Spatial decision support system for the potential evaluation of land consolidation projects

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Abstract: Land consolidation is the basis of making the land arrangement special plan, meanwhile, land consolidation sub area, ascertaining land consolidation item and setting land consolidation indices are mainly depended on land consolidation potentiality, so it is necessary to do this research. As the most important pattern of land consolidation, potential evaluation of cultivated land consolidation is more essential. However as far as theoretical and empirical researches in China's mainland, few discuss on the connotation and evaluation of cultivated land consolidation potentiality. Facing present condition, in order to analyze potentiality of cultivated land, some research is compiled in this paper. Nowadays, spatial decision support system (SDSS) has been applied in variety of profession and domain not only in the fundamental research but also in the concrete project application. SDSS not only solves quantitative problems but also deals well with the uncertain, fuzzy information. It can help decision-makers to make sensible decisions. Facing the land consolidation problem, aiming at evaluating the potential of land consolidation effectively, we developed a SDSS for evaluating potential of land consolidation. In this research, land consolidation potentiality was evaluated from the following four parts, potential of new effective area of arable land, potential of improving productivity, potential of reducing production costs and potential of improving the ecological environment. In order to check the result of the evaluation, Fuzzy Assessment Model, Gray Correlation Analysis Model and PPE model based on RGRA are adopted in this SDSS. Through this study, we provided to the land managers and political departments an approach that is scientifically sound and practical.

Key-Words: land consolidation, potential evaluation, model, SDSS

1 Introduction

Land consolidation (LC) is a tool for improving the effectiveness of land cultivation and for supporting rural development [1].As an important approach to achieve the sustainable utilization of land resource,land consolidation not only need to regard the amount of the farm land for the sake of achieve thing homeostasis of farmland，but also need display the active effect in other aspects, such as improve the quality of farmland， reform the ecological condition and promote the adjustment of the economic formation etc. During the eleventh Five-Year plan, land consolidation will be invested much than 300 billion RMB in China. To the national huge investment which area needed to be consolidated is cosiderable.The monitoring and management of the land consolidation project is vital.

Similarly in many other countries, national, regional or local authorities are financing rural innovation or land consolidation projects to adjust agricultural structures. Fragmentation of cultivated land is an important aspect of farm structure in many parts of the world. It generally results from population pressures and partible inheritance. Fragmentation data for Cyprus are examined, drawing especially on the 1946 and 1977 Agricultural Censuses. The main attempt to deal with this problem is the Cypriot Land Consolidation Law of 1969 [2]. Also one of the major structural problems in Dutch agriculture has been the fragmentation of land holdings [3].The land consolidation program in Uttar Pradesh, India, from the evidence of observation and the testimony of farmers and officials, as well as before-and-after landholding data, increases the number of "independent" farmers by increasing the economic viability of farms per unit area and helping to loosen the control of some farmers over others [4]. In Medan, Indonesia, the National Land Agency (BPN) carried out the PB Selayang Land Consolidation Project on 79 ha of urban fringe land in Medan from 1986 to 1990 as a pilot project for North Sumatra Province. Although it did not include the construction of the network infrastructure, the project provided valuable benefits and lessons [5]. The Albanian agricultural land privatization program begun in 1991 has resulted in the de facto distribution of nearly all of the agricultural land of the country to former members of cooperatives and workers on the ex-state farms [6].

Land Consolidation Projects (LCPs) are costly rural development actions that are often questioned. Integrated LCPs are geographically confined Land Rural Development Actions, in order to predict changes in farmers' behavior, patterns of land use and in crops and technologies used [7]. Therefore, in most countries, the accent of LCPs is shifting towards programs that give emphasis to the integrated development of rural infrastructures, environment and landscape. Agriculture is no longer the only sector involved and is, in many cases, even a minor partner. The consequence is a clear and urgent interest in integrated research for land consolidation project evaluation [8].

The Spatial Decision Support System (SDSS) is a new field developed on the basis of Geographic Information System (GIS) and Decision Support System (DSS). Nowadays, SDSS has been applied in various fields. The implementation of a SDSS developed as a tool for rural land use planning is described. The DSS fulfils the need for a tool that allows rural land managers to explore their land use options and the potential impacts of land use change [9]. SDSS is also being developed for long-term management of radioactively contaminated land resources. The system is designed to assist decision-makers in the evaluation and selection of remediation strategies for food production in agricultural and semi-natural ecosystems at a regional scale[10].Evaluation of land consolidation is a complicated large-scale system which involves many subjects and factors, and its qualities will directly influence land consolidation projects. SDSS provides a decision-making environment where users can analyze questions, construct models, and simulate the process and effects of decision .It has been an effective and powerful tool in solving some semi-structured and unstructured problems in evaluation of land consolidation. Land consolidation project within a region are not only redevelopment projects to increase the value of lots by reshaping lots and supplying community facilities but also affect the habitat quality and thus the biodiversity of a landscape. In order to assess the potential of land consolidation in production systems induced by scientific measures thus a multidisciplinary approach is indispensable. GIS-based, spatially distributed evaluating models allow local features of the landscape to be considered which might get lost in a lumped approach. They can support political decision-making in an integrative form.

2 Methodology and model of potential evaluation

2.1 Selection of evaluation unit

The evaluation units were composed of a series of similar factors that affected the potential of land consolidation, to reflect some definite space and entity to a certain extent. Selection of evaluation units should be based on the influence of land consolidation.

