Method of Farmland Grading by MAPGIS

——Taking Fengkai County of Zhaoqing City in Guangdong as a Case

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Abstract Taking Fengkai County of Guangdong Province as an example of the application of GIS technology in farmland grading. The application of GIS in farmland grading is discussed in order to provide a professional and high-efficient method to complete the work. The function of space analysis of MAPGIS software shows advantages in speed and precision and is regarded as a new way of farmland grading.

Key words Farmland grading, Geography information system, MAPGIS software, China

Studies on the grading and assessment of agricultural land began in China in the 1970s, and *Procedures on the Grading and Assessment of Agricultural Land* was finally compiled on the experience of pilot projects in 2003[1]. Ministry of Land and Resources listed the grading and assessment of agricultural land into a new round of great investigation project of land and resource after its foundation. From pilot projects in 1999 and provincial deployment in 2000 until now, fifteen provinces (including Guangdong Province) have basically completed testing work about land grading at the provincial level and assessment at the county level with the accomplishment of a series of achievement, including graphs, characters, libraries and standard sample land. But, technological as well as procedural operating problems which are of various extent are provincially different during the process. Therefore, from the point of GIS, here we take Fengkai County as a case to chiefly discuss the features and experience of farmland grading in Guangdong Province.

1 Software basis and technical route

1.1 Software basis MAPCAD/MAPGIS is china's first editing and publishing system of color maps. It achieves the computerization of inputting, editing and publishing of color maps[2]. And it possesses the following functions. Firstly, flexible and advanced graph inputting function (digitizer input, color scanning vectorization input, GPS input). Secondly, powerful and unique editing and processing function (topological process, error correction, projection transformation and arbitrary clip). Thirdly, system libraries which can expand freely (line type library, sub graph and symbol library, optional character library, design library and color library). Fourthly, high-quality color output function (color spray output, PS and EPS page format output). Fifthly, multi-graph data transformation format (ARC/ INFO, MAPINFO, AUTOCAD, SPDF, DLG and ECT.). Sixthly, managing abilities of mass map libraries which can run tens of thousands of graphs. Seventhly, complete and perfect function of spatial analysis, graph analysis and image analysis. Eighthly, high-efficient managing abilities of professional database and multimedia database. Ninthly, flexible further development platform.

All the above functions achieved the technical guarantee of farmland grading and ensured its successful completion. Therefore, MAPGIS has become software recommended by Ministry of Land and Resources as well as the preferred option in farmland grading.

1.2 Technical route According to the standard farming system in Guangdong Province and the light-temperature (climate) productive potential of specified crops, economic grades of farmland are to be assessed comprehensively through the gradual revision of land natural quality, land utilization level and land economic level. The province as a whole adopted Factor Method to calculate the scores of land natural quality. Guangdong Province determined to wholly adopt the investigation results of land utilization alteration in 2003 to calculate the overall farmland grading area in the province and fieldwork data were those of the last three years[3].

2 Grading procedures based on MAPGIS

2.1 Establishment of grading database Database covers map base and attribute base. Map base can use specialized digital software to vectorize or process directly by using MAPGIS. Scanning vectorization has the advantages of high speed, high precision and high automation and is becoming the most important method in GIS. To meet the demand of GIS's processing and analyzing maps, those maps should be preprocessed: through the overlay analysis after error correction and projection transformation in GIS system. Attribute base is built to adjust all maps into the same projection and coordinate system so as to directly input the attribute base of every map spot in MAPGIS as well as in Visual FoxPro or Excel. Map base and attribute base should be connected together according to a specific feature under specific circumstance with MAPGIS providing data interface. Attribute base chiefly contains literary descriptive data and attribute data corresponding to map data, such as code, county names, village names, road and river system names, terrain slope, land code, soil type, effective thickness of soil layer, soil texture, soil pH value, soil organic matter and nutri-

Received: September 7, 2010 Accepted: September 20, 2010

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ent content, *etc.* Investigation data include fieldwork complementary investigation records, pictures of soil profile and the landscape and so on. Procedures of building the database are shown in Fig. 1.

