

## GIS BASED STUDY ON THE REGIONALIZATION OF CHINA'S GRAIN PRODUCTION SYSTEM

Anrong DANG\*, Shouyong YAN\*\*, Yalan LIU\*\*

\* GIS Lab. School of Architecture, Tsinghua University, China  
danrong@tsinghua.edu.cn

\*\* Institute of Remote Sensing Application, CAS, China

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### ABSTRACT

Taking the achievements of previous agricultural regionalization as reference, the author discussed the theory, principle, method, and index of the grain production system regionalization according to its general framework of theory, model, structure, and functions. Based on the index and supported by the spatial database and attribute database of China's agriculture, for the first time in China, the author used GIS tools to determine the regionalization scheme of China's grain production system. The regionalization scheme includes nine first class regions and thirty four subclass regions.

## 1 THEORY AND METHOD OF GRAIN PRODUCTION SYSTEM REGIONALIZATION

### 1.1 Theory of Grain Production System Regionalization

Grain production system is one kind of complex system that is composed of factors such as food crop, natural resources, and social economic resources (Dang anrong, et al, 1998). Because of the regional diversity of both natural factors and social economic factors, grain production system has obvious characteristics of regional diversity. In order to develop and manage grain production scientifically, it is very important to divide regions with different features and unit regions with similar features at the same time based on the rules of regional diversity of grain production system. So, the theory basis and the essential task of grain production system regionalization are to determine a series of regions for grain production development.

Although the regionalization of grain production system is based on the natural rules of regional diversity, it is very difficult to determine the grain production region by applying traditional technology, because of the existence of spatial transition between different regions. So, the following points of view are very important for regionalization. First of all, the objective and significance of regionalization must be realized. Second, the characteristics of regional diversity for grain production must be studied. Third, the principle and index of regionalization must be determined (Zhou Lisan, 1981, 1993; Qiu Baojian, 1986). And fourth, new technique and method must be applied.

### 1.2 Method of Grain Production System Regionalization

Generally, there are two kinds of regionalization methods: one is dividing from large region to small one, and another is uniting from small region to large one (Deng Jingzhong, 1982). From large region to small one, the dividing method is to divide region based on the regional diversity. During the dividing process, the diversity between two regions is becoming little, and the comparability in the region is becoming great. The final regionalization scheme is determined while the diversity is reaching the minimum, and the comparability is reaching maximum (Agricultural Regionalization Committee, 1989). By contrast, from small region to large one, the uniting method is to unit regions based on the region comparability. During the uniting process, the comparability between two regions is becoming little, and the diversity in the region is becoming great. The final regionalization scheme is determined while the diversity is reaching the maximum, and the comparability is reaching minimum (Qiu Baojian, 1986). Both advantages and disadvantages are in existence in these two methods (Li Yingzhong, 1997; Wang Qing, 1993).

Supported by the new information processing technique GIS, this paper combined the two kinds of regionalization methods together to determine the regionalization scheme of China's grain production system. Concretely, the dividing method is used to determine the first class of grain production region based on the index of climate and topography. In each first class region, the uniting method is used to determine the subclass of grain production region based on the index of soil, social, economy, productivity, and structure of grain production. The regionalization scheme determined by means of such kind of combined method will have both characteristics of scientific and practicability.

## 2 PRINCIPLE AND INDEX OF GRAIN PRODUCTION SYSTEM REGIONALIZATION

### 2.1 Principle of Grain Production System Regionalization

Principle of grain production system regionalization is the basis of dividing first class and uniting subclass (Zhou Lisan, 1981, 1993). Of cause, different principles must be used to determine different class of region. Taking the four principles of China's general agriculture regionalization (Deng Qinzong, 1982; Zhou Lisan, 1993) as reference, the author put out five principles for China's grain production system regionalization as follows:

- (1) Considering about the comparability of natural, social, and economic conditions of grain production system
- (2) Thinking over the comparability of basic characteristics and development objects of grain production system
- (3) Taking the comparability of key problems and resolving approaches of grain production system into account
- (4) Integrating natural agriculture regions, climate agriculture regions, and general agriculture regions
- (5) Keeping in touch with the spatial integrality of each county administration region boundary

### 2.2 Index of Grain Production System Regionalization

Being used to determine the grain production region, regionalization index is the quantitative or qualitative indicators in quality or quantity of regional grain production features. Representation of regionalization principle and objective, regionalization index is the basis to determine the boundaries of grain production region (Qiu Baojian, 1986). So, the issue of how to select the index is an important scientific and practical problem for grain production regionalization scheme. On the one hand, the index must represent the regional diversity of natural factors, and the characteristics of natural ecosystem. On the other hand, the index must represent the regional diversity of social and economic factors, and the characteristics of human ecosystem. Therefore, the index must include both natural resources factors and social economic factors (Zhou Lisan, 1993; Guo Huancheng, 1992). According to the components and structure of China's grain production system, the regionalization index must be composed of natural resources index (such as climate index and topographic index) and social economic index (such as soil index, productivity level, and structure of grain production) (listing in table 1). Furthermore, the critical value of each index is also important and significant.

