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Problem Chosen

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2015 Mathematical Contest in Modeling (MCM) Summary Sheet

(Attach a copy of this page to your solution paper.)

Type a summary of your results on this page. Do not include
the name of your school, advisor, or team members on this page.

Sustainable development refers to the development that not only meets the needs of the present, but also brings no harm to the ability of future generation in meeting their own needs. How to determine the degree of a country's sustainability, how to forecast the developing tendency and how to create the most effective sustainable development plan that based on the current situation of a certain country is one of the most far-reaching research issues in the world. This paper discusses the above problems and analyzes deeply to obtain the result with great value.

First of all, in order to determine the degree of sustainability of a country, we propose two models to measure the sustainable level. In the first model, we use PCA and AHP to divide sustainability into three levels. On this basis, we introduce the concept of coordination degree to help the analysis of the degree of the coordination among each indicator. In addition, in order to further define the degree of sustainability of a country, we establish coupling model. It introduces the variable of time, making the judgment of a country's sustainability far more accurate in degree and in time.

Then, we choose a LCD country. In order to raise its level of sustainable development, through the establishment of grey model, we form a sustainable development plan for the country which based on the forecast of its development situation in the future 20 years. After that, we use the first model to evaluate the effect of the 20-year sustainability plan. Proceed from the LDC country's actual conditions, we also consider other factors that may affect the sustainable degree, and accordingly improve the first model. By using the new model, we evaluate the effect of the 20-year plan again and find out the increase of the sustainable degree of this country becomes lower, which is in accord with the fact. So it verifies the reasonability of the new model.

Finally, in order to achieve our final goal to create a more sustainable world, we find out the most effective program or policy of sustainable development for this LDC country. We solve the problem in two ways. One is to consider the influence of policies on the sustainability measure. Another is taking cost into account. We introduce the concept of the actual benefit, and establish the cost-benefit model. In this model, we calculate each strategy's ratio of benefit and cost, so as to determine the optimal strategy.

Key words: analytic hierarchy process, coupling model, cost-benefit model, sustainability measure

Make a Sustainable World

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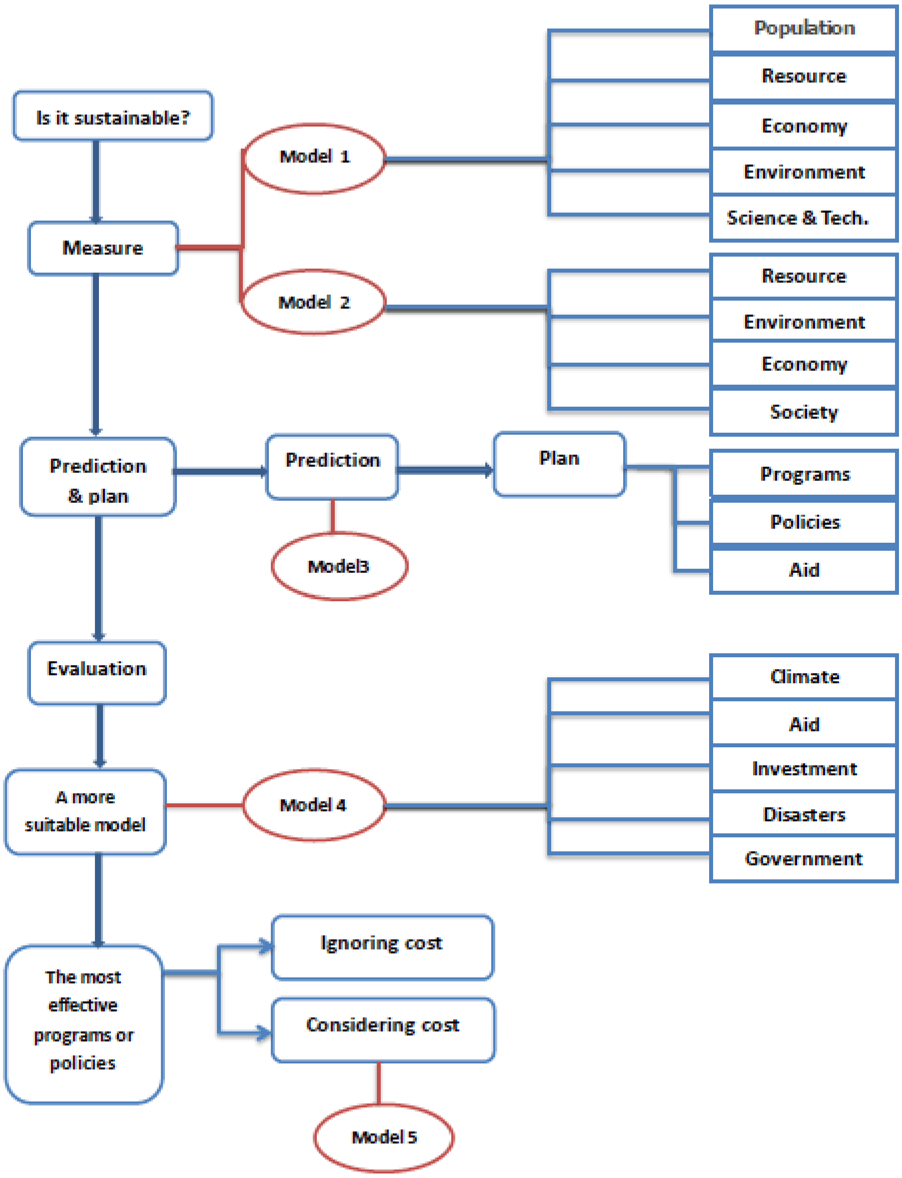
1 Introduction

What is sustainability? The 1987 Report of the Brundtland Commission, Our Common Future, defined sustainable development as, "meeting the needs of the present generation without compromising the ability of future generations to meet their own needs." Although there is several sustainability models such as 3-legged stool model, 3-overlapping-circles model that might help explain what a sustainable society looks like, these models will not be able to fully show when and how a country is sustainable or unsustainable. To help the International Conglomerate of Money (ICM) make a more sustainable world, we are expected to develop a reasonable, comprehensive and effective technique to provide a measure for distinguishing more sustainable countries and policies from less sustainable ones.



