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SPATIALIZATION MODEL OF POPULATION BASED ON DATASET OF LAND USE AND LAND COVER CHANGE IN CHINA

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ABSTRACT: The spatialization of population of counties in China is significant. Firstly, we can gain the estimated values of population density adaptive to different kinds of regions. Secondly, we can integrate effectively population data with other data including natural resources, environment, society and economy, build 1km GRIDs of natural resources reserves per person, population density and other economic and environmental data, which are necessary to the national management and macro adjustment and control of natural resources and dynamic monitoring of population. In order to establish population information system serving national decision-making, three steps ought to be followed: 1) establishing complete geographical spatial data foundation infrastructure including the establishment of electric map of residence with high resolution using topographical map with large scale and high resolution satellite remote sensing data, the determination of attribute information of housing and office buildings, and creating complete set of attribute database and rapid data updating; 2) establishing complete census systems including improving the transformation efficiency from census data to digital database and strengthening the link of census database and geographical spatial database, meanwhile, the government should attach great importance to the establishment and integration of population migration database; 3) considering there is no GIS software specially serving the analysis and management of population data, a practical approach is to add special modules to present software system, which works as a bridge actualizing the digitization and spatialization of population geography research.

KEY WORDS: spatialization models; population models; LUCC dataset; population spatialization; Deqing County

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1 INTRODUCTION

Population spatialization refers to the distribution pattern of population in space. Its typical pattern centralizes at towns with small patches of residential areas and roads linked as network in its surroundings. Fig. 1 is the sketch map of residential distribution.

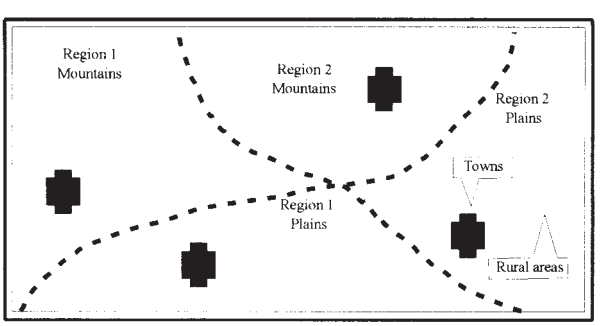

Fig. 1 Sketch map of residential distribution

Generally speaking, the residential scale of population is closely related size of towns. There are many kinds of population statistics models such as statistics based on administrative regions, physical environment distribution, economic zones, types of residential areas, etc.

According to the Fifth Census of China, the population densities of the east, middle and west of China are 452.3, 262.2 and 51.3 persons/km^2 respectively (http://www.xinhuanet.com.cn, 2000). The population density of the east is 8.8 times of that of the west. In the 1930s, HU Huan-yong, a well-known population geography expert found out and put forward the division line of population distribution in China

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named "Aihui-Tenchong Line". Until now, the population distribution pattern has not been changed with more people live in the east and little people live in the west. "Aihui-Tenchong Line" is a virtual geographical division line beginning at Aihui situated in the Northeast China and ending at Techong situated in the Southwest China, the east of the line with more people and less land while the west with more land and less people to live in.

The population density is directly related to land use types. Generally speaking, when the population density amounts to 2500 persons per square kilometer, its corresponding land use always represents as residential areas and towns. When the population density reduced to 35 persons per square kilometer, its corresponding land use represents as the original unused situation (WANG *et al.*, 2000).

Regarding areas of paddy field, dry land, forestry, grassland as independent variables and rural population as dependent variable, CHEN De-qing *et al.* (1998) analyzed their correlation, the result showed significant correlation between them.

It is an indirect method to make regression analyses based on types of land use and determine weights of population data of each type of land use under the condition that there are no residential data given, residential data (spatial data) directly reflect spatial distribution characteristics of population and residential areas reflect scales of population (WANG, 1997). Therefore, spatialization of population data based on residential data can reflect more better the real situation of population distribution (SHI *et al.*, 2000).

2 METHOD

As social and economic data, population data always are collected based on administrative regions, it is a complicated process to transform such data based on administrative regions into each grid with certain spatial size. Because the original data of population are spatial data with dot distribution, the spatialization of population should consider population distribution, i. e., the spatial difference for each analytical cell.

On the basis of the residential data in the land use map at a scale of 1∶100 000(created based on the project of Establishment of Remote Sensing Dynamic Serving Systems of National Basic Resources and Environment) and sample data of occupying areas per capita in towns and rural areas from the project of Study on National Overall Planning of Land Use, the author designed the implementation process of population spatialization.