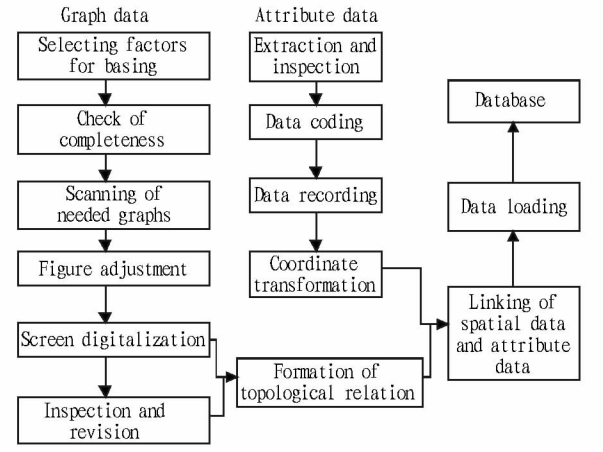

Fig. 1 Building procedures of database of farmland grading

2.2 Confirmation of farming system and specified crops as well as base crops According to *Farmland Grading Procedures* of Ministry of Land and Resource and *Technology Briefing of Farmland Grading* and *Assessment Project in Guangdong Province*, the standard farming system of Fengkai County is: one year double cropping system of paddy field (early rice-late rice) and one year double cropping system of dry land (peanut in spring-sweet potato in autumn). Base crop of Fengkai County is late rice while specified crops are early rice, late rice, spring peanut and autumn potato.

2.3 Confirmation of productive potential indices According to *Farmland Grading Procedures* of Ministry of Land and Resource, *Technology Briefing of Farmland Grading* and *Assessment Project in Guangdong Province*[4] and the latest light-temperature productive potential table of Guangdong Province, which was calculated by the country, the light-temperature productive potential index of early rice and laterice are 1 248 and 1 771; the climate productive potential index of peanut and autum sweet potato are 575 and 2 803 in Fengkai County.

2.4 Confirmation of yield ratio coefficient of specified crops Referring to the yield ratio coefficients of crops in hilly areas of central Guangdong in *Technology Briefing of Farmland Grading and Assessment Project in Guangdong Province* (number 6) and combining the actual situation of the highest and average output of specified crops in Fengkai County, Fengkai County confirmed the yield ratio coefficient of each specified crops as 1.000 of early rice, 1.000 of late rice, 1.970 of peanut, 0.686 of winter sweet potato and 0.686 of autumn sweet potato.

2.5 Division of grading units As the latest current map of land utilization updating has not been completed and considering time convenience, delineation method of detailed survey of land utilization is adopted. The original detailed survey map of land utilization of 1993 should be revised year by year to form the current map of 2003 which is taken as a base map. All farmland and suitable farmland in grading areas are selected. According to the demand of technical project in Guangdong Province, each map spot corresponding to statistical machine account is taken as grading and assessing unit. Thus, a current status map of the whole county's land is achieved with a proportion of 1∶50 000 and is used to calculate and process (Fig. 2).

Fig. 2 Layout of grading units in Fengkai County

2.6 Confirmation of grading factors and weights The assessing factors and weights of Fengkai County are confirmed according to those of the land in the secondary area of Guangdong Province in *Technology Briefing of Farmland Grading* and *Assessment Project in Guangdong Province* and are shown in Table 1.

Table 1 Determiners and weights of land grading factors in Fengkai County

Factor	Determiner	Weight
Conditions of land feature and hydrogeology	Landform	0.09
	Field slope	0.08
	Groundwater level	0.03
Basic characters of soil	Thickness of soil	0.17
	Texture of surface layer	0.12
	Profile construct	0.1
	Organic matter content	0.07
	PH value	0.09
Soil managing Conditions	Guarantee of water	0.15
	Irrigating facility	0.10

2.7 Establishment of scoring rules of grading factors "Relation table of each specified crop-grading factor-natural quality score in Fengkai County" has been established in accordance with the unified arrangement in *Technology Briefing of Farmland Grading and Assessment Project in Guangdong Province*. (Table is omitted).

2.8 Calculation of natural quality score Land natural quality score of each specified crop in each grading unit is calculated by Weighted Average Method. Each grading factor is calculated according to different specified crops and the determiners and weights showed in Table 2. According to scoring rules of each specified crop, index value of each factor is transformed into scores by "endowing with attribute according to parameter" function of MAPGIS, then crops are distinguished and

natural quality score of each unit is calculated according to table 2 and natural index as well as other indices are revised by using light-temperature productive potential indices and yield ratio coefficients. Calculation of attribute base in MAPGIS can be achieved by function of " attribute valuation in documents" .