2 Measure of Sustainability

2.1Assumptions

- Assume that the world's climate don't have dramatic changes
- Assume that there aren't development aids, foreign investment, natural disasters, or government instability.

- Assume that there aren't interactions between metrics.
- Assume that the data we searched is reliable.

2.2Model One

2.2.1 Introduction

In order to evaluate the ability of sustainable development of a country, we define the sustainable development comprehensive index (F) as standard to distinguish the different levels of sustainability between different countries. The index relates to the contributions of the subsystems, so we adopt the analytic hierarchy process to figure out the weight of each subsystem. In addition, in order to fully understand the situation of sustainable development of a country, we introduce the concept of coordination degree [1]. The closer are the value of five subsystems, the more coordinate is the development process of the country.

2.2.2 Nomenclatures

Nomenclatures	Explanation
y_{ij}	normalized value of the j_{th} index of the i_{th} country
m_{ij}	original data of the j_{th} index of the i_{th} country
σ_j	standard deviation of the j_{th} index
$\overline{m}_j$	average value of the j_{th} index
F_k	evaluation value of sustainability of the k_{th} subsystem
F	value of sustainable development comprehensive index
n	numbers of index in each subsystem
w_k	weight of the k_{th} subsystem
α_i	coordination degree of the i_{th} country
M_i	average evaluation value of subsystems of the i_{th} country
S_i	standard deviation value of subsystems of the i_{th} country
$C.I.$	The coincident indicator
$\lambda_{\max}$	The maximum eigenvalue of A
p_j	weight of the j_{th} index in each subsystem

2.2.3 Pretreatment: The Selection and Classify of Metrics for Assessment

The Selection of Metrics for Assessment

Evaluating the sustainability of a country is a result of a country's population, population growth rate, territory area, percentage shares in GDP, agricultural labor force, life expectancy at birth, transport and many other factors. To simplify the model, we choose population growth, life expectancy at birth, GDP per unit of energy use, arable land (hectares per person), food production index, improved water source and several other Metrics.

The Classify of Metrics for Assessment

The essence of sustainable development is to realize harmonious development of nature system and social system in a certain time. Its core is to realize sustainable, stable, balanced, orderly development of different elements, like population, resource, economy, environment, etc. In the field of sustainable development, the mutual action and mutual restriction between population, resource, economy, environment and technology formed a dynamic and open complex giant system, which called PREEST system [2]. In PREEST system, the target locations of the five subsystems (P, R, E, E, and ST) are different. The population subsystem is the target and goal; the resource subsystem is the basis and guarantee; the economy subsystem is the core and emphases; the environment subsystem is the conditions and constraints and the technology subsystem is the sustention and platform of the harmonious development of the PREEST system [3].

Based on the PREEST system model, we divide the above-mentioned indexes into five groups, as it shows in the table below.

Tab 1 Sustainable development index system Based on PREEST system

Population subsystem	Population growth
	Life expectancy at birth
Resource subsystem	Arable land
	Renewable internal freshwater resources per capita
Economy subsystem	Food production index
	Labor force participation rate
	GDP per capita
Environment subsystem	GDP per unit of energy use
	improved water source
	CO_2 emissions
Science &Technology subsystem	Scientific and technical journal articles

2.2.4 Model Building and Solving

Calculation of the comprehensive evaluation value based on AHP

Step 1 standardized treatment for the original data：

$$y_{ij} = \frac{m_{ij} - \overline{m_j}}{\sigma_j}$$

Step 2 evaluation value of sustainability calculation of single subsystem:

Based on the hierarchical analysis, we can figure out p_j , the weight of each index in each subsystem.

$$F_k = \sum_{j=1}^{n} y_{ij} p_j$$

Step 3 According to domain experts' advice, we get the significance judgment matrix of PREEST system [4]. The result of this method is presented in the table below.

Tab 2 Significance judgment matrix of PREEST system

	Population subsystem	Resource subsystem	Economy subsystem	Environment subsystem	ST subsystem
Population subsystem	1.000	0.800	0.700	0.500	0.600
Resource subsystem	1.250	1.000	0.875	0.625	0.750
Economy subsystem	1.429	1.143	1.000	0.714	0.857

Environment subsystem	2.000	1.600	1.400	1.000	1.200
ST subsystem	1.667	1.333	1.167	0.833	1.000

It was clear from table above that the relative importance degree of P, R, E, E, ST subsystems in PREEST system is respectively: 0.1361, 0.1701, 0.1945, 0.2723, 0.2269, and satisfying:

