Agricultural & Forestry Economics and Management (2021) Vol. 4: 6-10
Clausius Scientific Press, Canada
DOI: 10.23977/agrfem.2021.040102
ISSN 2616-2202

Study on Sustainable increase and system Analysis of Grain based on Principal component Analysis and Grey Prediction algorithm

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Keywords: Sustainable development, principal component analysis, comprehensive index system

Abstract: Food systems are essential to economic life because they provide the capacity that people need to live and work. For a long time, the food system has not received enough attention. But between 2019 and 2020, the COVID-19 pandemic left half of the planet closed. The food shortage caused by the COVID-19 pandemic shows the fragility of the highly centralized and immediate global food supply chain. In the process of economic reconstruction, the global food system should be improved. The paper provides a practical reference for solving the global food problem. In particular, this paper evaluates the advantages and disadvantages of the established model, comprehensively considering production, social, technical, environmental, economic and other factors, based on principal component analysis, grey prediction method and logistic model, our team establishes a comprehensive evaluation model of sustainable food system. In the process of analysis, we found that the principal component analysis method when the symbol of the factor load of the module is positive and negative, which reduces the clarity of our model, so we slightly improve our model. Rationalize the negative factor to zero and finally help us to get the final food system plan.

1. Introduction

Available data show that the drawbacks in the current food system (the United Nations estimates that there are 821 million people worldwide suffering from hunger) are the result of uneven production and distribution between countries and regions. The contemporary food system prioritizes efficiency and profitability, but this has a huge environmental damage on the planet. Just like the outbreak and spread of the new epidemic in 2019, the global economic growth has been delayed significantly and the unemployment rate has risen, which also makes the situation of vulnerable groups more difficult. Many restaurants, supermarkets and other public agencies have had to close or shorten their opening hours resulting from the epidemic, which could further push up food prices, making it harder for the poor to afford, leading them to malnutrition.As a result,some residents began to store food, among which fruit and vegetables are perishable, may cause unnecessary waste [1].

In order to increase the current food system, maintain or even improve our environmental health,

while producing more food, we need to establish an evaluation index model to determine the food system and set sustainable development goals for it. By selecting appropriate evaluation indicators, giving weight to indicators, and combining these lower indicators to achieve some comprehensive indicators. The model will be based on food production, the food price index, Engel coefficient, the scale of investment in the agricultural industry, and so on. We divide the countries of the earth into drew up and developing countries, and study the priorities of different types of national food systems separately [2].

2. Theoretical basis and index construction of the Sustainable development food system

According to the World Food Programme, 135 million suffer from acute hunger largely due to man-made conflicts, climate change and economic downturns [3]. The COVID-19 pandemic could now double that number, putting an additional 130 million people at risk of suffering acute hunger by the end of 2020.Secondly, the price of food and people's purchasing power of food determine to a large extent how many people in the world have access to food. Moreover, per capita food output is a measure of per capita food occupancy level [4]. a food security index that reflects micro and realistic needs.

3. Model foundation

(1) Standardize the given indicators and make the following changes

$$s\,x_{ij}^{*}=\frac{x_{ij}-\bar{x}_j}{s_j}\left(i=1,2,\ldots,n;\ j=1,2\ldots p\right) \tag{1}$$

Then, $\bar{x}_j=\frac{1}{n}\sum_{i=1}^{n}x_{ij}, s_j^2=\frac{1}{n-1}\sum_{i=1}^{n}\left(\bar{x}_{ij}-\bar{x}_j\right)^2\ \left(j=1,2\ldots p\right)$

(2) Calculate the correlation coefficient.

$$R=\begin{bmatrix} r_{11} & r_{12} & \ldots & r_{1p} \\ r_{21} & r_{22} & \ldots & r_{2p} \\ \ldots & \ldots & & \ldots \\ r_{n1} & r_{n2} & \ldots & r_{np} \end{bmatrix} \tag{2}$$

$r_{ij}(i=1,2,...n;\ j=1,2,...p)$ is the correlation coefficient between the original xi and yj, and its calculation formula is

$$r_{\mathrm{ij}}=\frac{\sum_{k=1}^{n}(x_{\mathrm{ij}}-\bar{x}_{\mathrm{j}})(x_{\mathrm{kj}}-\bar{x}_{\mathrm{j}})}{\sqrt{\sum_{k=1}^{\mathrm{n}}(x_{ki}-\bar{x}_i)^2\sum_{k=1}^{n}(x_{ki}-\bar{x}_i)^2}} \tag{3}$$

