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Summary Sheet

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Save the Environmentally Displaced Persons

Due to the natural hazards caused by climate change, a large scale of people has become environmentally displaced persons (EDP). Among all of these natural disasters, sea levels rise has caused the most serious problem. Some of the small island nations or coastal nations will be totally submerged, resulting in their citizens to be displaced and become "climate refugees".

In order to solve this problem, we carried out the following four aspects of analysis. First, we analyzed the major causes of climate change and assessed the potential size of the EDPs. Then, we identify the role of individual countries in the climate change process and suggest the worst offenders have a higher obligation to address these issues. Moreover, we offer a list of policy recommendations for refugee migration. And to ensure that the proposed policy can well protect the human right of refugee as well as their culture, we develop an Analytic hierarchy process (AHP)based model to estimate the proper host country of each vanishing nations.

Firstly, to analyze the scale of EDP problem, we start with discussing the population involved and the main driver of climate change. The sea level rise is proved to be the essential contributor of EDPs. The least square method and logistic function is used to fit the projective demographic curve of each country. With the open database provided by Word Bank and IDMC, we separately calculate the prospective number of populations inundated by the rising sea level and the sudden natural disasters based on the demographic prediction. Four nations and two territories are proved to be dangerous with totally submerged. The risk of losing these cultures is estimated by another model.

Secondly, we formulate a series of policies to guide the displaced persons to resettle in a new country based on the result from our models. These suggestions are developed in consideration of the liability obliged to be taken by large countries, dignity and rights of refugees, and the protection of distinctive culture. As for the UN, pressure should be put on the countries with more affection on global warming, and financial assistance will be grateful to deal with the refugee's welfare. Also, the bilateral agreement between refugee country and host country is encouraged.

Thirdly, for our policies, we use the AHP method to establish a comprehensive evaluation model for policy evaluation, and calculate the integration index between refugee and host countries to predict the possible impact of migration. The evaluation model integrates considerations of various factors such as the responsibilities and needs of the host country, the conditions of the refugee country, and the difficulty of immigration. Then, a rationality matrix between the refugee country and the host country is obtained.

Fourthly, we optimize the proposed policy based on the analysis. From conclusions obtained from the above mathematical method modeling. a suitable sustainable use policy is obtained, and the policy is continuously improved through the models we have established, including the specific locations of refugee migration, refugee protection programs and new national refugees should have rights and medical policies.

Finally, we analyzed the advantages and disadvantages of the model we built and areas for improvement.

Keywords: Climate Change; EDP; Sea Level Rise; Policy Evaluation; Cultural Protection;

CONTENTS

1 Introduction

1.1 Background

Due to the natural hazards caused by climate change, a large scale of people has become environmentally displaced persons (EDP). Among all of these natural disasters, sea levels rise has caused the most serious problem. Some of the small island nations or coastal nations will be totally submerged, resulting in their citizens to be displaced and become "climate refugees".

Since at least the start of the 20th century, the average global sea level has been rising. The sea level rise is closely linked to the climate change--increasing global temperature and melting glacier. Due to the rising sea levels, some island nations are losing their ground and even at risk of completely disappearing and the residents we called environmentally displaced persons (EDPs) is also at risk. Furthermore, their cultures, like languages, arts or building would disappear without the nations and citizens.

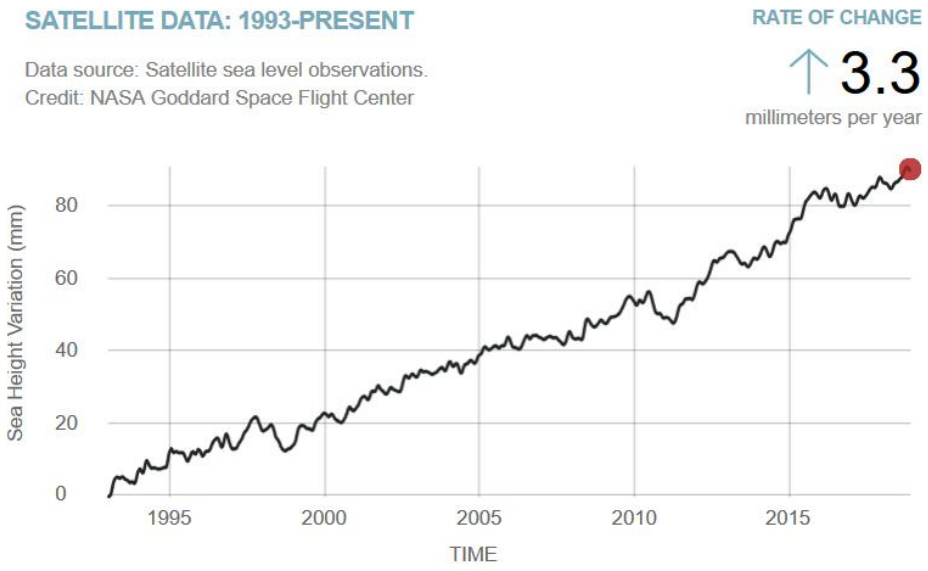

Figure 1 Sea level observations between 1993 and November 2018[1]

Many countries contributing great influence on climate change should take more responsibility of climate refugees. However, the EDPs is not identified as refugees by the UN, so they are faced forced migration which would cause a series of problems--their security, where should they relocate and how to preserve their cultures.

1.2 Our Work

Firstly, to analyze the scale of EDP problem, we start with discussing the population involved and the main driver of climate change. The sea level rise is proved to be the essential contributor of EDPs.

Secondly, we build a model to estimate the risk of losing cultural heritage of vanishing nations. In this part, we focus on the tangible cultural heritage like language, custom and social structures.

Thirdly, we formulated a series of policies to guide the displaced persons to resettle in a new country based on the result from our models.

Fourthly, for our policies, we used the AHP method to establish a comprehensive evaluation model for policy evaluation, and calculate the integration index between refugee and host countries to predict the possible impact of migration.

Finally, we analyzed the advantages and disadvantages of the model we built and areas for improvement.

2 Fundamental Assumption

1. **There is no any devastating disaster, such as meteorite hitting the earth**. That is to say the nations in risk would not disappear suddenly.
2. **All sea levels around the globe is the same as the average sea level**. In reality, the sea level is not the same all across the ocean, but here we assume the ocean is flat.
3. **No concerted action will be taken to control the climate change**. That is to say we talk the EDPs issue in current world environment. In this way, we can analyze what terrible things would happen if we take no action.
4. **The population growth curve can be described by logistic population growth model**.
5. **There is no world war or large-scale war**. The war can make host countries not suitable for living, same for other catastrophic events

3 The Scope of EDPs Issue

To understand the scope of Environmental Displacement Persons issue, we separately develop two sub-sections to explain the displaced population and the risk of loss of cultural heritage.

3.1 Population in Risk of Displacement

3.1.1 Threat of Climate Change

Before assessing the scope of EDPs population, we firstly explicit the driver of environmental displacement, in other words, the climate change events. There are two distinctive drivers: sudden climate events such as flooding, storms and earthquake, and slow climate process such as sea-level rise, desertification and drought. These disasters can destroy the environment on which dwellers are dependent, resulting in displacement of the residents.