$$C.I. = (\lambda_{\max} - n)/(n-1) = 0.004 < 0.1$$

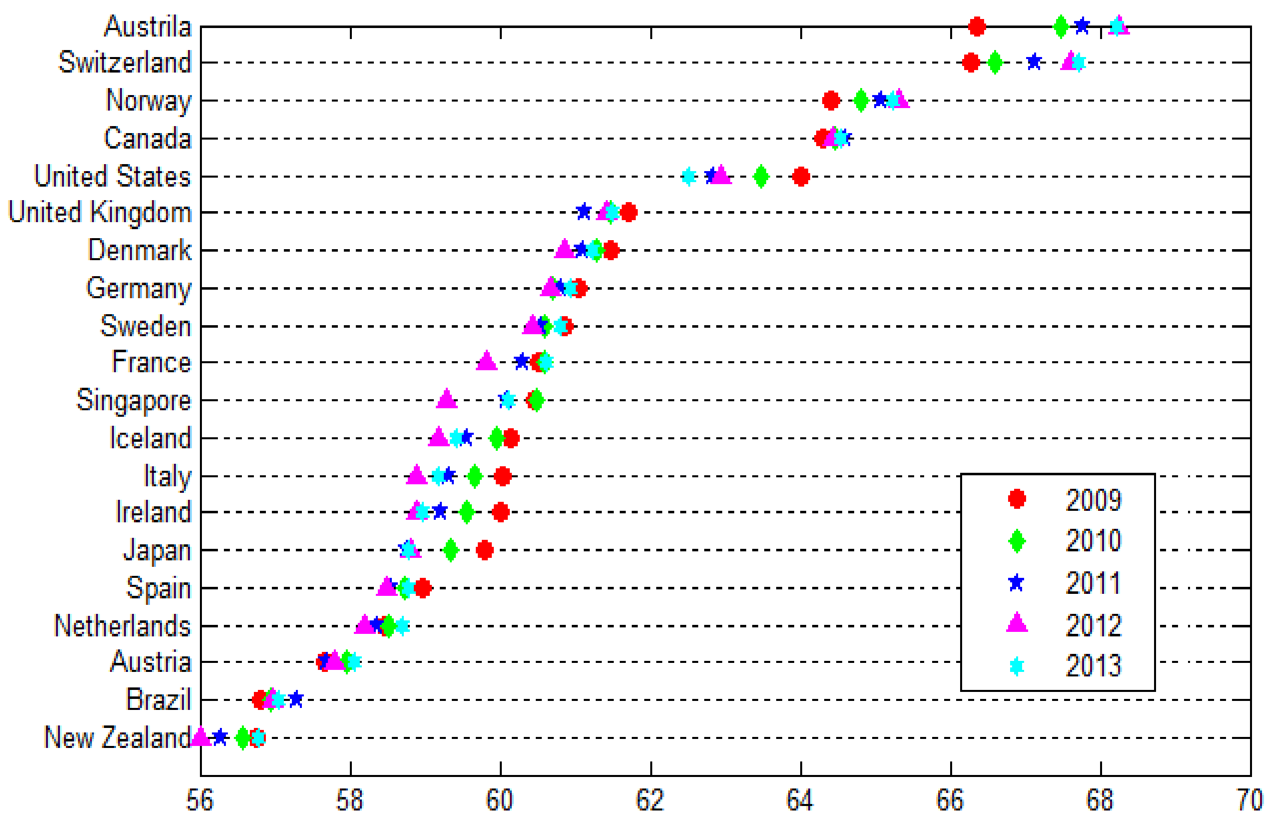
That is, the judgment of the relative importance degree of each subsystem in table is acceptable. Use the relative importance degree as the contribution rate w_k of sustainable development of each subsystem.

Step 4 according to the formula below

$$F = \sum_{k=1}^{5} F_k w_k \times 100$$

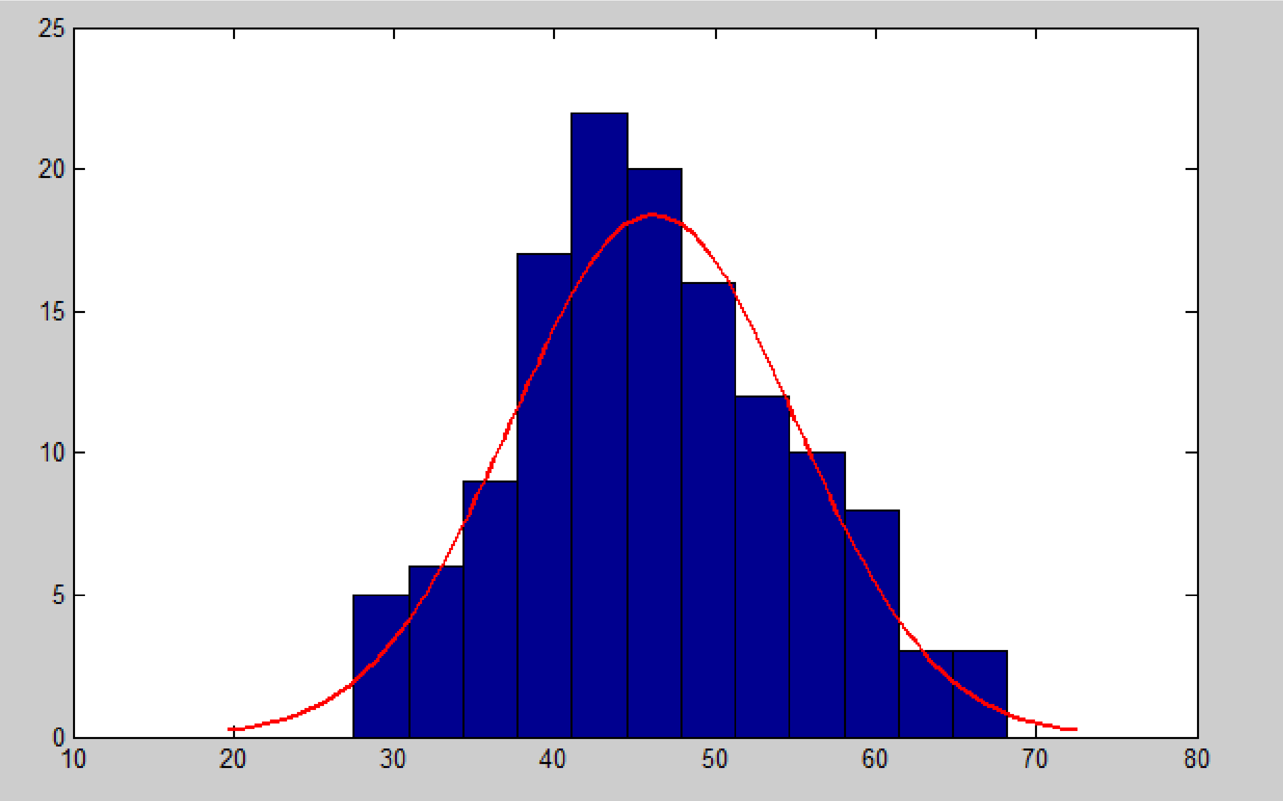
After substituting the data of several countries of a period of years (2009-2013)[5], we can get the figure below.

