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Research on the Suitability Evaluation of Temporary Land Reclamation for Oil Drilling Platforms in Sichuan Province

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Abstract: In light of the "dual carbon" objectives, conducting a suitability assessment for the reclamation of temporary land utilized by oil drilling platforms is essential for reinstating the carbon sink capabilities of farmland that is temporarily occupied. This study integrates the Analytic Hierarchy Process (AHP) with the TOPSIS approach to develop an evaluation model for assessing the suitability of reclaiming temporary land. An empirical analysis is presented using a specific drilling platform as a case study. The findings indicate that the model demonstrates strong applicability.

Keywords: Temporary Land; Reclaiming; Suitability.

1. Introduction

According to data from the International Energy Agency (IEA), by 2024, global annual carbon dioxide emissions reached 37.8 billion tons, an increase of 1.1% year-on-year, showing no downward trend. China remains its largest contributor. At present, there are less than six years left until the goal of peaking carbon emissions is reached. Focusing solely on clean energy and industry carbon emissions is difficult to ensure the timely peaking of carbon emissions. It is also necessary to rationally allocate the limited time and resources to the recycling and utilization of recyclable resources. This can not only help China fulfill its current emission commitments, but also increase the probability of exceeding the targets set by those commitments. The temporary land use of oil drilling platforms occupies farmland, forest land, grassland, etc., which not only disrupts the original carbon sink system but also has an adverse impact on the total amount of cultivated land in the region. At present, it is urgently necessary to conduct a reclamation suitability assessment of the temporary land for drilling platforms to support the restoration of its original carbon sink capacity, promote carbon reduction, and fill the gap in cultivated land. Therefore, this paper adopts the Analytic Hierarchy Process (AHP) and the TOPSIS multi-attribute decision-making method to establish an evaluation model for the suitability of temporary land reclamation, and conducts an empirical study on a certain drilling platform. To provide theoretical basis and practical support for the suitability evaluation of temporary land reclamation, and to promote the gradual development of temporary land reclamation in a standardized and scientific direction.

2. Construct the Evaluation Index System

Based on the analysis and research conducted, by referencing pertinent standards and thoroughly evaluating data availability along with the ratio of quantitative metrics, it has been determined that the primary assessment indicators influencing land reclamation following damage include: organic matter in the soil, thickness of the effective soil layer, slope of the terrain, pH levels of the soil, conditions for irrigation and drainage, as well as transportation conditions [1-5]. The system of evaluation indices pertaining to the suitability of temporary land reclamation for drilling platforms is illustrated in Figure 1.

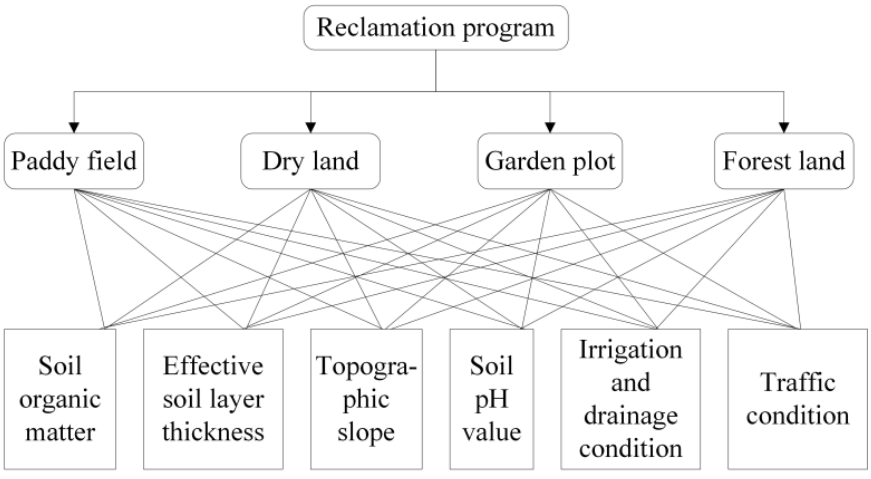


Figure 1. Evaluation Index System for the suitability of temporary land reclamation for drilling platforms

3. Establish the Evaluation Model

3.1. Determine the Weights of the Indicators

In the evaluation index system of land reclamation suitability, there are hierarchical differences in the importance of each index. The assignment of their weights not only faces uncertainties but also relies on expert experience. The Analytic Hierarchy Process can combine this subjective experience with objective calculation, thereby achieving a scientific distribution of weights [6-7]. Specifically, the weights of each evaluation index are ultimately determined by constructing the judgment matrix in the Analytic Hierarchy Process.

(1) Using the 1-9 scaling technique, a judgment matrix $P_{m\times m}$ is formulated.

(2) Determine the weights associated with the indicators. Within the AHP, calculating the weights can be simplified to finding the maximum eigenvalue and corresponding eigenvector of the judgment matrix. The square root method is frequently employed for computing the weights of indicators.

(3) Consistency test of the judgment matrix. The logicality is tested by the consistency ratio CR. When $CR < 0.1$, the judgment matrix has satisfactory consistency; otherwise, adjustments to the matrix are required to ensure satisfactory consistency. Among them, $CR = A/B$, $A = (c - n)/(n - 1)$, B is related to the order of the matrix, and c is the maximum eigenroot of matrix P.

