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Discussion on Environmental Displaced Persons

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ABSTRACT. *Due to the rising sea level caused by climate change, many island countries are in danger of disappearing because of the low altitude. The disappearance of the island countries will cause many people to become environmental displaced persons (EDP). Be homeless, life-threatening, and their precious culture will also face the risk of loss due to the migration of the people. To better solve and analyze the problem of climate refugees, this paper discuss it in several aspects. Firstly, build a three-dimensional roof model to simulate the shape of the island and predict the high degree of sea-level rise and the number of population by the end of 2020 of these island countries facing the risk of climate refugees through the grey prediction model. According to the model, calculate the area of island countries to be covered by rising sea level, so the number of EDPs caused by rising sea level in the world will be about 84951 by the end of 2020. Secondly, to analyze the risk of cultural loss quantitatively, this paper set up a model of the loss of cultural index (LCI). Eight main factors closely related to culture are selected to measure; besides, this paper set up life quality indicators (LQI), and use analytic hierarchy process (AHP) to determine the weight of each factor in these two indicators. Also, this paper selected eight indicators closely related to the basic strength of the country from three aspects and obtained the receiving nations indicators (RNI) of refugee receiving countries by using the entropy weight method and variation coefficient method. Finally, after obtaining the weights of each indicator, this paper obtained the comprehensive evaluation indicators (CEI) by using the weighted average algorithm (WAA). Then take Tuvalu as an example to calculate CEI and test the model. This paper use a fuzzy cluster analysis to divide the refugee receiving countries into four categories: very suitable, suitable, general and not suitable for immigration. The results of fuzzy cluster analysis also verify the correctness and rationality of our above evaluation indexes: LCI, LQI, RNI. Fourthly, use the CNP scoring model to quantitatively analyze whether different refugee receiving countries focus on human rights protection or cultural protection. When the CNP score is lower than 2.95, the policy formulation of the refugee receiving country should pay more attention to the human rights protection of EDP, when the score is higher than 3.31, it should pay more attention to cultural protection, and when the score is between 2.95-3.31, it should pay equal attention to both aspects. Finally, devise a set of policies based on the analysis of the results from our model. This paper emphasize that it is up to international organizations*

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such as the United Nations to adjust the arrangement and guidance of EDPs to each country through CEI, CNP scoring model, and the will and tendency between the refugee country and the receiving country. In the end, do a sensitivity analysis of the Model and discuss strengths and weaknesses.

KEYWORDS: *EDPs, Culture Preservation, Grey Prediction, Analytic Hierarchy Process*

1. Introduction

Currently, impacts of climate change are intensifying. Extreme weather events such as tsunamis and hurricanes occur frequently. Additionally, pollutants like carbon dioxide and other green-house gases harm several island nations, such as The Maldives, Tuvalu, Kiribati, and The Marshall Islands through the process of global warming which lead to rising sea levels. Global mean sea level has risen about 8–9 inches (21–24 centimeters) since 1880(as the Figure 1 shows), with about a third of that coming in just the last two and a half decades. The rising water level is mostly due to a combination of meltwater from glaciers and ice sheets and thermal expansion of seawater as it warms. [1] In the short term, it will cause population casualties, property damage, environmental degradation, etc. In the long term, however, these nations are being at risk of completely disappearing due to decreasing land area, and by the time of that, environmentally displaced persons (EDPs) need to not only relocate, but also preserve their marvelous culture.

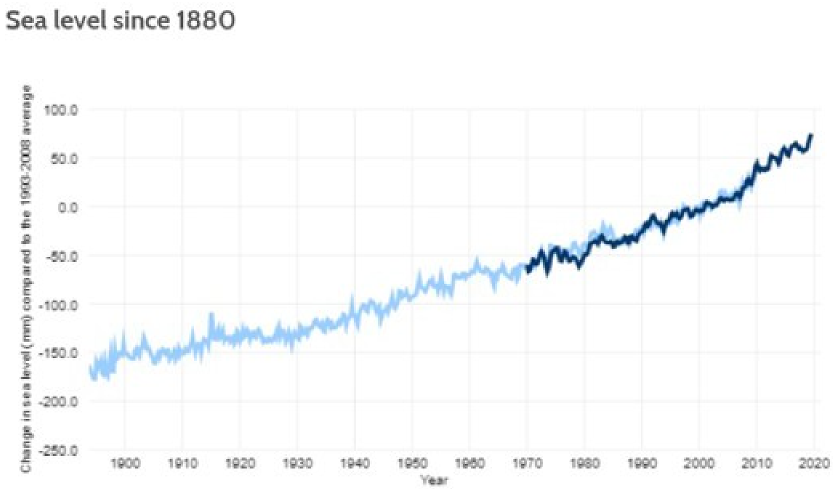

Figure 1. Sea Level since 1880 [2]

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Most of the island states lack the resources to carry out self-rescue. Letting them save themselves is the rise of anti-humanism that ignores the human rights of the citizens of the islands. We can't blame a few specific countries for resulting in global warming, to address which requires a shared human endeavour. Therefore, the intergovernmental organization like the United Nations (UN) have the obligation to address EDPs, by proposing policies in terms of protecting the rights of persons whose nations have vanished in the face of rising sea levels while also aiming to protect their culture heritage at risk of loss, which will be quite a challenge.

