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Problem Chosen

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Today, is the development sustainable?

Summary

Our purpose is to establish an evaluation system to judge whether a country is sustainable or not. We apply analytic hierarchy process model, dynamic weighted comprehensive model and connection model to draw up this evaluation system.

The target layer is sustainable development. Sustainable development can be determined by three main factors: society, economy and ecology. These three main factors form the first criteria layer, while they also can be respectively determined by several specific factors, which we set as the secondary criteria layer.

We search many materials to confirm the original data of each factor of the secondary criteria layer. For unifying the index, we select appropriate functions to process these data, and get all the processed indexes between zero and one.

Through the analytic hierarchy process, we can get the weight vector of all the factors in the criteria layer. Dynamic weighted comprehensive model is used to revise the indexes of the secondary criterion layer. The first criterion layer can be confirmed by weighted calculation and connection model between three main factors. After that, we will get the index of the target layer, which must be between zero and one.

We establish the reasonable assumptions through calculation and analysis. If the index of the target or first criterion layer is less than 0.4, which means this country or some main factors is unsustainable. Otherwise, we can consider it to be sustainable.

On behalf of the state, we select Haiti. We search for the original data of each factor of the secondary criteria layer about Haiti between 2005 and 2012, through which we gain its processed indexes of every year. All the indexes are less than 0.4, which means that Haiti is an unsustainable country. According to the corresponding indexes, we proposed the specific development plan in every five years. Through the figures of sustainable development indexes over the next 20 years, we found that its indexes have risen steadily, which are all towards the direction of sustainable country, showing that the proposed plan is effective and available.

When additional uncertain factors such as natural hazards occur, we consider the possibility of occurrence and its weight to establish a sub model to gain its effects. We aim at the secondary criterion layer and put forward the corresponding programs, aid and policy. Through the control variate method to evaluate the improvement of sustainable development indexes according to corresponding measures, we discover that improving public health and education in social category is the most effective measure to Haiti, followed by developing economy and improving environment.

Our model measure sustainable development indexes by several specific factors to help the ICM to evaluate the most effective measures and restored policies after the occurrence of additional uncertain factors. A little pity, our model consists of a little subjective mind, and the future planning and improvement measures depends greatly on the realistic factors, not just in accordance with our model.

Keywords: sustainability, evaluation system, hierarchy, Haiti.

contents

1. Introduction

1.1Background

In order to reconcile the balance between economic development and ecosystem health, a new proper noun “sustainable development” has been put forward.

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

Once we determine whether a country is sustainable or not, we can give corresponding measures and plans to make improvement. As a result, we need a standard to make judgment. However this concept is too broad and abstract, it is difficult to set a benchmark. In order to establish such a evaluate system, we consider to change this abstract concept into numbers.

1.2 Problem Process

There are two key elements in the definition of sustainable development, requirements and environmental limitations.

Firmly grasp these two points, we choose to use the hierarchical structure. The first level is sustainable development, and the second are social, economy and ecology. Social and economy correspond “needs” in the definition, and ecology corresponds “environment limitation”. In order to get more accurate data, the social can be divided into population, policy, community stability, public health and education. The evaluation system of economy is consists of science and technology, imports, exports and the poverty rate. Ecology is geography, energy and resources and environment. Each factor has its number and relative proportions to determine the upper structure. Finally, we can finish the judgment. So we search for the data and find the matching functions and models to establish links between them, then we can have a reasonable evaluation model. As we know, the concept of sustainable development is dispersed into several factors, according to the numbers of each factor, we can make better plans for sustainable development. Also when we meet additional factors, they can be divided into factors in the second level to analyze the influence.

2. Task 1: Establish the evaluation system

In order to measure a sustainable development, which is totally an abstract qualitative index, we need a quantitative index to help us measure it. Hence, we collect the corresponding data that we will process with later, use two basic types of evaluation model and one connection model to evaluate the indexes, and finally get an objective and effective score of sustainable development as much as possible.

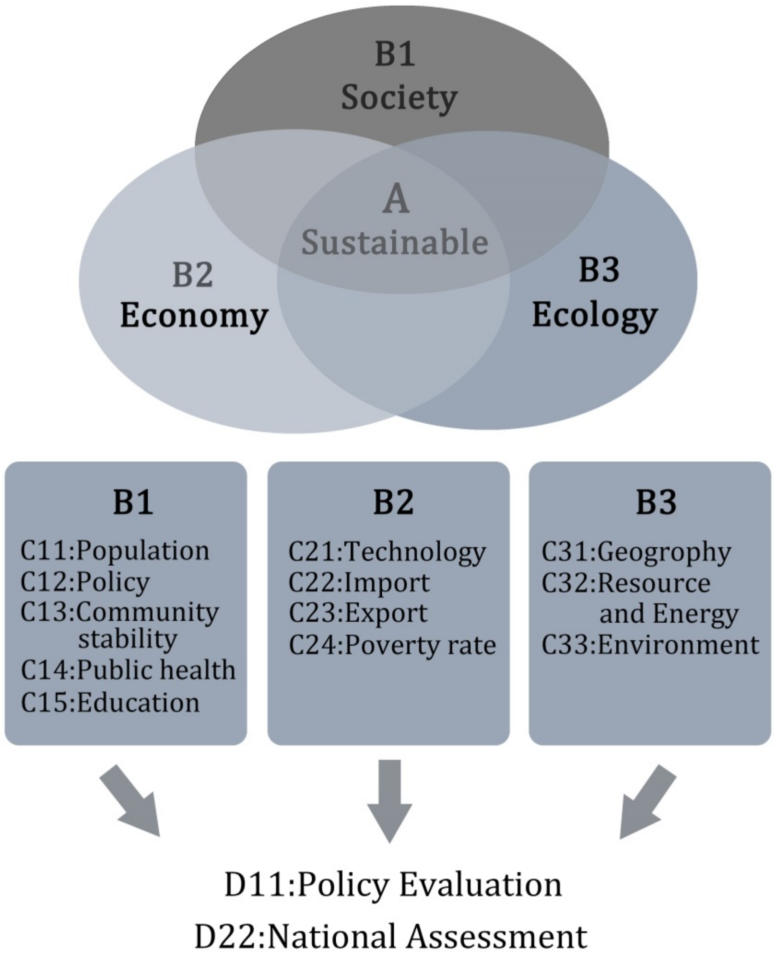
2.1 Analytic Hierarchy Process Model

We choose the analytic hierarchy process as the main body frame of our evaluation model to evaluate whether a country and its policy is sustainable. Since the sustainable development is a relatively abstract concept, we may need to quantize factors of different levels of the sustainable development, so we list out the main factors and search for the data to support the body of the analytic hierarchy process. Then we make the following assumptions:

- The sustainable development is mainly determined by three factors: the society, the economy and the ecology, and other factors nearly can be neglected.
- All the statistical datum are convincible and can show the characters of the total.
- A statistical data won’t fluctuate greatly if nothing unexpected happens.
- The set of the weight is comparatively objective and follow most people’s willing and ideas.

We set the target layer as ‘A-Sustainability’. Then we set the first criteria layer as ‘B1-Society’, ‘B2-Economy’ and ‘B3-Ecology’. Moreover, we set the secondary criteria layer as ‘C11-Population’, ‘C12-Policy’, ‘C13-Community stability’, ‘C14-Public health’, ‘C15-Education’, ‘C21-Technology’, ‘C22-Import’, ‘C23-Export’, ‘C24-Poverty rate’, ‘C31-Geography’, ‘C32-Resource and Energy’, and ‘ C33-Environment’. Finally, we set the alternatives layer as ‘D11-Policy Evaluation’ and ‘D12-National Assessment’.

Figure1: The model of task 1



For the first criteria layer, we compare every two elements by relative scale and gain the importance of BI to A. We define matrix $S=(s_{ij})$, where $s_{ij}=w_i:w_j$ stands for the importance of B_i to B_j. According to psychologists’ considerations for the relative importance, we usually set the parameter $s_{ij}\in(0,9]$. For the inconsistent pairwise comparison matrix S, we use the unit eigenvector $U=(u_1,u_2,u_3)$ as the weighting vector, where u_i stands for the weight it has on the target layer A. In addition, we need to test the consistency of matrix S. If it fails, we need to revise the matrix S. For the secondary criteria layer, we use the same method and gain the inconsistent pairwise comparison matrixs T_1,T_2,T_3 as well as the weighting vector $V_i = (v_{i1}, v_{i2}, \cdots, v_{im})$ of BI. Similarly, we need to ensure that matrixs T_1, T_2, T_3 are consistent. Otherwise, we also need to revise them.

In order to calculate the consistency of the matrix, we introduce an index that determines the consistency: $CI = \frac{\lambda - n}{n-1}$, where n stands for the dimension of the matrix, λ stands for the maximum of the eigenvalues of the matrix. Besides, we introduce the index RI that determines the random of the consistency to balance the influence of CI.

Table 1: RI-n correlation

RI-n correlation											
n	1	2	3	4	5	6	7	8	9	10	11	…
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	…

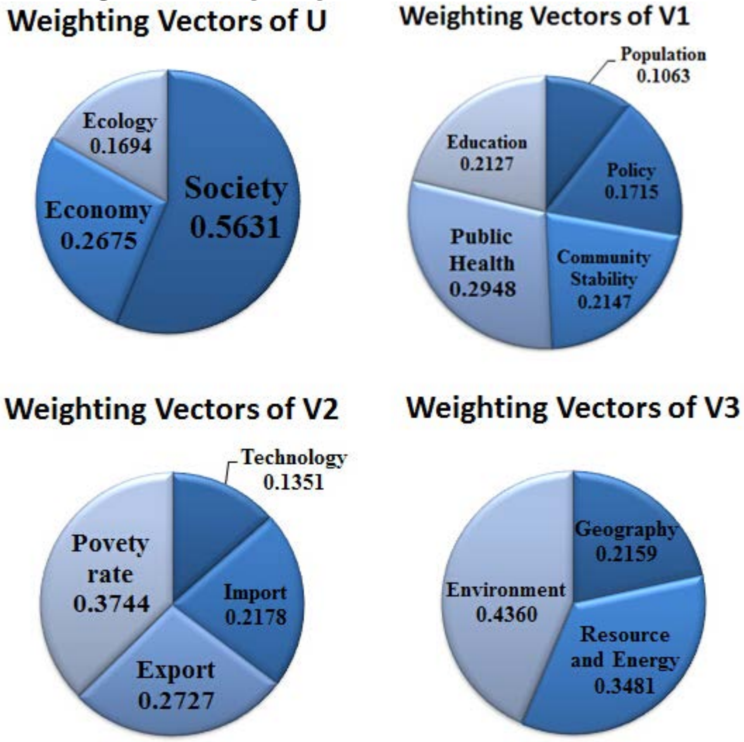
We define consistency ratio $CR = \frac{CI}{RI}$ to determine whether the matrix is consistent. If $CR < 0.1$, we can make a conclusion that the matrix is consistent. We establish the inconsistent pairwise comparison matrix S and T_1, T_2, T_3, and respectively calculate their weighting vector as well as test the consistency of the matrix.

$$S = \begin{pmatrix} 1 & 2 & \frac{7}{2} \\ \frac{1}{2} & 1 & \frac{3}{2} \\ \frac{2}{7} & \frac{2}{3} & 1 \end{pmatrix} \quad T1 = \begin{pmatrix} 1 & \frac{2}{3} & \frac{1}{2} & \frac{1}{3} & \frac{1}{2} \\ \frac{3}{2} & 1 & \frac{4}{5} & \frac{2}{3} & \frac{3}{4} \\ 2 & \frac{5}{4} & 1 & \frac{3}{4} & 1 \\ 3 & \frac{3}{2} & \frac{4}{3} & 1 & \frac{3}{2} \\ 2 & \frac{4}{3} & 1 & \frac{2}{3} & 1 \end{pmatrix} \quad T2 = \begin{pmatrix} 1 & 3 & \frac{3}{2} & 1 \\ \frac{1}{3} & 1 & \frac{3}{4} & \frac{2}{3} \\ \frac{2}{3} & \frac{4}{3} & 1 & \frac{4}{5} \\ 1 & \frac{3}{2} & \frac{5}{4} & 1 \end{pmatrix} \quad T3 = \begin{pmatrix} 1 & \frac{2}{3} & 1 \\ \frac{3}{2} & 1 & \frac{5}{3} \\ 1 & \frac{3}{5} & 1 \end{pmatrix}$$

