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Research Article

Evaluation of Farming Cultivated Land Quality Based on Extension Method in Reclaimed Region

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Abstract: This study proposed a new model of cultivated land by the use of extension method, which was based on the index and its evaluation criteria. Results of Yu Huan county, Zhejiang province demonstrated that the proposed models was effective for the evaluation of cultivated land quality and it would a new useful and objective method to evaluate the cultivated land quality.

Keywords: Cultivated land quality, extension method, Yu Huan county

INTRODUCTION

A large population with relatively little arable land is basic national conditions of China, especially the eastern coastal areas. The per capita cultivated land is less than 1 acre and land carrying capacity has been reached or even exceeded the limitation in the eastern coastal areas. Land provides an important resource security and support for the rapid economic growth of eastern coastal areas. However, the rapid progress of industrialization and urbanization makes the growing shortage of land resources. Tideland resources (Mudflat) is important, which can reserve land resources of eastern coastal areas. The economic value of tideland resources is the most reasonable in the six reserve land resources: barren hills and land, grassland, alkali land, wasteland and barren sand land. Tideland resources are the most viable investment and the greatest potential for development. The arable land that enclosed tideland for cultivation alleviated the contradictions to help supplement the amount of cultivated land.

Agricultural land is the basic material of agricultural production. It is the indispensable condition for the survival of mankind. Arable farmland is the essence of agricultural land and the lifeline of human survival and development. The size of arable land and the level of quality directly related to China's economic construction and social development especially in area of food security. The challenge brought by the decline of the quality of cultivated land will be large. It would be more potential for the socio-economic development after compared with the amount of cultivated land, which had been reduced in a period of rapid urbanization. Therefore, quantity management in farmland management should be detected and more attention should be paid to the quantity and quality of the farmland.

The quality assessment is the basic work of the Quality management of arable land. Cultivated Land Quality Evaluation contains the natural evaluation and economic evaluation and the coordination degree of arable systems (Xu, 2004). Natural quality evaluation of cultivated land mainly takes these two calculation methods by the use of Regulations of Farmland Grading: the geometric mean method and the weighted average methods, then use GIS classification (Liu *et al*., 2005; Dong *et al*., 2007; Yu and Zhao, 2006). The geometric mean method will enlarge the role of a limiting factor and the weighted average method will cover up the role of a limiting factor (Zhang *et al*., 2005). Both of them are difficult to completely reflect the differences in the natural quality of arable land. Thus, academic circles based on gray correlation method (Lu *et al*., 2006) and the cluster analysis method of fuzzy matter element proximity of Cultivated Land Quality Evaluation (Nie, 2005) was proposed to provide a certain amount of technical supporting for quality evaluation of cultivated land. However, these fuzzy setting based methods rarely focused on the thing itself in the domain and the variability of the nature of the things. The evaluation results are not reliable.

Extension theory can determine the extent of things belonging to a collection based on the magnitude of things about characteristics. The correlation function can make the evaluation robust and quantitative, which provides a new way to solve the identification problem. This article will introduce the extension theory based on the extension set, by setting up the extension model of the natural quality to evaluate the reclamation area and demonstrated.

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Extension theory: The Extension Theory was founded by Tsai *et al*. (1997) Chinese scholars. It focuses on the rules and methods by the formal tools to solve the problem of contradictions from the point view of the qualitative and quantitative research (Tsai *et al*., 1997). Extension theory mainly includes matter-element theory and extension set theory and its logic cell is matter-element.

Matter element theory: In order to describe the process of changing of the objective things and making the process to solve the contradiction problem of formalization, extenics introduced the concept of matter-element as the basic elements to describe things.

Definition 1 defines the things name N, the magnitude of the characteristic c is v, we use an ordered triad R = (N, c, v) as the basic element for describing things, called matter-element, where N represents the matter; c, the characteristics; v is the N's.

