Problem Chosen	2021	Team Control Number
E	ICM Summary Sheet	2118693

Re-Optimizing Food System Based on the SEEP Evaluation Model

Summary

The conventional food system doesn't pay much attention to sustainable development and equity over different regions. The improvement of the priorities of sustainability and equity has a great impact on both the ecosystem and the well-being of humans. We establish a more comprehensive food system and its corresponding scoring model called **SEEP** evaluation model to optimize current conditions with an extensive consideration of sustainability and equity.

First of all, to set a conceptual model of the food system, we research a wide range of authentic studies and integrate significant approaches, processes, and links to form the optimized food system.

Secondly, the selection of each sub-indicator of the four considering factors including **sustainability (S)**, **equity (EQ)**, **efficiency (EF)**, and **profitability (P)** is based on previous studies of the food system. To overcome the incompleteness of the data, we operated multiple imputations for the missing data through SPSS. To determine the weight of each indicator and factor, we apply a combination weight method resulting from the linear weighting composition of **AHP** and **EWM** methods to make it more reliable. The scoring values and rank results of countries are demonstrated in a world map exported through ArcGIS.

Thirdly, we provide several new perspectives to recognize and interpret the food system and upgrade our traditional notion of it. We analyze the Pearson correlation of several indicators and do a **coupling coordination analysis** of the four factors to illustrate potential interior relationships between various indicators and factors. The benefit-cost results can be clearly reflected in the plots and figures.

Besides, the forecast work is accomplished through the **Grey Model Prediction** method. The prediction model derives from historical data we collected for each region. We also verify the accuracy and reliability of the results of the model for some regions, the outcome is acceptable. We use the **sensitivity analysis** to determine the influencing factors of the model and the dependence of the relevant indicators on the model.

Finally, we summarize the strengths and weaknesses for further application and improvement.

Key words: Food system, Sustainability, Equity, AHP, EWM, Grey Model Prediction.

Contents

1 Introduction

1.1 Problem Background

The general background of this problem is that there is an urgent demand to face the challenge of environmental degradation and other unstable factors in human society. The Ambitious Millennium Development Goals (MDGs) have given way to Sustainable Development Goals (SDGs) or global goals, which appear the significance of transforming all aspects of the social operation to respond to these challenges.

The same goes for the food system, although the present food system is of enough efficiency and profitability driven by the capital profit around the globe, there are still 821 million people suffering from hunger all over the world [1] and the adverse environmental effects of the food system have not been considered, which bring the food system the "hidden costs" identified in this year's report [2]. The adoption of healthy diets that promote sustainability can significantly reduce these hidden costs, creating important synergies with other SDGs.

Moreover, the 2019 Coronavirus Disease (Covid-19) pandemic and the unprecedented desert locust epidemic in East Africa in the past year have made the global economy more uncertain. Hence, optimizing the current food system for both sustainability and equity has its enormous significance. However, there is no one-size-fits-all solution for countries, which indicate the policymakers to manage the trade-offs to achieve the required transformation of the food systems.

1.2 Restatement of the Problem

To optimize the existing food system to meet the requirements of sustainability and equity, the priorities of each factor in the food system are expected to be adjusted and the following tasks require consideration:

- Discover what changes will occur after optimizing the food system on sustainability and equity, and the duration for the optimized food system to be implemented. (Refer to Task 1)
- The strengths and weaknesses as well as the realizing duration of changing the priorities of the food system should be evaluated. Besides, discuss the differences of these merits and demerits applying the optimized food system on both the developed and developing countries. (Refer to Task 2)
- Support the conclusions discovered in previous tasks when applying the optimized food system model specifically on at least one developed country and one developing country. (Refer to Task 3)
- As for food systems of different sizes, explore the scalability of the optimized model; while discussing the adaptability to other places and regions. (Refer to Task 4)

1.3 Our work

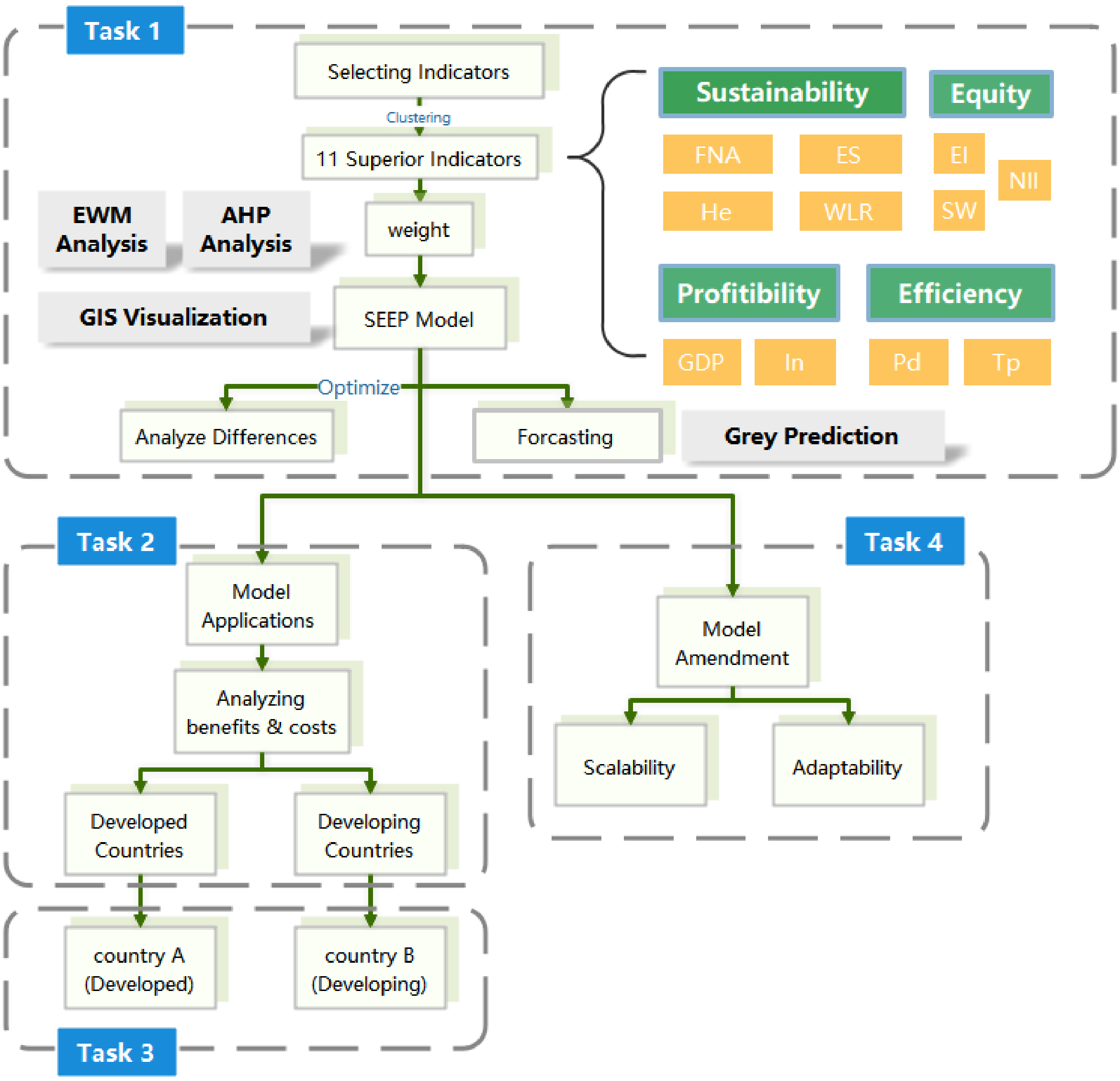

Figure 1: the Flow Chart of Our Work

2 Preparation of the Models

2.1 Assumptions

In order to simplify the considered problems and gather as much global data as possible, we make the basic assumptions as follows which are properly justified.

