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	Summary Sheet	

Better Food System & Better World

Today, the world is experiencing the greatest collective upheaval since World War II, as a result of the Covid-19 pandemic. Despite the efficiency of the current food system, the United Nations estimates that 821 million people around the world are still hungry, and there are still large numbers of food-insecure people. In order to better understand and solve these problems, this paper mainly measures the impact of food system equity and sustainability on the total utility of food system, predicts its development trend, and puts forward some reasonable suggestions.

- Firstly, we put forward the Food System Utility Model (FSUI), which specifically estimates the food system index of a certain country or region based on the entropy weight method (EWM). The model is evaluated from production, processing, transportation and marketing. Considering that some of the data are too large, we preprocessed the data and finally obtained a more effective evaluation model that is in line with the actual situation.
- Then, we designed an evaluation model between food system fairness and food system utility. Specifically, based on the TOPSIS model, the correlation between the proportion of women among landowners and total utility is explored. After verifying the generality of the evaluation system designed, we applied it to India, Nigeria, Australia and other countries, and compared the corresponding correlation coefficients among these countries. Based on this, we emphasized several suggestions to improve the effectiveness of the food system in the future.
- Thirdly, we designed a regression model between food system equity and food system utility. By training a three-layer neural network with 13 neurons, we obtained the relationship between the carbon dioxide equivalent of each ton of food produced by each country, water utilization and food system utility. This system is applied to the prediction of utility of several countries.
- Based on this, we propose healthier targets for the global food system by 2026 through the analysis of the final indicators of the three models. We used Grey-Verhulst model to predict and compare the degree to which improving the fairness and sustainability of food systems in different countries would improve FSUI, so as to evaluate the effectiveness of relevant practices. On this basis, we discuss the impact of achieving this level on human life, ecological environment and trillion-dollar agricultural industry.
- Finally, on the basis of the three models and in combination with relevant literature, we propose that in the food system, it will be more effective to reduce the gap between the rich and the poor in the society, adjust the proportion of agricultural import and export, and improve the priority of the food system at the current stage.

In conclusion, the proposed model formalizes a more equitable, sustainable, globally achievable goal and facilitation measures to improve the stability and effectiveness of the food system. In addition, they can be dynamically adapted according to production structure, natural environment, etc

Keyword: Food system utility index; EWM; TOPSIS; Artificial neural network

Contents

1Introduction

1.1Background

The current global COVID-19 pandemic has led to a deep and multidimensional crisis across all sectors of society. As countries contemplate their mobility and social-distancing policy restrictions, we have a unique opportunity to re-imagine the deliberative frame works and value priorities in our food systems. Pre-pandemic food systems at global, national, regional and local scales already needed revision to chart a common vision for sustainable and ethical food futures.

The system is a whole, which is composed of multiple subjects. Any change of the subject will change the cooperative relationship between the subjects, thus affecting the stability of the whole system. We hoped that through more systematic and comprehensive research, a sustainable food system will be constructed to meet the needs of food security, nutrition cultural suitability of regional food systems.

1.2 Overview of our work

When evaluating food system, we first established a food system evaluation model, the assessment, the three-level index evaluation method, the system utility index of grain as the primary index, the food supply, food, transport, food consumption as a secondary index, the average protein supply, grain production per ha, grain output and per capita arable land area, the density of railway, per capita GDP, percentage of the total amount of food imports of merchandise exports as a three-level index, thus formed the food system evaluation index system. In this system, we use line chart to evaluate FSUI.

Secondly, we established an evaluation model for the fairness of the food system. In the evaluation, we applied the TOPSIS method. We calculated the score of TOPSIS to reflect the correlation between the proportion of women in landowners and FSUI, and then evaluated the fairness of the food system. Next, we must establish a sustainable development of the food system model, in order to explore food system, the relationship between sustainable development and food system utility based on the previous data and fitting, we consider using artificial neural network model, in the model, establish the carbon equivalent and the utilization of water resources and food system utility between the black box model, establish the sustainable development of the food system quantitative analysis of the influence of the food system utility.

2 General Assumptions and Variable Description

2.1 Assumptions

Re-optimizing the food system is a complex issue. The current global pandemic of COVID-19 has brought a multi-faceted crisis to the society. Of course, it also includes the crisis of the food system. Various problems are reflected in this crisis. We are right The current food system is inspected in all aspects, and a sufficiently robust food system model is established to be able to adjust and optimize efficiency, profitability, sustainability, etc. It is impossible to simulate every possible situation, we made some reasonable assumptions and simplifications.

- The data we collect from online databases are all accurate and reliable, because our data comes from the website of an international organization (Food and Agriculture Organization of the United Nations), and we have reason to believe that their data is of high quality.
- In the process of model verification, the influence of ignoring the country's indicator data on the calculation and results of the weight is negligible.
- Food System Utility Index：FSUI= $(X_1 \times X_2 + X_2 \times X_3)/2$
  (X_1=Food supply, X_2=Food transportation, X_3=Food consumption)
- We always assume that the country involved is a whole, and does not consider the differences between the regions of a country, and the differences caused by internal factors of a country. This assumption is a prerequisite for our in-depth research.

- Only when it comes to policy issues will the gap between different continents be considered.

2.2 Variable Description

The symbols we used in the model are shown in the following table

form1 Evaluation index system of food system utility

Symbols	Definition
FSUI	Food system utility index
X_1	Food supply
X_2	Food transportation
X_3	food consumption
Y_1	Average protein supply
Y_2	Grain yield per hectare
Y_3	Total grain output
Y_4	Per capita cultivated land area
Y_5	Railway density
Y_6	Per capita GDP
Y_7	Food imports as a percentage of total exports

3 **Model** Establishment and Solutions

3.**1** Task1 Evaluate the current food system

3.1.1 Model Establishment

Firstly, establish a food system evaluation model to evaluate the current food system. In the evaluation, the food system utility index is used as the first-level index, and the food supply, food transportation, and food consumption are the second-level indicators. The average protein supply and the food per hectare Output, total grain output, per capita arable land, railway density, per capita GDP, and the percentage of food imports to total merchandise exports are used as three-level indicators, thus forming a food system evaluation index system. In this food system evaluation model, food supply is a necessary condition for the utility of the food system, but it is not a necessary and sufficient condition. Due to differences in per capita disposable income, food prices, storage capacity, trading capacity, etc., under the premise of sufficient food supply , The problems of food waste and food health are still prominent. Therefore, the supply and utilization of food is the ultimate way to optimize the food system. Economic stability is used to measure the impact of production fluctuations, price fluctuations and other uncertain factors on food supply, food acquisition, and food utilization. It is an important factor to determine the utility index of national grain system.