2. The Description of the Issue

How many EDPs will there be? With the rising sea level, how many islands will disappear? And how many people will lose their homes in the face of climate change? Only with a prediction of the scale of the issue, can the whole world be fully prepared.

Where can these EDPs go? The first problem these EDPs will face is their new residence. Not all nations are suitable to absorb them. We need to find out their potential new home.

Human rights and culture preservation, which one have the priority? Ideally, the receiving nations should guarantee the human rights of EDPs and preserve their culture so that cultural diversity would not be compromised. However, not all nations are capable of doing so. We need to find which nations can guarantee both and for those who can not, which one have the priority.

3. The Number Prediction Model of EDPs

3.1 Assumption

·Only The Marshall Islands in the Pacific, Kiribati, Tuvalu, Tonga, the Federated States of Micronesia, The Cook Islands, Antigua in the Caribbean, Nevis, and The Maldives will have EDPs.

The natural low-lying coastal systems of small island nations make them directly threatened by rising sea levels. Additionally, in the face of climate change (including climate variability and extreme weather), their governments are ill-equipped to regulate themselves, mitigate potential losses and cope with the aftermath. Hence, these regions are the most critical and vulnerable part of the world facing climate issues and we prioritize them. Such island states include The Marshall Islands in the Pacific, Kiribati, Tuvalu, Tonga, the Federated States of Micronesia, The Cook Islands, Antigua in the Caribbean, Nevis, and The Maldives in the Indian Ocean. [3]

·The island land is part of a sphere.

An explanation of this assumption is given in subsection 3.2.

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·There are no EDPs in the world before 2001.

The first nation having the EDPs due to the rising sea level was Tuvalu, [4] which declared its failure against climate changes in 2001.Hence, we only take the number of EDPs since 2001 into consider and assume there are no EDPs in the world before 2001.

3.2 Islands Terrain Model

Modeling terrains of islands needs to take many complex factors, which is random and non-linear, into account. Therefore, building an accurate terrain model is really tough. We can regard these terrains as the result of superimposing sine waves with different wave heights and different initial phases, and the formula is as follows.

$$\boldsymbol{\zeta(l)} = \sum_{\boldsymbol{i=1}}^{\infty} \boldsymbol{\xi_{ai}\cos(\omega_i + \varepsilon_i)}$$

·ξ_{ai}: Amplitude of the i-th cosine wave

·ω_i: Frequency of the i-th cosine wave

·ε_i: Phase of the i-th cosine wave

We simulated the model in MATLAB, and the result is shown as the Figure2.

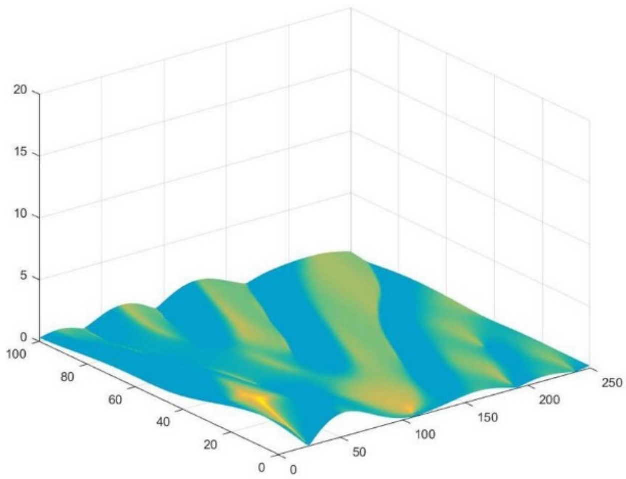

Figure 2. Terrain Situation of Islands

However, this model is not conducive to subsequent calculations, thus we simplify the model and regard the island land as part of a sphere, as shown in the Figure 3.

