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Research on new food supply system based on optimization system

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Abstract: Although the global food system has been tempered for many years, but recent events have shown us that our global food system is unstable even in the parts of the world that it generally serves well. So, researching out a better food system has great significance to humanity. First of all, this article collects various data on agricultural production in countries around the world, according to the data type, the food system is divided into four first-level indicators, using the comprehensive model of entropy weight method and analytic hierarchy process to establish evaluation models. Secondly, the article establishes a sub-model based on four first-level indicators for facilitately analysising problems. Due to the complexity of studying the global food system, this article focuses on local areas firstly. Multi-objective optimization of the two goals of equity and sustainability according to the established sub-model, observing the changes of the other two first-level indicators, can get the conclusions: the optimization will reduce the number of food scarcity people in the world. But it will also reduce the profit and efficiency of the food system, and the selling price of various crops may rise. From the variation of sub model parameters， the new food system is more stable than the original food system.

1. Introduction

1.1 Background of the Problem

With the continuous increase of the world total population, the problems of food shortage and unreasonable food distribution have gradually aroused people's attention. Recent events have shown us that our global food system is unstable even in the parts of the world that it generally serves well. The United Nations estimates 821 million people worldwide suffer from hunger. Therefore, it is necessary to rebuild a more sustainable, fair and profitable food system.

1.2 Model Assumptions

- It is assumed that all the data collected are true and reliable.
- It is assumed that there will be no natural disasters and other unexpected factors affecting the normal operation of the grain system in the future.
- It is assumed that the profit per 10000 square meters in the grain system is only related to material cost, working price and other costs, without considering the influence of other factors,

so as to ensure the accuracy of the regression equation.

- For the convenience of analyzing the problem, it is assumed that the weight set according to the grain priority is reasonable.

2. Analysis of Grain System Model Based on Entropy Method

Based on the current agricultural data of countries in the world, in order to study the current world food system operation mode, we study the world food system from four dimensions: profitability, efficiency, equity and sustainability.The original data of data collection is from the "world food and Agriculture Organization".

2.1 Data collection and preprocessing

Data normalization and standardization. The model uses linear transformation method to standardize the index data. The index data value is transformed into the interval of [0,1]. Set a_{ij} as the index after standardization.

2.2 Model establishment

After the data of each index is standardized, the proportion of index value of object i under index j is calculated as follows

$$y_{ij}=\frac{x_{ij}}{\sum_{i=1}^{m}x_{ij}} \quad (0\le y_{ij}\le 1);\quad e_{ij}=-k\sum_{i=1}^{m}y_{ij}\ln(y_{ij}) \tag{1}$$

Define d_j as the information utility value of the j-th index, then $d_j=1-e_j$, when d_j is larger, the index is more important. Define the weight w_j and the comprehensive score f_i :

$$w_j=\frac{d_j}{\sum_{j=1}^{n}d_j} \quad ; f_i=\sum_{i=1}^{n}w_i x_{ij} \tag{2}$$

2.3 The Model of Sub-model establishment

Firstly, the profit model is established. In order to establish the analysis model, it is assumed that farmers get the maximum net income fromselling grain - agricultural cost.Considering that the agricultural cost includes a lot of production inputs (chemical fertilizer, pesticide, etc.), referring to the relevant literature , we know that the profit model [1]:

$$max\ Pr=\sum_i\left[p_i q_i(X_{iy},P_i)-\sum_h P_y X_{iy}-\alpha_i X_{\text{other}}\right] \tag{3}$$

At present, the evaluation of agricultural production efficiency has always been an important topic in the research of agricultural regional economy. Here, we simply consider the agricultural production efficiency, that is, to quantify the efficiency by multiplying the yield of crops per hectare by the ratio of the market price and the income of crops per unit area in the world.

Therefore, referring to the relevant literature, we know that the profit model [2]:

$$Eff=\frac{\sum_{n=1}^{i}p_n y_n}{x_n};n=1,2,\cdots,i \tag{4}$$

In the formula, y_n represents the unit yield of the nth agricultural product, and x_n represents the global average yield per hectare of the nth agricultural product.