Definition 2 A thing can have multiple characteristics, if things can be described by n features c_1, c_2, ..., c_n and the magnitude corresponding to v_1, v_2,..., v_n then:

$$R = \begin{bmatrix} N, & c_1, & v_1 \\ & c_2, & v_2 \\ & \vdots & \vdots \\ & c_n, & v_n \end{bmatrix} = \begin{bmatrix} R_1 \\ R_2 \\ \vdots \\ R_n \end{bmatrix}$$

The above formula is n-dimensional matter-element. Where in $R_i = (N, c_i, v_i)$ is called sub-matter element of R, $C = [c_1, c_2,..., c_n]$ is a feature vector, $V = [v_1, v_2, ..., v_n]$ is the magnitude corresponding to feature vector.

Extension set theory: To quantify the problem-solving process, extension theory is used to establish the corresponding mathematical tool.

Definition 3 Let U be the domain of discourse, if U defined in any one element u, have a corresponding real number $K(u) \in (-\infty,+\infty)$, you called $A=\{(u,y)|u \in U, y = K(u) \in (-\infty,+\infty)\}$ is a extension set of the domain of discourse Where in y = K (u) is the correlation function of A, K (u) is the degree of association for extension set A.

THE NATURAL QUALITY EVALUATION OF RECLAMATION AREA ON EXTENSION METHOD

Factor index system and evaluation criteria: The natural quality evaluation of reclamation area involves many influencing factors, the prerequisite and basis of the quality evaluation was setting up the index system that can reflect and measure the block comprehensively. The evaluation factors were selected according to the Delphi method, which was in accordance with the system of comprehensive, scientific, comparability and operability requirements. The index system was composed by 7 indicators. These seven indicators are foundation soil fertility, soil texture, organic matter, plow layer thickness, irrigation, elevation and drainage (Table 1). The rating criteria of indicators determined by the Delphi method are shown in Table 2.

The minimum polygon formed by few maps (Soil maps, land use map and administrative maps) overlap as evaluation unit. The evaluation unit thus formed had clear space boundaries and administrative affiliation, accurate area and landform types, soil types, land use patterns and farming methods are basically the same. Then score of each evaluation unit was calculated based on the collected data and field surveys.

Table 1: The evaluation index of cultivated land quality in Yu Huan county

Indicators number	C_1	C_2	C_3	C_4	C_5	C_6	C_7
Indicators name	Basic fertile	Soil texture	Organic matter	Plow layer thickness	Irrigation	Altitude	Drainage

Table 2: The criteria of evaluation index of cultivated land quality in Yu Huan county

Quality scores	Basic fertile	Soil texture	Organic matter	Plow layer thickness	Irrigation	Altitude	Drainage
100	≧80	Loam	≧3	≧20	≧70	≦10	≧10
95				18-20		10-50	
90		Silt loam\clay loam	2.5-3.0	15-18		50-150	5-10
85	70-80				50-70		
80		The soil clays\sandy loam	2.0-2.5			150-300	
75							
70	60-70		1.5-2.0	10-15		300-500	3-5
65							
60		Clay	1.0-1.5		30-50		
55	50-60						
50				<10		500-800	
45							
40		Sand	0.5-1.0				
35	40-50						
30					<30	800-1000	<3
20			<0.5				
15	<40						
10						>1000	

Table 3: The weights of the evaluation index of cultivated land quality in Yu Huan county

Evaluation index	Basic fertile	Soil texture	Organic matter	Plow layer thickness	Irrigation	Altitude	Drainage
Weights	0.25	0.1	0.15	0.1	0.2	0.1	0.1

The extension model of natural quality evaluation of cultivated land of reclamation area:

Construction of the same intrinsic matter element model: N-dimensional with intrinsic material element model of the cultivated land evaluation unit according to the matter-element theory is as follows:

$$R_i = (N_i, C, V_i) = \begin{bmatrix} N_i, & C_1, & V_{1i} \\ & C_2, & V_{2i} \\ & M & M \\ & C_n, & V_{ni} \end{bmatrix} i = 1, 2, \cdots n$$

In the above formula N_i represents the i^{th} evaluation units of arable land; C_1, C_2, ..., C_n, represents the main features of the natural quality of the evaluation unit (the evaluation index), such as the basis of fertility, soil texture, organic matter, the plow layer thickness, irrigation, elevation and drainage; V_{li}, V_{2i}, ..., V_{nI} represents a magnitude which evaluation unit i correspond to C_j (j = 1, 2, ..., n).

