Problem Chosen	2023 MCM/ICM Summary Sheet	Team Control Number
D		2316472

How to establish peace, dignity and equality on a healthy planet

Summary

The SDGs are a blueprint for a better and more sustainable future. We were asked to build a correlation network between 17 SDGs. In order to achieve these goals, we optimize and improve the Analytic Hierarchy Process (AHP), build the ANCP model, and take six factors such as technological progress and war into consideration in the judgment. This model can be applied to calculation of priorities, simulation of dynamic processes, and adaptation to a variety of situations.

Based on Maslow's demand theory and the data posted by the United Nations, we build the ANCP model, and then clarify the connection between the 17 SDGs. Through the incidence matrix, we visualize the network contained in the SDGs. After receiving the P-value from SDGs, we conduct our development priorities (Partnerships to achieve the Goal).

Inspired by the survival curve, we introduce the Danger Index (DI) to evaluate the dynamic resolution of an event. In turn, DI coefficient also has an impact on the correlation network. We take technology advances, global pandemics, climate change and other influencing factors into the decision-making level of the incidence matrix, so that the results can generate feedback on the world changes. This provides a more enlightening idea for the dynamic change of correlation network.

We also note that regional differences also produce distinct SDGs preferences in the judging process. In our case study, we apply the model to the Middle East. Applying our model, the results highlight a range of environmental SDG priorities in the Middle East, a region with frequent crises such as wars and refugee activities in addition to its large fossil energy resources. Top priorities include sustainable food production and land resources, water resources, coastal and marine resources, energy and climate, and sustainable consumption and production.

The results suggest that SDGs network can be effectively constructed and incorporated into the ANCP decision-making framework to support regional and national priorities for sustainable development goals. The framework provides a sound evidence base for early achievement of the SDGs through cooperation.

Keywords:ANCP,SDGs,dynamic network

Contents

1 Introduction

1.1 Background and Restatement

2015 is the closing year of the United Nations MDGs (Millennium Development Goals), when countries around the world have united and cooperated for 15 years to implement the eight development goals. 25 September, the United Nations Sustainable Development Summit was held at the headquarters in New York, where the General Assembly adopted a framework of 17 SDGs (Sustainable Development Goals) - inherited from the MDGs - in terms of social, economic, and environmental dimensions to pursue a sustainable development path. Achieving the SDGs can bring the UN closer to creating peace, dignity, and equality on a Healthy Planet. The 17 goals represent optimal solutions in their respective areas and are interconnected - achieving one goal will also help to accomplish another. Such characteristics make it difficult to achieve goals consistently and can be affected by technological advances, global pandemics, climate change, regional wars, and refugee movements.

There are 4 problems to be answered:

Problem 1: Create a network among the 17 SDGs to find the highest priority goal to be addressed.

Problem 2: Discuss how the remaining 16 goals change after ten years of solving the highest priority goal.

Problem 3: Discuss how factors (Technological advances, global pandemics, climate change, regional wars, refugee movements ,and other factors) influence 17 SDGs.

Problem 4: Give companies and organizations some suggestions.

1.2 Our Work

Figure 1 is our mindmap. To solve these problems, we establish the Incidence Matrix (IM) between 17 SDGs by constructing the Analytic Network Correlation Process (ANCP) model and visualize it. According to parameters of ANCP, the priority of 17 SDGs can be calculated respectively. In the process of setting this goal, Danger Index (*DI*) is introduced to quantitatively evaluate the effect of the solution to the goal. The model will also calculate the *DI* of the six main factors to the world crisis, and then quantify the effect of the six factors. After fully taking into account the six factors, the *DI* will have an impact on the network structure among the 17 SDGs constructed by ANCP, which will lead to changes in the UN's decision-making. Finally, We verify the model for the Middle East region, draw the necessary conclusions and give suggestions.

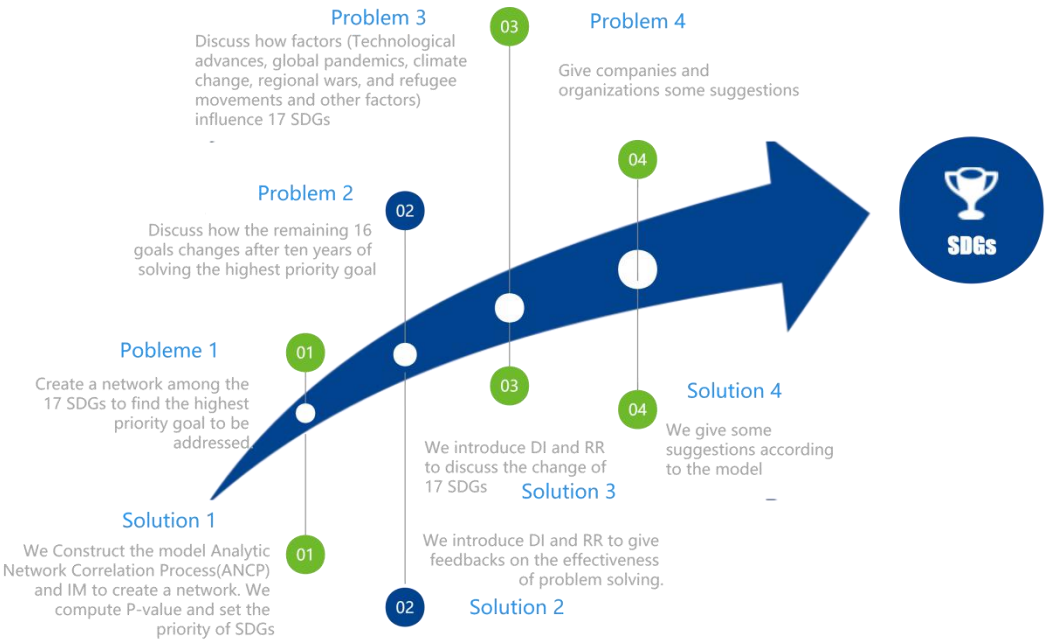


Figure 1:Our Mindmap

2 Main factors

17 SDGs cannot be achieved without both the efforts of the performers and the influence of the surrounding environment. We think that technological advances, global pandemics, climate change, regional wars, refugee movements and economic activities have enormous implications on goals. In the following, we abbreviate the goals of the 17 SDGs in order to streamline the text content, with the first goal being SDG1, and so on.

Technological Advances

Historically, technological advances can bring about a take-off in productivity. The first industrial revolution brought big machine assembly line production, and the second industrial revolution brought the world into the electrical age. Technology has produced huge economic benefits by increasing efficiency and liberating labor, directly impacting goals such as SDG1 and SDG2.

Global Pandemics

Pandemic Refers to a disease that spreads rapidly, involves a wide geographical area and a large proportion of the population, and can cross provincial and national borders or even continental borders to form a worldwide epidemic in a short period of time. 2019 New Crown epidemic has changed people's lifestyles and claimed many lives, which has also caused an impact on goals such as SDG3.