It is quite difficult to take all these disasters into consideration, since they are multifaceted of global warming, human activities, adaptation policies and so on. However, an

international organization IDMC (Internal Displacement Monitoring Centre) has developed their convinced assessment of displaced migrants. In their assessment, natural hazards consist of cyclones, earthquakes, floods, tsunamis and volcano, which are paroxysmal disasters. Taking advantage of this risk model [2], we can focus on the questions out of range, that is the gradual climate process.

Since most of the natural disaster are considered by IDMC, we mainly estimate the EDPs caused by sea level rise, which is an essential component of gradual climate process.

3.1.2 Projection of EDPs Caused by Sea Level Rise

A generally recognized report [3] of Intergovernmental Panel on Climate Change (IPCC) has published the global mean sea level rise projection shown on figure 2. Based on our fundamental assumption that global sea level is same and environmental protecting actions will not be taken, we can use the scenario RCP 8.5 where emissions continue to rise rapidly. In this case, sea levels are projected to rise about 74cm in 2100.

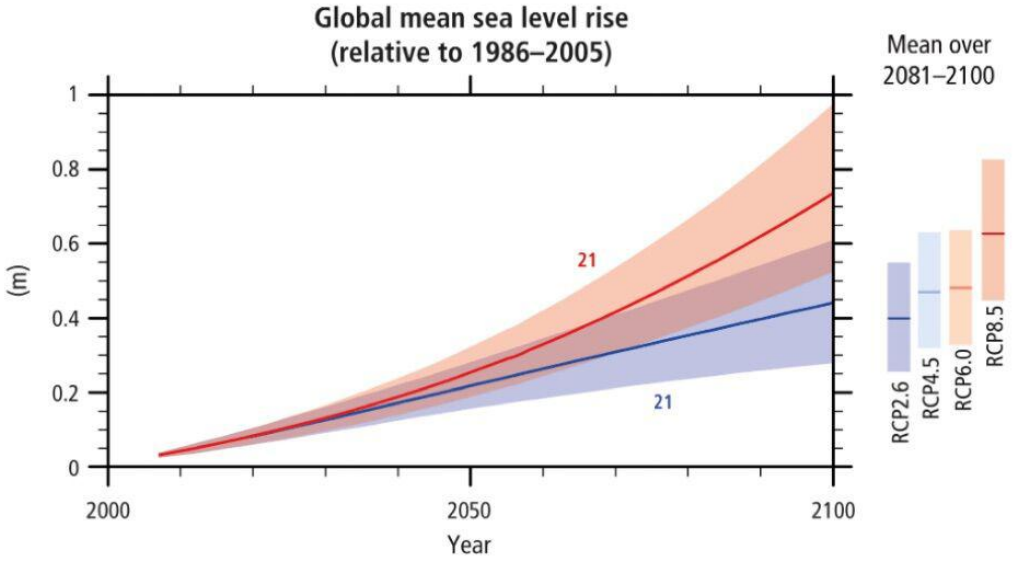

figure 2 Global Mean Sea Level Rise Predicted By IPCC

Since the districts with lower altitude also face other hazards such as storms and flood tide, we roughly assume that all the population living in areas where elevation is below 5 meters will become forced displacement by 2100.

Taking time factor into account, we calculate $P_{t,c}$ as the total population of country c in the year t. The gradual process of sea level rising is explained by parameter s_t which indicates the proportion of persons affected by the rising sea level. In this way, $I_{t,c}$ can be calculated by the following equation:

$$I_{t,c} = u_{2010,c} \times P_{t,c} \times s_t \tag{1}$$

where $u_{2010,c}$ is the percentage of population living in areas of elevation below 5 meters of the total population in country c in year 2010.

It is difficult to project the total population in the future year of a certain country as the result of variety in birth rate and death rate. Nevertheless, we can fit the population data using

a logistic curve to project the number of people in certain country. Logistic growth model is often used in projection of population, which can be described as:

$$P(T) = \frac{K \cdot P_0 \cdot e^{rT}}{K + P_0 \cdot (e^{rT} - 1)} \tag{2}$$

where K is environmental capacity, P_0 is the initial population when T equals 0, and r means the rate of rise. T is the period between t and t_0.

Using the database provided by The World Bank Group [4], we can fit the demographic curve for the past 50 years. Least square method is used to fit the curve. Two Python open source libraries are indispensable to complete the algorithm: Scipy for optimizing the fitting curve, and Matplotlib for plotting. Several representative countries' projected population is shown in the figure 3.

