

PAPER • OPEN ACCESS

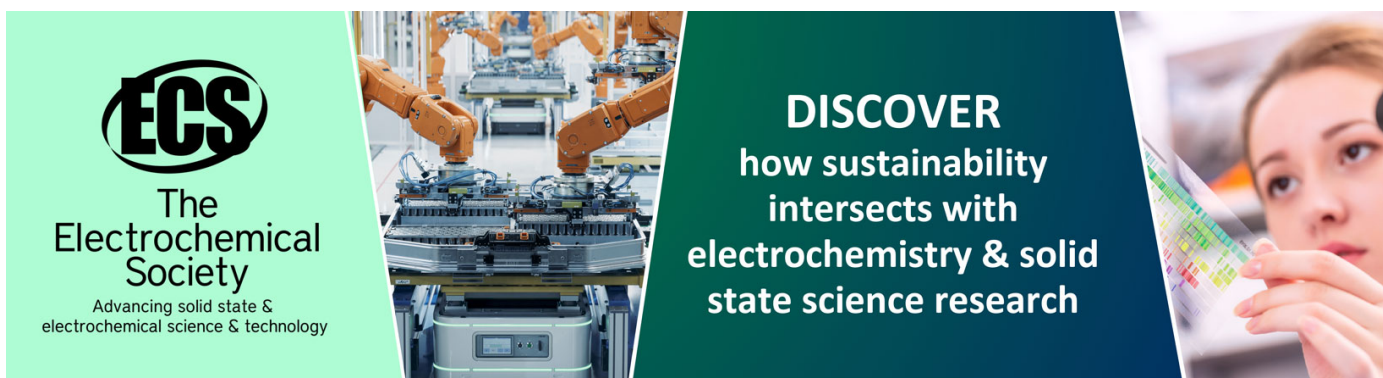
Evaluation Of Soil Ecological Benefits Of Japonica Rice In Southern Liaoning Based On AHP And Energy Analysis

To cite this article: Zhongyu Jin *et al* 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **508** 012099

View the [article online](#) for updates and enhancements.

You may also like

- [Study on the photocatalytic and antibacterial properties of silver nanoparticles synthesized by a green approach](#)
J Luis López-Miranda, J A Cervantes-Chávez, A R Hernández-Martínez et al.
- [First Report of Aspergillus Leaf Spot on Loquat \(*Eriobotrya japonica*\) Caused by *Aspergillus fumigatus* in Iraq](#)
Noor A. Al-Ghazali, Zainab L. Hameed and Ahmed B. Abu-Duka
- [Characteristics and Application Analysis of Traditional Chinese Medicine Containing *Sophora Japonica*](#)
Zhenzhen Wei, Suxiang Feng, Xiaoyan Fang et al.



ECS
The
Electrochemical
Society
Advancing solid state &
electrochemical science & technology

DISCOVER
how sustainability
intersects with
electrochemistry & solid
state science research

Evaluation Of Soil Ecological Benefits Of Japonica Rice In Southern Liaoning Based On AHP And Energy Analysis

Jin Zhongyu¹, Sun Yizhe¹, Yang Ping^{12*}

¹ College of Information and Electrical Engineering, Shenyang Agricultural University, Shenyang, 110866, China;

² Liaoning Agricultural Information Technology Center, Shenyang 110866, China)

* Corresponding author: Yang Ping xdx7128@126.com 13664184401

Abstract. In this paper, the ecological benefit evaluation of Panjin japonica rice in south Liaoning was carried out. Based on the Analytic Hierarchy Process (AHP) and energy value analysis, the ecological benefits of japonica rice soil were evaluated from the aspects of organic matter, alkali-hydrolyzed nitrogen, rapidly available potassium and rapidly available phosphorus. The results show that the comprehensive evaluation index of soil is stable when the integrated technology is used to achieve the purpose of increasing yield and efficiency. It indicates that the ecological benefit evaluation method proposed in this paper is an effective and scientific method, which can be used for soil ecological benefit evaluation and has a profound significance for land ecological research.

