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Research on Food System Evaluation Model Based on TOPSIS Improved Analytic Hierarchy Process

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Abstract: At present, the shortcomings of the current global food system which focuses on efficiency and profitability have brought about enormous perplexity. Together with its instability, social problems related to the environment, livelihoods or politics resulting from its lacking of consideration for equity and sustainability have attracted extensive attention. We establish the evaluation model of food system by AHP and TOPSIS. We selected efficiency, profitability, equity and sustainability as four indexes at the criterion layer and 10 indicators at the scheme layer. It is concluded that the food system scores of all countries have been steadily increasing from 2010 to 2020 by processing data with TOPSIS.

1. Introduction

Food is the most important material basis to ensure sustainable development of human beings in the world which plays an irreplaceable role in supporting social and economic development. Research on food systems is a hotspot of international community research programmers which has been achieving more and more attention. Current food systems focus on efficiency and profitability, allowing relatively cheap and efficient production and distribution of food, yet under such a food system, even though the food produced globally is enough to feed everyone in the world, 821 million people worldwide are still suffering from hunger according to data released by the Food and Agriculture Organization of the United Nations (FAO), and more than 2 billion people have no stable access to safe and nutritious food. Food insecurity is found in all countries and nations of the world, whether rich or not, regardless of race or color [1].

The model of food system needs to be further optimized and reconstructed under new circumstances, and the traditional idea "efficiency is security, profit is purpose" should be abandoned. The new food system aiming at equity and sustainablility can not only conform to the trend of environmental protection and governance, but also reduce the quantity of hungry people left by traditional food system, and play an invisible but indispensable role in social security [2] [3].

2. Food System Evaluation Model

We comprehensively evaluate the food system from 2010 to 2020 by means of Analytic Hierarchy Process (AHP) combined with TOPSIS (technique for Order Preference by Similarity to Idea Solution). To start of, we analyze the elements of each layer and divide the decision-making problem into three levels by using AHP. The first one is the target layer: the food system scores of each year;

The second is the criterion layer, which includes food efficiency, food profitability, equity and sustainability of the future of food; the third is the scheme layer, which consists of 10 levels (as shown in figure 1):

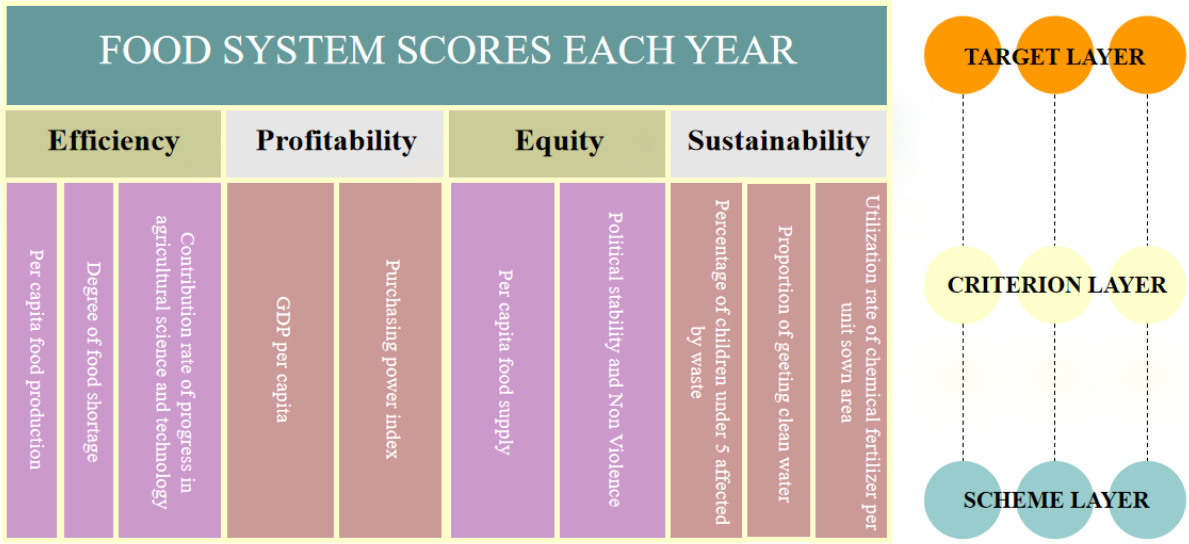

Figure 1: AHP sketch map

Together with AHP, we use TOPSIS method to improve the reliability and authority of data because of the former one's strong subjectivity. TOPSIS is a common comprehensive evaluation method, which can make full use of the original data information and reflect the gap between the results of each evaluation scheme accurately.

