APPLICATION OF GIS COMBINING WITH LIMITS OF VORONOI DIAGRAM IN SOCIOECONOMIC FACTOR OF AGRICULTURAL LAND GRADING

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Abstract: As regards the influencing radius and influencing area of agricultural land grading factor, the agricultural land grading regulation simply use decay method or exponential method to determine their values, what is more, it only considers the natural factors of land grading and takes little account of socioeconomic factors. So, there are some defects in agricultural land grading. To address above issues, this paper purposes the limits of Voronoi diagram method to determine the influencing radius and influencing area of agricultural land socioeconomic factors to overcome these deficiencies, besides, verifies its feasibility combining with GIS in theory.

Key words: limits of Voronoi diagram, agricultural land grading, GIS

1. INTRODUCTION

Agriculture land grading is an overall evaluation for present agricultural land and unused agricultural land in county-level districts according to their natural, economic and social conditions. In order to carry out Chinese agricultural land grading policy, some researchers have implemented

comprehensive research work, especially the development of GIS in land grading. GIS is a computer system which can import, store, process spatial data and connect attribute data with spatial data, besides, it is convenient for managing and analyzing land information. GIS will play an important role in agricultural land grading and increase efficiency. Some Chinese researchers have made certain achievements in land grading system based on GIS by now.

In theoretical research, agricultural land grading methods based on GIS mainly involve with the database creation, the method and comparison of defining grading units (Lingchao Wang et al., 1999; Junguo Liao et al.,2001). On the basis of these, application of GIS spatial analyzing functions is another research area (Qigang Zhou et al., 2006). Agricultural land grading based on GIS is essentially the process of developing a software, it ranges over every detail in system development, hence, the agricultural land grading combining with GIS theory is priority research areas (Shaoshan, Li et al. 2002; Jianxin, Lin et al.2002; Yong, Zhou et al.2002).

From this, it can be seen that applying GIS in agricultural land grading has mainly played a role in database management, spatial analysis and decision support. The main technical points for using GIS in land grading are the foundation of basic map database, attribute database and defining grading factors and models.

2. VORONOI DIAGRAM

At first, this paper will put emphasis on application of Voronoi diagram in agricultural land grading before introducing limits of Voronoi diagram.

Voronoi diagram is a data structure which describes spatial adjacent relations, it was proposed by Russian mathematician Voronoi in 1908 at the earliest. In other fields, Voronoi diagram is also called Thiesesn polygon, Dirichrit grid, Wigner-Seitz region, centre shaft, internal skeleton and so on. The wide use of Voronoi diagram in practice has great developed in the last thirty years, its research and application areas involve the processing of geometry bodies reconstructing graphic image and pattern recognition, physicochemical molecular biology, robot movement planning, processing of path planning and so on (Yongqiang Du, 2005).

Voronoi diagram is originally defined for point-group which divides a plane surface into a number of regional planes, each point corresponds to one region. Besides, each region is composed of the points which are nearer than others in set. That is, set $S = \{P1, P2, \ldots, Pn\} \in E2$ as the N-point collection on the plane, Pi, Pj are any two points and i ≠ j, hence, define

$V(Pi) = \bigcap H(Pi, Pj)$ as Voronoi diagram which Pi matches along with and then it must meet the requirement

$V(Pi) = \{P \in E2 \mid P - Pi \leq P - Pj, i \neq j, i = 1,2,3,\ldots,n\}$, the Voronoi diagram of S (Vor(S)) is defined as a union of all Voronoi polygons which every points corresponding to, so, $Vor(S) = \bigcup(Pi)$. That is to say, Voronoi diagram on plane can be regarded as that every point in S is an organic centre which expands its area at the same speed until they meet and the graph is formed (Lina Chen et al., 2007). Here is a Voronoi diagram generated by points:

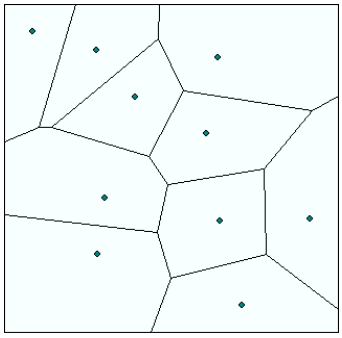

Fig.1: Voronoi diagraph generated by point factors

3. SOCIOECONOMIC FACTORS OFAGRICULTURAL LAND GRADING

3.1 An overview about grading units of agricultural land socioeconomic factors

According to natural conditions such as the distribution of farmland, geomorphic type and property of soil, the main methods of dividing grading units of agricultural land are overlay method, land parcel method, grid method and polygon method. However, these methods are based on natural factors. Under certain conditions, socioeconomic factors also have effects on agricultural grading, for this reason, it is necessary to consider social influence, anyway, the effects between natural and socioeconomic factors is entirely different, so, it is inappropriate to use classification methods of natural factors on socioeconomic factors while dividing grading units. Because agricultural land grading regulations have not got involved in the

division of grading units of agricultural land socioeconomic factors, this paper applies Voronoi diagram in it in order to overcome these shortcomings.

