Problem Chosen	2020 ICM Summary Sheet	Team Control Number
F		2000376

EDP prediction based on GA-BP and cultural preservation model based on SEIR

Summary

The large number of existing or potential environmentally displaced persons(EDP) caused by climate change has become a severe problem for human society in the 21st century.It is attracting increasing attention from countries and international organizations。What to do with the people displaced by climate change has become one of the most serious problems.To help The United Nations address this problem,our team did following works.

- Firstly, we searched the literature and referred to the semi-empirical method to projecting the sea-level rise in 2100.Then we analyzed the phenomenon and concept of environmental displaced persons. We used the Grey Prediction and **The neural network based on genetic algorithm (GABP)** is constructing to predict the scope of the crisis.The results show that in 2050, sea level is expected to rise by **109.897 mm** by 2020 and the EDP is expected to reach **146 million**.We also assesses the **risk of cultural loss** in countries' at climate risk **by rating their cultural soft power.**
- Secondly, through the **Analytic hierarchy process**, We simulated the EDP's choice of destination on the basis of fully respecting their human rights, which proves **the necessity of policy intervention**.The policy intervention is considered to make the allocation of EDP more fair and reasonable.
- Then, we took the impact of time and the increasing complexity of the problem due to various factors into account and analyzed the issues that need to be concerned about.
- In addition, we defined the cultural value of EDP. Through tracing the number of language, religion, intangible cultural heritage and other cultures in the major countries of departure,We set the **Mathematical models of epidemic diseases(SEIR)** to simulate how the cultural would spread when EDP settled down in a new community.It has proved that **Zoning policy** can effectively promote the **cultural preservation of EDP**.
- Finally,to address this problem,policy proposes were put forward from four aspects: **Subsidy, Publicity, Zoning and Negotiation**. Moreover, according to the **potential adverse effects of the proposes**, Suggestions for improvement and some innovations that we think are possible in the future were put forward.

We believe these Suggestions can help the United Nations to play a better role in climate change crisis and make contribution to effectively solving the problem faced by EDP.

Content

1 Background

As global carbon emissions have increased dramatically, the global climate has undergone vicious changes. Among them, global warming has led to accelerated melting of glaciers, global sea level rise, and frequent extinction of polar organisms. To make matters worse, some islands may even disappear completely as sea levels accelerate, such as the Maldives, Tuvalu, Kiribati, and the Marshall Islands. The disappearance of the country has made the indigenous people "refugees," and the United Nations will assist these environmentally displaced persons based on the principles of nationalism and equality and mutual assistance. The assistance here mainly includes two aspects: relocation and resettlement. The International Climate Change Foundation (ICM-F) has hired our team to advise the United Nations on the growing challenges of environmentally displaced persons.

Throughout the human process, climate change has spawned, nurtured, temporarily interrupted, and even ended human civilization, especially after the Industrial Revolution. The climate has become increasingly abnormal. Extreme weather continues to threaten the world's natural and cultural heritage, resulting in the annihilation of indigenous tribal cultures, and the continued emergence of climate refugees who have lost their cultural practices during frequent migration. [1] Therefore, in addition to making reasonable arrangements for the displacement and resettlement of environmentally displaced persons, how to protect their cultural value is also one of the considerations.

2 Restatement of the Problems

After our team accepted the commission of ICM-F, we investigated the problems of disappearing existing islands and increasing the number of environmentally displaced persons, and constructed and solved models according to the requirements of the topic.

2.1 Understanding of the EDP Migration Model

First of all, we need to clearly define the environmentally displaced persons, not only to set the standards (defined as the criteria for environmentally displaced persons), but also to define and predict the size and characteristics of environmentally displaced persons. Then we need to screen out immigrants fairly based on the two most important parameters, carbon emissions and GDP per capital, and establish migration models for environmentally displaced persons between immigrants and immigrants. Then explain the best EDP migration strategy based on the model. The model needs to consider three basic factors: human rights, nation-state responsibility, and personal choice.

2.2 Understanding of EDP Placement Model

After the environmentally displaced persons migrated into the country, they were caught in the dilemma of assimilation and harmonious living in their own national culture. In order to properly handle the tension between EDP assimilation and accommodation, we need to focus on the issue of cultural value of the country of departure. Culture is not only intangible cultural heritage, but also minor languages and other cultural expressions. We need to ensure that in the process of resettlement EDP, we must ensure reasonable and safe accommodation and avoid major cultural losses.

2.3 Understanding of crisis dynamic models

In order for the UN and other government organizations to properly solve the EDP problem in the future, this article needs to introduce factors such as time, climate, sudden negative events, the rise of nationalism, and the global political atmosphere, and transform the original static migration model into a crisis-resistant Dynamic model.

And this paper needs to use the crisis dynamic model to put forward long-term policy recommendations that protect the cultural value of high-risk countries while placing EDP. The crisis dynamic model needs to have a certain degree of sensitivity and stability, which means that the model can not only adjust the strategy of the scheme in time with the occurrence of crisis events, but also can keep the error that changes with time in the security environment is small and remains significant .

2.4 Understanding of environmentally displaced persons assistance policies

Facing worldwide problems such as environmental refugees, the international community can provide reasonable and effective international assistance under the unified guidance of the United Nations. However, the evaluation of policies is particularly important here, especially in terms of how to measure the potential impact of policies. And we need to establish a suitable model to improve and optimize the recommendations, so that policy recommendations can present a state of progress. Finally, we need to compare the policies before and after optimization to explain the importance of our proposed policies and the feasibility of the evaluation model.

3 EDP Crisis Range Prediction

3.1 Environmentally Displaced Persons

3.1.1 Definition of EDP

The official definition of climate refugees are persons who have to move because their home has become uninhabitable due to climate change.The concept of environmental displaced persons is not the same with climate refugees. It refers to people who have to move because their homes become uninhabitable due to environmental change.There are different academic interpretations of the term "environmental displaced persons".And There has been a lot of controversy over the term EDP.Even until now, there has been no systematic classification of "environmental refugees".
Therefore, there is no special explanation in this paper.We defined EDP are those people who have to move because their homes become uninhabitable due to the rise of sea level.