Confirming basic unit on potential evaluation of cultivated land consolidation, based on the evaluation unit and the end of potential evaluation of cultivated land consolidation, data of this paper were based on the county administrative division—the basic statistic unit and the land-use map. Series of county administrative divisions combining with land-use maps were chosen as the basic units for land consolidation potential evaluation.

2.2 Establishment of the evaluation index system

The establishment of a proper evaluation index system is basic for the scientific analysis of land consolidation potential. The multidisciplinary evaluation of land consolidation potential was affected by many factors, including natural features and man-made features. So chosen factors should be able to represent the features of the regional land consolidation system. The main land consolidation problems should be taken into account when the researchers chose the index groups. At the same time, access to the required data should also be considered when selecting factors. Based on the analysis of regional land consolidation characteristics, the land consolidation potential evaluation index system of consolidation area was established by 4 big groups and 9 small groups, total of 12 factors after consulting with some land consolidation experts.

Table.1 Evaluation index system

First grade(A)	Second grade(B)	No.	Third grade(C)	No.	Fourth grade(D)	No.
Potential evaluation of land consolidation	Potential of new effective area of arable land	B1	Potential of improving gullies and roads	C1	Rate of gullies and roads in the land consolidation area	D1
			Potential of improving sporadic plots	C2	Rate of sporadic plots in the land consolidation area	D2
	Potential of improving productivity	B2	Potential of improving low-yielding farmland	C3	Rate of Low yielding farmland in the land consolidation area	D3
			Potential of improving irrigation facilities	C4	Index of trench density	D4
					Index of farming trench density	D5
			Potential of improving drainage facilities	C5	Index of trench for drainage	D6
					Index of farming trench density	D7
	Potential of reducing production costs	B3	Potential of centralizing plots	C6	Count of plots in the land consolidation area	D8
			Potential of Constructing road in the field	C7	Density index of road in the field	D9
					Density index of road for production	D10
			Potential of Coordinating plots	C8	Coordination degree of plots	D11
			Potential of Formatting plots	C9	Gaps of height in the plots	D12
			Potential of adjusting property of land	C10	Area of needing to adjust property	D13
	Potential of improving theecological environment	B4	Potential of Farmland shelter-building	C11	Rate of shelter belt	D14
			Potential of soil and water management	C12	Rate of soil and water management	D15

2.3 Weight of evaluation factors

The weight of each factor was determined with the method combining with Analytic Hierarchy Process (AHP) according to the expert advice. AHP was a systematic analyzing evaluation method to treat the complex and multi-index system quantitatively, which could decompose the complex problem to some layers and some factors, and could compare and calculate as the result of weight. Due to its ability of assigning proper weights to various factors of complex systems, potential evaluation of land consolidation system was suitable to employ AHP. In the research, based on the Delphi expert advice system, the AHP method was applied to determine the weight of each factor.

AHP method is used to determine the weight of each maintainability attribute in the paper. AHP method is widely used in decision and evaluation of complex problem, and the weight of each attribute is acquired by a pair-wise comparison matrix in the method. The elements of pair-wise comparison matrix express the relative importance for each two attributes, which has 9 classifications denoted by number 1 to 9 (from "equally preferred" to "extremely preferred"). The weights vector for all attributes is the unitary eigenvector corresponding to the principal eigenvalue ($\lambda_{\max}$) of the pair-wise comparison matrix, namely

$$W = \left[w_1 \, w_2 \cdots w_n \right] \qquad \textbf{(1)}$$

Where w_{i} is the weight of the ith attribute, and n is the number of all attributes. To ensure the consistency of pair-wise comparison matrix, the consistency judgment must be checked by consistency ratio, that is,

$$C_R = C_I / R_I(n) \qquad \textbf{(2)}$$

Where $C_I = (\lambda_{\max} - n)/(n-1)$ is the consistency index, and $R_I(n)$ is the random consistency index. If C_R don't exceed 0.1, the consistency is accepted.

2.4 Fuzzy comprehensive assessment model

2.4.1 Select assessment parameters and establish assessment criteria

It is crucial to select assessment parameters that are representative, rational and accurate to form an assessment factor set U, which is based on the actual local situation, and can be expressed as:

$$U = \{u_1, u_2, \ldots, u_n\}$$

Where n is the number of selected assessment parameters (n=9 in the current assessment). The assessment criteria set V is established from the land consolidation potential evaluation standards.

$$V = \{v_1, v_2, \ldots, v_m\}$$

Where m is the number of assessment criteria categories. The grade of the potential can be classified on five levels, Level 1, Level 2, Level 3, Level 4, and Level 5.

2.4.2 Establish membership functions of fuzzy environmental quality

The membership functions represent the degree to which the specified concentration belongs to the fuzzy set. The membership degrees of assessment parameters at each level can be described quantitatively by a set of formulae of membership functions as follows:

(1)For the index increased by degrees the bigger the actual value the bigger the potential is. The evaluation language is $V = \{v_5, v_4, v_3, v_2, v_1\}$ = {Level 5, Level 4, Level 3, Level 2, Level 1}.The formulae of membership functions are as followed:

$$r_{v1}(u_i) = \begin{cases} 0.5(1+\dfrac{u_i - k_1}{u_i - k_2}), u_i \geq k_1 \\ 0.5(1+\dfrac{k_1 - u_i}{k_1 - k_2}), k_2 \leq u_i < k_1 \\ 0 \cdots\cdots\cdots\cdots\cdots\cdots u_i < k_2 \end{cases} \qquad (3)$$

$$r_{v2}(u_i) = \begin{cases} 0.5(1-\dfrac{u_i - k_1}{u_i - k_2}), u_i \geq k_1, \\ 0.5(1+\dfrac{k_1 - u_i}{k_1 - k_2}), k_2 \leq u_i < k_1 \\ 0.5(1+\dfrac{u_i - k_3}{k_2 - k_3}), k_3 \leq u_i < k_2 \\ 0.5(1-\dfrac{k_3 - u_i}{k_3 - k_4}), k_4 \leq u_i < k_3 \\ 0 \cdots\cdots\cdots\cdots\cdots\cdots u_i < k_7 \end{cases} \qquad (4)$$

$$r_{v3}(u_i)=\begin{cases}0,\cdots\cdots\cdots\cdots\cdots\cdots u_i\ge k_2\\ 0.5(1-\dfrac{u_i-k_3}{k_2-k_3}),k_3\le u_i<k_2\\ 0.5(1+\dfrac{k_3-u_i}{k_3-k_4}),k_4\le u_i<k_3\\ 0.5(1+\dfrac{u_i-k_5}{k_4-k_5}),k_5\le u_i<k_4\\ 0.5(1-\dfrac{k_5-u_i}{k_5-k_6}),k_6\le u_i<k_5\\ 0\cdots\cdots\cdots\cdots\cdots\cdots u_i<k_6\end{cases}\tag{5}$$

$$r_{v4}(u_i)=\begin{cases}0,\cdots\cdots\cdots\cdots\cdots\cdots u_i\ge k_4\\ 0.5(1-\dfrac{u_i-k_5}{k_4-k_5}),k_5\le u_i<k_4\\ 0.5(1+\dfrac{k_5-u_i}{k_5-k_6}),k_6\le u_i<k_5\\ 0.5(1+\dfrac{u_i-k_7}{k_6-k_7}),k_7\le u_i<k_6\\ 0.5(1-\dfrac{k_7-u_i}{k_6-u_i}),u_i<k_7\end{cases}\tag{6}$$

$$r_{v5}(u_i)=\begin{cases}0,\cdots\cdots\cdots\cdots\cdots\cdots u_i\ge k_6\\ 0.5(1-\dfrac{u_i-k_7}{k_6-k_7}),k_7\le u_i<k_6\\ 0.5(1+\dfrac{k_7-u_i}{k_6-u_i}),u_i<k_7\end{cases}\tag{7}$$

(2)For the index decreased by degrees the smaller the actual value the bigger the potential is. The evaluation language is $V=\{v_5,v_4,v_3,v_2,v_1\}$ = {Level 1, Level 2, Level 3, Level 4, Level 5}.The formulae of membership functions are as followed:

$$r_{v1}(u_i)=\begin{cases}0.5(1+\dfrac{k_1-u_i}{k_2-u_i}),u_i\le k_1\\ 0.5(1-\dfrac{u_i-k_1}{k_2-k_1}),k_1\le u_i<k_2\\ 0\cdots\cdots\cdots\cdots\cdots\cdots u_i>k_2\end{cases}\tag{8}$$

$$r_{v2}(u_i)=\begin{cases}0.5(1-\dfrac{k_1-u_i}{k_2-u_i}),u_i<k_1,\\ 0.5(1+\dfrac{u_i-k_1}{k_2-k_1}),k_1\le u_i<k_2\\ 0.5(1+\dfrac{k_3-u_i}{k_3-k_2}),k_2\le u_i<k_3\\ 0.5(1-\dfrac{u_i-k_3}{k_4-k_3}),k_3\le u_i<k_4\\ 0\cdots\cdots\cdots\cdots\cdots\cdots u_i>k_4\end{cases}\tag{9}$$

$$r_{v3}(u_i)=\begin{cases}0,\cdots\cdots\cdots\cdots\cdots\cdots u_i<k_2\\ 0.5(1-\dfrac{k_3-u_i}{k_3-k_2}),k_2\le u_i<k_3\\ 0.5(1+\dfrac{u_i-k_3}{k_4-k_3}),k_3\le u_i<k_4\\ 0.5(1+\dfrac{k_5-u_i}{k_5-k_4}),k_4\le u_i<k_5\\ 0.5(1-\dfrac{u_i-k_5}{k_6-k_5}),k_5\le u_i<k_6\\ 0,\cdots\cdots\cdots\cdots\cdots\cdots u_i\ge k_6\end{cases}\tag{10}$$

$$r_{v4}(u_i)=\begin{cases}0,\cdots\cdots\cdots\cdots\cdots\cdots u_i<k_4\\ 0.5(1-\dfrac{k_5-u_i}{k_5-k_4}),k_4\le u_i<k_5\\ 0.5(1+\dfrac{u_i-k_5}{k_6-k_5}),k_5\le u_i<k_6\\ 0.5(1+\dfrac{k_7-u_i}{k_7-k_6}),k_6\le u_i<k_7\\ 0.5(1-\dfrac{u_i-k_7}{u_i-k_6}),u_i\ge k_7\end{cases}\tag{11}$$

$$r_{v5}(u_i)=\begin{cases}0,\cdots\cdots\cdots\cdots\cdots\cdots u_i<k_6\\ 0.5(1-\dfrac{k_7-u_i}{k_7-k_6}),k_6\le u_i<k_7\\ 0.5(1+\dfrac{u_i-k_7}{u_i-k_6}),u_i\ge k_7\end{cases}\tag{12}$$

2.4.3 Calculate the membership function matrix

Substitute the monitoring data of each assessment parameter at each monitoring site and the national standards into the membership functions. Then, we can get the fuzzy matrix $\tilde{R}$, which can be expressed as:

$$\tilde{R} = \begin{pmatrix} r_{11} & \cdots & r_{1m} \\ \vdots & \ddots & \vdots \\ r_{n1} & \cdots & r_{nm} \end{pmatrix} \tag{13}$$

Where $r_{ij}(i = 1,2,\ldots n; j = 1,2,\ldots m)$ is the membership degree of the ith assessment parameter at the jth level.