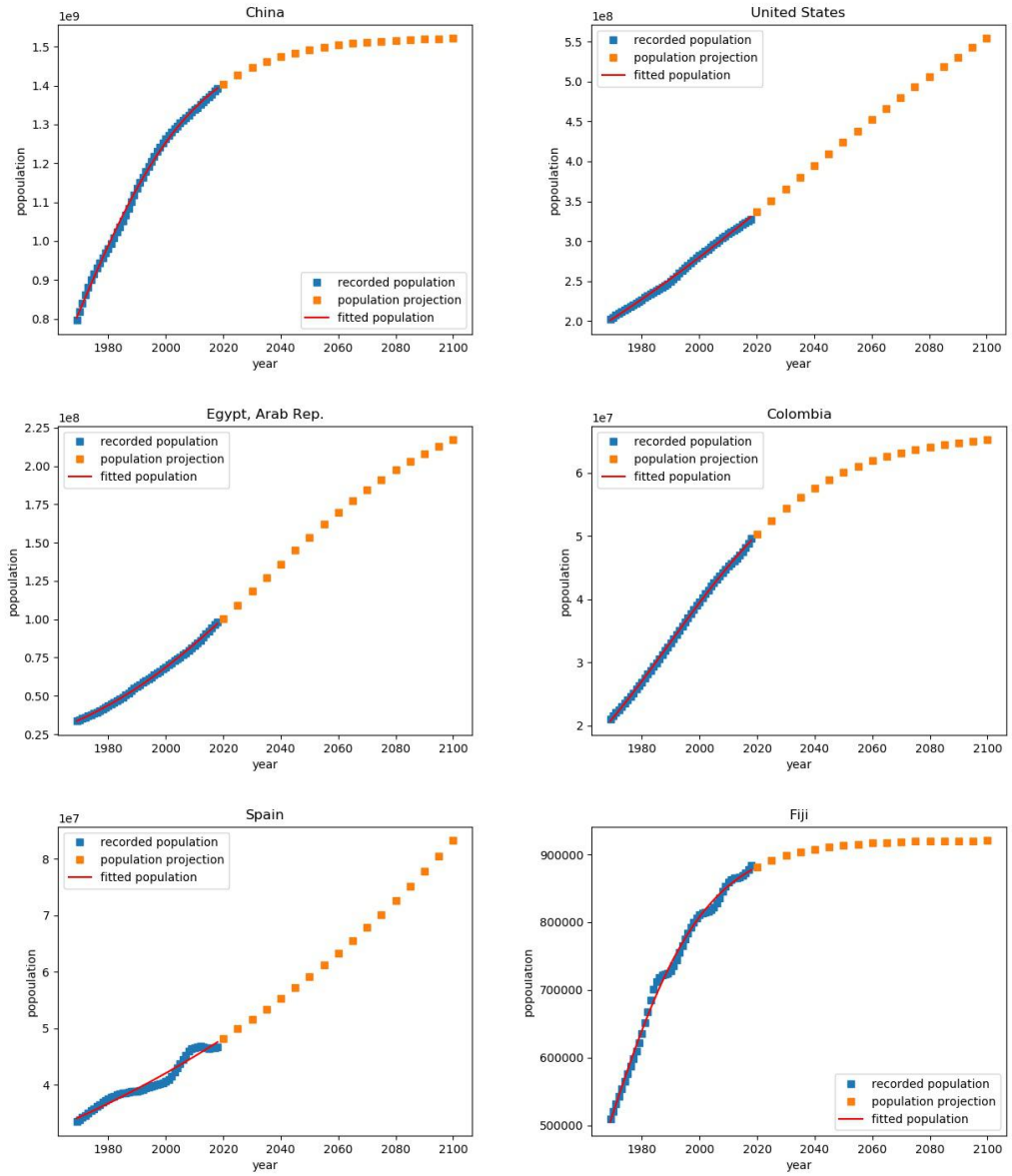

figure 3 projected population of representative countries

Therefore, we got the variable $P_{t,c}$. The World Bank Open Data also provides the percent of people living in elevation below 5 meters for each country, which is $u_{2010,c}$ in the proposed equation. At last, we calculate s_t by multiplying the extent of sea level rise r_t and the proportion n of people living by seaside. Equation (3) explained st.

$$s_t = r_t \times n \tag{3}$$

To simplify the issue, we assume that sea level grows linearly and 70% of people living the low altitude will be affected by the ocean. Considering artificial protection, the affected proportion should be halved. Then the parameter s_t can be expressed by equation (4).

$$s_t = \frac{t}{2100-2010} \times 70\% \times \frac{1}{2} \tag{4}$$

We sum up the inundation number for each country having inhabitants in low elevation to get global projected inundation number G_t. G_t can be calculated by the expression (5).

$$G_t = \sum_{c \in A} I_{t,c} \tag{5}$$

The country set A means all the countries in the world. By calculating G_t, we found that there will be more than 262 hundred million people displaced by sea level rise. In account of several assumptions we have made, it is probably a relatively conservative number, since sea level is always higher in tropical region than the mean level. The projection curve is show in figure 4.

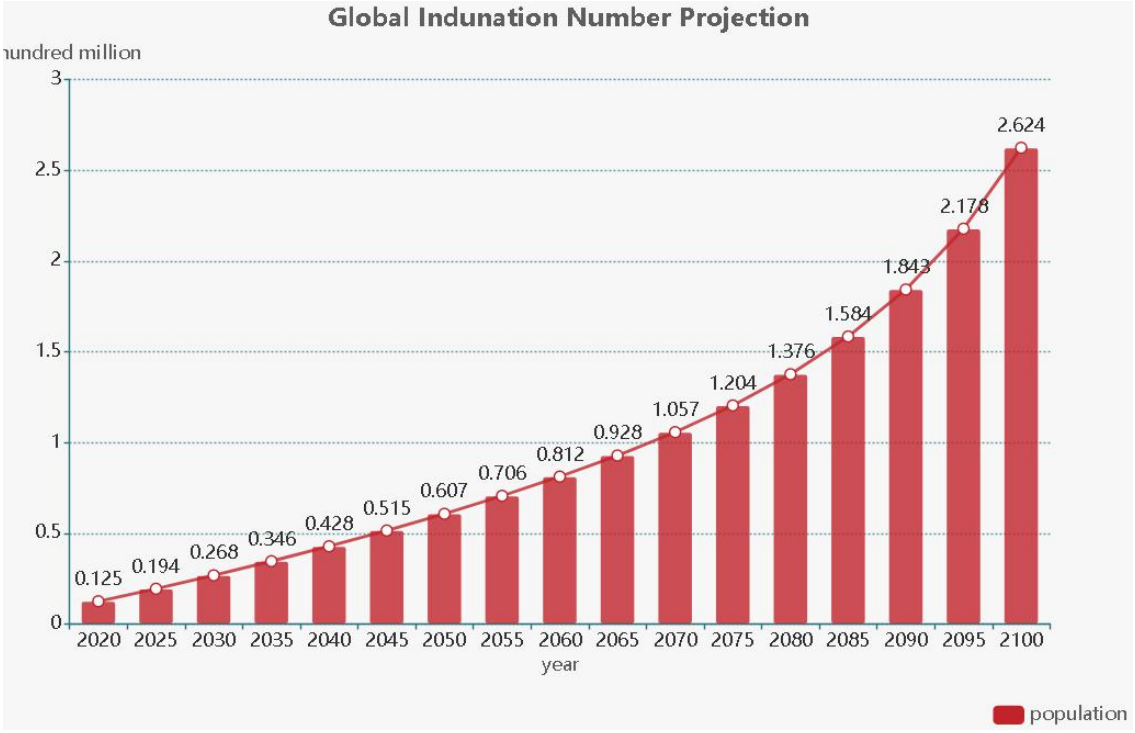

figure 4 Global Projected Inundation

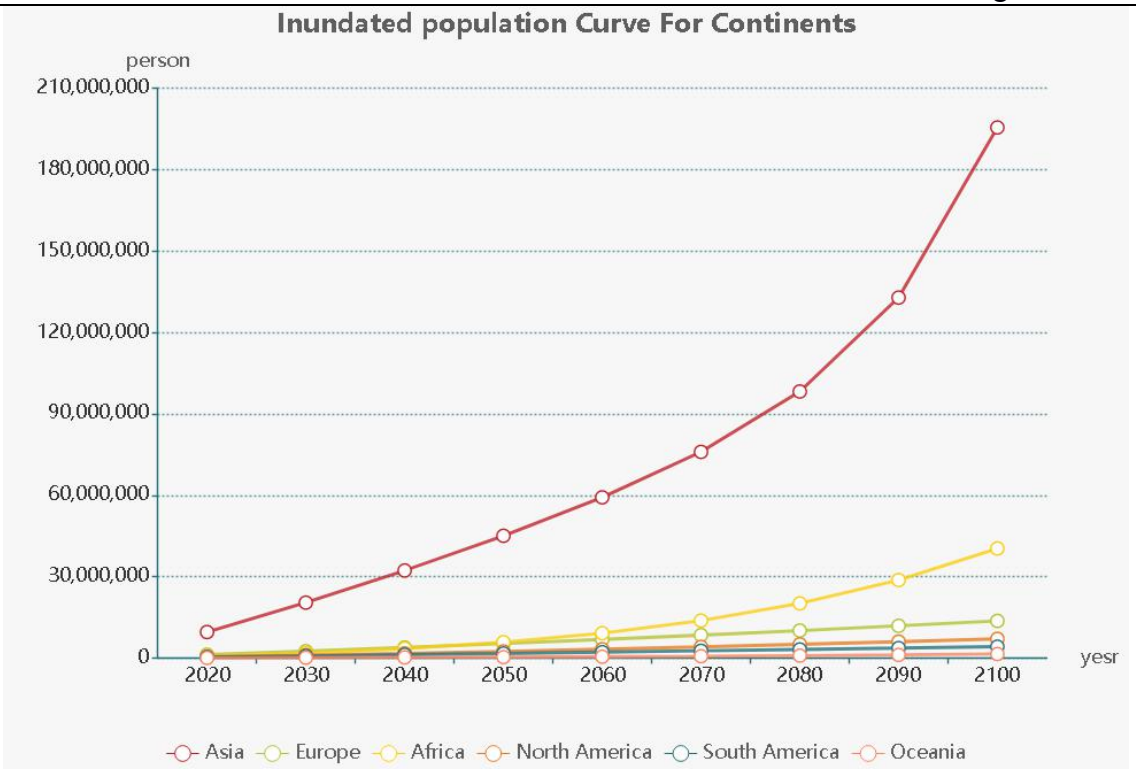

Figure 5 Inundated Population Curve for Continents

Figure 5 demonstrates the variant curve for each continent, which indicates that Asia suffers most from the rising sea level and will continue to take the greatest loss. Europe may have several years not to worry about sea level rise, but it will be quickly exposed to the danger of inundation.