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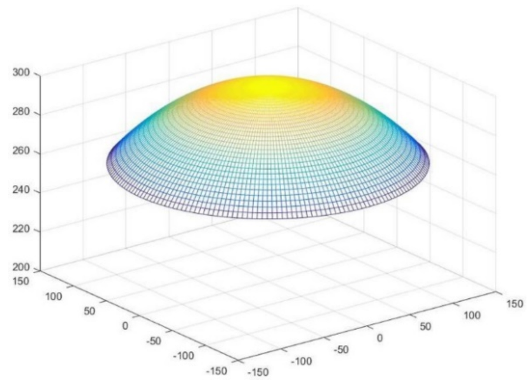
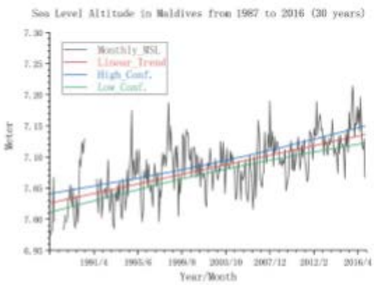


Figure 3. Simplified Terrain Situation of Islands

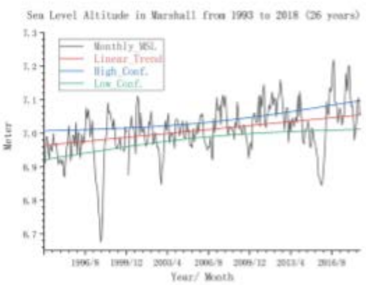
3.3 Sea Level Altitudes in Islands

We can find the data about sea level altitudes in Kiribati, The Maldives, The Marshall Islands and Tuvalu. [5] While the data is shown as follows.

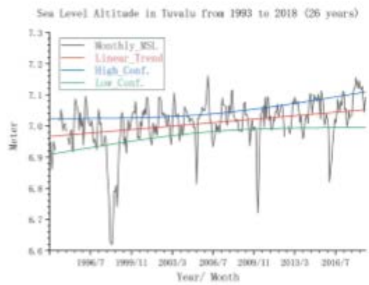
(a) Sea Level Altitude in Kiribati



(b) Sea Level Altitude in The Maldives



(c) Sea Level Altitude in The Marshall Islands



(d) Sea Level Altitude in Tuvalu

Figure 4. Sea Level Altitudes in Kiribati, the Maldives, the Marshall Islands and Tuvalu

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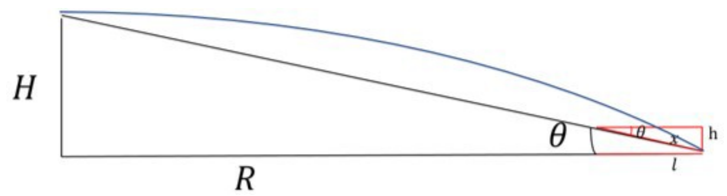
Using the above data and applying the GM (1.1), [6] we can estimate the mean sea levels (MSLs) in these islands, which is as the Table 1 shows:

Table 1 MSLs in the Maldives, Tuvalu, Kiribati, and the Marshall Islands in 2001 and 2020

Years	MSL/m			
	Maldives Island	Tuvalu Island	Kiribati Island	Marshall Island
2001	7.081	6.996	6.922	6.955
2020	7.1508	7.0588	6.9668	7.0621

3.4 Land Area Reduction in Islands

We regard the island land as part of a sphere, as can be seen from the above.



Since $R \gg H$ and $\theta \approx 0, cos\theta = 1$. Futhermore, we can find that the land areas of the Maldives, Tuvalu, Kiribati, and The Marshall Islands in 2001 were $S_1 = 298km^2, S_2 = 26km^2, S_3 = 430km^2, S_4 = 181.3km^2$ respectively. [7]

As can be known from the figure above, we can calculate the land radius are $R_1 = \sqrt{\frac{S_1}{\pi}} = 9741.89m, R_2 = \sqrt{\frac{S_2}{\pi}} = 2877.54m, R_3 = \sqrt{\frac{S_3}{\pi}} = 11702.25m, R_4 = \sqrt{\frac{S_4}{\pi}} = 598.61m$ respectively. [7]

We can also know from the figure,

$$\frac{\boldsymbol{H}}{\boldsymbol{R}} = \boldsymbol{tan\theta}$$

$$\Rightarrow \boldsymbol{\theta} = \boldsymbol{arctan}\frac{\boldsymbol{H}}{\boldsymbol{R}}$$

Because,

$$\frac{\boldsymbol{H}}{\boldsymbol{x}} = \boldsymbol{sin\theta}$$

$$\Rightarrow \boldsymbol{x} = \frac{\boldsymbol{H}}{\boldsymbol{sin\theta}}$$

Also because,

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$$\boldsymbol{cos\theta = \frac{x}{l} \approx 1}$$

$$\boldsymbol{\Rightarrow x = l}$$

In conclusion,

$$\boldsymbol{l = x = \frac{h}{sin(arctan\frac{H}{R})}}$$

So,

$$\Delta \boldsymbol{S = \pi[R^2 - (R - l)^2] = \pi[R^2 - \left(R - \frac{h}{\sin(arctan\frac{H}{R})}\right)^2}]$$

Using the formula above, we can calculate that, by the end of 2020, The Maldives, Tuvalu, Kiribati, and The Marshall Islands will have witnessed a reduction, which will be $\Delta S_1 = 33.66km^2, \Delta S_2 = 2.13km^2, \Delta S_3 = 10.94km^2, \Delta S_4 = 11.96km^2$ respectively, of their own land area.