2.4.4 Calculate the weights matrix

Allocate the weights of each assessment parameter at each monitoring site to get matrix $\tilde{B}$ with the formulae $W_i(k) = a_{i(k)} \Big/ \sum_{i=1}^{n} a_{i(k)}$ and $a_{i(k)} = x_{i(k)} \big/ s_i$

Here, the monitoring site is marked by k, $x_{i(k)}$ is the monitored concentration of the ith assessment parameter at the kth monitoring site, s_i is the average assessment criteria of the ith assessment parameter, $W_{i(k)}$ means the weight of the ith assessment parameter at the kth monitoring site. $\tilde{B}(k)$, weight matrix $\tilde{B}$ at the monitoring site k, can be expressed as $\tilde{B}(k) = \left[W_{1(k)}, W_{2(k)}, \ldots, W_{n(k)}\right]$ (n is the number of selected assessment parameters). Here s_i is an average assessment criterion. $a_{i(k)}$ indicates the rate of exceeding the average assessment criterion, as we assume that this includes not only the difference between each pollutant element, but also the degree of pollution. This method is easy and clear. Determination of the fuzzy algorithm of $\tilde{B}\square\tilde{R}$ can be computed by matrix multiplication. This method is described as followed:

Fuzzy matrix $\tilde{R} = (a_{ij})_{n \times m}$ weight matrix $\tilde{B} = (W_i)_{1\times n}$. Then, the assessment results can be obtained: $\tilde{B}\square\tilde{R} = (b_1, b_2 \ldots, b_m)$ where

$$b_j = \sum_{i=1}^{n} W_i a_{ij}, j = 1,2\ldots m$$

2.5 Gray correlation coefficient analysis

Gray correlation coefficient analysis is a method to determine whether or not variables are correlated and to determine the degree of their correlation. By calculation of characteristic serial curves and the degree of geometrical similarity of these curves, key factors and minor factors can be determined.

$$\left\{x_1^{(0)}(i)\right\}, i = 1,2,\ldots\ldots, N_1$$
$$\left\{x_2^{(0)}(i)\right\}, i = 1,2,\ldots\ldots, N_2$$
$$\vdots$$
$$\left\{x_m^{(0)}(i)\right\}, i = 1,2,\ldots\ldots, N_m$$

Where $N_1, N_2 \ldots, N_m$ are nature numeric collection $N_1, N_2 \ldots, N_m$ are not all identical, time series $\left\{x_0^{(0)}(i)\right\}, i = 1,2,\ldots\ldots, N_0$ is named father series and $\left\{x_k^{(0)}(i)\right\}, k = 1,2,\ldots, m$ is named son series.

The standard pretreatment process of source series is that each time a series element is divided by the average value of that series, the correlation coefficient between father and son series can be described as belowed:

$$r_{0k}(i) = \frac{1}{N_0} \sum_{i=1}^{N_0} \xi_{0k}(i) \tag{14}$$

$$\xi_{0k}(i) = \frac{\min_k \min_i \left|x_0^{(0)}(i) - x_k^1(i)\right| + \rho \max_k \max_i \left|x_0^{(0)}(i) - x_k^1(i)\right|}{\left|x_0^{(0)}(i) - x_k^1(i)\right| + \rho \max_k \max_i \left|x_0^{(0)}(i) - x_k^1(i)\right|} \tag{15}$$

where i = 1, 2, . . ., N; k = 1, 2, . . .,m, ρ is differentiation coefficient, its role is to diminish the anamorphosis effect away from a big absolute error and to improve the prominence difference of the obtained correlation coefficient. The value of $\rho \in (0,1)$ is usually assigned between 0.3 and 0.7. Using Gray correlation coefficient analysis in the process of evaluating the system with variety of indicators, we could regard the distribution of the evaluation criteria as a group of curve using the above formulas to analyze.

While using the formulae we should notice that the evaluation criteria is the concept of interval, not the concept of point. We need to improve the traditional gray correlation analysis and make it suitable for interval distance .The specific way to substitute absolute value with the following formula:

$$\Delta_i(k) = \begin{cases} a_i(k) - x_0(k), x_0(k) \le a_i(k) \\ 0 \cdots\cdots\cdots a_i(k) < x_0(k) < b_i(k) \\ x_0(k) - b_i(k), x_0(k) \ge b_i(k) \end{cases} \tag{16}$$

Correlation coefficient is a series so the information is dispersed. The measure of the area is compared to solve the problem of discommodious compare. The relations between the correlation weighted averages are as followed.

$$r_{ij} = \sum_{i=1}^{n} \omega_i \xi_{ij}(k) \tag{17}$$

ω_i is the weight of the corresponding index. The value is determined by AHP mentioned before.

According to the definition of correlation which is the similarity between the potential of land consolidation and the evaluation criteria of each level, we could acquire the order of the correlation by calculating. This method not only can distinguish the level of the potential but also can overcome the limitation of the fuzzy assessment.