Table 2: n-CI-RI-CR correlation

n	**3**	**5**	**4**	**3**
CI	0.0013	0.0021	0.0145	0.0006
RI	0.58	1.12	0.9	0.58
CR	0.0023	0.0019	0.0161	0.0011

Figure2: Weighting Vectors of U, V1, V2, V3



2.2 Data Process

Due to the various types of collected data as well as the inconsistent unit of the data, we need a consistent data to determine our indexes. Therefore, we process the datum by enabling them to be consistent.

For the data that is quantitative, we transfer it into an index that belongs to [0, 1]. Different data has different ideal index, so we choose different functions that best fit the character of the data to process the data. For the data that is qualitative, we establish a fuzzy membership function to transfer the data into an index that belongs to [0, 1].

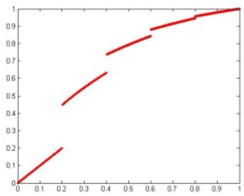
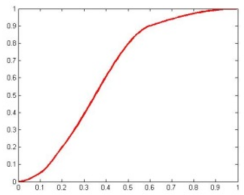
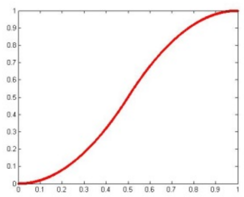
Table 3: Data type and corresponding function

Type	Corresponding function
Extreme	$x' = 1 - \frac{2}{\pi * \arctan(\lvert x - M \rvert)}$
Intermediate	$x' = \begin{cases} \frac{2(x-m)}{M-m}, m \le x \le \frac{1}{2}(M+m) \\ \frac{2(M-x)}{M-m}, \frac{1}{2}(M+m) \le x \le M \end{cases}$
Interval	$x' = \begin{cases} 1 - \frac{a-x}{c}, x < a \\ 1, a \le x \le b \\ 1 - \frac{x-b}{c}, x > b \end{cases}$
Fuzzy	$f(x) = \begin{cases} \left[1 + \alpha(x-\beta)^{-2}\right]^{-1}, 1 \le x \le 3 \\ \gamma \ln x + \eta, 3 < x \le 5 \end{cases}$

2.3 Dynamic Weighted Comprehensive Model

We use the linear weighted method to process the indexes gained in Chapter 2.2 and the weights gained in Chapter 2.1, which cannot shows the particularity of the indexes. For this, we consider using dynamic weighted methods to process the consistent index. We use different dynamic functions to show the difference of index due to its different levels. Usually we consider five levels and choose the dynamic function that best fits the index. We are more likely to use the following three dynamic functions.

Table 4: Dynamic function and corresponding figures

Dynamic function	Expression（Usually we take m=5）	Figure	Corresponding factors
Segmented power function	$w_i(x)=x^{\frac{1}{k}}, x\in[a_k^{(i)},b_k^{(i)}]$ $(k=1,2,\cdots;1\le i\le m)$		Policy Technology Import Export Geography
Partial large normal distribution	$w_i(x)=\begin{cases}0, x\le\alpha_i\\ 1-e^{-\left(\frac{x-\alpha_i}{\alpha_i}\right)^2}, x>\alpha_i\end{cases}$ where $\alpha_i\in\left[a_1^{(i)},b_1^{(i)}\right)$		Community Stability Poverty rate Environment
S-type distribution function	$w_i(x)=\begin{cases}2\left(\frac{x-a_1^{(i)}}{b_K^{(i)}-a_1^{(i)}}\right)^2, a_1^{(i)}\le x\le c\\ 1-2\left(\frac{x-b_K^{(i)}}{b_K^{(i)}-a_1^{(i)}}\right)^2, c<x\le b_K^{(i)}\end{cases}$ where $c=\frac{1}{2}\left(a_1^{(i)}+b_K^{(i)}\right)$, $w_i(c)=0.5$, $(1\le i\le m)$		Population Public Health Education Resource and Energy

For the consistent index x_j, we select corresponding dynamic function $w_j(x)$ that best fits the character of the index x_j and finally we gain de dynamic weighted index $X=x_j w_j(x_j)$.

2.4 Connection Model

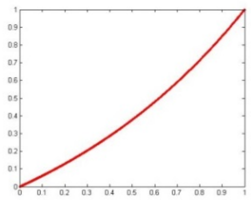
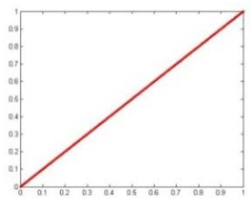
When we carefully consider and measure three main factors of the sustainable development, we find that there are relations with each main factor. One of main factor is in the condition of sustainable development, which will bring positive effect on the remaining main factor, and vice versa. We use the linear weighted method to process the dynamic weighting indexes gained in Chapter 2.3 and the weights gained in the secondary criteria layer to describe three main factors of the sustainable development in the first criteria layer. So we make the following assumptions:

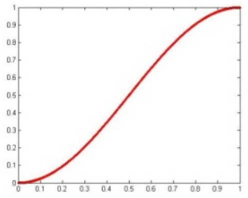
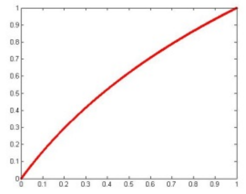
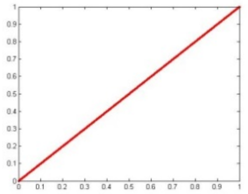
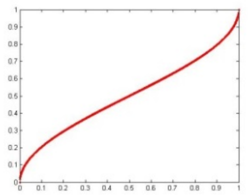
- The connection between the one main factor and another main factor can correspond to the proportion of one main factor and the proportion of main factor for each other.