3.1.3 Estimation of Displaced Population

The last sub-section projected the number of displaced persons by sea level rise, now we can project the total EDP number by combining this projection with EDP number caused by other environmental disasters.

In the global displacement risk model [3] mentioned above, cyclones, earthquakes, floods, tsunamis and volcano are taken into consideration by IDMC. We can easily access the prospective average annual displacement (AAD) using this model. The relative AAD is the number of people per 100,000 inhabitants expected to be displaced each year. IDMC noted that AAD should not be considered as an explicit value, but an indicator of the potential magnitude of displacement. Prospective AAD are used to roughly project the future displacement persons by sudden on-set natural hazard.

As we have projected the total population of each continent in the last sub-section, the remained displacement $R_{t,C}$ of continent C can be calculated by equation (6):

$$\mathrm{R}_{t,C} = AAD_C \times P_{t,C} \tag{6}$$

where $\mathrm{P}_{t,C} = \sum_{c \in C} P_{t,c}$ and C is the country set of one continent. The height of rose chart in figure 6 shows the AAD of each continent and the arc degree shows the proportion of prospective displacement. Figure 6.a is the result of year 2020, and figure6.b is the result of year 2100.

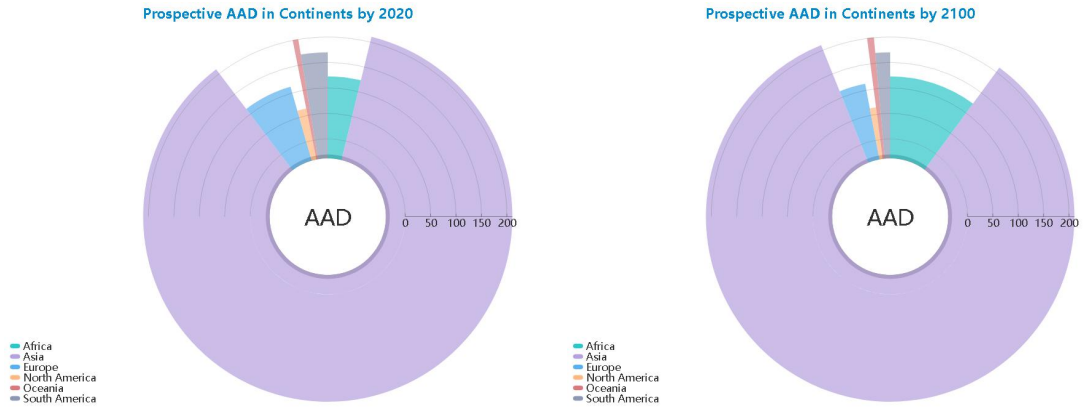

Figure 6.a Prospective AAD in Continents by 2020 Figure 6.b Prospective AAD in Continents by 2100

We can observe the displacement in Asia is prominent in the world, and the number in Africa increase quickly, replacing the former runner up continent Europe in 2100.

Combing displacement caused by natural disaster and sea level, we can finally estimate the number of EDPs in the world. Figure 7 shows the projection number and each year's components. We can conclude that sea level rise is the main reason for EDP and it grows rapidly resulting in much larger scale of problem.

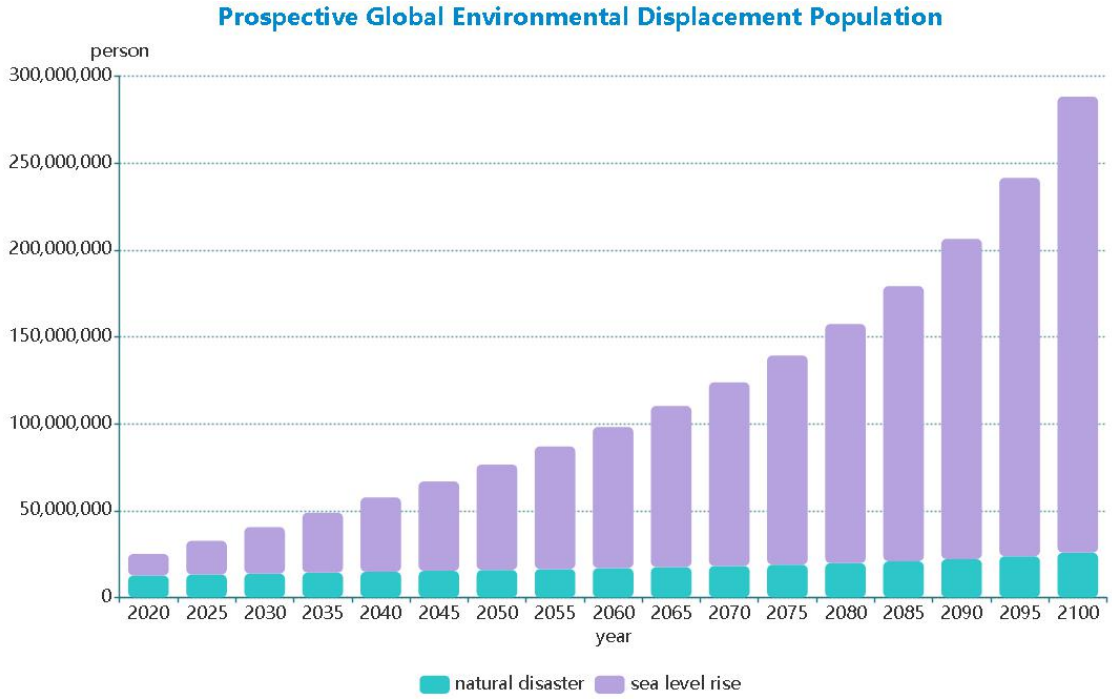

Figure 7 Prospective Global Environmental Displacement Population

3.2 Risk of Loss of Culture

When climate change causes migration, what would happen to the cultural heritage of these islands？ Migration involves the loss of the familiar, including language (especially colloquial and dialect), attitudes, values, social structures and support networks. [5]

As for those intangible culture heritages, the impact of sea level rise is listed in the table 1:

table 1 The Impact of Climate Change

Climate Change Risk	Impacts on Cultural Heritage
•Costal flooding •Sea-water incursion	•Costal erosion/loss •Intermittent introduction of large masses of strange water to the site which may disturb the metastable equilibrium between artifacts and soil •Permanent submersion of low-lying areas •Population migration •Disruption of communities •Loss of rituals and breakdown of social interactions

Certain subsistence patterns, like fishing for a particular species, are closely tied to particular landscapes. When those practices are no longer possible, either because of direct environmental changes or because the population practicing them was itself forced to move, the loss of tradition or subsistence resource could be seen as a threat to the culture itself. [6]