Figure 1 Sustainable Development Ranking of Several Countries



Substitute the data of 131 countries in 2003, then we can get another figure shown in the below.

Figure 2 Distribution of Countries' Sustainability



We can see the different level of each country from the table. From the above, we can see the evaluation value of the sustainable development ability in many countries. Reference to relative researches of sustainable development, and according to textual research on actual situation of countries' sustainable development, we divided sustainable development into three levels by the difference of parameters between the better and the worse in different country. As shown in the table below, the larger the value F, the higher the sustainable development level.

Tab 3 Sustainable development evaluation standards

Grade	Comprehensive evaluation value(F)	Sustainability
1	$0<F<35$	Less sustainable
2	$35 \le F \le 55$	Medium sustainable
3	$55<F<100$	More sustainable

The calculation of coordination degree

The closer are the evaluation value of sustainable development of the five subsystems, the more coordinate is the development process of the country. So the coordination degree of the i_{th} country is defined as:

$$\alpha_i = 1 - \frac{S_i}{M_i}$$

2.2.5 Strengths and Weaknesses

Strengths

- A corresponding strength of our model is that it would be relatively easy to distinguish more sustainable countries and policies from less sustainable ones.
- The analytic hierarchy process (AHP) has been perfectly used in our models, and the results are consistent with the reality.

Weaknesses

- Some special data can't be found, and it makes that we have to do some proper assumption before the solution of our models. A more abundant data resource can guarantee a better result in our models.
- Evaluation contains many factors. We didn't consider all of the indexes, but just part of them.
- We didn't consider the interaction between causal factors and each subsystem.

2.3Model Two: A modified model——Coupling model

2.3.1 Introduction

In the above model, we can easily distinguish which countries are stronger in terms of sustainable development, and which countries weaker. In order to make a better assessment of when a country should be considered as sustainable or unsustainable, and its degree of sustainability, we established a coupling model based on entropy method.

2.3.2 Useful Notation

Notation	Explanation
e_j	Entropy of the j_{th} indicator
p_{ij}	the j_{th} indicator of the i_{th} sample
g_j	redundancy
w_{ij}	Weight of the j_{th} indicator

2.3.3 Model Building and Solving

Coupling analysis

A country's sustainable development roots in the limitation of resources and environment. Its core problem lies in that the social economic development cannot exceed the carrying capacity of resources and environment. So it is very important to realize the coordinated development of the two. Based on a definite relationship between resource environment and economy of a country, we can use the ideas of systematic evolution theory to establish a model of coordinated development evaluation. So we can analyze coupling relationship and dynamic evolution process between the two.

Step1 Establish general functions between resource environment(R) system and social economy system(S)

Both of resource environment and social economic systems are nonlinear systems. According to the first approximate theorem of Lyapunov, we approximate the evolution equation (1) and get approximate linear system equation (2). Based on approximate linear system(近似线性系统), we establish general functions between R and S.

r: the element of resource environment system

s: the element of social economic system

p and q is the weight of each element.

$$\frac{dx(t)}{dt} = f(x_1, x_2, ...x_n); i = 1, 2, ..., n \qquad (1)$$

$$\frac{dx(t)}{dt} = \sum_{i=1}^{n} a_i x_i, i = 1, 2, ..., n \qquad (2)$$

$$\begin{cases} f(R) = \sum_{i=1}^{n} p_i r_i \\ f(S) = \sum_{i=1}^{n} q_i s_i \end{cases} i = 1, 2, ..., n \qquad (3)$$

Step2 Establish the relationship between R and S

Due to the interaction, the coupling of resource environment system and social economic system, to meet the system, the evolution equation of the composite system can be expressed as:

$$M = \frac{df(R)}{dt} = M_1 f(R) + M_2 f(S), V_M = \frac{dM}{dt} (4)$$

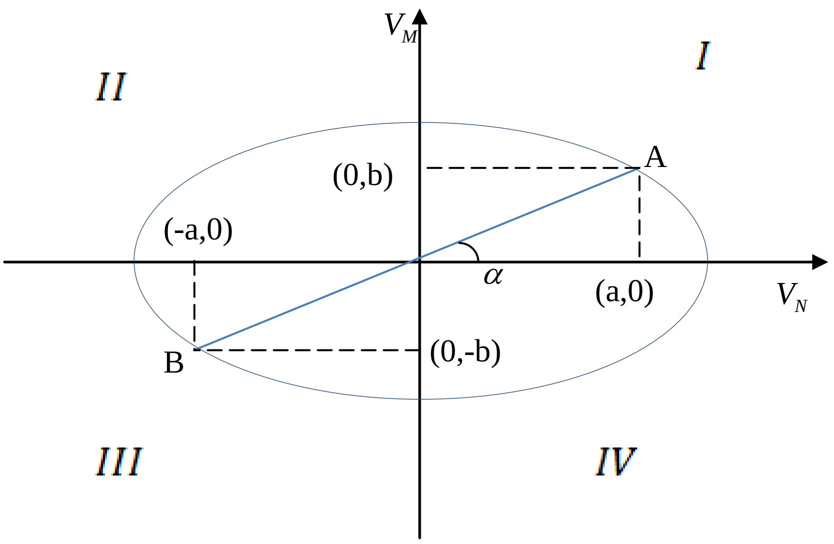
$$N = \frac{df(S)}{dt} = N_1 f(R) + N_2 f(S), V_N = \frac{dN}{dt} (5)$$

M, N respectively represent evolutionary states of resource environment system that under the internal and the external influence, sustainable development subsystem of social economic system. V_M , V_N are the evolution rate. The whole system contains only two elements $f(R)$ and $f(S)$.We define that the whole system is coordinated developed when $f(R)$ and $f(S)$ has progressed in coordination.