3 SPATIALIZATION MODELS OF COUNTY POPULATION

The necessary data for spatialization of county population concern statistical population data of counties, distribution map of towns, rural market and rural areas at 1∶100 000. Regarding the secondary grade cells in the land use planning map of China as the basic division element to determine the occupying areas per capita of cities, towns, rural markets and rural areas, such data, as supposed values, can be used to disclose the residential density values. After the spatializtion of population data, we can get their verified data. Based on DEM data, we can get topographical types closely related with the residential scale of population in the Land Use Map of China at a scale of 1∶100 000. For instance, different topographical types have different residential areas per capita, and based on the survey, we can get the ratios of residential areas per capita of towns, rural markets, rural areas between different topographical types (LIU *et al.*, 2000).

The final result of population spatialization is to determine the population residential density based on statistical data of population, different levels of planning elements, topographical types and residential types, and to calculate the population values based on residential areas. The basic element is a map speckle with single environmental background or certain residential types. Based on Fig. 1, the authors made the further analyses(YAN, 1998; ZHANG, 1995; ZHANG, 1997).

The studied county has been divided into two parts: Region 1 and Region 2. The division of topographical types further divided each part with two subparts: mountains and plains. All the four parts have been classified into towns or rural areas. The basic requirement of population spatialization is to keep the population ratios of towns and rural areas between or within each part, and to keep certain ratios of population residential density of towns and rural areas in mountains or plains areas in each element (CHEN *et al.*, 1998). Based on the above premises, we can calculate population residential density (person/m^2) and residential areas of each planning element, each kind of topographical types and residential types. Therefore, there are eight variables in the models to be calculated, i. e., the population residential density of four parts and two kinds of residential areas in each part. The equation group is as follows:

$$\begin{cases} \sum_i \sum_j \sum_k SX_{ijk} = P & \text{Calculated population equalizes the real value} \\ \dfrac{\sum_j SX_{1j1}}{\sum_j S_{1j1}} : \dfrac{\sum_j SX_{2j1}}{\sum_j S_{2j1}} = a_{101}:a_{201} & \text{Residential density ratios of towns between Region 1 and Region 2} \\ \dfrac{\sum_j SX_{1j1}}{\sum_j S_{1j1}} : \dfrac{\sum_j SX_{1j2}}{\sum_j S_{1j2}} = a_{101}:a_{201} & \text{Residential density ratios of towns and rural areas in Region 1} \\ \dfrac{\sum_j SX_{2j1}}{\sum_j S_{2j1}} : \dfrac{\sum_j SX_{2j2}}{\sum_j S_{2j2}} = a_{101}:a_{201} & \text{Residential density ratios of towns and rural areas in Region 2} \\ X_{111}:X_{121} = a_{111}:a_{121} & \text{Residential density ratios of towns between mountains and plains in Region 1} \\ X_{112}:X_{122} = a_{112}:a_{122} & \text{Residential density ratios of rural areas between mountains and plains in Region 1} \\ X_{211}:X_{221} = a_{211}:a_{221} & \text{Residential density ratios of towns between mountains and plains in Region 2} \\ X_{212}:X_{222} = a_{212}:a_{222} & \text{Residential density ratios of rural areas between mountains and plains in Region 2} \end{cases}$$

In the equation group, ijk represents the known or unknown parameters of planning element "i", topographical type "j" and residential area "k" of a certain county; $i=1, 2$ (1 is for Region 1; 2 is for Region 2); $j=1, 2$ (1 is for mountains; 2 is for plains); $k=1, 2$ (1 is for towns; 2 is for rural areas); either of i, j or k with "0" shows the corresponding factors can be neglected; X is the residential density (person/m^2); α is supposed or sample value of residential density; S represents the residential areas, while P is the total population. The analyses for the above equation group show that it has exclusive linear feasible solution.

The above equation group, however, is a kind of generalization of the real question. For instance, a certain county can be divided into many planning element and can be classified many kinds based on topographical types or residential types, which lead to the complex to calculate the linear feasible solution.

Through the in-depth analyses of calculating steps, we found an effective method to calculate the solution. Here, the authors give a demonstration based on the solution of the above example.

(1) According to the supposed values "α" (supposed or sample value of towns or rural residential density in each planning element), calculating the towns and rural population of Region 1 and 2 and the total population "P" of certain county, and calculating a rectified coefficient "β", i. e., ratios of presupposed population P' and the real population P, and multiplying β with the above calculated population values, then we can get the real population values of towns and rural areas of Region 1 and Region 2.