Climate Change

Climate change is an alteration in the state of the climate over a long period of time. Bad changes in climate bring about global warming, ozone layer depletion and acid rain. Climate action is relevant to everyone, so much so that the United Nations has a special SDG13 to

illustrate his importance.

Regional Wars

War is the supreme means of resolving inter-regional conflicts through violent means. With the advancement of technology, the destruction and cost of warfare has increased. Large-scale wars destroy the environment and also cause the death of people, without which there can be no talk of development.

Refugee Movements

Refugees displaced by war or the economy are currently facing a crisis. Those who have not managed to flee have suffered the ravages of war, some have died in smuggling, and others face questions of identity when they arrive in a new country. There are more refugees than ever before.

Economic Activities

Economic activity refers to all the activities of human beings to obtain and use various means of living through the process of labor or payment of appropriate prices in order to survive under a certain social organization and order.

Economic activity generates benefits that ensure people's survival, and it is because of economic benefits that people never give up pursuing throughout their lives. SDGs primary goal is to address poverty. Funding is needed to implement activities such as climate action and public health governance. Technology development also depends on funding, refugee resettlement requires relief money, and conflicts arise between regions over interests. Economic activity is not only an important factor affecting the SDGs, but also greatly influences other factors, so we believe that economic activity is also a factor to be considered.

Table 1: The Factors that We Take into Account

Factor	Example: Related International Organization
Technological Advances	United Nations Industrial Development Organization
Global Pandemics	World Health Organization
Climate Change	World Meteorological Organization
Regional Wars	United Nations Truce Supervision Organization
Refugee Movements	United Nations High Commissioner for Refugees
Economic Activities	The World Bank, International Monetary Fund

3 Assumptions

- **Our data sources are reliable and accurate.** The statistics we use comes from data published by the United Nations. All data comes from the financial report and audited financial statements of the United Nations, meaning that data can find its source.
- **Our seventeen policies mainly contain (or are caused by) only six factors in the text.** In accordance with content above, international crises can be divided into six factors, and for modeling, the evaluation factors of each decision are therefore simplified.
- **To simplify the impact of policy implementation, it is assumed that the effect of policy implementation can be represented by an ease-in and ease-out function.**

Based on expert advice and literature collection, a model that includes all factors is unrealistic. The use of a survival curve can be used to model the problem-solving process.

- **We calculate problem-solving process over 10 years.** Because the process of policy re-implementation is not a year or two to get a very significant effect, it is feasible to calculate 10 years based on the previous information collection.

4 Symbol Explanation

The primary notations used in this paper are listed in Table 2. We define the main parameters while specific values of those parameters will be given later.

Table 2: Notations

Symbol	Description
FJM	Judgement Matrix of Factor consists of judgments given by the relative importance of each factor at each level.
FJV	Judgement Vector of Factor is the normalized eigenvector of Judgement Matrix of Factor.
SJM	Judgement Matrix of Strategy consists of judgments given by the relative importance of each factor at each level.
SJV	Judgement Vector of Strategy is the normalized eigenvector of Judgement Matrix of Factor.
WV_{t-f}	The weight vector of the target's influence on the factor.
WV	Weighting of each factor under each objective.
WM	Weighting Matrix.
DI	Danger Index indicates threat trends in SDGs over time.
I_{value}	Incidence-value indicates the level of correlation between different SDGs.
IM	The incidence Matrix is augmented by the correlation index
P_{value}	P-value indicates the priority of SDGs.
CI	Consistency Index
RI	Average Random Consistency Index
CR	Consistency Ratio
RR	Resolution Ratio

5 Model：Analytic Network Correlation Process

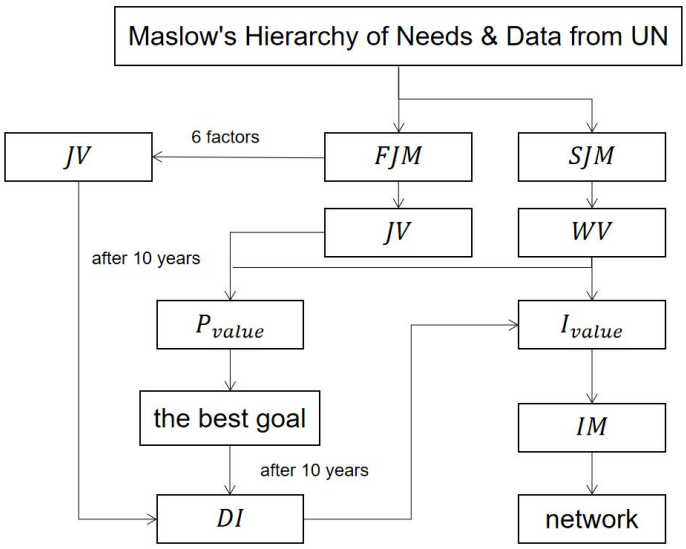


Figure 2: The Framework of ANCP

Figure 2 shows the framework of the **Analytic Network Correlation Process(ANCP)** model we built, and the parameters are described in the third part, and we will elaborate on the model of ANCP step by step. It is an refinement of the **Analytic Hierarchy Process (AHP)** to better fit our model.

5.1 Evaluation Based on Data and Maslow's Hierarchy of Needs

First of all, according to Abraham H. Maslow 's hierarchy of needs theory, human needs are divided into five levels, as shown in Figure 3.