3.1.2 Scope of the Crisis

3.1.2.1 Approaches to projecting future sea-level rise

Understanding and predicting sea-level change is a dynamic and difficult topic. It has a complex mechanisms and influenced by many factors. By referring to the literature of Stefan Rahmstorf (2007), we referred to the results of semi-empirical approaches to predicting future sea level.

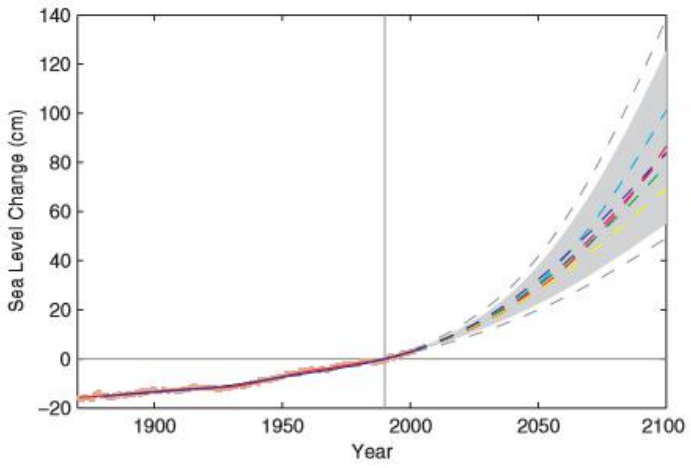

Figure.1 Sea level change

Past sea level and sea-level projections from 1990 to 2100 based on global mean temperature projections of the IPCC TAR. The gray uncertainty range spans the range of temperature rise of 1.4 ℃to5.8 ℃.It shows that sea level rise of 0.5-1.4 meter by 2100 using a semi-empirical method.

At the same time, we used the Grey Prediction to give our views on the sea-level rise.

(1)The historical data of sea level are very clear. We established a time series from 1880 to 2020 based on these data.And We set the sea level data of 2020 as the benchmark to generating relative sea-level of other years:

$$H_{2020} = 50.209 \text{ ..... } H_k \text{ refers to real sea level attitude} \quad (1)$$

$$RH_{2020} = 0$$

$$RH_k = H_k - H_{2020} \text{ ..... } RH_k \text{ refers to relative sea level attitude} \quad (2)$$

Then we made the prediction with the newly obtained time series RH_K.

(2)Calculate λ_K

$$\lambda_k = \frac{RH_{k-1}}{RH_k} \quad (3)$$

(3) $\lambda_K \in (0.228,1.608)$.Using GM (1,1) model will have a higher precision, so we established GM (1,1) model

(4) Using matlab to calculate the predicted value of sea-level

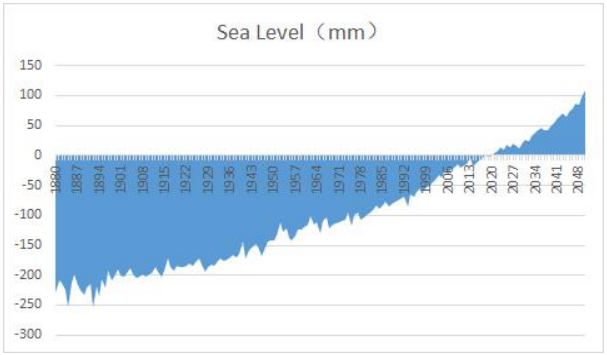

Figure.2 Sea level change by Grey prediction

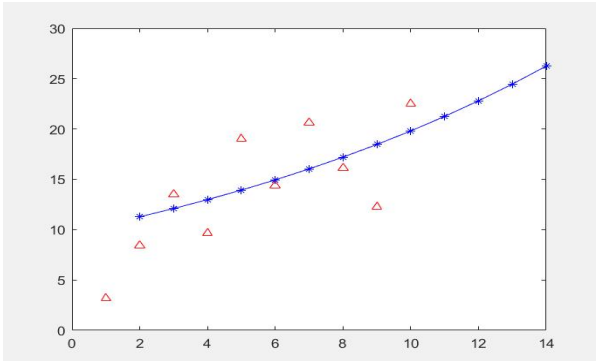

Figure.3 Confidence analysis

Figure 2 is the result of the Grey Prediction. The data after 2020 represent the increase of sea-level in the following years.It shows that sea-level would increase **109.897 millimeter** in 2050. Clearly the predicted increasing rate of sea-level is very rapid.Sea-level changes are quite complex and impacted by many factors, so we cannot say that this prediction is absolutely accurate. However, the growth rate excavated from the previous time series does show that the sea-level has been increasing rapidly from the past to the present.So,It is urgent to deal with the climate crisis.

In conclusion,referring to the recent global climate conference (2019). The most widely accepted sea-level rise estimate by the end of the next century based on 1℃ to 4.5 ℃global temperature rise is 0.5-l.0 meter,which has taken into account the various causes of sea-level rise.Majority believe that the reasonable prediction is that the global sea-level will rise l meter by the end of the next century.

3.1.2.2 Scope of the Crisis based on GA-BP method

In this paper, based on the researches of EDPs and sea-level changes, a neural network method is proposed

to predict the crisis scope.Our team processed data by normalization and we adopted the neural network optimized by genetic algorithm which could achieve more accurate prediction of the crisis scope by iterating the results.