Step3 Establish a model of evolution rate: $V = f(V_M, V_N)$. By controlling V_M and V_N, we analyze the variation of V to consider a country's sustainable development.

We set V_M and V_N as variables to plane coordinate system，the changing trajectory of V is a ellipse(the changes of resource environment is slower than economy, with smaller amplitude). Therefore, we determined the evolutionary state of a national system by $\tan\alpha$.

$$\tan\alpha = \frac{V_M}{V_N} \qquad (6)$$



Weighted entropy method

Step1 Select and clarify the indicators

We take two aspects into consideration which are the main indicators, involving the health of human, safety about food, access to clean drinking water and energy, quality of the local environment, means of livelihood, vulnerability of our society, and so on. These indicators can be clarified into two sides as below.

Tab 4 R&S Indicators

Sort	Indicator
Resource and environment	Arable land
	Combustible renewables and waste
	CO2 emissions
	Energy use
	Depth of the food deficit
	Alternative and nuclear energy
	Energy production
	CPIA business regulatory environment rating
	Improved water source
	Energy use
	Cereal yield
	……
Social and economy	Trade
	Life expectancy at birth
	Foreign direct investment, net inflows
	Labor force participation rate
	Electric power consumption
	GDP growth
	High-technology exports
	Mortality rate
	Population growth
	Health expenditure
	GDP per capita
	Prevalence of undernourishment
	……

Step2 Definition of entropy indicators

Supposing there are m evaluation objects and n pieces of indicators in the indicator system, which form the original data matrix **X=** $(x_{ij})_{m\times n}$**,** after normalization, we can get x'_{ij} **.** According to the definition of entropy, entropy of the indicator is determined by:

$$e_j = -k\sum_{i=1}^{m} p_{ij} \ln p_{ij}$$

$$p_{ij} = \frac{x'_{ij}}{\sum_{j=1}^{m} x'_{ij}}$$

$$k = \frac{1}{\ln m}$$

Step3 Calculation of the indicator's entropy weight

Entropy weight of the j_{th} indicator is determined by

$$g_j = 1 - e_j$$

$$w_{ij} = \frac{g_j}{\sum_{i=1}^{m} g_j}$$

Stage division

The stage of development of a country can be divided into four stages.

Tab 5 The relationship of evolution between R and S

Stage	α	Relationship between $f(R)$ and $f(S)$	Relationship between V_M and V_N
More sustainable stage(I)	$\alpha = 0^o$	In the period of early social economic development, resource environment is unaffected by economy. Development is unlimited by resource environment, it only influenced by its own factors.	V_M =0, $V_N \to$ plus limit
	$0^0 < \alpha < 32^0$	Social economic and resource environment start to influencing each other and achieving common development.	0< $\frac{V_M}{V_N}$ <0.618(golden ratio), V_M ,V_N >0
	$\alpha = 32^0$	Social economic develops in harmony with resource environment	$\frac{V_M}{V_N}$ =0.618,V_M ,V_N >0
	$32^0 < \alpha < 90^0$	The pace of economic development is conditioned by the current amount of resources. In order to meet the needs of social economic development, the growth of resource environment at a faster rate than economic development.	$\frac{V_M}{V_N}$ >0.618, V_M ,V_N >0
	$\alpha = 90^o$	Economic growth reached a limit in the influence of resource environment. At the request of the limit value of economic growth, resource growth presents infinite growth trend.	$V_M \to$ plus limit， V_N =0

sustainable stage (II)	$90^o < \alpha < 180^o$	Resource environment growth began to slow, the economic growth went into reverse, and the country is in a process of entropy increase.	$V_M > 0$, $V_N < 0$
	$\alpha = 180^o$	The speed of economic development reaches the trough, and the development of resource environment also stops.	$V_M = 0$, $V_N \to$ minus limit
Bottom sustainable stage (III)	$180^0 < \alpha < 212^0$	At the same time with resource environment recession, the economic recessions has eased a bit, but still continue to be in negative growth.	$0 < \frac{V_M}{V_N} < 0.618$, $V_M, V_N < 0$
	$\alpha = 212^0$	The negative effect between resource environment and social economy brings the biggest side-effect to the national development.	$\frac{V_M}{V_N} = 0.618, V_M, V_N < 0$
	$212^0 < \alpha < 270^0$	While the recession of resource and environment continues to deepen, economic recession starts to slow down.	$\frac{V_M}{V_N} > 0.618, V_M, V_N < 0$
	$\alpha = 270^o$	The economic recession stops, resource environment presents the down trend.	$V_M \to$ minus limit, $V_N = 0$
Unsustainable stage(IV)	$270^o < \alpha < 360^o$	Through the self-organization of resource environment and society, economy starts to recover, the recession of resource environment slows down, and the country enters a new evolution cycle.	$V_M < 0, V_N > 0$

From the index α in the corresponding stage in the table above, we can consider a nation's sustainable development. We can also change the value of some index, observe the changes of α, to consider the sustainability of the policy. We determine $\alpha = 180^o$ as critical conditions, the corresponding time t is the basis for judgment of a nation's sustainable development.

2.3.4 Strength and weakness

Strength

- Our main model's strength is its enormous applicability. It can be applied to most countries.
- Our coupling model agrees with reality on different aspects, implying it behaves as we want.
- The models used in our paper is promotional, in view of different consideration,

Weakness

- Weaknesses of the model include assumptions made for simplicity that likely do not hold.
- We didn't consider all of the indexes, but just part of them.