3.5 The Number of EDPs in 2020

Through looking up some data, we know populations of The Maldives, Tuvalu, Kiribati and The Marshall Islands before 2018. [8] Then applying the GM (1.1), we can estimate the population of these four countries by the end of 2020, which is shown in the Table 2:

Table 2 Number of EDPs in the Maldives, Tuvalu, Kiribati and the Marshall Islands

Years	Population of Island ($\times 10^4$ person)			
	Maldives Island	Tuvalu Island	Kiribati Island	Marshall Island
2013	41. 56	1. 09	10. 79	5. 69
2014	43. 5	1. 10	10. 94	5. 72
2015	45. 49	1. 11	11. 09	5. 74
2016	47. 55	1. 12	11. 25	5. 77
2017	49. 64	1. 14	11. 42	5. 81
2018	51. 57	1. 15	11. 58	5. 84
2019	53. 93	1. 17	11. 75	5. 87
2020	56. 28	1. 19	11. 92	5. 90

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We can make

- $n_1 = 56.28 \times 10^4 person$
- $n_2 = 1.19 \times 10^4 person$
- $n_3 = 11.92 \times 10^4 person$
- $n_4 = 5.90 \times 10^4 person$

Hence, by 2020, the population density of these four countries will be

- $\rho_1 = \frac{n_1}{S_1 - \Delta S_1} \approx \frac{n_1}{S_1} = 1888.59 person/km^2$
- $\rho_2 \approx \frac{n_2}{S_2} = 457.69 person/km^2$
- $\rho_3 \approx \frac{n_3}{S_3} = 277.21 person/km^2$
- $\rho_4 \approx \frac{n_4}{S_4} = 325.427 person/km^2$

Therefore, by 2020, the number of EDPs of these four countries will be

- $p_1 = \rho_1 \cdot \Delta S_1 = 63570 person$
- $p_2 = \rho_2 \cdot \Delta S_2 = 975 person$
- $p_3 = \rho_3 \cdot \Delta S_3 = 3033 person$
- $p_4 = \rho_4 \cdot \Delta S_4 = 3892 person$

Similarly, we can calculate the number of EDPs of Tonga, The Federated States of Micronesia, The Cook Islands, Antigua in the Caribbean and Nevis by 2020 will be

- $p_5 = 13445 person$

In conclusion, by 2020, the total number of EDPs worldwide will be

- $p = 84915 person$

4. Indicators Affecting Policies Proposal

The indicators affecting policies proposal include some factors which is as the Figure 5 shows.

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Figure 5. Some Factors Included in the Indicators

4.1 Cultural Loss Indicators (CLI)

4.1.1 Indicators showing the Gap between Disappearing Islands and Receiving Nations

We select five indicators reflecting the gaps between these two kinds of nations, which imply the possibility of disappearing island nations to loss their unique culture. According to how large the gaps are, we mark the indicators from 0(the gaps are largest and the risk of cultural loss is greatest) to 10(the gaps are narrowest and the risk of cultural loss is minimal).

- The Gap in Religious Beliefs (C1)

The gap in religious beliefs are most likely to lead to cultural conflicts, such as the Crusades. If one of the countries is not a religious country, this indicator scores 10; if both countries are religious countries and their beliefs are different, this indicator scores 0.

- The Gap in Diet (C2)

Different geographies, climates and religions will all cause the gap in diet. We score this indicator from 0 to 10 based on the degree of the gap.

- The Gap in Languages (C3)

Language is an important part of culture, and it is inseparable from people's daily lives. If the EDPs don't say the mother tongues of the nations absorbing them, their own culture will be severely affected. If the countries share their mother tongue, this indicator scores 10; If neither country uses a common language, this indicator scores 0.

- The Gap in Social Customs (C4)

The EDPs need to adapt to local customs of the nations absorbing them. We score this indicator from 0 to 10 based on the degree of the gap.

- The housing typology of EDPs living in other states (C5)

If the nations absorbing the EDPs let them live together, their special culture will be less likely to be lost. We score this indicator from 0 to 10 based on how concentrated the EDPs live.

4.1.2 Indicators Affecting Mortality of Inheriting People

In terms of cultural protection and inheritance, as an indispensable part, the inheriting people plays a vital role. Hence, we should take their mortality rate during migration into consider. According to figure from high to low, we mark the indicators from 0(the risk of cultural loss is greatest) to 10(the risk of cultural loss is minimal).