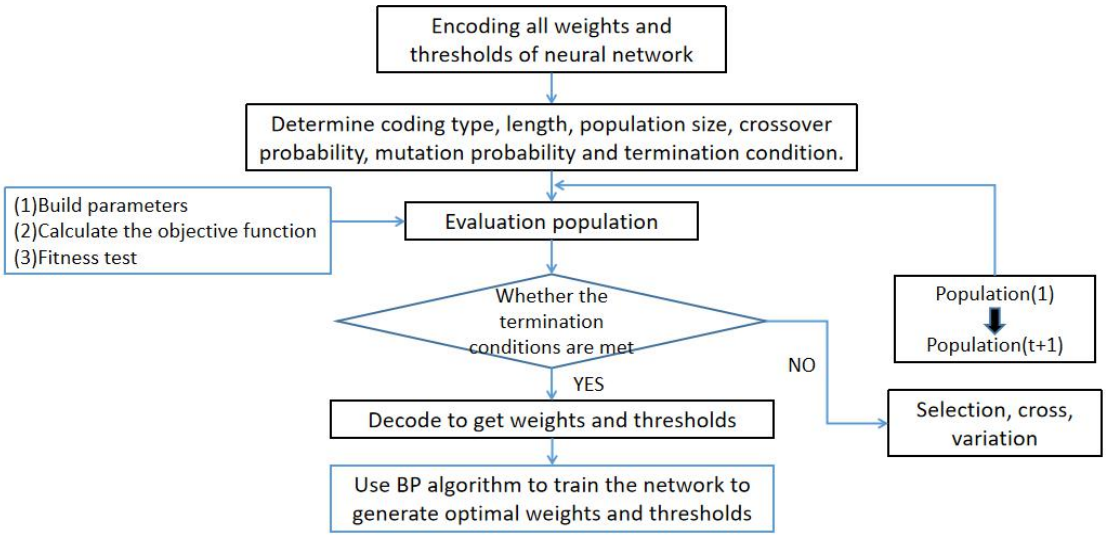

Figure.4 The algorithm process

Following is our target function

$$\text{Max}(y)$$
$$y=200*\exp(-0.05*x)*\sin(x), x \in [-2,2] \quad (4)$$

The neural network is divided into input layer, hidden layer and output layer. According to previous experiments, the optimal number of hidden layer nodes in the single hidden layer neural network is between 3-13.We selected the number of hidden layer nodes in matlab toolbox.

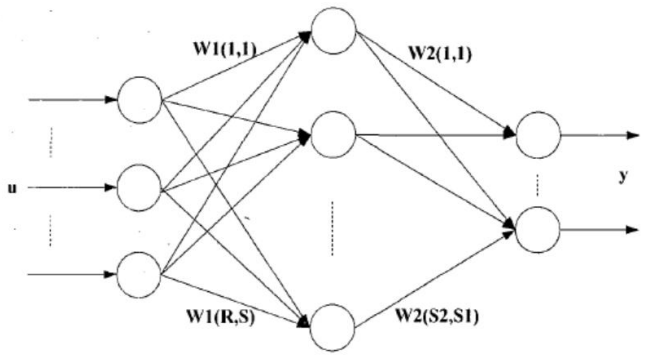

Figure.5 Layer and node

- The range of weights(matrix W) and thresholds is [-2.2]
- The input vector：u；The output vector：y
- Number of input layer neurons：R
- Number of hidden layer neurons：S_1
- Number of neurons in the output layer：S_2

(1) A group of distributions is generated randomly and a coding scheme is used to encode each weight or threshold in the group, then a code chain is constructed. On the premise that the network structure and learning algorithm have been determined, the code chain corresponds to a neural network with a specific weight and threshold.

- Precision=0.0001
- Initial population=50

(2) Genetic manipulation：selection, crossover, variation。

- Maximum algebra=12
- Variation probability：P_v=0.009

- Crossover probability： P_c=0.9

(3) Repeat the steps to make the initial set of weight distribution continuously evolve until the training target is satisfied or the number of iterations reaches the preset target.

(4) The optimized weights and thresholds are brought into the neural network to obtain the network output, that is, the predicted results.By 2050,the Population of pacific countries would be **382 million** and the number of EDP will reach **146 million**.

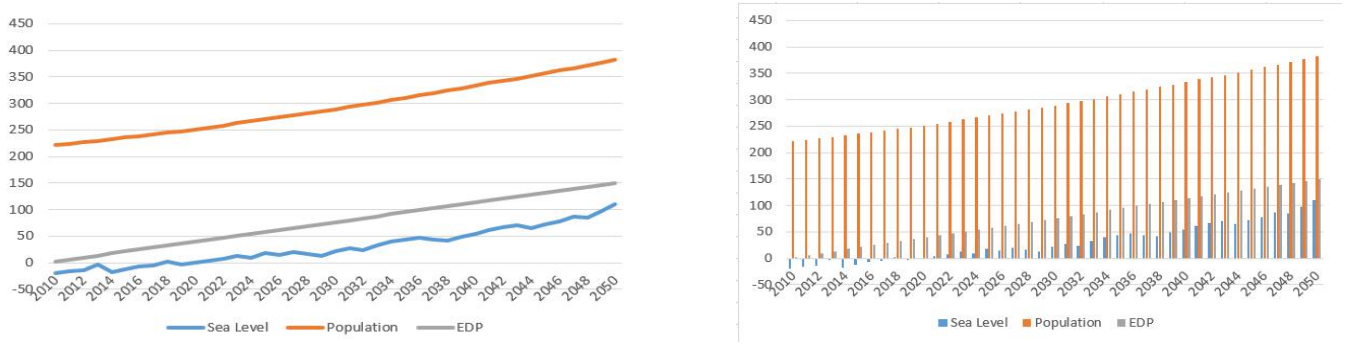

Figure.6 Population,sea-level and number of EDP

Year	Population	EDP	Year	Population	EDP
2020	250.8357	39.2677	**2036**	315.2429	98.4177
2021	254.5777	42.9577	**2037**	319.2837	102.1177
2022	258.4773	46.5077	**2038**	324.1745	105.6577
2023	262.3591	50.2577	**2039**	328.9133	109.4377
2024	265.9844	53.9677	**2040**	333.7542	113.0677
2025	269.7662	57.5677	**2041**	338.2325	116.7577
2026	273.4938	61.3677	**2042**	342.5680	120.4777
2027	277.3276	65.0377	**2043**	346.8905	124.1877
2028	281.5758	68.7277	**2044**	351.8573	127.8377
2029	285.4666	72.4177	**2045**	356.6489	131.4277
2030	289.2684	76.1977	**2046**	361.7197	135.1777
2031	293.3523	79.9877	**2047**	366.3924	138.8777
2032	297.6992	83.7577	**2048**	371.2720	142.4877
2033	301.8128	87.4377	**2049**	376.5136	146.1477
2034	306.1643	91.1477	**2050**	382.0552	149.9277
2035	310.7011	94.8877			