Local languages in these small islands are vulnerable. Statistics show their rich linguistic heritage. But the language diversity is vulnerable. For example, Papua New Guinea has close to 850 indigenous languages spoken. Among these languages, UNESCO's Atlas of the World Languages in Danger identifies at least 98 as vulnerable, endangered, or even extinct.

table 2 Data of SIDS

Small Islands Numbers of Developing States (SIDS)	Number of World Heritage Properties		Number of Representative Intangible Heritage Listed (Extant/Extinct)
	Inscribed		
Antigua and Barbuda	0	0	2(2/0)
Bahamas	0	0	3(2/1)
Bahrain	1	0	3(3/0)
Barbados	0	0	2(2/0)
Belize	1	1	8(8/0)
Cape Verde	1	0	2(2/0)
Comoros	0	0	6(6/0)
Cuba	9	1	3(3/0)
Dominica	1	0	3(3/0)
Fiji	0	0	10(10/0)
Grenada	0	0	3(3/0)
Guinea-Bissau	0	0	22(22/0)
Guyana	0	0	17(16/1)
Haiti	1	0	3(3/0)
Jamaica	0	1	3(3/0)
Kiribati	1	0	2(2/0)
Maldives	0	0	1(1/0)
Marshall Islands	1	0	2(2/0)
Mauritius	2	0	6(6/0)
Micronesia (Federated States of)	0	0	18(18/0)
Nauru	0	0	3(3/0)

Palau	0	0	4(4/0)
Papua New Guinea	1	0	841(830/11)
Samoa	0	0	2(2/0)
Singapore	0	0	21(21/0)
St. Kitts and Nevis	1	0	2(2/0)
St. Lucia	1	0	2(2/0)
St. Vincent and the Grenadines	0	0	2(2/0)
Seychelles	2	0	3(3/0)
Solomon Islands	1	0	74(71/3)
Suriname	2	0	17(17/0)
Tonga	0	1	3(3/0)
Trinidad Tobago	0	0	6(6/0)
Tuvalu	0	0	2(2/0)
Vanuata	1	1	110(108/2)

Here I use a formula to estimate the risk of culture loss in the 5 nations where would vanish:

$$\mathrm{R} = \frac{P_r(10-i)}{P_t} \tag{7}$$

where the variables are described in table 3:

table 3 Symbol Used in formula

Symbol	Meaning
Pr	number of People in risk in the nation
Pt	total population in the nation
i	the population growth rate in the nation

Calculating the R value of each countries in danger, we obtain the result shown in Figure 8. Based on the result, Greenland is exposed to the highest risk of losing its culture, and Netherland is also facing a higher possibility of risk.

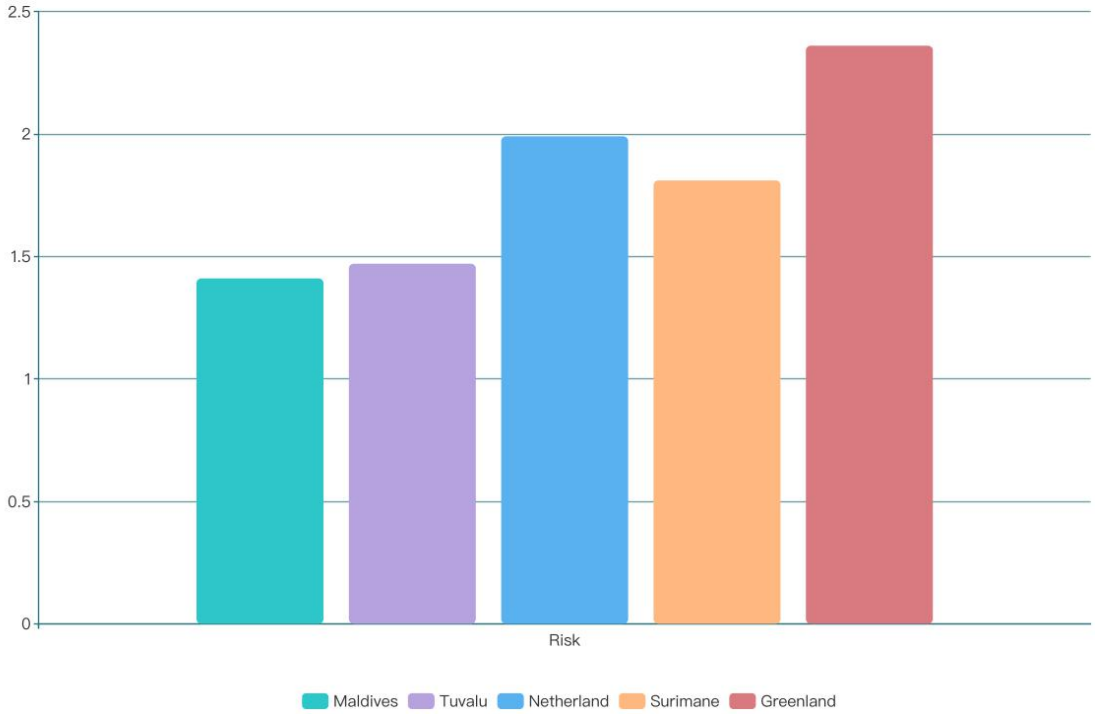

Figure 8 Risk of Loss of Culture in Vanishing Nations

4 Proposed Policy

Regarding the whereabouts of refugees, first consider those countries that have a large impact on environmental degradation, and secondly consider the difficulty of migration and cultural similarities, and choose the nearest country to migrate. In the case of the Maldives, relocation to India, China, Indonesia and Australia is recommended. Tuvalu chose China, Japan, the Philippines and the United States and Canada. Refugees in the remaining three countries should migrate to Britain, Germany, Italy, or Brazil, the United States, and Canada in the Americas. Other consideration of large nations' liability, Migrants' dignity and protection of culture are discussed below.

4.1 Responsibility of Contributor of Climate Change

The contributors of climate change, which directly cause the environmental displacement, should be called on to take actions. Greenhouse gas and environmental pollution largely accelerates the process of climate change, that is why the worst offenders should undertake their obligation. Since the worst offenders are the most developed countries, we formulate several policies based on common sense.

1. A foundation should be built to compensate the loss of climate refugees and support the reaches of environmental problems. The biggest green house generator should sponsor the largest part of this foundation.
2. As the candidate of host countries, the developed countries should construct several projects to provide job opportunity for other nations' climate refugees.
3. Climate refugees should be recognized by the global society, with careful protection when they lose their nationality because of climate change.

4.2 Migrant with Dignity

Considering the demanding human rights of climate refugees, the means of livelihood should be provided. Also, facing up-coming forced displacement, individual choice should be respected. We make several suggestions based on the protection of human dignity.

1. Countries facing the worst loss situation of EDP should provide education chance to their citizens in advance. If the refugees have some labor skills, they will be gladly received by the host country.
2. People who are about to be climate refugees should be recognized to receive humanitarian care by the UN. Their volunteer migrant in advance should be support to avoid future loss.

3. The explicit definition of climate refugee or upcoming climate refugee should be made. To exactly support people who are volunteer to move before the natural disaster destroy their home, a clear definition is indispensable.