1. Introduction

In the process of food production, the use of various technologies to achieve the purpose of high yield and efficiency, while also to make the land resources can be sustainable use, therefore the protection of soil resources is imperative. In the project of "grain abundance during the 13th five-year plan", south Liaoning (hereinafter referred to as "southern Liaoning") adopted the matrix half-pot seedling nitrogen efficient mechanized cultivation technology to achieve japonica rice yield and efficiency. At the same time, the technology needs to continue to develop steadily. From the analysis of the cruel reality of ecological crisis, it is concluded that the ecological values of harmonious coexistence between man and nature must be established and a new scientific ecological value theory should be constructed [1]. It will not only increase production but also make the technology sustainable and keep the ecological environment intact. As secretary Xi Jinping has said, "green mountains and clear water are mountains of gold and silver." According to AHP and the method of energy value analysis, the ecological benefit evaluation in the implementation of the technology is carried out [2]-[6].

2. Study Area Overview

Area test site is located in the southwest of Liaoning province Panjin merchant TangJia Town LiuJia Village saline-alkali land use in Liaoning province institute of experimental base (41 ° 02 'N, 122 ° 10' E), the region with rainfall and sufficient sunshine, frost-free period is long, the characteristics of accumulated temperature high, heavy, soil barren, salt and alkali, replace with out-soil seedlings cultivation soil, rice blast happened frequently, lodging is serious, the phenomenon of low utilization rate of nitrogen fertilization and excessive, adopted for the region "to soil fertility, salinity, art detract from, scale mechanization" synergistic technology route, technology and integrated high efficiency



models, That is, rice machine transplanting technology, half pot blanket/hemp film seedling technology, rice nitrogen fertilizer efficient light simple application technology, autumn pulping straw returning to the field technology, rice mechanization and other aspects of the application of technology. From this paper, ecological benefit evaluation is carried out for the land in the part of seedling cultivation in the implementation technology mode, and the main factors of land evaluation are selected for research, and ecological benefit evaluation is carried out according to the final research and analysis results.

3. Selection Of Evaluation Methods

Through consulting experts and going to the grass-roots level to listen to the opinions of researchers, AHP and energy value analysis are combined to better evaluate the ecological benefits of japonica rice soil. AHP was used to determine the weight of the index layer and each evaluation factor, the solar energy value of each single index and its corresponding weight value were multiplied, and the calculated values of all selected japonica rice soil ecological benefit evaluation factors were summed up to calculate the comprehensive index of japonica rice soil ecological benefit evaluation index.

3.1. Energy Value Analysis

Energy value analysis was developed in the 1980s by a team led by H.T.Odum, a prominent American ecologist. It defines energy value as the amount of energy of another kind contained in one kind of flowing or stored energy [7]. Energy value is the value of solar energy it has, in solar joule (sej). The practical application is the solar value conversion rate, that is, a unit of energy or material equivalent to multiple solar joules of energy conversion [8]. This method converts different types of energy substances into energy values through the conversion rate of energy values, thus transforming the problem into a problem that can be addressed by data and quantitatively analyzed [9]. Energy value analysis is used in quantitative analysis, which provides a new research method for the measurement and comparison of ecological and economic systems, and establishes a common measurement standard for the expression of environmental resources.

According to the principle of selecting evaluation factors by the material through the energy conversion and unified to value, the total output can remove all purchase value can be worth to natural environment system free energy input, japonica rice soil free energy is the difference between the before and after the application of technology for the japonica rice soil ecological benefits, by energy value/ currency rate into Energy value - monetary value [7] .