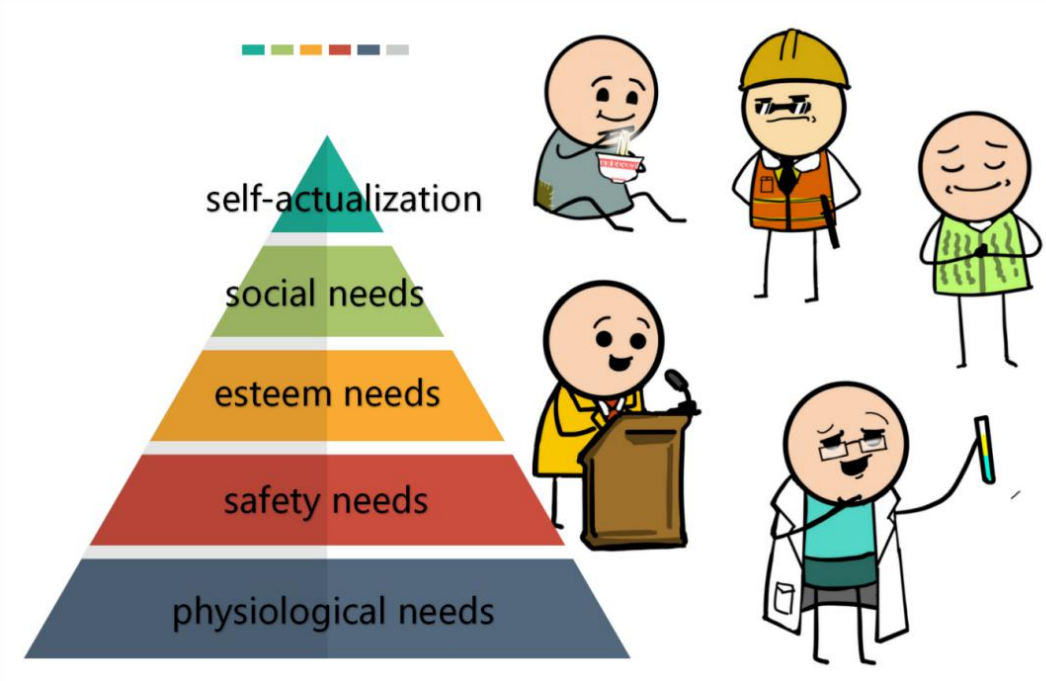


Figure 3: Maslow's Hierarchy of Needs

These 17 SDGs can be roughly divided into five categories. As the level of needs rises by Abraham H. Maslow, the power of needs diminishes accordingly. Lower-level needs must be satisfied before higher-level needs can emerge. We base our judgment on Maslow's Hierarchy of Needs, and we have collected the published financial expenditures of various UN organizations in recent years, and the relevant data tables are in the Appendix, as a basis for assigning initial values to *FJM* and *SJM*.

5.2 Construction of FJM and SJM and Calculation of FJV and SJV

Firstly, we give weight to every index by using ANCP.

Step 1: Build layers

The **indicators** are divided into **six components**: technological advances, global pandemics, climate change, regional wars, refugee movements, and economic activities.

Step 2: Establishment of the **judgment matrix of factor** and **judgment matrix of strategy**.

Construct a **judgment matrix of factor**, *SJM* has the same format but with 17 rows and 17 columns:

$$FJM = \begin{pmatrix} FJm_{1,1} & \cdots & FJm_{1,6} \\ \vdots & \ddots & \vdots \\ FJm_{6,1} & \cdots & FJm_{6,6} \end{pmatrix}$$

$$FJm_{i,j} > 0, FJm_{i,j} = \frac{1}{FJm_{j,i}}, FJm_{i,i} = 1$$

We get the following matrix after inputing the elements:

$$FJM = \begin{pmatrix} 1 & 1/4 & 2 & 1/8 & 4 & 1/2 \\ 4 & 1 & 8 & 1/2 & 16 & 2 \\ 1/2 & 1/8 & 1 & 1/16 & 2 & 1/4 \\ 8 & 2 & 16 & 1 & 32 & 4 \\ 1/4 & 1/16 & 1/2 & 1/32 & 1 & 1/8 \\ 2 & 1/2 & 4 & 1/4 & 8 & 1 \end{pmatrix} \begin{matrix} \textit{technological advances} \\ \textit{global pandemics} \\ \textit{climate change} \\ \textit{regional wars} \\ \textit{refugee movements} \\ \textit{economic activities} \end{matrix}$$

Step 3: Consistency check

Calculate the consistency index *CI*, and then find the corresponding average random consistency index *RI*, while later calculating the *CR*. Due to space limitations, we omit the specific process here. The consistency of the matrix is considered **acceptable** if $CR < 0.1$.

Step 4: Calculate the normalized weights

The vector *FJV* satisfy:

$$FJW \cdot FJV = \lambda_{\max} \cdot FJV$$

According to the above inference, $FJV=\left[FJv_1,\cdots,FJv_6\right]$ will satisfy the following conditions, of course, the same formula is available for the elements in SJV :

$$\overline{FJv_i}=\sqrt[6]{\prod_{j=1}^{6}FJm_{ij}}$$

$$FJv_i=\frac{\overline{FJv_i}}{\sum_{j=1}^{6}\overline{FJv_j}}$$

From this we get:

Table 3: The weight of *FJV*(after Normalization)

FJv_1	FJv_2	FJv_3	FJv_4	FJv_5	FJv_6
0.0635	0.2540	0.0317	0.5079	0.0159	0.1270

This is exactly what we need to satisfy when inputing the weights of the judgment matrix. According to the above formula, we can get the **indicator** representing the ultimate goal of the 17 SDGs.

5.3 Construction of IM and Calculation of P-value

Step 1: Construct *WM* and *WV*.

We **combine** 17 *SJV* into a **matrix** by column to make the augmentation of the dimensionality of the data and **normalize** each row of data by row to obtain *WM*:

$$WM=\begin{pmatrix} SJV_{1,1} & \cdots & SJV_{17,1} \\ \vdots & \ddots & \vdots \\ SJV_{1,6} & \cdots & SJV_{17,6} \end{pmatrix}$$

The meaning of $SJV_{n,m}$ is the mth element of the nth X-vector.

After decomposing *WM*, the first column is WV^1, contains 6 elements, and the sixth element is $WV^1(6)$.

Step 2: Compute I_{value} and construct *IM*.

The design formulas of I_{value} as follows, means the **correlation between two goals** (SDGs):

$$I_{\text{value}}{}^{n,m}=\min\left[WV^n(1),WV^m(1)\right]+\min\left[WV^n(2),WV^m(2)\right]+\cdots+\min\left[WV^n(6),WV^m(6)\right]$$

IM can be constructed from I_{value} meaning the **incidence matrix** between the objectives (SDGs):

$$IM=\begin{pmatrix} I_{\text{value}}^{1,1} & \cdots & I_{\text{value}}^{1,17} \\ \vdots & \ddots & \vdots \\ I_{\text{value}}^{17,1} & \cdots & I_{\text{value}}^{17,17} \end{pmatrix}$$

According to *IM* we can construct the correlation **network** between each goal (SDGs).

Step 3: Calculate P_{value}

The Design Formulas of P_{value} means the correlation between two objectives (SDGs):

$$P_{value}{}^{n}=FJv_1*WV^{n}(1)+\cdots+FJv_6*WV^{n}(6)$$

The significance of P_{value}^{n} is the **importance of the** nth **goal**, and the calculation of P_{value}^{n} allows us to provide suggestions to the United Nations when formulating development strategies.

5.4 Danger Index

We introduce a hazard index to describe the extent to which the problem has been solved. The problem is solved slowly at the beginning. At acceleration, this process is called **ease-in**. When the problem is about to be solved, the speed also decreases until it approaches zero, a process known as **ease-out**. The process is similar to a **sigmoid curve**. Therefore, it is possible to specify the **"survival curve"** of the relevant goal after the policy is issued. The Kaplan-Meier nonparametric estimation method proposed by Edward Kaplan and Paul Meier allows us to estimate the survival function. Kaplan-Meier solves the problem by re-estimating the survival probability each time it occurs. We, therefore, assume that censoring is not related to the possibility of the event occurring, and survival rates are comparable in the early and late stages of the research. By **collecting data** for **fitting**, we construct the functional equation of Danger Index (*DI*) as follows, DI_0 represents the extent of the danger if our priorities are initiated. We use the function of easing in and easing out for fitting it. DI_n decreases with DI_0 decreasing. Since their P_{value} are different, they decrease differently. There are 16 DI_n.