4.3 Protection of Culture

Because refugees have lost their country, the culture of some countries may disappear with the disappearance of the country and the separation of people. Countries that host refugees have an obligation to help them preserve their original artifacts and culture, including their language, habits, religions and traditions. Therefore,

1. The government should help refugees to consciously retain some traditional culture for a long time. The host country needs to create a relatively free cultural environment for the refugee country. In the process of rapid integration into the new country, they are not forced to immediately lose their original habits.

2. The Government shall establish a special cultural relics preservation institution for refugees. The most difficult part of cultural protection is that it is not possible to bring all refuges together to live, so it is also difficult to collect cultural relics and culture. The remaining parts should be better protected.

3. The government should call on people to treat minority cultures different from their own countries with more equality and respect, promote international humanitarianism, and implement the humanitarian principles of fairness and justice.

4. Establish a funding platform to teach refugees in the language of the host country, and also encourage refugees to use their own language to protect the language and culture of the refugee country.

5. There should be a compatible mentality for refugees' different religions.

5 The Model for Evaluating Proposal

Each of these measures is an indication of how well traffic flow is being accommodated by the freeway. The three measures of speed, density, and flow or volume are interrelated. If values for two of these measures are known, the third can be computed.

5.1 The Establishment of The Model

Policy evaluation applies evaluation principles and methods to examine the content, implementation or impact of a policy. Evaluation is the activity through which we develop an understanding of the merit, worth, and utility of a policy.

With regard to refugee migration policies, there are many factors that restrict the formulation of them. Therefore, after formulating policies, we need to establish a reasonable model to judge the results of their implementation and impact on both refugees and host countries. But it will be greatly affected by the subjective consciousness of the judges in the process. we need to use a scientific one that can addresse multiple factors and fuzzy

subjective judgments. AHP was proposed to solve this situation. multiple factors and fuzzy subjective judgments. AHP was proposed to solve this situation.

AHP method, also known as analytic hierarchy process or multi-level weight analysis method, was proposed by American operations research expert T.L.Saaty [6] in the 1970s. This method is a multi-objective decision-making method combining qualitative and quantitative analysis It can effectively analyze the non-sequential relationship between the levels of the target criterion system, and effectively comprehensively measure the judgments and comparisons of decision makers.

For the evaluation of the impact of our policies, we use the better integration and rationality between refugee countries and host countries to determine the policy, and draw conclusions through the AHP method. In other words, if we provide refugee immigration suggestions in our policy, we can use this model to evaluate the rationality of this refugee migration policy for both sides of refugees and host country. The greater the rationality index, the smaller the impact for two parties; This proves that our policies can be implemented reasonably. If the policy is not reasonable, it indicates that some areas need to be improved, or that the two countries are not suitable for refugee migration. At the same time, we have established a reasonable index system, and put forward some clear judgment indicators for both sides.

5.1.1 Index System

Our index for judging the rationality are a dual consideration of the host country and the refugee country. We have obtained two levels of final judgement indicators (figure 9). The indicator system is divided into four parts, taking into account the responsibility of the host country, the needs of the host country, the degree of integration between the host country and the refugee country, and the quality of the refugee country. Something should be noted:

1. The United Nations Refugee Fund and migration fund from refugees are unable to estimate specific values, so they are measured on a scale of 1-10 (rarely-many), and these indicators will also become two aspects of our policy improvement. So, we set the initial value to 5, which can be adjusted based on the final score.

2. Regarding the degree of population acceptance, we determine the number of accepted migrant's P_h and the number of refugees P_r (P_h is based on previous immigration data from the host country). We simply build a formula to characterize this index (Population acceptance):

$$PA = \frac{P_h}{P_r} \tag{9}$$

3. The level of medical care and education is determined by the ratio of GDP.

4. The difficulty of migration is simply judged by the distance between countries.

5. The education similarity index is determined by the difference between the education indexes of the two countries. (The education index is the combination of the Mean Years of Schooling and Expected Years of Schooling.)

6. In order to make the final score more real, other data will be converted into tenths.

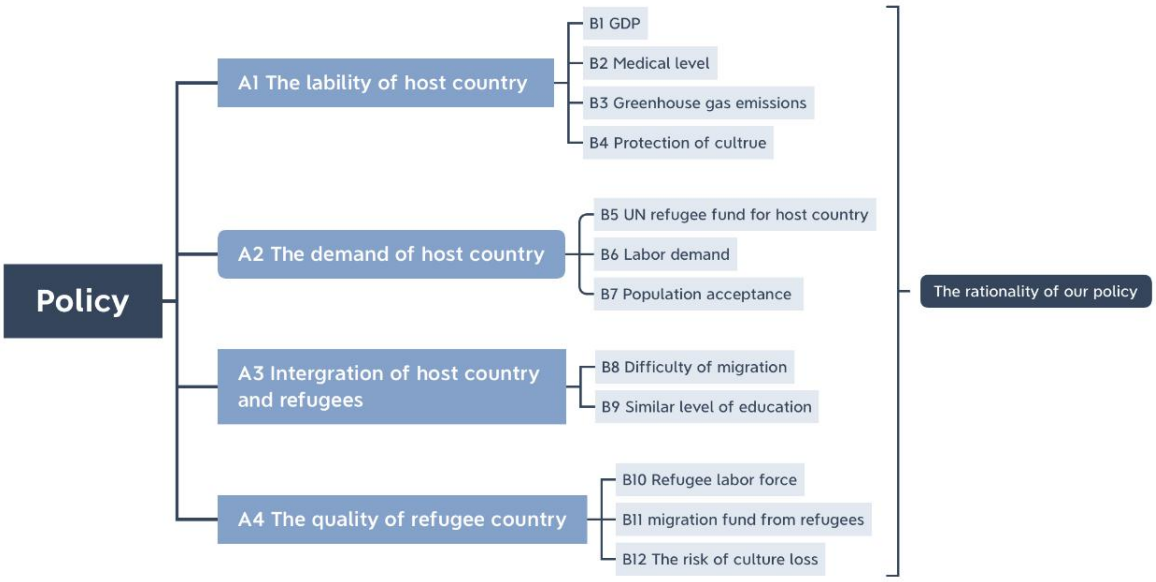

Figure 9: Index System

5.1.2 Establishing the judgment matrix

Assuming the order of the judgment matrix is m, and evaluating the numerical value in a judgement matrix of policies which describes the importance of the i-th index relative to the j-th index, ($1 \le i, j \le 12$) expressed as aij ,

$$A = [a_{ij}]_{m \times m} = \begin{pmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mm} \end{pmatrix} \tag{10}$$

among them, $a_{ji} = \frac{1}{a_{ij}}, a_{ij} > 0$.

For indicators at different levels, the judgment matrix is the importance between these two indicators and the previous layer's one.

5.1.3 Calculating the relative weight of indicators

(1) To calculate the m-th root of the product of the elements in each row of the matrix, $p_i = \sqrt[m]{\prod_{j=1}^{m} a_{ij}} (i = 1, 2, \ldots m)$, then get the vector $P = (p_1, p_2, \ldots, p_m)^T$.

(2) To normalize the vector, $b_i = \frac{p_i}{\sum_{k=1}^{m} p_k}$, then get the vector $B = (b_1, b_2, \ldots, b_m)^T$

(3) The weights of these indicators can be obtained according to the AHP method. After normalizing the vector, the hierarchical single order is obtained. Then to synthesize the product of each hierarchical weight and you can obtain the final total ranking weight value, which is to multiply the single-layer sorting weight of the elements by its corresponding previous layer's elements, successively get the final value.