2.6 PPE model based RAGA

With the application of fuzzy mathematics，fuzzily gathered kind analysis is applied in evaluation of land consolidation recently. It brings the significant breakthrough in theory research and then obtains the widespread application. But fuzzily gathering kind analysis has different methods to establish fuzzy similar matrix. Different persons may use different methods, like correlation quotients method, distance measure method，the included angle cosine law method, and so on. Established fuzzy similarity matrixes are different. Moreover, when finally determining the best graduation X, it needs to do further analyses and judgments according to the actual situation. Therefore, we integrates the improved Genetic Algorithms(GA)-Real coding based Accelerating Genetic Algorithm(RAGA) and Projection direction Pursuit Evaluation Model(PPE model). By optimizing the projection direction parameters in the PPE model through RAGA, it transforms the high dimension to lower that combines multi-appraisal targets to a overall target.

Then it arrays and recognizes the projection value, finally realizes the land consolidation evaluation. It provides a new method for the land consolidation research. The Projection Pursuit Model is a multi-dimension analysis method that can be used both in exploring and defining analysis PPE method's main characteristics are described as:

l) The PPE method can successfully overcome the high dimension data's "disaster of the dimension" that brings serious difficulty.

2) It may remove disturbances caused by data construction and inessential variables.

3) It can solve the multi-dimensional problem with the one-dimensional statistical method.

4) The PPE method may also be used to solve the non-linear problem.

Step1: Sample evaluation target normalized processing. Supposing sample collection of each figure for { $x^*(i,j)$ i=l-n，j=l-p,}. $I_n x^{*(i,j)}$,i is the sample and j refers to the list price for sample. And n, p are sample number and target value, respectively. In order to eliminate various targets dimensions and unify the range of each figure value, it may carry on normalized processing as below.

Regarding to much great more superior target:

$$x(i,j) = \frac{x^*(i,j) - x_{\min}(j)}{x_{\max}(j) - x_{\min}(j)} \tag{18}$$

Regarding to much smaller more superior target:

$$x(i,j) = \frac{x_{\min}(j) - x^*(i,j)}{x_{\max}(j) - x_{\min}(j)} \tag{19}$$

In the formula: $x(i,j)$ is target characteristic normalization sequence; $x_{\max}(j)$, $x_{\min}(j)$ are respectively the target maximum value and the minimum value.

Step 2: To construct projection target function $Q(a)$. The PPE method is to synthesize p dimensional figure { $x^*(i,j)$ i=l-n, j=l-p,} to one-dimensional projection value.

$$z(i) = \sum_{j=1}^{p} a(i)x(i,j)(i = 1-n) \tag{20}$$

As a={ a(1),a(2),a(3),...a(p)},projection direction and then carry on the classification according to $\{z(i) \mid i = 1-n\}$ the one-dimensional dispersion pattern. “a” is the unit length vector in formula. When synthesize projection prices, the character of request projection value $z(i)$ should be supposed to be: the partial projection points should be as crowded as possible, best be condensed as certain spots group .But between the projection point group disperses are as far as possible in the whole. Therefore, the projection target function may be shown as $Q(a) = S_z D_z$.

Where, S_z is standard difference of project value $z(i)$, D_z is local density of projection value $z(i)$ .Namely:

$$S_z = \sqrt{\frac{\sum_{i=1}^{n}(z(i)-E(z))^2}{n-1}} \quad (21)$$

$$D_z = \sum_{i=1}^{n}\sum_{j=1}^{n}[(R-r(i,j))]u[R_r(i,j)] \quad (22)$$

Where, $E(z)$ is average value for sequence $\{z(i) \mid i=1-n\}$. R is the window radius of local density that may be determined according to tests result or be equal to a constant r(i,j) is the distance among samples; r(i,j)=|z(i)-z(j)|; u[R-r(i,j)] is a unit step leap function, if t=R-r(i,j),then [R-r(i,j)]=u(t).If t>=0,then its value is l;if t<0,then its value is 0.

Step 3: Optimizing projection target function. When each figure of list price sample is assigned, the projection target function $Q(a)$ changes with the a projection direction is the most possible to expose the projection direction of high dimension according to some kind of structure characters. Therefore, we may estimate the best projection direction through solving maximization question of projection target function. Maximization objective function: $Q(a)_{\min} = S_z D_z$

Constraint condition: $\sum_{j=1}^{p} a^2(j) = 1$

This is a complex non-linear optimization question by {a(j)|j=1-p} as optimized variable. It is very difficult to process with the traditional optimized method. Therefore, we use the real number code acceleration genetic algorithms(RAGA) that simulates biology superior win and the inferior wash out rule and the community interior chromosome exchange of information mechanism to solve its optimizing question in overall high dimension situation.

Step 4: Classified arrangement. Putting the best projection direction a^* to equation may result in various samples projection values $z^*(i)$. Comparing $z^*(i)$ with $z^*(j)$, when the two more approaches, it indicates the sample i and j will be divided into the identical class. If arranging the value $z^*(i)$ from big to small, then we arrange the samples from superior to the worst.

Real Number Code Acceleration Genetic Algorithms(RAGA). The genetic algorithm is proposed by Holland professor of American Michigan University. It stimulates the biology heredity in evolution process of the natural environment and an auto-adapted optimization probability search algorithm. It mainly includes such operating processes as selection, crossover and mutation and so on. The traditional GA algorithm has some weakness. Therefore the real number code acceleration genetic algorithm (RAGA) was proposed.