- Migration Methods (C6)

Different migration methods lead to different mortality rates. With more unpredictable risks, water and air traffic is riskier than land traffic and therefore has the larger mortality rate of inheriting people. Besides, there are more options for land transportation. Hence, we score this indicator based on the ratio of land transportation distance to total migration distance.

- Distance between the nations disappearing in the face of climate change and the states absorbing EDPs (C7)

If the distance is shorter, the mortality rate of inheriting people will be lower. We score this indicator based on the difference between the longitude and latitude of these countries.

The formula about CLI is as follows.

$$CLI = \alpha 1C1 + \alpha 2C2 + \alpha 3C3 + \alpha 4C4 + \alpha 5C5 + \alpha 6C6 + \alpha 7C7$$

We will later assign weights α1, α2, α3, α4, α5, α6, α7 to these indicators in subsection 5.1.

4.2 Life Quality Indicators (LQI) of EDPs

The life quality of EDPs can be reflected in the following five indicators. According to people's satisfaction with them, we mark the indicators from 0(life is difficult) to 10 (life is beautiful).

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- Living Environment (A1)
- Job Opportunity (A2)
- Educational Resources (A3)
- Whether Their Cultures are Respected (A4)
- Security (A5)

The formula about LQI is as follows.

$$LQI = \beta 1A1 + \beta 2A2 + \beta 3A3 + \beta 4A4 + \beta 5A5$$

We will later assign weights β1, β2, β3, β4, β5 to these indicators in subsection 5.1.

4.3 Receiving Nations Indicators(RNI)

According to domestic situation in the receiving nations, we mark the indicators from 0 (stable country) to 10(turbulent country).

4.3.1 Political Indicators (RI)

• The Governance Capacity of the Government (B1)

This indicator directly represents the governance capacity of governments, including the quality of public managers and civil servants, which plays a vital role when facing social crisis.

• The Construction of the Law (B2)

This indicator measures the confidence and efficiency of a government in legislation and law enforcement, which have a lot to do with long-term stability of a country.

• The Possibility of Coups (B3)

Countries that have experienced violent overthrow are extremely unstable and may lack the political mechanisms to ensure a peaceful power transition.

4.3.2 Economic Indicators (EI)

• The Increase of Gross Domestic Product (GDP) (B4)

GDP is a monetary measure of the value of all final goods and services produced in a period (quarterly or yearly). GDP per capita is often used as an indicator to present living standards. The principle here is all citizens would benefit from their country’s increased economic production as it leads to an increase in consumption opportunities which in turn increases the standard of living.

• The Gap between Rich and Poor (B5)

This indicator is related to the probability of a conflict event within a country.

4.3.3 Safety Indicators (SI)

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• Social Conflict (B6)

This indicator represents the ability of a state to maintain peace and safeguard personal security within its borders. We refer to data on major political violence from 1946 to 2019, including a comprehensive record of all forms of major armed conflict in the world, to score this indicator.

• The Number of Domestic Refugees (B7)

This indicator represents whether a nation can quell revolutions and ethnic wars initiated by revolutionaries. We can find the data on United Nations High Commissioner for Refugees (UNHCR) website.

• Terrorist forces (B8)

This indicator represents whether a country is capable of claiming its sovereignty and maintaining a monopoly on the use of armed forces throughout the territory.

5. Weights of Indicators

5.1 Evaluate CLI and LQI with Analytic Hierarchy Process (AHP)

5.1.1 Introduction to AHP

Analytic Hierarchy Process (AHP) organizes the indicators that have an impact on decision- making into a hierarchical structure, and gives them a certain number of priorities, and uses mathematical methods to calculate the comprehensive score or goodness of each indicator and plan to guide decision-making. In the quantitative evaluation of each indicator, experts and decision-makers should make a reasonable evaluation based on their own experience and understanding of the project. However, due to the different starting points and professional levels of the evaluators, there are often differences in the evaluation of the evaluation scale, and as a result, the consistency check is not satisfied. [9]

When applying the AHP to analyze decision-making problems, the problem must first be organized and layered to construct a hierarchical structural model. Under this model, complex problems are decomposed into component parts, and these elements will be divided into several levels, and the elements of the previous level will be used as rules to control the relevant elements of the next level. [10]

5.1.2 Calculation Process

In this subsubsection, we use the AHP to compare each evaluation indicator of CLI according to its degree of influence in the decision of cultural loss risk and its role in the evaluation system. Then we make a judgment matrix. The comparison standard uses the 1-9 scale method which is as the Table 3 shows.