Table.1 Population forecast(million)

3.3 The risk of loss of culture

At the same time, the setting of weights should be based on a comprehensive reflection of the evaluation goals. This article adopts a multi-indicator comprehensive economic benefit analysis method to determine the weight of each indicator. In the specific analysis process, this article refers to the weight determination method in [2] to enhance the rationalization of the determination of indicator weights. Due to the limited space, the weights and indicators are set as shown in the following table:
Cultural soft power represents the cohesion,attraction and influence of a country's culture. [1] To some extent,cultural soft power also represents the tenacity of a country's culture and the risk of cultural loss. Therefore, in order to measure the risk of cultural loss, we used cultural soft power as the evaluation criteria and adopted **Analytic Hierarchy Process (AHP)** to evaluate it.
Through analyzing of AHP,we **ranked the cultural soft power** of following five countries to analyze the **risk of loss of culture** during and after migration.
The evaluation index and weight of cultural soft power are the key work to evaluate risk of cultural loss. In the selection of indicators, the independence between different indicators should be guaranteed to avoid the crossover and duplication of indicators. At the same time, the setting of the weight should be based on the comprehensive reflection of the evaluation goal.So,We adopts the **multi-index comprehensive economic benefit analysis method** to determine the weight of each index. In the specific analysis process,we used the weight determination method in [2] to enhance the rationality of index weight determination. Due to limited page, weights and indicators are set as shown in the following table:

The Secondary Indicators	Weight	Ranking	The Third Indicators	Weight	Ranking
Cultural foundation (A)	0.2574	2	Traditional culture(A1)	0.1067	4
			Cultural services(A2)	0.0645	9
			Culture input(A3)	0.0862	7
Cultural productivity (B)	0.2958	1	Industry scale(B1)	0.0955	5
			Industrial quality(B2)	0.2003	1
Cultural consumption power(C)	0.0265	6	Consumption scale(C1)	0.0541	10
			Consumption structure(C2)	(0.0276)	12
Cultural circulation (D)	0.1317	4	Culture domestic trade(D1)	0.1727	2
			Culture foreign trade(D2)	(0.041)	13
Cultural attraction (E)	0.1238	5	Domestic cultural exchange (E1)	(0.0157)	11
			International cultural exchange(E2)	0.1395	3
Cultural innovation (F)	0.1649	3	Innovation input(F1)	0.0895	6
			Innovative product(F2)	0.0753	8

Table.2 Index weight of cultural soft power of the country of departure

After determining weights by collecting data of the five countries,we scored them on third-level.Then, according to the weights, the cultural soft power score of each country is obtained as follows:

	Maldives	Tuvalu	Kiribati	Marshall	Bangladesh
Cultural Soft Power Index	1.7613	1.6588	1.7553	1.7495	1.8356

It can be seen from the results that the cultural soft power index of Bangladesh is the highest, which is 1.8356, indicating that the cultural influence of Bangladesh is the largest among the five countries that have moved out, and **the ability to resist cultural destruction** is the strongest. So,it has the least risk of cultural loss. Similarly, the soft power index of Tuvalu culture is the lowest, which is 1.6588. This indicates that tuvalu culture has the smallest influence among the five countries and it has a poor ability to resist cultural destruction and faces a great risk of cultural loss.

4 Environmental displaced persons migration model

4.1 Determine the Parameters

While fully **respecting the human rights and choices** of the environmentally displaced persons and without outside intervention, we simulated how the environmentally displaced persons would choose the destination of their migration.

We defined the factors affecting the choice of environmental displaced persons as the following three parameters and assigned their weights to obtain the comprehensive score of destination.

- The policy of the country

Whether EDP are accepted by the country of immigration has a significant impact on the choice of refugees. Here, we quantify the policy as the acceptance rate of EDP of the country, which can be divided into four levels:Fully accepted,Highly accepted,Some accepted and totally unaccepted.

- The environment of the country

The environment of the destination country is another important decisive factor affecting the choice of EDP. The environment of the country is composed of the following four secondary parameters:

1）GDP Per capital

2）Public security

3）The friendliness of the residents

4）climate

- The difficulty of reaching the country ：

Whether EDP can afford to travel is another decisive factor. We measured how difficult it is for EDP to reach the country by measuring the costs of travel.

4.2 Model

By consulting the data and determining relative weights, the weight is shown in Table 3 is obtained:

Name	Weights	Factor
Acceptance rate of EDP	0.581	Policy
GDP per capital	0.061	Environment
Public security	0.027	
Friendliness of locals	0.048	
Climate	0.032	
cost	0.250	The difficulty of reaching

Table.3 Criteria weights of hierarchy II

4.3 Why we need policy

According to the weights table, we draw some conclusions:

- ✓ When refugees make their own choice, the policy of the country of entry has the greatest impact on their choice. **It means that a country can reject the EDP freely by making a policy against EDP**;
- ✓ The cost of migration can also affect refugee choice.This conclusion is very much in line with the reality that **most EDP have a poor economic foundation**. They can hardly afford the high cost of migration,

so they need policies to guarantee their basic needs;

- ✓ Regardless of the economic capacity of the target country, the environmental factors affecting the refugees' choice of destination country are the friendliness of the indigenous people.

Obviously, with **no external intervention**, the EDP will choose the country with the highest score.But does the result of free movement is **efficient**?Can we achieve the **lowest cost** of the entire migration in this way?And can we achieving **fairness** at the national level?

To solve above , we selected some countries as the target layer to simulate the selection of EDP.Considering the national **total carbon emissions**, productivity and distance, we selected following countries.