$$DI_0=\left\{\frac{\sqrt{1-(2x)^2}+1}{2}\,|\,0\le x\le 0.5;\frac{1-\sqrt{1-(2x-2)^2}}{2}\,|\,0.5\le x\le 1\right\}$$

$$DI_{\text{n}}=1-I_{value}{}^{n,0}\cdot(1-DI_0)$$

Varying with DI_0 and DI^m, the significance of DI^m is the extent of following danger of following the six factors as the 17 SDGs are addressed. The results by computing FJv_m, DI_n, DI_0 need normalization because the result by calculating DI_0^m may be negative not meeting the signification of the extent of the following danger. There are 6 normalized DI^m:

$$DI^{m}{}_0=1-(1-DI_0)\cdot(FJv_m)-(1-DI_1)\cdot(FJv_m)-\cdots-(1-DI_{16})\cdot(FJv_m)$$

$$DI^{m}=\frac{DI^{\text{m}}{}_0}{1-\min\left(DI^{1}{}_0,DI^{2}{}_0,\cdots,DI^{6}{}_0\right)}$$

To well express the functional properties of DI_0, We normalize the abscissa axis part of the formula DI_0(indication of the extent of danger) . We obtained the time axis normalized to DI_0, as shown in Figure 4.

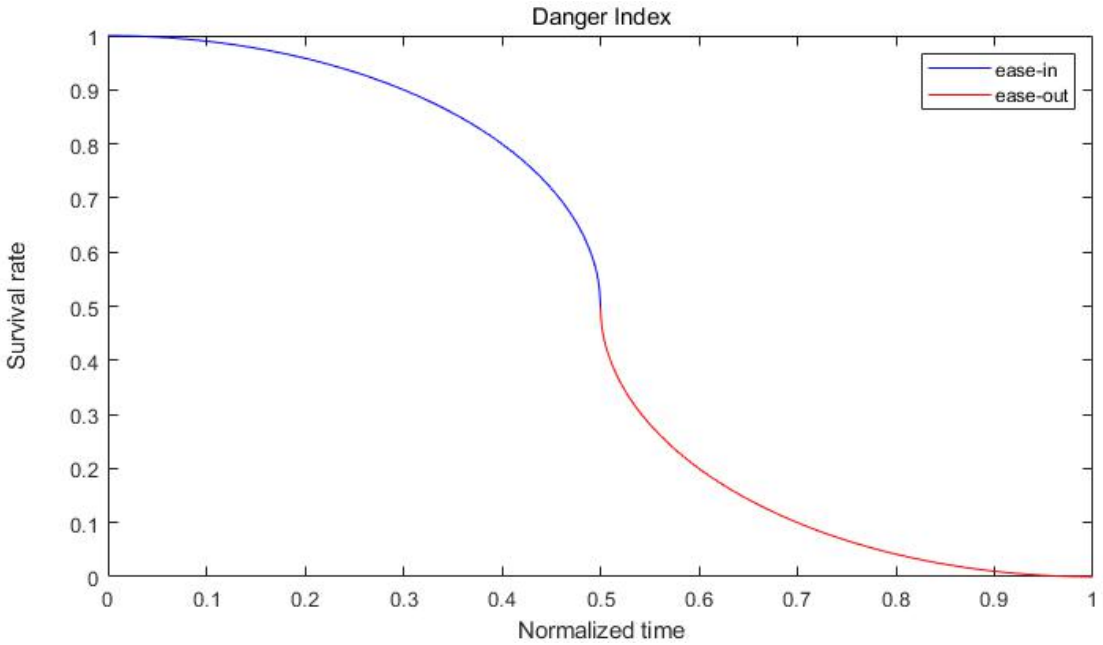


Figure 4: DI_0 Changes with the Value of the Normalized Time(Survival Curve)

5.5 Impact of *DI* on network results

According to our calculations, we obtained *DI* which can be fed back to *SJM* and *FJM*. When evaluating the coefficients of the feedback, we set the index (Resolution Ratio) to facilitate feedback *SJM* and *FJM*, the design formula of *RR* as follows:

$$RR_{n,m} = DI_n / DI_m$$

The meaning of $RR_{n,m}$is the resolution ratio of the nth goal to the mth goal. If $RR_{n,m} < 1$, it means that the nth goal gains less resolution. If $RR_{n,m} > 1$, it is on the contrary.

In the feedback session, we plug $RR_{n,m}$ into *SJM* and *FJM*. The same design formula as follow:

$$FJM = \begin{pmatrix} 1*RR_{1,1} & \frac{1}{4}*RR_{1,2} & 2*RR_{1,3} & \frac{1}{8}*RR_{1,4} & 4*RR_{1,5} & \frac{1}{2}*RR_{1,6} \\ 4*RR_{2,1} & 1*RR_{2,2} & 8*RR_{2,3} & \frac{1}{2}*RR_{2,4} & 16*RR_{2,5} & 2*RR_{2,6} \\ \frac{1}{2}*RR_{3,1} & \frac{1}{8}*RR_{3,2} & 1*RR_{3,3} & \frac{1}{16}*RR_{3,4} & 2*RR_{3,5} & \frac{1}{4}*RR_{3,6} \\ 8*RR_{4,1} & 2*RR_{4,2} & 16*RR_{4,3} & 1*RR_{4,4} & 32*RR_{4,5} & 4*RR_{4,6} \\ \frac{1}{4}*RR_{5,1} & \frac{1}{16}*RR_{5,2} & \frac{1}{2}*RR_{5,3} & \frac{1}{32}*RR_{5,4} & 1*RR_{5,5} & \frac{1}{8}*RR_{5,6} \\ 2*RR_{6,1} & \frac{1}{2}*RR_{6,2} & 4*RR_{6,3} & \frac{1}{4}*RR_{6,4} & 8*RR_{6,5} & 1*RR_{6,6} \end{pmatrix} \begin{matrix} \textit{technological advances} \\ \textit{global pandemics} \\ \textit{climate change} \\ \textit{regional wars} \\ \textit{refugee movements} \\ \textit{economic activities} \end{matrix}$$

We can use *SJM* and *FJM* to calculate new *SJV* and *FJV*. Therefore we can get different *IM* and compute respectively P_{value} of 17 SDGs. This process can result in a change in the priority of the 17 SDGs and a change in the structural network between the 17 SDGs. *DI* also

feeds back to the network structure and decision-making in this way.

6 Application of ANCP

According to our model, we calculate that the most important SDG is SDG17. Next are SDG6, and SDG2, P_{value} calculated finally for each goal is shown in Table 4.

Table 4: P_{value} of each SDG(after 10 years)

SDG	**5**	**14**	**15**	**13**	**16**	**11**	**12**	**1**
P_{value}	0.0068	0.0239	0.0272	0.304	0.0433	0.0525	0.0614	0.0638
8	**3**	**10**	**7**	**4**	**9**	**2**	**6**	**17**
0.0691	0.0701	0.0724	0.0734	0.0738	0.0759	0.0850	0.0852	0.0858

According to P_{value} and *IM* calculated by ANCP, we can draw the following picture of the network by using network3D of R-Studio 4.2.2. In Part(I) of the Figure 5, we construct an *IM* graph between the 17 SDGs. The size of nodes represents the size of P_{value}, the node with the larger value of P_{value} is larger, on the contrary, the node with the smaller value of P_{value} is smaller. The color of the nodes represents the general classification of these 17 SDGs.

