Journal on Artificial Intelligence
DOI:10.32604/jai.2021.017408
Article

Evaluation Model of Farmer Training Effect Based on AHP–A Case Study of Hainan Province

Shengjie Li and Chaosheng Tang*

School of Computer and Cyberspace Security, Hainan University, Haikou, 570228, China
*Corresponding Author: Chaosheng Tang. Email: tcsjk@hainanu.edu.cn
Received: 29 January 2021; Accepted: 28 March 2021

Abstract: On the basis of studying the influencing factors of training effect evaluation, this paper constructs an AHP-fuzzy comprehensive evaluation model for farmers' vocational training activities in Hainan Province to evaluate farmers' training effect, which overcomes the limitations of traditional methods. Firstly, the content and index system of farmer training effect evaluation are established by analytic hierarchy process, and the weight value of each index is determined. Then, the fuzzy comprehensive evaluation (FCE) of farmer training effect is carried out by using multi-level FCE. The joint use of AHP and FCE improves the reliability and effectiveness of the evaluation process and results. The overall comprehensive evaluation result of the farmer training effect evaluation is "good".

Keywords: Farmer training effect; evaluation index system; AHP; FCE

1 Introduction

With the continuous development of industrialization and urbanization in China, the number and composition of farmers have changed accordingly [1]. The problems of "shortage of manpower in key farming hours, shortage of talents in modern agriculture" have become increasingly prominent problem [2]. "How to plant land well" have become realistic and urgent issues. Under this background, China urgently needs to cultivate a group of new professional farmers with high comprehensive quality, so as to increase the scientific and technological content in the agricultural production process, and promote the transformation from primitive low-efficiency agriculture to modern agriculture [3]. Therefore, the construction of a scientific evaluation system for the training effect of professional farmers is helpful to improve the implementation effect of training, inject high-quality talents for rural revitalization, and promote the process of agricultural modernization and urbanization in China [4].

In the process of evaluating the effect of farmers' vocational training, some evaluation factors or comments used are vague to some extent, and it is difficult to appraise with an exact positive or negative, so it is appropriate to adopt AHP and FCE. Applying fuzzy comprehensive evaluation method (FCE), the weight of each index plays an extremely important role, but when applying FCE, the weight of each index is often put forward by experts according to personal experience, which inevitably has certain subjectivity [5]. The analytic hierarchy process (AHP) is just a method that combines qualitative evaluation with quantitative evaluation. It can process and express individual subjective judgment in a quantitative form, so as to minimize the unscientific evaluation that may be caused by individual subjective assumption, and make the evaluation result more credible [6].

This article uses Analytic Hierarchy Process (AHP) to establish a 9-level evaluation index model, and determines the membership index of each member, and uses the fuzzy comprehensive evaluation method (FCE) to comprehensively evaluate the training effect of farmers in Hainan Province.

2 The Determination of Evaluation Index System of Farmer Training Effect and Its Weight

The so-called weight refers to the total objective decomposed into multiple sub-factors, each sub-factor in the overall proportion of the size of the overall, indicating the relative importance of the sub-factor in the overall degree. The weight set is used to describe the relationship between the importance degree of each index in the same level and the index in the last level, reflecting the mutual relationship between each sub-factor and other sub-factors. The weight has a certain guiding function, so in the specific determination of the weight of an indicator, we should scientifically analyze the importance of each indicator (factor) in the overall goal, and then reasonably allocate and determine its weight. The weight of the index has several characteristics: one is the sum of the weight of many indicators of the same level should be equal to 1; Second, if an index at the same level is continued to be decomposes into smaller subsystems, the sum of the weights of each index in a single subsystem should also be equal to 1.

Generally speaking, the modeling of AHP includes four steps: establishing hierarchical structure model, constructing pair comparison judgment matrix, hierarchical single ordering and hierarchical total ordering [7]. The specific analysis is as follows.