See the following formula for details:

$$U = m \times T_r \quad (1)$$

In the formula: U stands for energy; m stands for mass; T_r is the conversion rate.

$$UF = \sum_{i=1}^a UT_i - \sum_{i=1}^b UC_i \quad (2)$$

In the formula: UF is the unpaid energy input;

UT_i represents the output of ecological benefit evaluation factor energy value;

UC_i is the energy input;

a represents the number of selected ecological benefit evaluation factors;

b stands for the number of energy categories.

$$P = (UF_2 - UF_1) \quad (3)$$

In the formula: P represents the increase of soil ecological benefit energy value by using technology;

UF_2 represents the amount of unpaid energy input before the use of soil technology;

UF_1 represents the amount of unpaid energy input after the use of soil technology.

3.2. AHP

AHP is adopted to determine the weight of evaluation factors, which has good logic, conciseness and practicability[10]-[11].

AHP is an evaluation method combining qualitative analysis and quantitative calculation proposed by American operations research scientist Thomas seti in the mid-1970s[12]-[15]. It divides the parameters related to the decision result into target level, criterion level and result level, in which criterion level is divided into primary index and secondary index, calculates the importance of different indexes, combines different elements according to the membership relation, and forms a multi-level evaluation model[1].

Suppose that for an evaluation objective h , there are n influencing factors $P_i (i = 1, 2, \dots, n)$, and the weight of importance of P_i is $w_i (i = 1, 2, \dots, n)$, respectively. In which the:

$$\sum_{i=1}^n w_i = 1 \quad (w_i > 0) \quad (4)$$

$$h = w_1 P_1 + w_2 P_2 + \dots + w_i P_i = \sum_{i=1}^n w_i P_i \quad (5)$$

Due to the influence of factor P_i on the target h (the importance weight) is not the same, so compare two P_i , n elements can be obtained on the importance of the target weight ratio (the relative importance) matrix consisting of A :

$$A = (a_{ij})_{n \times n} \quad (6)$$

Where A is called judgment matrix, which satisfies the following properties:

- ① $a_{ii} = 1 (i = 1, 2, \dots, n)$;
- ② $a_{ij} = \frac{1}{a_{ji}} (i, j = 1, 2, \dots, n)$;
- ③ $a_{ij} = \frac{a_{ik}}{a_{jk}} (i, j, k = 1, 2, \dots, n)$;

Where ③ is called the complete consistency condition of A .

According to the following formula, the important weights of n factors of objective h are obtained by solving the eigenvalue problem, that is, the normalized eigenvector is obtained by $AW = \lambda_{\max} \times W$.

$$AW = (a_{ij})_{n \times n} \times (w_1, w_2, \dots, w_n)^T = \lambda \times (w_1, w_2, \dots, w_n)^T = \lambda W \quad (7)$$

In the formula: λ is an eigenroot of A , $W = (w_1, w_2, \dots, w_n)^T$ is the eigenvector corresponding to A . Due to the complexity of objective things or one-sided understanding of things, it is necessary to conduct consistency and randomness test on the judgment matrix to determine whether the eigenvector (weight) obtained by the judgment matrix is reasonable. The test formula is:

$$CR = CI / RI \quad (8)$$

In the formula: CR represents the random consistency ratio of the judgment matrix;

CI represents the consistency index of judgment matrix,

Calculated from the following formula:

$$CI = \frac{1}{m-1} (\lambda_{\max} - m) \quad (9)$$

$\lambda_{\max}$ represents the largest characteristic root;

m stands for order of judgment matrix;

RI represents the average of the judgment matrix to perform the index.

RI is given by a large number of experiments. For the low-order judgment matrix, the values are listed in table1.

Table 1.The Average Random One-time Index Value Table Of AHP[16]

m	1	2	3	4	5	6	7	8	9	10	11
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51

When $CR < 0.1$ in formula(8), the judgment matrix is considered to have satisfactory consistency[17], indicating that weight distribution is reasonable. Otherwise, the judgment matrix needs to be adjusted until a satisfactory value is obtained[18].

