GIS AND MATHEMATICAL MODELS FOR REGIONALIZATION OF LAND USE PLANNING IN CHINA

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ABSTRACT

There are some problems about land use in China. It would be troubls for the development of the country. In order to manage the land economicly, the Land Use Planning covering the continent of China had been made by the government of the state in 1991. Regionalization is a part of it. Geographical Information Systems with Mathematical Models has been supported to the research. 18 overlays in the spatial data base, 52 added items in the attribute data base covering the overlays and 7 mathematical models to analysis the data both spatial and attribute data had been set up in the systems. As the result, the project with recognized 11 first-level regions and 37 second-level subregions for land use planning has been comleted. It is the first project of regionalization of land use planning in the history of China, it will be the basis for the govenment to make different land use policies in different regions for next decade.

Key Words: GIS, Models, Land Use Planning, Regions

INTRODUCTION

China is a large country both in land and in population. There are more and more land use problems and conflicts among diffrent users and diffrent regions in the process of the regional development and population increased in China especially in last decade. There is general agreement that it is necessary for the govenment to manage the land use accoding to the regional economic development and to adopt different land use policies for differnt regions. The project of Land use planning in China had been made by the State Land Administration of China in 1991 and it will be the formal document of the state government to quide the land use after beeing aproved by the law progress this year. The regionalization of land use planning in China is a part of it. The main responsibilities of it are following:

. Devide the continent of China into different regions of land use planning;
. Indicate the main directions, indexes and the structures of land use for nest decade for every regions;
. Make diffrent land use policies for every regions so that the directons, indexes and the structures of land use planning can be reliezed in the next decade.

THE FRAMEWORK OF GIS FOR RLUP IN CHINA

Three subsystems had been recognized in the Geographical Information Systems for the regionalizaton of land use planning in China (Fig.1).

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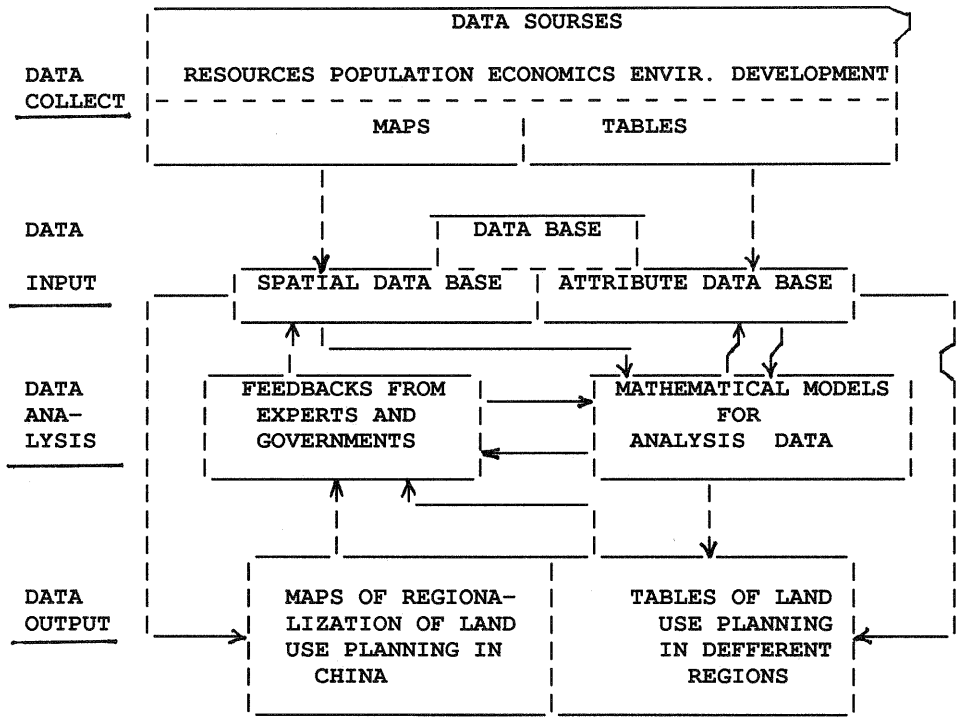
It is the basic work to collect data and to set up the data base which were necessary for the research including the spatial data base and the attribute data base, but it is the key work for the research to construct a series of mathematical models for the regionalization of land use planning including the structures and the indexes of the models. Because the project should be practiced by the commitions, ministries of the state (such as the Ministries of Agrruculture, Forestry, Railways, Communications, Mitallurgical Industru and others) and provincial govenments which are related to the land use, furthermore, it will be the basise for the regional policies for land use in different regions, the feedbacks of them to the project are more important.