The detailed steps for establishing of the model are as follows:

• Determining the weights corresponding to each index value using AHP:

$$W = (w_k, k = 1,2,\cdots,12)$$

Eliminate those particularly small weights while using the remaining m (m<16) indexes in the scheme layer, then the corresponding weights of the five indexes in the criterion layer will be obtained.

• For the matrix of 10 evaluation objects of 4 evaluation indexes, the specific types of each index will be judged first, and then get forward processing.

• Standardize the forward matrices to eliminate the effects of different dimensions:

$$X = \begin{pmatrix} x_{11} & x_{11} & \cdots & x_{14} \\ x_{21} & x_{21} & \cdots & x_{24} \\ \vdots & \vdots & \ddots & \vdots \\ x_{101} & x_{102} & \cdots & x_{104} \end{pmatrix}$$

The standardized matrix is recorded as Z, for each element in the Z:

$$z_{ij} = \frac{x_{xj}}{\sqrt{\sum_{i=1}^{n} x_{ij}}}$$

• Combined the standardized matrix with the weight to calculate and normalize the score of the evaluation index. The 2010-2020 food system, which can be expressed as a standardized matrix with 10 subjects to be evaluated and 4 evaluation indicators:

$$Z = \begin{pmatrix} z_{11} & z_{11} & \cdots & z_{14} \\ z_{21} & z_{21} & \cdots & z_{24} \\ \vdots & \vdots & \ddots & \vdots \\ z_{101} & z_{102} & \cdots & z_{104} \end{pmatrix}$$

Maximum definition $Z^+ = (Z_1^+, Z_2^+, \cdots, Z_4^+) =$

$$\left(\mathrm{m}\ (z_{11}, z_{21}, \cdots, z_{101}), \mathrm{m}\ (z_{12}, z_{22}, \cdots, z_{102}), \cdots, \mathrm{m}\ (z_{14}, z_{24}, \cdots, z_{104})\right)$$

Minimum definition $Z^- = (Z_1^-, Z_2^-, \cdots, Z_4^-) =$

$$\left(\mathrm{m}\ (z_{11}, z_{21}, \cdots, z_{101}), \mathrm{m}\ (z_{12}, z_{22}, \cdots, z_{102}), \cdots, \mathrm{m}\ (z_{14}, z_{24}, \cdots, z_{104})\right)$$

Define the distance between the number $i(i = 1,2,\cdots,10)$ evaluation object and the maximum:

$$D_i^+ = \sqrt{\sum_{j=1}^{4} w_j \left(Z_j^+ - z_{ij}\right)^2}$$

Define the distance between the number $i(i = 1,2,\cdots,10)$ evaluation object and the minimum:

$$D_i^- = \sqrt{\sum_{j=1}^{4} w_j \left(Z_j^- - z_{ij}\right)^2}$$

Then, we can calculate the unnormalized score of the evaluation object numberi $(i = 1,2,\cdots,10)$:

$$S_i = \frac{D_i^-}{D_i^+ + D_i^-}$$

• The food system of each year is sorted according to the TOPSIS evaluation score. It is easy to find that the higher the score, the better the evaluation result. The food system can be classified using the score obtained.

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3. Model Solving

Compare the elements of each layer by using Analytic Hierarchy Process (AHP). Construct judgment matrix and check consistency of judgment matrix.The maximum eigenvalues and corresponding eigenvectors of each judgment matrix can be obtained by matlab programming.

Using matlab programming and analytic hierarchy process to determine the weight of comprehensive evaluation of food, and then using TOPSIS method to calculate the comprehensive evaluation score of global food system from 2010-2020. The results are shown in Table 1.

Table 1: Annual Assessment Scores for Global Food Systems

year	2010	2011	2012	2013	2014	2015
Food system assessment scores	0.6017	0.6234	0.6478	0.6516	0.6373	0.6798
	2016	2017	2018	2019	2020	
	0.7017	0.7340	0.7784	0.8069	0.8230	

4. Conclusion

We use analytic hierarchy process and TOPSIS method to construct the food system evaluation model. The contrast matrix formed by analytic hierarchy process and the actual situation has greatly improved the accuracy of parameter. Based on the weight of the parameters, the TOPSIS method is used to make up for the deficiency brought by the analytic hierarchy process, which makes the evaluation model more authoritative and makes the final goal.

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