3.1.2 Model Solving

We selected corresponding variables from FAOSTAT as the three-level indicators to form a food system utility evaluation index system. After a series of screenings, we continuously eliminated incomplete and discontinuous evaluation units, the data set of food system evaluation factors for 40 countries (20 developed countries and 20 developing countries) from 2005 to 2019 is finally obtained. The content and calculation method of the index system are shown as follows.

We adopt a multi-index comprehensive evaluation and proceed in the following steps:

- Data standardization processing: adopt range standardization method for data standardization processing:

(1) Pair positive index:

$$X'_{ij} = \left(X_{ij} - minX_{ij}\right) / \left(maxX_{ij} - minX_{ij}\right) \tag{3.1}$$

(2) Pair negative indicators:

$$X'_{ij} = \left(maxX_{ij} - X_{ij}\right) / \left(maxX_{ij} - minX_{ij}\right), i = 1,2,\ldots,40;\ j = 1,2,\ldots,7 \tag{3.2}$$

In the formula: X_{ij} is the original data of j index of the ith country (in alphabetical order); X'_{ij} is the corresponding normalized variable value, $X'_{ij} \in [0,1]$;$\max(X_{ij})$、$\min(X_{ij})$ are the maximum and minimum values of the JTH index respectively.

- Weight determination based on mean square deviation: Since the purpose of the food system utility evaluation in this paper is to re-optimize the food system, the determined index weight should be able to reflect the relative dispersion degree of the value of each index sample. For this reason, the mean square error method is used to determine the weight of each index. The steps are as follows.

(1)Calculate the mean square deviation (standard deviation) of each evaluation index from 2005 to 2019 based on standardized data set:

$$\partial=\sqrt{\frac{\sum_{i=1}^{n}(X_{ij}'-X_{ij})^2}{n}},\quad i=1,2,...,40;j=1,2,...,7 \tag{3.3}$$

In the formula: ∂ indicates the mean square error of the indicator; X_{ij} is the standardized variable value of the j-th indicator of the i-th country; X_{ij}' is the mean of standardized variable values; n is the number of participating countries.

(2)Based on the mean square deviation, the weight coefficients of the three indexes of grain supply, food transportation and food consumption from 2005 to 2019 are calculated respectively:

$$\omega_{mkj}=\frac{\partial_{mkj}}{\sum_{k=1}^{K}\partial_{mkj}} \tag{3.4}$$

In the formula:

m represents the year number: m=2005, 2006, …, 2019;

k is the number of three-level indicators included in food supply, food transportation, and food consumption, k is 4, 1, 2;

j represents the serial number of the three-level indicator, j=1, 2,... , 7;

Denotes the weight of item j in year m under the corresponding index of the next level.

(3) Calculate the mean weight coefficient of all three levels of indicators from 2005 to 2019, and take this as the unified weight of all three levels of indicators during the research period:

$$\omega_j=\sum_{m=2005}^{2019}\omega_{mkj}/15, k=4,1,2; j=1,2,...,7 \tag{3.5}$$

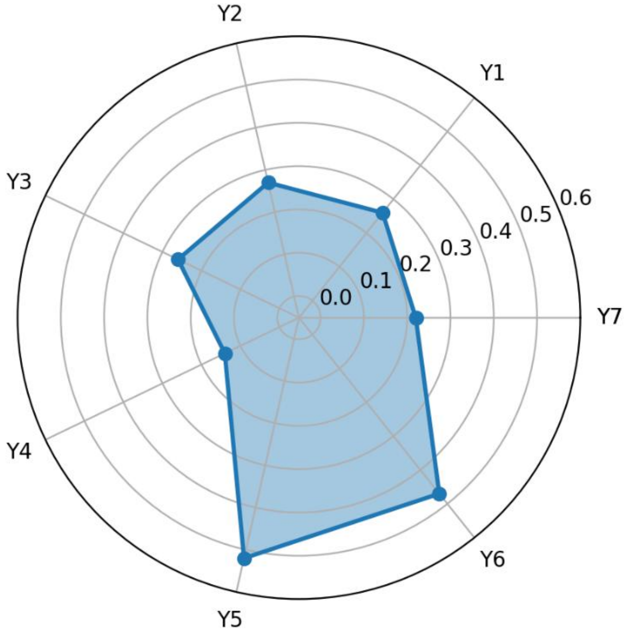
In the foemula: ω is the weight of each three-level index, and the calculated results are shown in the table below.

Form2 The weight of three level indicators

Secondary indicators	Food supply				Food transportation	food consumption	
Level 3 index code	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7
weight	0.22	0.26	0.28	0.26	0.14	0.53	0.47

The radar chart of the weight of the third-level indicators is as follows:

Figure 1 Radar chart of weight of three-level indicators



- Second-level index evaluation: Based on standardized data set and third-level index weight, the second-level index evaluation model is established to evaluate the food supply (X1), food transportation (X2) and food consumption (X3) of different countries from 2005 to 2019:

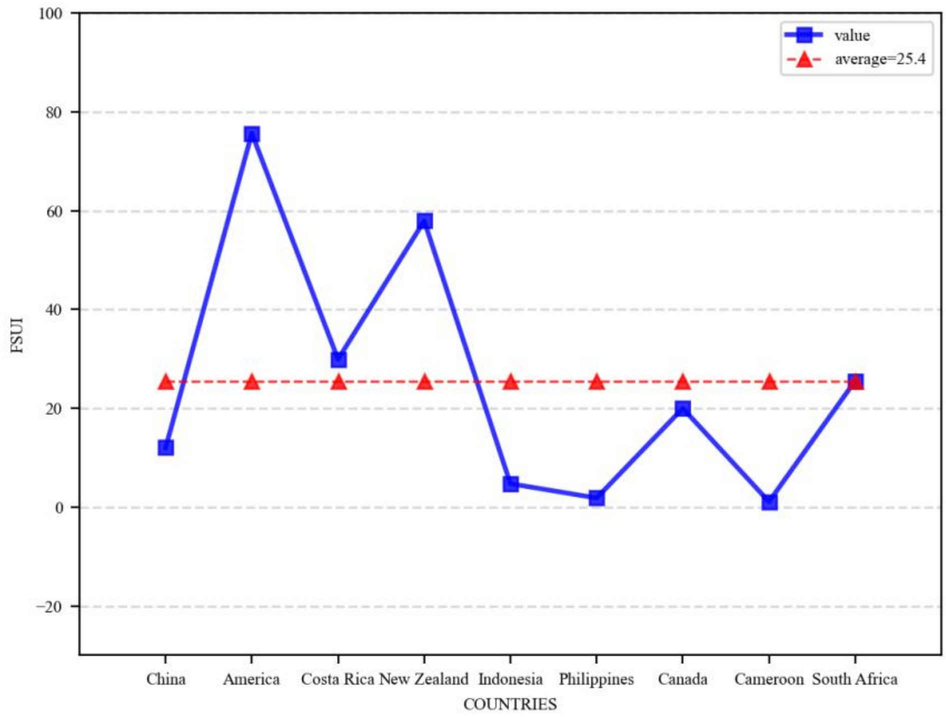
$$X_1 = 0.22Y_1 + 0.26Y_2 + 0.28Y_3 + 0.26Y_4;\quad X_2 = 0.14Y_5;\quad X_3 = 0.53Y_6 + 0.47Y_7 \tag{3.6}$$

Substituting the data into the above formula, we can get the evaluation results of food supply, food transport and food consumption in each country from 2005 to 2019.

- Establish FSUI evaluation line chart model: For the food system, adequate food supply is obviously the first premise of food system, on this basis, the optimization of food system also needs to transport food and food consumption to achieve, and how to supply stable, reliable, obtain and make use of food requires economic and fairness as a guarantee. It can be seen that food supply, food transportation and food consumption constitute the joint transfer relationship to the food system, and the line chart model can better reflect this relationship. Therefore, FSUI was used to represent the food system utility index and a line graph model was established to evaluate the utility of the food system.

$$FSUI = (X_1 \times X_2 + X_2 \times X_3)/2 \tag{3.7}$$

Figure 2 FSUI evaluation line chart



3.1.3 Analysis and Evaluation of results

We set up a food system evaluation model to evaluate the effectiveness of a country's food system, through the three-level index weight radar map (figure 1), we can simulate the all countries all roughly three indicators (average protein supply, grain production per ha, grain output and per capita arable land area, the density of railway, per capita GDP, percentage of the total amount of food imports of merchandise exports) average. Above data as the weight, we make the ev1 aluation of secondary index, including food supply, food, transport, food consumption and secondary indexes of evaluation results, and finally, by using the line chart to FSUI evaluation, we found that for the food system, adequate food supply is obviously the first premise of food system, on this basis, the optimization of food system also need to transport food and food consumption, thus, food supplies, food, transport, food consumption for food system has a good joint transmission relationship, through the line chart we can see it clearly.

3.2 Task2 Impact on food system equity

3.2.1 Model Establishment:

Next, we need to establish a food system equity evaluation model to evaluate the food system equity. In the evaluation, we apply TOPSIS (Technique for Order Preference by Similarity to ideal Sulution) to make full use of the existing data, and the results can accurately reflect the gap between the evaluation schemes. The inequities of the food system are reflected in the fact that even in rich countries, there are areas of food shortage, where there is not enough food and nutrients. We hope that through this method, validation when fairness aspect is optimized, what will happen to food system, these problems will not improve, need how long can be realized, we calculated by TOPSIS scores to reflect the land owners what proportion of women in the correlation between FSUI and strength, and the fairness of the evaluation in food system.

3.2.2 Model Solving

We selected the corresponding data from Faostat and World Wide Encyclopedia as the calculation basis to form the food system equity evaluation system. After a series of screening, incomplete and discontinuous units of data were constantly eliminated, and finally the data set of food system equity evaluation factors for 20 countries from 2014 to 2016 was obtained. The system content and calculation methods are shown as follows. (Take the following four countries). We used TOPSIS method for evaluation, following the following steps:

- Step 1: Forward the original matrix

  There are four common indicators: very large indicators, very small indicators, intermediate indicators, and interval indicators. Then, in the TOPSIS method, all indicators are unified and positive, and all of them are converted into very large indicators.

  (1) Transformation of extremely small indexes into extremely large indexes:

$$\max - x \tag{3.8}$$

  (2) Intermediate indicators are converted into maximum indicators:

$$M = \max\{|x_i - x_{best}|\}, \overline{x_i} = 1 - \frac{|x_i - x_{best}|}{M} \tag{3.9}$$

  (X_{best} is the best data in a series of intermediate indicators)

  (3) Interval indicators are transformed into very large indicators:

$$M = \max\{a - \min\{x_i\}, \max\{x_i\} - b\} \tag{3.10}$$

$$\tilde{x}_i = \begin{cases} 1-\dfrac{a-x_i}{M}, x_i < a \\ 1-\dfrac{x_i-b}{M}, x_i > b \end{cases} \tag{3.11}$$

- Step 2: The forward matrix standardization aims to eliminate the influence of different dimensions

(1) Assume that there are n objects to be evaluated, and the forward matrix composed of m positive evaluation indexes is as follows:

$$X = \begin{pmatrix} x_{11} & \cdots & x_{1m} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nm} \end{pmatrix} \tag{3.12}$$

