Equity Assessment of Global Food Development

Zichen Han, Yuxuan Liu, Long Xu, Kui Wan, Qifan Jiang

Hohai University, Changzhou, China

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Abstract: As an important part of natural resource, food plays an important role in people's lives. Based on the perspective of fairness, this article assesses the state of global food development. We conduct researchs on food equity in-depth and analyse influencing factors of the regional differentiation of equity levels, thus making targeted policy recommendations. We study the overall fairness of the global food system by solving the weighted coefficient of variation and the Gini coefficient. Through the Theil Index, we decompose the overall difference into differences between the six continents and differences within the six continents. This article creatively defines the economy-food matching index and energy-food production matching index. We focus on analysing and evaluating the fairness of water utilization in all continents based on economic and ecological dimensions. The conclusion shows that the overall fairness of the food system is poor. The value of the Gini coefficient has been declining year by year. However, it kept the level above 0.4, indicating that food equity has gradually improved. From the data analysis results of the Theil index, we can find that Europe, North America and Oceania are economically fair. In particular, Europe has the highest MIe index and the highest degree of fairness. Asia, Africa and South America are in a state of economic inequality. In particular, Africa has the lowest index, which shows that it is in a more serious state of unfairness.

1. Introduction

We usually evaluate the effect of resource allocation from the two dimensions including efficiency and fairness. Nowadays more and more attention is paid to fairness and sharing, the research on fairness of resources has become more and more important. Government enterprises [1] pay great attention to the fairness factor in resource allocation and decision-making coordination, and try to let all members share the development results. Food resources [2], as an important part of the natural environment, is no exception. As a security strategic resource to ensure people's livelihood, food should be treated from the perspective of the overall national security perspective to assess the level of development of the food system [3]. Sorting out relevant literature, some scholars analyze the current problems from the dimensions of specific industries such as education [4] and medical [5], and explore ways to achieve fairness. Some scholars have also studied the overall fairness from the macro perspective of public resources [6], rural revitalization [7], urbanization [8], and urban governance [9], expressing their demands for fairness in the future. However, there are relatively few studies on the optimization path for the evaluation of the level of equity in the food system.

Based on the macro and micro perspectives, this article focuses on the fairness of the global food development state, and compares and analyzes the fairness of the food system in different regions. This article defines the economy-food matching index and water-food matching index, focusing on analyzing and evaluating the fairness of water use in all continents from both economic and ecological dimensions. With the outbreak of crises such as climate warming, resource shortages, and raging epidemics, the resource and environmental situation has become increasingly serious. Based on this background, this research has strong application value and practical significance.

2. Data Processing and Model Assumptions

2.1 Data Sources

The data used in this article includes the total food output value, agricultural population, agricultural water use, and agricultural production in six continents, China, the United States, India, Indonesia, and China's Yangtze River Delta, Jiangsu Province, Qinghai Province, Hainan Province, and Shaanxi Province in the past 20 years. Energy consumption, arable land area, per capita renewable fresh water resources, per capita greenhouse gas emissions, etc. Besides, we obtained industrial energy consumption through the International Food Agency, and searched the World Bank database and the China Statistics Yearbook and China Energy Yearbook from 1999 to 2020. The required values are obtained through post-formula processing.

2.2 Model Assumptions and Symbol Description

The food system includes agriculture, forestry, animal husbandry, fishery and other crops. The water and energy consumption data for food production can approximately equals to the number of the fresh water and energy consumed by agriculture. The population participating in the food production can be approximated by the proportion of the agricultural population to the total population. The output value of the system can be obtained from the ratio of the GDP of agriculture, forestry, animal husbandry and fishery to the gross national product.

The meanings of the symbols are shown in Table 1.

Table 1 Symbol Description

symbol	symbol description
GFS	Global food system
MI_e	The economy-food matching index
MI_s	The water-food matching index

3. Model Construction and Analysis

We first judge the overall fairness of the world by solving the weighted coefficient of variation. We use the proportion of the population of each continent in the population of the country as a weighted weight to measure the fairness of food resources.

$$v = \frac{1}{\overline{x}} \sqrt{\sum_{i=1}^{n} [(x_i - \overline{x})^2 \times \frac{P_i}{P}]}$$

Among them, v represents the weighted coefficient of variation of the representative. xi represents the food output value per capita of the continent i. $\overline{x}$ represents the global per capita food output value. Pi represents the population of the continent i. P represents the global population.

Next, we take the Gini coefficient to compare the difference in the amount of food distribution between different continents. The trapezoidal formula method are employed and the area myopia under the Lorentz curve is calculated as a number of trapezoids.

$$\int_0^1 f(x)dx \approx \frac{1}{2} \sum_{i=1}^{6} (p_i - p_{i-1})(y_{i-1} + y_i)$$

Sort the six continents in order of total food production from low to high. Set the proportion of the cumulative population of the continents from group 1 to group i to the global population as pi. The proportion of cumulative food output to the total global food output as wi. The Gini coefficient is calculated as follows.

$$1 - \sum_{i=1}^{6} (p_i - p_{i-1})(y_{i-1} + y_i)$$

When $i = 0$, then $x_i = 0, y_i = 0$. Regarding the selection of the "warning line" of the Gini coefficient, economics often regard 0.4 as the warning line for the income distribution gap. This paper defines the reasonable range of Gini coefficient as 0-0.4.