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Table 3 1-9 Scale Method

Grade	Relative Importance
1	Equally Important
3	Generally more Important
5	Far more Important
7	More Important at the Second Highest Degree
9	More Important at the Highest
2,4,6,8 represents the impotance	Level is in between according to the above
The reciprocal value(1/2, 1/7…)	Express 'Less important'

We then normalize the judgment matrix to find the geometric mean and weight coefficient of each row:

Step 1: Calculate the product m_i of the elements of each row of the judgment matrix.

$$m_i = \prod_{j=1}^{n} c_{ij} (i, j = 1, 2, ..., n)$$

Step 2: Calculate the geometric mean of m_i

$$\overline{w_i} = \sqrt[n]{m_i}$$

Step 3: Normalize the vector $\bar{w} = [\overline{w_1}, \overline{w_2}, \ldots, \overline{w_n}]^T$ to find the weight coefficient w_i

$$w_i = \frac{\overline{w_i}}{\sum_{i=1}^{n} \overline{w_i}}$$

$\bar{w} = [\overline{w_1}, \overline{w_2}, \ldots, \overline{w_n}]^T$ is the eigenvector we seek. And the result is shown as follows.

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	C_1	C_2	C_3	C_4	C_5	C_6	C_7	Weights
C_1	1	6	1	4	1/3	4	5	0.2094
C_2	1/6	1	1/5	1/3	1/6	2	2	0.0518
C_3	1	5	1	4	1/4	3	4	0.1869
C_4	1/4	3	1/4	1	1/4	3	3	0.0927
C_5	3	6	4	4	1	4	5	0.3708
C_6	1/4	1/2	1/3	1/3	1/4	1	2	0.0513
C_7	1/5	1/2	1/4	1/3	1/5	1/2	1	0.0371

So, $\boldsymbol{\alpha_1 = 0.2094, \alpha_2 = 0.0518, \alpha_3 = 0.1869, \alpha_4 = 0.0927, \alpha_5 = 0.3708, \alpha_6 = 0.0513, \alpha_7 = 0.0371}$.

After the judgment matrix is established, it must be checked for consistency to check whether the judgment matrix has satisfactory consistency. [11] The process is as follows:

Step 1: Calculate the maximum eigenvalue λ_{max} of the judgment matrix

$$\boldsymbol{\lambda_{max} = \sum \frac{(CW)_i}{nw_i}}$$

·CW = C × w, while C is the judgment matrix.

Hence,

$$\boldsymbol{CW = C \times w =} \begin{bmatrix} 1 & 6 & 1 & 4 & 1/3 & 4 & 5 \\ 1/6 & 1 & 1/5 & 1/3 & 1/6 & 2 & 2 \\ 1 & 5 & 1 & 4 & 1/4 & 3 & 4 \\ 1/4 & 3 & 1/4 & 1 & 1/4 & 3 & 3 \\ 3 & 6 & 4 & 4 & 1 & 4 & 5 \\ 1/4 & 1/2 & 1/3 & 1/3 & 1/4 & 1 & 2 \\ 1/5 & 1/2 & 1/4 & 1/3 & 1/5 & 1/2 & 1 \end{bmatrix} \times \begin{bmatrix} 0.2094 \\ 0.0518 \\ 0.1869 \\ 0.0927 \\ 0.3708 \\ 0.0512 \\ 0.0371 \end{bmatrix} = \begin{bmatrix} 1.5918 \\ 0.3934 \\ 1.4208 \\ 0.7048 \\ 2.8185 \\ 0.3896 \\ 0.2823 \end{bmatrix}$$

So,

$$\boldsymbol{\lambda_{max} = \sum \frac{(CW)_i}{nw_i} = \frac{1.5918}{7 \times 0.2094} + \frac{0.39338}{7 \times 0.0518} + \frac{1.4208}{7 \times 0.1869} + \frac{0.7048}{7 \times 0.0927} + \frac{2.8185}{7 \times 0.3708}}$$

$$\boldsymbol{+ \frac{0.3896}{7 \times 0.0512} + \frac{0.2823}{7 \times 0.0371} = 7.6027}$$

Step2: Calculate consistency index CI.

$$\boldsymbol{CI = \frac{\lambda_{max} - n}{n - 1} = 0.1004}$$

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Step3: Calculate consistency ratio CR.

$$CR = \frac{CI}{RI}$$

• When CR < 0.1, the judgment matrix is considered to have satisfactory consistency. Otherwise, the values of the elements in the judgment matrix need to be readjusted until the judgment matrix has satisfactory consistency.

• RI is the average random consistency index, whose value can be obtained from Table 4.

Table 4 Average Random Consistency Index Value

n	1	2	3	4	5	6	7	8	9
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

The Table 4 shows that when n = 7, RI = 1.32. Hence,

$$CR = \frac{CI}{RI} = \frac{0.1004}{1.32} = 0.076 < 0.10$$

The consistency check passes, so the judgment matrix is considered to have satisfactory consistency.

