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Predicting Changes in Regional Land Use Pattern: The Case of Jiangsu Province, China

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Additional information is available at the end of the chapter

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1. Introduction

1.1. Predict changes in regional landscape pattern

Space-time simulation of regional landscape change is important to regional ecological management. Effective policies and measures according to the study on regional landscape could guarantee the regional sustainable development. The simulation of land use change (LUC) is a frequently required but difficult process. To make informed planning decisions must be able to predict land use change. Many land use change models use remotely-sensed images to make predictions based on historical trends. Accurate land use change information is needed for land use policy making and scientific research. Therefore, scientists realized the need to assess the land use change dynamics and related the special situation of the regional pattern. Recently a large number of studies on future land use change have been conducted at regional scale (Andrew Gilg, 2009; Andy, 1997; C. Ma, 2012)

The Markov method of land use change can provide useful result. This research predicts the landscape pattern with the quantity model. Only do the numerical prediction of research regional, without considering the change of landscape form (2D and 3D).

Land use models are core subject of LUCC. In recent years, the LUCC community has produced a large set of operational models that can be used to predict or explore possible land use change trajectories (Verburg et al., 2006). The landscape pattern development model, and simulate different situations of the land using change pattern in the future. Investigate and evaluate the system of land using changes in reality and the potential ecological environment influence and feedback process. It have been considered by many researchers that it's revealed with land use system terrestrial ecosystem interaction mechanism. Optimize land using pattern. It's one of the effective ways to reduce the level of risk potential ecological process in the land using process.

The model's biggest significance can predict the future changes and have very good guidance function for scientific decision. On the one hand, according to the former development trend and direction, decide to the driving factors and the weight and make model operate to the different time in the future. Analyze each scene to the change of land using produce situation. This kind of model can build-up mixed related model. The advantage is that it considers the driving factors in model forecasting, Because of much relationship and the resistance in establishing model, it is not easy to cause the scientific results.

About the prediction model of the landscape pattern, including the concept model and mechanism model. it's classified into dynamic model, CA model, system dynamic model (SD model) that is based on cybernetics, System theory and information theory and it's characterized by studying feedback System structure, function and the dynamic behavior dynamic model. Its outstanding characteristic is to reflect the complex System structure, function and the dynamic behavior of the interaction between the relations. So as to study complex System change behavior and trend in different situations, and provide decision supporting (Chen Shupeng, 1999). The existing research shows that system dynamics model can reflect land using system of complex behavior on macroscopic and it is the good simulation tools in land using (Zhang Hanxiong, 1997; van et al., 1999; Li and Simonovic, 2002). Li, such as using the SD model for North America grasslands waters increased temperatures and ice melt water flooding caused by area of various ways simulation, obtained a good simulation results (Li and Simonovic, 2002). ZhangHanXiong applies system dynamics theory to establish Jin Shan loess hilly-gully region soil erosion dynamic SD model. Markov chain models basically does not consider the landscape pattern changes affecting the driving force, only using the past changes of the landscape pattern and the degree of change. According to the mathematical functions, speculated that the future of the landscape pattern utilization condition. It is based on two period of the landscape pattern and use data to calculate the types of land using change as the transition probability ratio. Markov process on matrix calculate to speculate that different stages of the land utilization condition. For example, Turner and Ruscher rules to mesh the study area and use Markov chain model to calculate the change of landscape plaques type probability, plus eight image elements and the effect of land using category, to determine each box type change the landscape of probability matrix (Turner, 1987, 1989; Ruscher, 1988). In order to reduce the general error that using Markov chain prediction model of the landscape pattern condition. Aoki, etc, introduce Hopfield neural network model. First the research in the area of the landscape pattern changes similar degree is divided into several sub-regional (sub-area).again with Markov chain respectively model to calculate the transition probability matrix. Using this method in the central business district in Tokyo, forecast to 2014 years of urban landscape pattern condition (Aoki et al, 1996).

The feasibility of the model is also an important aspect of the model, at present in the big, mesoscale landscape pattern prediction area using model is Markov chain models. This kind of dynamic simulation model using Markov model can forecast a quantitative description of dynamic landscape plaques. Markov transfer matrix make dynamic of landscape patches

quantitative (Han Wenquan, 2005). If many in the period of transformation probability are compared, and further explains the change in ecological meaning, it can make the landscape plaques dynamic quantitative research more valuable.

2. Materials and methods

The data of land use and land cover (LULC) were obtained from Chinese Academy of Science. Landsat Thematic Mapper (TM) images for the 1985,1995,2000 and 2005 years after being geometrically registered. They were classified analysis and aggregated into six major land types, they are build-up-up, forest, water ,farm, grass and other land. There are main three types for studying. There are main reasons accounted for selecting this scheme of LULC classification. First, three LULC types represented the dominant ecosystems and reflected the land use in the study area. Second, the selection keeps in accordance with the local official standards for land use classification and at the same time considers the ability of TM images to interpret LULC patterns. The local official standards for land use classification divided the LULC into two hierarchica levels.