3.2 The division of socioeconomic grading units of agricultural land

As shown in Fig.1, we can see that Voronoi diagram is composed of multi-polygons, if we regard the rectangle in Fig.1 as a farmland, every point as a socioeconomic factor, so that the polygon is a region which the corresponding point affects on, in other words, the polygon is a socioeconomic unit. Therefore, the division process has been done. This method is under the conditions that every factor is same and the division only has connection with the distance among factors, it is a perfect state. Here are the feasibilities about this method.

1.Voronoi diagram represents the geometric spatial arrangement, the irregular spatial distribution of socioeconomic factors (e.g. central city, farmer's market, warehouse, road capacity) are extremely similar to the points' distribution within Voronoi diagram;

2. Each polygon of Voronoi diagram can be regarded as the grading unit of socioeconomic factors;

Here are the concrete steps of applying Voronoi diagram in the division of agricultural land grading units according to socioeconomic factors:

1. Determine the grading factors;

2. Attribute grading factors to points, lines and polygons according to the research area scale;

3.Generate Voronoi diagram based on points, lines and polygons as centers separately, the polygons within Voronoi diagram are the grading units (if there is grade differential, use weighted Voronoi diagram (Yu Pang et al., 2007) to divide grading units).

Compared with the methods of agricultural land grading regulations, the division of grading units of agricultural land socioeconomic factors based on Voronoi diagram has no limits of conditions, such as present land-use map, soil map and so on, this method divides socioeconomic grading units of farmland is more scientific and reasonable.

3.3 The influencing radius of agricultural land socioeconomic factors

The traditional influencing patterns of land grading factors can be classified into points, lines and polygons. For points, the agricultural land grading defines them as concentric circles diffusivity factors. The formula of influencing radius is:

$$R = (S / n\pi)^{1/2} \quad (1)$$

Where: Ris the influencing radius of agricultural land grading (m),S is the influencing area of grading factor (m^2); unit: square meter;n is the number of grading factors. $R = S / 2L$

For lines, the formula is:

$$R = S / 2L \quad (2)$$

Where: L is the length of grading factors (m).

The above formulas are defined under the assumable conditions that the research area is regular, but the influencing radius will decrease if the research area is irregular or there are barriers such as rivers, railways in the area (Yongqiang Du, 2005). Therefore, it is necessary to improve these formulas.

In regard to the problem, Voronoi diagram can play its unique advantages, especially under the circumstances of the irregular shape of research regions, the grading factors are uneven distribution. For this reason, some researchers have applied Voronoi diagram in land grading.

In urban land grading, Voronoi diagram can define the influencing radius of grading factors and this method is more accurate than traditional methods (Shiyuan Hu et al.,2004,2006). Jianhua Zhu (2005) used Voronoi diagram in trade estate grading, he regards every Voronoi polygon as an assessment classification unit, completed the trade estate division, in addition, defined the influencing area of each business center. So, it is clear that Voronoi diagram can help to finish land grading and play a good role in it.

3.4 The influencing radius of agricultural land using Voronoi diagram

Because of the uneven distribution of farmland grading factors in reality, we can take the advantage of Voronoi diagram to define the influencing radius of grading factors more scientific and reasonable.

The polygons of Voronoi diagram are close, hence, we can regard them as the units of grading factors, the maximum distance from grading factor to its corresponding polygon is the influencing radius of grading factor and the polygon's area is the influencing area of grading factor. It is practical to generate Voronoi diagram according to the grading factors' shape, and compute the influencing radius.

In the process of agricultural land grading, we can make use of GIS software or programming languages to generate varied Voronoi diagrams. In the diagram, each polygon is the corresponding influencing area of grading factor and its radius is the influencing radius of grading factor. As to cross-impact factor, generate Voronoi diagram of each factor separately on its

layer firstly, then, overlay these layers and compute their influencing radius by weighted method.