- **We assume that the countries used as case studies in Task 3 are regular and representative.** Select the two countries based on the completeness of the data and whether its superior indicators are almost of an average value. Therefore, the A and B countries can properly represent the developed countries and the developing countries respectively.
- **We ignore the differences in different ages when analyzing the indicators which refer to physical health such as hunger and obesity.** Our model focuses on the general feature

of the whole crowd and the comparison among regions. Therefore, ignoring the inner varies of the populations is reasonable.

- **We ignore the explosive changes when predicting the development of the food system.** The data we use to establish the evaluation model is relatively stable which can only reflect some trends and correlations instead of the significant fluctuations and instability. Therefore, our model ignores the explosive changes are robust enough and can be applied to stable regions.

2.2 Notations

The primary notations used to describe our models in this paper are listed in Table **??**. And Other symbols that are used only once will be described later.

Symbol	Definition
C	system coupling degree
T	systematic evaluation index
D	coupling coordination degree
CI	consistency indicator
CR	consistency ratio
RI	mean random consistency index
ω_i	weight/priority of ith factor

Table 1: Notations

3 The Models

3.1 Food System Conceptual Model

We aim to discuss a sustainable food system through our SEEP evaluation model. And the sustainability of the future food system has the three major characteristics shown as follows:

- **Economically Feasible:** the sustainable food system does not contradictory to the global as well as national development agendas, which means it is profitable throughout;
- **Socially Equitable:** has broad-based benefits for society (social sustainability);
- **Environmental and physical sustainability:** It has a positive or neutral impact on the natural environment and physical health.

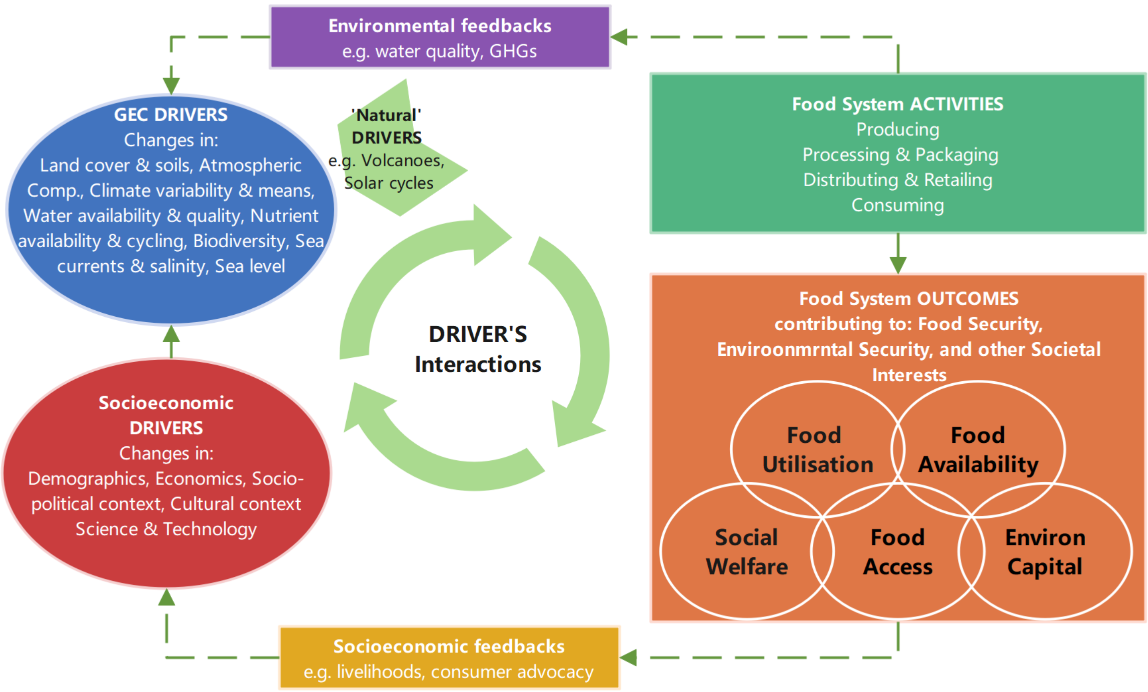

Figure 2: The Conceptual Model of Food System [3]

Ericksen et al. have built a conceptual model for the food system in the article *Conceptual food systems for global environmental change research* [3]. The food system involves not only the producing-consuming-disposal lifetime for all kinds of food, but also the environmental and socioeconomic drivers as it is displayed in Figure 2. And this conceptual model would be used as the theoretical basis for us to select the 11 superior indicators and discuss their correlations later.

3.2 SEEP Evaluation Model

3.2.1 Indicators Selection

Accosub-ining to the 17 Sustainable Development Goals from UN [4], realizing equity is one of the sub-goal of realizing sustainability. However, Aiming to add detailed consideration of sustainability as well as the equity in the food system, we separate the equity from sustainability as an independent evaluation indicator.

"S" for sustainability We select the indicators that represent sustainability according to the research results of *Seven Food System Metrics of Sustainable Nutrition Security* from David et al. [5].

- **FNA-Food Nutrient Adequacy:** We use Shannon diversity to represent this indicator with the calculation formula as follow:

$$Shannon\ Diversity = -\Sigma_i s_i ln(s_i) \tag{1}$$

  Where s_i indicates how much does the i_{th} food item weight when being supplied. Thus, the smaller the indicator value means that the degree of the unequal distribution is higher.

- **He-Health:** According to the goal of good health and well being [4], we select the mean life expectancy to show the average health condition of one region.

Factor	Superior Indicator	Notation	Indicator	Notation	Weight of Superior Indicator	Target
Sustainability	FNA-Food Nutrient Adequacy	S_1	Shannon diversity	S_{11}	0.057	↑
	He-Health	S_2	Life expectancy	S_{21}	0.1286	↑
	ES-Ecosystem Stability	S_3	GHG emissions	S_{31}	0.6496	↓
			Net freshwater withdrawals	S_{32}		↓
			Food production per capita	S_{33}		↑
			Energy use per capita	S_{34}		↓
			Arable land per capita	S_{35}		↑
	WLR-Waste and Loss Reduction	S_4	Pre-consumer food loss	S_{41}	0.1648	↓
			Fertilizer usage	S_{42}		↓

Figure 3: The Weight and Indicators of Sustainability Factor

- **ES-Ecosystem Stability:** In this section, we sufficiently consider the correlation between one food system and the ecosystem with 5 indicators refer to the work of David et al. [5]: GHG (greenhouse gases) emissions, net freshwater withdrawals, food production per capita, energy use per capita, arable land per capita. And their correlation with the SEEP score is shown in Figure 3.

