Economic evaluation model of greenhouse soil information collection technology based on fuzzy comprehensive evaluation

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Abstract. The purpose of soil information collection is to grasp the real-time status of soil, which is of great significance to improve the yield and quality of crops and improve the ecological environment. The purpose of this paper is to build a comprehensive benefit evaluation model of soil information collection technology based on the fuzzy comprehensive evaluation of the economy of greenhouse soil information collection technology. The experimental results show that in terms of economic and environmental benefits, the scores of wired communication technology and wireless acquisition technology are average and good respectively. In terms of social benefits, the scores of wired communication technology and wireless acquisition technology are good and excellent respectively, the scores of comprehensive benefits of wired communication technology and wireless acquisition technology are general and good respectively, and the membership degrees of corresponding grades are 0.4144 and 0.5898 respectively.

Keywords: Wireless Sensor, Greenhouse Soil, Fuzzy Comprehensive Evaluation, Economic Evaluation Model

1. Introduction

In modern precision agriculture, the collection of agricultural environmental information is particularly important[1]. In general precision agriculture, a large number of environmental information such as weather, temperature, humidity and so on need to be collected[2-3]. Because of the diversity of the environment, and different crops have different requirements for the environment, it is particularly suitable to use wireless sensor network to build the corresponding monitoring system[4-6]. It is very important to study the economic evaluation model of greenhouse soil information collection technology for improving the overall economy of wireless sensor network[7].
Jiang J used AHP and entropy weight method to evaluate the weight of each criterion and corresponding sub criteri\textsuperscript{[8]}. Sujithra T proposed a multi model data acquisition and hardware setting system. By using wireless sensor remote sensing technology, environmental data such as macro nutrients (n, K, P), pH value and water content of soil were collected\textsuperscript{[9]}. Zhang Q applied the fuzzy comprehensive evaluation method (FCEM) to tee, and established the evaluation index system of tee based on AHP, and introduced the concept of fuzzy optimization\textsuperscript{[10]}. At present, the research of low-power wireless sensor nodes has made great progress, which will promote the further application of sensors. Based on the characteristics of wireless sensor technology, this paper constructs an evaluation index system and evaluation method to evaluate its comprehensive economic benefits, taking full account of its horizontal and vertical factors. The results show that the evaluation model is scientific and feasible.

2. Proposed Method

2.1. ZigBee Technology

ZigBee protocol is the most widely used protocol in wireless sensor network, ZigBee network can only have three kinds of nodes. The functions of each type of node are as follows: coordinator: no matter which ZigBee network topology, there must be one and only one co coordinator node in the network. The main function of coordinator node is to initialize the network and manage the whole network. Routing: the main function of a routing node is to forward information between nodes. Terminal: the main function of terminal node is to send and receive information. ZigBee network can realize three types of network topology: star, tree and network.

2.2. Fuzzy Sets

U is a domain, element X is an element in domain u, and a is an attribute. The element with attribute a can form a set a = \{x / a (x)\}. In the traditional set theory, the element either has the attribute or does not have it, that is a (x) = 1 or 0, a (x) is called the characteristic function.

In fuzzy set theory, the characteristic function can take any value between 1 and 0, which is called membership function. In order to distinguish from traditional set theory, µ(x) is defined as membership function, that is µ(x) ∈ [0,1]. The higher the value of µ(x) is, the higher the membership degree of X belongs to A. on the contrary, the lower the value of µ(x) is, the lower the membership degree of X belongs to a.

The representation of fuzzy sets is as follows:

\[ A = \frac{x_1}{\mu(x_1)} + \frac{x_2}{\mu(x_2)} + ... + \frac{x_n}{\mu(x_n)} \]  \hspace{1cm} (1)

Among them, elements with membership degree of 0 can be omitted.

The logical operation of fuzzy set is different from that of ordinary set. For element x, set a, B, membership degree Union, intersection and redundancy are defined as follows:
\[
\begin{align*}
\mu_{A \cup B}(x) &= \max[\mu_A(x), \mu_B(x)] \\
\mu_{A \cap B}(x) &= \min[\mu_A(x), \mu_B(x)] \\
\mu_{-A}(x) &= 1 - \mu_A(x)
\end{align*}
\] (2)

3. Experiments

3.1. Qualitative Indicators

The soil samples are mainly brown soil and cinnamon soil, followed by tidal soil, and the sampling area is brown soil. Before and after each irrigation, the soil samples were taken at the depth of 0 ~ 5, 5 ~ 10, 10 ~ 20, 20 ~ 30, 30 ~ 40, 40 ~ 60 cm in each treatment membrane. The soil moisture content was measured by soil drying method, and the soil salt content was measured by conductivity meter. The principle for determining the qualitative indexes of the comprehensive benefit evaluation model is shown in Table 1.

**Table 1.** Determination principles of qualitative indicators

| Evaluation level | Excellent | Preferably | Commonly | Difference | Range |
|------------------|-----------|------------|----------|------------|-------|
| V1               | 0.70      | 0.30       | 0        | 0          | 0     |
| V2               | 0.25      | 0.50       | 0.25     | 0          | 0     |
| V3               | 0         | 0.25       | 0.50     | 0.25       | 0     |
| V4               | 0         | 0          | 0.25     | 0.50       | 0.25  |
| V5               | 0         | 0          | 0        | 0.30       | 0.70  |

4. Discussion

4.1. Construction of Evaluation Model

The specific steps of the comprehensive benefit evaluation model of wireless sensor technology constructed in this paper are as follows:

Using analytic hierarchy process to calculate the weight of each index, the evaluation system is divided into four levels: index level (d), sub criterion level (c), criterion level (b), target level (a). The fuzzy membership degree of each index is determined by establishing membership degree equation. The membership equation selected in this paper makes the adjacent evaluation level smooth transition, avoiding the disadvantages of too large or not obvious change of boundary value.