For example, “Resource Use” is including SDG2, SDG6, SDG7, and SDG12. We can see that each goal is related to the other 16 goals. A thicker line between two nodes means a greater correlation between the two SDGs, while a thinner line means less correlation as shown in the second part of Figure 5, where we can move any node alone to the outside of the entire network structure to see its relationship with other nodes more clearly.

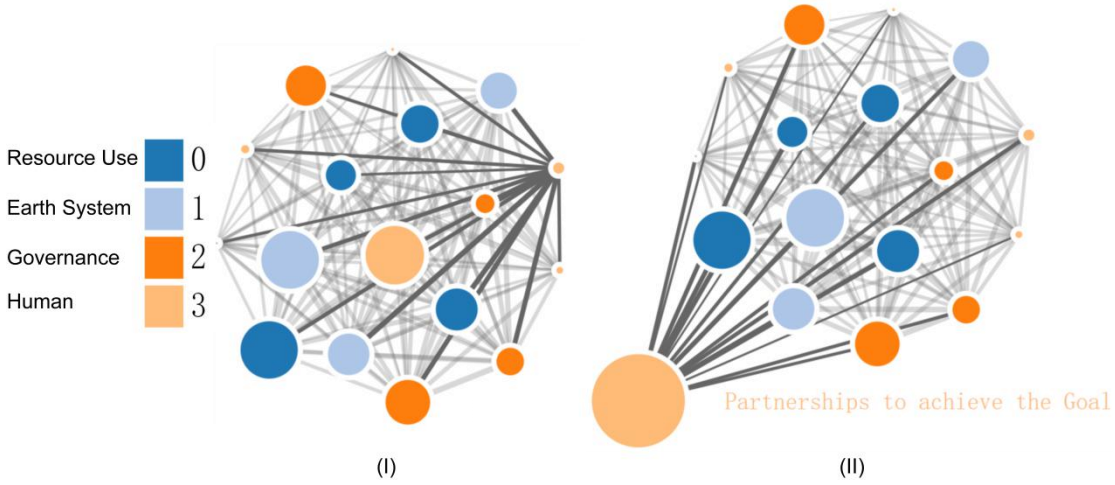


Figure 5: A Network Structure Diagram Calculated Based on Today's Situation

We can also draw a chordal graph(Figure 6) between the 17 SDGs, in which the segments of each SDG are labeled, and the thickness of the chord emitted from each segment represents I_{value}, with thicker chords representing higher I_{value} and greater correlation between the two SDGs.

Figure 6: Association Network between 17 SDGs (Chordal Graph)

Figure 7 also allows us to compute the extent of correlation between the 17 SDGs, with dark colors, and large numbers representing a high extent of correlation. Due to space limitations, we use a chordal graph representing the change in network structure, which is more clear.

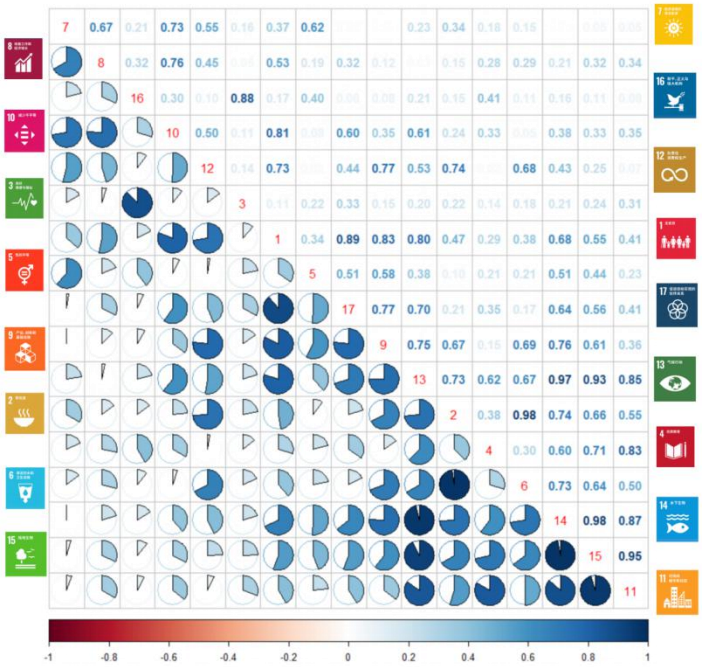
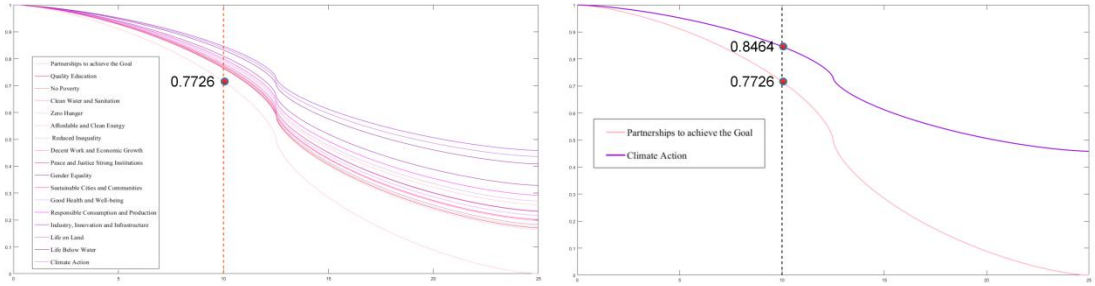


Figure 7: Intercorrelation between the 17 SDGs (the Larger the Calculated Value, the Higher the Degree of Correlation)

After the construction of the network structure, we introduce a solution curve, and then we calculate the *DI* for each goal, afterwards, we calculate the *DI* for each factor to feedback to *FJM* and *SJM,* the specific calculation steps are explained in the section 5.5. In 10 years, Figure 8 shows the changes we obtained for *DI* with time.

We used the survival curve in Section 5.4 to fit an ease-in-out function to represent the extent of danger to each SDG, with lower values implying that it gets solved better.



(I) (II)

Figure 8: Changes in DI Value of Individual SDGs over Time (over 10 Years)

In the first part of the above graph, the 17 SDGs are decreasing with time.

I_{value} between SDG17 gets bigger, and the decreasing function drops faster. The smallest extent of correlation is SDG13 as *DI* dropping most slowly. The second part of the graph above shows respectively the values of DI_0 dropping fastest and DI_{13} declining most slowly at the point of the tenth year. According to fitting curves, we finally found that the highest P_{value} was solved at the point of the twenty-fifth year.

Figure 9 shows the change of DI^m(It is *DI* of six factors respectively).