- The proportion of the main factor to the influence of one part can correspond to the function of [0, 1]*[0, 1], and the opposite of proportion influence will be its inverse function.
- The selection and formation of the influencing function are agreed by the majority of the people.
- We will set a certain index to distinguish sustainable and unsustainable development, which will present whether effects are positive or not.
- Combining effects with the last index we gain in the Chapter 2.3, we can gain the final index, which shows that the index of this main factor. If the final index is negative, we will view index as zero. If the final index is more than one, we will view index as one. This kind of situation will only occur in the country which is in zero development or ideal country, not in real life, so there is no differentiation. According to such a situation, we do the approximate processing to ensure that the final index is in the range of zero and one.

We consider the relations between society, economy and ecology. Based on the assumptions, we only need to describe the relationship between one part to another, which can be showed in the simulation of the corresponding function. Then according to the assumptions, its inverse function naturally described the opposite effect. Firstly, society influences the development of economy. In the early stage of social development, society drives little to economy, but with the progress of the society, economic development will improve rapidly. We select the exponential function to simulate. Ecological effect to the society is almost synchronous, which means if ecological development is well, society will develop excellent, too. Therefore, we select a linear function to simulate. Economic effect to the ecology is evident. Economy is the key to the early stage of the ecological development, while relatively well ecological development to some extent doesn't rely on the economy anymore and will enter into the steady stage. According to this, we select sine function to simulate.

Table 5: The proportion of impact between two factors and corresponding function

The proportion	Function	Figure
The impact of the society on the economy	$f12(x)=\frac{1}{e-1}\left(e^{x}-1\right)$	
The impact of the ecology on the society	$f31(x)=x$	

The impact of the economy on the ecology	$f23(x)=\frac{1}{2}\sin\pi\left(x-\frac{1}{2}\right)+\frac{1}{2}$	
The impact of the economy on the society	$f21(x)=\ln\left[\left(e-1\right)x+1\right]$	
The impact of the society on the ecology	$f13(x)=x$	
The impact of the ecology on the economy	$f32(x)=\frac{1}{\pi}\arcsin\left(2x-1\right)+\frac{1}{2}$	

We set the index of the main factor i to x_i, j to x_j, and the certain index e to distinguish sustainable and unsustainable development.

The influence of the main factor i on the main factor j is:

$$\delta_{ij}=(f(\mathrm{x}_i)-\mathrm{f(e)})*\mathrm{X'}_j,(i\neq j), where\ X'_j=\begin{cases}X_j,\ f(\mathrm{x}_i)-\mathrm{f(e)}\geq 0\\ 1-X_j,\ f(\mathrm{x}_i)-\mathrm{f(e)}<0\end{cases}$$

The final index of the main factor j is:

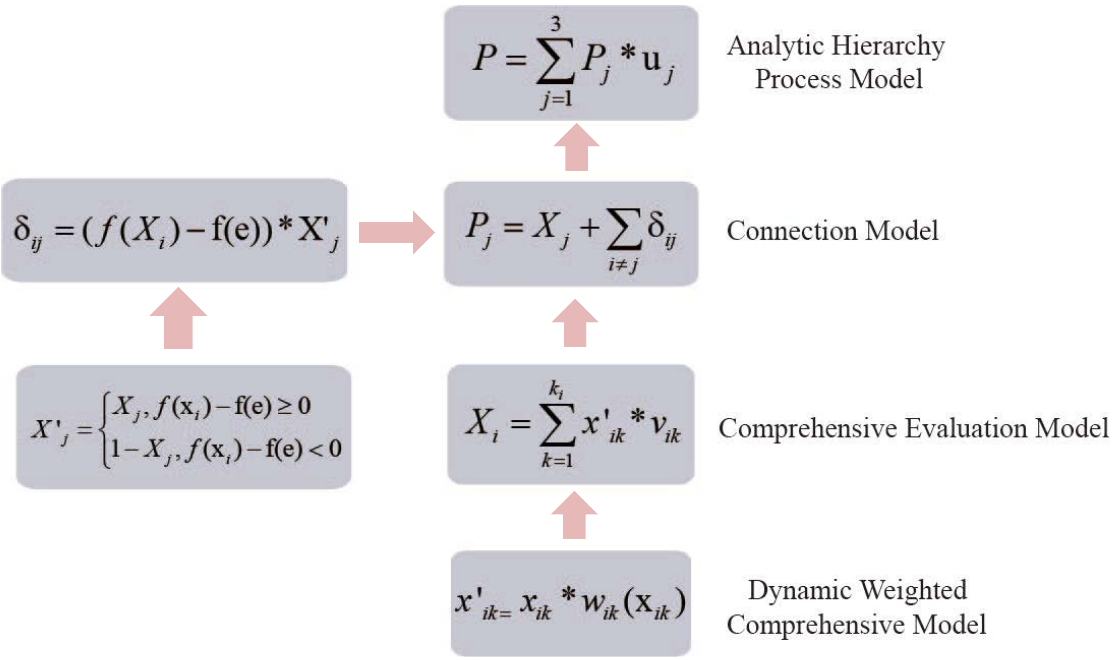
$$P_j=\begin{cases}0 & ,(X_j+\sum_{i\neq j}\delta_{ij}\leq 0)\\ X_j+\sum_{i\neq j}\delta_{ij}, & (0<X_j+\sum_{i\neq j}\delta_{ij}<1),\\ 1 & ,(X_j+\sum_{i\neq j}\delta_{ij}\geq 1)\end{cases}\qquad (\mathrm{i,j}=1\,2\,3)$$

2.5 Total Model

Table 6: Symbol table

Symbol	Definition
x_{ik}	The consistent index of the factor k that belongs to the main factor i
X_i	The consistent index of the main factor $(i \neq j)$
P_j	The final index of the sustainability of the main factor j
P	The final index of the sustainability of all
v_{ik}	The weight of the x_{ik}
u_j	The weight of the main factor j
$w_{ik}(x)$	The corresponding dynamic function of x_{ik}
$f(x)$	The corresponding connection function of X_i
δ_{ij}	The influence of the main factor i on main factor j $(i \neq j)$

Figure3: Total Model



We have already set u_j and v_{ik} in Chapter 2.1, $w_{ik}(x)$ in Chapter 3.3 and $f(x)$ in Chapter 3.4 in details. Now we need to consider the ultimate determining index e. We choose several developing countries and developed countries and take the reference of their indexes of the sustainable development, and finally we set e as 0.4. In most times, when the index of a developing country reaches 0.4, the developing country is in sustainable development. However, if the developing country wants to advance the index from 0.4 to 0.6, it will be a tremendously harsh process, which is also the process that a developing country turns into a developed country gradually.

