Appropriateness Evaluation Study of Land Reclamation of Pre-drilling Project in Southwest China Under Dual-carbon Background

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Abstract: Cultivated land and forest land are important carbon sink systems in the context of dual-carbon, so it is necessary to do a suitability evaluation study of pre-drilling project land reclamation to support the restoration of carbon sink function of the temporarily occupied farmland. In this paper, the suitability evaluation model of pre-drilling engineering land reclamation was established by adopting hierarchical analysis method and TOPSIS multi-attribute decision-making method, and the suitability evaluation study of pre-drilling engineering land reclamation was carried out on a drilling platform in Southwest China.

Keywords: Dual carbon; carbon sink; suitability evaluation model.

1. Introduction

According to the World Resources Institute (WRI), as of 2021, the annual global carbon dioxide emissions have exceeded 40 billion tonnes. The large amount of carbon emissions into the atmosphere leads to an increase in the concentration of greenhouse gases, which in turn triggers the phenomenon of global warming. The World Meteorological Organisation (WMO) released the report The Global Climate Situation in 2022 which states that the global average temperature in 2022 will be about 1.15°C higher than the pre-industrial level. Given this, on 22 September 2020, the Government of China put forward the "double carbon" goal: carbon emissions strive to peak by 2030, and strive to achieve carbon neutrality by 2060. In the context of "double carbon", the reclamation of land for pre-drilling works of oil drilling platforms has become a point of concern. The temporary occupation of farmland, woodland and grassland by pre-drilling projects has destroyed the original carbon sink system. There is an urgent need to make a suitability assessment of pre-drilling project land reclamation to support the restoration of its carbon sink capacity. Therefore, this paper establishes a pre-drilling land reclamation suitability evaluation model using hierarchical analysis [1] and TOPSIS multi-attribute decision-making method [4] and carries out a pre-drilling land reclamation suitability evaluation study on a drilling platform in Southwest China. It provides a basis for the establishment and evaluation of land reclamation suitability evaluation indexes for pre-drilling projects and promotes the development of pre-drilling project land reclamation in the direction of standardisation and certification.

2. Constructing Land Reclamation Suitability Evaluation Index System of Pre-drilling Project

Referring to *the Technical Procedures for Cultivated Land Strength Survey and Quality Evaluation* (NY/T1634-2008), *Land Reclamation Quality Control Standards* (TD/T1036-2013), *Technical Procedures for Cultivated Land Reserve Resource Survey and Evaluation* (TD/T1007-2003), *China's 1:1,000,000 Land Resource Map*, and *Soil Environment Quality Standards (Revised)* (GB15618-2008), the system of indicators for the evaluation of the suitability of pre-drilling project land reclamation has been developed gradually towards standardisation and scientific development. GB15618-2008), etc. and concluded that the dominant factors affecting land use after destruction are: soil organic matter, effective soil layer thickness, topographic slope, soil pH, irrigation and drainage conditions, and traffic conditions, based on which the land reclamation suitability evaluation index system of pre-drilling project is constructed as shown in Figure 1.

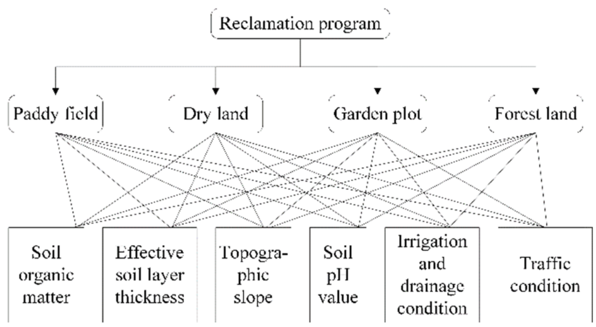

Figure 1. Evaluation index system of land reclamation suitability of pre-drilling project

3. Establishment of Pre-drilling Project Land Reclamation Suitability Evaluation Model

3.1. Determine the weights of indicators

Due to the different importance of each evaluation indicator in the land reclamation suitability evaluation index system, there are many uncertainties in the process of determining the weights of the land reclamation suitability evaluation indicators, and at the same time, it is also necessary to judge the size of the weights of the indicators based on the personal experience of the experts in the process of confirming the weights of the indicators, so this paper applies a kind of hierarchical analysis method integrating qualitative and quantitative to determine the weights in the evaluation indexes of the suitability of land reclamation. Therefore, this paper uses a hierarchical analysis method that combines qualitative and quantitative methods to determine the weights of the evaluation indicators of land reclamation suitability, so the weights of each evaluation indicator of land reclamation suitability can be established by using the form of a judgement matrix in the hierarchical analysis method.

(1) Construct the judgment moment drop $A_{m\times n}$ using the 1-9 scaling method [7]:

(2) Calculate indicator weights. The problem of weight calculation in hierarchical analysis method can be reduced to the problem of calculating the maximum characteristic root and eigenvector of judgment matrix. The square root method is commonly used to calculate the indicator weights.

(3) Consistency test of judgment matrix. The consistency ratio CR test logic, when CR<0.1, the judgment matrix has satisfactory consistency. Otherwise, it is necessary to adjust the judgment matrix, so that it has satisfactory consistency. Where $CR = CI/RI$, $\mathrm{CI} = (\lambda_{max} - n)/(n-1)$, λ_{max} is the largest characteristic root of matrix A.

3.2. TOPSIS-based land reclamation suitability evaluation method for pre-drilling project

TOPSIS method, i.e., the ranking method of approximating the ideal solution, is a very effective method for solving multi-objective decision-making problems. The core idea is to set a positive ideal solution and a negative ideal solution, and then evaluate the best decision-making scheme according to the distance between the evaluated object and the initially set ideal solution, stipulating that the evaluated object is as small as possible from the positive ideal solution, and as large as possible from the negative ideal solution, and the specific evaluation process is as follows.

