COMPUTER AIDS LAND RECLAMATION PLAN IN MINE AREAS[1]

Bian Zhengfu[2], Wang Junsheng[3], Wang Tongji[4]

Abstract. Land reclamation plan is a basic and complex work for land reclamation engineering. This paper introduces the technique of a computer-aided subsided land reclamation plan (**CASLRP**) and focuses on the suitability evaluation of subsided land. Through suitability evaluation, how much land is suitable for development can be determined and the border of different land utilization and the program chart of land use can be drawn by computer. A practical example is given in which the **CASLRP** technique is applied to a mined area of Jiangsu Province.

Additional Key words: reclamation plan, suitability evaluation, subsidence.

Introduction

Land reclamation planning is basic and complex work for mine land reclamation engineering (Bian Zhengfu and Guo Dazhi 1990). The Stipulations of Land Reclamation (State Council of the People's Republic of China, Novemeber 1988) clearly stipulates that a land reclamation plan should determine the direction of land use according to economical principle, natural conditions, and the state of land destruction; the plan should be in tune with the overall plan of land use, and integrated with the mine plan. Therefore, appropriate evaluation of the features of land destruction is necessary before the land reclamation plan is made, and suitable measures to harness subsided lands must be taken into account. Thus, a land reclamation plan must be made based on a full investigation, precise data, and adequate evaluation. The investigation should include the features of climate, the state of land destruction, the distribution of water bodies and other resources, the state of soil erosion, the amount and types of plants, etc.

The basic data for a land reclamation plan includes not only social, economic, environmental, geological, and mining aspects, but also some basic charts such as a physical chart with the natural features of subsided land, statistical curves with information about such things as the output of a mine, reclamation conditions, a surface-underground contrast plan with the terrain and coal face on it, a present map of land utilization, and a distribution map of water bodies. To reasonabaly evaluate the suitability of land, it is necessary for land undermined with potential subsidence to predict its subsidence and a map of subsidence prediction results must be drawn. Therefore, a great deal of work processing data and drawing charts is necessary. It is inconceivable that this work be completed by hand.

Over the past years, we devoted ourselves to the development of a Computer Aided Subsided Land Reclamation Planning (**CASLRP**). This technique provides a highly efficient and reliable method of generating a reclamation plan for subsided land. The **CASLRP** technique comprises of five parts (Bian Zhengfu et al. 1993): 1)creating the basic charts; 2)processing the data; 3)evaluating the suitability of the site; 4)optimizing the reclamation plan and 5)outputing the final plan. In the past, except for the part of evaluating the suitability of the site, the other parts have been researched in some detail (Lin Jiacong and Bian Zhengfu, 1989). This paper will concentrate on

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the suitability evaluation of subsided lands.

Model for Evaluating the Suitability of Subsided Land

Suppose there are m factors that affect a certain land use. For example, they are X_1, X_2, X_3, ..., Xm. Their state vector is $\mathbf{C}_i$,
where:

$$\mathbf{C}_i = (c_{i1}, c_{i2}, \ldots, c_{ij}, \ldots, c_{in}) \tag{1}$$
$$i = 1, 2, \ldots, m;$$
$$j = 1, 2, \ldots, n.$$

i represents a factor, j represents a suitability grade of a certain land use. For each land use every state vector is a totally ordered set ranging from an optimal grade to a bad grade. That is:

$$c_{i1}>c_{i2}>\ldots>c_{ij}>\ldots>c_{in} \tag{2}$$

Suppose a_i means the weight of influence factor i on a certain land use ($0<a_i<1$), p_{ji} in hundred-mark system represents the influence of a different factor on the grade j of the land use object. If a grided data structure is used, every grid block has a corresponding index vector $\mathbf{UN}(O_k)$.

$$\mathbf{UN}(O_k) = \sum_{i=1}^{m} a_i p_{ji} = (un(O_k))_j \tag{3}$$

Suppose $\mathbf{U}(O_k) = 1-|\mathbf{UN}(O_k)-p_{ji}/100| = (u(O_k))_j$
Where, O_k represents the land use target, k = 1~t. Then, j making the value of $u(O_k)$ maximum is the grade of the grid block.

Suppose $\mathbf{C}_i(O_k)$ represents the state vector of target O_k to be evaluated which can be used for scaling the target O_k, $\mathbf{U} = \{O_t, t\in\mathbf{T}\}$, $\mathbf{T}$ is target set, then the step to determine which grid block is suitable for the target and which suitability grade it belongs to is as follows:

(1) Choose targets. Choose t targets O_1, O_2, ..., O_t from $\mathbf{U}$ as following rules, that is, $c_i(O_1)>c_i(O_2)>\ldots>c_i(O_t)$ is always right under the condition of $1<i<m$.

(2) Evaluate the grade of suitability. The suitability grade can be regarded as a fuzzy subset within its universe of discourse U, written as **N**. The membership function of **N** must be determined before the grade of grid block is determined by its membership grade of $\mathbf{UN}(O_k)$. The mark of the reference target can be determined by Delphi Method (Huang Xingyuan 1989, Huang Xingyuan and Ni Shaoxiang 1993).