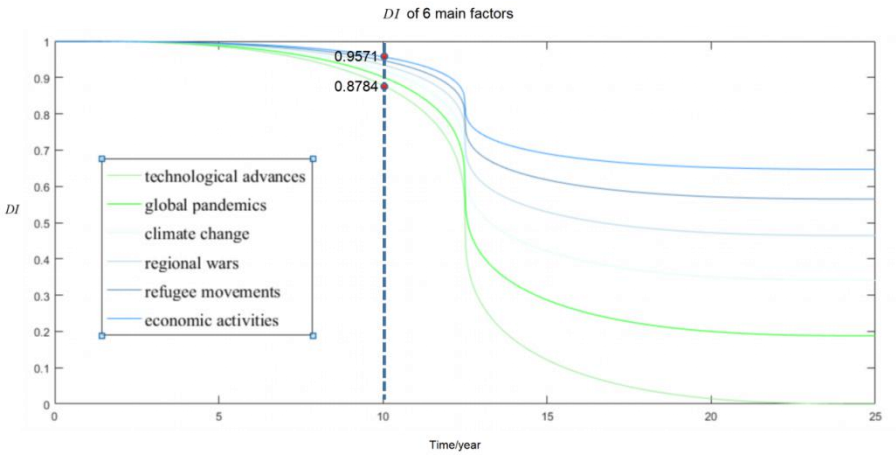


Figure 9: Change in *DI* value for each factor over time (after ten years)

In Figure 9, we can see that the values of some of the factors tend to stabilize at the time of the twenty-fifth year and do not change. According to the simulated curve, at the time point of the twenty-fifth year, we only have one goal solved, which can only solve some world crisis, and the *DI* of these factors will reach 0 only when all SDGs are solved.

After deciding the highest P_{value}, we will solve SDGs to different extents in the next

decade. At the same time, six factors will also be solved to different extents. It is represented by a decline of *DI*. The value drops faster representing factors solved more. Table 5 and Table 6 show *DI* of the 17 goals and the six factors calculated over a decade.

Table 5: The *DI* value of each SDGs (after Ten Years)

SDG	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
DI	0.7649	0.7683	0.7779	0.7629	0.7890	0.7665	0.7726	0.7822
9	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
0.8095	0.7336	0.7930	0.7992	0.8464	0.8400	0.8321	0.7825	0.7163

Table 6: *DI* Value for each Factor (after Ten Years)

Factor	**Tech**	**Pan**	**Cli**	**War**	**Ref**	**Eco**
DI	0.8784	0.9013	0.9199	0.9349	0.9471	0.9571

If we achieve one goal, we need to assign 0 for the *DI* of the goal to compute *DI* of remain. The values are shown in Table 7 and Table 8:

Table 7: The DI value of each SDGs (One Goal is Achieved)

SDG	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
DI	0.1710	0.1835	0.2172	0.1645	0.2564	0.1770	0.1986	0.2325
9	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
0.3286	0.2021	0.2705	0.2922	0.4585	0.4360	0.4084	0.2340	0

Table 8: *DI* Value for each Factor (One Goal is Achieved)

Factor	**Tech**	**Pan**	**Cli**	**War**	**Ref**	**Eco**
DI	0.8337	0.8119	0.8304	0.8194	0.9200	0.8213

The feedback from the *DI* back to the network (the specific calculation process is in section 5.5) results in a change of the network structure, which is reflected not only in the change of P_{value} of each SDG, the change of priority of each goal but also in the change of I_{value} between each SDG, the change of the network structure between SDGs. The change in the network structure is shown in Figure 10.

Figure 10: Association Network between 17 SDGs (Chordal Graph)

7 Practical Application of ANCP in the Middle East

7.1 Background of the Middle East

The Middle East refers to the southern part of the eastern Mediterranean Sea to the Persian Gulf coast, including most of West Asia except Afghanistan, Egypt in Africa, and Transcaucasia, which is located on the border with Russia. It is known as the land of two oceans, three continents, and five seas, and has had an important strategic position since ancient times.

Most of the terrain in the Middle East is a plateau, the climate is dry and hot, and it is under the control of the subtropical high pressure and the northeastern trade winds from the arid areas of the Asian interior, so there is little rain. At the same time, the region’s closed plateau terrain, blocking the entry of moist ocean air, further exacerbates the region's aridity, so the formation of a tropical desert climate is dominated by the characteristics. As a result, the Middle East is facing problems such as scarce arable land, water scarcity, and food shortage.

Relying on the topography, the rich oil reserves of the Middle East were explored as history progressed, bringing wealth and disaster to the countries of the Middle East. Ethnic and religious issues are also becoming increasingly acute. When will the Middle East regain its former glory?

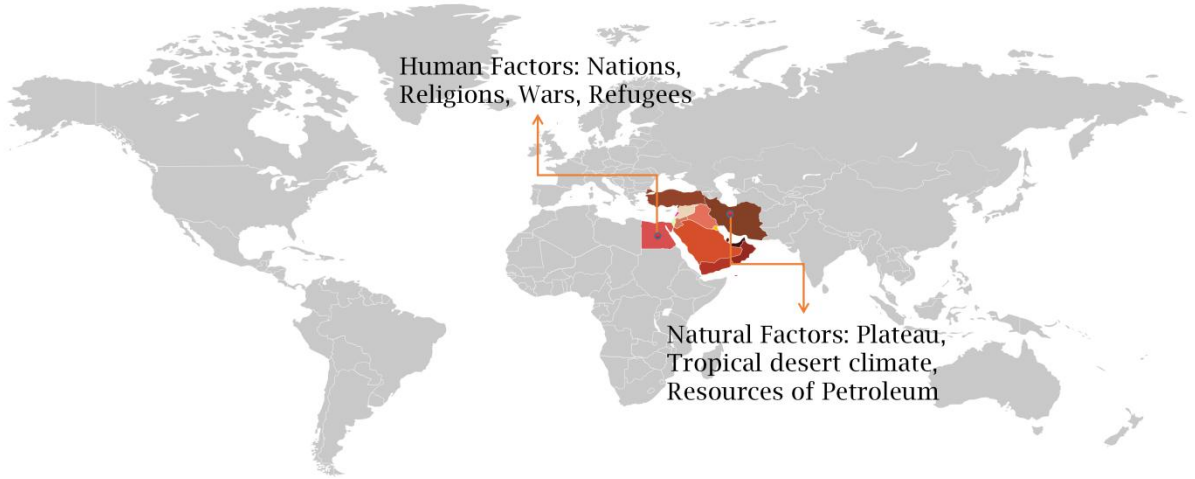


Figure 11: Select the Middle East region

7.2 Application in the Middle East

Based on the above special circumstances in the Middle East, we need to reconstruct *SJM* and *FJM*, then calculate the new network. The specific calculation process is described in detail in sections 5.2 and 5.3. *IM* and P_{value} calculated by ANCP can create a new network. P_{value} has changed for each SDG in Table 9, we can see that the highest priority SDG has changed from the previously calculated SDG17 to SDG7, and the top-ranked SDGs have also changed significantly.