2.1. Study area

Jiangsu Province is located in the lower reaches of the Yangtze River, east of the Yellow Sea, at latitude $30^{\circ} 46'N$ - $35^{\circ} 02'N$, longitude $116^{\circ} 22'E$ - $121^{\circ} 55'E$. The province's total area of

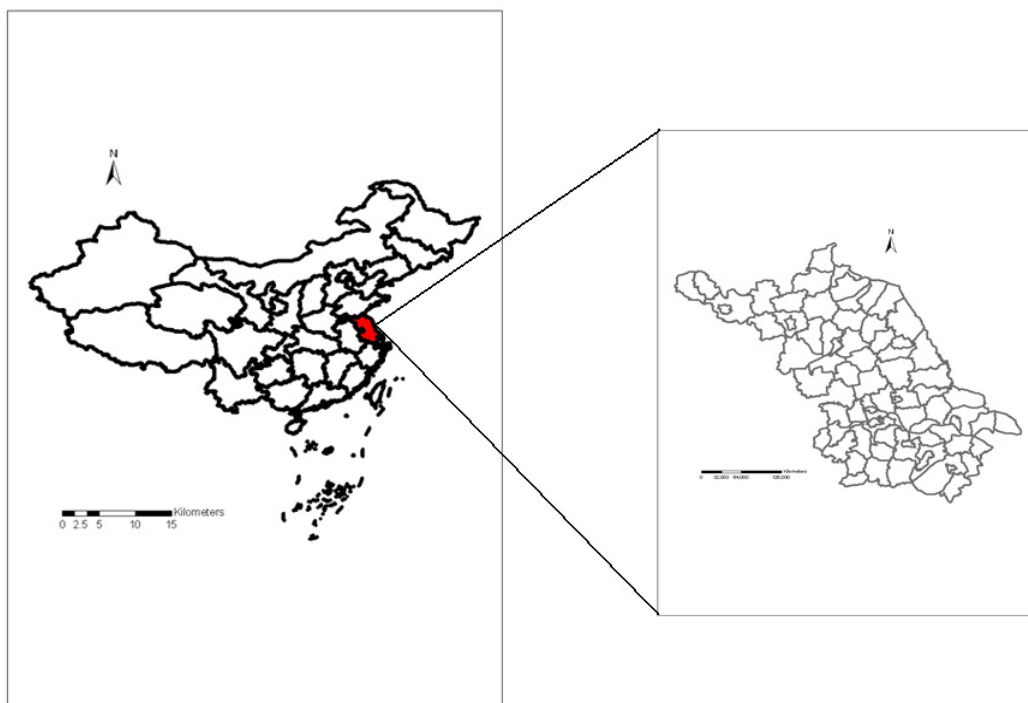


Figure 1. The Study area location map

approximately 102,600 square kilometers, accounting for 1.06% of the total area of 954 km long coastline.

2.2. Method

Markov model has been widely applied in the prediction of urban landscape change, however, it can be amended through the regional socio-economic indicators to improve its forecast accuracy. Based on TM satellite images in different years (1995, 2001, 2005 and 2008), urban land-use change maps were created and analyzed in Taicang County of Jiangsu Province, then a weighed Markov model was established based on the driving force of urban land-use change to predict the urban landscape structure (agricultural land, constructive land, etc.) in 2013. Based on the analysis of driving forces of land-use change, the periods of driving forces were divided into 1995 - 2001 and 2001 - 2005 two stages. The transfer matrixes were used as the weighted factors of Markov model whose weights were calculated to constitute the model in order to build-up a transfer matrix more in line with the urban landscape change in the stage from 2008 to 2013, then the structure of the urban landscape in 2013 was predict. On the basis of status value (2008) of urban landscape, the weighted Markov model was more reasonable than the non-weighted Markov model.

2.2.1. Using Markov model

The Russian mathematician Andrei Andreyevich Markov (1856–1922) developed the theory of Markov chains in his paper “Extension of the Limit Theorems of Probability Theory to a Sum of Variables Connected in a Chain” (Markov, 1907). A Markov chain is defined as a stochastic process fulfilling the Markov property (Eq. (3)) with a discrete state space and a discrete or continuous parameter space. In this paper, the parameter space represents time, and is considered to be discrete. In this process, the outcomes of a given experiment can the out come of the next experiment. This type of process is called a Markov chain. Accordingly, a Markov chain represents a system of elements making transitions from one state to another over time. The order of the chain gives the number of time steps in the past influencing the probability distribution of the present state, and can be greater than one.

$$P(X_t = j | X_s = i) = P_{ij}(s, t) \quad (1)$$

The conditional probabilities are called transition probabilities of order $r=t-s$ from state i to state j .