We use the Thiel index and related algorithm, which is weighted by the proportion of GDP, to analyze the fairness of food in all continents. By decomposing the Thiel index, the overall difference is decomposed into the differences between the six continents and the differences within the six continents. The fairness level in the food system is evaluated in detail. The formula is as follows.

$$TI = \sum_{i=1}^{n} g_i \ln \frac{g_i}{w_i}$$

Among them, gi is the proportion of the GDP of the continent i to the global GDP. Wi is the proportion of the food output value of the continent i to the global food output value. The decomposition formula of Theil index is as follows.

$$\begin{aligned} T_d &= T_{WR} + T_{BR} \\ &= \sum_{i=1}^{6} \frac{G_i}{G} \sum_{i=1}^{6} \frac{G_{ij}}{G} \ln\left(\frac{G_{ij}/G_i}{W_{ij}/W_i}\right) + \sum_{i=1}^{6} \frac{G_i}{G} \ln\left(\frac{G_i/G}{W_i/W}\right) \end{aligned}$$

We define the economy-food matching index and water-food matching index, focusing on analysing and evaluating the fairness of water use on all continents from the economic and ecological dimensions. The matching index refers to the ratio of the contribution rate of the regional evaluation index to the contribution rate of food. It can be calculated as follows.

$$MI_j = \frac{V_{ij}/V_j}{W_i/W}$$

Among them, MI_j represents the matching index of food production. V_{ij} represents the value of the index j on the continent i. Wi represents the value of food output on the continent i. W represents the value of global food output. When the index j is GDP, the economy-food matching index can be obtained as follows.

$$MI_e = \frac{G_i/G}{W_i/W}$$

When the indicator j is renewable water resources, the water-food matching index can be obtained as follows.

$$MI_s = \frac{T_i/T}{W_i/W}$$

As shown in fig.1, when $MI_e > 1$, it showed that the contribution rate of the indicator GDP was greater than the contribution rate of its food production, which was relatively fair. From an economic point of view, the degree of food matching was relatively high. On the contrary, fairness was poor.

As shown in fig.2, when $MI_s > 1$, it showed that the indicator renewable water resources had a higher contribution rate than food resources, and was relatively fair. From an ecological perspective, the food matching index was relatively high. On the contrary, fairness is poor.