2.1 The Content, Index System and Structural, Model

It is necessary to establish a hierarchical structure model for analyzing problems. First of all, complex problems should be layered, and the problems to be studied should be decomposed into several hierarchical elements according to attributes or interrelationships, so as to establish a hierarchical structure model.

According to this, referring to the literature related to evaluation of farmer vocational training effect and after field investigation [8], this paper sets up the content and index system of farmers' vocational training evaluation from three aspects: organization management and service, content matching degree and overall evaluation of training teachers.

1. organization, management and service

Good training service not only pays attention to whether the soundness of teaching equipment can meet the teaching content set by training objectives, but also pays attention to the rationality of training time arrangement and whether the time arrangement will interfere with farmers' labor time; And whether farmers can afford the training cost.

2. Content matching degree

The teaching methods of farmers' vocational training include classroom teaching, network training, personal experiment, etc. This index examines whether the training teaching is arranged according to farmers' own characteristics [9].

And whether the training content is targeted, whether it can be linked with the actual farm work of farmers, and whether it can improve work efficiency and work quality. Training contents should be expanded according to farmers' needs, and various training contents should be arranged while teaching farmers professional skills.

3. Overall evaluation of training teachers

Teachers play an important role in the dissemination of vocational training knowledge, and teachers' mastery and control ability of training content is an important indicator to measure teaching quality. Training teachers can be concise and easy to understand when teaching. Because farmers' general knowledge and cultural level is low, we should fully consider farmers' personal cultural level to design training content, so as to teach students in accordance with their aptitude.

During the teaching, the teacher interacts with the students, pays attention to the students' learning situation and answers the students' questions in time.

After making clear the evaluation contents and the relationship between them, we can establish a hierarchical structure model composed of evaluation objects and their evaluation index system, as shown in Tab. 1. Among them, each index in the table follows the principle of overall integrity and relative independence [10].

Table 1: Hierarchical structure model

Target layer	Criterion layer	Index layer
Evaluation of training effects A	Management system B1	Training organization and management X1
		Training duration X2
		Training expenses X3
	Content matching degree B2	Training methods X4
		Training content X5
	Overall evaluation of training teachers B3	Teacher's knowledge level X6
		Is the teacher's lecture easy to understand X7
		Teacher's attention to students X8
		Does the teacher answer the students' questions in time X9

2.2 Construction of Pairwise Comparison Judgment Matrix

In AHP method, constructing pairwise comparison judgment matrix is one of the key steps. According to the hierarchical structure model established above, the factors of the same level are compared with the previous level to which they belong, and the relative importance of each factor in each level is judged, thus constructing a comparative judgment matrix [11]. This kind of judgment is generally given independently by many experts who are familiar with the evaluation of farmers' vocational training effect. As for the quantitative assignment method to measure the relative importance, the numbers 1–9 and their reciprocal are generally used as the scale. According to this, the quantitative assignment criteria of the importance of each factor in the judgment matrix are compared in pairs, as shown in Tab. 2.

Table 2: Quantitative evaluation criteria for the importance of each factor in the pairwise comparison judgment matrix

Assignment a_{ii}	Meaning of importance	Assignment a_{ii}	Meaning of importance
1	Ai and Aj are equally important	2	Between slightly importance and equally importance
3	Ai is slightly more important than Aj.	4	Between obviously importance and slightly importance
5	Ai is much more important than Aj.	6	Between very obvious importance and obvious importance
7	Ai is very mouch more important than Aj.	8	Between absolute importance and very obvious importance
9	Ai is absolutely more important than Aj.		

Comparing the values in the judgment matrix in pairs has two remarkable characteristics: first, the values on both sides of the main diagonal of the matrix are reciprocal to each other; Second, the values on the main diagonal of the matrix are all 1, because any factor is always equally important compared with itself, so it is assigned as 1.

Among them, $A_i = (i = 1,2,3,\ldots,n)$ is the evaluation index and $a_{ij}(i,j = 1,2,3,\ldots,n)$ is weight, and its quantitative assignment is given according to the quantitative assignment standard of the importance of each factor in the pairwise comparison judgment matrix given in Tab. 2.

