SPATIAL ASSESSMENT OF THE CHANGE OF MOUNTAIN RANGE FARMLAND USE BASED ON RS AND GIS

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ABSTRACT:

Assessment of the change of farmland use is of great important. After comparing the different ways of the assessment of farmland use change, a spatial assessment of the change of mountain range farmland use based on RS and GIS technology was presented. Such spatial assessment way has the virtue of quantified and visual characters. It use the land change information fast gained ability of RS, the formidable spatial data processing and the analysis ability which GIS provides, and integrating the statistical analysis software package. After the analysis to the primary factors reflects the farmland use, a spatiotemporal change model of had been put forward to assess the farmland use change. A comprehensive factor for sustainable development model (CISD) is made to reflect the region development situation. Finally, based on the mountain range farmland use change spatial assessment method mentioned above，the change of mountain range farmland use of Shaoguan city in Guangdong province (China)was studied, and a good effect was obtained. Such application proves the validity and feasibility of the spatial assessment method of the change of mountain range farmland use mentioned in this paper.

1. INTRODUCTION

Farmland is the most basic natural resource and the basic living condition for human. In order to implement the farmland sustainable development management and decision-making, carrying on the assessment of farmland use change is of great important. The key part of farmland use change assessment research is selecting the suitable assessment index and establishing the quantitative assessment model and the method establishment. However, not only spatial data, but also statistical data compartmentalized by administrative cell is in such farmland use change assessment indexes. So how to assimilate the data form different data types are of the most importance for farmland sustainable use assessment. The traditional procedure is coarsening and dispersing the spatial data to the administrative unit to match the statistical data. Obviously, such traditional procedure will let some spatial data losing their spatial distributed information. Therefore, the synthetic assessment index obtained finally can not reflect the region sustainable development different spatial distributed information well.There are still some problems exiting in land sustainable use assessment:

1) Lacking united theory. The attitudes to the index selection are not unanimous and the selection is short of feasibility.
It is difficult to establish the weight coefficient and the quantify method for the index system. The artificial factors are severity in the expert mark method (JIA Shaofeng, MAO Hanying. 1999).

2) When selecting the index and devising the quantify model, most of the statistical data are compartmentalized by administrative cell and lack of spatial distributed information.

3) The quantitative assessment model is too simple. Each index is not independent with others. Certain index groups got by the sustainable development composite index would be emphasized and its influences would be exaggerated in some quantification assessment models.

In order to overcome the shortage of foregone farmland use assessment method, a spatial quantify method of the farmland use change assessment index, a spatial quantitative assessment model of farmland use and a spatial assessment of the change of mountain range farmland use based on RS and GIS technology was presented in this article. Finally, based on the spatial assessment method of the change of mountain range farmland use mentioned above，the mountain range farmland use change in Shaoguan city in Guangdong province (China)was studied.

2. ASSESSMENT MODEL DESIGN

2.1 Assessment index selection

Different complexity indicator system can be formed with different scale and different characteristic. A farmland sustainable utilization assessment index system is proposed by the author. Such index system is considerate to the land

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productively, stability, protection properties, economic feasibility and society acceptability as table 1.

Table 1. Farmland use spatial change assessment index system

Assessment standard	Indication factor	Assessment index
Productively	Farmland quality	Thickness of soil layer, Soil character, Organic matter content, Pickled degree
Stability	Dry and waterlogged disaster resisting ability	Irrigation degree, Dry and waterlogged disaster frequency, Ground smoothness
	Product protection system	Plant protection system、Road connexity, mechanization level
Protection properties	Soil pollution	Heavy metal, Pesticide rudimental
	Soil erosion	Soil erosion modulus, Soil erosion proportion, dune area proportion
	Water resource protection	Water resource balance, Water resource quality
Economic feasibility	Cost	Fertilizer, Pesticide, power, seed
	Income	Average production, total production
	Economic benefit	Land cost and income compare, total income、Average income
Society acceptability	The acceptability to the farmland management of the farmer	Farmland policy acceptability, The quantity of farmland tax rejection ,The quantity of farmland protection rejection