To solve optimization problems by RAGA algorithm follows 8 steps. Now we take $f_{\max}(x), a_j \le x_j \le b_j$ as an example:

Step1:Distributing N groups of random variables in area $\left[a_i, b_i\right]$.

Step2:Computing goal function value then arranging them from big to small.

Step3:Computing evaluation function value based on foreword.

Step4:Carrying on the choice operation ,to generate new group.

Step5:Operating crossover to the new group generate in step4.

Step6:Operating mutation to the new group generated in step5.

Step7:Evolution iteration.

Step8:Past the seven steps above are standard genetic algorithm(SGA).

Because SGA can't guarantee the overall restrains. There often appears being far away from overall situation in the practical application then lead to SGA stop seeking the superior work. Then it reenters algorithm step 1 and recalculates SGA so it can accelerative run. The outstanding individual sector will gradually reduce and close to merit point. The algorithm doesn't stop running until the value of the most superior individual optimized criterion function is smaller than some setting value or running times achieved presetting number. The conclusion of the best individual is assigned to be the RAGA result. The eight steps above are based on solid code genetic algorithms(RAGA).

3 System architecture

SDSS lend themselves well for solving spatial decision problems that arise in the land consolidation application. The analysis results depend not only on the geographic distributions of various features and attributes, but also on the value judgments involved in the decision making process reflecting the user's personal influence. The SDSS framework allows users to explore a variety of alternatives to help support their decision making process. The GIS-based SDSS described here, is designed primarily to be used for regional potential evaluation of land consolidation. It is intended as a tool for optimizing the plan of land consolidation in relation to spatially variable parameters, which greatly affect radiological effectiveness, technical feasibility and environmental and agricultural impacts. A key objective was to create a flexible and user-friendly tool for land managers. The SDSS mainly supports the following functions:

(1) Guiding the users to specify their land consolidation interests and preferred evaluation factors for those intended uses.
(2) Automatically choosing land consolidation methodology and model to evaluate land consolidation potential and giving a suitable plan according to the results of the evaluation.
(3) Connection spatial data and property data and mutual query for spatial data and property data.
(4) Access the database, retrieve and display required data graphically.
(5) Mining useful spatial data .
(6) Generate cartographic displays and tabular reports.

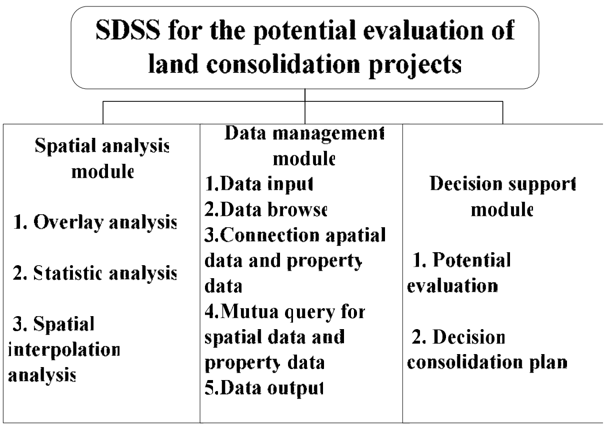


Fig.1 The system function architecture

The architecture of SDSS is composed of a user interface, spatial analysis subsystem, data management subsystem, decision support subsystem (Fig. 1).

The spatial analysis subsystem accepts user deals with spatial data by overlaying, statistic analysis, spatial interpolation analysis. Users can apply a common scale of values to diverse and dissimilar input to create an integrated analysis. Topological overlays may be broadly classified into simple and weighted methods. After reclassification of thematic maps in terms of suitability for an activity has been accomplished, simple overlay can be accomplished by applying mathematical or logical operators to the layers. This can often generate very valuable outcomes. Statistical data can include area, perimeter and other quantitative estimates, including reports of variance and comparison among images. The data management subsystem supports data input , data output, data browse, it also can connect spatial data and property data and mutual query for spatial data and property data. The decision support sub system supports model selection. The system can also guide the user in capturing, eliciting and representing the problem structure and developing the potential evaluation model. It also can give the user a scientific land consolidation plan according to the result of the evaluation

4 The operational framework

For any land consolidation evaluation, users can view and edit land quality attribute data, review study area background information, explore the logic basis for a evaluation scenario. They also can review the specific land consolidation potential indicators, develop priorities and thresholds for land consolidation limiting factors and their indicators and review a variety of other tables, graphs and maps that provide supporting documentation related to spatial distributions of land consolidation potential indicators. Fig.2 shows the operational framework of the land quality assessment decision support system.

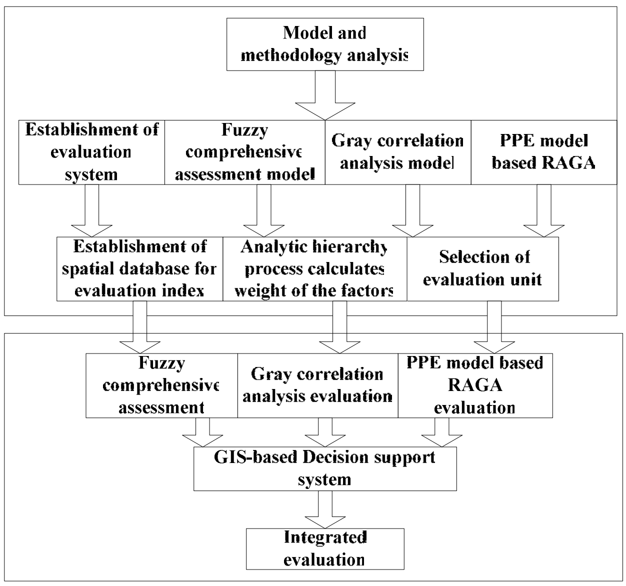


Fig.2 The operational framework of the land quality assessment decision support system.