They are denoted as the transition matrix P . For k states P has the form , The purpose of this section is to introduce the concept of a stochastic complement in an irreducible stochastic matrix and to develop some of the basic properties of stochastic complementation. These ideas will be the cornerstone for all subsequent discussions. It is a non-negative matrix (such a matrix is called stochastic). The transition probabilities matrix can be described as following:

$$P = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1k} \\ p_{21} & p_{22} & \cdots & p_{2k} \\ \cdots & \cdots & \cdots & \cdots \\ p_{k1} & p_{k2} & \cdots & p_{kk} \end{bmatrix} \quad (2)$$

At time 0 the initial distribution of states is $P(X_0 = i) = p_i(0) \quad \forall i \in \{1, \dots, k\}$

The state probabilities $p_i(t)$ at time t are estimated from the relative frequencies of the k states, resulting in the vector $P(t) = (p_1(t), p_2(t), \dots, p_k(t))$

Denoting the v -th observed state with i_v , a stochastic chain fulfilling is a first-order Markov chain:

$$P(X_{t+1} = i_{v+1} \mid X_t = i_v, X_{t-1} = i_{v-1}, \dots, X_0 = i_0) = P(X_{t+1} = i_{v+1} \mid X_t = i_v) \quad \forall v \geq 2, \forall i_0, i_1, \dots, i_{v+1} \in \{1, \dots, k\}$$

Predictions of future state probabilities can be calculated by solving the matrix equation

$$p(t) = p(t-1) \cdot P \quad (3)$$

Agriculture land demand data are stochastic time series data, so Markov chain model can be employed to forecast the future data according to historical data. Generally time series data can be divided into a continuous real number zone. In order to use Markov chain model, the continuous real number zone should be divided into finite number unambiguous state sets.

2.2.2. Computation of transition potential

Markov transfer matrix simulate the dynamic landscape pattern not only need to understand a landscape status changes to another landscape the present situation of the process, the more important is clear and the reason for the variation of the landscape pattern. The landscape pattern evolution is the result from a combined effect of natural, economic, social and cultural factors, from the change of landscape pattern driving factors, different driving factors in the landscape pattern change have different functions, establish landscape pattern evolution simulation model of driving mechanism. perhaps is the landscape pattern evolution trend of the development of simulation. The current limit landscape pattern of dynamic simulation of a major reason is the lack of landscape processes and the landscape pattern of the interaction of the understanding and how to integrate this knowledge in the model. The mutual transformation of the landscape, patch and gallery. As the study area of Jiangsu province, the landscape pattern has significantly characteristics. From 1980 to 2005 yr., while the agriculture land area from 1980 in 7.23 km² reduced to 2005 years of 6.85 km². But in the whole study, regional landscape in the proportion of minimum is 69% (2005 yr.). So its landscape's substrate position is unshakable. The basal characteristics, the single transfer matrix will not be reflected in the study period. But the whole state as a kind of "information" is retained, how to use this

information? Researching needs a model that can have absorbing function for the global information.

Markov process according to system development, time discrete into $k = 1, 2, \dots, n$, each state with X_k to say, Take n discrete values $X_k = 1, 2, \dots, n$ to introduce the state vector and transition probability vector respectively for

$$(A_1(k), A_2(k), \dots, A_n(k)), P = \{p_{ij}\}_{mm}$$

$$A(k+1) = A(k)P$$

Every step of the transition probability can usually through the statistical data to determine, according to all kinds of random factors, the system the whole process of change can usually expressed as

$$X_0 \xrightarrow{P_1} X_1 \xrightarrow{P_2} X_2 \xrightarrow{P_3} \dots X_{m-1} \xrightarrow{P_m} X_m$$

In the past the study, application Markov process research the process, main is both the math model:

1. $X_{t1} \xrightarrow{p} X_{t2} \xrightarrow{p} X_{t3}$, among $P = P_1 P_2$
2. $X_{t1} \xrightarrow{p_1} X_{t2} \xrightarrow{p_2} X_{t3}$ Use local linearization stages measuring method.

2.2.3. Present problems

The above two models of science has been confirmed. In the actual landscape forecast research, the former method is currently using in the widest range, the last only study in the succession in the forest landscape (XiongLiMin, 1991). The shortage of the Method lies in: (1) In many cases, it is an idealized model by the impact of the initial value (Forman, 1986; Zhao Yi , 2001; ShenJing , 2006). Model sometimes does not reflect the authenticity of the system, the transfer matrix of the simple Markov model with the increase of the transfer step is only related to the most recent time and it's also different with the facts.(2) Segmentation processing methods often require transient from X_{m-1} to X_m or mutant, Rather than a gradual process. If this process is the time span, data integrity, it can be used to describe as P_{t-1} or P_t the status changes.

Otherwise it will cause a large deviation. But the larger regional landscape pattern changes in a gradual process, and began to study the time is not long, such a model can not reflect the actual situation of the regional landscape pattern changes.

Need to construct state transition information on the entire process of absorption of the Bayes method, in order to solve this regional landscape pattern sub- Markov process.