From the table below, we can evaluate the sustainability better and smoothly. Only when $P_1, P_2, P_3 \geq 0.4$, the country's development is totally sustainable.

Sometimes even when $P \geq 0.4$, we cannot exclude the potential possibility that the country will become unsustainable soon because maybe its P_1 or P_2 or P_3 is very low, and vice versa.

Table 7: Evaluation of the sustainability

P_1	P_2	P_3	P	Condition
≥ 0.4	≥ 0.4	≥ 0.4	≥ 0.4	Sustainable
Two of them ≥ 0.4, the left < 0.4			≥ 0.4	Less Sustainable
			< 0.4	Less Unsustainable
Two of them < 0.4, the left ≥ 0.4			≥ 0.4	Less Sustainable
			< 0.4	Less Unsustainable
< 0.4	< 0.4	< 0.4	< 0.4	Unsustainable

3. Task 2: Is Haiti development sustainable?

We select Haiti from the 48 Least Developed Countries list as our study object to verify whether our model is practicable or not.

3.1 Why do we select Haiti?

This depends on background of Haiti. The Republic of Haiti is a parliamentary democracy in transition, struggling with a 200-year legacy of political conflict and repression. From 1986, when the 30-year dictatorship of the Duvalier family ended, until 1991, a series of provisional governments ruled Haiti. Haiti is a very mountainous country with more than 3/4ths of the territory above 700 feet. Its climate is tropical and semiarid. Due to the geographical position, Haiti's natural hazards frequently occur. For instance, lies in the middle of the hurricane belt and subject to severe storms from June to October, occasional flooding and earthquakes, periodic droughts. Especially, an earthquake occurred in Port-au-Prince in 2010, so local people had a serious issues in health and shortage of sources. Also, Environment was damaged. Many countries made their effort to help Haiti. It is worth mentioning that a lot of kidnappings and murders occur in Haiti. In a nut shell, Haiti is an ideal choice for us to establish a model which includes comprehensive three main categories: society, economy and ecology and additional environmental factors such as development aid, natural disasters, and government instability.

3.2 Whether Haiti is a sustainable country or not now?

Through Task 1, we establish a model and do a research on Haiti. We find out twelve factors in three main categories. All statistics are in the following table:

Table 8: The original data about Haiti

	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**Factor**
Population	9.26	9.39	9.51	9.64	9.77	9.9	10	10.2	Society
Policy	2.17	2.25	2.25	2.25	2.25	2.25	2.17	2.17	Society
Community	7.4	7.3	7.2	7.4	7.1	8	6.8	7	Society
Public health	22.6	22.9	23.2	23.5	23.7	23.9	24.2	24.4	Society
Education	0.936	0.963	0.983	0.993	0.997	1	1.003	1.009	Society
Technology	3.2	8.7	4.3	5.2	7	5.8	14	20	Economy

Import	42.9	45	38.9	44.2	42.6	64.7	59	53.2	Economy
Export	14	14.5	13.2	12.7	15.7	15.3	17.4	16.9	Economy
Poverty	51.7	49.2	46.8	44.5	43.8	44.5	43.2	42	Economy
Geography	2	2	2	2	2	2	2	2	Ecology
Resource and Energy	0.9	0.9	0.5	0.5	0.7	0.6	0.3	0.5	Ecology
Environment	3.8	3.8	3.8	3.7	3.7	3.7	3.6	3.6	Ecology

For all the data can be substituted into model, we make a transformation on data and let all indexes between zero to one. The transformation's method has been introduced in our model. The Transformation data is in the following table:

Table 9: Transformation data

	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Population	0.46	0.45	0.44	0.43	0.42	0.41	0.4	0.38
Policy	0.5948	0.6238	0.6238	0.6238	0.6238	0.6238	0.5948	0.5948
Community	0.52	0.54	0.56	0.52	0.58	0.4	0.64	0.6
Public health	0.452	0.458	0.464	0.47	0.474	0.478	0.484	0.488
Education	0.468	0.4815	0.4915	0.4965	0.4985	0.5	0.5015	0.5045
Technology	0.0003	0.0009	0.0004	0.0005	0.0007	0.0006	0.0014	0.002
Import	0.542	0.5	0.622	0.516	0.548	0.106	0.22	0.336
Export	0.7	0.725	0.66	0.635	0.785	0.765	0.87	0.845
Poverty	0.2075	0.27	0.33	0.3875	0.405	0.3875	0.42	0.45
Geography	0.5245	0.5245	0.5245	0.5245	0.5245	0.5245	0.5245	0.5245
Resource and Energy	0.09	0.09	0.05	0.05	0.07	0.06	0.03	0.05
Environment	0.1267	0.1267	0.1267	0.1233	0.1233	0.1233	0.12	0.12

Then we apply our model to analysis of categorical data from three transformation data:

Table 10: Indexes from model

	P1(Society)	**P2(Economy)**	**P3(Ecology)**	**P4(Total)**
2005	0.1130	0.1643	0.0579	0.1174
2006	0.1203	0.1658	0.0589	0.1221
2007	0.1260	0.1750	0.0606	0.1280
2008	0.1174	0.1522	0.0568	0.1164
2009	0.1326	0.1864	0.0629	0.1352
2010	0.1049	0.1231	0.0527	0.1009
2011	0.1172	0.1566	0.0527	0.1176
2012	0.1207	0.1642	0.0586	0.1218

*P4 comes from P1, P2 and P3, and their relationship have been introduced in our model.

According to the model we design, indexes represent whether a country is sustainable. If index is less than 0.4, which means this country or one main factor of it is unsustainable.