(2) The normalized matrix is denoted by Z, and each element of Z is:

$$z_{ij} = x_{ij} / \sqrt{\sum_{i=1}^{n} x_{ij}^2} \tag{3.13}$$

(3) Obtain the standardized matrix Z:

$$Z = \begin{pmatrix} z_{11} & \cdots & z_{1m} \\ \vdots & \ddots & \vdots \\ z_{n1} & \cdots & z_{nm} \end{pmatrix} \tag{3.14}$$

- Step 3: Calculate scores and normalize them

(1) Define the maximum value:

$$Z^+ = (\max\{z_{11}, z_{21}, \ldots, z_{n1}\}, \max\{z_{12}, z_{22}, \ldots, z_{n2}\}, \ldots, \max\{z_{1m}, z_{2m}, \ldots, z_{nm}\}) \tag{3.15}$$

(2) Define the minimum value:

$$Z^- = (\min\{z_{11}, z_{21}, \ldots, z_{n1}\}, \min\{z_{12}, z_{22}, \ldots, z_{n2}\}, \ldots, \min\{z_{1m}, z_{2m}, \ldots, z_{nm}\}) \tag{3.16}$$

(3) Define the distance between the i-th(i = 1,2,…,n) evaluation object and the maximum value:

$$D_i^+ = \sqrt{\sum_{j=1}^{m} (Z_j^+ - z_{ij})^2} \tag{3.17}$$

(4) Define the distance between the i-th(i = 1,2,…,n) evaluation object and the minimum value :

$$D_i^+ = \sqrt{\sum_{j=1}^{m} (Z_j^- - z_{ij})^2} \tag{3.18}$$

(5) Finally, we can calculate the normalized score of the i-th(i = 1,2,…,n) evaluation

object:

$$S_i = \frac{D_i^-}{D_i^+ + D_i^-} \tag{3.19}$$

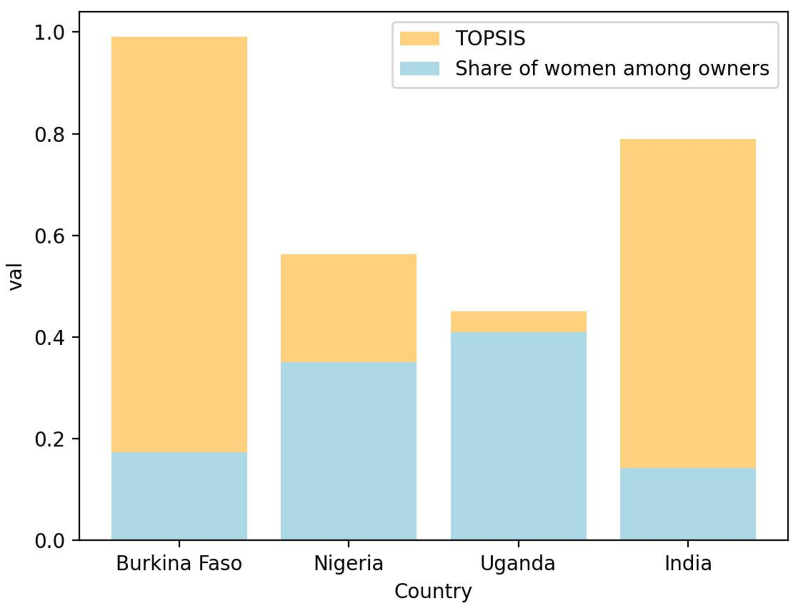
It can be clearly seen from the above formula that 0≤Si≤1, and the larger Si is, the smaller Di+ is, that is, the closer to the maximum value.

The TOPSIS score and the percentage of women among landowners are shown in the followingtable:

Form3 Equity Data in the Food System (Excerpt)				
Country	**FIUS**	**Share of women among owners**	**TOPSIS**	**Ranking**
Burkina Faso	1.502293042	17.30%	0.992161238	1
Nigeria	3.439137718	35.10%	0.563267938	3
Uganda	0.928323805	41.20%	0.45949535	4
India	19.67139168	14.30%	0.749530686	2

(Take Burkina Faso, Nigeria, Uganda and India as examples)

Figure 3 Histogram of scores and the percentage of women among landowners



3.2.3 Analysis and Evaluation of results

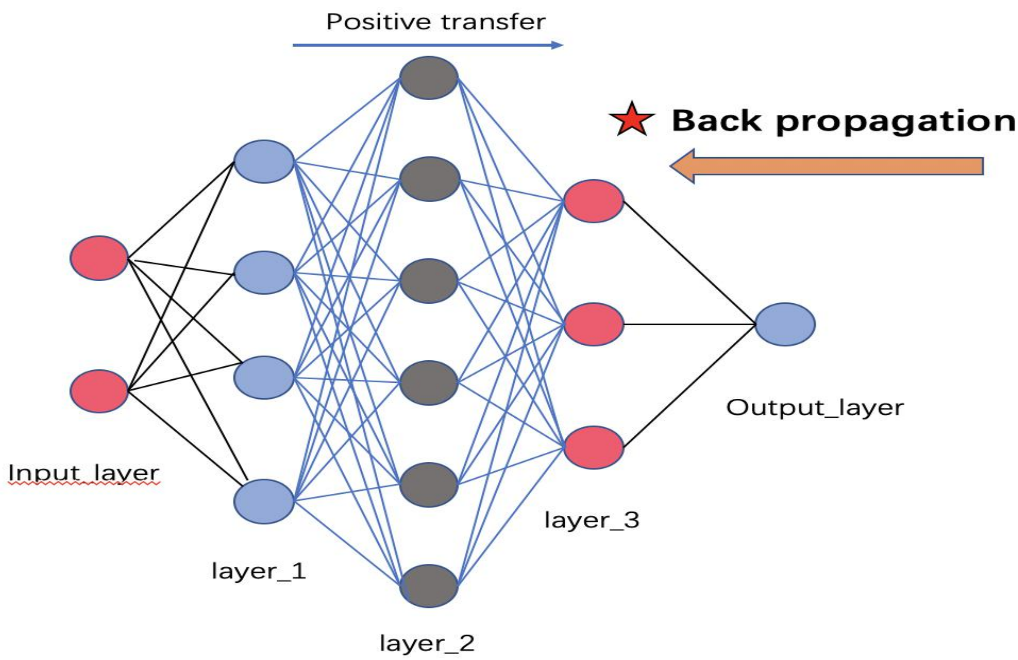
Based on TOPSIS method, by TOPSIS score can reflect the land owners in the proportion of women and the correlation of FSUI strength relation, we can see intuitive TOPSIS in table 3 scores, TOPSIS the higher the score, the proportion of women in land owners FSUI is larger, the influence of the correlation between the stronger, the male to female ratio of social unfairness caused by the negative effect will be more food system utility index. It can be seen that when the proportion of female landowners approaches 50%, the impact of equity on the utility of the food system will be improved. In addition to improving social stability, benefits will also be improved. Therefore, optimization of equity will have positive effects on the food system.