- **WLR-Waste and Loss Reduction:** In this section, we consider two factors: pre-consumer food loss and fertilizer usage. As for the pre-consumer food loss, it has a great adverse impact on the ecosystem since both the production and decomposing process have a large environmental footprint. And fertilizer is one of the main approaches for human releasing into the environment. Furthermore, fertilizer abuse has caused great disaster such as red tide recent years.

"E" for Equity We select the indicators that represent equity also according to the research results of *Seven Food System Metrics of Sustainable Nutrition Security* from David et al. [5].

Factor	Superior Indicator	Notation	Indicator	Notation	Weight of Superior Indicator	Target
Equity	EI-Economical Inequity	EQ_1	Inequality index (Gini)	EQ_{11}	0.2098	↑
			Extreme poverty	EQ_{12}		↓
	NII-Nutrient Intake Inequity	EQ_2	Hunger	EQ_{21}	0.5499	↓
			Obesity	EQ_{22}		↓
	SW-Sociocultural Wellbeing	EQ_3	Number of people in poverty	EQ_{31}	0.2402	↓
			Gender equity	EQ_{32}		→1

Figure 4: The Weight and Indicators of Equity Factor

- **EI-Economical Inequity:** This section contains two sub-indicators: the Gini index which represents the inequality in long history [6](range from 0 to 100, and higher for the higher income equality), and the extreme poverty(the percentage of the population living on less than \$3.2).

- **NII-Nutrient Intake Inequity:** The depth of the food deficit indicates how many calories would be needed to lift all undernourished people from their status, which indicates the degree of hunger. And take the prevalence of Body Mass Index(BMI)>=30 kg/m to represent obesity, which is confirmed by World Health Organization [7]. It leads to huge inequity that around 821 million people suffering from hunger even though 39 percent of adults over age 18 were overweight or obese in the year 2016 [8].

- **SW-Socio-cultural Wellbeing:** According to reference [5], sustainability contains the aspect of socio-cultural wellbeing (be composed of gender equity, the extent of child labor, respect for community rights, and animal health & welfare). Consider the data acquisition and the meaning of the indicators, we select the gender equity to represent the SW indicator. Gender would be optimized to be approaching 1 since it displays the ratio of male and female. Moreover, considering that poverty could be one of the main reasons limiting the nutrition intake of impoverished families. We introducing the number of people in poverty to represent the equity of one food system. Besides, the higher the poverty population is, the lower one food system will be scored.

"E" for Efficiency We select the indicators to represent efficiency according to the conceptual model of food system 2.

Factor	Superior Indicator	Notation	Indicator	Notation	Weight of Superior Indicator	Target
Efficiency	Pd-Productivity	EF_1	Productivity	EF_{11}	0.5	↑
	Tp-Transportation	EF_2	Road density	EF_{21}	0.5	↑

Figure 5: The Weight and Indicators for Efficiency Factor

- **Pd-Productivity:** This indicator can be a direct reflection to the total efficiency of one food system, which could be optimized to a higher value.
- **Tp-Transportation:** Infrastructure is also an important factor in the efficiency of one food system, among which the road density would be the most representative indicators. The higher the density is, the more the efficiency the food system it would be.

"P" for Profitability We select the indicator to represent profitability according to the conceptual model of food system 2.

Factor	Superior Indicator	Notation	Indicator	Notation	Weight of Superior Indicator	Target
Profitability	GDP	P_1	GDP	P_{11}	0.5	↑
	In-Income	P_2	Income per person	P_{21}	0.5	↑
			CPI	P_{22}		↓

Figure 6: The Weight and Indicators for Profitability Factor

- **GDP:** Since the food system is a complex system covering many aspects from primary to tertiary industries, this indicator could represent the profitability of one food system well.
- **In-Income:** This section contains two indicators: income per capita and consumer price index (CPI).CPI shows the changes in the consumer price index, which are used to assess price changes related to the cost of living.

3.2.2 Methods and Scoring

1) **Analytic Hierarchy Process (AHP):** After selecting 11 superior indicators with 20 indicators, we use AHP analysis (shown in Figure 7.

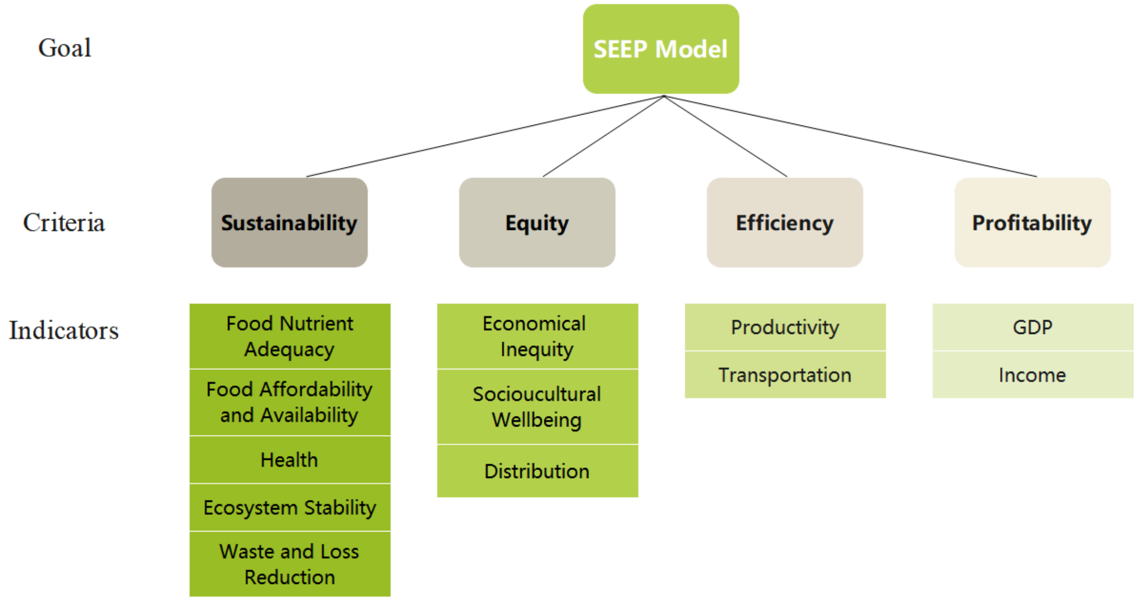

Figure 7: The Schematic Figure of AHP analysis

2) **Entropy Weight Method (EWM):** EWM could calculate the weight coefficients based on the varies of information entropy, the detailed steps are as follows: Firstly, assume there are n samples with m indicators to establish the original data matrix X:

$$X = [x_{ij}]_{n\times m}(i = 1, \cdots, n; j = 1, \cdots, m) \tag{2}$$

Then, normalize the original data:

$$x^* = \frac{x - x_{min}}{x_{max} - x_{min}} \tag{3}$$

Next, compute the information entropy of each indicator x_i:

$$e_j = -k \sum_{i=1}^{n} p_{ij} ln(p_{ij}) \in [0, 1] \tag{4}$$

where

$$k = 1/ln(n) p_{ij} = \frac{x_{ij}}{\sum_{j=1}^{m} x_{ij}} \tag{5}$$

And finally, calculate the weight ω_j of the $j^t h$ indicator:

$$w_j = \frac{1 - e_j}{m - \sum_{j=1}^{m} e_j} \in [0, 1] \tag{6}$$

Equation 6 shows that one indicator would have a larger impact on the evaluation result if it has smaller information entropy, which means that it has a larger weight contribution and vice versa.