(2) Based on the towns population values of Region 1 and the residential density ratios of mountains and plains of towns, we can get the residential density of mountains of towns in Region 1 based on the below formula.

$$X_{111} = \frac{P_{101}}{S_{111} + \dfrac{\alpha_{121}}{\alpha_{111}} \times S_{121}}$$

The more general formula is as follows:

$$X_{i1k} = \frac{P_{i0k}}{S_{i1k} + \dfrac{\alpha_{i2k}}{\alpha_{i1k}} \times S_{i2k}}$$

$$X_{i2k} = \frac{\alpha_{i2k}}{\alpha_{i1k}} \times X_{i1k}$$

where, P_{i0k} represents the population values of region i with topographical type k.

The authors found that there is no complex added with the increase of regions numbers, topographical types and kinds of residential types besides the increase of variables. That is, we can get the population density directly after two-step calculations.

4 SPATIALIZATION OF POPULATION DATA OF DEQING COUNTY IN ZHEJIANG PROVINCE

Deqing County spans two land use planning elements: coastal hills, garden plot and forest land, and paddy field and aquatic product areas in the east of Zhejiang (Region1) and plain paddy field and fresh water agricultural areas along the river band (Region 2).

The topographical types include mountains, hills and plains. The residential types can be classified into two types: town market (including county town) and rural residential areas. Table 1 shows the ratios between the supposed residential density and residential density under different topographical types. Fig. 2 shows the distribution of residential areas and residential density of Deqing County.

Table 1 Ratios of the supposed residential density (person/m^2) to the residential density of different topographical types of Deqing County

		Town market	Rural areas
Land use areas	Region 1	0.00642	0.00728
	Region 2	0.00837	0.00820
Topographical types	Mountains	1	1
	Hills	0.7	0.7
	Plains	0.8	0.8

The main calculating operations include the following steps:

(1) Overlaying the land use areas and the administrative boundaries of county and getting the land use areas in Deqing County.

(2) Extracting the residential cells of Deqing County.

(3) Creating the elevation and slope maps based on the contour map with the resolution of 1:250 000 and the topographical types map based on the topographical division.

(4) Overlaying the data got from the above operations and getting the residential cells with the detailed attribute.

The above spatial processes were finished in the *ArcInfo* software environment installed in *Sun* workstation. We transformed the residential data from the INFO tables into DBASE files, processed the data using *Statistica* software and got the residential density of different kinds of land use types, topographical types and residential types (Table 2). Finally, we jointed the values we got with the INFO file in *ArcInfo* environment and displayed the residential population in each cells in the residential map.

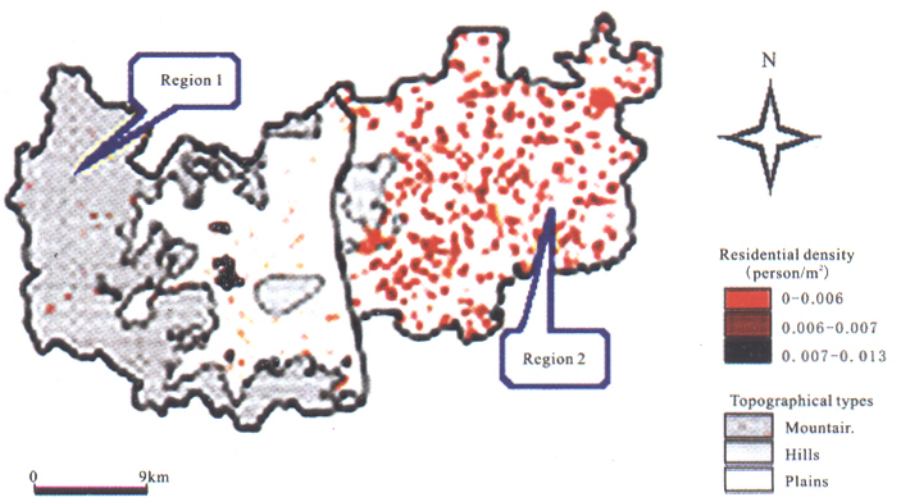

Fig. 2 Distribution of residential areas and residential density of Deqing County

5 POPULATION SPATIALIZATION OF CHINA IN 1995

Based on the coverage database of towns and rural resident of National Resources and Environment Remote Sensing Database at a scale of 1:100 000 (ZHAO *et al.*, 1993), we have finished population spatialization and got the population density map of China with the resolution of 500m × 500m. Fig. 3 shows the population grids map with resolution of 10km × 10km and population values of each grid lie in the scale of population numbers shown in the legend.