3.**3** Task3

3.3.1 Model Establishment:

Next, we have to establish a food system sustainable development model to explore the relationship between the sustainable development of the food system and the utility of the food system. Based on the previous data sorting and fitting, we consider using the artificial neural network model. The unit on the left is the input layer. It only needs two data: carbon dioxide equivalent per 10,000 tons of grain and water resource utilization. In the middle layer, we decided to choose a three-layer network containing 4, 6, and 3 neurons through repeated experiments to obtain the optimal model and the smallest loss value. The final output layer is the utility of the food system. In the model, a black box model between carbon dioxide equivalent, water use efficiency and food system utility is established, and a quantitative analysis of the impact of the sustainable development of the food system on the food system utility is established. (See the appendix for the code)

Figure 4 Neural network model



3.3.2 Model Solving

We selected the corresponding carbon dioxide equivalent and water resource utilization rate from FAOSTAT, and after a series of screening, continuously eliminated incomplete and discontinuous evaluation units, finally obtained the relevant data of 40 countries (20 developed countries and 20 developing countries) from 2005 to 2019 (see Table 4). As a training set for neural networks. The model establishment process is as follows:

- In order to better realize the prediction, we first conduct data processing on FSUI of each country, and select every 4 countries as a training sample (including 2 developed countries and 2 developing countries):

$$\widehat{FSUI} = \frac{FSUI_j}{\sum_{i=1}^{4} FSUI_i} \tag{3.20}$$

- The activation function selected in the process of neural network construction is sigmoid function:

$$y = \frac{1}{1+e^{-x}} \tag{3.21}$$

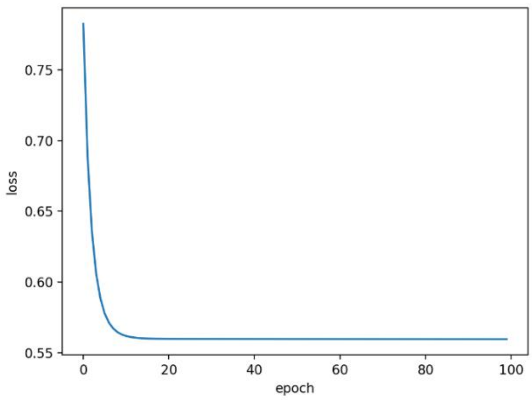
- We choose the appropriate loss function, and then update the parameters continuously through the back error propagation to reduce the error value:

$$\mathrm{Cos}\,t = \frac{1}{2}(t\arg et_{0_1} - out_{o_1})^2 + \frac{1}{2}(t\arg et_{0_2} - out_{o_2})^2 \tag{3.22}$$

$$\frac{\partial\,\mathrm{Cos}\,t}{\partial W_5} = \frac{\partial\,\mathrm{Cos}\,t}{\partial Out_{o_1}} \frac{\partial Out_{o_1}}{\partial Input_1} \frac{\partial Input_1}{\partial w_5} \tag{3.23}$$

3.3.3 Analysis and Evaluation of results

Through multiple rounds of training, we have established an artificial neural network model with strong generalization ability, and the loss can be controlled below 0.55. It can be seen that the change of carbon dioxide equivalent and water resource utilization rate will have a corresponding impact on the food system utility index, which provides a model basis for exploring how to improve the total utility index for the sustainable development of food system (The loss value of neural network is shown in the right figure)

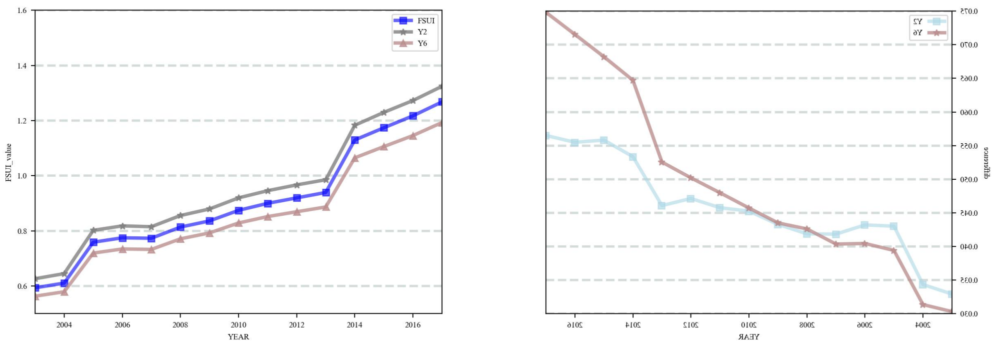


4 **Sensitivity analysis**

In this section, we test the sensitivity of the three models related to our work by changing the parameters and comparing the differences between the original results and the changed results.

- In the first model, we change Y2 and Y6 respectively.
- The important parameters of the second and third models are mainly affected by the food system utility index model, so we only analyze the first model at this stage.