From the index we could know that Haiti's society, economy and ecology were all in unsustainable condition between 2005 and 2012 years. In conclusion, Haiti is an unsustainable country now.

3.3 Third question: What to do to let Haiti become sustainable?

The answer is a 20 year sustainable development plan for Haiti.
According to our index's trend, we put forward three proposals from three aspects:

- Our destination: Education data with ten percent rise in every five years.

Our reason: As it is known to all, a country's educational level is vital because it can stand for a country's culture and the development of science and technology level. All the technology data are the lowest one every year in Table Two. However, it is difficult for people who haven't got enough knowledge to create innovations, so first developing education is what they need to do.

Specific action: Building new schools at abandoned buildings make almost all children from poor family have chance to study. Teachers can invite the local patriotic undergraduates. Government awards aid to those who are outstanding students to go abroad to further study, and when they graduate, they must come back to work for Haiti.

- Our destination: Environment data with fifty percent rise in every five years. Public health with twenty-two percent rise in every five years.

Our reason: Environment problem is not only concerned by us but also by the world. Haiti's environment problem is serious than any other developed countries. There are two reasons: one is that it experienced earthquake in 2010 (from the index in 2010 in Table Three, ecology decreased from 0.0629 to 0.0527) and the other one is that people don't protect their environment. The earthquake caused infectious diseases and society unrest. People's health and lives were all under threat. We reckon that effective measures should be taken to change this situation. Only when their environment is clear, tourist may travel here to play and make consumption.

Specific action: Establishing some hospitals in different areas can make the poor get treatment. Government also schedule a date per month to supply food and daily necessities to the poor and plan a punishing measures to fine people who destroy the environment. For example, people who throw the litter on the street fine 5 dollars and swap the street two days.

- Our destination: Poverty data with twenty-one percent rise in every five years.

Our reason: People in Haiti can not have enough food and safety houses to live for crimes and poverty. Also, they haven't got a sustainable job to live on. They supposed to do some field work to get money and make country's economy increase. After that, their resource and energy will rise with agriculture growth.

Specific action: Government encourage every family to do field work, and according to the number of people who work, the portion of land and implements are allocated to them. Before preparing that, these lands should be tested whether is suitable to sow crops.

4. Task 3: Additional factors and Improvement

4.1 Whether it can help Haiti to become a sustainable country in 20 years?

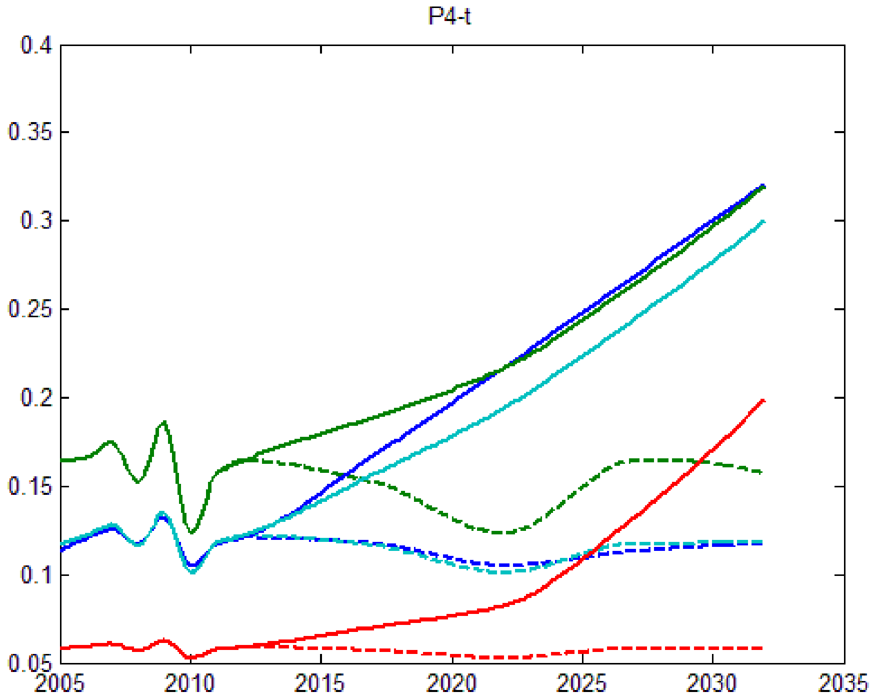
We apply our plan to our model and see what will happen in every five years:

Table 11: Every five years change in indexes

	P1(Society)	P2（Economy）	P3（Ecology）	P4（Total）
First year	0.1207	0.1642	0.0586	0.1218
After five years	0.1672	0.1890	0.0699	0.1566
After ten years	0.2168	0.2168	0.0822	0.1940
After fifteen years	0.2689	0.2642	0.1324	0.2445
After twenty years	0.3207	0.3201	0.1994	0.3000

*P4 comes from P1, P2 and P3, and their relationship have been introduced in our model.

Figure 4: According to P4's change in every five years



*The pecked lines represent the path before we plan to change, while the solid lines represent the path with our plan. The green lines stand for P4, the light blue lines stand for P2, the purple lines stand for P1 and the red lines stand for P3.

What we conclude from the table and diagram above? Of course, all the indexes are stably growth in every five years. From the diagram, we could see that P1 increase rapidly and all the indexes may over 0.4 in the near future, except that P3 is a little low for its reason. Between 2020 and 2025 years, it is obvious that all the indexes have a twist towards an increase direction.

4.2 Additional factors

In Task1, we consider many factors in the secondary criteria layer, but actually these factors are certain factors. Their indexes are equivalent and will not fluctuate greatly in a short period. However, for the sake of the condition of Haiti, we need to consider uncertain factors such as earthquake, flood, storm, foreign investment, government aid, kidnapping and government instability. These uncertain factors have a certain probability of occurrence, but when they don't happen, we can nearly neglect their influences, while when they happen, they would undoubtedly become the determining factors. Then we make the following assumption:

- Every factor in the first criteria layer has an uncertain factor in the secondary criteria layer. We consider the government instability, government aid and natural hazard as the main uncertain factors.
- Some uncertain factors are positive while others are negative. We set their indexes as the dispersion index which only contains zero and one.
- The possibility of the occurrence of the uncertain factor is influenced by the potential possibility and the effect of the index of the main factor in the first criteria layer that the uncertain factor belongs to. Usually we consider the effect to be linear.
- The weight of the uncertain factor is influenced by the original weight and the effect from the rest main factor. Usually we consider the effect to be linear.