The SDSS adopts three-level open structure, user-level, middle-level and data-level. The function of the user-level is to display system through graphical user interface, and implement interaction between user and system. Middle-level is used to acquire user's requests and process data. It is the key-level of the system. Data -level provides data storage management services. Spatial data, attribute data and text data are stored and managed by SQL Server database. The spatial data is imported into SQL by ArcSDE and all the data are unified managed by SQL database.

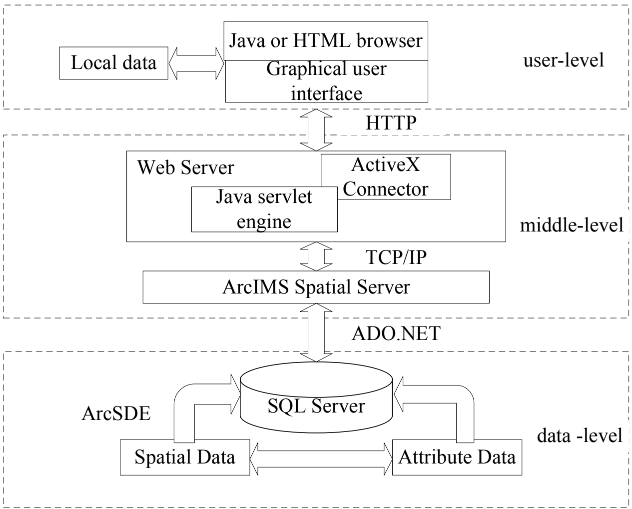


Fig.3 System Architecture

5 Case study

5.1 Study area and data source

The study area is Changgou town which located in south-west of Fang shan district, at the confluence of the Juma river, covering approximately 25km^2. The geographic coordinates (latitude/longitude) approximately range from 115°45' 46'' E, 03°08'00''N to 115°46'25''E, 03°10'39''N, the image of study area are shown in Fig. 4. This area is characterized by rolling topography and flourishing vegetation.

The SPOT 5 images, acquired on 29 September 2006, without any clouds/hazes, are used in this study. A SPOT 5 image has four multi-spectral bands (i.e. near-infrared(NIR), red, green, and Short Waved-length Infrared) with 10-metre spatial resolution and one panchromatic band with 2.5-metre spatial resolution. Both dates of imagery were geo-referenced to a Transverse Mercator projection and Krasovsky spheroid with an RMSE of 1 pixel. It was necessary to radio metrically normalize the multiple dates of remote sensor data even though they were obtained on near anniversary dates.

Fig.4 The image of the land consolidation area

5.2 Results

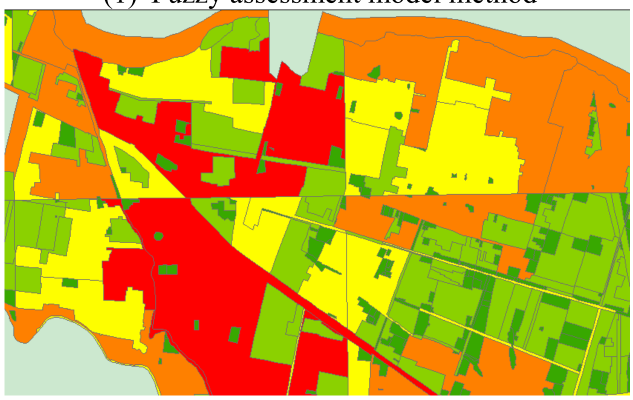
According to the equality distribution function, the results of the multidisciplinary evaluation index were graded as five levels. Each level presented the spatial distribution speciality and the regional differences of land consolidation potentiality.

Table.2 Weights of factors

Factors	Weights
C1	0.174
C2	0.383
C3	0.086
C4	0.077
C5	0.017
C6	0.035
C7	0.094
C8	0.037
C9	0.017
C10	0.029
C11	0.046
C12	0.015

In the case of the SDSS presented here, land managers calculate the potential of the land consolidation by using the SDSS to identify grade of land consolidation area through three different evaluation methods. Further, the SDSS can also be used to determine the land consolidation plan. The results of different methods are as follows.

(1) Fuzzy assessment model method



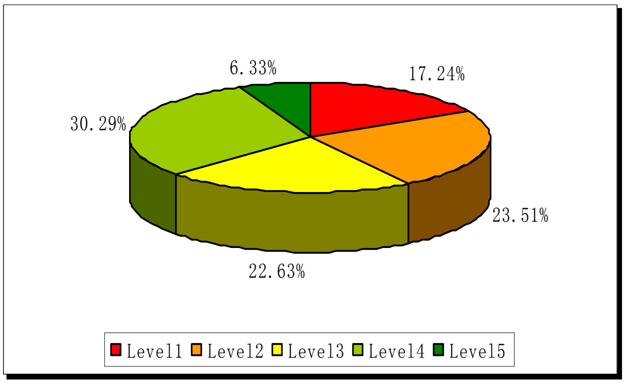
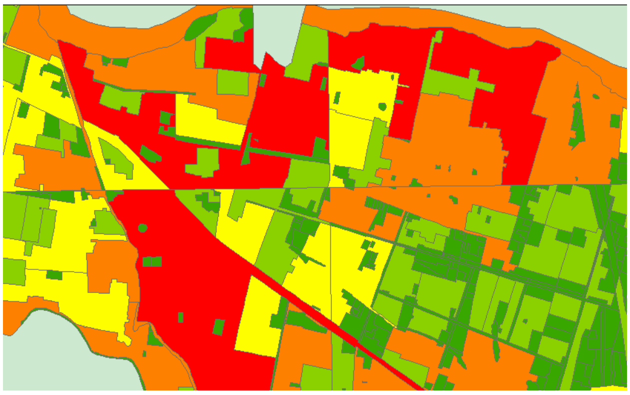