DATA SOURCES

The primary data sources for the regionalization of land use planning in China were derived from several mapped data and from information kept by th State Land Administration and the State Ministry of Agruvulture, Forestru, Railqays, Mitallurgical Industry. The data about the economics and population were derived from the State Statistics Administration, State Planning Committee, State Capital Construction Commission and the State Population Committee. These indentify sites were both for present and for the development in the future. The data about the elevation, raimfall, median temperature and soil were derived from various published sources, these data sources were augmented by information abtained from the Land Use Planning Office of the State Land Administraton.

Fig. 1: THE FRAMEWORK OF GIS FOR REGIONALIZATION OF LAND USE PLANNING IN CHINA



DATA BASE

DIGITIZED SPATIAL DATA

From the infornation obtained, several key spatial features about land use planning were digitied including:

. The boundaries of administration;
(2182 counties, 188 cities and 136 districts)
. land use;
. Rivers (A, B, C levels);
. Towns and cities;
. Railways amd Roads.

As the sequence of the digitized spatial data, the overlays which would be the basis of the research were performed to synthesise the data in the spatial data base.

INPUTTED ATTRIBUTE DATA

From the information obtained related to the administration regions, most important attribute features for every parcials about regionalization of land use planning werer inputted including:

. Areas of the region;
. Elevation;
. Mean rainfall;
. Median temperature accumulation;
. Soil erosion degree;
. Areas of farmland;
. Areas of orchard;
. Areas of forestry;
. Areas of grass;
. Areas of town and urban,
. Areas of ground water;
. Areas of railways and roads;
. Areas of unused land;
. population;
. Gloss National Product (GNP);
. Total output of grain crops;
. Special regional policies for open door;
. Special regional policies for supportting poor counties;
. Special regional policies for developing marketable grain;
. Special regional policies for developing cotton;
. Special regional policies for developing forestry;
. Other special regional policies;
. The main regional problems of land use

CALCULATED ATTRIVUTE DATA

Based on the inputted attribute data, another 15 items data were calculated in the attribute data base, which would be important factors to be selected in the later models, including:

. Land areas per person;
. Farmland areas per person;
. Forestry areas per person;
. Grassland areas per person;
. Proportion of areas of farmland;
. Proportion of areas of orchard;
. Proportion of areas of forestry;
. Proportion of areas of grassland;
. Proportion of areas of town and urban land;
. Proportion of areas of ground water;
. Proportion of areas of railways and roads;
. Proportion of areas of being used land ;
. GNP per hecta;
. Proportion of urban population;
. Total output product of grain per hecta.

MATHEMATICAL MODELS

THE BASIC IDEARS OF DESIGNING MATHEMATICAL MODELS FOR REGIOALIZATION OF LAND USE PLANNING

Genarary speaking, there are two ways to design the mathematical models for regionalization: one is the way from handling spatial data to attribute data and another is handling attibute data to spatial data. Because of two levels for the regionalization are necessary, both ways were adopted in the research.

Based on above ideas, the following models are necessaty for regionalization of land use planning:

. The models for handeling data;
. The models for selecting and determining the factors of regionalization;
. The models for determining the weights of every factors;
. The models for classifying the parcials of regionalization;
. The models for combinations of the partials;

MODELLING OF HANDELING DATA

QUANTITATIVE TO THE QULIATITIVE DATA

A few data such as special regional policies were explaned with the quanlitative method, it should be quantitatived in the first step so that it might be used together with other data. We give them as 1 or 0 for yes or no.

STANDARLIZED TO THE QUANTITATIVE DATA

In order to compare the data to each other, it is necessary to standarlize to the quantitative data, so that the defferences between the levels and the classifiers of the data could be eliminated.

$$X'_{ij} = \frac{X_{ij} - X_{jmin}}{X_{jmax} - X_{jmin}}, \quad (i = 1, 2, ... 2506, \; j = 1, 2, ... 22)$$

where:

X'_{ij} is the standarded data for X_{ij},
X_{jmax} (X_{jmin}) is the max (min) value in the jth item.

MODELLING OF DETERMINING THE FACTORS FOR REGIONALIZATION

In the process of selecting and determining the necessary factors, the model of analysis main factor were applied.

. R - Relationship Matrix:

$$R = (r_{ij}) = \begin{pmatrix} r_{11} & r_{12} & ..... & r_{1p} \\ r_{21} & r_{22} & ..... & r_{2p} \\ . & . & ..... & . \\ . & . & ..... & . \\ r_{p1} & r_{p2} & ..... & r_{pp} \end{pmatrix}$$

in which: $r_{11} = r_{22} = r_{33} = ... = r_{pp} = 1$
(i, j = 1, 2, ... p, p = 22).

$$r_{ij} = \left(\sum_{k=1}^{n} X'_{ki} * x'_{kj}\right) / (n - 1)$$
(i, j, = 1, 2, ... p, p = 22, n = 2506).