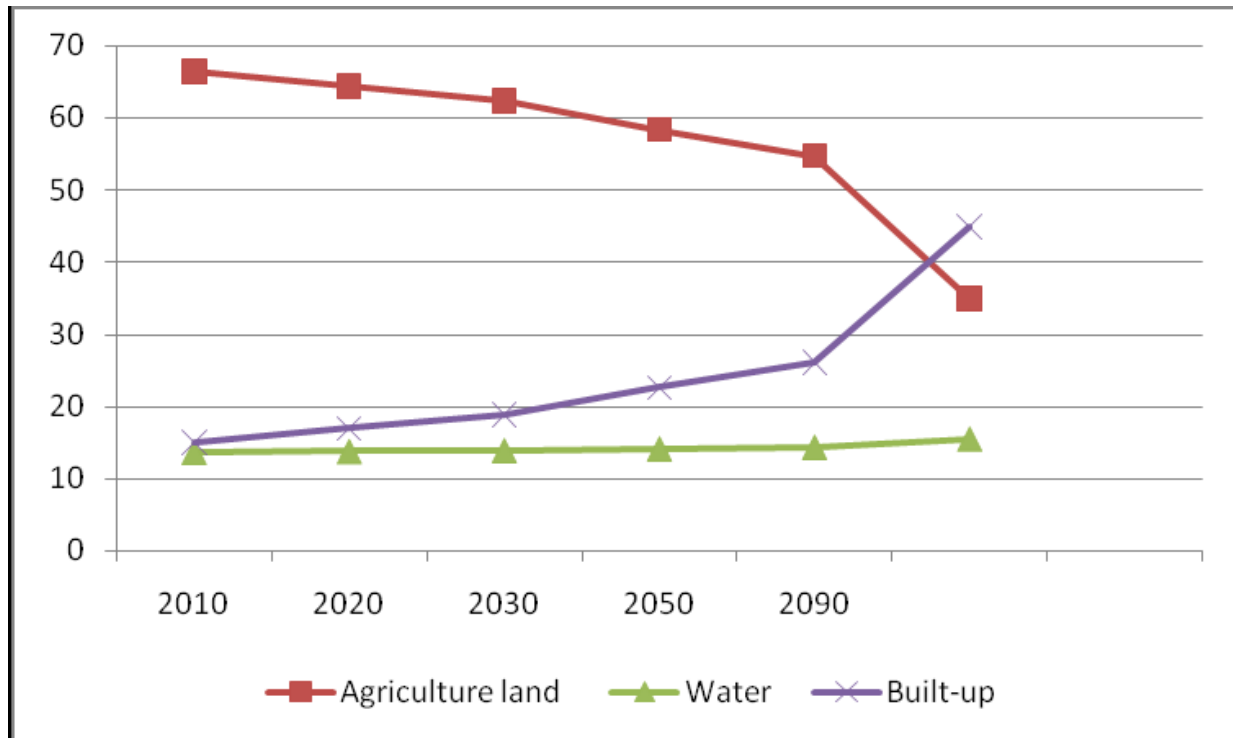


Figure 2. Fig2. Types of land change trends use SM model

2.3. Combination process of Marcov model and Baysian fomula

The change of the landscape pattern is one of the changes of the elements. This change including numbers and forms, Form the landscape pattern change is one of the important research directions in the future. In the stable number of elements, it's better to grasp the landscape pattern. This research predicts the landscape pattern with the quantity model. Only do the numerical prediction, without considering the change of landscape form (2D and 3D). Landscape elements quantity change over time, because of the area of restrictions, the original plaques elements (image element) covered area of change, this state will eventually reach a stable state. The researchers hope to understand the changes among this process . Through the analysis of the development of different opinions predicted results, to explore in this situation, the land using the changes will tend to which direction, what effects. Maybe considering the different degrees of land management policy, predicting the changes and consequences of land using situation in the future.

The changes and the trend of the landscape pattern of Jiangsu province can be used Bayesian-Markov model for research,

There are reasons 1. in research area, different landscape types with mutual transformation can be sex each other 2. Landscape types of mutual transformation between process contains a multiple function relation which can accurate description of events 3. This research data is all kinds of data of land use which is got from TM satellite image data analysis in 1980, 1985, 1995, 2000 and 2005 , largely reflects the changes of landscape in jiangsu province, and to represent the future trend of the development in a certain period 4. GIS technology can provide technical

support for establishing a realistic probability transfer matrix 5. This is a practical method which predict short-term changes of landscape structure trend using Markov chain quantitatively. We can consider the effect in the build-uping of model of Markov and proposed the Bayes transition probability model. We will forecast regional changes of landscape structure based on this area.

2.3.1. B-M model

For know initial state X_0 , in the system, we set up its state transition of the prior distribution as $P(X_1)$. After $P(X_k|X_{k-1})$ to X_{k-1} occurred under the conditions of a priori probability distribution. Replacement of the Bayes formula, the a priori probability distribution is amended to get the posterior probability distribution.

First set the state to change the whole process as follows,

$$X_0 \xrightarrow{P_1=P(X_1/X_0)} X_1 \xrightarrow{P_2=P(X_2/X_1)} X_2 \cdots X_{m-1} \xrightarrow{P_{m-1}=P(X_m/X_{m-1})} X_m$$

Among $m \geq 2, P_k = P(X_k / X_{k-1}) (k = 1, 2, \dots, m)$ is the state transition probability.

$$P_k = \begin{pmatrix} a_{11}^{(k)} & a_{12}^{(k)} & \cdots & a_{1m}^{(k)} \\ a_{21}^{(k)} & a_{22}^{(k)} & \cdots & a_{2n}^{(k)} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1}^{(k)} & a_{n1}^{(k)} & \cdots & a_{nm}^{(k)} \end{pmatrix}$$

$$\sum_{j=1}^n a_{ij}^{(k)} = 1 (i = 1, 2, \dots, n), k = 1, 2, \dots, m$$

That the k transition probability matrix, first remove the last three state as follows.