4. Establishment Of Ecological Benefit Evaluation Index System

4.1. Select Evaluation Factor

Based on the principle of soil ecological environment evaluation index selection, appraisal factor according to the difference principle and operability principle, namely the evaluation factors in the use of technology before and after the change, no difference without evaluation, selection of soil evaluation factors should have the possibility of data collection and data to calculate the evaluation index system should reflect the japonica rice high efficiency before and after the technology to test the influence of the base of the ecological environment, can reflect the intensity of soil quality and ecological function of factors as evaluation factors.

Total nitrogen, total phosphorus and total potassium refer to the available and unusable nitrogen, phosphorus and potassium contained in soil, which have little correlation with soil fertility. However, alkali-hydrolyzed nitrogen, available phosphorus and available potassium refer to nitrogen, phosphorus and potassium that can be directly and quickly used by plants or directly used after simple transformation, and have a greater correlation with soil fertility. Soil organic matter is the most active part of soil and the foundation of soil fertility. Therefore, organic matter, alkali-hydrolyzed nitrogen, available phosphorus and available potassium were selected as evaluation factors.

4.2. Determine The Weight Of Evaluation Factors

According to the quality of the evaluation factor in the experiment, it is substituted into the AHP for calculation. Finally, the weight of the evaluation factor is obtained, as shown in the figure1.

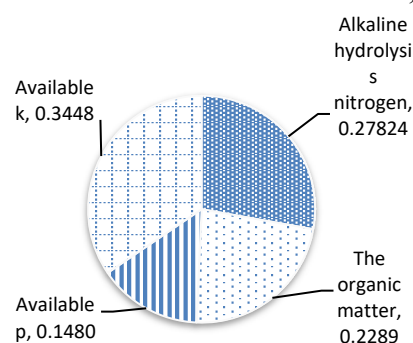


Figure 1.The AHP Weight Figure

4.3. Calculate The Ecological Benefit Evaluation Score

In japonica rice soil ecological benefit evaluation index set up complete, using AHP to the evaluation factor can value analysis, the quantitative value of each single factor and its corresponding weight value multiplication, and evaluation index of ecological environment of all elected to numerical and calculate the southern Liaoning japonica rice soil ecological benefit evaluation of composite index.

The quality of evaluation factors (raw data) in japonica rice soil was obtained.

According to the above two algorithms, the following formula can be obtained:

$$G = \sum_{i=1}^n w_i m_i T_i \quad (10)$$

In the formula: G stands for comprehensive evaluation index;

w_i is the weight of the factor;

m_i is the mass of the factor;

T_i represents the conversion rate of the solar value of the factor.

The factor mass and solar energy values are shown in table2.

Table 2 Original Data And Solar Energy Value Table

project	conversion rate of energy value (sej/g)	2017processed		2017unprocessed		2018processed		2018unprocessed	
		the original data (mg)	solar energy value (sej)	the original data (mg)	solar energy value (sej)	the original data (mg)	solar energy value (sej)	the original data (mg)	solar energy value (sej)
alkaline hydrolysis nitrogen	4.62×10^9	115.27	5.33×10^5	112.47	5.21×10^5	132.93	6.14×10^5	148.33	6.85×10^5
the organic matter	2.7×10^6	27059	7.31×10^6	25186	6.8×10^6	26686	7.21×10^6	26074	7.04×10^6
available P	1.78×10^{10}	58.82	1.05×10^6	74.40	1.32×10^6	45.32	8.07×10^5	52.26	9.3×10^5
available K	1.74×10^9	237.68	4.14×10^6	225.87	3.93×10^6	267.36	4.65×10^6	228.88	3.98×10^6