(3) Construct the matrix **A**.

$$\mathbf{A} = \begin{bmatrix} a_1p_{11} & a_2p_{12} & \cdots & a_mp_{1m} \\ a_1p_{21} & a_2p_{22} & \cdots & a_mp_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ a_1p_{n1} & a_2p_{n2} & \cdots & a_mp_{nm} \end{bmatrix} \tag{4}$$

The row vector of matrix **A** is a quantitative form of n reference vectors in every class.

(4) Compute the membership grade of grid block. The method is as formula(3). $UN(O_k)$ is the mark of target O_k also.

(5) Calculate and compare $u(O_k)$.

$$U(O_k) = 1- \mid UN(O_k)-p_{ji}/100 \mid \; = (u(O_k))_j \tag{5}$$

Grid block, which makes the value of $u(O_k)$ maximum, can be classified as grade j.

Case Study Example of CASLRP Applied to Mine Land in Jiangsu Province

General Situation of Reclamation Area

Geographic Location. The reclaimed area is 30 km northeast of Xuzhou City shown as Figure 1. The Tuntou River, which is the main river in this area, is located south of the reclaimed area, and the Jiawang district of Xuzhou City is at the north. The subsided land resulted mainly from mining of the Hanqiao and Xiaqiao coal mines, Which are state-run. In this area, many lands tend not to subside, and only few areas will continue to subside. Parts of subsided lands have been reclaimed by local residents without planning.

Social and Environmental Problems. The population is about 110,000 in this area, and with increasing coal production, cultivated land is decreasing which results in increased unemployment. The ammount of waterflooded land is vaste because of subsidence. The percentage of afforestation is lower than that of the adjacent area.

According to practical conditions and the demands of the local residents, the prescribed future planned land uses in this area are only for agriculture and fishery.

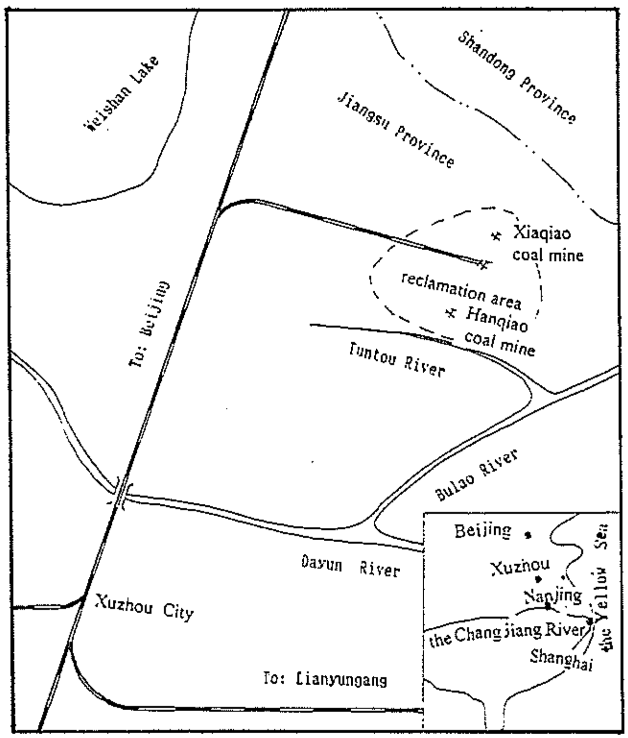

Figure 1. Map of geographic location of the subsided land.

Evaluation Factors and Standard for Grading

Before evaluation, climate condition, soil texture and soil structure do not vary much, these factors are not chosen for evaluation; in contrast, present state of land use (F1), flooded nature (F2), vertical drop in elevation due to subsidence (F3), condition of irrigation and drainage (F4), and location of the unit to be evaluated (F5) are important, therefore were selected as part of the analyses.

The standards used for grading are listed in Tables 1 and 2.

Table 1. Standard for grading agriculture land

Class	Evaluation factor	F1	F2	F3	F4	F5
	Weighting	0.2	0.25	0.20	0.25	0.10
1	Mark	20	25	20	25	10
	Condition	rice-field, vegetabe plot , irrigated land	No	<0.5	Good	Good
2	Mark	10	16	13	20	6
	Condition	nonirrigated land	T	<1.5	Or	Or
3	Mark	5	8	6	10	3
	Condition	wasteland, beach	S	<3.0	Poor	Poor
4	Mark	0	0	0	0	0
	Condition	wastehill, site of fly ash kiln	P	>3.0	W	W

T=temporary, Or=ordinary, S=seasonal, P=perennial, W=worst.

Flowchart of the Program

As was described in the evalua-tion model, a program was developed to determine the total suitability grade for each grid block in the study area. The flow chart for the program is shown in Figure 2.

Reading of Data. The data can be obtained by means of a grided data structure for the map of the present land utilization. Every grid is not only the point of data-collected, but also the point of data-processed.

Coding of Data. Data of every grid block is stored in a three-dimensional array named F(I,J,K), I and J represent the abscissa and ordinate from the corner west-south of the grid. K represents the order of the data for the grid.