Figure 5 line diagram of sensitivity analysis



We changed the weights of Y2 and Y6 respectively, and the step sizes were 0.05 and -0.05 respectively. Using data from the Philippines from 2003 to 2017, we obtained the left chart. Through the image, the curve fluctuation is small, the model sensitivity is high, and it has strong adaptability. By comparing the original model in the right figure, it can be concluded that Y6 has a greater influence on the model than Y2.

5 **Problem solving**

5.**1** Equity and sustainability in food system

5.1.1 Fairness Issues

Women's social status reflects a country's democratic development and civilization progress. The promotion of young and middle-aged women's social status in the new era not only helps women realize their life ideals and dreams in the process of pursuing a better life, but also helps women make unique contributions to the development of socialist modernization in the fields of economy, politics and culture. The improvement of women's social status is conducive to improving the social contribution rate of this group. At the same time, it will promote the sustainable development of the economic and social fields.

Women's economic status mainly refers to the rights and status of women in social and economic life, which are comprehensively measured by the degree of economic participation, income and consumption level. In the process of participating in economic activities, young and middle-aged women, on the one hand, as producers, investors and managers, promote the development of enterprises with their own advantages of human resources; On the other hand, as consumers, driven by the increasingly vigorous consumption demand, quietly updated consumption concept and consumption behavior, they have formed new consumption formats, promoted the emergence and development of "Smart Life", and further promoted the overall economic growth.

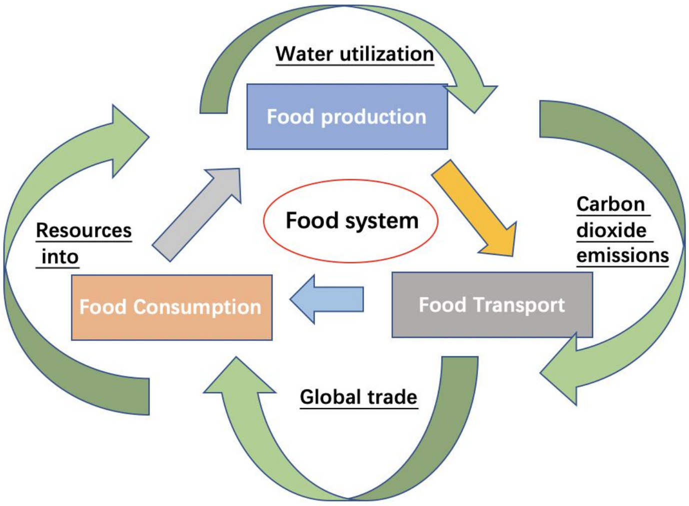
Because of women's social status is the direct reaction of fairness, home to the owner of the proportion of women is close to 50%, which means that the higher the women's social status, women's economic status is also more prominent, this also means that when fairness is optimized, food system utility index will get improved, compared with the current food system, when the land owners women close to 50%, the influence degree of the fairness problem of the food system utility will be improved, in improving the stability of the society at the same time, the interest will be improved, so the optimization of fairness will be a positive effect on the food system.

We use grey prediction GM (1, 1) model to predict how long it takes to achieve the fairness of the food system, through to the specific data calculation, meanwhile considering the change of government policy, we predict that the time for 5 ~ 6 years, during this time, because the fairness problem in food system caused by the negative utility was reduced by 40% or so, FSUI index increased significantly.

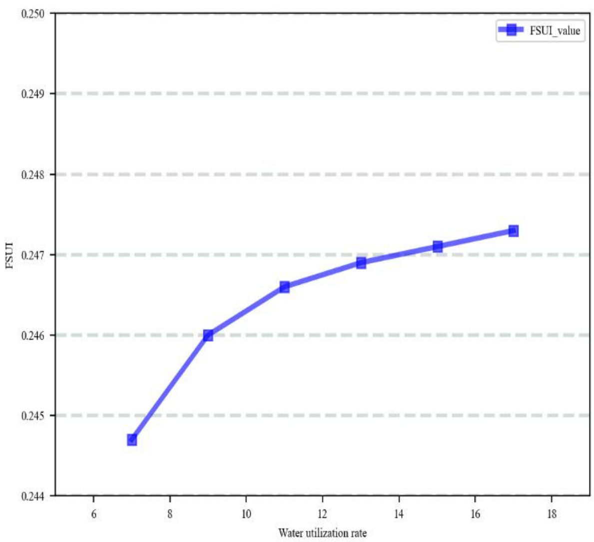
5.1.2 Sustainability issues

The research object of agricultural green development is the food system, which includes multiple interrelated and interacting elements (or parts) such as animal and plant production, processing, consumption and environmental emissions. It is an organic whole with certain structure and function and belongs to the category of system science [1]. Based on the sustainability regression model established during the modeling process, we will focus on optimization based on CO2 equivalent and water use efficiency. Artificial neural network is used to determine the relationship between carbon dioxide equivalent, water use efficiency and food system utility, and make prediction analysis.

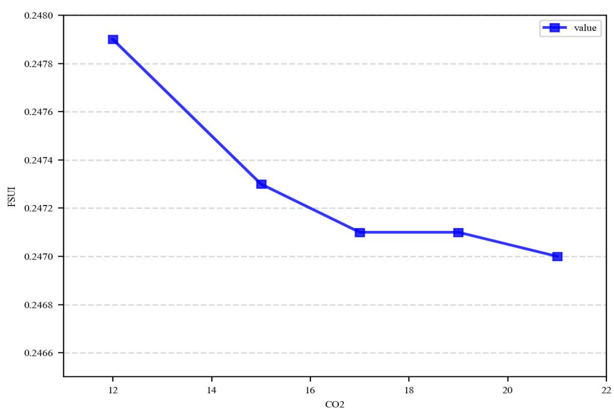
Figure 6 Sustainable development model of the food system



Water resources play an important role in the economic development of the world. Lack of water resources in many regions leads to low crop yields, which will affect the healthy development of food systems in the long run. Using the artificial neural network model, we found that under the assumption of constant carbon dioxide emission equivalent, the increase of water use efficiency is proportional to the utility of the food system. (e.g., below)