(1) Formation of decision matrix

With m evaluation objects and n decision-making indicators, the target decision matrix $X_{m\times n}$:

(2) Data normalisation

The indicators are normalized using the polar deviation method. Forward indicators using the formula: $y_{ij} = [x_{ij} - x_{min(j)}]/[x_{max(j)} - x_{min(j)}$, reverse indicators using the formula: $y_{ij} = \left[x_{max(j)} - x_{ij}\right]/[x_{max(j)} - x_{min(j)}]$; after data processing to obtain the normalization matrix Y.

(3) Determine the positive and negative ideal solutions of the indicator

The maximum and minimum values of the columns of the normalized matrix Y constitute the optimal and inferior vectors for the ideal solution and the negative ideal solution: $Y^{+} = [y_1^{+} \quad y_2^{+} \quad \cdots \quad y_n^{+}]$, $Y^{-} = [y_1^{-} \quad y_2^{-} \quad \cdots \quad y_n^{-}]$, $y_j^{+/-} = \max/\min(y_{ij})$, $i = 1,2,\cdots m$; $j = 1,2,\cdots n$

(4) Calculate the distance between the evaluation object and the ideal solution

The distance between the ith evaluation object and the positive rational solution and the negative ideal solution is.

$$D_i^{+} = \sqrt{\sum_{j=1}^{n} w_j (y_j^{+} - y_{ij})^2}\ D_i^{-} = \sqrt{\sum_{j=1}^{n} w_j (y_j^{-} - y_{ij})^2}\ (i = 1,2,3\cdots m)$$

D_i^{+} represents the distance between the evaluation object and the positive ideal solution, the larger D_i^{+} is, the farther the evaluation object is from the positive ideal solution: D_i^{-} represents the distance between the evaluation pair and the negative ideal solution, the larger D_i^{-} is, the farther the evaluation object is from the negative ideal solution.

(5) Calculate the closeness of the evaluation object to the rational comfort solution. $C_i^{-} = D_i^{+}/(D_i^{+} + D_i^{-})$, C_i^{-} represents the similarity and closeness of the evaluation object and the negative ideal solution, the larger C_i^{-} is, the closer the evaluation object is to the negative ideal solution, and the more backward it is ranked.

4. Empirical Analysis

A drilling platform area of 17000 ㎡ has a well site, oil and water tanks, gas field water tank area, living area, combustion pool area, soil dump, slope, emergency pool 8 types of pre-drilling project temporary facilities. Now the drilling platform work task is completed, the drilling rig equipment has been relocated out of the field. Except for the concrete facilities of the oil production equipment in the centre of the platform, all concrete facilities have been dismantled. After dismantling, a reasonable reclamation evaluation of the platform is required to support the implementation of the reclamation program.

Through the hierarchical analysis method to evaluate the land reclamation indexes of the pre-drilling project, the following judgment matrix is obtained by comparing the two judgments.

$$A = \begin{bmatrix} 1 & 3 & 5 & 8 & 2 & 8 \\ 1/3 & 1 & 2 & 6 & 1/4 & 6 \\ 1/5 & 1/2 & 1 & 3 & 1/3 & 6 \\ 1/8 & 1/6 & 1/3 & 1 & 1/7 & 4 \\ 1/2 & 4 & 3 & 7 & 1 & 8 \\ 1/8 & 1/6 & 1/6 & 1/4 & 1/8 & 1 \end{bmatrix}$$

The weight vector of the indexes is obtained by the maximum characteristic root method as follows.

$$W = [0.389 \quad 0.292 \quad 0.149 \quad 0.102 \quad 0.044 \quad 0.024]^T$$

Maximum characteristic root $\lambda_{max} = 6.4652$, the consistency test coefficient of judgment matrix A is $CR = 0.0738$. The results of weight calculation passed the consistency test.

The experts give their evaluation scores in the four reclamation directions of paddy field, dry land, garden land and forest land by combining the evaluation index profiles to derive the initial evaluation matrix, and the results of the evaluation of land reclamation suitability for pre-drilling project are as follows through the calculation of the steps in section 3.2.

Table 1. Evaluation Results of Land Reclamation Suitability for Drilling Projects on a Platform

Reclamation programs	Positive ideal Solution distance (D+)	Negative ideal Solution distance (D-)	Composite score Index (C^{-})	Ranking
paddy field	0.635	0.752	0.542	2
dryland	0.594	0.744	0.556	1
garden plot	0.742	0.533	0.418	3
forest land	0.829	0.245	0.228	4

The results show that the platform's pre-drilling project land is suitable for declared development as dryland, followed by paddy land, garden plots and forest land in order of suitability.

5. Conclusion

This paper explores how to establish the index and method system of land reclamation suitability evaluation of the pre-drilling project from the perspective of double carbon.

First of all, according to the land reclamation-related norms and standards and actual engineering. Construct the evaluation system of land reclamation and straightness of the station project, including six evaluation indexes: soil organic matter, effective soil layer thickness, topographic slope, soil pH value, irrigation and drainage conditions, and traffic stripes, and then use hierarchical analysis to calculate the weights of the evaluation indexes. On this basis, the suitability of the four reclamation programs of paddy fields, drylands, gardens, and forests was evaluated from the dimensions of these six evaluation indexes using the TOPSIS method. Finally, a drilling platform in Southwest China was selected as an empirical case study, and the results of the study showed that the most suitable amount of reclamation for this platform was dryland. The combined effect of various evaluation indicators produced this result. Among them, the weights of soil organic matter, effective soil layer thickness, and terrain slope are in the first three places, which are regarded as the key indicators to determine the suitability of land reclamation.

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