3 Prediction and Plan

3.1Model Three: Grey Prediction

3.1.1 Introduction

In order to devise an effective 20 year sustainable development strategy for our selected LDC country—Nepal, we firstly need to predict the future trend in terms of each subsystem. In view of current situation, we adopt a Grey Forecasting Model to get data with higher reliability, thus successfully making the plans.

3.1.2 Assumptions

- In fact in reality factors affect each other, but in order to simplify the model, we ignore the interactions between factors.
- The influence of some factors such as natural disasters, the world's climate and government instability can be neglected
- Additional assumptions are made to simplify analysis for individual sections. These assumptions will be discussed at the appropriate locations.

3.1.3 Model Building and Testing

Firstly, we need to do the necessary inspection with the known data column in order to guarantee the feasibility of modeling method. Suppose the original sequence is

$$x^{(0)} = (x^{(0)}(1), x^{(0)}(2), ..., x^{(0)}(n))$$

Its ratio is

$$\lambda(k) = \frac{x^{(0)}(k-1)}{x^{(0)}(k)}, k = 2, 3, ..., n$$

If $e^{-\frac{2}{n+1}} < \lambda(k) < e^{\frac{2}{n+2}}$ is correct for all k, the sequence can be used as the data of GM (1, 1) Model. Otherwise, we need to deal with the original sequence to meet the requirements.

Building the GM (1, 1) Model, we can get the predicted value:

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

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

Suppose residual is

$$\varepsilon(k) = \frac{x^{(0)}(k) - \hat{x}^{(0)}(k)}{x^{(0)}(k)}, k = 1, 2, ..., n$$

According to the data of Nepal [6], the testing result is shown in the table below.

Tab 6 Residual

Population subsystem	Resource subsystem	Economy subsystem	Environment subsystem	ST subsystem	Whole system
-0.0001	-0.0013	0.0021	-0.0005	0.0067	0.0156
-0.0013	0.0019	-0.0019	0.0004	0.0041	-0.1040
0.0027	0.0002	-0.0025	0.0006	0.0117	-0.0258
-0.0014	-0.0008	0.0023	-0.0006	0.0091	0.0207

We can see in the table that $\varepsilon(k)$ <0.1 is correct for all data, which meet the general requirements.

Suppose residual of ratio is

$$\rho(k) = 1 - \left(\frac{1-0.5a}{1+0.5a} \right) \lambda(k)$$

The testing result is shown in the table below according the data of Nepal[7].

Tab 7 Residual of ratio

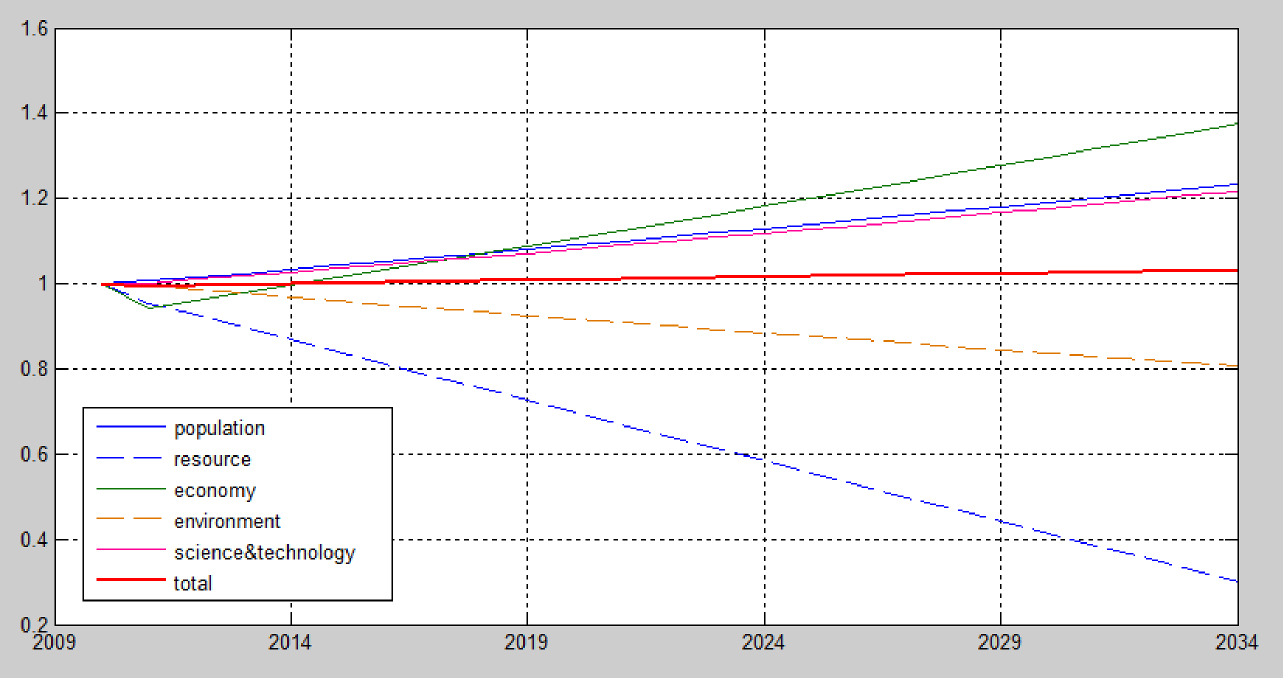
Population subsystem	Resource subsystem	Economy subsystem	Environment subsystem	ST subsystem	Whole system
-0.0031	-0.0007	-0.0128	0.0034	0.0138	-0.0049
-0.0061	0.0032	-0.0032	0.0015	-0.0355	-0.0066
0.0051	-0.0017	-0.0005	0.0003	-0.0249	-0.0039
-0.0052	-0.0009	0.0039	-0.0019	0.0640	0.0116

We can see in the table that $\rho(k)$ <0.1 is correct for all data, which also meet the general requirements. Above all, the prediction is relatively reliable. Therefore, the GM (1, 1) Model is efficient and accurate.