As for traditional irrigation technology, it simply irrigates water resources to farmland without considering the waste of water resources in the irrigation process, which is also an important factor affecting the development of water-saving irrigation technology. In order to solve the problem of low utilization rate of water resources, we can improve the irrigation methods, optimize and improve the previous irrigation methods, pay attention to the promotion of various water-saving technologies, and develop various ways to use water resources [2]. The generation and application of water-saving irrigation technology cannot be separated from the support of science and technology. The use of corresponding scientific equipment for farmland irrigation can improve the effect of water-saving irrigation to a large extent and promote the utilization rate of water resources to be above 50% [3]. Through low pressure transport, it can also reduce the loss of water resources, shorten the time of water delivery. By collecting relevant data, it can be found that a global irrigation system, which takes 2-3 years to populate, can increase water use by 50%, thus increasing grain yield per hectare in the food production process, total grain yield, per capita grain yield and net profit in food sales, contributing to the improvement of food utility index. We expect the increase to be in the range of 0.8% to 5%. At the same time, we also call on countries with advanced agricultural science and technology to make public or provide technical assistance to relatively backward countries。



The total amount of carbon emissions from agricultural sources is huge, accounting for almost 30% of the total carbon emissions from human activities. In the process of model building, we also found that the change of carbon dioxide equivalent is inversely proportional to the food system utility index, that is, the decrease of carbon dioxide equivalent increases the food system utility index. (As shown in the right figure) The core of agricultural low-carbon production is the adoption and promotion of low-carbon technology. Technological progress has a direct impact on improving factor utilization rate and restraining the growth of agricultural carbon emissions. However, in the process of policy promotion, the application of technology is often slow and unsustainable [4]. But at present, with the global greenhouse effect and the establishment of a global village. A 10-year analysis of carbon dioxide emissions in 40 groups of countries shows that carbon dioxide emissions have recently declined in most countries. We collected nearly 15 years' worth of CO2 emissions equivalent to predict multi-country CO2 equivalents using a grayscale prediction model GM(1,1).

- For gray prediction model GM (1, 1):

Might as well set x (0) = (x0 (1), x0 (2),... . X0 (n)) x (0) = (x0 (1), x0 (2),... .x0(n)) meets the requirement of prediction, and establishes GM (1,1) model with it as the data column:

$$x^{(0)}(k) + a z^{(1)}(k) = b \tag{5.1}$$

The estimated values of a and b were obtained by regression analysis, so the corresponding bleaching model is:

$$\frac{dx^{(1)}(t)}{dt} + ax^{(1)}(t) = b \tag{5.2}$$

Solution for:

$$x^{(1)}(t) = (x^{(0)}(1) - \frac{b}{a})e^{-a(t-1)} + \frac{b}{a} \tag{5.3}$$

So you get the predicted value:

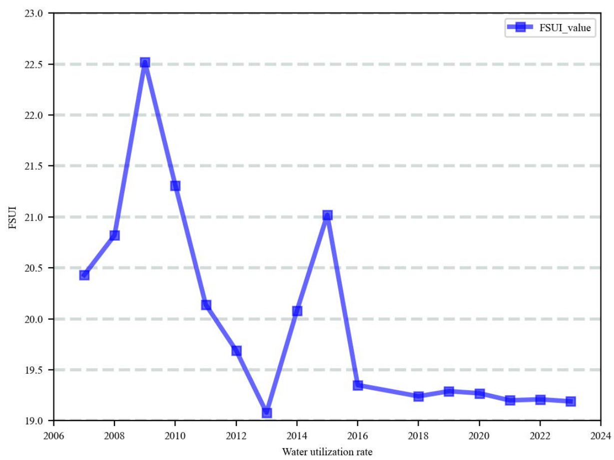
$$\hat{x}^{(1)}(k+1) = (x^{(0)}(1) - \frac{b}{a})e^{-ak} + \frac{b}{a}, \quad k = 1,2,...,n-1 \tag{5.4}$$

The predicted value can be obtained accordingly:

$$\hat{x}^{(0)}(k+1) = \hat{x}^{(1)}(k+1) - \hat{x}^{(1)}(k), k = 1,2,...,n-1 \tag{5.5}$$

Below, we will take Malaysia as an example for an overview. The gray scale prediction model is used to predict the carbon dioxide equivalent, and the accuracy rate is more than 70%. And use it to forecast the relevant data in 2020-2023. (as shown in the figure below)

Figure 9 Relevant data from 2020 to 2023



Under the assumption that the utilization rate of water resources in Malaysia remains unchanged, after repeated tests, we concluded that the FSUI value reached the local maximum value when the CO2 equivalent approached 19.187. We tentatively assume that this target will be reached in 2023 under current conditions (the 2023 forecast is 19.19). Therefore, this optimization reform will take three years. Countries that persist in reducing carbon emissions and improving the utilization of agricultural resources will increase the FSUI value by 2%-4%。

5.2 Assessment and analysis based on changing food system priorities:

At present, all countries are optimizing the food system by improving the food supply problem, and all countries are committed to improving the efficiency of the food system by improving the per mu yield and land utilization rate. We obtained the data based on changing priority through sensitivity analysis. Through data processing and processing, we found that::
Through sensitivity analysis, a combination of indicators and data, we can clearly feel that the size of the food system utility index more than food and supplies (including average protein supply, food production, total grain output per hectare), also depends on the size of the per capita GDP and the percentage of the total amount of food imports of merchandise exports, through sensitivity analysis and regression analysis, we found that by changing the size of the three-level index of per capita GDP and the percentage of the total amount of food imports of merchandise exports and change the secondary indicators of food consumption in FSUI is utility, Is much more dramatic and optimistic than changing the food supply.

