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Comprehensive Evaluation on the Agricultural Sustainable Development with the Smallest Generalized Deviation

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Abstract Evaluation index system of agricultural sustainable development is constructed with the four components of social index, agricultural economic index, resources index, and environment index. According to the comprehensive evaluation model of agricultural sustainable development with the participation of single person, comprehensive evaluation model of agricultural sustainable development with the smallest generalized deviation and the participation of many people is established. Based on the case studies, agricultural sustainable development status of a certain region is evaluated. Result shows that the evaluation scores of the social index and agricultural economic index are high in this region, but the score of resources index is general and the evaluation result of environment index is not very good. The comprehensive evaluation value of overall sustainable development is 0.665 5; and the evaluation result is "good".

Key words Model with the smallest generalized deviation, Sustainable development, Comprehensive evaluation, China

Sustainable development seeks for the sustained and coordinated development of society, economy and ecology. Among them, sustainable development of ecology is the foundation; sustainable development of economy is the condition; and sustainable development of society is the objective. In the middle 1980s, with the combination of agricultural development and the theory and concept of sustainable development, the concept of agricultural sustainable development has gradually formed. With the development of sustainability, its concept constantly evolves. In the *Agriculture and the Environment Conference* held in Holland in the year 1991, it was pointed out that the three objects of agricultural sustainable development are as follows: firstly, actively increase grain output, and stabilize grain supply. Secondly, greatly promote the comprehensive development of agriculture, expand the rural employment, and increase farmers' income. Thirdly, rationally utilize the natural resources, protect ecological environment, and create conditions for the human survival and development[1]. The way to evaluate the sustainable development of agriculture in a region or a country should firstly establish an evaluation index system, then select corresponding evaluation method. This research analyzes the evaluation index system of agricultural sustainable development. According to the subjectivity and preference in independent evaluation, evaluation information acquisition model with the smallest generalized deviation and the participation of many people is put forward. Finally, the status of agricultural sustainable development in a given region is analyzed, and the evaluation result is "good".

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1 Evaluation index system of agricultural sustainable development

People obtain the resources and energy for development through the activity of agricultural production, and then release wastes to the environment through production and consumption. At the same time, the quality of resources and environment affects the acquisition and emission of people. In order to obtain more resources and energy from the environment, people use a series of countermeasures. These activities constitute the four systems of society, economy, resource and environment in agricultural sustainable development[2]. Therefore, considering the agricultural sustainable development, we should investigate on the coordination degree of the four systems during this period, and evaluate the coordination development degree by a series of indices system. According to the meaning of agricultural sustainable development, the evaluation index system of agricultural sustainable development capacity should consist of four parts[1-3]. Firstly, social index mainly evaluates the sustainable development of rural society from the aspects of population scale, change trend, farmers' quality and living quality in rural areas. Secondly, agricultural economic index evaluates the sustainable development capacity of agricultural economy mainly from the aspects of rural industrial structure status, agricultural management effect, agricultural management mode, agricultural modernization degree and so on. Thirdly, resources index evaluates the sustainable development of agriculture mainly from the quality and quantity of natural resources in agricultural production. Fourthly, environmental index is not only an important sign of evaluating the sustainable development, but also is an important index reflecting the coordination degree of society, economy, resource and environment.

2 Comprehensive evaluation method for the agricultural sustainable development with the smallest generalized deviation

2.1 Comprehensive evaluation model of agricultural sustainable development with the participation of single person The comprehensive evaluation model usually used is based on the participation of single person. Comprehensive evaluation model of agricultural sustainable development with independent decision – maker is the simple weighted[3]:

$$Development = A \times W_1 + B \times W_2 + C \times W_3 + D \times W_4$$

where *Development* is the comprehensive evaluation value of agricultural sustainable development, A, B, C, D are the social index, agricultural economic index, resources index, and environment index, respectively, and W_i ($i = 1, \cdots, 4$) is the weighted value of A, B, C, D. Fig. 1 illustrates the major evaluation process.