Besides, internal attribute data in MAPGIS can be outputted into dbf format through ODBC so that attribute data can be processed more flexibly in Visual FoxPro or Excel. Meanwhile, new ID fields should be added into MAPGIS in case of valuation error while processing maps.

Calculating formula of Weighted Average Method:

$$C_{Ljk} = \sum_{k=1}^{m} w_k \cdot f_{ijk}/100$$

In the formula, C_{Ljk} stands for natural quality score of specified crops in each grading unit; i is the name of grading unit; j refers to the name of specified crop; k means grading factor; m is the number of grading factors; f_{ijk} means index value of number k grading factor of number j specified crop in number i grading unit, with value ranges from 0 to 100; w_k is the weight of number k grading factor.

As a result of calculating, natural quality score of rice grading unit in Fengkai County is 0.633 – 0.984, that of sweet potato is 0.654 – 0.984 and that of peanut is 0.661 – 0.991.

2.9 Confirmation of land natural quality grade According to the country's *Farmland Grading Procedures*, natural quality index and other indices of land grading units in Fengkai County range from 2 006 to 2 970 by adding up all indices of each specified crop. By method of equal space, land natural quality in Fengkai County can be classified into 5 grades from grade 11 – 15, with 200 scores as a grade.

2.10 Land utilization and economic coefficient calculation and classification of equivalence regions To make it convenient for field checking and statistical comparative analysis, calculation of the highest unit yield and maximum yield-cost indices of specified crops of land utilization coefficient are separately done by adopting the highest values in the county. Calculation of economic coefficient advance adopts maximum yield-cost index of the county.

Taking village as a unit, those with the closest coefficients are classified into one equivalence region through clustering method. Unit yield of specified crops in each village within the equivalence region adopts average yield of the past three years filled in by each county to make sure that integrity of administrative units at village level won't be broken by the border of an equivalence region and to show differences of actual unit yield among each equivalence region at the mean time.

Considering other differences of natural and economic conditions, borders of equivalence regions which are preliminarily divided are revised under the principle that land utilization coefficients of specified crops should be basically the same. Equivalence regions after revision should meet the following three terms. Firstly, utilization coefficient value of each sample spot in equivalence regions should be within $\overline{X} \pm 2S$ ($\overline{X}$ stands for average value, S stands for standard deviation). Secondly, difference value exists among utilization coefficient values of equivalence regions. Thirdly, utilization coefficient values of both borders of an equivalence region have jump features.

As specified crops in Fengkai County, early rice, late rice, peanut and sweet potato all have three equivalence regions of utilization coefficient. Only peanut has three equivalence regions of economic coefficient and all others have four.

2.11 Calculation of utilization parity index and economic parity index of each specified crop Land utilization parity index and economic parity index are acquired by using land utilization coefficient and economic coefficient of each specified crop to revise the corresponding natural parity indices of specified crops. By using way of " endowing with attribute according to spatial position" , land utilization coefficient and economic coefficient of each specified crop calculated in maps of each equivalence region are endowed to grading unit maps according to spatial position. Then utilization parity index and economic parity index of each specified crop can be calculated by processing the attribute data. Two parity indices of each specified crop are added up to get the two indices. Utilization parity index is 1 303 – 2 711 and economic parity index is 731 – 2 515, which can be directly applied to land grading.

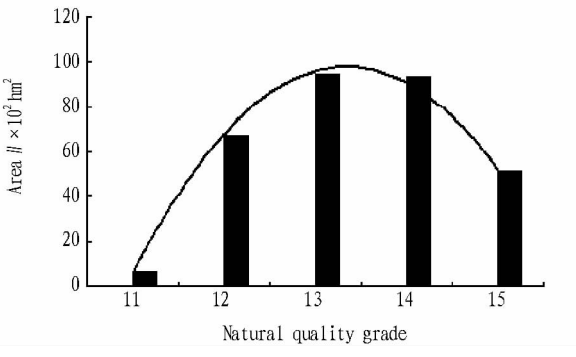

Fig.3 Area of grading unit quality in Fengkai County

Land utilization is divided into 8 grades with 200 scores as a grade by method of equal space according to utilization parity indices. Land utilization grades of Fengkai County range from 7 to 14 and mainly focus on 5 grades between 9 and 13, basically showing a normal distribution.