3) **Combination Weighting Method (CWM):** In this paper, we utilized a combination weight method to determine the weight of food system indicators. CWM organically combined the advantages of AHP and EWM, avoiding the shortcomings of these two methods. The results of CWM is accessed through the linear weight method applied on the subjective and objective empowerment methods. The results of EWM can give suggestions of adjustment on the weight calculated from AHP to lower the subjectivity of the

values of weight and maintain a certain degree of objectivity at the same time. Take ω_x as the weight derived from AHP and ω_y as the weight derived from EWM to compute the ω:

$$w = \lambda w_x + (1-\lambda)w_y \tag{7}$$

where λ is the weight from EWM, which can be computed through variation coefficient method:

$$\lambda = \frac{n}{n-1}[\frac{2}{n}(P_1 + 2P_2 + \ldots + nP_n) - \frac{n+1}{n}] \tag{8}$$

Where P_i represents the column factor after ascending sorting of ω_x, and n is the number of indicators.

Finally, calculate the total SEEP score based Equation 9.

After selecting 11 superior indicators with 20 indicators, we use AHP analysis (shown in Figure 7 and the entropy weight method (EWM) to confirm the weights in Equation 9, which ensure that both the subjective and the objective are well reflected in our SEEP evaluation model. And the results of the weights of the four factors are shown in Table 2.

$$T = \omega_1 \times S + \omega_2 \times EQ + \omega_3 \times EF + \omega_4 \times P \tag{9}$$

Factor	Symbol	Value
Sustainability	ω_1	0.414342
Equity	ω_2	0.196477
Efficiency	ω_3	0.281276
Profitability	ω_4	0.125005

Table 2: The Weight Results of the Four Factors

Besides, we collect the data of the 20 indicators with nearly 200 countries and in the last 50 years (due to the limitation of the data resources, some indicators do not present that long) from all kinds of official websites. Then we select the total SEEP score (ranged from 0 to 1) for 55 countries from a decade. Furthermore, aiming to visualize the scoring results of the SEEP evaluation model for the 55 countries, we use ArcGIS software to plot the maps(refers to Figure 8).

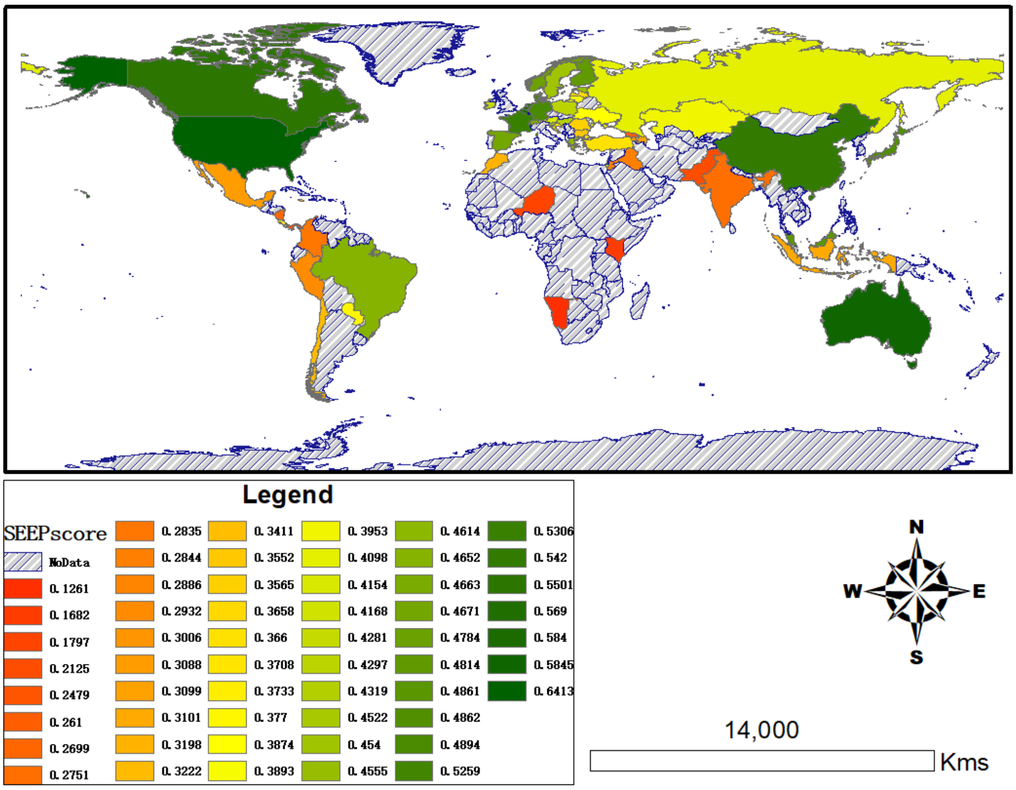

Figure 8: The SEEP Evaluation Model Scoring Results of 55 Countries Based on ArcGIS

From Figure 8, we can clearly discover that the developed countries get a higher score (marked in green) and those backward countries get a lower score (marked in red) in our SEEP evaluation model. And among the selected 55 countries, the top three countries are United States (SEEP= 0.6413), Australia (SEEP= 0.5845), and Belgium (SEEP= 0.584) respectively. It means that the food systems of the three countries are the most balanced between economical efficiency and sustainability. Additionally, the countries with deficiency food systems which are marked in red are mainly distributed in Africa, Southeast Asia, South America.

For specific continent with visualized SEEP scores, refer to Appendix.

4 Analysis and Answers to Problems

4.1 Changes of Priority on Sustainability and Equity

In a conventional food system, the leading factors taken into consideration are profitability and efficiency. A big amount of industrial processing of food has been certified to be a non-negligible source of environmental pollution. The distance of distribution is over a large scale, inevitable losses probably occur in the transportation. The quality of food in different regions differs greatly. Significant inequity of food security can be found from city to worldwide scale. Excessive packaging which is common recently not only has caused another trouble on the disposal of food but also has an impact on the price of local food, which is another incentive for inequity in the food system.

The newly optimized food system model based on SEEP evaluation model coupled the four factors–sustainability, equity, efficiency, and profitability together to solve the problems mentioned above and propose a new way for understanding the food system. **(the answer to**

question 1 of task 1)

4.1.1 Coupling Degree Analysis

System coupling degree(C) indicates the extent of the interaction between two factors, while the systematic evaluation index(D) indicates the proportion of the benign coupling in the interactions which describe whether the coupling condition is good or not (refers to Equation 10 and 11).

$$C = \sqrt[4]{\frac{S \times EQ \times EF \times P}{S + EQ + EF + P}}; \tag{10}$$

$$D = \sqrt{C * T} \tag{11}$$

According to the coupling coordination degree value calculated based on the collected data of the four factors, the general outcome of the coupling coordination level for some examples countries is imbalance and the only difference occurs at the extent of imbalance (refer to Figure 9). This implicates that the combined analysis of the four factors needs to be better integrated, providing support reference for adopting suitable measurements to optimize the conditions now.