Determination of the classical domain and section domain:

$$R_0 = \begin{bmatrix} N & G_1 & G_2 & L & G_m \\ C & V_1 & V_2 & L & V_m \end{bmatrix} = \begin{bmatrix} N & G_1, & G_2 & L & G_m \\ C_1 & <a_{11},b_{11}> & <a_{12},b_{12}> & L & <a_{1m},b_{1m}> \\ M & M & M & M & M \\ C_n & <a_{n1},b_{n1}> & <a_{n2},b_{n2}> & L & <a_{nm},b_{nm}> \end{bmatrix}$$

R_0 is the same matter-element body of the same intrinsic matter-element R_1, R_2, ... R_m, where G_j represents evaluation category j, C_i represents indicators i, V_{ij} = $<a_{ij}, b_{ij}>$ is the value range predetermined by N_j about C_i, that is the classic domain of data range of the corresponding indicators on each of the categories.

Let,

$$R_p = [P, \quad C, \quad V_p] = \begin{bmatrix} P & C_1 & V_{1p} = <a_{1p}, b_{1p}> \\ & C_2 & V_{2p} = <a_{2p}, b_{2p}> \\ & M & M \\ & C_n & V_{np} = <a_{np}, b_{np}> \end{bmatrix}$$

where,

P = All categories

V_{ip} = The magnitude range taken by P about C_i

P = Section domain and V_{ij}<VIP (i = 1, 2, ... and n; j = 1, 2, ..., m)

In this case, the classic domain of each indicators of the evaluation unit is:

$$R_{0t} = \begin{bmatrix} N_t & C_1 & X_{t1} \\ & C_2 & X_{t2} \\ & C_3 & X_{t3} \\ & C_4 & X_{t4} \end{bmatrix} t = 1, 2, 3, 4$$

In the above formula N_t represents the evaluation unit level, when t = 1, 2, 3, 4, N_t respectively level 1, 2, 3 and 4, respectively. X_{t1}, X_{t2}, X_{t3}, X_{t4} represents the magnitude of the range specified in the corresponding feature about N_t, when t = 1, 2, 3, 4, the scope of its magnitude is <75, 100>, <50, 75>, <25, 50>, <0, 25> respectively.

Setting section domain in this example is:

$$R_p = [P, \quad C, \quad V_p] = \begin{bmatrix} P & C_1 & <0,100> \\ & C_2 & <0,100> \\ & M & M \\ & C_{20} & <0,100> \end{bmatrix}$$

Determination of the weight coefficient of pending matter element and index: The score results obtained was in accordance with the evaluation index of the pending evaluation unit Q, which was represented by matter element:

$$\begin{bmatrix} q & C_1 & V_1 \\ & C_2 & V_2 \\ & M & M \\ & C_n & V_n \end{bmatrix}$$

calling pending matter element of q.

V_i is the magnitude of q for the evaluation C_i, in other words q is the index score.

The weight coefficient of the arable land natural quality was set up using the Delphi method. The evaluation factors indicators C_i of Yu Huan reclamation area is a_i and T $\sum_{i=1}^{n} a_i = 1$, shown in Table 3.

Calculation of the degree of association of the evaluation: Establish the correlation function of the evaluation unit q on level j as follows:

$$K_j(v_i) = \begin{cases} \dfrac{-\rho(v_i, V_{ij})}{|V_{ij}|} & v_i \in [a_{ij}, b_{ij}] \\ \dfrac{\rho(v_i, V_{ij})}{\rho(v_i, V_{ip}) - \rho(v_i, V_{ij})} & v_i \notin [a_{ij}, b_{ij}] \end{cases}$$

Among them:

$$\rho(v_i, V_{ij}) = \rho(v_i, <a_{ij}, b_{ij}>) = \left| v_i - \frac{a_{ij} + b_{ij}}{2} \right| - \frac{b_{ij} - a_{ij}}{2}$$