$$X_{m-1} \xrightarrow{P_{m-1}} X_m \xrightarrow{P_m} X_{m+1}$$

$$P^{m-1} = P(X_{m-1} / X_m) = \frac{P_{m-1} \cdot P(X_m / X_{m-1})}{P(X_m)} = \frac{P_{m-1} \cdot P(X_m / X_{m-1})}{\sum_j P_{m-1} \cdot P(X_m / X_{m-1})} = \frac{P_{m-1} \cdot P_m}{\sum_j P_{m-1} \cdot P_m}$$

$P^{m-1} = (b_{ij}^{(m-1)})_{1 \times n}$ Among $P^{(m-1)}$ is $n \times n$ matrix, defined by

$$b_{ij}^{(m-1)} = \frac{a_{ij}^{(m)} a_{ij}^{(m-1)}}{\sum_{j=1}^n a_{ij}^{(m)} a_{ij}^{(m-1)}} \rightarrow \quad i = 1, 2, \dots, n \quad \text{then} \quad \sum_{j=1}^n b_{ij}^{(m-1)}$$

This state transition $X_{m-2} \xrightarrow{P_{m-1}} X_{m-1} \xrightarrow{P_m} X_m$ is revised to $X_{m-2} \xrightarrow{P^{m-1}} X_{m-1} \xrightarrow{P^m} X_m$.

Then revised to $X_{m-3} \xrightarrow{P_{m-2}} X_{m-2} \xrightarrow{P^{m-1}} X_{m-1} \xrightarrow{P^m} X_m$

$$P^{(m-2)} = P(X_{m-2} / X_{m-1}) = \frac{P_{m-2} P(X_{m-1} / X_{m-2})}{\sum_j P_{m-2} P(X_{m-1} / X_{m-2})} = \frac{P_{m-2} P^{m-1}}{\sum_j P_{m-2} P^{m-1}}$$

set to as follows:

$$P_i^{(m-2)} = (C_{ij}^{(m-2)})_{1 \times n}$$

$$C_{ij}^{(m-2)} = \frac{a_{ij}^{(m-2)} b_{ij}^{(m-1)}}{\sum_{j=1}^n a_{ij}^{(m-2)} b_{ij}^{(m-1)}} = \frac{a_{ij}^{(m-2)} \left[\frac{a_{ij}^{(m)} a_{ij}^{(m-1)}}{\sum_{j=1}^n a_{ij}^{(m)} a_{ij}^{(m-1)}} \right]}{\sum_{j=1}^n a_{ij}^{(m-2)} \left[\frac{a_{ij}^{(m)} a_{ij}^{(m-1)}}{\sum_{j=1}^n a_{ij}^{(m)} a_{ij}^{(m-1)}} \right]} = \frac{a_{ij}^{(m-2)} a_{ij}^{(m-1)} a_{ij}^{(m)}}{\sum_{j=1}^n a_{ij}^{(m-2)} a_{ij}^{(m-1)} a_{ij}^{(m)}} \rightarrow$$

The state transition probability once again amended to next

$$X_{m-3} \xrightarrow{P^{m-2}} X_{m-2} \xrightarrow{P^{m-2}} X_{m-1} \xrightarrow{P^{m-2}} X_m$$

In accordance with the above steps, the final transition probability can be revised to

$$P^{(1)} = P(X_1 / X_2) = \frac{P_1 P(X_2 / X_1)}{\sum_j P_1 \cdot P(X_2 / X_1)} = \frac{P_1 P^{(2)}}{\sum_j P_1 \cdot P^{(2)}}$$

$P^{(1)}$ in i row element $P_i^{(1)}$

$$P_i^{(1)} = \left[\frac{\prod_{k=1}^m a_{ij}^{(k)}}{\sum_{j=1}^n \left[\prod_{k=1}^m a_{ij}^{(k)} \right]} \right]_{1 \times n} \quad (i = 1, 2, \dots, n)$$

This Bayesian - Markov transition probability formula , this model is called as the landscape patch change forecast Bayesian - Markov model (BM model).

2.3.2. Computation of transition by B-M model

From the results of the study in chapter 3,we can see the deceleration of the agriculture land area in our province experiences from increase than sharp decrease than slow decrease and decrease again ,during the process of rapid urbanization, industrialization, on the one hand,scale the construction land use has expanded, valuable agriculture land resources are invaded,on the other hand,in the amount of land in city or development zone, there are scattered layout, land intensive degree lower outstanding problems.At present the notable

features is the rapid expansion of the built-up urban scale in the change of land use in Jiangsu province(Zhao YaoYang, 2006),research predict that the population of Jiangsu Province will reach 76.9519 million in 2010 and increase average 0.3086 million every year from 2005 to 2010,but the population will reach 79.192 million by 2020,and increase average 0.2240 million every year from 2010 to 2020,which explain that population growth has a stable state (Yang LiXia, 2006),the development of traffic promotes the Regional towns nearby,for 30 years, jiangsu's traffic will enter the period of big development of network, balanced development situation is clear (han jia, 2008),through the results of this study,we can preliminary judge, the fastest change in regional landscape pattern is in the build-up land in the next period,while the share of agriculture land will be stability have fall.