Similarly, we can obtain the LQI judgment matrix and weights through this method, which is shown as follows.

	A_1	A_1	A_1	A_1	A_1	Weights
A_1	1	1/3	1/2	1/5	1/2	0.0693
A_1	3	1	3	1/4	1/3	0.1485
A_1	2	1/3	1	1/4	1/4	0.0827
A_1	5	4	4	1	3	0.4562
A_1	2	3	4	1/3	1	0.2433

So, $\beta_1 = 0.0693, \beta_2 = 0.1485, \beta_3 = 0.0827, \beta_4 = 0.4562, \beta_5 = 0.2433$. And we can calculate CI = 0.096, CR = 0.086 < 0.10, which means the LQI judgment matrix passes the consistency check.

5.2 Evaluate RNI with Entropy Weight Method and Coefficient of Variation Method

5.2.1 Entropy Weight Method

In this section we adopt the Entropy Weight Method as the means of delivering each factor’s weight. The basic idea of the Entropy Weight Method is that entropy is

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a measure of the degree of disorder of the system. In other words, the size of the indicator variability determines the objective weight. [12]

We need to determine the weight of each evaluation indicator of RNI and get a combination of it. First, we standardize each variable, making the optimal and worst value be 1 and 0. The evaluation indicators are $B_1, B_2, \dots, B_n$, where $n = 8, B = \{B_{i1}, B_{i2}, \dots, B_{in}\}$. n is the number of sovereign countries.

For the cost-type indicators, the situation of a country is proportional to the value of the indicator. However, in terms of the gain-type indicators, the higher the value is, the worse the country will be. Thus, we have

$$f(x) = \begin{cases} y_{ij} = \dfrac{B_{ij} - min(B_i)}{max(B_i) - min(B_i)} \\ y_{ij} = \dfrac{max(B_i) - B_{ij}}{max(B_i) - min(B_i)} \end{cases}, j = 1, 2, ..., n$$

Where y_{ij} is the standardized value of each evaluation indicator of each country, $max(B_i)$ and $min(B_i)$ are the maximum and minimum value of the evaluation indicator B_i.

$$max(B_i) = max\{B_{i1}, B_{i2}, ..., B_{in}\}, min(B_i) = min\{B_{i1}, B_{i2}, ..., B_{in}\}$$

After standardization, we succeed in substituting y_{ij} for B_{ij} to implicate the situation of a country. Then we introduce,

$$P_{ij} = \frac{y_{ij}}{\sum_{j=1}^{n} y_{ij}}$$

According to the concepts of self-information and entropy in the information theory, we can calculate the information entropy E_i of each evaluation indicator,

$$E_i = -ln(n)^{-1} \sum_{j=1}^{n} P_{ij} ln P_{ij}$$

On the basis of the information entropy, we will further compute the weight of each evaluation indicator we defined before.

$$\omega_i = \frac{1 - E_i}{k - \sum_i E_i}, i = 1, 2, ..., k$$

Then, we can get

$$\begin{cases} PI_j = \omega_1 y_{1j} + \omega_2 y_{2j} + \omega_3 y_{3j} \\ EI_j = \omega_4 y_{4j} + \omega_5 y_{5j} \\ SI_j = \omega_6 y_{6j} + \omega_7 y_{7j} + \omega_8 y_{8j} \end{cases}$$

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5.2.2 Coefficient of Variation Method

Furthermore, we apply coefficient of variation method to weight these three indices and merge them into a Comprehensive Evaluation Indicator (CEI). Coefficient of variation method utilizes the information from various indexes and achieve the weight of each index through calculating, which shows to be an objective approach to giveweight. Owing to the influence of different dimension, it is hard to compare the index directly, so it needs the coefficient of variation of each index to measure the difference extent of them. [13] The formula of each index can be expressed as

$$\gamma_i = \frac{\chi_i}{\overline{\varphi_i}}, i = 1, 2, 3$$

Where γ_i is the coefficient of variation of the index i, which can also be called as standard deviation coefficient, and $\gamma_i$means the standard deviation of the index i. And the ϕ_1, ϕ_2, ϕ_3 separately means PI, EI, SI. Then the weight of each indicator comes to us.

$$\gamma_i = \frac{M_i}{\sum_{i=1}^{n} M_i}, i = 1, 2, 3$$

Through this way, we are able to achieve the weight of each indicator without any subjective impression. Finally, after getting the weight, we can derive the RNI.

$$RNI = \gamma_1 \times PI + \gamma_2 \times EI + \gamma_3 \times SI$$

Because it is a traditional method, we ignore its calculation process and get the weights.