Land economic grade of Fengkai County is divided into 10 units, ranging from 4 to 13, with 200 scores as a grade by method of equal space. The grading result shows that economic grading area of Fengkai County ranges from 4 to 11 with a basically normal distribution and the land grade of Fengkai County is generally low. This is related to its economic development. Only some traditional farmlands maintain fair productivity, thus more outstanding. This kind of distribution is relatively practical which is shown in Fig. 4.

Function of " endowing with attributes according to parameters" provided by MAPGIS can be used to grade land of the whole county according to grading indices. And different colors can be endowed through " endowing with parameters according to attributes" .

3 Land grading result of Fengkai County

Fengkai County possesses cultivated land of 31 144. 97 hm^2

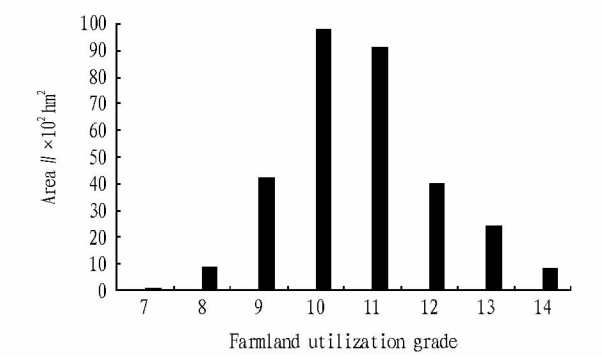

Fig. 4 Area of farmland utilization grades in Fengkai County

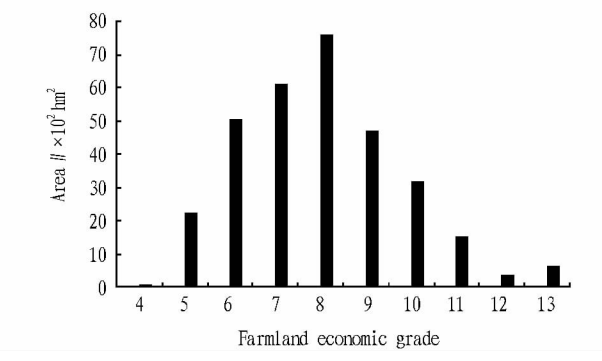

Fig. 5 Area of farmland economic grades in Fengkai County

which has been divided into 10 grades by adopting MAPGIS software. Detailed information is shown in Table 3 and Fig. 6.

Because of combining factors of opportunity cost and cultivating conditions, distribution of economic parities shows a rule of higher in town areas, national highway areas and plain areas and lower in remote mountainous areas. This rule is basically in accordance with soil quality, land utilization level and agricultural development of Fengkai County.

From the point of administrative regions, soil of part of the areas in counties like Nanfeng, Yulao, Changan and Jinzhuang has features of paddy soil, high fertility, thick layer, small terrain slope and high irrigation guarantee. While, counties like Baigou, Dayukou, Douping and Dazhou are the centered area of low productivity with features of mountain soil, thin soil and poor texture because of being in remote mountains.

4 Discussion

Firstly, since data in farmland grading are widely provided, many approaches can not be used to control quantity errors. Otherwise, great obstacles may be created for the later work. Therefore, the design of the table of fieldwork investigation data should be reasonable and accord with ways of thinking of the investigated. The collected data in calculating land utilization coefficients and economic coefficients are required to be objective and under normal circumstances, not personal estimated values. Average yields of the past three years uniformly filled in are required to be consulted. However, calculation of living labor force needs a relatively unified standard which is made according to the actual situation of the town or county. Otherwise, the calculation values would be unreal and not beneficial to the application of the result.

Secondly, farmland grading is made based on the updating current maps of land utilization with a proportion of 1∶50 000 between 1993 and 2003. Because of short time and acute work, it would be impossible to show all changes on the updating map. With such a map proportion, effect of each factor can not be all specified to the block degree of land. So it would be more precise with a proportion of 1∶10 000.