2.3.3. Summary of the data and the transfer matrix of the generation of landscape

Because this data is made up by two different format in different period, and data of different precision ,at first,they should be unified into the grid of image formats,what's more,we should united them to 1000km * 1000km. Like size of pixel , we can get plaque kind of pixel conversion matrix in Arc Gis spatial analysis.The following were listed four stages patches type number transfer matrix and plaques between the type of transition probability matrix.Due to the limitation of length,we make two transfer number matrix in our four stages, the following table 1 shows for 1980-1985,the following table 2 shows the period of 2000-2005 yr..

Unit 1km ²	Agriculture	Forest land	grass	waters	Build-up land	Other land
Agriculture land	80861	17	0	91	1069	3
Forest land	6	3154	0	0	11	0
grass	17	0	948	4	2	0
waters	19	0	0	10756	7	0
Build-up land	4	0	0	3	4055	0
Other land	0	0	0	0	0	10

Table 1. In 1980-1985, six kinds of number transfer matrix of the landscape types

Unit 1km ²	Agriculture land	Forest land	grass	waters	Build-up land	Other land
Agriculture land	60821	673	85	2159	8359	5
Forest land	638	2490	20	77	177	6
grass	172	22	593	196	121	0
waters	1341	77	79	10447	2890	2
Build-up land	5311	119	40	187	6342	2
Other land	2	6	2	2	0	6

Table 2. In 2000-2005, six kinds of number transfer matrix of the landscape types

From this result, we can generate the transition probability matrix of regional landscape type plaques of the Jiangsu province, respectively table 3 – table 6,

3. Result

3.1. Model validation

Remote sensing (RS) and geographic information systems (GIS) are essential tools for monitoring land distribution area, and spatial and temporal analysis of wetland dynamic change.

P	Agriculture land(AL)	Forest land(FL)	grass	waters	Build-up land	Other land
AL	9.86E-01	2.07E-04	0.00E+00	1.11E-03	1.30E-02	3.66E-05
FL	1.89E-03	9.95E-01	0.00E+00	0.00E+00	3.47E-03	0.00E+00
grass	1.75E-02	0.00E+00	9.76E-01	4.12E-03	2.06E-03	0.00E+00
waters	1.76E-03	0.00E+00	0.00E+00	9.98E-01	6.49E-04	0.00E+00
Build-up land	9.85E-04	0.00E+00	0.00E+00	7.39E-04	9.98E-01	0.00E+00
Other land	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00

Table 3. In 1980-1985 six kinds of transition probability matrix of plaques types

p	Agriculture land	Forest land	grass	waters	Build-up land	Other land
Agriculture land	9.92E-01	3.09E-04	4.94E-05	1.85E-03	6.09E-03	0.00E+00
Forest land	4.73E-03	9.85E-01	0.00E+00	1.58E-03	9.15E-03	0.00E+00
grass	9.60E-02	0.00E+00	7.65E-01	6.43E-02	7.49E-02	0.00E+00
waters	1.66E-03	0.00E+00	4.61E-04	9.97E-01	6.45E-04	0.00E+00
Build-up land	3.30E-03	0.00E+00	0.00E+00	3.89E-04	9.96E-01	0.00E+00
Other land	7.69E-02	0.00E+00	0.00E+00	1.54E-01	0.00E+00	7.69E-01

Table 4. In 1985-1995 six kinds of transition probability matrix of plaques types

p	Agriculture land	Forest land	grass	waters	Build-up land	Other land
Agriculture land	8.69E-01	8.55E-03	2.42E-03	2.14E-02	9.89E-02	3.74E-05
Forest land	1.20E-01	8.29E-01	8.36E-03	1.16E-02	2.93E-02	1.93E-03
grass	4.45E-02	1.67E-02	8.57E-01	5.84E-02	2.09E-02	2.78E-03
waters	3.98E-02	4.83E-03	1.12E-02	9.38E-01	5.92E-03	9.11E-05
Build-up land	2.88E-01	1.36E-02	1.68E-02	2.39E-02	6.57E-01	1.75E-04
Other land	0.00E+00	3.00E-01	0.00E+00	1.00E-01	1.00E-01	5.00E-01

Table 5. In 1995-2000 six kinds of transition probability matrix of plaques types

p	Agriculture land	Forest land	grass	waters	Build-up land	Other land
Agriculture land	8.44E-01	9.33E-03	1.18E-03	2.99E-02	1.16E-01	6.93E-05
Forest land	1.87E-01	7.31E-01	5.87E-03	2.26E-02	5.19E-02	1.76E-03
grass	1.56E-01	1.99E-02	5.37E-01	1.78E-01	1.10E-01	0.00E+00
waters	1.10E-01	6.29E-03	6.46E-03	8.54E-01	2.36E-02	1.63E-04
Build-up land	4.43E-01	9.92E-03	3.33E-03	1.56E-02	5.28E-01	1.67E-04
Other land	1.11E-01	3.33E-01	1.11E-01	1.11E-01	0.00E+00	3.33E-01

Table 6. In 2000-2005 six kinds of transition probability matrix of plaques types

3.2. Analysis of transition matrix

According to 2.1 section, the derivation of process, and the transition probability matrix we get in 2.3 section, after four times the iterative calculation we can get that in the 1980-2005 study period, considering effect of global information, the leaf Markov transition probability matrix, based on this, we can take 1980, 1985, 1995, 2000 and 2005 years of plaque in the share of landscape type respectively for the initial P_0 and the product of the transfer matrix, the landscape pattern change forecast, here to solve the lack of data in 1990, to 1985 years for the initial vector, multiplied by the Bayesian transition probability matrix $P^{(1)}$, (see table 7).