For example, the weight value of layer B to layer A is W_{B_i} and layer A is W_{A_i}, and finding the total weight of layer B as $W_{A_i} \times W_{B_i}$.

5.1.4 Consistency check

(1) To find the maximum eigenvalue of a matrix, $\lambda_{\max} = \sum_{i=1}^{m} \frac{(AW)_i}{mW_I}$

(2) To calculate the Consistency Index,

$$CI = \frac{\lambda_{\max} - m}{m-1} \tag{11}$$

(3) To calculate the Relative Consistency Ratio, $CR = \frac{CI}{RI}$ (RI: Table 4) , if CR<0.1, the consistency of the judgment matrix will be considered acceptable.

Table 4: Mean Random Consistency Index RI Values

Matrix order	1	2	3	4	5	6	7	8	9	10	11	12
RI	0.00	0.00	0.51	0.89	1.12	1.26	1.36	1.41	1.46	1.49	1.52	1.54

5.2 Solving the model

5.2.1 Level one index layer

The scale of the judgment matrix is based on the 1-9 scale method obtained by T.L.Saaty through simulation experiments. It is an effective method to quantify subjective thinking into different scales in AHP. By constructing a judgment matrix in this way, the meaning of the scale is shown in the following table. (Table 5)

Table 5 Scale Value Internal

Scale Value Internal	Meaning
1	ai and aj are equally important
3	ai is little important than aj
5	ai is obvious important than aj
7	ai is strongly important than aj
9	ai is extremely important than aj
2, 4, 6, 8	Median of adjacent scales
Reciprocal	If the ratio of importance of ai and aj is aij,than the ratio of importance of aj and ai is $\frac{1}{a_{ij}}$

We have set up a reasonable judgment matrix based on the existing policy's consideration of these factors and the resolutions of some professionals, and converted the

qualitative comparison results into a quantitative matrix to calculate the weights w of different factors.

(1) Constructing the first-level indicator layer judgment matrix

In our judgment matrix, we consider the degree of integration between the two parties more important. It is as follows:

$$A=\begin{pmatrix} 1 & 4 & \frac{1}{3} & 3 \\ \frac{1}{4} & 1 & \frac{1}{6} & \frac{1}{2} \\ 3 & 6 & 1 & 5 \\ \frac{1}{3} & 2 & \frac{1}{5} & 1 \end{pmatrix} \tag{12}$$

By using square root method, we can obtain $P_A=(1.4142,0.3799,3.0801,0.6043)^T$

(2) Calculating eigenvalues and eigenvectors

Normalizing vector can obtain $B_A=(0.2581,0.0693,0.5622,0.1103)^T$

(3) Consistency check

To calculate the eigenvalue $\lambda_{\max}=4.0795$, CI=0.0265 by using MATLAB software, and to find RI=0.89 in the table.

Then $CR=\frac{CI}{RI}=0.0298<0.1$, indicating that the test is passed.

In summary, the weight vector of the first-level indicator layer is $W_A=(0.2581,0.0693,0.5622,0.1103)^T$

5.2.2 Level two index layer

(1) Constructing the judgment matrix

Since there are only two secondary indicators in the A3 primary indicator, there is no need to judge the weight through the matrix. Therefore, we set the weight $W_3=(0.7,0.3)^T$ according to the experts' recommendations.

The judgment matrix of other secondary indicators is as follows:

$$A_1=\begin{pmatrix} 1 & 5 & 2 & 3 \\ \frac{1}{5} & 1 & \frac{1}{3} & \frac{1}{2} \\ \frac{1}{2} & 3 & 1 & 2 \\ \frac{1}{3} & 2 & \frac{1}{2} & 1 \end{pmatrix} \quad A_2=\begin{pmatrix} 1 & 3 & \frac{1}{3} \\ \frac{1}{3} & 1 & \frac{1}{5} \\ 3 & 5 & 1 \end{pmatrix} \quad A_4=\begin{pmatrix} 1 & 2 & \frac{1}{3} \\ \frac{1}{2} & 1 & \frac{1}{5} \\ 3 & 5 & 1 \end{pmatrix}$$

The weights obtained through them are:

$$W_1=(0.4832,0.0882,0.2717,0.1569)^T$$
$$W_2=(0.2583,0.1047,0.6370)^T$$
$$W_4=(0.2297,0.1220,0.6483)^T$$

(2) Consistency check

The eigenvalues of the three judgment matrices are calculated as:

$$\lambda_{\max 1}=4.0146,\quad \lambda_{\max 2}=3.0385,\quad \lambda_{\max 4}=3.0037$$

The relative consistency ratios obtained from the eigenvalues are: $CR_1 = 0.0055$, $CR_2 = 0.0383$, $CR_4 = 0.0036$, all less than 0.1, indicating that the test is passed.

(4) Total weight value

By multiplying the weights obtained by the two-layer indicators we can calculate the total weight of each secondary indicator. The calculated results are shown in the following table (Table 6):

Table 6: Total Weights of index

First-level index	Weights	Second-level index	Total Weights
A1 The lability of host country	0.2581	**B1** GDP	0.1247
		B2 Medical level	0.0228
		B3 Greenhouse gas emissions	0.0701
		B4 Protection of cultrue	0.0405
A2 The demand of host country	0.0694	**B5** UN refugee fund for host country	0.0179
		B6 Labor demand	0.0073
		B7 Population acceptance	0.0442
A3 Integration of host country and refugees	0.5622	**B8** Difficulty of migration	0.3935
		B9 Similar level of education	0.1687
A4 The quality of refugee country	0.1103	**B10** Refugee labor force	0.0253
		B11 migration fund from refugees	0.0135
		B12 The risk of culture loss	0.0715

Figure 10 describes the weight results in pie chart, which indicates the importance of B8 Similar level of education and A3 integration of host country.