Types of Index	Terms of Index
Climate Index	Temperature Sum of Daily Mean Temperature $\geq 10^{\circ}\text{C}$ Continuous Periods of Daily Mean Temperature $\geq 10^{\circ}\text{C}$ Average Temperature of Most Hot Month Average Temperature of Most Cold Month Monthly Precipitation, Frost-free Period Annual Precipitation, Dryness Ratio
Topography Index	Topography: Altitude, Terrain Landform: Slope, Aspect
Soil Index	Soil Attribute: Texture, Depth of cultivation, pH Value Soil Nutrient: Organic Matter, Nitrogen, Phosphorus, Potassium
Social and Economic Index	Production Condition: Irrigation, Fertilizer, Agro-Machine, Power Economic Condition: Production per Capita, Output per Capita Production Level: Production per Labor, Output per Labor
Productivity of Grain Production	Current Productivity: Grain Yield, Total Grain Production Potential Productivity: Absolute Productivity, Relative Productivity, Total Grain Productivity
Structure of Grain	Structure of Production: Output of Paddy, Wheat, Maize, Soybean Structure of Sown Area: Sown Area of Paddy, Wheat, Maize, Soybean

Table 1. Regionalization index of China's grain production system

## 3 REGIONALIZATION SCHEME OF CHINA'S GRAIN PRODUCTION SYSTEM

Supported by geographic information system (GIS), the regionalization process workflow is worked out as figure 1 based on the spatial database (county unit) and attribute database (in 1994). Of cause, the method and index selected above are applied during the regionalization process. And the concrete process is discussed below in detail.

### 3.1 Data Compiling

Data compiling is one of the basic process for grain production system regionalization. According to the regionalization factor and index selected above, the first step of data compiling is to retrieve and prepare data from China's agriculture production database which include spatial database (such as administrate region, soil classification, and potential grain productivity) and attribute database (such as climate records, soil features, and agriculture statistics). Supported by GIS, the second step is to join attribute database with spatial database by using a series of related spatial analysis functions, such as match, overlay, and interpolation. The result of data compiling process is an integrated database of spatial and attribute data which include all of the regionalization factor and index data and some auxiliary data.