We can get the vector of the occupies plaques of virtual landscape types in 1990, (farmland, forest land, meadow, waters, construction land, unused land) $^T = (78.76588, 3.133267, 0.901077, 10.77607, 5.46728, 0.007758)^T$

So we can have a data set of six flags, than we can take the Bayes transition probability matrix $P^{(1)}$ as a step (five years) transfer matrix, because we must consider global effective forecasting methods, the study of data, in this way we can make the data complete, because in the landscape pattern, the basic data of integrity is very common, Markov provides reference method for the missing data of The landscape pattern, at the same time we also must see that when we use this method, we should keep the main character information preserved of the characteristics of landscape, but this method can't handle mutations, through the raw data we can see, the area of the build-uping land plaques is nearly doubled during from 1995 to 2000 yr.. The thing which is increasing of the landscape pattern plaques will be weakened because of the global of fusion ways of Bayesian-Markov, we can think that mutations are not resolved, and Bayes framework provides a very good idea. We can add mutations factor in the global transfer matrix. In order to make the prediction based on the stable landscape plaques in this study, the environment of forecast period must be the same with that of 1980-2005. we can take the data of 1980, 2000, 2005 yr. as the initial state to forecast something, agriculture land, for example, starting share is 81.199% in 1980, while he forecast result is 75% if we take the initial state of agriculture land area of 2005. While by the actual measurement data of the gods we can know that in 2000, proportion of agriculture land has less than 70%. But this just shows, feature that the changing proportion in the growth of acceleration in regional landscape pattern plaques. Existing research conclusion

points out that when we use Markov models to make prediction, Recent effect of prediction is better than long-term that of prediction (ShenJing, 2006). In order to the reliability prediction, we should choose the data of 2005 to do initial matrix and predict future years. Get table8.

P ⁽¹⁾	Agriculture land	Forest land	grass	waters	Build-up land	Other land
Agriculture land	0.926304	0.000417	2.3257E-05	0.001705937	0.071577	1.3454E-08
Forest land	0.094777	0.851918	0.00278079	0.000916227	0.04962	1.0811E-05
grass	0.060054	0.002472	0.84407206	0.038840138	0.012852	1.9104E-08
waters	0.010645	7.16E-05	0.00016138	0.98	0.009923	1.1433E-08
Build-up land	0.093941	0.00144	0.00029571	0.001649559	0.901701	8.3021E-08
Other land	0.057783	0.722013	0.00013623	0.023523454	0.003758	0.12960613

Table 7. Bayesian transition probability matrix during study period

year	Agriculture land	Forest land	grassland	water	Build-up land	other land
2010	64.60235	2.956314	0.711314685	12.9051	18.78414	0.012721832
2015	62.06647	2.5771644	0.676184411	12.81858873	21.845609	0.009731691
2020	59.96652	2.262479	0.587888366	12.73299	24.40454	0.001291957
2025	58.22519	1.990883	0.513177977	12.64582	26.54399	0.000194895
2030	56.78195	1.760878	0.449939727	12.55778	28.33319	0.00013

Table 8. Bayesian-Markov model to simulate the prediction of proportion of the land type (unit %)

3.3. Analysis result

If we analysis research index of landscape types simply,we can have some knowledge of the landscape pattern.if we want to have further study of the change trend of landscape pattern,we need to do research on the change of type of the landscape or inside structure (Yue TianXiang, 2000). From transfer matrix of the four stages of the landscape plaques, we can see the transfer of the patches of landscape, for example, from the transfer matrix of the plaque-sin 1980-1985,there are 17 zero accounting for nearly half of the total conversion type, in1985-1995 yr. there are 12 zero, in 1995-2000 there are 2 zero,in 2000-2005 yr., in patches transfer matrix, there is only about 1 zero(did not use the land to build-up land type). From this change we can draw a conclusion that is conversion activities in the increase in the regional landscape pattern plaques,change of type of regional landscape plaques enter into the active period around 2000 yr. or so. We can get table 9 through comparing the plaques number of urban construction land. From the table we can see that during agriculture land into land for construction, it experiences that the change of agriculture turning into building-up increased in process of the first and then decreased, rapid increase again. Agriculture land is the main "origin" for the build-uping land

plaques. for their own growth of urban construction land use, we can understand their own patch expansion, also can be used as a proof of urbanization. Have to, there are also turn out, the advantage of the transfer matrix is that it can let researchers from two aspects to see a problem. when we take 2000-2005 years of plaques in the land transfer condition built turn out as an example, we will see table 10 for 2005 years to build-up land moved on to turn out and balance in this time. We can see clearly that the water is the second source of the land for construction, in the process of build-uping land expansion. In the study period, the occupation of arable land is very obvious.