In this paper, seven experts who are familiar with the evaluation of agricultural vocational training

effect are invited to evaluate the importance of comparing each level of evaluation index with other evaluation indexes, and construct a judgment matrix according to the quantitative evaluation criteria given in Tab. 2.

According to the basic principles of analytic hierarchy process, on the basis of relevant investigations, the judgment matrix between adjacent levels is constructed, and the judgment matrix of daily target level relative to criterion level calculated by MATLAB is as follows:

$$\begin{bmatrix} A & B_1 & B_2 & B_3 \\ B_1 & 1 & \frac{1}{4} & \frac{1}{2} \\ B_2 & 4 & 1 & 3 \\ B_3 & 2 & \frac{1}{3} & 1 \end{bmatrix}$$

According to MATLAB, the judgment matrix of the criterion layer relative to the index layer is as follows:

$$\begin{bmatrix} B_1 & X_1 & X_2 & X_3 \\ X_1 & 1 & \frac{1}{3} & \frac{1}{5} \\ X_2 & 3 & 1 & \frac{1}{2} \\ X_3 & 5 & 2 & 1 \end{bmatrix} \begin{bmatrix} B_2 & X_4 & X_5 \\ X_4 & 1 & \frac{1}{7} \\ X_5 & 7 & 1 \end{bmatrix} \begin{bmatrix} B_3 & X_6 & X_7 & X_8 & X_9 \\ X_6 & 1 & 3 & 7 & 5 \\ X_7 & \frac{1}{3} & 1 & 4 & 3 \\ X_8 & \frac{1}{7} & \frac{1}{4} & 1 & 2 \\ X_9 & \frac{1}{5} & \frac{1}{3} & \frac{1}{2} & 1 \end{bmatrix}$$

2.3 Check the Consistency of the Judgment Matrix

2.3.1 Single Sorting of Levels

The first is the hierarchical single sorting. After the judgment matrix is constructed, the maximum eigenvalue of the judgment matrix and its corresponding orthogonal eigenvectors are obtained, and the weight value of the relative importance of each factor in each level relative to a factor in the previous level and its ranking are calculated [12].

Hierarchical single sorting is to normalize the feature vector of the largest feature root of the judgment λ_{max} matrix and express it as W. W represents the weight ranking of the relative importance of the same layer of factors relative to the previous layer of factors.

$$\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n}\frac{(AW)_i}{W_i} \tag{1}$$

If you want to confirm the ranking of hierarchy list, you should first check the consistency of the model, that is, determine the allowable range of inconsistency for the index factors in the judgment matrix. Consistency indicators are expressed as

$$CI = \frac{\lambda_{\max}(A) - n}{n-1} \tag{2}$$

When $CI = 0$, there is complete consistency; When CI is close to 0, there is satisfactory consistency; The larger the CI, the more serious the inconsistency. In order to measure the size of CI, the random

consistency index RI is introduced. By randomly generating m pairs of comparison matrices $A_1, A_2, \ldots, A_m$ to obtain the consistency index $CI_1, CI_2, \ldots, CI_m$, then

$$RI = \frac{CI_1 + CI_2 + \ldots + CI_m}{m} \tag{3}$$

Due to the large number of scheme layers designed in this paper, high-order random consistency index is required [10], and the results are shown in Tab. 3.

Table 3: Random consistency index table

n	1	2	3	4	5	6	7	8	9	10	12. 7
RI	0	0	0. 58	0. 90	1. 12	1. 24	1. 32	1. 41	1. 45	1. 49	1. 71

Finally, considering that the deviation of consistency may be caused by random reasons，the test coefficient CR is constructed,

$$CR = \frac{CI}{RI} \tag{4}$$

If $CR < 0.1$, the consistency is satisfied.

The calculated CR values of each judgment matrix are shown in Tab. 4.

Table 4: CR value of each judgment matrix

Matrix	A	B1	B2	B3	X1	X2	X3	X4	X5	X6	X7	X8	X9
CR	0	0. 0036	0	0. 0654	0	0	0	0	0	0	0	0	0

It can be seen from Tab. 4 that each judgment matrix has passed the consistency test.