In the application of energy value analysis and AHP combined ecological benefit evaluation method, the original data are numerous, time-consuming and heavy workload. Using Java language of computer programming method, the ecological benefit evaluation method to compile algorithm, reduce a lot of work, make the ecological benefit evaluation method is more simple, is advantageous to the popularization and application of ecological benefit evaluation, the ecological benefit evaluation provides a new method, has a profound impact, ecological benefit evaluation methods of the core code is as follows:

```
import java.text.DecimalFormat;
import java.util.Scanner;
public class Test {
    final static double N = 0.27824;
    final static double P = 0.148;
    final static double K = 0.3448;
    final static double C = 0.2289;
    final static double NE = 4.62E9;
    final static double PE = 1.78E10;
    final static double KE = 1.74E9;
    final static double CE = 2.7E8;

    public double calculate(double n,double p,double k,double c) {
        double result = 0;
        result = n*N + p*P + k*K + c*C;
        return result;
    }
    public double calculate_sej(double m,double energy_conversion) {
        double result = 0;
        result = energy_conversion * m * 1E-3 ;
        return result;
    }
}
```

```

    }
    public static void main(String[] args) {
        Scanner scanner = new Scanner(System.in);
        System.out.print("Please enter the mass of N element per kg of soil (mg) :");
        double n = scanner.nextDouble();

        System.out.print("Please enter the mass of P element per kg of soil (mg) :");
        double p = scanner.nextDouble();

        System.out.print("Please enter the mass of K element per kg of soil (mg) :");
        double k = scanner.nextDouble();

        System.out.print("Please enter the mass of the organic matter per kg of soil
(mg) :");
        double c = scanner.nextDouble();
        scanner.close();
        Test test = new Test();
        double ne = test.calculate_sej(n, NE);
        double pe = test.calculate_sej(p, PE);
        double ke = test.calculate_sej(k, KE);
        double ce = test.calculate_sej(c, CE);

        ne = Double.valueOf(new DecimalFormat("#.##E0").format(ne));
        pe = Double.valueOf(new DecimalFormat("#.##E0").format(pe));
        ke = Double.valueOf(new DecimalFormat("#.##E0").format(ke));
        ce = Double.valueOf(new DecimalFormat("#.##E0").format(ce));

        double result = test.calculate(ne, pe, ke, ce);
        result = Double.valueOf(new DecimalFormat("#.##E0").format(result));
        System.out.println("The comprehensive evaluation index is " + result);
    }
}

```

All the soil factor related data measured in the experiment were calculated by using the program, and the final calculation results were as table3:

Table 3 Comprehensive Evaluation Result Table

	2017processed	2017unprocessed	2018processed	2018unprocessed
comprehensive evaluation index	3.52×10^6	3.32×10^6	3.48×10^6	3.42×10^6

5. Results And Discussion

According to the comprehensive evaluation index, in 2017 and 2018, after implementing the corresponding technology on japonica rice in the experimental base of saline and alkaline land utilization research institute of Liaoning province, the soil evaluation index after treatment was higher than that of untreated soil in the same year. At the same time, soil PH experiment:

The soil PH value processed in 2017 was 7.43, The PH value of unprocessed soil was 7.61.

The soil PH value processed in 2018 was 7.31. The PH value of unprocessed soil was 7.45.

It can be seen from both horizontal comparison and vertical comparison that the use of technology is beneficial to the reduction of PH value and the acid-base balance of soil in southern Liaoning. It not only achieves the purpose of increasing yield and efficiency, but also improves the utilization efficiency of water resources and fertilizer, improves the soil quality, and realizes environmental friendly and effective improvement of soil environment.

In this paper, AHP is used to determine factor weights in the evaluation process, and qualitative and quantitative analysis methods are effectively combined through energy value analysis. The scientific and effective evaluation of ecological benefit was strengthened, and the important indexes of soil before and after the application of comprehensive technology were evaluated respectively. It can not only reflect the feasibility of evaluation factors and evaluation process, but also reduce the influence of individual subjectivity. On the basis of traditional ecological benefit evaluation, a quantitative evaluation method of ecological benefit by combining energy value analysis and AHP is proposed. This method was demonstrated in the experimental base of the institute of saline-alkali land in Liaoning province. The results show that the ecological benefit evaluation method proposed in this paper is an effective and scientific method, which can be used to evaluate the ecological benefit of soil after using a certain technology, and it has a profound significance for land ecological research.