Assumptive, there are n regional affects to the land sustainable use, it make up of the muster N. And m affects will be selected to form the index system:

$$Sindex = \{x1, x2,., xm\} \ (Sindex \subset N)$$

2.2 Assessment index spatial quantified

In the assessment indexes system, some indexes are the spatial data that have geographical position; others are statistics data that are quantified with administrative border. How to assimilate the data form different data types are of the most importance for land sustainable use assessment. According to the index data type, all the data can be divided into 3 kinds: the spatial data, the statistical data and the remote sensing data. The slope, elevation and landform data are the spatial data which references to the geographic coordinate; foodstuff output, economy income and so on are statistics data are references to the administrative unit; but some indexes such as vegetation index is got from the remote sensing data. The remote sensing data belongs to a special kind of spatial data.

In order to find out the spatial differentiation characteristic of land sustainable use development, data from different data types are assimilated. After such spatial quantify, all the data will in the same spatial coordinate. The variable which has the spatial continuous distribution characteristic like the population density can be uninterrupted by spatial interpolation according to its spatial distribution rule, such as Kriging, TIN, Spline, Trend surface interpolation method. In order to match other data layers, some statistical variables which don't have the obvious spatial statistical distribution characteristic or not distributing continuously would be raster with the administrative unit as spatial unit directly (ZHANG Xianfeng, CUI Weihong, 2001).

2.3 Quantitative assessment model design

The most commonly quantitative assessment method is to uses the actual value of the index to eliminate with its ideal value. The realization is obtained, and all indexes would be synthesized to a composite index. In order to avoid the difficulty of artificial determination weight, the factor analysis method is utilized to scorify the composite index which can attribute the region sustainable development condition. The farmland use spatial change assessment (FUSCA) model is established as Fig.1.

3. APPLICATIONS

Shaoguan city is located the north of Guangdong Province (China) and in the east longitude 113°27' to 113°43' and the north latitude 24°53'. It is the intersections of Guangdong province, Hunan province and Jiangxi province. Its area is 18,594 km2, and approximately 10.5% of the Guangdong province area. Nanling Mountains crosses its north and Zhujiang River passes through from the north to the south. Shaoguan is the subtropical monsoon climatic region, the annual average temperature is 18.8-21.6℃, and the annual rainfall is 1300-2400 millimeteres. The whole year frost-free period is about 310 days. At the end 2004, the total population is 3.1485 millions. The non-agricultural population is 1.2505 millions, and the agricultural population 1.898 millions. The population density is169 peoples per square kilometer.