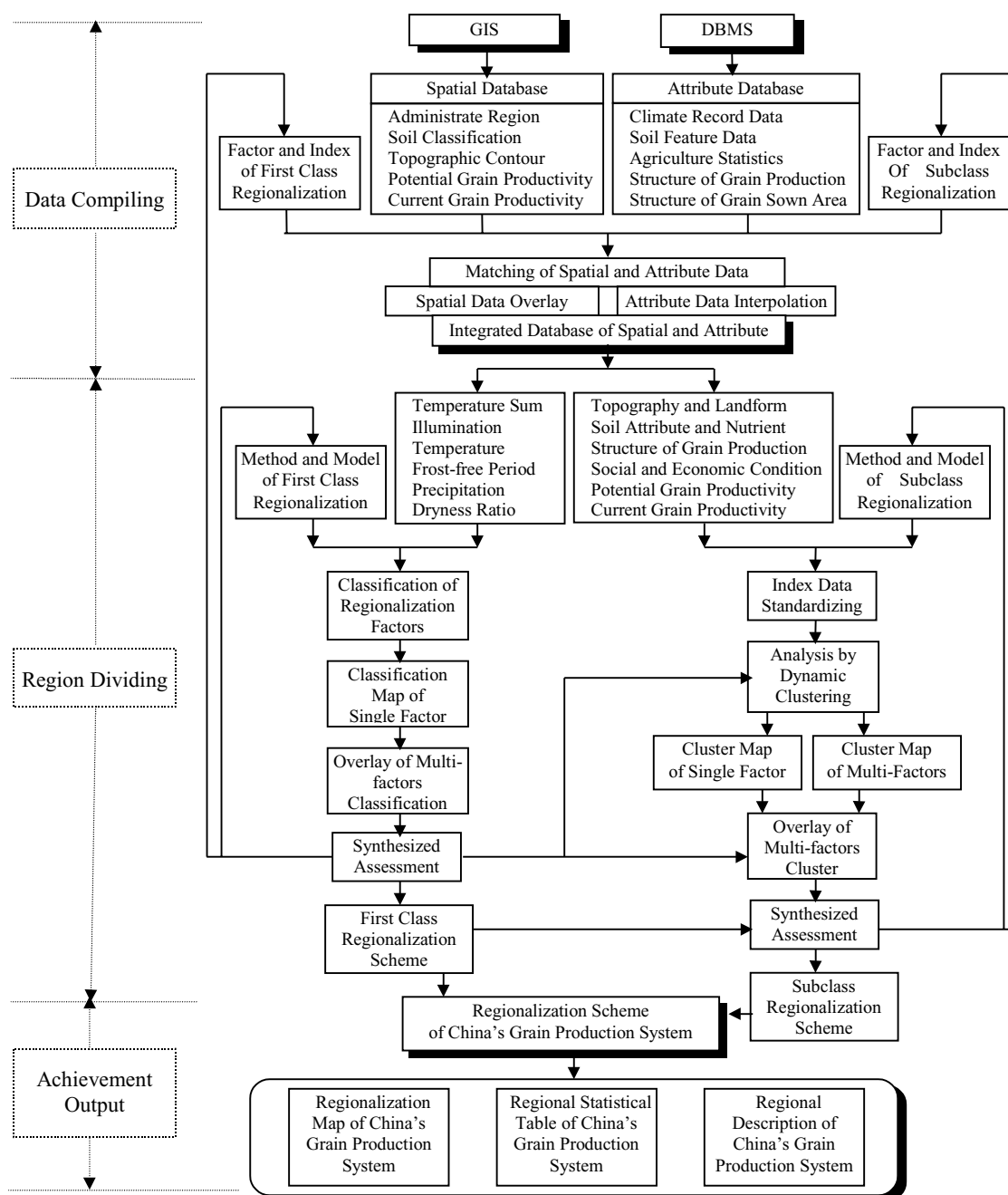


Figure 1. Flow chart of China's grain production system regionalization based on GIS

### 3.2 Region dividing

Region dividing is the key process for grain production regionalization. Based on the integrated database of spatial and attribute data obtained in data compiling process, the first class region of China's grain production system is determined in the following three steps by applying the dividing method from large region to small one.

- Step 1: Supported by statistical function of GIS, classification map of single factor is obtained according to the factor, index, method, and model of first class regionalization.
- Step 2: Supported by spatial analysis function of GIS, integrated classification scheme is acquired by overlaying the multi-factors classification map obtained above.
- Step 3: Supported by synthesized assessment method, the integrated classification scheme is evaluated quantitative and qualitative criteria (He Guangwen, 1987). If the integrated classification scheme is perfect, the first class regionalization is determined. Otherwise, the factor, index, method, and model of first class regionalization must be adjusted at first, and then, repeat step one and step two again, until the result becoming perfect.

Based on the first class regionalization obtained above, the subclass regionalization of China's grain production system is determined in the following four steps by applying the uniting method from small region to large one.

- Step 1: In order to avoid the influence of data value and unit, some index data in the integrated database of spatial and attribute is standardized by a series of data processing to create synthesized index.
- Step 2: Based on the integrated database and synthesized index data, clustering map of both single factor and multi-factors are achieved by dynamic clustering analysis (Yao Jianxu, 1988).
- Step 3: Supported by spatial analysis function of GIS, integrated clustering scheme is acquired by overlaying the single factor and multi-factors clustering map achieved above.
- Step 4: Supported by synthesized assessment method, the integrated clustering scheme is evaluated by quantitative and qualitative criteria. If the integrated clustering scheme is perfect, the subclass regionalization scheme is determined. Otherwise, the factor, index, method, and model of subclass regionalization must be adjusted at first, and then, repeat step one to step three again, until the clustering result becoming perfect.

Finally, the regionalization scheme of China's grain production system can be determined by integrating the first class regionalization scheme with the subclass regionalization scheme. The final regionalization scheme of China's grain production system contains nine first class regions and thirty four subclass regions.