Results

Grading Map of Land Use and Evalua-tion Results. Figure 3 shows the grading map of subsided lands after evaluated. Table 3 shows the results of the evaluation.

Advantages and Disadvantages. The main advantage of the method presented above is that it is easy to change the factors and to adjust their weights. Secondly, by means of the technique of **CASLRP**, the

Table 2. Standard for grading fishery.

Class	State of flooding	Ground subsidence	source of water
1	Perennial	>3.0 m	Good
2	Seasonal	>1.5 m	Ordina
3	Temporary	>0.5 m	BE
4	No	<0.5 m	Poor

BE=barely enough

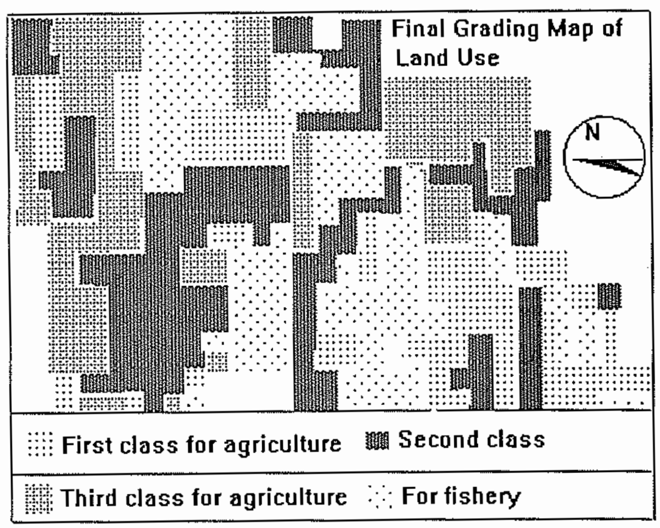

Figure 3. Final grading map of land use

results of evaluation can be output directly to figures and tables.

The main disadvantage is that the weight of every factor is subjective. This can be overcome by a combination of experts' grading and theoretical deduction based on statistical data.

Table 3. Area of land use in every class (unit: ha.)

Item	Area
Total area	1575
First-class for agriculture	292.6
Second-class for agriculture	449.7
Third-class for agriculture	335.1
For fishery	260.8
Others	236.8

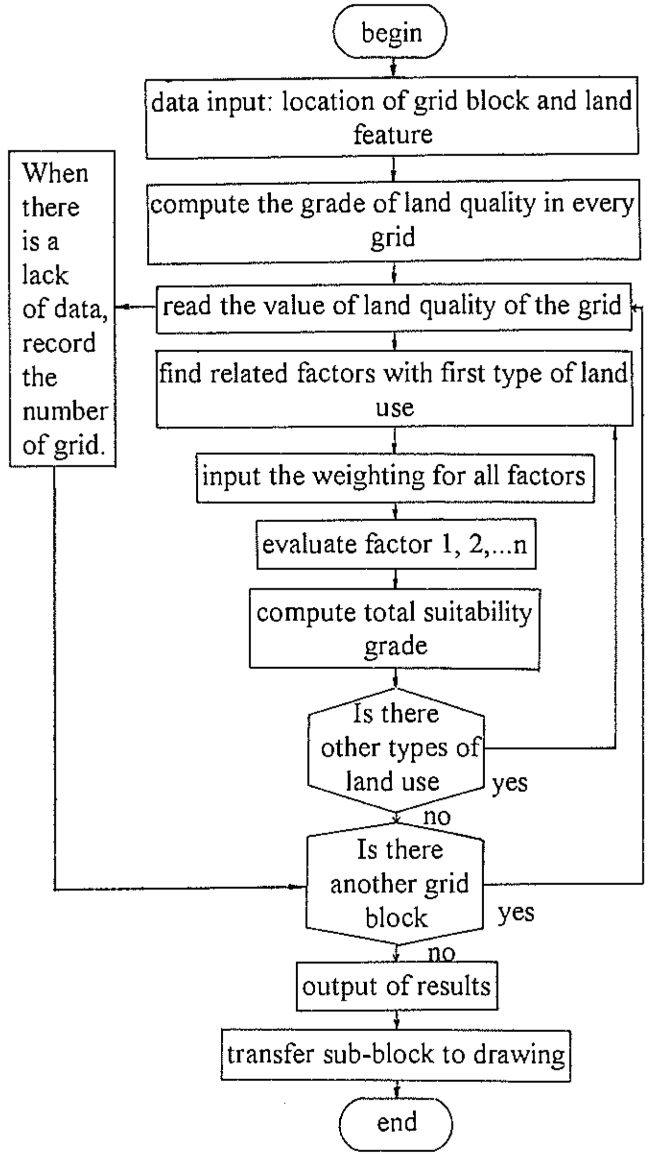

Figure 2. Flow chart to determine the total suitability grade

Conclusions

The model of subsided land suitability evaluation for reclamation as a part of the **CASLRP** technique was discussed, and a practical example in Xuzhou coal mine area was presented. It was demonstrated that the **CASLRP** technique is an effective tool for mine land reclamation, and that the results of evaluation are reliable and practical.

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