Table 9: The DI value of each SDGs

SDG	**5**	**10**	**1**	**17**	**16**	**4**	**15**	**11**	**8**
DI	0.0068	0.0201	0.0256	0.3477	0.3478	0.3693	0.0440	0.0576	0.0613

...	**3**	**14**	**6**	**2**	**9**	**12**	**13**	**7**
...	0.0681	0.0791	0.0792	0.0809	0.0810	0.0895	0.0999	0.1004

In Figure 12, we obtain a network structure in which different nodes correspond to different SDGs, and the connecting lines between them contain the extent of correlation between them, the larger the extent of correlation the thicker the line. By analyzing and modeling the special situation in the Middle East, we reach a completely different conclusion from the previous one in Section 6, which means that the model can be applied in different regions or countries, and our model is applicable to modeling and analysis at all levels. In the Middle East, the greater importance of resource issues means that the priority of each of the 17 SDGs changes as they are implemented in the region.

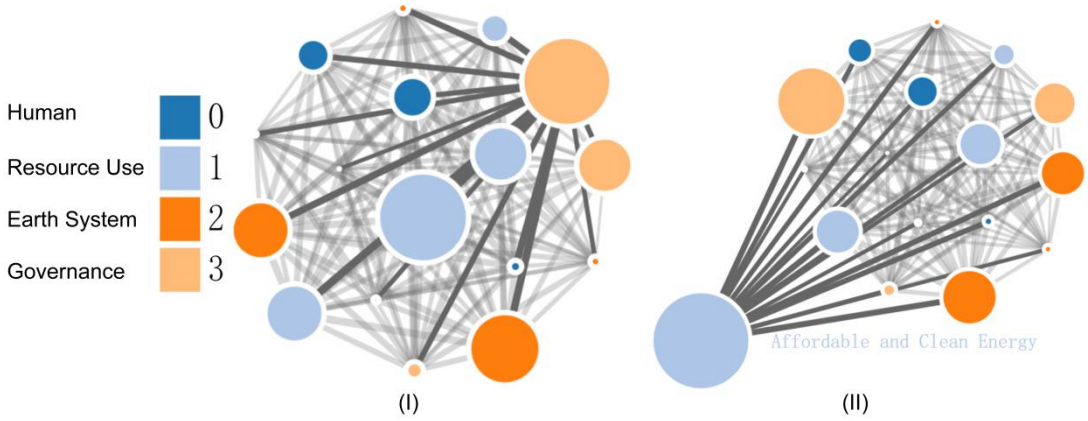


Figure 12:A Network Structure Diagram Calculated in Middle East

Figure 13 shows the chordal graph of the network structure in the Middle East, in which we can get the extent of correlation between each SDG, and we can find a significant difference from the previous chordal graph, which is mainly due to our reconstructing *SJM* and *FJM* and modeling analysis.

In Figure 13, we can see that our ANCP model can be applied to a variety of situations, whether it is the whole world or a single region. At the same time, ANCP can fully take into account the correlation between each SDG and can build a network structure between multiple SDGs, and we can also introduce *DI* to evaluate the extent of resolution and feedback to the network to change the network structure, which is powerful enough to solve the problem.

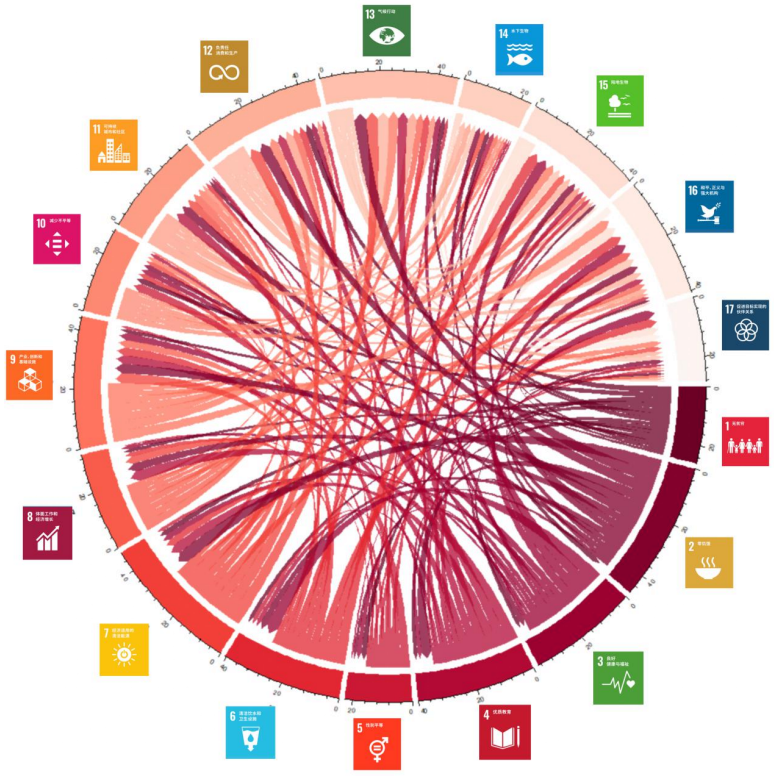


Figure 13: Association Network between 17 SDGs (Chordal Graph)

The results of the ANCP highlight a range of environmental SDG priorities for the Middle East. High-ranked goals include sustainable food production and land resources, water resources, coastal and marine resources, energy and climate, and sustainable consumption and production. These priorities broadly correlate with recent environmental assessments in the region. In particular, the water–energy–food nexus is well-covered and is considered critical for the region.

Take the conservation and sustainable use of the oceans and Marine resources for sustainable development as an example. The Middle East region has extensive coastal areas spanning the Mediterranean, Red Sea, Gulf, and Atlantic oceans, where most of the population lives in densely populated economic centers and relies on local fisheries and marine resources for their livelihoods. The current lack of a regional approach to the sustainable use and conservation of marine resources. Although much needed, it is complicated due to the number of marine ecosystems in the region.

8 Advice: For Sustainable Development

Based on our results above, we will make our advice from two aspects, SDGs and main factors.

First, we need to strengthen international cooperation in multiple areas. According to our research, SDG17 is the first matter to be dealt with. Among the SDGs, SDG17 is different from the other sixteen goals. It is a means to achieve the other goals. In fact, no goal can be accomplished by an individual or a single country alone. The fate of all mankind is tied to the earth, and all human beings need to help each other and work in solidarity to achieve sustainable development.

Second, regional wars are the factor that has the greatest impact on the achievement of SDG goals. Since ancient times, wars have caused irreparable harm to people and the environment such as human casualties and environmental damage. We should try to prevent wars and strive for a peaceful world in order to better develop sustainably.

Therefore, we need international cooperation in many fields to combat war and other factors.