Table 3 Summarized result of farmland economic grading area in Fengkai County

Grade	Area /// hm^2	Ratio /// %
Grade 4	38.61	0.12
Grade 5	1 956.14	6.28
Grade 6	4 120.15	13.23
Grade 7	7 262.80	23.32
Grade 8	7 022.23	22.55
Grade 9	5 089.40	16.34
Grade 10	3 200.21	10.28
Grade 11	1 504.50	4.83
Grade 12	345.04	1.11
Grade 13	605.89	1.95

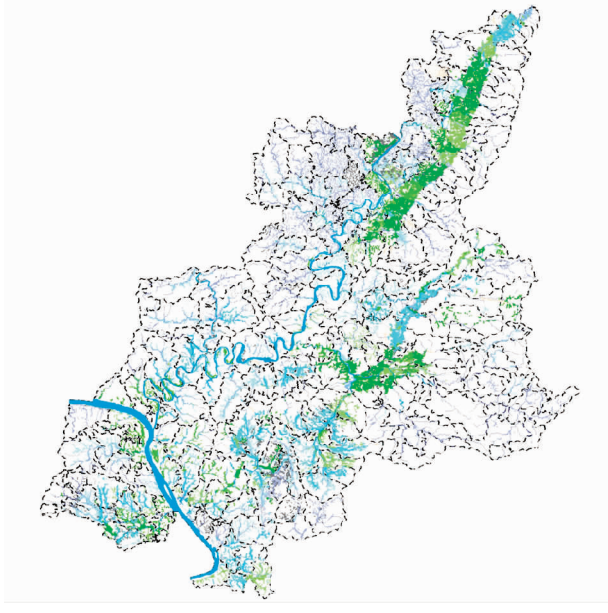

Fig. 6 Distribution of farmland economic grades in Fengkai County

Lastly, principles of not breaking administrative boundaries and taking current map spots as grading units were greatly challenged in the process of grading. This is because Fengkai County has a geographical feature of 80% of mountains, 10% of waters and 10% of lands and with various and complex landforms and microclimate. Question of whether map spots of this kind of landform can meet the demand of equal quality in one unit, basically equal attributes and relatively big differences among units is to be discussed. Formation of farmland grading

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tional level, that is the fruit of the Western Development. Secondly, from the perspective of P_i, the component of structural deviation, the three industries in the three time periods are all positive value, which shows that the industrial structure of Gansu Province is good. In addition, the value of W can prove this, for in the first stage, the W is bigger than 1 and in the following two periods, W is smaller than 1, which indicates that in the first time period of the development of Gansu Province, the proportion of the sunrise industry with rapid growth is large, the overall economic structure is good and the contribution rate to economic development is great. Thirdly, from the perspective of deviation component, each industry varies hugely in different time periods. From 1978 to 1987, the D_i of the secondary industry is negative and the whole deviation degree is negative, and the competitive effect index is smaller than 1, which indicates that the competitiveness of the primary industry and the tertiary industry is relatively weak. From 1988 to 1997, the competitiveness of the secondary industry is the same to that in the first time period, but the deviation of the total competitiveness has increased slightly, which means that comparing with the second period, the regional competitiveness of the first period has increased. Notably, in the third period, the effect is more obvious. The D_i is positive in the three industries and the competitive effect index U is bigger than 1, which shows the great increase of the competitiveness of the three period. But comparing with the component of structural deviation, the deviation component of competitiveness is still low and the task restructuring is still very hard. So the relevant department should provide some preferential policies in economy and policy, to improve the competitiveness of the three industries.

Table 3 The value of *L*, *W* and *U* of Gansu Province since the start of the reform and opening up

Time period	The relative growth rate (L)	The structural effect index (W)	The competitive effect index (U)
1978 – 1987	0.895 01	1.100 80	0.813 05
1988 – 1997	0.952 94	0.986 05	0.966 42
1998 – 2008	1.097 51	0.992 22	1.106 12

3 Conclusions

On the basis of the above analyses, we can draw the conclusion that since the start of reform and opening up, the restructure of the economic structure of Gansu Province has made great process and the joint developmental pattern of mutual development of diverse forms of ownership have formed. The industrial structure has tentatively formed the structural pattern of " the secondary industry, the tertiary industry and the primary industry" based on the primary industry, but the proportion of the tertiary industry to GDP still has wide gap with that of the secondary industry. The industrial structural interests of three industries in Gansu Province differ hugely to some degree not only in the comparative labor productivity of the three industry but also in the deviation coefficient of industrial structure, and the industrial structure is extremely asymmetry to the employment structure. The most important thing is that the sunrise industry has made great contribution to economic growth but the competiveness of three industries is relatively weak. Thus, there is still room for Gansu Province to further adjusting the optimizing its industrial structure.

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units of each province can be done by overlaying current maps of land utilization, landform maps and soil maps in areas with obvious terrain waving, not by method of guillotine cutting.

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