3.1.4 Model Analysis

The result of prediction is show in the figure below.

Fig 3 Prediction of the future



It is clear from the tendency chart of the various indicators to measure sustainable development, the sustainable state index of each indicators(population, economy, science and technology) represent an increase, which indicates that the sustainable degree of each aspects in Nepal(population, economy, science and technology) will be gradually increased in the whole international environment in the next 20 years. Bur we cannot ignore the hidden problems. For example, the sustainable state index of Nepalese population still at a low level even if it is already improves a bit. Through the reference literature, Nepal has a much larger population density than 100 people per square kilometer; it is one of the denseness population areas in the world. And it is also entered the aging society, the problem of population sustainable development is very serious.

In addition, the sustainable state index of Nepalese resource and environment are showing a downward trend in the next 20 years, the sustainable development is not optimistic. Through the reference literature, agriculture is the basic industry and strategic industry of the national economy. There is 80% of the population occupied with agriculture. Backward methods of agriculture and illogical use of land resources are the main reasons why the land in Nepal is increasingly scarce, sustainable development of land resources has been badly damaged. We can see from the last tendency chart of Nepalese's overall state of sustainable development, the sustainable development degree will be gradually increased in the next 20 years, but it will still stay at a low level.

Therefore, it is very necessary for us to design a 20-year plan of sustainable development for Nepal. And hoping ICM can stress aid at resource and environment to help Nepal to improve its sustainable development degree faster and more efficiently.

3.1.5 Strengths and Weaknesses

- Strengths

The advantage of using Grey Forecasting Model is that we can get more reliable results with lacking accessible data, which perfectly fitted with our current situation.

- Weaknesses

The data we searched from the Internet may be inaccurate. In addition, the precision of the prediction method is not very high.

3.2Making Plan

3.2.1 Program and Policy

According to the above analytical results, we put forward a development plan for 20 years to promote the sustainable development of Nepal. It includes the plan and policy below:

➢ **Population**

- Control population growth, hold population growth rate to 0.5%, adopt different policies for urban and rural area management (deal with urban mercifully while rural area strictly).
- Governments should strengthen the quality and education of their citizens to reach the world average level.
- The problem of population aging is already emerged in Nepal.
- To strengthen healthy and active aging, governments should make great efforts that rely on community service and family funding, basis on laws and regulations.[8]

➢ **Resource**

- Aiming at the problem of sustainable use of land resource, governments should change the traditional agriculture production way, develop the ecological agriculture, control the farmland-use, enhance arable land conservation, recede furrow to forests and grazing for steep slope lands with slope grade over 25 degree.
- Set a limitation to resource account, such as tree felling and fishing. Set a limitation to the number of the enterprise on a certain business to avoid crowdedness.[9]
- Focus on strategic resources deposition; reinforce the protective work over air, land, mineral resource and so on.
- According to the correlation relationship and degree between enterprise management (or product production) and utilization of sustained resources, encourage development and

productions that beneficial to projects of sustainable development by making specific deration policies.

- **Economic**
- Take reasonable using, protecting and improving the natural resources and ecological environment as the core, food production as the main, increase food production capacity to solve the problem of food security for all. Based on large agriculture, integrate and coordinate development of forestry, animal husbandry and fishery industry, increase farmers' income, eliminate rural poverty and achieve unity of economic, social and ecological benefits and sustainable development.
- Adjust the industrial structure, improve the overall quality of industry, change roughing extensive product development model mainly in resources and raw materials, innovative high-tech industry, and accelerate the transformation of science and technology to the existing productive forces.[10]
- **Environment**
- In determining the market price, consider the additional costs of environmental protection expenditures and use of cleaner production methods, etc., such as a higher price of organic agricultural produce as 0.5 - 1.5 times more than the same ordinary.
- Polluters must take measures to reduce the costs of environmental pollution, such as fertilizer and pesticides production and use are to be taxed.
- Achieve minimization, recycling and harmless waste, efforts to improve urban sewage and garbage disposal rate, control urban sewage, air, noise, solid waste pollution, such as $ 0.1 tax for per bag of garbage collection.
- **Science & Technology**
- Enact fiscal policy to promote SME Technology Innovation and encourage technology transfer. For example, SMEs, due to technological development and purchase of patents, in addition of subsidizing 15% of the study investment costs, government should subsidize another 30 percent of the cost to support its patent purchase.
- Introduce advanced technology, absorb it and innovate. Cultivate technological talents and teams, set up a "scholarship program", earmarked to strengthen personnel training. Technological institutions and universities nurture talent together.

3.2.2 Assistance

From the above, we can see that the index of sustainable development state of resource and environment in Nepal showed a decreasing tendency, suggesting that it urgently needs the assistance from ICM in these two aspects. According to Nepal’s special national population, natural environment, economic, social and political conditions, ICM can give assistance as below:

- Resource
- Enhance the technology popularizing, such as renewable energy technologies.
- According to its rich hydro energy resources, ICM can offer the technological scheme of the sustainable development of hydro energy to expand the scale of rural electrification.
- To counter the problems of low agricultural productivity, ICM can provide modern agriculture

technology.

- Environment

- Provide a detailed set of recommendations about environmental management; help it to form plans of management. Those plans can be involved in river-lake improvement, prevention of desertification and protection of wildlife, etc.
- Offers financial aid at environment protection plans and projects, provides the funding for environmental improvement in Nepal.
- Organize global environmental governance conference, emphasis on international collaboration to improve environment.