Fig.5 The result of fuzzy assessment model method

(2) Gray correlation analysis model method



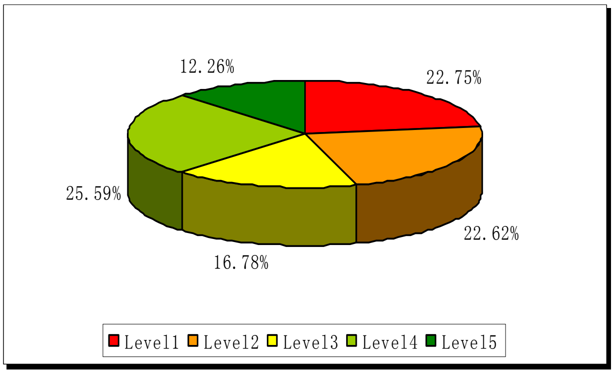
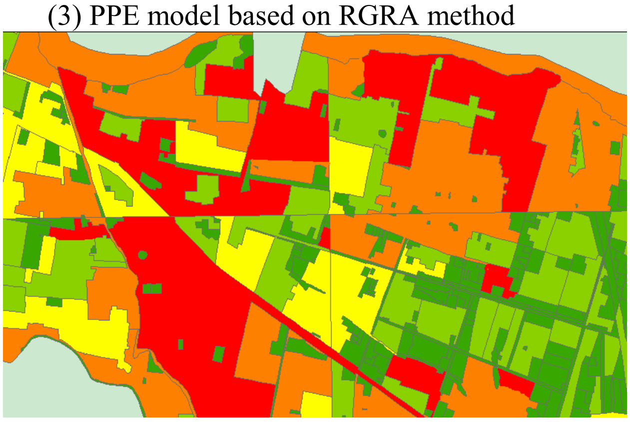


Fig. 6 The result of gray correlation analysis model method

(3) PPE model based on RGRA method



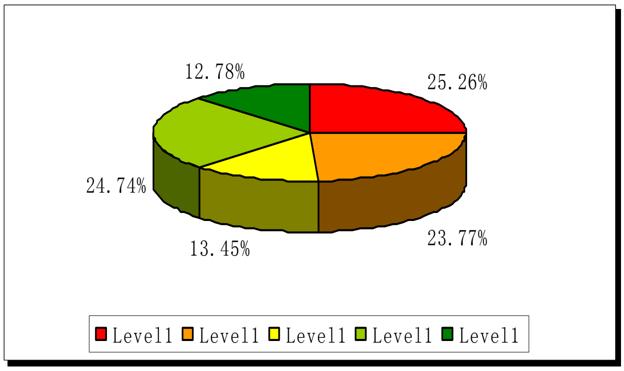


Fig.7 The result of PPE model based on RGRA method

(4) Comparing the three models

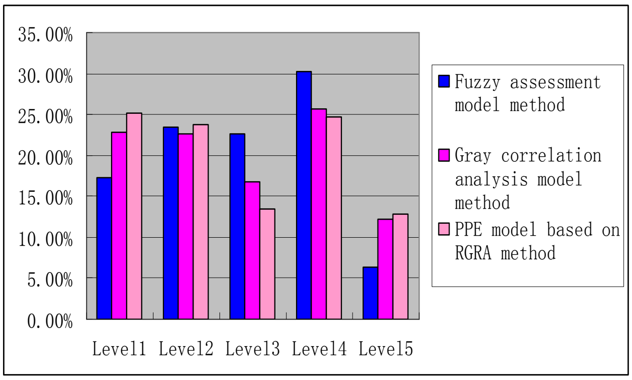


Fig.8 The result of Comparing the three models

6 Conclusions and discussion

This paper presents the application of SDSS tools to help decision makers in the plan of land consolidation for evaluating the potential of the land consolidation area. The system developed in the study allowed the integration of evaluation factors and a comprehensive evaluation model. This integration is aimed at evaluating the potential of land consolidation in an effective way. The use of ArcIMS and ArcSDE made possible the integration of diverse spatial data into a comprehensive database. This organized database allowed easy access and input to the comprehensive model .This SDSS renders the result of evaluation accessibly to the user through a user-friendly interface. Also, visual output in the form of thematic maps for the different levels of the potential provides a quick and intuitive understanding of their spatial distribution. It is very important to calibrate and validate the scientific of the model. Nevertheless, the validation of only one model is difficult. More than relative model results are needed. In this SDSS, with three models calibration and validation, it allowed land managers to visualize and understand the results of the evaluation which lead to the land consolidation project in a clear and transparent way. Decision makers and planner can effectively use the SDSS by comparing three models. Thus, instead of an absolute perspective, a relative perspective of evaluation result could be visualized. Though the outcomes are perhaps premature, there will be a need to establish or update this SDSS.

7 Acknowledgements

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