	Country	C	D	Coupling Coordination Type	Coupling Coordination Level
Developing	Brazil	0.23	0.33	Low coupling coordination	Mild imbalance
	Chile	0.1	0.22	Low coupling coordination	Moderate imbalance
	China	0.26	0.35	Low coupling coordination	Mild imbalance
	Colombia	0.13	0.24	Low coupling coordination	Moderate imbalance
	Kenya	0.09	0.19	Low coupling coordination	Serious imbalance
Average		0.162	0.266	Low coupling coordination	Moderate imbalance
Developed	Denmark	0.22	0.34	Low coupling coordination	Mild imbalance
	France	0.23	0.35	Low coupling coordination	Mild imbalance
	Greece	0.18	0.3	Low coupling coordination	Mild imbalance
	Japan	0.19	0.31	Low coupling coordination	Mild imbalance
	Switzerland	0.22	0.33	Low coupling coordination	Mild imbalance
Average		0.208	0.326	Low coupling coordination	Mild imbalance

Figure 9: The Coupling Analysis of the Developed and Developing countries

4.1.2 Grey Model Prediction:

We use GM(1,1) to predict the data. GM(1,1) is a type of grey models which adds the original data (or through other methods) to generate the approximate exponential trend, and then model again. This method could merely analyze the developing process with linear relation.

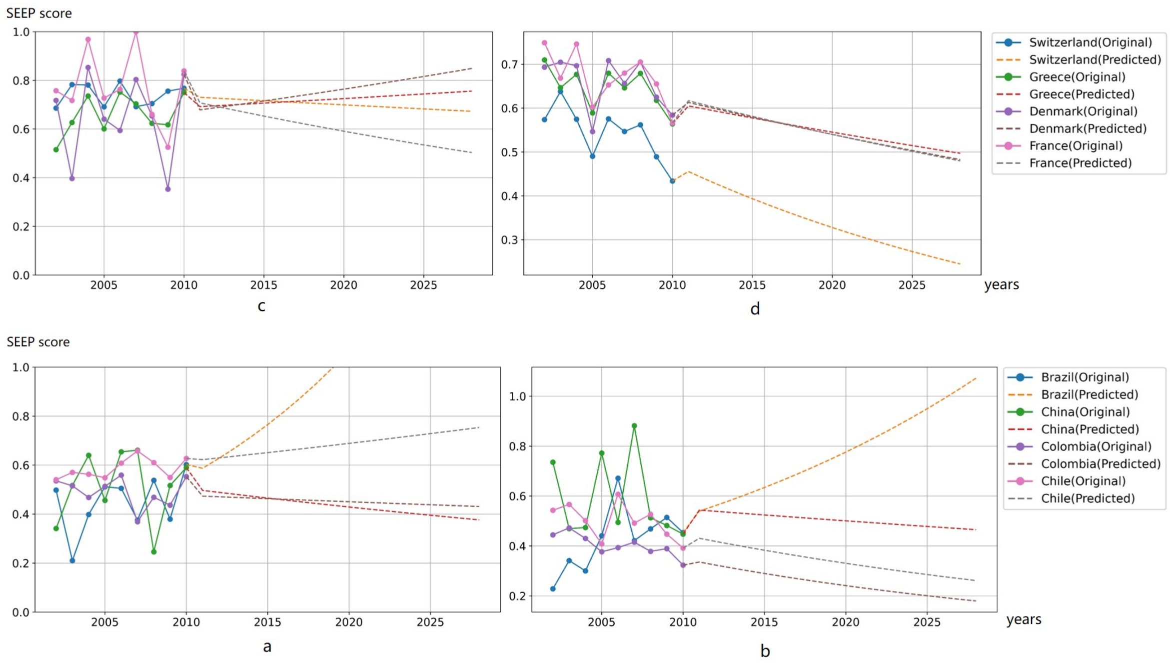

Figure 10: GM(1,1) Prediction

Figure 10 was made based on collected data of several countries (including both developing and developed countries) and the Grey Prediction Model. Solid lines depict the trends of Sustainability and Equity index under the control of conventional food system while the dashed lines show the prediction results of the future situation after optimized.

The charts demonstrate that the increase of the Equity index value is relatively slower than Sustainability. For different countries, the speed of increment somehow varies. For typically developed countries, the basic value of the S and EQ index is higher than developing ones. There are many factors that need to be considered in order to optimize the food system and to realize the goal of optimization. The time it takes to achieve goals at different levels is also different. If it takes several years to improve the coupling and coordination of subsystems in food systems, it may take longer to perfect and link the specific links involved in their subsystems. In regions with a more mature food system, it is a relatively easier to implement sustainable development and equity promotion measures, and it takes relatively short time.

The time needed for implementation of the optimized food systems in different regions should account for the basic situation of the region. Take Japan as an example, which has increased the country's sustainability by more than 10 percent in just five years since 2010. But for Colombia, it will take more than a decade to achieve the same level of improvement.

4.2 Benefits and Costs: Comparison of the Developed and Developing Countries

From the heat map of Pearson correlation, the only negatively proportional relationship can be found between equity and efficiency factors, implicating that optimizing one indicator will have a negative impact on another to some extent.

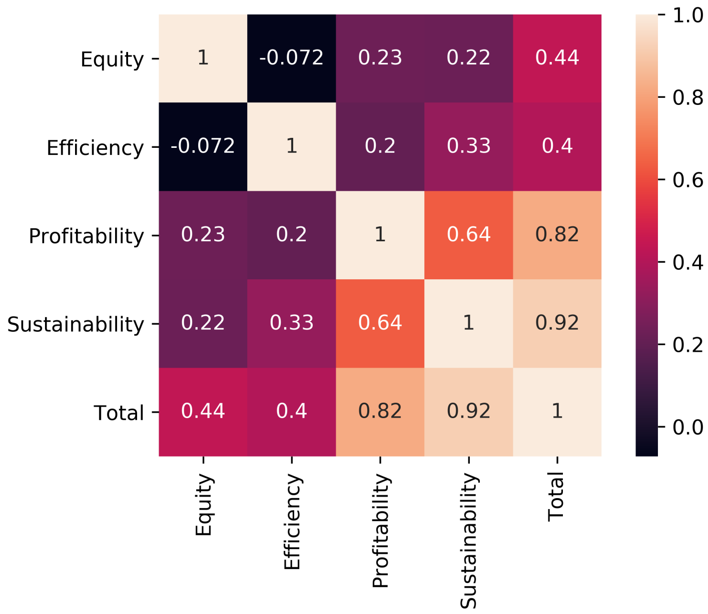

Figure 11: The Correlation Heat Map of the 4 Factors and the Total Score

According to the sustainable development goals set by United Nations [4], part of the targets of our model is to achieve the aims of zero-hunger and enlarging the productivity and incomes of small-scale food producers by 2030, and maintaining the diversity of crops. Benefits of our model include all the above.