RNI			
Indicators	Weight	Indicators	Weight
PI	0.356	B_1	0.411
		B_2	0.259
		B_3	0.331
EI	0.241	B_4	0.643
		B_5	0.357
SI	0.403	B_6	0.429
		B_7	0.387
		B_8	0.184

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5.3 Fuzzy Cluster Analysis

First we introduce comprehensive evaluation indicators (CEI). Take Tuvalu as an example, we carry out fuzzy cluster analysis [14] to determine whether other countries are suitable as its immigrants. Assuming n is the number of sovereign nations in the world, to simplify the issue, we only select 10 countries which are England, Australia, Germany, Russia, Lran, Japan, Sudan, Brazil, India and Canada, nations with different geographical locations, economic degrees and climatic characteristics, for our analysis. Using the weights of CLI, LQI and RNI mentioned above and the Weighted Average Algorithm (WAA), [15] we can deduce that:

$$CEI = W_1 \times CLI + W_2 \times LQI + W_3 \times RNI$$

Where $W_1, W_2,$ and W_3 are the weights of CLI, LQI, and RNI, respectively. And using the AHP through the data of the expert system can get their values: 0.218, 0.351, 0.431 Since the specific values of CLI, LQI, and RNI have been obtained, we can calculate the CEI values of all countries, and use fuzzy cluster analysis to divide these countries into four categories: very suitable, suitable, general, not suitable, and these four types of nations correspond to different ratings. The higher the CEI value is, the more suitable it is to move in. The clustering results are as follows.

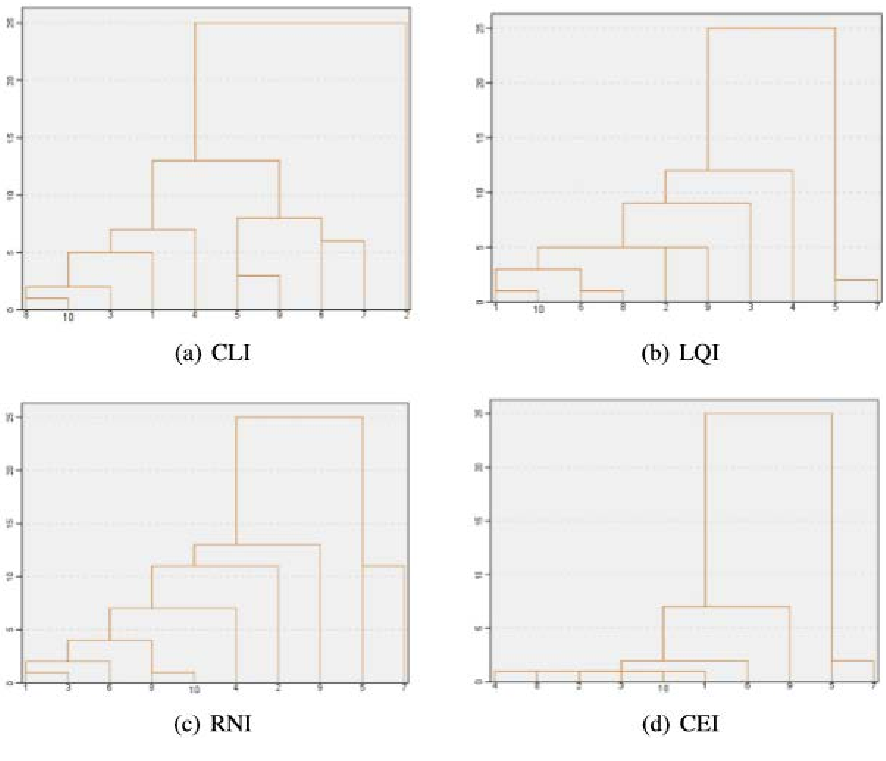

Figure 6. Clustering Results of Four Indicators

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• The sequence number along the abscissa axis represents the country:1 England;2 Australia;3 Germany;4 Russia;5 Lran;6 Japan;7 Sudan;8 Brazil;9 India;10 Canada

We can see that CLI, LQI and RNI are slightly different from the CEI in classification criteria. Since their focus is on various developments in a country, the final comprehensive evaluation level will also be different.

• From the Figure (a), we can see that the clustering result separates Australia, and our analysis result show that, for EDPs from Tuvalu, moving to Australia is more conducive to protecting culture.

• From the Figure (b), we can see that Iran is divided into one category, and our analysis results show that, for EDPs from Tuvalu, Iran may be lacking in social security.

• From the Figure (c), we can see that Iran, Sudan and India are divided into one category, and our analysis results show that, for EDPs from Tuvalu, the management of these three countries is unsatisfactory.

• From the Figure (d), we can see that Iran and India are divided into one category, and our analysis results show that, for EDPs from Tuvalu, these two countries are not suitable for moving in.

The graphic results obtained by fuzzy cluster analysis are consistent with the actual situation, which can prove that CLI, LQI, RNI, and CEI we established are correct and satisfactory.

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