The following table summarizes the total carbon dioxide emissions of each country from the industrial revolution to 2014, and selects 10 target countries to immigrate according to their carbon emissions and GDP per capital in 2018. We believe that, from a fair point of view, countries or regions with high carbon emissions should take more responsibility. In addition, we have added two countries, New Zealand and Australia, to integrate the factors of distance. Finally, according to the carbon emission as the main keyword, the per capital GDP as the secondary keyword is ranked, and the following 12 target countries are obtained:

Nation	Total CO2 emissions from fossil-fuels and cement production(thousand metric tons of C)	2018 GDP per capital （dollar）	Number
United State of America	102510260	62600	C1
China(Mainland)	47649834	9780	C2
United Kingdom	20500813	42500	C3
Japan	14585037	39300	C4
Germany	12764185	42800	C5
India	11385351	2015	
Russian Federation	10466421	11300	
France(Including Monaco)	9697149	41500	
Canada	8038299	46100	
Poland	6960097	15400	
Australia	4252724	57300	C6
New Zealand	444694	42000	C7

Table.4 Carbon emissions and per capital GDP

After ranking the score of these counties,we got the result that New Zealand and Australia are the two countries most welcomed by EDP without external intervention, because they have a more friendly immigration policy and EDP spend less on the road to them.

Even if the United States and China have emitted the most greenhouse gases in the world, in the case of EDP's own choice, **they still do not need to bear the international responsibility because of their strict immigration policy.**

Clearly, while fully respecting the rights of the EDP and in without external intervention, **it cannot guarantee a fair outcome**, which is why policy intervention is so essential.

4.4 Policy

We can influence parameters through policies to change the selection of EDP and enhance a more equitable and efficient movement.So,we suggest policies of following three aspects.

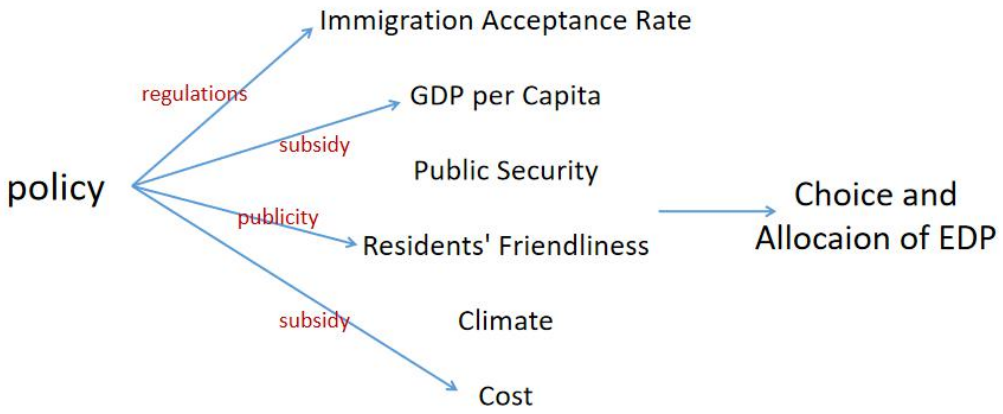

Figure.7 Policies and recommendations

- ✓ **Subsidy**: Establish a fund to subsidize EDP.
- ✓ **Publicity**: This is a way to improve community friendliness and ensure that EDP are not being discriminated against. UN organizations can actively advocate against discrimination in social propaganda and help EDP to build non-discrimination and non-xenophobic communities.
- ✓ **Negotiate and make rules:**The United Nations only has the right of suggestion, it does not have the right of coercion. However, the United Nations could consult among its member states on the issue of migration caused by climate change and work out an agreement on coping with EDP, so as to change the negative policies of some countries in dealing with climate migration.

4.5 The best migration route

Four high-risk countries, namely Maldives, Tuvalu, Marshall islands and Kiribati, were selected and a sample of migration model was established with the target cities including Perth, Adelaide, Melboume, Canberra, Sydney and Brisbane as the main countries of migration. The best migration routes and cities of entry for refugees from different high-risk countries are shown in Figure 8:

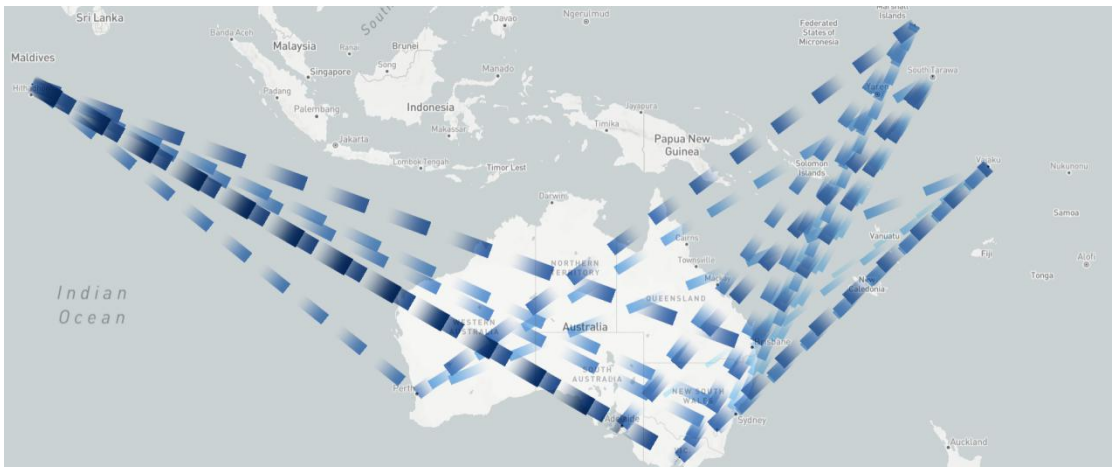

Figure.8 Migration roads

5 The placement model of EDP

5.1 The culture of the country of departure

First of all, cultural value is a kind of relation, which contains the stipulation of two aspects: on the one hand, there exists the object that can satisfy a kind of cultural need; on the other hand, On the other hand, there is a certain subject with cultural needs. Moreover, when certain subjects find objects that can meet their cultural needs and occupy such objects in a certain way, cultural value will appear. In short, it is when the culture of the host country can be spread and needed that the host country has cultural value. Here we only consider the relationship of cultural value of the country of departure under the static condition, that is, the relationship between the object and the subject of culture.