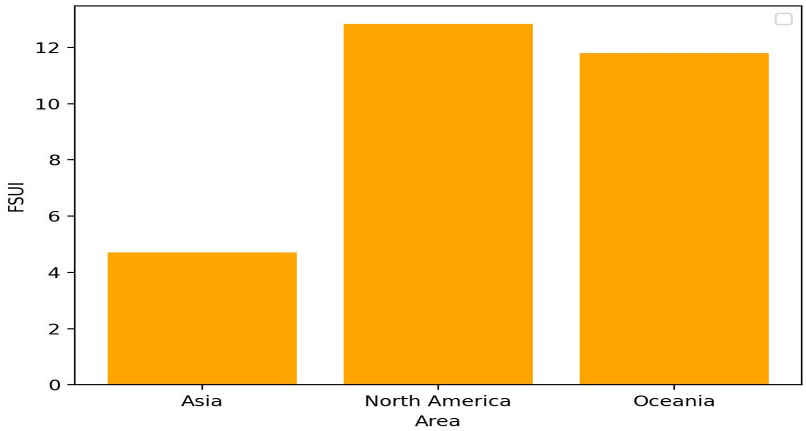
- On the economic front, as the gap between rich and poor has narrowed, so has the fairness of the food system. According to the Global Wealth Report, a bank, Credit Suisse, the poorest 20% of the population control less than 1% of wealth. The top 1 percent control nearly half of the world's assets, and the top 10 percent of adults own 89 percent. In addition to improving social stability, various utility indicators of the food system itself have also been improved to varying degrees, and finally affect FSUI, resulting in positive growth of its indicators. Such positive feedback generated by positive utility also optimizes our food system. Under this model, all countries should strive to increase per capita GDP while reducing the gap between the rich and the poor, make more resources equitable, improve the utilization rate of resources, constantly eliminate the gap between the rich and the poor, improve the economic and social impact caused by the gap between the rich and the poor, and finally affect FSUI.
  For most developed countries, with the advent of the current Industry 4.0 era, more and more robots will be assembled in the manufacturing industry, which will make more and more manufacturing workers unemployed. They will face more severe employment situation and living difficulties. Unemployment reduces their source of income, but also widens the gap between the rich and the poor and intensifies social conflicts. [1] Faced with the coming challenges, developed countries should actively face them and take the initiative to change. In the face of developing countries, the development of the world economic community will bring both challenges and opportunities. Whether the gap between the rich and the poor will be enlarged or narrowed depends on whether the country can seize the opportunities and formulate appropriate policies.。

- In terms of percentage of the total amount of export food imports of goods, based on the analysis of national economic strength, by adjusting the percentage of the total amount of export food imports of goods, reasonable distribution to optimize food production system, national FSUI got different degree of increase, in this model, all countries should meet under the premise of self-sufficiency as far as possible to reduce imports, thus stimulating the economy level, make the food system to optimize effective. However, in today's global economic integration trend is gradually significant, both developing and developed countries are facing the same opportunities and challenges. Choose a more excellent food production system, and then adjust the food adjustment of food imports accounted for the percentage of total exports, it is a top priority.

6 **Evaluation of the model**

6.1 **For the larger food system**

In the previous work of our team, the food systems discussed were all established on the basis of national data samples. The hope is that this model can be applied to larger food systems, such as national organizations or continents. Here we try to use this model to evaluate the food systems of different continents.
After collecting and integrating the data of different continents, we found that the value of the total grain yield was too large, which seriously affected the final forecast result. Therefore, after comparative analysis, we decided to cancel the weight of the total grain yield in the current model, and changed the three-level index to eight. At the same time, because part of the data is difficult to obtain, we take the method of averaging the data of different countries to replace it. After the model evaluation, we get a relatively satisfactory result. (Some data are shown in the figure below)



From the figure above, we can see that North America, where developing countries are more concentrated, has a better food system utility index, while Asia, where third world countries are more concentrated, has a more pessimistic food system utility index. So closing the direct wealth gap between developed and developing countries would have a huge positive impact on improving the global food system.

6.2 For smaller food systems

We through the observation of Chinese agricultural data between around the city, found that sometimes the effect is not ideal when using the system analysis, through the regression analysis found that, with the result of not ideal parts such as a large industrial zone, to have less farmland, less engaged in farming population, and to buy food is bigger, the proportion of the railway density is bigger, so it caused the eventually produce the result of the more extreme.

Based on the above conclusions, we believe that this model is suitable for comprehensive cities located in plain areas with land suitable for cultivation. For cities that are not suitable for farming or large industrial areas, we should analyze them from the perspective of food consumption and increase the weight of GDP and urban wealth gap. Therefore, the applicability of the model is improved.

7Reference

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8 Appendix Code of Model 3

```
import numpy as np
import torch
import matplotlib.pyplot as plt
xy = np.loadtxt('National_data （1） .csv', delimiter=',', dtype=np.float32)
x_data = torch.from_numpy(xy[:, :-1])
y_data = torch.from_numpy(xy[:, [-1]])
class Model(torch.nn.Module):
    def __init__(self):
        super(Model, self).__init__()
        self.linear1 = torch.nn.Linear(2, 4)
        self.linear2 = torch.nn.Linear(4, 6)
        self.linear4 = torch.nn.Linear(6, 3)
        self.linear5 = torch.nn.Linear(3, 1
        self.sigmoid = torch.nn.Sigmoid()
    def forward(self, x):
        x = self.sigmoid(self.linear1(x))
        x = self.sigmoid(self.linear2(x))
        x = self.sigmoid(self.linear4(x))
        x = self.sigmoid(self.linear5(x))
        return x
model = Model()
criterion = torch.nn.BCELoss(reduction='mean')
optimizer = torch.optim.SGD(model.parameters(), lr=0.5)
epoch_list = []
loss_list = []
for epoch in range(0, 100):
    y_pred = model(x_data)
    loss = criterion(y_pred, y_data)
    print(epoch, loss.item())
    epoch_list.append(epoch)
    loss_list.append(loss.item())
    optimizer.zero_grad()
    loss.backward()
    optimizer.step()
x_yuce = torch.Tensor([[15, 17], [15, 15], [15, 13], [15, 11], [15, 9], [15, 7] ])
print(model(x_yuce).data)
plt.plot(epoch_list, loss_list)
plt.ylabel('loss')
plt.xlabel('epoch')
plt.show()
```