3. Establishment of the Model

According to the grain output, China can be divided into three parts: the high producing area(A), the middle producing area(B) and the low producing area(C). We give priority to use analytic hierarchy process to get weight according to the differences among the three regions.

For the importance of each factor at the same level with respect to the corresponding target at the upper level, the paired comparison matrix is constructed with paired comparison method and comparison scale, and the relative scale is used in the comparison, so as to reduce the difficulty of comparing different factors as much as possible and improve the accuracy.

According to the above principles, the pairwise comparison matrix of a, B and C is established:

$$A=\begin{pmatrix} & A & B & C \\ A & 1 & 3 & 7 \\ B & \frac{1}{3} & 1 & 5 \\ C & \frac{1}{7} & \frac{1}{5} & 1 \end{pmatrix}$$

The corresponding eigenvectors are obtained by MATLAB program W=(0.6491 0.2790 0.0719).Consistency test of judgment matrix:

(1) Calculate the index mark to measure the inconsistency of a paired comparison matrix A (n>1 order square matrix) as CI, substitute into the calculation to get: CI= 0.0324

(2) Concordance ratio: $CR=\frac{CI}{RI}=0.0624<0.1$, Much less than 1, Therefore, it passed the consistency test.

Assuming that the population of A, B and C is respectively P_A、P_B、P_C, the grain storage of the three regions in 2020 is respectively $FoodA$、$FoodB$、$FoodC$, the grain growth rate is respectively y_A、y_B、y_C, and the grain consumption rate per unit population is respectively yA、yB、yC, the grain storage equation is obtained, considering fairness (reasonable distribution) and additional weights

$$Y=(0.649Food_A y_A+0.279Food_B y_B+0.072Food_C y_C)$$

The above equation reflects the annual grain yield. From the perspective of sustainability, the higher the Y is, the stronger the sustainability is. For these three areas, they should meet the first constraint: the annual grain storage should be able to meet the local demand, that is: $P_i * y_i \leq Food_i \quad i=A,B,C$. The second constraint is that the grain growth rate of each region can not be negative, that is to say: $y_i>0$.

4. Multi-objective optimization analysis results

4.1 Solution of the Model

By analyzing the above reserve equation considering sustainability, we can conclude that the parameters of area A (the high producing area,) have a greater impact on the target.

a) If the grain system is optimized for the sake of fairness, that is, the weights of the parameters of the three regions are close to 0.33, referring to the paired comparison matrix, although the grain production capacity of the three regions is different, the impact on the storage of the grain system is the same, which may lead to the low production efficiency of the grain system, but the positive impact is that the people who have no food security in the world, can afford nutritious food will reduce the number of people suffering from hunger in rich countries, and will also alleviate areas where food is scarce.

b) If it is optimized in accordance with sustainability, that is, the storage volume Y increases, and the above formula is used to obtain the increase in the annual growth rate of the food system y_i, which causes the price of Pr agricultural products to decrease. According to the efficiency model, the production efficiency of the food system will be reduced.

4.2 Analysis of the Solution

If the food system is optimized for fair and sustainable development, it will reduce the number of food insecure people in the world, but it will also reduce the benefits and efficiency of the food system. At this time, the government will flexibly adjust revenue and efficiency according to the principle of negative feedback. Therefore, the government may increase the selling prices of various crops. In order to increase sustainability, the government may also advocate reducing carbon emissions and increasing the prices of fertilizers and pesticides.

5. Conclusion

By establishing a composite model, the model is no longer easily restricted by a single scope of application, so that the model the model in this paper is based on the analysis of real problems and has no particularity. It is easier to generalize and compare and can be used in more complex scenarios with more factors.Our model is more flexible. Through the evaluation model, we can make judgments on various situations and analyze the degree of correlation and priority among factors. We can adopt different coping strategies for different situations, so as to solve problems in a more targeted manner.However, the data of our model mainly comes from data published on the Internet, and there is no on-site investigation of the real situation, so there may be some deviation in solving actual problems.

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