The target allocation weight set of each level index obtained by MATLAB 7. 0 operation:

$$\lambda_{A_1} = 3.0000, \mathrm{W}_{A1} = (0.1429, 0.5714, 0.2857)$$

$$\lambda_{B_1} = 3.0037, \mathrm{W}_{B1} = (0.1096, 0.3092, 0.5813)$$

$$\lambda_{B_2} = 2.0000, \mathrm{W}_{B_2} = (0.1250, 0.8750)$$

$$\lambda_{B_3} = 3.0000, \mathrm{W}_{B_3} = (0.5664, 0.2524, 0.1004, 0.0807)$$

2.3.2 General Ranking of Levels

Multiply the weight of indicator layer by the weight of criterion layer to get the weight of importance of indicator layer to target layer, as shown in Tab. 5.

3 Fuzzy Comprehensive Evaluation of Farmers' Training Effect

According to Tab. 1, we know that the evaluation index system of farmers' training effect has two levels. Therefore, for each level index, namely, management system B1, content matching degree B2H and overall evaluation B3 of training teachers, there is a process of fuzzy comprehensive evaluation. The whole process is as follows: First-level fuzzy$B_i(i = 1,2,3)$ comprehensive evaluation is carried out on the second-level indicators$B_i(i = 1,2,3)$ to which each first-level indicator belongs, and then fuzzy comprehensive operation is carried out with the weight value of the first-level indicators, so as to obtain the results of second-level fuzzy comprehensive evaluation [13]. The whole process is as follows.

3.1 Construct the Evaluation Factor Set, Comment Set and Weight Set of Evaluation Index

Table 5: Relative weight table of each index of farmer training effect evaluation

	First-class indicators and their weights	First-class indicators and their weights
Evaluation of training effect A	Management system B1 (0. 1429)	Training organization and management X1 (0. 0157)
		Training duration X2 (0. 0422)
		Training expensesX3 (0. 0830)
	Content matching degree B2 (0. 5714)	Training methods X4 (0. 0714)
		Training content X5(0. 5000)
		Teacher's knowledge level X6 (0. 1618)
	Overall evaluation of training teachers B3 (0. 2857)	Is the teacher's lecture easy to understand X7 (0.0721)
		Teacher's attention to students X8 (0. 0287)
		Does the teacher answer the students' questions in time X9 (0.0231)

According to Tab. 5, we can construct the evaluation factor set of the evaluation index as follows:

$$A = \{B_1, B_2, B_3\}, B_1 = \{X_1, X_2, X_3\}, B_2 = \{X_4, X_5\}, B_3 = \{X_6, X_7, X_8, X_9\}$$

At the same time, the comment set is constructed as five grades: $V = \{V_1, V_2, V_3, V_4, V_5\} = \{\text{excellent, good, medium, fair and poor}\}$.

3.2 Construct Membership Matrix

The membership matrix is $Ri = \{r_{i1}, r_{i2}, ..., r_{im}\}$, refers to each of the comment sets corresponding to the i-th index of the evaluated factor $V_1, V_2, ..., V_m$, and $r = \frac{N_{ij}}{N}$, among them, N is the total number of people participating in the survey of farmers' training effect, and N_{ij} is the total number of people who participate in the evaluation work, and the number of people who choose the comment $V_j (j = 1,2,...,m)$ when evaluating the i-th index. In this paper, 47 farmers with reference to vocational training were investigated by anonymous questionnaire, and the evaluation results are shown in Tab. 6. The value in the table in is the proportion of students who choose corresponding comments (%).