Table12: Symbol Table

Symbol	Definition
C	The potential
w	Weight
δ	The proportion other factors impact on X
α	Proportion
U_i	The weight of X_i

We can have:

$$x_s = \begin{cases} 1, \text{the influence of } X_s \textit{ is positive} \\ 0, \text{the influence of } X_s \textit{ is negative} \end{cases}, \quad x_s \in X_j$$

$$C = C_0 + (1 - C_0)(1 - y_0)$$

$$w = \begin{cases} w_0 - w_0 * \delta * \alpha, \delta >= 0 \\ w_0 \text{-} (1\text{-}w_0) * \delta * \alpha, \delta < 0 \end{cases}$$

$$\alpha = \frac{1}{2} \frac{\sum_{i \neq j} U_i}{\sum_{i = j} U_i}$$

$$X_j = (1 - C) X_{j0} + C((1 - w) X_{j0} + w X_s)$$

We combine this sub model into our total model. According to the history of the Haiti, we search the data to determine the potential possibility and the original weight. For example, we use the days that people are suffering from the natural hazards in a year to determine the potential possibility of the natural hazard. Finally, we revise the data and abandon the strange data, so we gain C_0=[0.03 0.01 0.05], w_0=[0.6 0.1 0.8].Then we can use the data in our model and gain the result.

4.3 What effect will cause if additional environmental factors occur?

We just consider three major uncertain factors: natural hazards, development aid and government instability. Here we show our transformation data in natural hazards and regime coups.

Table 13: Natural hazards in Haiti transformation data

Years	Accident	Flood	Storm	Earthquake	Epidemic
2004-2005	1	0.155958	0.090334	1	1
2005-2006	1	0.125666	0.105137	1	1
2006-2007	0.5	0.105137	0.155958	1	1
2007-2008	0.155958	0.155958	0.090334	1	1
2008-2009	0.179167	0.204833	0.155958	1	1
2009-2010	0.105137	0.105137	0.295167	0.5	0.5
2010-2011	0.295167	0.125666	0.155958	0.5	0.5
2011-2012	0.295167	0.125666	0.155958	1	0.295167
2012-2013	0.295167	0.155958	0.295167	1	0.295167
2013-2014	0.125666	0.5	1	1	0.5

Table 14: Regime coups in Haiti transformation data

Year	Times	Distance	[0, 1]
1806-1859	4	53	0.86038
1859-1911	4	52	0.86154
1911-1915	7	4	0
1934-1950	4	16	1
1950-1986	4	36	0.88889
1986-1996	4	10	1
1996-2011	4	15	1
2011-present	1	4+	<1

We consider these uncertain factors and apply them to our model. Then we get new indexes.

Table 15: Considering uncertain factors' indexes

	P1(Society)	P2（Economy）	P3（Ecology）	P4（Total）
2005	0.0594	0.1518	0.0153	0.0767
2006	0.0642	0.1528	0.0154	0.0797
2007	0.0672	0.1587	0.0158	0.0830
2008	0.0638	0.1442	0.0147	0.0770
2009	0.0706	0.1659	0.0164	0.0869
2010	0.0587	0.1256	0.0135	0.0689
2011	0.0632	0.1470	0.0149	0.0774
2012	0.0647	0.1518	0.0153	0.0796

When we add uncertain factors, the indexes are all lower than Table Nine's. Society is the significant cause in three indexes and Ecology is the second reason. In our opinion, development aid is just a little assistance to Haiti, so we need to change the data in twelve factors and see what factor is the most important.

There are two different way to change the data. One is that every original data rise 0.1, the other one is that increase every original data with ten percent. They are different change for each factor.

Table 16: Different factors' indexes rank (rise 0.1 in data)

	P1(Society)	P2(Economy）	P3（Ecology）	P4（Total）	P4(Rank)
Population	0.0690	0.1534	0.0155	0.0825	7
Policy	0.0731	0.1548	0.0156	0.0852	3
Community	0.0650	0.1519	0.0153	0.0798	10
Public health	0.0817	0.1580	0.0160	0.0910	1
Education	0.0771	0.1563	0.0158	0.0879	2
Technology	0.0649	0.1524	0.0153	0.0799	8
Import	0.0680	0.1635	0.0162	0.0847	5
Export	0.0682	0.1644	0.0163	0.0852	3
Poverty	0.0648	0.1521	0.0153	0.0798	10
Geography	0.0658	0.1577	0.0216	0.0829	6
Resource and Energy	0.0648	0.1523	0.0158	0.0799	8
Environment	0.0647	0.1518	0.0153	0.0796	12

Table 17: Different factors' indexes rank (with ten percent increase in data)

	P1(Society)	P2（Economy）	P3（Ecology）	P4（Total）	P4(Rank)
Population	0.0661	0.1523	0.0154	0.0806	7
Policy	0.0702	0.1538	0.0155	0.0833	4
Community	0.0649	0.1519	0.0153	0.0797	8
Public health	0.0726	0.1547	0.0156	0.0849	1
Education	0.0707	0.1540	0.0155	0.0837	2
Technology	0.0647	0.1518	0.0153	0.0796	10
Import	0.0654	0.1544	0.0155	0.0808	6
Export	0.0677	0.1624	0.0161	0.0843	3
Poverty	0.0647	0.1519	0.0153	0.0797	8
Geography	0.0651	0.1544	0.0179	0.0810	5
Resource and Energy	0.0647	0.1518	0.0153	0.0796	10
Environment	0.0647	0.1518	0.0153	0.0796	10

We can get some information from Table 14 and Table 15 and we will give our suggestion when these uncertain factors occur. Firstly, however we change the data, indexes rank almost not change, so this Rank is valid. Secondly, public health (Rank 1) and education (Rank 2) are the most essential factor in improving country's sustainable problem. These two factors reflect that getting sustainable society is the first thing we should change. We advise that Haiti should maintain stable regime and unity. Thirdly, Haiti need to develop the economy quickly itself, for development aid is just a temporary help. From Rank 3, we get export is an indispensable factor Haiti should to improve. They can export more to earn money and make economy increase rapidly.