. I - Eigenvalue C - Eigenvector

$| R - I | = 0$ (with the method of JACOB1)
$1 > 2 > 3 > .... > p >= 0$,
$C_i = (C_1, C_2, ... C_p)$, (i = 1, 2, ... p),

. Selecting main factors:

$$a = \left(\sum_{i=1}^{m} \lambda i\right) / \left(\sum_{i=1}^{p} \lambda i\right), \quad (p = 1, 2, ... 22 \; (m <= p).$$

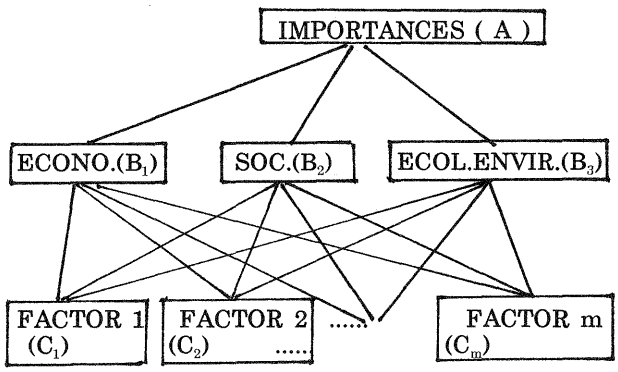
Acoording to the factors and the data which had been adopted, a = 0.9574 was been determined as the index to selecte the factors. 18 factors had been selected among the 22 factors.

MODELLING OF DETERMINING THE IMPORTANCES OF EVERY SELECTED FACTORS

The models of determining the importances of every selected factors had been set up with the method of Analytical Hirerarchy Process.
(Fig. 2)

Fig.2: Hirerarchy Structure of the factors

. Hirerarchy Structure:



. Ajudgement Vetrix

A	B_1	B_2	B_3
B_1	b_{11}	b_{12}	b_{13}
B_2	b_{21}	b_{22}	b_{23}
B_3	b_{31}	b_{32}	b_{33}

B_1	C_1	C_2	...	C_m
C_1	c_{11}	c_{12}	...	c_{1m}
C_2	c_{21}	c_{22}	...	c_{2m}
..	..	..	...	..
C_m	c_{m1}	c_{m2}	...	c_{mm}

B_2	C_1	C_2	...	C_m
C_1	c_{11}	c_{12}	...	c_{1m}
C_2	c_{21}	c_{22}	...	c_{2m}
..	..	..	...	..
C_m	c_{m1}	c_{m2}	...	c_{mm}

B_3	C_1	C_2	...	C_m
C_1	c_{11}	c_{12}	...	c_{1m}
C_2	c_{21}	c_{22}	...	c_{2m}
..	..	..	...	..
C_m	c_{m1}	c_{m2}	...	c_{mm}

. Determine the Importances in Different Levels

To calculate the eigenvalue and eigenvector for the matrix B:

$$B * W = \lambda_{max}$$

. Determine the Importances in Tatal Levels

$$C_i = \sum_{i=1}^{3} B_i * w_i$$

$$\sum_{j=1}^{m} \sum_{i=1}^{n} b_i * c_j = 1$$

MODELLING OF CLASSIFYING THE PARCIALS

The mathematical models of the fuzzy cluster had been applied in this process.

MODELLING OF REGIONAL COMBINATION

Based on the analysis of regional features of land use in China, the indexes and the models for the 2nd-level regions of land use planning had set up as following:

$$U = \begin{cases} 0 & ARC_i \bigcup ARC_j >< \emptyset, \text{ and } L_i = L_j \\ & (i, j = 1, 2, \ldots. 2506) \\ & ARC_i \bigcup ARC_j = \emptyset, S_i <= 10 \ (cm^2) \\ 1 & S_i > 10 \ (cm^2), \text{ and } L_i >< L_j \\ & (i, j = 1, 2, \ldots 2506) \\ U_{An}(A_k) = \max [U_{Ai}(A_k), U_{Aj}(A_k)] & ARC_k \bigcup ARC_i >< \emptyset, \quad ARC_k, \\ & ARC_j >< \emptyset, \text{ and} \\ & L_k >< L_i >< L_j \\ & (k, i, j = 1, 2, \ldots 2506) \end{cases}$$

CONCLUTION

GIS with mathematical models has successfully supported to the research. It is a very useful tool in managing the immense data (18 overlays, more than attribute data in the 2182 counties, 188 cities and 136 districts which covering the continent with areas of 9.60 millions squre kilemeters) and analysis the complex factors in the precede decisions in the challenges of information and decision. Two different projects of regionalization of land use planning had been completed in 1991, which were reported to the State Land Administration of China and one of them had been selected to reporte to the state government. The project had been examined by the government of the State Land Administration and the committee of examination including 9 professors and experts in the fiels of GIS and Remote Sensing, Land Use Cartography, Land Use Planning, Mathematics and Agricultural Regionalization in March 1992. It is the first project of regionalization of land use planning in Chinese history, it will be the basis for the govenment to make different land use policies in different regions for next decade.