	1980-1985	1985-1995	1995-2000	2000-2005
P15	1069	493	7929	8359
P25	11	29	91	177
P35	2	71	15	121
P45	7	7	65	289
P55	4055	5125	5762	6342
P65	0	0	1	0

Table 9. the plaques number of the transfer of the land to build-up in each phase (number of pixel)

	Turn to build-up	Build-up turn to other types	D-value
Agriculture land	8359	5311	3048
Forest land	177	119	58
grass	121	40	81
waters	289	187	102
Build-up land	6342	6342	0
Other land	0	2	-2

Table 10. Interconverting table of build-up land and other types (2005)

From the number prediction of landscape plaques, we can see that after 2005 years land use type change trend for the decrease in the number of agriculture land, forest land reduce more slow, grassland area to reduce slow, build-up the area of land to increase, and after a certain time period of slowing rate increase, unused land is constantly slowly decrease. We can see that at present the landscape pattern is steady change, agriculture land, build-uping land is the biggest patch types of area change. It indicates the landscape pattern in jiangsu province is affected from human activities. Natural landscape in the research area gradually blurred. It is form of urban and rural economic integration of the landscape pattern, if agriculture land diminishing, it is a challenge for the landscape structure based on agriculture land. But at present the implementation of land management policy and considering the effect of global Bayesian-Markov forecast model results show the agriculture land area of landscape plaques, and build-up land types and the rate of change in patches type slow (figure 3). As the economy and population growth, it will be the main form of regional patches type unit bearing capacity of the change of regional landscape pattern, and there are changes in jiangsu province in the future.

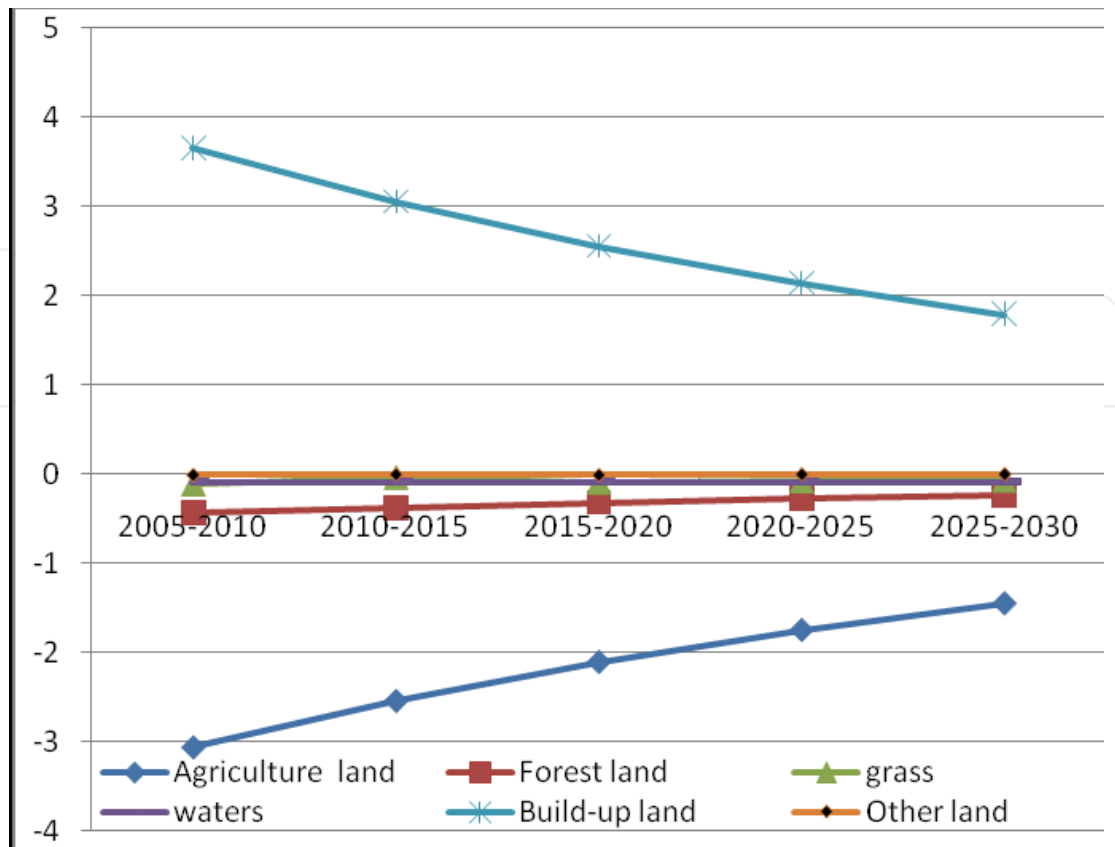


Figure 3. Change difference figure of forecast model of landscape types in different period (%)

4. Conclusion and direction for the future

Bayesian - Markov model landscape pattern of the number of patch types the proportion of change in the whole Jiangsu Province Forecast (2010-2030). Results show that the type of landscape pattern in the region of plaque volume changeson will be leveled off, and arable land remains the matrix characteristics of the region, construction sites still show a growth trend, but not doubling phenomenon around 1995-2000 yr.. Economic, population growth, the region of the plaque type unit bearing capacity increase is the main form of Jiangsu Province regional landscape pattern change, and the layout of the landscape patch types in space is worthy of further study.

It also studied the main driving factors of landscape changes and established a systematic landscape model and made empirical research by using Jaingsu as a subject. The paper's conclusions may offer some essential refernces to the decision making for the regional sustainable development. At last this predict model will use B-M spatial model . This is quantitative model to location model.

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