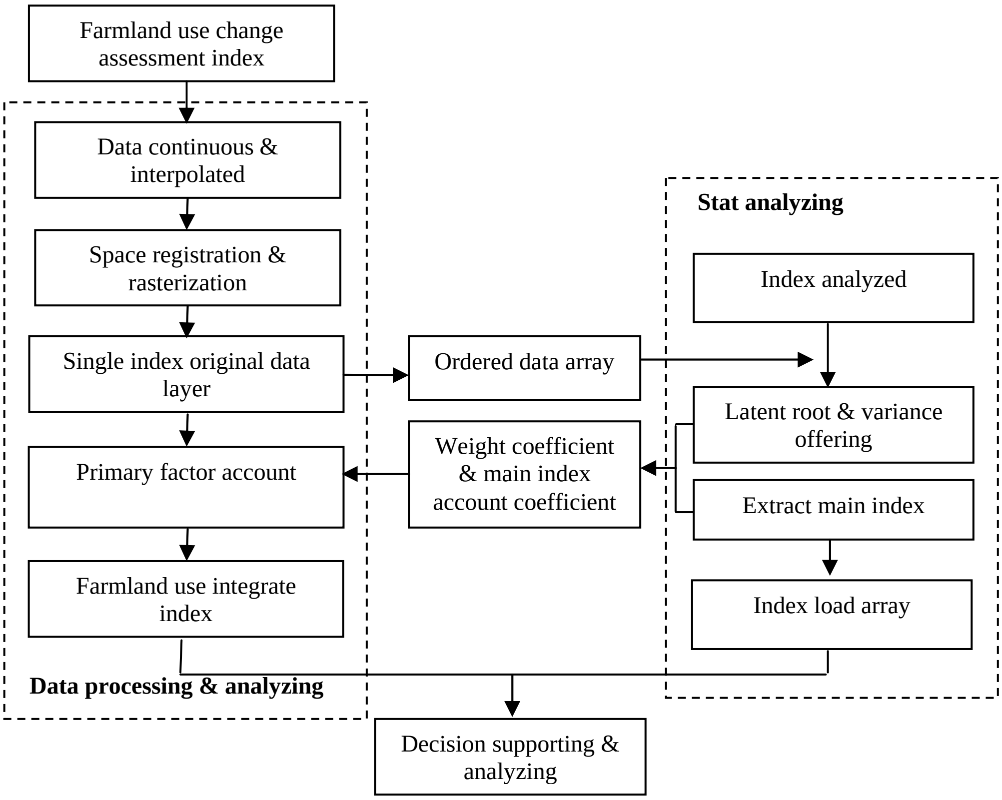

Fig.1 Space based Statistical Analysis Approach

Fig.2 Study area(Shaoguan city in Guangdong province. China)

In order to study the sustainable development situation and the ability presently and provides the basis to sustainable development plans and manages, the research from resources use, environmental protection, economy and social development factor to diagnoses and monitors the farmland use situation of Shaoguan are made.

3.1 Index selection and quantification

According to the farmland sustainable use assessment system principle, 11 indexes are selected to the Shaoguan city mountainous area farmland assessment system:
Sindex = {soil pollution, irrigation potential, landform, slope, thickness of soil layer, vegetation index, population density, average farmland per person, road connexity, average food per person , average oil plants per person}

3.1.1 Remote sensing classification detection

Using TM images supervised classification method, the Shaoguan land use in 1996 and 2004 are classified, and the change of each objects are got form the different period classification map. The Shaoguan land use classification map in 1996 and 2004 are as Fig.3 and Fig.4.


Fig.3 Shaoguan land use classification map in 1996

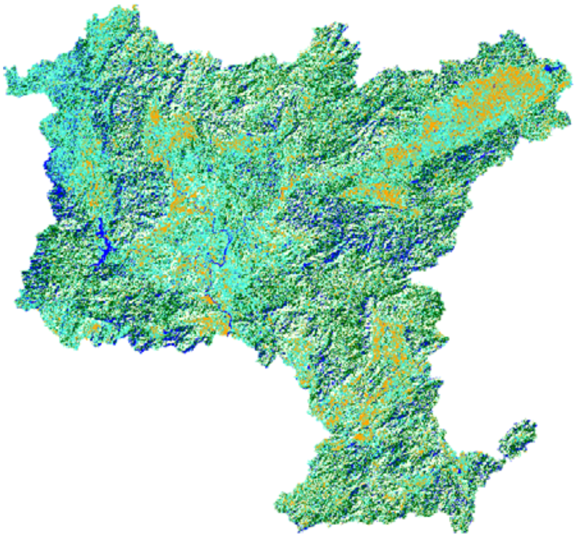

Fig.4 Shaoguan land use classification map in 2004

3.1.2 Data preparation and index quantification

Among the chosen 11 index, the soil erosion, the landform and the thickness of soil layer are the thematic map. They can be digitized to coverage data format of Arc/Info. But the irrigation potential, the road connexity, the slope and the vegetation indexes are obtained by computing from water system distribution map, road transportation map, topographic map and remote sensing data.