3.5 The application of limits of Voronoi diagram in agricultural land

The above Voronoi diagrams are generated under no interruptive and limit conditions, however, it is an ideal status. Although the method is simple, the practical situations are not well considered, that is to say, it takes no account of natural or man-made constrains, so, the grading unit and influencing radius will be incorrect in such a case. In order to define the socioeconomic grading units and influencing radius of agricultural land more reasonable, Voronoi is a better way.

Limits of Voronoi diagram can be defined as:

In the Euclidean plain, set $S = \{P1, P2, \ldots, Pn\}$ as original generator points set, $R = \{Q1, Q2, \ldots, Qm\}$ as noncrossing any shape of geometry set, use $R(S, Pi) = \bigcap_{i \neq j} \{P \mid O(P, Pi) < O(P, Pj)\} (i = 1, 2, \ldots, n)$ to segment the plane, the segmented regions are called generator based on $Pi(i = 1, 2, \ldots, n)$. $Qi(i = 1, 2, \ldots, m)$ is called limits of Voronoi diagram (Qingjie Cao,2007). Fig.2 shows the limits of Voronoi diagram:

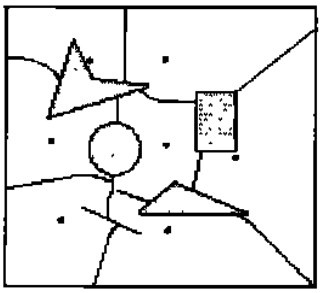

Fig.2: Voronoi diagraph with obstacles

In the situation that there are obstacles among grading factors (e.g. a river separates two farmer's markets, shown as Fig.3), limits of Voronoi diagram can solve this problem.

As shown in Fig3, A,B,C,D are farmer's markets, the rectangle is a farmland, the area between blue lines is a river. The graph has divided grading units (influencing area) by Voronoi diagram based on A,B,C,D, if there was no river, the polygons which A,B,C,D corresponding to are the grading units for every farmer's market, the polygon's radiuses are the influencing radiuses. A is in farmland, once there has business deal, A

should be the first selection. However, the river is an obstacle between the markets which causes inconveniences, so that if we still chose A, it will no longer a good choice. In such case, in order to get reasonable grading units and influencing radius, it is necessary to consider the river, afterwards, divide the units by Voronoi diagram that will generate new grading units and influencing radius. Hence, in the condition of obstructive factors, the agricultural land grading work should consider these limits in accordance with the objective disciplines and divide the research area using limits of Voronoi diagram, thereby, define the grading units and influencing radius.

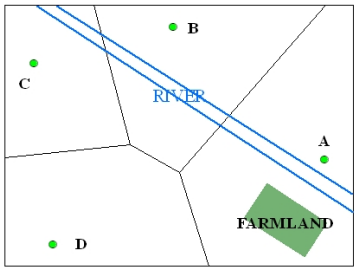

Fig.3: Sketch of obstacle factors

4. AGRICULTURAL LAND GRADING BASED ON GIS COMBINING WITH LIMITS OF VORONOI DIAGRAM

GIS has the capacity of inputting, storing, processing, managing, analyzing and outputting spatial data, the agricultural land grading based on GIS is a new field of application. GIS can manage farmland's spatial and attribute data effectively, in addition, process, analyze these data and finish farmland classification finally. Whether the grading results are accurate or not mainly rely on the algorithms' reasonableness. For the confirmation of grading unit and influencing radius, applying limits of Voronoi diagram in agricultural land grading can optimize traditional algorithms and get more scientific and reasonable results.

The existing GIS software such as ARCINFO, MAPGIS all have the function of generating Voronoi diagram. The limits of Voronoi diagram can be generated by secondary development based on GIS, therefore, it is feasible to use limits of Voronoi diagram in agricultural land grading. The application of GIS's spatial analysis functions and limits of Voronoi diagram in agricultural land grading will compute and analyze the influencing radius and area of farmland grading factors better, what is more, can also help to locate and program the grading factor (Jun Lu et al., 2003).

5. CONCLUSION

At present, there are some defects in agricultural land grading regulation, for this reason, this paper applies limits of Voronoi diagram in the division of grading unit and influencing radius of agricultural land grading, proposes the method of generating limits of Voronoi diagram in agricultural land grading according to practical and obstructive conditions, verifies this method's feasibility and reasonableness in theory.

Chinese researchers have developed some agricultural land grading systems based on GIS and apply it in practical work, so, after improving the theory of agricultural land grading, based on GIS will play a better role in agricultural land grading.

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