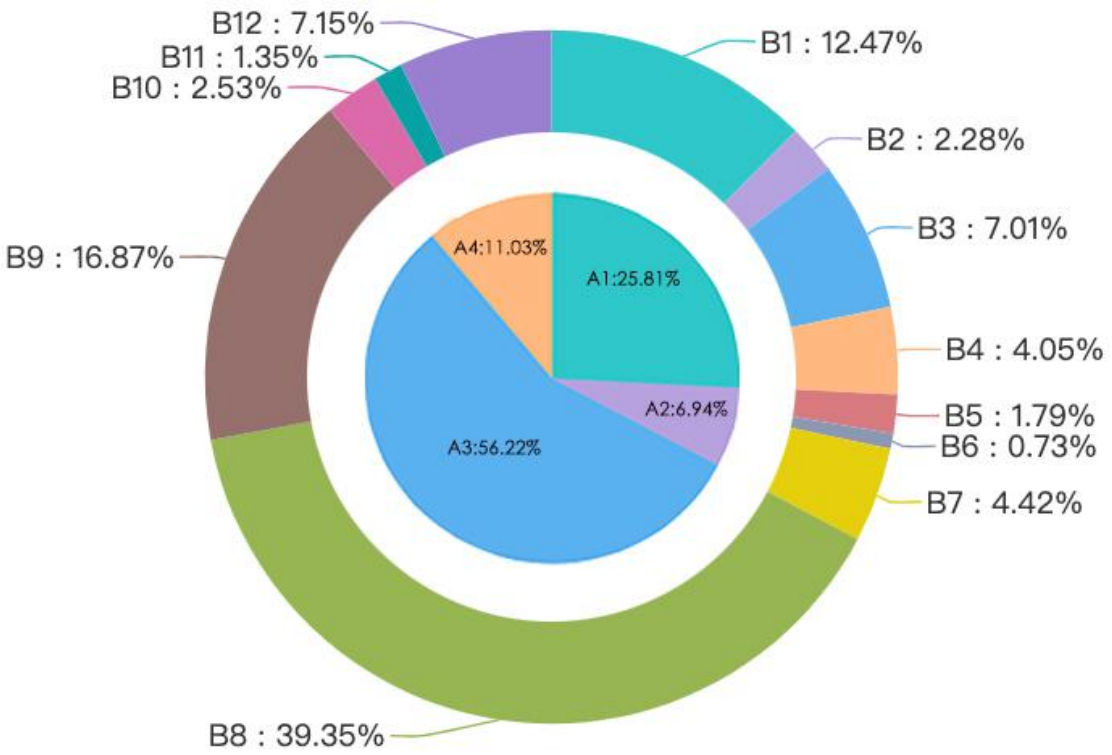

Figure 10 Weight Results

5.3 Final Score

After obtaining the weights of the indicators, we compiled the data of each country, and calculated the rationality score between 5 refugee countries and 17 possible host countries, and compiled the following matrix:

Table 2 Score Matrix for 5 Refugee and 17 Host Countries

	Maldives	*Tuvalu*	*Suriname*	*Nertherland*	*Greenland*
Australia	4.6358	97.4667	4.6422	2.8521	21.9483
Indian	2.9687	187.9336	2.9177	1.7330	41.2089
China	5.7189	6.3834	3.7962	6.3645	6.5683
Japan	4.5579	39.8112	4.2338	3.6820	11.6002
South Korea	4.8971	6.9374	2.0647	1.6844	3.0830
France	2.5281	94.4365	4.4329	2.3686	21.0405
Germany	2.2478	189.8794	6.2571	2.0311	40.7317
USA	7.4475	374.5565	7.5172	4.3149	81.8785
Canada	2.9897	96.7078	4.0135	3.4361	21.3235
Italy	5.6029	96.6591	4.1143	3.4223	22.4867
Indonesia	2.1848	19.6031	1.5312	2.0183	6.0865
Brazil	2.3644	22.5446	4.0663	3.3859	7.0610

UK	3.6751	94.8309	5.4389	4.6977	23.7668
Sri Lanka	1.7527	5.6042	4.5251	1.2479	2.2399
Philippine	1.7489	5.9549	2.1871	3.6984	4.5657
Fiji	4.0729	8.3385	3.6786	2.0092	3.3951
Poland	4.3604	8.3723	1.6594	2.4108	5.3731

5.4 Policy Optimization Recommendations

From the data obtained at the end, we can see that the result is the immigration choices obtained after integrating the 12 indicators. China and the United States have high indexes for each refugee country, which may be due to China and the United States' GDP and greenhouse gases. Emissions differ greatly from other countries. The remaining suitable countries are options that are closer to the territory of the refugee country and other indicators.

Therefore, we understand that in the "climate refugees" incident, countries like China and the United States will undoubtedly be held accountable for this. As high-scoring countries, they must contribute to refugee migration programs or the UN Refugee Fund. Although, for refugees, in addition to China and the United States, there are other migration countries to choose from. This may allow them to integrate into the life of their new country faster.

In our previous policy, we proposed some possible solutions for migration. Based on the data obtained, it seems that the strategy we used is quite reasonable. But with accurate data we can propose more reasonable and scientific choices than before. For the Maldives, we think they should move to China or Australia; for Tuvalu refugees, Australia, the United States or India; and Suriname, the Netherlands and Greenland is closer to North America or Europe, and refugees should move to Britain, the United States, and Germany, respectively.

Of course, if we increase the refugee fund share for other countries in our model, their index of receiving refugees will also be higher. Therefore, if the refugees relocate to countries other than the policy recommendations themselves, they can increase their share Compensate for their score.

6 Conclusion

6.1 Strengths

In the displaced population model, we find that the sea level rise is the biggest impact to EDPs. An advantage is that it takes into account the growth of the population under the influence of time elapsing.

In the evaluating model, the indicator system is multifaceted. We consider whether the integration between the refugee country and the host country is easy as an important factor. Additionally, the protection of the refugee culture and medical security are considered more thoroughly.

6.2 Weaknesses

In terms of statistics of data, due to time limitation and lack of techniques, it is not precise for our models, so errors in the result are inevitable.

The disadvantage of displaced population model is that it simplifies the process of sea level rise and the impact of human intervention, and only describes these two factors with a linear function, lowering the persuasion the model.

When using the analytic hierarchy process model, it is impossible to avoid subjective judgments on the importance of indicators, and when processing data is from various countries, the data is complex and the processing of the data is not detailed enough, which would result in inaccurate results.

6.3 Recommendation

Our policy is actually a guide for refugee migration, an explanation of the responsibility of the host country, and a constraint on both sides. If we do not analyze the impact of the environment and formulate related policies, it will cause refugees to have no direction when migrating, and their human rights will not be well protected. This is even more the case for cultural protection, and measures taken in advance will minimize losses and risks and make refugee migration smoother. Of course, optimization of the model is also essential. Our policies can be more reasonable after we propose them in advance.

Several essential recommendations are listed below:

1. High-scoring countries with higher GDP and carbon dioxide emissions, they must contribute to refugee migration programs or the UN Refugee Fund.
2. Countries about to be inundated should improve the labor skill and education rate of their citizens, while host countries are supposed to provide special project for climate refugees.
3. Both the refugee country and the host country should take actions to protect the varnishing culture. Distinctive communities can be developed for this reason.

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Appendix: Index data from host countries.

Country	GDP (:billion)	Medical Index	Greenhouse gas (:Ton) emissions	Culture Industry	UN fund	Labor demand (:million)	Population acceptance	Education Index
Australia	1433	96	420	0.694	5	12910	2.5	0.927
Indian	2719	46	2654	0.65	5	521900	5	0.473
China	13608	78	10065	0.446	5	806700	0.1	0.61
Japan	4872	94	1162	0.714	5	65010	1	0.808
South Korea	1531	90	659	0.575	5	27750	0.1	0.895
France	2778	92	338	0.798	5	30680	2.5	0.816
Germany	3948	92	759	0.711	5	45900	5	0.884
USA	20544	89	5416	0.797	5	160400	10	0.89
Canada	1713	94	568	0.696	5	19520	2.5	0.85
Italy	2084	95	10421	0.741	5	25940	2.5	0.79
Indonesia	1042	42	615	0.388	5	125000	0.5	0.603
Brazil	1869	60	457	0.672	5	104200	0.5	0.661
UK	2855	90	379	0.798	5	33500	2.5	0.86
Sri Lanka	89	71	23	0.617	5	8913	0.1	0.738
Philippine	331	47	135	0.548	5	42780	0.1	0.61
Fiji	5.5	53	2.1	0.691	5	353	0.1	0.762
Poland	5856	82	344	0.63	5	17600	0.1	0.825