6 CONCLUSIONS AND DISCUSSIONS

At present, the scale is not large enough to abstract residential distribution map from land use map at scale of 1:100 000 (XU and WAN, 1997). Especially in mountainous areas, the distribution of residential areas is dispersed and some of map speckles are not large that

Table 2 Residential density and population of Deqing County based on the spatialization models

Regions	Topographical types	Residential types	Residential density (person/m^2)	Population (person)
Region 1	Mountains	Town market	0.007916	0
		Rural areas	0.008495	0
	Hills	Town market	0.005541	2739
		Rural areas	0.005947	403
	Plains	Town market	0.006333	59393
		Rural areas	0.006796	273634
Region 2	Mountains	Town market	0.013065	342
		Rural areas	0.007100	4220
	Hills	Town market	0.009145	0
		Rural areas	0.004970	0
	Plains	Town market	0.010452	44519
		Rural areas	0.005680	29592
Total			0.006880	414841

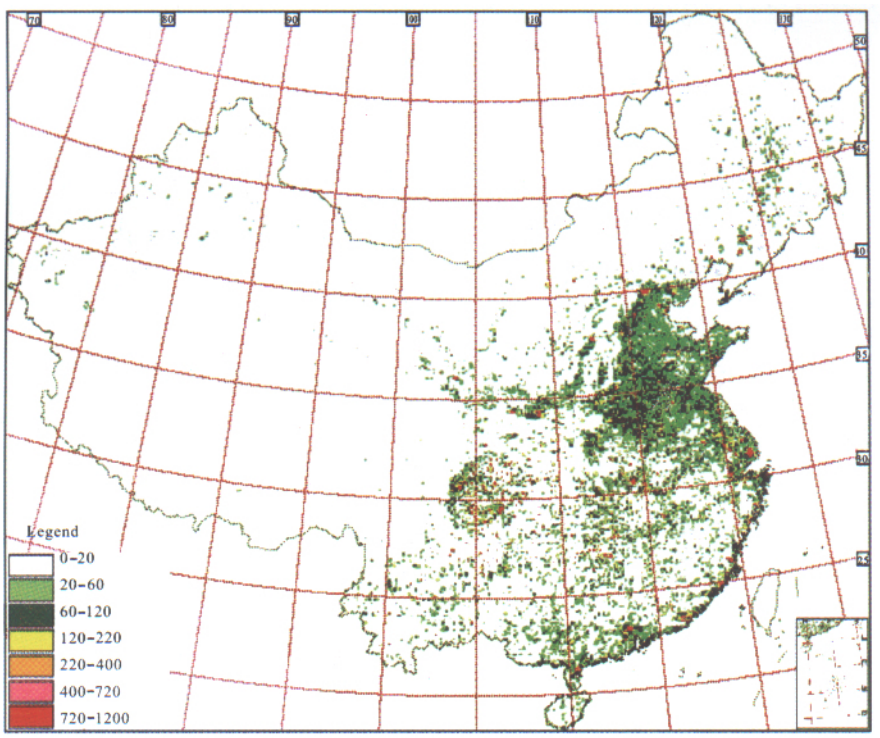

Fig. 3 Population distribution map with resolution of 10km × 10km of China in 1995 (excluding Hong Kong, Macao and Taiwan)

they will be ignored during the course of drawing maps, which results that the calculated population residential density is high than the real situation and most of the population is distributed into towns or rural areas with large scale. Therefore, it is necessary to abstract or identify the residential map speckles from the TM images to rectify such errors (MO *et al.*, 2000). In some sense, it is an effective method to improve the precision of population spatializtion. Furthermore, according to the population migration information, we can get the fluctuation ranges of population in each residential area and the real residential population and registered permanent residential population of certain regions.

In addition, based on the population spatialization of counties in China, on the one hand, we can get the supposed or experienced values of residential density of

all kinds of residential types; on the other hand, we can effectively integrated the spatialization data of population with other kinds of data covering natural resources, environment and society and economy, etc., and get the derived data and information of occupying amounts per capita, population density and economy and environment of 1km grids, which are significant to the management and macro control and adjustment of natural resources and the dynamic monitoring of population.

When we establish the population information systems for national government the following aspects should be considered carefully.

(1) Establishing the complete geographical spatial data infrastructure including the establishment of residential electronic map with high resolution using topographical map at large scale and remote sensing data with high resolution, and establishing a complete set of attribute database and rapid data updating capacities.

(2) Establishing the complete systems of census, improving the efficiency of census data shifted into the electronic database and enforcing the connection of census database and geographical spatial database, in the meanwhile, strengthening the establishment and standardization of population migration database.

Until now, there is no professional GIS software with capability to analyze and manage the population data. Because China is a big country with large population, the management of population data and the sustainable development of resources, environment and population need the support of population database, and the strong spatial analytical and handling capacities to assist the natural resources management, resources allocation and macro economic decision making. At present, the most feasible approach is to add the function modules of inputting, managing and analyzing population statistical data so as to actualize the digitization of Population Geography research and the population spatialization of China.

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