### 3.3 Achievement Output

Generally, there are three kinds of achievement output: table listing, map layout, and text reporting. First of all, taking the comprehensive agriculture regionalization of China (Zhou Lisan, 1981, 1993) and the characteristic of agricultural natural resources and crop cultivation distribution in China (Zhu Zhongyu, 1992) as reference, the code system and name of each region can be defined and listed in table 2. Then, supported by polygon dissolving function of GIS, the regionalization map of China's grain production system can be compiled as shown in figure 2 by using the coding system and pattern system at the same time.

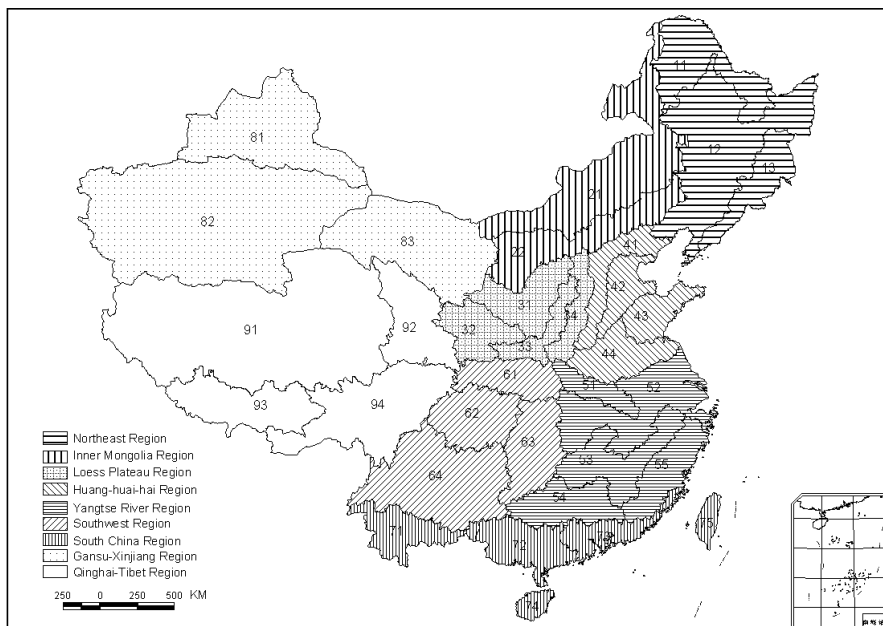


Figure 2. Regionalization map of China's grain production system

Furthermore, based on the spatial data of regionalization scheme and the integrated database of spatial and attribute, the quantitative characteristics such as natural resources, social and economic resources, production condition, and grain productivity of each region can be calculated and listed in regional statistical tables (omitted). And the existent problems of current grain production and development measure of future grain production in each region can be analyzed and worked out as regional description report (omitted).

First Class Region		Subclass Region	
Code	Region Name	Code	Region Name
1	Northeast region of soybean, maize, and spring wheat	11	Xin-anlin mountain region
		12	Northeast plain region
		13	Changbai mountain region
2	Inner Mongolia and Great Wall region of maize and spring wheat	21	Inner Mongolia plateau region
		22	Great Wall along region
3	Loess Plateau region of winter wheat and maize	31	Loess hill plateau region
		32	Loess platform plateau region
		33	Fen-wei river valley region
		34	Taihang mountain region
4	Huang-huai-hai region of winter wheat, maize, and soybean	41	Mountain foot plain region
		42	Low-lying plain region
		43	Peninsula hills region
		44	Huang-huai plain region
5	Middle and lower reach of Yangtse River region of double or single-cropping rice and soybean	51	South Henan lower mountain and plain region
		52	Middle and lower reach of Yangtse River region
		53	South Yangtse River hill and Mountain region
		54	Nanlin mountain and hill region
		55	Zhe-Min hill and mountain region
6	Southwest region of double-cropping rice and maize	61	Qin-Ba mountain region
		62	Sichuan basin region
		63	Chuan-E mountain region
		64	Yun-Gui plateau region
7	South China region of double-cropping rice	71	South Yunan plateau region
		72	South Guangxi mountain region
		73	Yue-Min seashore region
		74	Hainan island region
		75	Taiwan island region
8	Gansu-Xinjiang region of spring wheat and maize	81	North Xinjiang region
		82	South Xinjiang region
		83	Meng-Gan region
9	Qinghai-Tibet plateau region of highland barley and wheat	91	North Tibet plateau region
		92	Qing-Gan transition region
		93	Brahmaputra valley region
		94	Chuan-Zang plateau region

Table 2. Regionalization scheme of China's grain production system

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