3.1.3 Spatial representation

The population data of Shaoguan city is got from administrative villages' statistics; Producing Point type coverage of population data layer in Arc/Info; forming an estimate face model by Kriging interpolation method. Some statistical variables which don't have the obvious spatial statistical distribution characteristic or distributing not continuously would be raster with the administrative unit as spatial unit directly.

3.1.4 Rasterization and registration

Based on information not losing principle, the sampling density size is equipped with the smallest polygon size of thematic map. After rasterizating the indexes, a sample space is got:

S = { (X1,Y1,Z1),(X2,Y2,Z2),.,(Xn,Yn,Zn)}

3.2 Factor analysis

After the 11 indexes are being factor analyzed, 3 primary factor-s are got as table 2.

Table.2 Principal component score

Variable name	Primary factor 1	Primary factor 2	Primary factor 3
EROSION	0.126	0.672	0.056
GRAINPER	0.972	−0. 036	0.098
LANDFORM	−0. 071	0.798	0.281
NDVI	−0. 009	−0. 092	0.556
POPDEN	0.072	0.283	0.633
ROADDIS	0.058	0.471	−0. 126
SOILDEPTH	−0. 243	0.689	0.145
SLOPE	0.011	0.570	−0. 128
P	0.475	−0. 029	−0. 058
OILPER	0.980	−0. 040	−0. 059
LANDPER	0.290	−0. 029	−0. 678
Wi	0.44	0.35	0.21

The primary factor 1 has highest loads in 3 variables as the average food per person, the average oil plants per person and the irrigation potential. It reflected the influence of humanity economic activity to Shaoguan city sustainable development condition.

The primary factor 2 is mainly made up of the landform, the thickness of soil layer, soil erosion and slope. It reflected the influence of natural condition to Shaoguan city sustainable development condition.

The primary factor 3 has highest loads in 3 variables as the average farmland per person, the vegetation index and the population density. It reflected the influence of environment-population pressure to Shaoguan city sustainable development condition.

3.3 Indexes account

Three primary factors promulgate the influence of humanity economic activity, the natural condition and the environment-population pressures to Shaoguan city sustainable development situation. 3 primary factors are synthesized into the Comprehensive Factor for Sustainable Development (CFSD). Each primary factor weight coefficient is as the latent root rate from factor analysis. Computational method as follows:

a) Primary factors weight coefficient compute:

$$W_i = \frac{E_i}{\sum_{i=1}^{3} E_i}$$

W_i is the i primary factors weight coefficient, E_i is the i primary factors latent root.

b) Primary factors score coefficient compute:

$$^{\wedge}F_i = \begin{bmatrix} ^{\wedge}F_1 \\ ^{\wedge}F_2 \\ \vdots \\ ^{\wedge}F_k \end{bmatrix} = A * R^{-1} * L$$

$^{\wedge}F_i$ is the i primary factors score coefficient, A is the original data array, R is the correlative coefficient array ,L is the load of factor in orthogonal estate.

c) CFSD computes:

$$CFSD = \sum_{i=1}^{k} a_i * f_i$$

a_i is the weight coefficient, f_i is the i primary factors score.

With the result of the application, it is found that the CFSD can reflect the mountain range farmland use situation and its spatial distribution of rule of Shaoguan city well.

4. CONCLUSIONS

Using the land change information fast gained ability of RS, the formidable spatial data processing and the analysis ability which GIS provides, and integrating the statistical analysis software package, this article has established a spatial assessment of the change of mountain range farmland use based on RS and GIS method. Such method has the merit as: (1) can assimilate the non- spatial data and spatial data the well; (2) the assessment index number is without any limit, and can be operationally easy; (3) each index can be synthesized into the describe region composite index, it has good objectivity and does not need to produce the weight of the index artificially; (4) breaking the limitation of the administrative unit assessment method, and promulgate leading affects index of the region development and its spatial distributing diversity rule.

With the application of Shaoguan city in Guangdong province (China), the affects the primary factors of the farmland sustainable use ability can be promulgated and good decision support to sustainable development plans and policy for the government can be provided by the assessment mention in this paper.

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