According to the principle of maximum membership degree, the corresponding sub criteria level is evaluated. The evaluation methods of criteria level and target level are also evaluated according to this method. The input fuzzy evaluation results are shown in Table 2.

**Table 2.** Fuzzy comprehensive evaluation results of soil information collection technology input

| Evaluation objectives | Soil information collection technology | Membership matrix | Evaluation results |
|-----------------------|----------------------------------------|--------------------|--------------------|
According to the principle of maximum membership, the comprehensive benefits of wired communication technology and wireless soil information collection technology are evaluated by using the two-level fuzzy evaluation model. The results show that: (1) In terms of investment, the maximum membership degree of wired communication in the range level is 0.3333, while the maximum membership degree of wireless soil information collection technology in the poor level is 0.4359. Wireless collection technology can greatly improve the efficiency of greenhouse soil information collection and liberate the labor force. At the same time, the relatively large investment of its equipment is the reason to lower its score. Although the investment of wired communication equipment is small, its greenhouse utilization efficiency is very low. (2) In terms of promotion effect, the maximum membership degree of wired communication in general level is 0.5, and the maximum membership degree of wireless acquisition in better level is 0.3742, as shown in Figure 1. Although the cost of wireless acquisition limits its promotion, it has good application effect, and the best promotion effect is wireless acquisition, which differs from wired communication by more than one level.

| Investment | Wired communication | Wireless acquisition |
|------------|---------------------|---------------------|
| Poor       | [0,0,0.3333,0.222,0] | [0.0449,0.2743,0.2949,0.4359,0] |

**Figure 1.** Fuzzy comprehensive evaluation results of the promotion effect of soil information collection technology

### 4.2. Economic Benefit Evaluation

In terms of economic and environmental benefits, the scores of wired communication technology and wireless acquisition technology are average and good, as shown in Figure 2. In terms of social benefits, the scores of wired communication technology and wireless acquisition technology are good and excellent respectively, the scores of comprehensive benefits of wired communication technology and wireless acquisition technology are general and good respectively, and the membership degrees of corresponding grades are 0.4144 and 0.5898 respectively.
Figure 2. Fuzzy comprehensive evaluation results of economic benefits of soil information collection technology

5. Conclusion

Based on the research of the application of wireless sensor in agricultural environment information collection, this paper takes the comprehensive evaluation of wireless sensor network economy as the goal, and makes active exploration from ZigBee technology and fuzzy set comprehensive evaluation, and combines the research and application project of key technology of soil information collection in Greenhouse of M city, In the aspect of fuzzy comprehensive evaluation, the research of economic evaluation model is carried out. The main research results of this paper are as follows: in the aspect of economic and environmental benefits, the scores of wired communication technology and wireless acquisition technology are general and good respectively.

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References

[1] Robinson N J , Dahlhaus P G , Wong M , et al. Testing the public–private soil data and information sharing model for sustainable soil management outcomes[J]. Soil Use and Management, 2019, 35(1):94-104.

[2] Chao W , Ping J , Xiaoxing W , et al. Risk Assessment Study of the Intelligent Transportation Project Based on Fuzzy Comprehensive Evaluation Method——A Case Study of the Intelligent Transportation Project of A Company in Chaling City[J]. Journal of Hunan Institute of Engineering, 2016, 78(5):648-653.

[3] Ningbo Wang, Zhihong Li, Jiajiao Wu. The Potential Geographical Distribution of bactrocera Dorsalis (Diptera: Tephrididae) in China Based on Emergence Rate Model and Arcgis[J]. Ifip advances in information & communication technology, 2016, 393(1):334-342.

[4] Abel Wadoufey, Paul Dayang, Albert Ngakou. Monitoring An Experimental Field Through A
WebMapping Technology[J]. international journal of computer, 2016, 22(1):20-28.

[5] E, Lehiste H , Kiik M , et al. Soil sampling automation using mobile robotic platform[J]. Agronomy Research, 2018, 16(3):917-922.

[6] Zhou R , Chan A H S . Using a fuzzy comprehensive evaluation method to determine product usability: A test case[J]. Work, 2017, 56(1):21-29.

[7] Xie Q , Ni J Q , Su Z . Fuzzy comprehensive evaluation of multiple environmental factors for swine building assessment and control[J]. Journal of Hazardous Materials, 2017, 340(oct.15):463-471.

[8] Jiao J , Ren H , Sun S . Assessment of surface ship environment adaptability in seaways: A fuzzy comprehensive evaluation method[J]. International Journal of Naval Architecture & Ocean Engineering, 2016, 8(4):344-359.

[9] Sujithra T , Durai S , Thanjaivadivel M . Measuring macro nutrients of the soil for smart agriculture in coconut cultivation[J]. International Journal of Civil Engineering & Technology, 2017, 8(9):768-776.

[10] Zhang Q , He D . The application of analytic hierarchy process and fuzzy comprehensive evaluation method for the evaluation of enterprise training effectiveness[J]. International Journal of Computational Science and Engineering, 2017, 14(2):126.