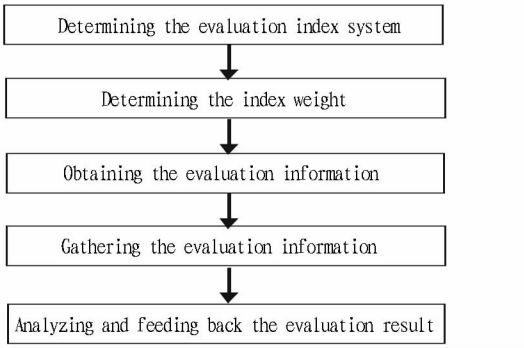

Fig. 1 Evaluation process of agricultural sustainable development

This evaluation model is widely applied, but has only the participation of independent decision-maker with strong subjectivity and personal preference. Thus, the evaluation result is not usually rational. However, the comprehensive evaluation of agricultural sustainable development with participation of many people can integrate the evaluations of experts in various disciplines, and utilize the advantages of all the experts to carry out scientific and rational evaluation. Thus, the evaluation results are more credible. And the comprehensive evaluation model of agricultural sustainable development with the participation of many people is the major research focus of agricultural sustainable development.

2.2 Comprehensive evaluation model of agricultural sustainable development with the smallest generalized deviation and the participation of many people During the comprehensive evaluation of agricultural sustainable development with the participation of many people, the final evaluation value of the group should have small differences with the evaluation result of independent expert. In other words, the deviation between the evaluation value of the ith expert and the final evaluation vector is the smallest. Assuming that the final comprehensive evaluation vector of group experts is $B = (b_1, b_2, b_3, b_4)$ and the evaluation value of the jth index by the ith expert is a_{ij}, the following model for expert comprehensive evaluation information is established:

$$\min J = \sum_{i=1}^{m} [h_i \sum_{j=1}^{4} (a_{ij} - b_j)^{\alpha}]$$

where expert weight is $h = (h_1, \cdots, h_m)$, and index weight is $w = (w_1, \cdots, w_4)$. Parameter α can be selected within $1 - \infty$ according to the personal preferences. According to the different parameters α, the comprehensive evaluation information with the smallest generalized deviation determines that the model can be changed as follows:

When $\alpha = 1$, the model can be simplified as

$$\min J = \sum_{i=1}^{m} [h_i \sum_{j=1}^{4} | a_{ij} - b_j |]$$

When $\alpha = 2$, the model can be simplified as

$$\min J = \sum_{i=1}^{m} [h_i \sum_{j=1}^{4} (a_{ij} - b_j)^2]$$

The model is the evaluation information determination model with the smallest square sum of the relative error.

When $\alpha = \infty$, the model can be simplified as

$$\min J = \sum_{i=1}^{m} [h_i \max_{j=1, \cdots, 4} | a_{ij} - b_j |]$$

where $\max_{j=1, \cdots, 4} | a_{ij} - b_j |$ refers that the maximum value of $| a_{ij} - b_j |$ is selected when $j = 1, 2, 3, 4$.

When $1 < \alpha < \infty$, the model can be simplified as

$$\min J = \sum_{i=1}^{m} [h_i \sum_{j=1}^{4} (a_{ij} - b_j)^{\alpha}]$$

This model is used to solve the problems. Thus, the evaluation values under different evaluation indices by group experts are obtained, that is, comprehensive evaluation vector is $B = (b_1, b_2, b_3, b_4)$. Then, the comprehensive evaluation model of is used to obtain the final group comprehensive evaluation value:

$$Development = b_1 \times w_1 + b_2 \times w_2 + b_3 \times w_3 + b_4 \times w_4$$

3 Evaluation and trend analysis of agricultural sustainable development

A total of five experts are invited to evaluate the status of rational agricultural sustainable development. Fuzzy judgment set of " extremely good" , " very good" , " relatively good" , " general" , " relatively poor" , " poor" , " very poor" and " extremely poor" is selected. Table 1 reports the comparison between triangular fuzzy number and fuzzy language.

