenario.
- The areas of arable land, water and unused land would reduce while the other three land use types would be enlarged.
- The ecosystem services of Yunnan province from 2000 to 2020 shows an increasing trend.