4 Plan Evaluation

We've developed a series of sustainable development plans according to the forecast. According to the plan, we put the data into Model 1. We get the results shown in the table below. Supposing the evaluation value of each subsystem is x_1 without the plans, and x_2 is the value after implementing the plans. Define

$$\Delta = x_1 - x_2$$

$$\Delta_t = F_2 - F_1$$

Tab 8 Change of value

	Population subsystem	Resource subsystem	Economy subsystem	Environment subsystem	ST subsystem	Whole (F)
x_1	0.9397	0.0090	0.3216	0.5207	0.3750	41.8849(F_1)
x_2	0.9519	0.0099	0.3524	0.5501	0.4051	44.1489(F_2)

Δ_t =44.1489-41.8849=2.264

It can be seen from the table that after implementing the plan, the value of each subsystem rise obviously, improving that our plan is very effective.

5 Model Four : Improvement Based on Model One

Considering additional environmental factors such as climate change, development aid, foreign investment, natural disasters, and government instability, the relative importance degree of P, R, E, E, and ST subsystems in PREEST system is changed. By doing research and searching related references, we have got the following matrix.

Tab 9 Significance judgment matrix of PREEST system

	Population subsystem	Resource subsystem	Economy subsystem	Environment subsystem	ST subsystem
Population subsystem	1.000	0.875	1.250	0.750	0.625
Resource subsystem	1.143	1.000	1.429	0.857	0.714
Economy subsystem	0.800	0.700	1.000	0.600	0.500
Environment subsystem	1.333	1.167	1.667	1.000	0.833
ST subsystem	1.600	1.400	2.000	1.200	1.000

It was clear from table above that the relative importance degree of P, R, E, E, ST subsystems in PREEST system is respectively: 0.1702, 0.1945, 0.1361, 0.2269, 0.2723, and satisfying:

$$C.I. = (\lambda_{\max} - n)/(n-1) = 1.3659\text{e-}5 < 0.1$$

That is, the judgment of the relative importance degree of each subsystem in table is acceptable.

According to the new weight of each subsystem, through substituting the previous data, we get the results shown in the table below.

Tab 10 Change of value

	Population subsystem	Resource subsystem	Economy subsystem	Environment subsystem	ST subsystem	Whole (F)
x_1	0.9397	0.0090	0.3216	0.5207	0.3750	42.5716(F_1)
x_2	0.9519	0.0099	0.3524	0.5501	0.4051	44.7027(F_2)

$$\Delta_t^{'} = 44.7027\text{-}42.5716 = 2.1311 < \Delta_t$$

We can draw the conclusion according to the results shown in the table: These interference factors have caused some certain influence on the implementation of the plans. But overall, due to these plans, Nepal's sustainability presents continual development. By comparing $\Delta_t^{'}$ and Δ_t, the modified model accords with the reality better.

6 Determine the Most Effective Programs or Policies

6.1 Ignoring Cost

To make a better decision that which programs or policies produce the greatest effect on the sustainability measure for Nepal, we create the following method.

6.1.1 Comparing the Difference

To identify the most effective strategy, we need to analyze the change of evaluation value in each subsystem.

Tab 11 Difference

	Population subsystem	Resource subsystem	Economy subsystem	Environment subsystem	ST subsystem
x_1	0.9397	0.0090	0.3216	0.5207	0.3750
x_2	0.9519	0.0099	0.3524	0.5501	0.4051
Δ	0.0122	0.0009	0.0308	0.0294	0.0301

According to the above-mentioned information, we can compare the variation of all aspects. Then we come to the conclusion that environmental strategy has the largest effect to improve the capacity of sustainable development.

6.1.2 Considering the Weight

In fact, all the effects that policies perform, on the whole, produce different contribution rates on promoting the sustainable development capacity. For the reason, according to w, we adjust the evaluation on our varied strategies.

Tab 12 Adjustment based on weight

	Population subsystem	Resource subsystem	Economy subsystem	Environment subsystem	ST subsystem
x_1	0.9397	0.0090	0.3216	0.5207	0.3750
x_2	0.9519	0.0099	0.3524	0.5501	0.4051
w	0.1702	0.1945	0.1361	0.2269	0.2723
$\Delta \cdot w$	0.2210	1.9450	1.3034	1.2811	2.1857

The chart shows that after considering the weight factor, science and technology strategy plays the biggest effective role in the promotion of sustainable development capacity.

6.2 Model Five: Comparison of η

6.2.1 Introduction

In the above model, we don't consider the cost of the implementation of these plans. In order to better identify that which strategies can jump into more benefits under some certain economic conditions, we therefore introduce the following model.

6.2.2 Some notation

Notation	Explanation
η	the actual benefit of a program or policy
E_0	proportionality coefficient
ω	The geographical factor's impact on costs
ΔO	The amount of CO_2 emissions
Δw_{ij}	The amount of water a region can't provide by itself
b_i	Freshwater attribute
d_{ij}	Donations transferring distance
T	The total number of year
σ	The standard deviation of total water resource
p_0	The desalinization cost of tons of seawater
C_{kj}	The amount of food production
E_{kj}	The rate of labor force participation

6.2.3 Model Building

In the above model, we don't take the cost into consideration. In order to evaluate the actual benefit of our plans, we have devised:

$$\eta = \frac{k}{E_0 \cdot \omega} \bullet \frac{\Delta O}{\log k + \log \Delta O}$$

$$\eta_{ij} \propto \frac{\Delta w_{ij}}{e^{-b_i b_j} \cdot d_{ij} \cdot \log \Delta w_{ij}}$$

$$\eta = \frac{2T\sigma}{p_0[1 + \ln(T\sigma)]}$$

$$\eta_k = \frac{\sum_j^n \Delta C_{kj}}{\sum_j^n E_{kj}}$$

According to these function of our plans, the benefit analysis of a strategy are evaluated in terms of economy, resources and environment. Then we can determine the specific value of the parameters in these equations using Data Mining.

However, η only relates to the current coat and results. It does not take the future impact into account, such as economic, cultural, and environment implications.

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