Table 1 Comparison between fuzzy language and triangular fuzzy number

Fuzzy language	Triangular fuzzy number	Fuzzy language	Triangular fuzzy number	Fuzzy language	Triangular fuzzy number
Extremely good	(0.8,0.9,1)	Relatively poor	(0.3,0.4,0.5)	Relatively good	(0.5,0.6,0.7)
Very good	(0.7,0.8,0.9)	Poor	(0.2,0.3,0.4)	General	(0.4,0.5,0.6)
Good	(0.6,0.7,0.8)	Very poor	(0.1,0.2,0.3)	Extremely poor	(0,0.1,0.2)

It is assumed that the weight of the 5 experts is $h = (0.1, 0.25, 0.30, 0.15, 0.2)$. The experts are invited to compare the importance of four evaluation indices. Then, the complementary judgment matrix R is obtained:.

$$R=\begin{bmatrix}0.5 & 0.4 & 0.6 & 0.7\\ 0.6 & 0.5 & 0.7 & 0.8\\ 0.4 & 0.3 & 0.5 & 0.6\\ 0.3 & 0.2 & 0.4 & 0.5\end{bmatrix}$$

Table 2 reports the evaluation information of the 5 experts.

Table 2 The evaluation information of experts

Expert	Social index	Agricultural economic index	Resources index	Environment index
1	0.9	0.8	0.5	0.6
2	0.7	0.9	0.8	0.4
3	0.5	0.7	0.5	0.5
4	0.9	0.7	0.6	0.7
5	0.6	0.8	0.7	0.5

Firstly of all, based on the complementary judgment matrix, the weight vector of the four evaluation indices is $w=(0.27, 0.31, 0.23, 0.19)$.

The model with the smallest generalized deviation is used to calculate the comprehensive evaluation information of group experts. Parameter $\alpha=2$ is selected:

$$\min J=\sum_{i=1}^{5}[h_i\sum_{j=1}^{4}(a_{ij}-b_j)^2]$$

After introducing the weight vector of expert and the evaluation information into this model, the comprehensive information vector of group expert is

$$B=(0.670\,0, 0.780\,0, 0.630\,0, 0515\,0)$$

After concentrating the comprehensive information of group experts, the comprehensive evaluation value of regional agricultural sustainable development is obtained:

$$Development=0.670\,0\times0.27+0.780\,0\times0.31+0.630\,0\times0.23+0.515\,0\times0.19=0.665\,5$$

The comprehensive evaluation value is introduced into the fuzzy judgment set of "extremely good", "very good", "relatively good", "general", "relatively poor", "poor", "very poor" and "extremely poor" to calculate the membership degree. Thus, the evaluation value belongs to "relatively good" with its membership degree being 0.334 5. The membership degree of "good" is 0.655; and the membership degrees of other fuzzy judgment sets are all 0. According to the principle of maximum membership degree, it can be concluded that the comprehensive evaluation result of regional agricultural sustainable development is "good".

According to the expert evaluation on regional agricultural sustainable development, both the social index and agricultural economic index have relatively high evaluation, but the evaluation result of environment index is not idea. Thus, the overall sustainable development result is only "good", but can not reach the "very good" or "extremely good". During the late period of development, agricultural development of this region should improve the environment index, pay attention to the health status of rural drinking water, pesticide application degree and so on, and make the agricultural sustainable development in this region reach a higher level.

4 Conclusion

The "Three Agricultural Problems" has always been an issue of concern to China. The state has made great efforts to improve the "Three Agricultural Problems", and has paid great attention to the sustainable development of agriculture. Developing the agricultural economy with low consumption, low pollution, high utilization rate, and high circulation rate is the main direction to solve the agricultural problems in China. During the development of agricultural sustainable development, we should strengthen management based on the actual conditions of China, pay attention to the evaluation and feedback of sciences, and promote the coordinated and sustainable development of regional agriculture.

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