Thereby obtaining:

The membership matrix of management system B1 is:

$$R_1 = \begin{bmatrix} 0.234 & 0.489 & 0.213 & 0.064 & 0 \\ 0.170 & 0.447 & 0.298 & 0.085 & 0 \\ 0.255 & 0.404 & 0.298 & 0.043 & 0 \end{bmatrix}$$

The membership matrix of content matching degree B2 is:

$$R_2 = \begin{bmatrix} 0.277 & 0.553 & 0.128 & 0.043 & 0 \\ 0.255 & 0.596 & 0.106 & 0.043 & 0 \end{bmatrix}$$

The membership matrix of the overall evaluation B3 of training teachers is:

$$R_3 = 0\begin{bmatrix} 0.362 & 0.511 & 0.106 & 0.021 & 0 \\ 0.277 & 0.617 & 0.085 & 0.021 & 0 \\ 0.234 & 0.468 & 0.277 & 0.021 & 0 \\ 0.277 & 0.553 & 0.149 & 0.021 & 0 \end{bmatrix}$$

Table 6: Evaluation results of 47 farmers on the training effect of farmer

	Evaluation content		Excellent	Good	Medium	Fair	Poor
	First-class indicators and their weights	First-class indicators and their weights	V1	V2	V3	V4	V5
Evaluation of training effect	Management system B1	Training organization and management X1	0. 234	0. 489	0. 213	0. 064	0
		Training duration X2	0. 170	0. 447	0. 298	0. 085	0
		Training expenses X3	0. 255	0. 404	0. 298	0. 043	0
	Content matching degree B2	Training methods X4	0. 277	0. 553	0. 128	0. 043	0
		Training content X5	0. 255	0. 596	0. 106	0. 043	0
	Overall evaluation of training teachers B3	Teacher's knowledge level X6	0. 362	0. 511	0. 106	0. 021	0
		Is the teacher's lecture easy to understand X7	0. 277	0. 617	0. 085	0. 021	0
		Teacher's attention to students X8	0. 234	0. 468	0. 277	0. 021	0
		Does the teacher answer the students' questions in time X9	0. 277	0. 553	0. 149	0. 021	0

3.3 One-Factor Fuzzy Evaluation

According to formula $Ki = Wi * Ri = (w_{i1}, w_{i2}, ..., w_{im})(r_{i1}, r_{i2}, ..., r_{im})$, the composite operation of fuzzy matrix is carried out by using the membership matrix r and the weight set W obtained above, and the one-factor first-level fuzzy evaluation result expressed by membership degree can be obtained.

Then, the first-level fuzzy evaluation matrix of farmer vocational training effect evaluation is as follows:

$$K = \begin{bmatrix} K1 \\ K2 \\ K3 \end{bmatrix} = \begin{bmatrix} 0.2264 & 0.4266 & 0.2887 & 0.0583 & 0 \\ 0.0569 & 0.1213 & 0.0253 & 0.0091 & 0 \\ 0.3208 & 0.5368 & 0.1213 & 0.0210 & 0 \end{bmatrix}$$

3.4 Comprehensive Evaluation (Secondary Fuzzy Comprehensive Evaluation)

The final comprehensive evaluation (secondary fuzzy comprehensive evaluation) of the farmer vocational training effect evaluation expressed by membership degree can be obtained by using K and the weight set W obtained above for the compound operation of fuzzy matrix

$$P = W * K = (0.1565, 0.2836, 0.0904, 0.0193, 0) \quad (5)$$

From the final evaluation results of farmers' training effect evaluation, it can be seen that 15. 65% may be "excellent", 28. 36. 00% may be "good", 9. 04% may be "moderate" 1. 93% may be "fair" and 0% may be "poor". According to the principle of maximum membership degree, we have $0.2836 \succ 0.1565 \succ 0.0904 \succ 0.0193 \succ 0$ in the comprehensive membership degree of "excellent, good, medium, fair and poor". Therefore, the overall comprehensive evaluation result of this farmer training effect

evaluation is “good”.