We did some correlation analysis between indicators. The top two lines of Figure 12 show the relationships between the income and normalized production loss index (Remark: production loss data has been forward-processed and normalized to get the normalized production loss index. The greater the value, the less the production will loss) in some typical countries. Most of the countries show directly proportional relationship between the income and normalized production index, which means that the higher the income, the less the loss in the process of production.

Besides, by applying our model to promote sustainable and equal development, some implicit effects such as CO_2 emissions will also be lower to some extent, which can help mitigate the serious and developing greenhouse gas effect we have currently (See in the four figures in the lower two lines of Figure 12). The costs of the model mainly occur in the field of large-scale profitability and part of the efficiency. A larger amount of investment will be given to small-scale food development.

Also, restrictions and distortions existing in current international export or import trade will be regulated to ensure the equity of the world food market on one hand, and enhance the developing countries; farming capacity on the other hand. This will somehow impair the interest and profit of the countries with macro and relatively stronger food systems or markets. Due to the lag effect, these costs are expected to take place months after the optimization measures are taken.

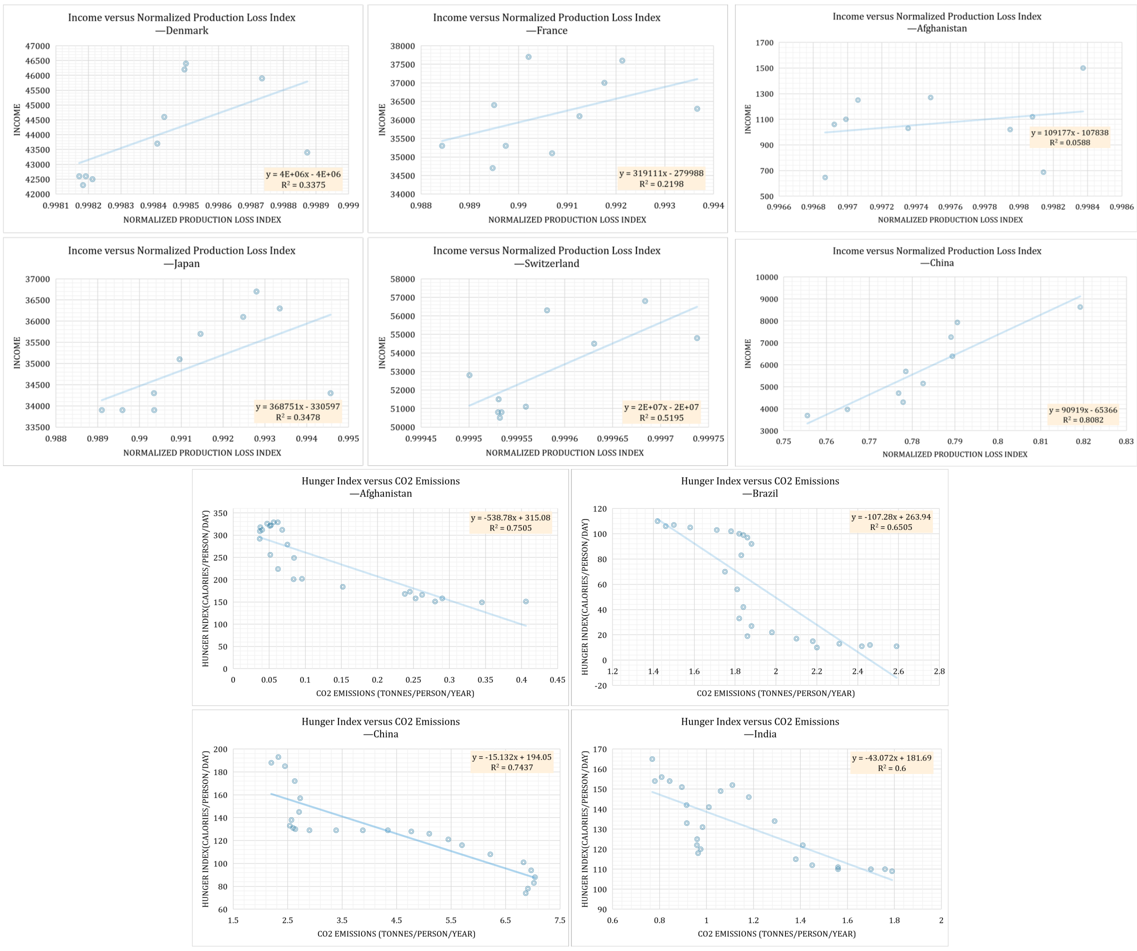

Figure 12: The Linear Relationship of Indicators

4.3 Case Study Developed and Developing Countries Respectively

4.3.1 Application Example in Developing Countries: China

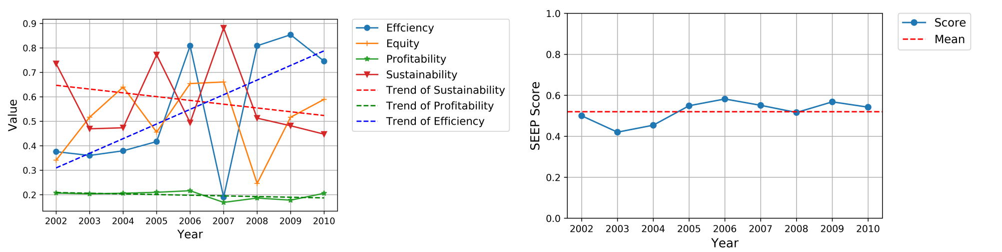

Figure 13: Changes in SEEP Factors in China (left) and Changes in SEEP Score in China (right)

We choose China as an example of SEEP evaluation model in developing countries. After data normalization and forward-processed, we calculate the final score of China's food system. The figure below shows the overall score changes of Chinese food system during the research period. The general trend of Chinese food system score from 2002 to 2010 was relatively stable, slightly fluctuating around 0.5 which implicating that the food system of China is stable. The upward trend of China's food system score indicates that further measurements for improvement need to be taken.

The left plot in Figure 13 shows the changing trends of the four main factors in Chinese food system during the study period.

- Firstly, sustainability index which is greatly affected by ecological stability of China fluctuates between 0.4-0.9, and there is an overall downward trend. China has a large amount of greenhouse gas emissions, water consumption, and a series of pollution problems caused by the development of economy and stress from increasing population, which makes the situation not optimistic. Accounting for this situation, China urgently needs to improve the stability of the ecosystem and the food system. Being aware of this, Chinese government has put forward various policies take into account economic and environmental benefits, and even prioritize environmental benefits, putting environmental protection in a very important position.

- Secondly, Chinese efficiency index has shown an overall upward trend, increasing by more than 150% from 2002 to 2010, but there was a sharp drop in 2007, probably due to the economic crisis around 2008. However, since efficiency is likely to have a negative impact on the stability of Chinese food system, we should not allow Efficiency to grow without any control.