Acknowledgments

Fund program: “The 13th five-year plan” National key R&D Program of China (2018YFD0300300, 2018YFD0300309)

References:

- [1] Yu Huifang, Zou Ge. Evaluation method of implementation benefits of planning and design technical standards based on analytic hierarchy process [J]. *China equipment engineering*, 2019, pp 176-178.
- [2] Sun Song. Comprehensive evaluation of productivity and ecological and economic benefits of double cropping system and triple cropping system in rice field [D]. Jiangxi agricultural university, 2017.
- [3] Lan Shengfang, admiration. Energy value analysis of ecosystem [J]. *Chinese journal of applied ecology*, 2001(01), pp 129-131.
- [4] Liu Wei. Analysis of ecological economic benefits of three-dimensional planting and raising efficient farmland in north China [J]. *Agricultural technology and economy*, 1999(01), pp 64-65.
- [5] Wang Xiaoke, Yang Ning, Wu Fan, Ren Yufen, Wang Siyuan, Bo Guimin, Jiang Gaoming, Wang Yukuan, Sun Yujun, Zhang Lu, Ouyang Zhiyun. Ecological benefits and characteristics [J]. *Acta ecologica sinica*, 2019, 39(15), pp 5433-5441.
- [6] Yin Bing. Study on ecological benefit evaluation of farmland consolidation [J]. *Modern agriculture*, 2019(02), pp 63-65.
- [7] Chang Chun, Jin Xiaobin, Zhan Wei, Zhou Yinkang. Evaluation method and empirical study on ecological benefits of land consolidation based on energy value theory [J]. *Henan science & technology*, 2009, 27(07), pp 857-861.
- [8] Yang Bingshan. Theory and application of energy value analysis [D]. Northeast normal university, 2006.
- [9] Guo Rui, Sun Haili. Research progress of the analysis method of energy energy in agroecosystem [J]. *Agriculture and technology*, 2015, 35(12), p 19.
- [10] Wang Tao, Wang Deping, Jiang Yudong, Peng Hao. Study on factors influencing planting area of crops in base period based on AHP method [J/OL]. *Hubei agricultural sciences*, 2019(18), pp 1-4
- [11] Li Lihong, Ma Liqiang, Li Zhongcai. Evaluation of land health in Shandong province based on analytic hierarchy process [J]. *Land and natural resources research*, 2019(04), pp 42-43.
- [12] Li c b, Yang J y. evaluation of distributed energy system based on grey relation of ahp-dea [J]. *Modern commercial industry*, 2019, 40(26), pp 215-218.
- [13] Su Shenglin. Comprehensive benefit impact evaluation of irrigated areas based on AHP method [J]. *Heilongjiang water conservancy*, 2017, 3(12), pp 47-49.
- [14] Han l, Mei q, Lu y m, Ji m. Analysis and research on ahp-fuzzy comprehensive evaluation method [J]. *Chinese journal of safety science*, 2004(07), pp 89-92+3.

- [15] Zhu Yin, Meng Zhiyong, Kan Shuyu. Weight calculation by analytic hierarchy process [J]. *Journal of north traffic university*,1999(05), pp 119-122.
- [16] Xiaofan Jiang.Study on Construction Science & Technology Development using AHP-SWOT Method[A]. Proceedings of 2015 2nd International Conference on Education,Management and Computing Technology(ICEMCT 2015)[C].Computer Science and Electronic Technology International Society,2015:6.
- [17] Yingchen WANG, Yonghao SUN, Xiaoxiao GENG, Xuyan WU. Research of AHP Model on Combination between the Social Responsibility and the Economic Benefits in Corporation[A]. Engineering Technology Press, Hong Kong 、 Intelligent Information Technology Application Association, Hong Kong.2008 International Seminar on Business and Information Management Volume 2[C].Engineering Technology Press, Hong Kong、 Intelligent Information Technology Application Association,2008:4.
- [18] Yu Na. Study on ecological benefit evaluation of land development and consolidation [D]. *Nanjing agricultural university*,2008.