Table 4: Scores of the evaluation index of each project

	Evaluation index				
Evaluate on unit	C_1	C_2	C_3	C_4	C_5
q_1	72	70	65	45	75
q_2	60	55	85	75	80
q_3	35	45	30	55	75
q_4	40	35	20	30	25
q_5	50	55	35	40	20
q_1	72	70	65	45	75
q_2	60	55	85	75	80

$$\left|v_{ij}\right| = \left|b_{ij} - a_{ij}\right|$$

$$\rho(v_i, V_{ip}) = \rho(v_i, <a_{ip}, b_{ip}>) = \left|v_i - \frac{a_{ip}+b_{ip}}{2}\right| - \frac{b_{ip}-a_{ip}}{2}$$

Calculation of matter element based on comprehensive correlation degree: According to the degree of association on level j, which was determined by weight coefficient a_i of indicator Ci and each evaluation of evaluation unit q, the comprehensive correlation degree of pending matter element was calculated as $K_j(q) = \sum_{i-1}^{n} a_i K_j(v_i)$.

Rating: Comparing the size of each level associated degrees to determine the results of the assessment. The degree of association of the level j greater, which indicates that the evaluation unit q compliance this level set was good. If $K_{j0}(q) = \max_{j\in\{1,2,L m\}} K_j(q)$, the evaluation unit q is belong to level j_0.

Calculate Level variable eigenvalue of the evaluation unit q:

$$j^* = \sum_{j=1}^{m} j\bar{K}_j(q) \Big/ \sum_{j=1}^{m} \bar{K}_j(q)$$

among them:

$$\bar{K}_j(q) = \frac{K_j(q) - \min_j K_j(q)}{\max_j K_j(q) - \min_j K_j(q)}$$

The level variable eigenvalues reflect the deviation degree of the level j_0 of the evaluation unit q tend to the other categories.

Case study: Five evaluation units of Yu Huan were used to test the proposed extensive comprehensive evaluation model. According to Table 1 and 2, scores these five evaluation unit of the various factor index, the results are demonstrated in Table 4.

The correlation about level j of the various factor index of these five evaluation unit was calculated based on the correlation function of the above established evaluation unit q and the evaluation index about j, the results are shown in Table 5.

Five units evaluation results was obtained by the calculation of the weight of each evaluation value, which was based on the comprehensive correlation

Table 5: Correlation values of K (v) about the level j for each evaluation index of the evaluated projects

		v_1	v_2	v_3	v_4	v_5	v_6	v_7
K1 (vi)	q_1	-0.0968	-0.1429	-0.2222	-0.4000	0.0000	0.2000	0.4000
	q_2	-0.2727	-0.3077	0.4000	0.0000	0.2000	-0.2222	0.1200
	q_3	-0.5333	-0.4000	-0.6000	-0.3077	0.0000	-0.2727	-0.3333
	q_4	-0.4667	-0.5333	-0.7333	-0.6000	-0.6667	-0.6000	-0.4000
	q_5	-0.3333	-0.3077	-0.5333	-0.4667	-0.7333	-0.5333	-0.3077
K2 (vi)	q_1	0.1200	0.2000	0.4000	-0.1000	0.0000	-0.2000	-0.4000
	q_2	0.4000	0.2000	-0.4000	0.0000	-0.2000	0.4000	-0.1200
	q_3	-0.3000	-0.1000	-0.4000	0.2000	0.0000	0.4000	0.0000
	q_4	-0.2000	-0.3000	-0.6000	-0.4000	-0.5000	-0.4000	-0.1000
	q_5	0.0000	0.2000	-0.3000	-0.2000	-0.6000	-0.3000	0.2000
K3 (vi)	q_1	-0.4400	-0.4000	-0.3000	0.2000	-0.5000	-0.6000	-0.7000
	q_2	-0.2000	-0.1000	-0.7000	-0.5000	-0.6000	-0.3000	-0.5600
	q_3	0.4000	0.2000	0.2000	-0.1000	-0.5000	-0.2000	0.0000
	q_4	0.4000	0.4000	-0.2000	0.2000	0.0000	0.2000	0.2000
	q_5	0.0000	-0.1000	0.4000	0.4000	-0.2000	0.4000	-0.1000
K4 (vi)	q_1	-0.6267	-0.6000	-0.5333	-0.3077	-0.6667	-0.7333	-0.8000
	q_2	-0.4667	-0.4000	-0.8000	-0.6667	-0.7333	-0.5333	-0.7067
	q_3	-0.2222	-0.3077	-0.1429	-0.4000	-0.6667	-0.4667	-0.3333
	q_4	-0.2727	-0.2222	0.2000	-0.1429	0.0000	-0.1429	-0.3077
	q_5	-0.3333	-0.4000	-0.2222	-0.2727	0.2000	-0.2222	-0.4000