- Thirdly, Chinese Equity indicator value fluctuates between 0.2-0.7, with an average value of around 0.5. One of the goals of Chinese political proposition is to narrow the inequalities in society, such as narrowing the gap between the rich and the poor, and feeding the whole people to access zero-hunger target. In addition, the system and basic technology of agriculture in China is relatively mature, which makes it more capable to support the big population. Thus, equity index is fairly stable and high.

- Finally, the profitability index has the lowest value among the four factors which may be related to the policies implemented in China.

4.3.2 Developed Country Application Example: Belgium

We chose Belgium as an example of SEEP in developed country. After the same steps as above, Figure X shows results. Figure X shows the overall score changes of food system of Belgium. In general, the overall trend of Belgian food system score from 2002 to 2010 was relatively stable, fluctuating around 0.6, with a slight downward trend.

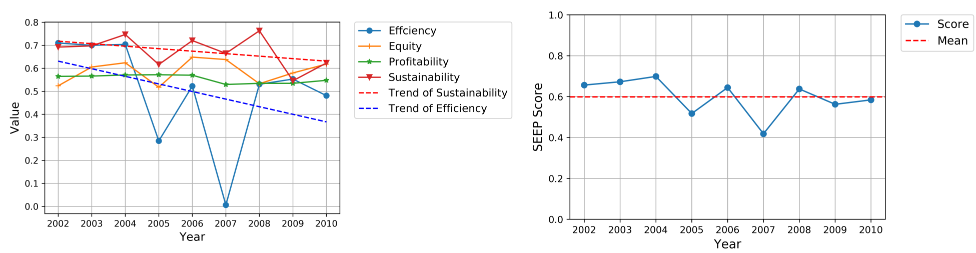

Figure 14: Changes in SEEP Factors in Belgium (left) and Changes in SEEP Score in Belgium (right)

The left plot in Figure 14 shows the changing trends of the four main factors of the Belgian food system during the study period. The overall scores are high, indicating that the current Belgian food system is relatively comprehensive under the premise of higher stability and equality.

Specifically, Belgian Sustainability index is all above 0.6, but with a slight downward tendency, and it needs to be improved by further measurements. In addition, Belgian efficiency shows a downward trend, and there was a gap in 2006-2008 which is probably due to the food crisis in 2006. Although its Equity and Profitability are relatively low, they are basically stable at around a acceptable value of 0.6. It can be concluded that Belgium as a developed country with advanced industrial development, has the ability to maintain high sustainability and equity while ensuring a certain economic capacity.

4.4 The Scalability and Adaptability of SEEP

The model is based mainly on data at the national scale, and when applying the food system on a larger scale, such as on a continental and global scale, comprehensive consideration of the contribution of various countries and regions within the scale is required, and an analysis of the indicators of correlation between countries needs to be added to provide appropriate theoretical support for further measures. When the scale of the application is small, such as a city, township, the model can be well implemented. In the reference to the national scale data to build a model, a number of the detailed indicators were included in the scope of consideration, small-scale areas can ignore some macro factors for application.

5 Sensitivity Analysis

The sensitivity of one model is measured by calculating the output values when one of the parameters changes with other parameters remains the constants. More specifically, take the fluctuation of the output value made by the slight disturbance of the parameter ranging from -5% to 5%.

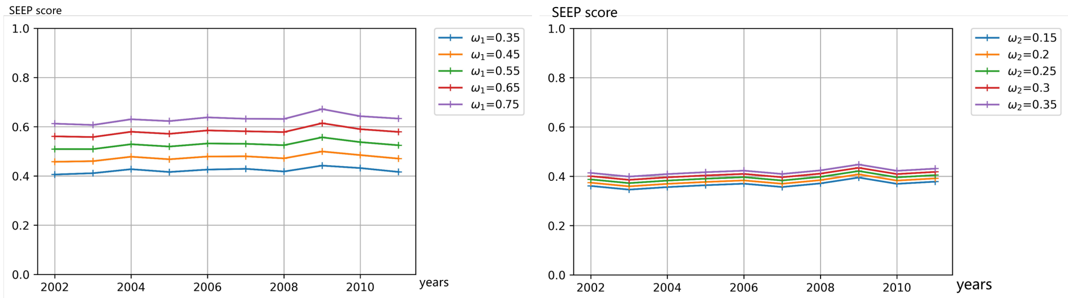

Figure 15: The Sensitivity Analysis of Sustainability (left) and Equity (right)

According to Figure 15, sustainability is more sensitive to the total SEEP score than equity.

6 Strengths and Weaknesses

The SEEP evaluation model has plenty of strengths:

- **Valid Conceptual Model:** We establish a relatively complete theoretical conceptual model of the food system and present it in a clear chart, indicating the structure of the food system.
- **Reliable Indicators Selection:** The selection of influence factors (Sustainability, Equity, Efficiency, Profitability) and their specific indicators (11 Superior indicators and 20 Indi-

cators) is based on the previous research of experts and scholars, with high persuasiveness and reliability.

- **Extensive aspects for interpretation:** Allowing for the complicated relationship of the composition of the food system itself and the various influence factors, we calculate the coupling coordination value of the factors in the model and made the correlation analysis of the various factors. By utilizing these analysis results, we can more easily expound on the food system from varying perspectives.
- **Usage of Multiple Methods:** Many methods with strong theoretical support are used in the process of modeling, such as AHP(Analytic Hierarchy Process), EWM(Entropy Weight Method), which is used to determine the weight of indicators. We also use the Grey Prediction Model, which is applied to predict the trend of development.

It also has weaknesses:

Some of the data we collect is incomplete and lacking, for the convenience of further data analysis, we apply multiple imputation method to access missing data, which may differ from the real-situation data.

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Appendix: Visualized SEEP Scores of Continents Based on ArcGIS