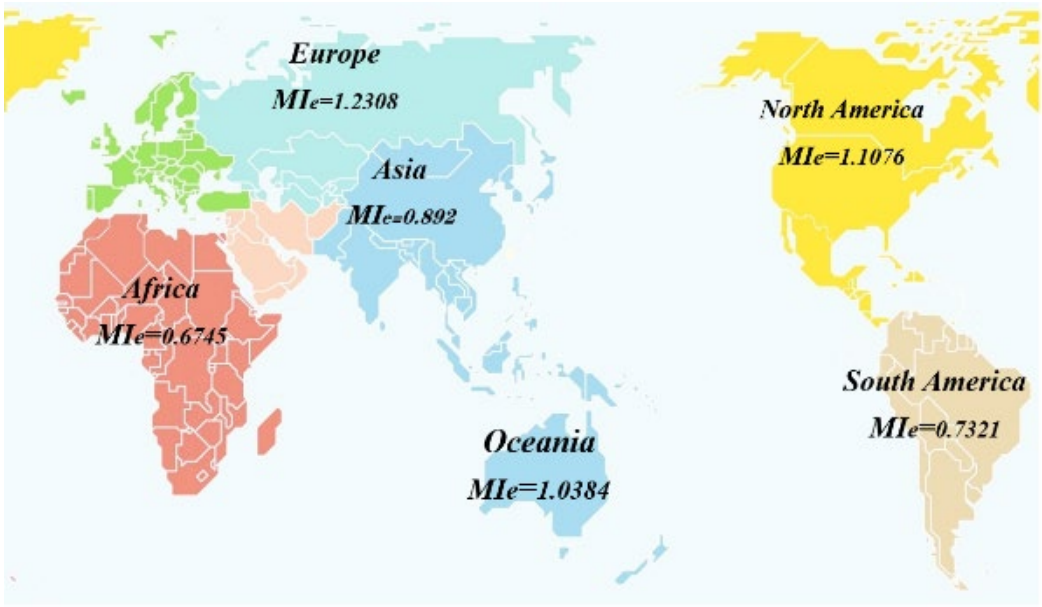

Fig.1 The Global Distribution of MI_e

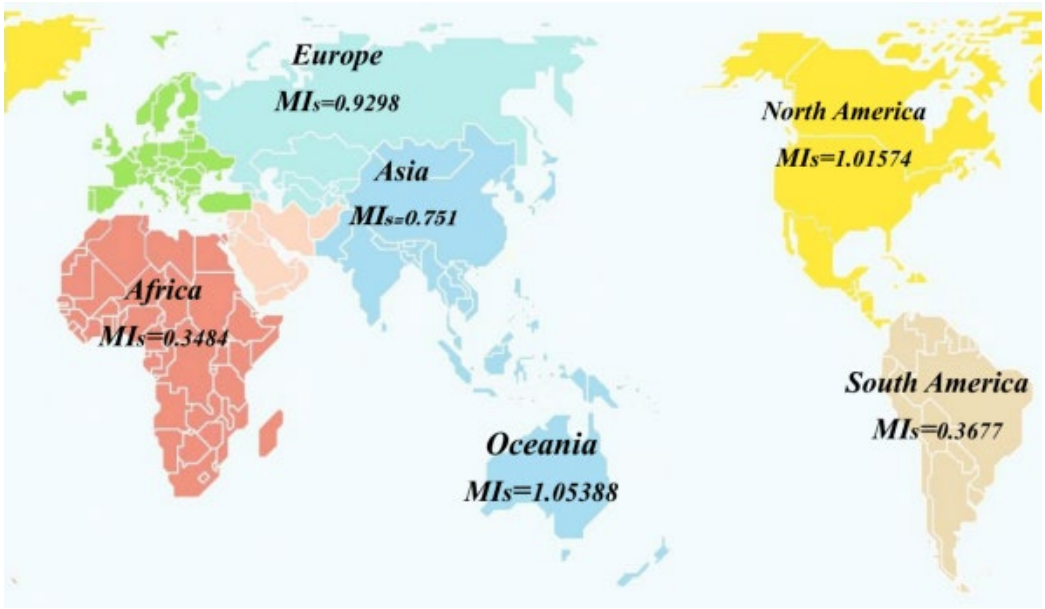

Fig.2 The Global Distribution of MI_s

We can find that the weighted coefficient of variation fluctuates around 0.2, which indicates the lack of overall global fairness. The value of the Gini coefficient has been declining year by year, but has been at a level greater than 0.4, which indicates that the food system is gradually becoming fair. However, the overall situation is unfair. From the GDP-weighted Theil coefficient, it can be seen that Europe, North America and Oceania are economically fair, especially Europe. It has the highest MIe index and the highest degree of fairness. In addition, Asia, Africa and South America are economically unfair. In particular, Africa has the lowest index and is in a more serious state of unfairness.

4. Conclusions and Recommendations

4.1 Conclusions

By assessing the overall fairness of the global food system and in-depth research on the fairness level of different regions, we Draw the following conclusions. The conclusion shows that the overall fairness of the food system is low, but it has gradually improved in recent years. From the

results of the Theil index data analysis, we found that Europe, North America and Oceania are economically fair. Among them, Europe has the highest MIe index and the highest degree of fairness. In contrast, Asia, Africa, and South America are economically unfair. Among them, Africa has the lowest index, indicating that the development of the food system is extremely unfair and the degree of unfairness is the highest.

4.2 Advantages and Disadvanteges

Regarding advantages, in the fairness measurement standard, Theil coefficient is more comprehensive than other measurement indexes, such as coefficient of variation, Gini coefficient, etc. Regional differences can be decomposed, and overall differences can be divided into intra-regional and inter-regional differences. We measure the contribution rate of the gap between regions and inside regions at the same time.

Regarding the shortcomings, this article only studies the fairness of the six continents, which can be further divided through more data analysis. For example, we can also discuss its fairness from different countries' physiques, different economic regions and different geological environments

4.3 Recommendations

Based on the above conclusions, the following suggestions can be put forward.

Firstly, give full play to the overall advantages and leading role of the global food system. Use the relatively powerful self-adjustment ability of the system to adjust and improve the subsystem. All regions around the world need to focus on win-win cooperation, strengthen institutional updates and exchanges, and establish a more complete and reasonable food subsystem based on the stability of the global food system.

Secondly, pay attention to play the key role of advanced technology and transnational cooperation. Through the comparison and overall analysis of six continents, most people in the food system of developing countries have relatively poor fairness, which needs to be improved. For example, Africa and South America should increase national investment in food production, strengthen environmental protection technology and equipment. Besides, they must face up to their own shortcomings, strengthen mutual assistance and exchange between neighboring countries, improve technical efficiency and further improve the performance of the food system.

Finally, it is suggested to accelerate development and promote regional coordination. In addition to the more serious situation in Africa and South America, although the European region's economy-food matching index is relatively fair, the water-food index is in an unfair state. It can promote multi-level allocation of food, rational use of water resources, establish a recycling water system, optimize the consumption structure of water resources system. Also, pay attention to reducing water resources waste and random discharge of waste water, and put emphasis on the discharge of industrial sewage after purification.

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