4 Conclusion

On the basis of studying the influencing factors of farmers’ training effect evaluation, this paper constructs an AHP- fuzzy comprehensive evaluation model to evaluate farmers’ training effect, and overcomes the limitations of traditional methods. Firstly, the content and index system of farmers’ training effect evaluation are established by AHP, and the weight value of each index is determined Then, the multi-level FCE is used to comprehensively evaluate the training effect of farmers. The fuzzy comprehensive evaluation of the second part is based on the analytic hierarchy process of the first part, so as to give full play to the advantages of their respective methods and jointly improve the reliability and effectiveness of the evaluation process and evaluation results.

Funding Statement: This work was supported by the Hainan Provincial Natural Science Foundation (618ms025); the Hainan Higher Education and Teaching Reform Research (hnjg2020-12).

Conflicts of Interest: The authors declare that we have no conflicts of interest to report regarding the present study.

References

[1] W. F. Liu, “Thoughts on cultivating new professional farmers in the context of rural revitalization,” *Journal of Agricultural Engineering Technology*, vol. 40, no. 21, pp. 77–79, 2020.

[2] Z. H. Ning, “Cultivation of new professional farmers and its implementation path,” *Journal of Tropical Agriculture Engineering*, vol. 43, no. 4, pp. 136–139, 2019.

[3] B. Z. Li, L. S. Yang, X. Huang and Q. B. Zhu, “Income effect and its difference analysis of new professional farmer training,” *Journal of Agricultural Technical Economics*, vol. 18, no. 2, pp. 135–144, 2019.

[4] K. Y. Liao, J. X. Yang and X. Y. Liu, “Evaluation of training effect of new professional farmers and its influencing factors: a survey of 812 farmers in Chengdu, Sichuan province,” *Vocational and Technical Education*, vol. 40, no. 36, pp. 45–50, 2019.

[5] X. X. Mao, G. Q. Zhang and Z. Chen, “Analysis of influencing factors of training effect of farmers' entrepreneurship based on data of Zhejiang Farmers University,” *Journal of Zhejiang Agricultural Sciences*, vol. 61, no. 8, pp. 62–65, 2020.

[6] Y. L. Huang and F. L. Jiang, “Study on the effect of non-coal mine safety training based on AHP–fuzzy comprehensive evaluation,” *China Public Safety (Academic Edition)*, vol. 43, no. 4, pp. 31–36, 2017.

[7] Y. H. Wu and Y. Z. Shi, “A fuzzy comprehensive evaluation of classroom teaching quality in local application-oriented undergraduate colleges from the perspective of students,” *Journal of Bangbu University*, vol. 9, no. 5, pp. 94–98, 2020.

[8] M. L. Jiang, M. Yu and H. Li, “A study on the training effect and influencing factors of farmers' training institutions–A case study of Ningbo city,” *Agricultural Outlook*, vol. 11, no. 8, pp. 55–62, 2015.

[9] X. M. Jiang, X. Y. Zheng and W. P. Liu, “Analysis of the effect of technical training on the increase of income of camellia oleifera farmers: an estimation based on the trend score matching method,” *Journal of Forestry Economics*, vol. 39, no. 10, pp. 93–99, 2017.

[10] Y. Wang, F. Subhan, S. Shamshirband, M. Z. Asghar, I. Ullah *et al.,* “Fuzzy-based sentiment analysis system for analyzing student feedback and satisfaction,” *Computers, Materials & Continua*, vol. 62, no. 2, pp. 631–655, 2020.

[11] Q. Dang, H. Zhang, B. Zhao, Y. He, S. He *et al.,* “Electrical data matrix decomposition in smart grid,” *Journal of Internet of Things*, vol. 1, no. 1, pp. 1–7, 2019.

[12] M. Ning, J. Guan, P. Liu, Z. Zhang and G. M. P. O’Hare, “Ga-bp air quality evaluation method based on fuzzy theory,” *Computers, Materials & Continua*, vol. 58, no. 1, pp. 215–227, 2019.

[13] J. Zuo, Y. Lu, H. Gao, R. Cao, Z. Guo *et al.,* “Comprehensive information security evaluation model based on multi-level decomposition feedback for IOT,” *Computers, Materials & Continua*, vol. 65, no. 1, pp. 683–704, 2020.