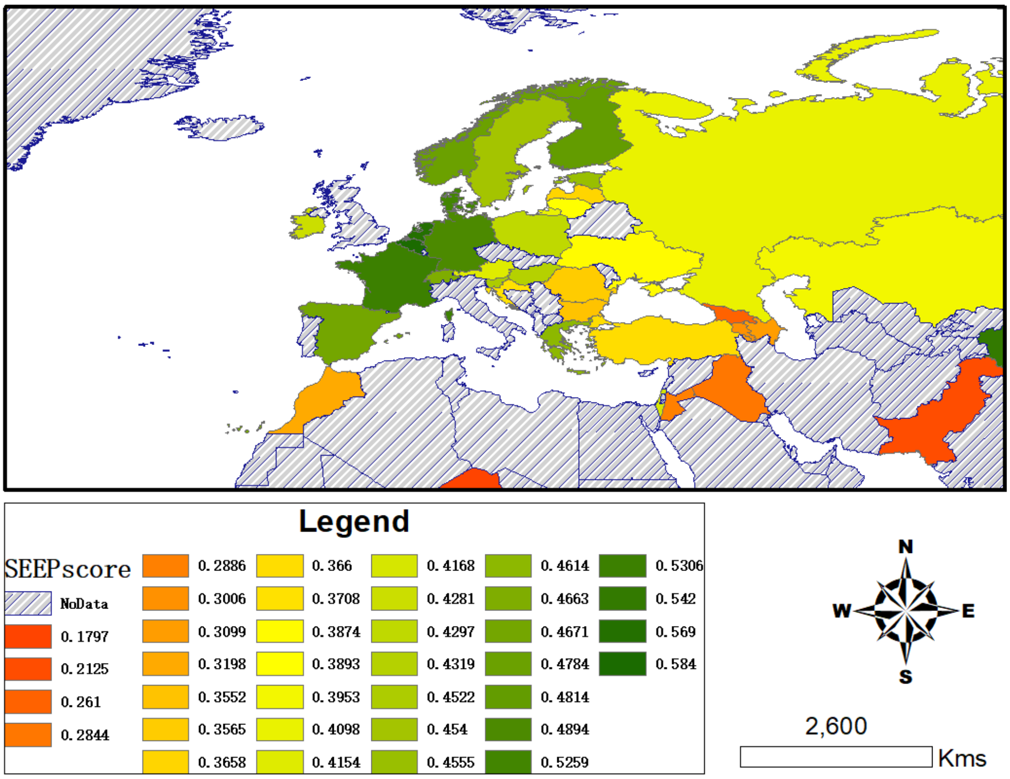

Figure 16: The SEEP Score of Europen Countries(partially)

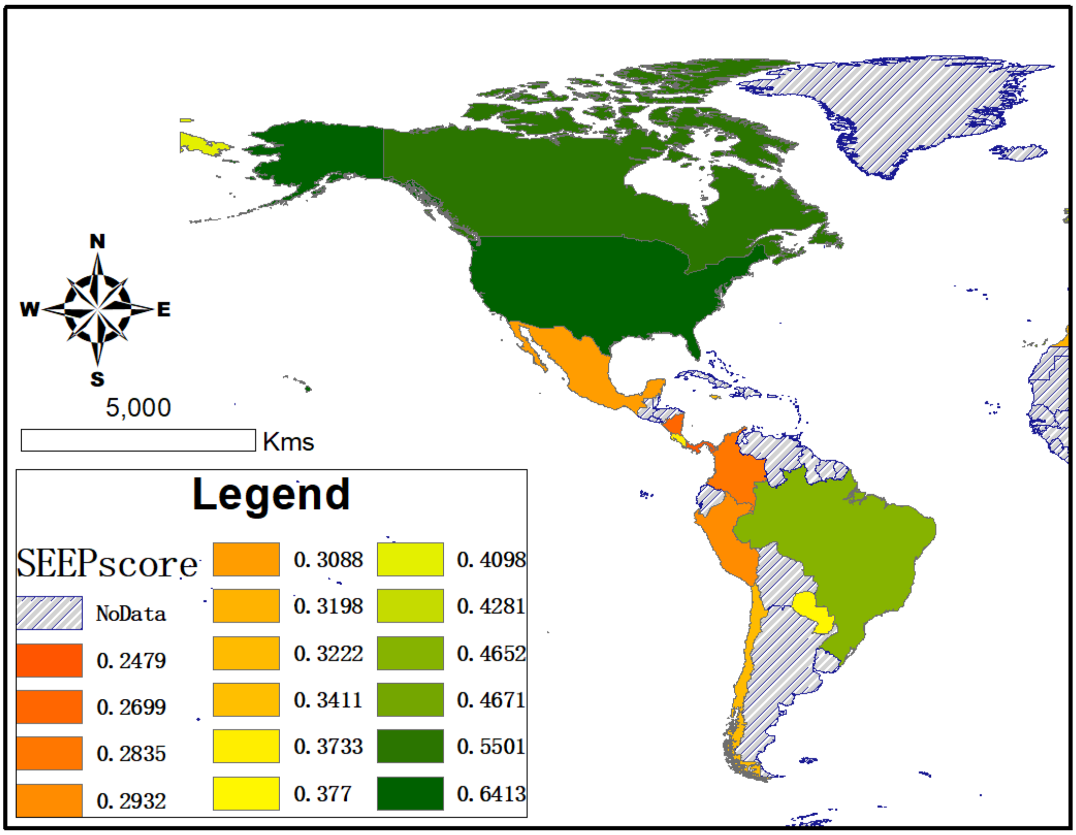

Figure 17: The SEEP Score of American Countries(partially)

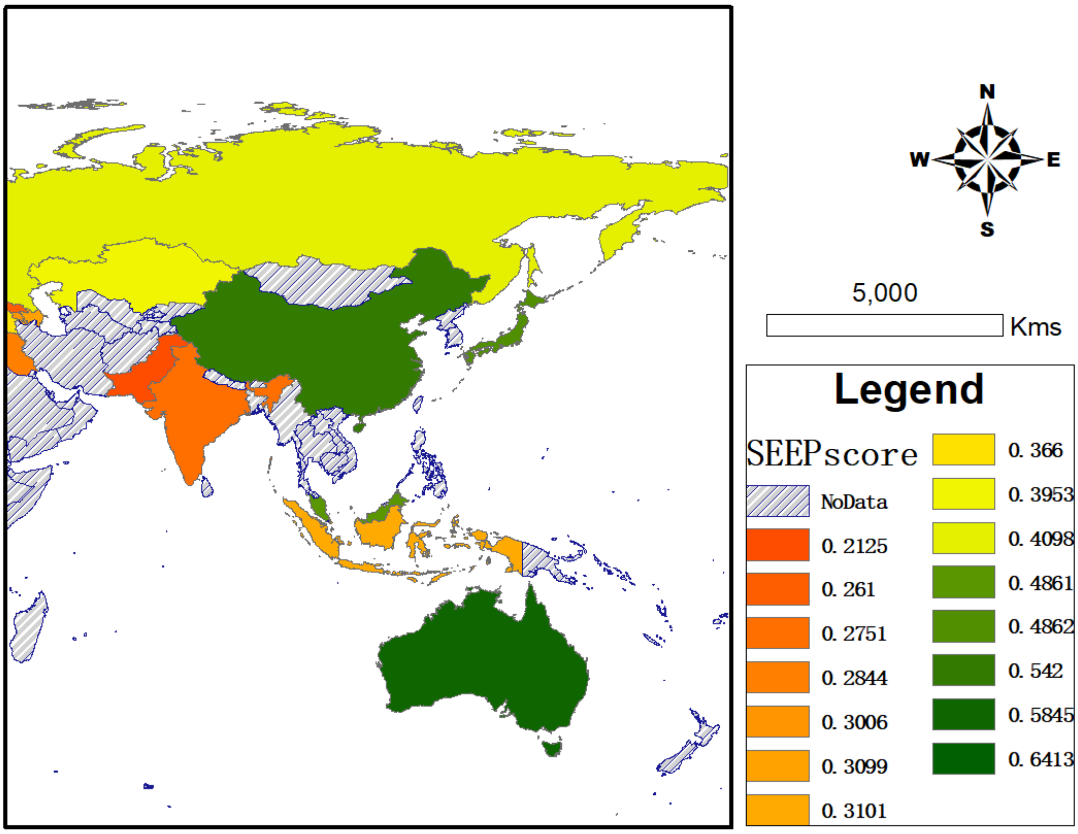

Figure 18: The SEEP Score of Aisan and Oceania Countries(partially)