(3) Due to R is the real symmetric matrix (rij=rji), the paper only need to calculate the triangular element or the lower triangular element. According to the food yield per hectare, food price index and per capita food consumption, global hunger index, Engel coefficient and other data collected from the World Bank, Data World and Food and Agriculture Origination of the United Nations from 1961 to 2005, the production sustainability module, the economic sustainability module and the social

sustainability module are respectively applied to the production sustainability module, the economic sustainability module and the social sustainability module. Technical sustainability module, calculating correlation coefficient

Table 1: Calculating correlation coefficient

	X1	X2	X3	X4
X1	1.0000	-0.0575	1.0000	0.2900
X2	-0.0575	1.0000	-0.0575	0.5948
X3	1.0000	-0.0575	1.0000	0.2900
X4	0.2900	0.5948	0.2900	1.0000

Calculate eigenvalues and Eigenvectors:

First of all, solve the characteristic equation. $|\lambda I - R| = 0$, the paper use Jacbo to Calculate the eigenvalues $\lambda_i (i = 1,2,...p)$, and arrange them in order of size

$\lambda_1 \geq \lambda_2 \geq .... \geq \lambda_p \geq 0$, then the paper calculate the eigencomponents corresponding to the eigenvalue λ_i respectively $e_i (i = 1,2,...p)$, $\left\|e_i\right\| = 1, \sum_{j=1}^{p} e_{ij}^2 = 1$ eij represents the j component of the vector ei. Calculate the principal component contribution rate and the main contribution rate

Contribution rate of principal component Zi is $\frac{\lambda_i}{\sum_{k=1}^{p} \lambda_i} (i = 1,2,...p)$

Generally, the eigenvalues with a cumulative contribution rate of 85% and 95% are taken. λ_1, λ_2,...., λ_m The corresponding m (m < p) principal component, the contribution rates of eigenvalues and principal components are calculated as follows:

Table 2: Contribution rates of eigenvalues and principal components

Principal component	Eigenvalues	Contribution rate
1	2.1637	0.5409
2	1.5053	0.3763
3	0.3310	0.0827
4	0.0000	0.0000

(3) Calculation of principal component load

The calculation formula is

$$I_{ij} = p(z_i, x_j) = \sqrt{\lambda_i} e_{ij} (i, \ j = 1,2,...p) \quad (4)$$

After the load of each principal component is obtained, the principal component score can be obtained according to further calculation.

$$Z = \begin{bmatrix} z_{11} & z_{12} & \cdots & z_{1m} \\ z_{21} & z_{22} & \cdots & z_{m} \\ \cdots & \cdots & & \cdots \\ z_{n1} & z_{n2} & \cdots & z_{nm} \end{bmatrix} \tag{5}$$

4. Model solving and analysis

The paper analyze the production sustainability, social sustainability, economic sustainability and technological sustainability by principal component analysis, and get the order of importance under each sustainability index, If the current indicators are not required to achieve the sustainable development goals, and the priority of the indicators of the current food system is obtained by using the existing data analysis, the paper use the entropy method to determine the weight of each first-level index in the system, and get the following results:

Table 3: Weight of each first-level index

The current food system				
First level indicator	Proportion	Object	Priority order	meaning
production	0.308	Ddeveloping Counterys	1>2>3	Numbers represent secondary indicators
		Developed Countrys		
social development	0.109	Ddeveloping Counterys	4>6>5>7	
		Developed Countrys	5>7	
technology	0.23	Global	9>8	
Economic	0.453	Global	11> 10> 13> 12	

If the current food system is required to achieve the goals set above, then

Table 4: Sustainable development food system

Sustainable development food system				
First level indicator	Proportion	Object	Priority order	Meaning
Sustainable production	0.303	Ddeveloping Counterys	1>2>3	Numbers represent secondary indicators
		Developed Countrys		
Sustainable social development	0.114	Ddeveloping Counterys	4>6>5>7	
		Developed Countrys	5>7	
Sustainable technology	0.333	Global	9>8	
Economic sustainability	0.248	Global	11> 13> 10> 12	

5. Conclusions

Considering the complexity of the food system, the paper have established a comprehensive and accurate multi-index comprehensive evaluation system to grade different areas from many angles to determine their sustainable development scores.The production of food is very important. As a necessity for survival, the rapid increase of population leads to an increasing demand for food. Under ideal circumstances, a sustainable food system should meet everyone's demand for food.

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