Security is the primary consideration. Armed conflicts break out between regions because of their respective interests, and because the international society lacks one of the most powerful and violent institutions to maintain order, peace is difficult to be permanent. For this reason, it is necessary to unite local and external forces to resolve disputes. The government should first mobilize the military to clear the ceasefire zone as a way to ensure the safety of the citizen people. And it can communicate and cooperate with other countries or international organizations. Secondly, it should try to resolve the root of the conflict by expanding the ceasefire zone and negotiating a truce with the army battling. Finally, if a truce is not possible, try to guarantee the security of evacuated people.

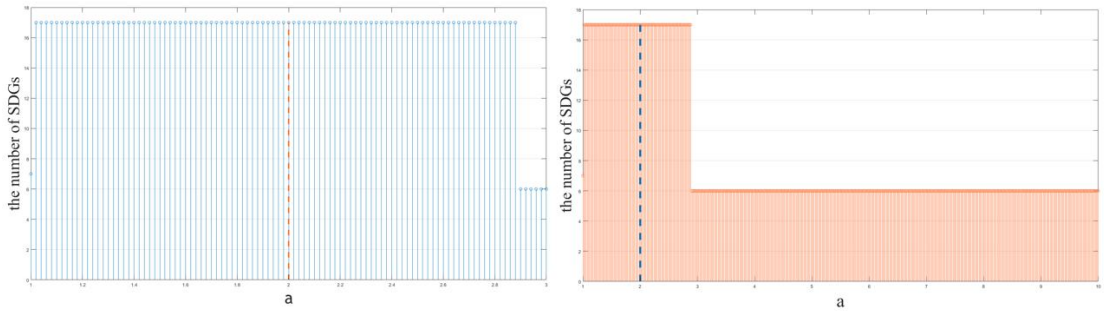
Technological enhancement will bring a leap in productivity. There should be more technology exchanges between governments to collaborate on technology development and technology transfer. Encourage companies to add a large number of research internships to

increase opportunities for talents to use their innovative abilities. Develop co-branded certificate programs with schools or social organizations to encourage practical implementation of theoretical knowledge.

We have only one planet, and environmental problems cannot be ignored. Environmental pollution and climate change deserve to be taken seriously. The government and local NGOs should develop periodic activities to ensure the implementation of the goals. We suggest that governments and social organizations establish nature schools to raise public awareness of environmental protection through education, with themed summer camps, students can have the chance to solve the environmental problem by themselves and form knowledge systems and get some research reports for local governments or organizations. Inter-regional nature schools can establish partnerships to break down information barriers and share knowledge and practice.

9 Sensitivity Analysis

When we calculate the *FJM*, we assume that each of the six factors in the matrix is the extent of importance of 2^n, the value of the most important factor is 32, the value of the least important is 1. Under this circumstance, the most important factor has a more significant value compared to other factors. In fact, it is not accurate because different decision makers have different priorities with respect to their preference. In particular, different people has diverse values of *FJM*, therefore it has an influence on the calculation. To completely verify the stability of the model, we change the extent of importance between six factors into a^n. The value of the most important factor is a^5, the value of the least important is 1. When a changes, we observe whether P_{value} changes and draw a following figure:



(I) (II)

Figure 14: Sensitivity analysis of weights of the indicators; (I)1<a<3;(II)1<a<10

In Figure 14, the P_{value} corresponding to the node $a = 2$ is SDG17, this has been finished in section 5. When $a = 2.9$, P_{value} changes into SDG6. Because survival needs to be placed the first when the crisis gets worse. Therefore clean water is the key to live. When $a = 1$ (All the factors have the same extent of influence), P_{value} changes into SDG7. Exploiting source of energy is the best choice against catastrophe when effects of factors are dramatically different.

10 Strengths and Weaknesses

10.1 Strengths

- Our model is versatile and able to adjust to different scenarios based on the real situation.
- We improved the analytic hierarchy process to analytic network correlation process so that it can be used for the multi-factor network computing.
- We build networks that can change over time, the model is also dynamic and suitable for calculation on different time scales.
- Our model can make a very good visualization, able to intuitively show the changes in the network

10.2 Weaknesses

- Some of the model parameters are based on approximation and not very accurate.
- To simplify the impact of policy implementation, we use a curve to fit it. Better results may be obtained by other curve fitting methods.

11 Conclusions

In our work, a model of the network structure has been given. Our method can comprehensively consider the influence of each 17SDGs and six major factors, we apply it to the calculation of network structure and consider the dynamic changes of network structure. The results show that the network structure will change greatly in special areas, so we can consider the special situation of regions when carrying out the 17SDGs.The model has wide applicability.

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Appendix

1.AHP

```
M=input('M=');
[~,n] = size(M);
[V,D] = eig(M);
Max_Eig = max(max(D));
CI = (Max_Eig - n) / (n-1);
RI=[0 0.0001 0.52 0.89 1.12 1.26 1.36 1.41 1.46 1.49 1.52 1.54 1.56 1.58 1.59
1.60 1.61 1.613 1.621 1.628];
CR=CI/RI(n);
disp('CI='); disp(CI);
disp('CR='); disp(CR);
    if CR<0.10
        S = 1;
    else
        disp('fause');
        S = 0;
    end
    if S == 1;
        [r,c] = find(D == Max_Eig,1);
        disp( V(:,c) ./ sum(V(:,c)) )
        sum_A = sum(M);
        B=ones(n,n);
    for i = 1:n
        B(:,i) = sum_A(i);
    end
        Stand_A = M ./ B ;
        disp(sum(Stand_A,2)./n)
        Geo_A = prod(M,2);
        Geo_n_A = Geo_A .^ (1/n);
        disp(Geo_n_A ./ sum(Geo_n_A))
    else S == 0;
        disp('fause')
    end
```

2. Calculate I value

```
WM;
Ivalue=[];
for i=1:16
for n=i:16
  I=0;
for j=1:6
```

```
    I=I+min(WM(i,j),WM(n,j));
    j=j+1;
end
      Ivalue(i,n)=I;
      n=n+1;
    end
    i=i+1;
  end
```

3. Draw picture

```
chordDiagram(
  x = mydata,
  grid.col = hcl.colors(16, palette = "Reds"),
  directional = 1,
  direction.type = c("arrows", "diffHeight"),
  diffHeight = -0.02,
  annotationTrack = c("name", "grid", "axis"),
  annotationTrackHeight = c(0.05, 0.08),
  link.arr.type = "big.arrow",
    link.sort = TRUE,
    link.largest.ontop = TRUE,
    transparency = 0.25
  )
  corrplot(
      corr = abs(M),
      order = 'AOE',method = 'pie',
      type = 'lower',
      tl.pos = 'd')
  corrplot(
      corr = abs(M),
      add = TRUE,
      type = 'upper',
      method = 'number',
      order = 'AOE',
      diag = FALSE,
      tl.pos = 'n',
      cl.pos = 'n')
  mydata=as.data.frame(mydata)
  mydata2=as.data.frame(mydata2)
  forceNetwork(Links = mydata, Nodes = mydata2, Source = "source",
               Target = "target", Value = "value", NodeID = "name",
               Nodesize = 'size', radiusCalculation = "d.nodesize",
               Group = "group", opacity = 1, legend = T, bounded = F)
```