Table 6: Results of evaluation

	Kj (q)					
Evaluate on unit	N_1	N_2	N_3	N_4	j_0	J^*
q_1	-0.0518	0.0400	-0.4050	-0.6141	2	1.75
q_2	-0.0092	0.0480	-0.4210	-0.6140	2	1.72
q_3	-0.3547	-0.0850	0.0200	-0.3611	3	2.56
q_4	-0.5733	-0.3600	0.1700	-0.1197	3	3.17
q_5	-0.4715	-0.1750	0.0800	-0.2062	3	2.97

function. There are two evaluation units in the level 2 and 3 evaluation units in level 3. In other words, q_1 and q_2 evaluation results is the Level 2 and the remaining three evaluation unit level is 3. According to the level of characteristic values j of the evaluation unit (the smaller value of the characteristics of the present study the higher of the level), its excellent degree sequence is q_2, q_1, q_3, q_5 and q_4, which is shown in Table 6.

CONCLUSION

This study proposed the extension evaluation model which applied quantitative solutions to the natural quality evaluation of arable land of the reclamation area. This model can reduce the ambiguity and subjectivity of the evaluation and reflect the scientific and objective of the natural quality evaluation of arable land of the reclamation area. The extension evaluation model is further enriched the division method of the natural quality of agricultural land and can provide the basis for farmland grading. The results of the quality evaluation of cultivated land can provide technical support for the specific technical process of the general Land Use Planning (Xiao *et al*., 2009) (such as structural adjustment and layout of agricultural land, urban development direction, land consolidation area delineation, the reserves of back-up area of arable land, farmland demand forecast and determine the insurance number of cultivated land, etc.). The evaluation results could also be used for the conversion coefficient of farmland grading determination and arable production capacity accounting, etc. In addition, the causing and constraints of different natural quality space differences can be determine by extracting certain attributes like soil condition value, irrigation situation, etc. Optimization of the transformation measures, such as through the strengthening of irrigation and water conservancy facilities construction, changing farming systems of dry farming, optimizing planting structure, promoting water-saving irrigation, afforestation and grass, water saving and sand fixing, improving the production capacity of low-grade farmland, was be possible by the use of this proposed model.

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REFERENCES

Dong, Y., Z. Zhou, X. Zhang and Y. Zhang, 2007. GIS support under the agricultural land classification study. Soil Water Conserv. Res., 4: 162-164.

Liu, J., Y. Liu and J. Yang, 2005. GIS in agricultural land classification application. Mapping Geospatial Inform., 6: 108-110.

Lu, W., Q.L. Ni and J. Chen, 2006. Gray correlation degree in cultivated land quality evaluation. Land Resour. Technol. Manag., 4: 91-94.

Nie, Y., 2005. Evaluated based on the quality of cultivated land of the GIS and fuzzy matter-element the proximity cluster analysis model. Soil Sci., 4: 551-558.

Tsai, W., C. Yang and W. Lin, 1997. Extension Engineering Methods. Science Press, Beijing.

Xiao, B., Y. Chen, B. Lu and J. Chen, 2009. The application problems and suggestions in China agricultural land classification achievements. China Agr. Resour. Reg. Plan., 6: 16-20.

Xu, S., 2004. Plot scale farmland quality evaluation and method explore. Resour. Environ. Yangtze River Basin, 1: 47-52.

Yu, D. and X. Zhao, 2006. Agricultural land grading information system design and development in Jiangxi Province. J. Agr. Eng., 6: 208-210.

Zhang, F., W. Yun and C.Z. Hu, 2005. Few theoretical issues and direction in regulations of farmland grading. Resour. Sci., 2: 33-38.