In order to resolve the tension between EDP assimilation and accommodation, while properly protecting the culture of the host country, we need to establish an EDP placement model.Our definition of "culture" consists of the following four parts:

Language： This refers to the language prescribed for use in a country. People preserve and transmit the achievements of human civilization through language, and language is one of the important characteristics of a nation;

Intangible cultural heritage: This mainly refers to the number of items that have been listed as intangible cultural heritage by UNESCO in the country of departure.

- ✓ **Religious brief:** Here refers to the religion of the largest number of people in the country of emigration. Religious brief has great influence on people's life style and customs
- ✓ **Others:** Cultural contents that do not belong to the above three elements, such as industrial development, featured clothing, featured diet, folk dance and other cultural forms that have little impact on the overall cultural value assessment.

The following is a brief introduction to the culture of the main countries of departure:

- **Maldives:** the main language is Divehi, with 0 items of intangible cultural heritage. Its main religion is Islam-sunni. The traditional dance is Bodu Beru;
- **Tuvalu:** the main languages are English and Tuvalu, with 0 items of intangible cultural heritage. Its main religion believes in Christianity. They like to gather together and is backward in agriculture and fishing industry;
- **Kiribati:** the main language is English, with 0 items of intangible cultural heritage. Its main religion is Roman Catholic. Its agriculture is backward with fishing as the main industry;
- **Marshall islands:** the main languages are English and Marshall, with 0 items of intangible cultural heritage, its main religion is Catholicism. The residents' family complex is heavy and the matriarchal society is outstanding;
- **Bangladesh:** the main language is Bengali, with 4 intangible cultural heritage, its main religious beliefs are Islam, Hinduism, Buddhism, Christianity. Women like to wear saris and Muslims ban alcohol.

5.2 Model Preparation

5.2.1 SEIR Model

The traditional SEIR model divides the participants in the system at time t into four states: susceptible (S), latent (E), infected (I) and recovered (R). [3]Similarly, when studying cultural transmission, we divide participants in the system into four states:

- **S-Susceptible Person:** Indigenous people who have not accepted foreign culture；
- **E-Exposed Person:** Indigenous people who have accepted the culture of the host country and EDP who have accepted the culture of the host country

- **I-Infected Person:** Indigenous people who have accepted the culture of the host country and EDP who have accepted the culture of the host country
- **R-Rehabilitation Clients:** Indigenous people who will not accept EDP culture

In this SEIR model, in addition to the four basic states, the probabilities of various behaviors in the infectious disease model are also important. According to the purpose of the model, we defined the infection rate, exposure rate, infection efficiency, transmissibility rate, cure rate and case fatality rate, which are detailed in the following table:

Parameters	Definition	Explanation	Type
S	Susceptible Person	Indigenous people who have not accepted foreign culture	Integer
E	Exposed Person	Indigenous people who have accepted the culture of the host country and EDP who have accepted the culture of the host country	Integer
I	Infected Person	A person with the cultural characteristics of an emigrating country	Integer
R	Rehabilitation Clients	Indigenous people who will not accept EDP culture	Integer
D	Died Patient	Indigenous people who accept EDP culture and abandon native culture	Integer
h	Infection Rate	The probability that residents of the country of emigration accept the culture of the country of emigration	Floating Point
a	Contact Rate	The probability that each resident of the country of entry is exposed to EDP population	Floating Point
b	Efficiency of Infection	The probability that people accept other cultures (including the probability that the original residents accept EDP culture and the probability that EDP accepts the culture of the country of entry)	Floating Point
i	Transfer Rate	The probability of rejecting an alien culture at first and then accepting it later	Floating Point
r	Recovery Rate	The probability of accepting an alien culture at first and then rejecting it	Floating Point
k	Fatality Rate	The probability of abandoning native culture after being exposed to foreign culture	Floating Point
P	Population	Sample population of EDP	Integer
HPSA	Hospital-Patient-Segregation-Area	People in the country far from the EDP settlement	Integer
HFR	Human-Flow-Range	Upper limit of population movement	Integer

IIN	Initial-Infectious-Number	The number of initial infections	Integer
LT	Latent-Time	From the exposure to culture to the acceptance of culture	Integer
RCRT	Receive-Cure-Response-Time	The time from infection to recovery	Integer

Table.5 Parameter List

In the traditional model, the pattern of node state transition is shown in Figure 7. The parameter definitions in the system are shown in Table 6.S(t), E(t), I(t) and R(t) respectively represent the proportion of participants of various cultural communication in the total number of participants at time t. We assume that S(t), E(t), I(t), and R(t) in the model are continuously different functions of t.

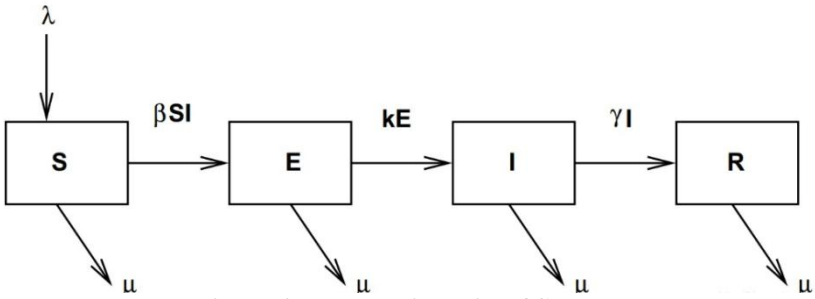

Figure.9 The relationship of S E I R

After defining the above parameters correctly, we need to establish the function of the infectious disease model.The model consists of the following five differential equations:

$$\begin{aligned}
\frac{dE}{dt} &= h(E+I) - iE \\
\frac{dS}{dt} &= -h(E+S) \\
\frac{dI}{dt} &= iE - rI - kI \\
\frac{dR}{dt} &= rI \\
\frac{dD}{dt} &= kI
\end{aligned} \tag{5}$$

The differential equations of E, S, I, R and D are solved respectively, and the formulas at t and t+1 are as follows:

$$\begin{aligned}
E_{t+1} &= E_t + h(E_t + I_t) \\
S_{t+1} &= S_t - h(E_t + I_t) \\
I_{t+1} &= I_t - rI_t - kI_t + iE_t \\
R_{t+1} &= R_t + rI_t \\
D_{t+1} &= D_t + kI_t
\end{aligned} \tag{6}$$

Due to the conservation relationship :S(t)+E(t)+I(t)+R(t)= Constant, the latency cultural recovery rate γ_1 and the accepted cultural recovery rate γ_2 are generally different. We assume that the incubation period for the development of zealots is α, and the SEIR model, compared with the SIR model, further takes into account the fact that only a fraction of people exposed to cultural communicators are infectious. This makes the transmission cycle of culture longer. And the final uninfluenced number S and influenced number R in cultural transmission can be obtained by numerical simulation.