Finally, Natural Hazards for Haiti are more than other counties, but they still can't avoid. Only when Haiti owns sustainable society and economy, they can make the influences lower. Just like China and Japan, these countries all restored the influences bringing from disasters quickly.

In a brief sum, if additional environmental factors occur, they should make society and economy sustainable. Otherwise, they just follow our 20 years plan to do, and in the near future, they will reach the index and become a sustainable country.

5. Sensitivity Analysis

First of all, we set a sensitivity analysis for the weight vector of first level index layer and second level index layer. Taking the weight of first level index layer as an example, the original weight vector U is [0.5631 0.2675 0.1694]. Now we consider the new weight vector U' =[0.5531 0.2775 0.1694], then we can get the corresponding index.

Table18: Sensitivity Analysis

	U = **0.5631 0.2675 0.1694**				U' = **0.5531 0.2775 0.1694**			
	P_1	P_2	P_3	P	P_1	P_2	P_3	P
2005	0.1130	0.1643	0.0579	0.1179	0.1130	0.1643	0.0579	0.1174
2006	0.1203	0.1658	0.0589	0.1225	0.1203	0.1658	0.0589	0.1221
2007	0.1260	0.1750	0.0606	0.1285	0.1260	0.1750	0.0606	0.1280
2008	0.1174	0.1522	0.0568	0.1168	0.1174	0.1522	0.0568	0.1164
2009	0.1326	0.1864	0.0629	0.1357	0.1326	0.1864	0.0629	0.1352
2010	0.1049	0.1231	0.0527	0.1011	0.1049	0.1231	0.0527	0.1009
2011	0.1172	0.1566	0.0572	0.1180	0.1172	0.1566	0.0572	0.1176
2012	0.1207	0.1642	0.0586	0.1222	0.1207	0.1642	0.0586	0.1218

We can intuitively see from the data that the one class indexes are almost no change, the general indexes produce a slight float and its floating rate is smaller than the floating rate of weight by an order of magnitude.

Therefore, the weight is insensitive to our model. In the same way, it is insensitive to the model considering additional factors as we expect.

Secondly, we consider the functions in the model. The general functions are selected based on the characteristics of indexes. Moreover, our functions are either linear or smooth. The function we choose must largely reflect the change trend and the subtle difference will not cause enormous effect to our model.

Appling a multi-layer model helps us to eliminate the influence of some sensitive data. For instance, the influence of the unexpected second level data is correspondingly weakened after the treat of dynamic weighted aggregative model and analytic hierarchy process model, making our model is in a stable state. Indexes depending on time test are appropriate to describe the sustainable development.

6. Strengths and Weaknesses

6.1 Strengths

- **Simplicity.** We transform the assessment of the sustainable development into a number ranging from 0 to 1, which is intuitive and easy to understand. In addition, we can distinguish the strengths from the weakness according to the corresponding sustainable development of the main factors.
- **Relationship.** When we think about the index of the main factors, we take the influence between main factors into consideration instead of merely thinking about the main factor itself.
- **Comprehensiveness.** We use analytic hierarchy process model, dynamic weighted comprehensive model and connection model across in order to make our efforts to ensure that the index can reflect both quantity difference between factors and quality difference in each link. At the same time, this can highlight the connection well.
- **Capability.** Our model can evaluate various sorts of indexes. As long as something can be located accurately, it can be an influence factor. For example, we can put people's happiness index into the realm of social factors.
- **Convenience.** The replacement and increase of sub models are extremely convenient. For instance, the evaluators are provided with great convenience when adding additional uncertain factors.
- **The range of application.** Our model can be applied not only in the evaluation of sustainable development but also in the evaluation of other kinds of indexes, such as grade calculation, the assessment of annual benefit of a company and so on.

6.2 Weaknesses

- **Parameters.** There are quite a few parameters in our model. Irrationality and error in setting parameters can be easily added up exponentially. In the end, it will influence the evaluation results greatly.
- **Inconsistency.** Although we set scientific standards, follow the opinions of the majority and sum up from the historical data during data selection, weight setting and function selection, such as the potential occurrence rate, we still cannot avoid the subjective color and uncertainty in the process, causing impossibility to achieve consistent, rational, objective index.
- **Ideal hypothesis.** We do some idealistic process in some assumptions to simplify the model and facilitate the assessment. In the case, the influence of probability due to the index is linear. In fact, it is very difficult to achieve in the reality.
- **Incomplete assumptions.** Although some assumptions are made, they are not comprehensive. For example, we consider the relationship among the main factors. However, the factors in the secondary criteria layer also have links and the corresponding situations are more complex. Thus, we do not consider them.

7. Conclusion

Our evaluation model is the combination of analytic hierarchy process model, dynamic weighted comprehensive model and connection model, which illuminates the influence of unexpected data as well as shows the link between main factors to present a relatively objective, available index to determine the sustainability. Then we take the additional uncertain factors into consideration and put a sub model into our model. Through our model, by using control variate method, we can determine which policies or strategies are the most effective. In other words, the factor should be greatly improved if its positive devotion to the sustainability is the biggest, which can be measured by our model.

We select Haiti as our target country. We use our model to determine the sustainability of Haiti and draw the conclusion that Haiti is totally unsustainable. We carry out a feasible 20 year plan and are pleased to see that Haiti is developing towards the less unsustainable period or even less sustainable period by implementing our measures, which is predicted by our model. For the sake of rapid occurrence of natural hazards, we appeal Haiti to greatly improve their public health and education. After all, a stable society is the base of economy development and ecology restoration, especially to those LDC countries like Haiti. In one word, our model determines whether a country is sustainable and which measure is the most effective, helping to ultimate the goal to create a more sustainable world.

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