3.2. Evaluation Method for the Suitability of Temporary Land reclamation for Oil Drilling Platforms Based on TOPSIS

The TOPSIS method serves as a powerful technique frequently utilized in multi-objective decision-making contexts. This approach is grounded in the establishment of two ideal solutions—positive and negative—that function as a reference framework for evaluation. Options are prioritized based on the degree of proximity of each alternative to these two benchmark solutions [8-10]. An optimal decision-making solution is expected to exhibit a minimal distance from the positive ideal solution while maintaining a maximal distance from the negative ideal solution. The comprehensive evaluation procedure is outlined below:

(1) Form a decision matrix

we start with m evaluation objects and n indicators for decision-making, resulting in a target decision matrix represented as $E_{m\times n}$.

(2) Data normalization

The range method is adopted to normalize the indicators. The formula for the positive indicators is: $F_{ij} = [e_{ij} - e_{min(j)}]/[e_{max(j)} - e_{min(j)}]$ and the formula for the negative indicator is: $F_{ij} = [e_{max(j)} - e_{ij}]/[e_{max(j)} - e_{min(j)}]$. Subsequent to data processing, the normalized matrix F is derived.

(3) Determine the ideal solutions

The optimal and worst vectors constructed from the maximum and minimum values of each column in the normalized matrix F correspond to the positive ideal solution and negative ideal solution, respectively. Their expressions are as follows: $F^+ = [f_1^+ \ f_2^+ \ \cdots \ f_n^+ \ ]$, $F^- = [f_1^- \ f_2^- \ \cdots \ f_n^- \ ]$, $f_j^{+/-} = \max/\min(f_{ij})$, $i = 1, 2, \cdots m$; $j = 1,2, \cdots n$.

(4) Calculate the distance

The distances between the i-th evaluated object and the positive as well as negative ideal solutions are given by:

$$JL_i^+ = \sqrt{\sum_{j=1}^{n} w_j (f_j^+ - f_{ij})^2}, JL_i^- = \sqrt{\sum_{j=1}^{n} w_j (f_j^- - f_{ij})^2}, (i = 1,2,3 \cdots m)$$

Specifically, JL_i^+ denotes the distance between an evaluated object and the positive ideal solution, with a larger JL_i^+ indicating a greater distance between the two; JL_i^- represents the distance between the evaluated object and the negative ideal solution, and a larger JL_i^- similarly signifies a farther distance from the negative ideal solution.

(5) Calculate the closeness of evaluated objects to ideal solutions: $C_i^- = JL_i^+/(JL_i^+ + JL_i^-)$, where C_i^- refers to the similarity closeness between an evaluated object and the negative ideal solution. A larger C_i^- means the object is closer to the negative ideal solution and has a lower ranking.

4. Empirical Analysis

A drilling platform with a total area of approximately 17,000 m² comprises eight types of temporary facilities. Upon completion of the drilling mission, core equipment such as drilling rigs has been removed from the site, and on-site demolition is basically finished, leaving only the concrete part of the oil extraction equipment at the platform center. To effectively guide reclamation practices, a systematic assessment of the platform's reclamation potential has become a top priority.

By applying the AHP, through pairwise judgment and comparison of the evaluation indicators for the suitability of temporary land reclamation for oil drilling platforms, the judgment matrix is formed as follows:

$$A = \begin{bmatrix} 1 & 3 & 5 & 6 & 6 & 9 \\ 1/3 & 1 & 2 & 3 & 3 & 5 \\ 1/5 & 1/2 & 1 & 2 & 2 & 4 \\ 1/6 & 1/3 & 1/2 & 1 & 1 & 2 \\ 1/6 & 1/3 & 1/2 & 1 & 1 & 2 \\ 1/9 & 1/5 & 1/4 & 1/2 & 1/2 & 1 \end{bmatrix}$$

The index weight vector obtained by the maximum eigenroot method is:

$W = [0.480 \quad 0.205 \quad 0.129 \quad 0.073 \quad 0.073 \quad 0.040]^T$

$c = 6.607$, $CR = 0.011$, and the weight calculation results pass the consistency test.

Using the steps outlined in Section 3.2, the suitability evaluation results for the reclamation of oil drilling platform temporary land were obtained as follows.

Table 1. Evaluation Results of the suitability for reclamation of temporary land for a certain platform's oil drilling platform

Reclamation programs	Positive ideal Solution distance (D+)	Negative ideal Solution distance (D-)	Composite score Index (C^-)	Ranking
paddy field	0.464	0.805	0.634	2
dryland	0.255	0.887	0.777	1
garden plot	0.563	0.569	0.503	3
forest land	0.980	0.200	0.170	4

The results show that the temporary land for the oil drilling

platform of this platform is suitable for development as dry land. In order of suitability, it is paddy fields, garden plot and forest land.

5. Conclusion

Centered on the dual carbon goals, this study aims to establish an evaluation framework and methodology for the reclamation suitability of oil drilling platform temporary land. Firstly, integrating land reclamation standards and engineering practices, an evaluation system was constructed, encompassing six indicators. The AHP was adopted for indicator weight assignment. Subsequently, based on these six indicators, the TOPSIS model was utilized to conduct a comprehensive evaluation of four reclamation directions. Finally, an empirical analysis was performed with a drilling platform in Sichuan province as a case study. Results indicate that the optimal reclamation direction for this plot is dry land, a conclusion driven by the combined effect of multiple indicators. Among them, soil organic matter, effective soil layer thickness, and topographic slope rank top three in weight and serve as the key factors influencing reclamation decisions.

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