5.2.2 Hypothesis

Since cultural transmission and infectious disease transmission are different in nature, in order that cultural transmission can adapt to the SEIR model, we propose the following hypothesis:

- ✓ Cultural transmission only exists between the EDP and the local population.
- ✓ There is no mandatory and effective way to stop transmission at this stage;
- ✓ The influence of environmental factors on the case fatality parameter was not considered.
- ✓ Ignore people leaving the country, people dying and people moving internationally;
- ✓ The recovered person does not interfere with the cultural acceptance of others.

5.3 Solution of model

5.3.1 Results analysis of the SEIR model

Next, we set the sample parameters reasonably， including:Population(1000hundred)、hospital-patient-segregation-area(1000)、human-flow-range(33)、infection-rate(100%)、transform-rate(80%)、recovery-rate(20%)、Initial-infectious-number(5hundred)、latent-time(100days)、receive-cure-response-time(50days)、receive-rate(10%)。We used the program to determine the population predicted number of four states of susceptible persons (S), latent persons (E), infected persons (I) and recovered persons (R) before the implementation of policy control, as shown in Figure 10.

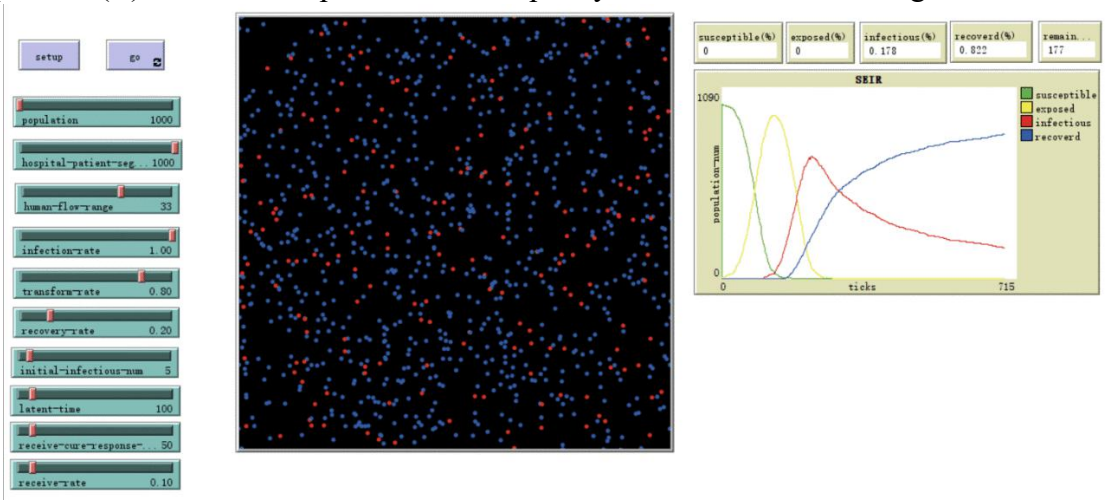

Figure.10 Cultural communication before policy implementation

As shown in Figure 10, S and E decrease over time and eventually approach 0. But I and the number of R rendering of the more interesting changes: The initial increase in I was accompanied by a logarithmic increase in the number of R. However, the number of hospital-patient-segregation area is relatively large, and the range of people that can be contacted by an infected person is limited. Therefore, the number of infected people will fall rapidly after reaching a threshold, and will eventually be far lower than the number of recovered people.From the perspective of cultural transmission, the number of infected people and recovered people determines the retention and transmission of culture in the country. When the infected people are far less than the recovered people, the cultural retention is low and the cultural transmission is not ideal.

5.3.2 The potential impact of divisional placement

To avoid such a disappointing situation, we propose a policy proposal that EDP relocated to a country will be subdivided. We advocate that the EDP should be divided into groups according to the appropriate ratio of gender and age structure (the focus of this paper is not to solve the ratio and age structure) and then they need to be placed in different regions of the country.

For example, the number of people far away from the EDP settlement in the country will be greatly reduced, so we changed the hospital-patient-segregation area to 500 (hundred). Besides, when other parameters are stable, the following results are presented:

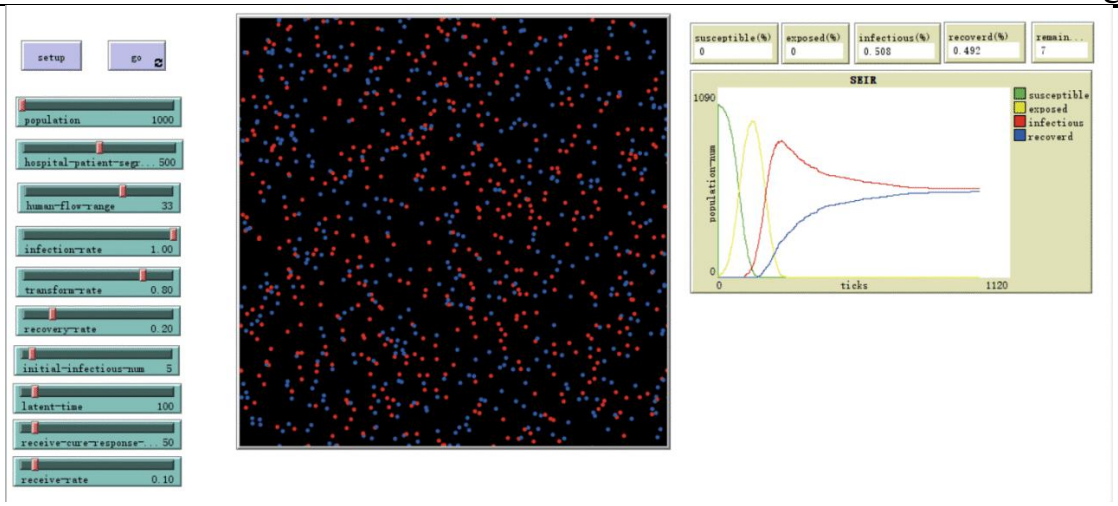

Figure.11 Cultural communication after policy implementation

When I and R finally equal to each other, the cultural retention of EDP in this country is relatively high and the cultural transmission is ideal.Finally, the cultural exchanges between the countries of destination and destination reach a balance.

By comparing the cultural retention degree and the final trend of cultural communication before and after the implementation of the policy, it can be seen that the policy of "EDP district resettlement" has a positive impact.

6 Policy

6.1 Dynamic crisis

If a country is devastated by a sudden catastrophic event such as a tsunami or hurricane, indigenous people cannot live normally.For people in the country, there is limited time to prepare for evacuation and find new homes.Therefore, we designed a crisis dynamic model to simulate sudden crisis events.However, the above EDP migration model and EDP placement model lack the parameters that change with events, and cannot reflect the sudden occurrence of crisis events. Therefore, before constructing the crisis dynamic model, we firstly set up new parameters that are applicable to dynamic changes from four factors.

Time factor

In our opinion, the most important time factor is the population growth rate of the EDP group itself, whether it is the protected EDP or the immigrant EDP.Their own growth rates pose a challenge to the proper placement of EDP.Simply put, when the rate of refugee population growth is higher than a certain value, the efficiency of migration can be negative.In this case, if the given EDP population value is still used, the resulting error will be larger and larger, and eventually the model will become invalid.According to the number of environmental refugees calculated by the world bank from 2000 to 2014, we established a prediction function to predict the number of environmental refugees from 2020 to 2050. The results are shown in the following figure:

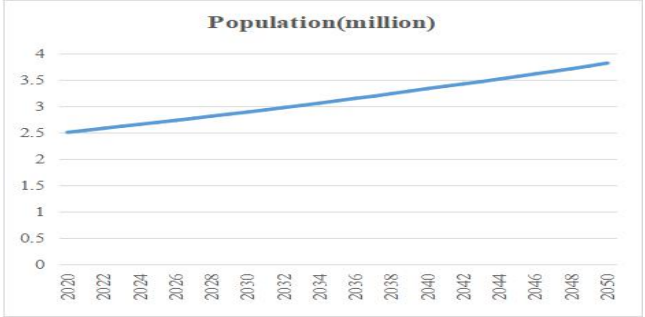

Figure.12 Refugee Population

The climate

Sudden natural disasters, such as tsunamis, hurricanes and earthquakes, can cause huge damage that is difficult to repair in a short time. Affected countries are struggling to come up with quick relief plans to cope with the sudden increase in population of EDP. Drastic climate changes, such as continuous heavy rain and drought, will threaten the resources available to the countries of migration or even cause resource shortage, which makes the countries of migration in the EDP migration model reach the maximum capacity quickly.

Sudden and negative events

Some sudden and negative events will also affect the effectiveness of EDP migration and placement models.For example, the economic crisis and epidemic situation in the host country will affect its capacity and the maximum refugee capacity, while war and terrorism can affect the population of EDP, which can also change the world's perception of refugees.

The rise of nationalism and the global political climate

The protection of refugees is an important part of human rights law, which promotes and encourages respect for human rights and fundamental freedoms of all human beings.The essence of the protection of refugees is the protection of human rights。[4]

The number of people in the world who oppose unilateral nationalism is increasing, and more and more voices are emphasizing nationalism in the world concept and advocating mutual help and common progress.The proposal of a community with a Shared future for mankind also further contributes to the unity of global political and economic forces.All of this is changing the way the world looks at EDP.

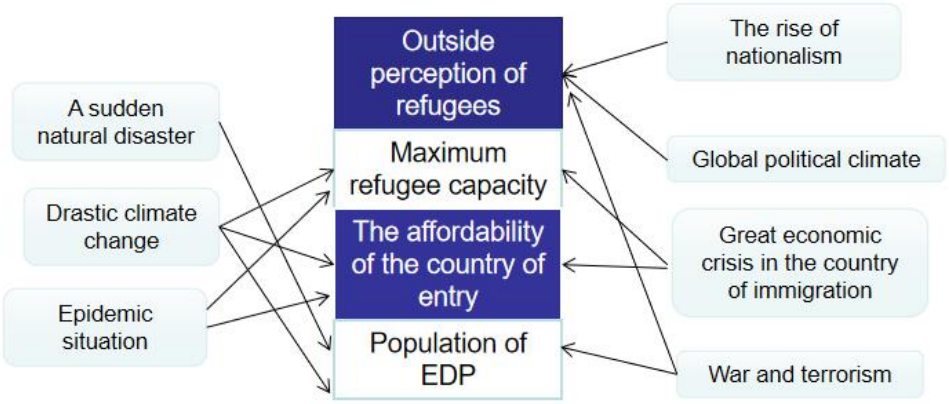

Figure.13 The impact of the new parameters

6.2 Summary of policies

The issue of EDP has attracted increasing attention. Some small island countries are actively seeking solutions. Some international conferences are also discussing the international protection of climate refugees and trying to find solutions.**To achieve the four objectives:Respecting Human rights of refugees, Ensuring fairness, Efficient allocation and Cultural preserve**, we proposed four policy directions:

(1) **Subsidy**: It refers to the establishment of the fund to provide economic support for the environmental displaced persons,which could help EDP protect its own rights and guide EDP to make choices.

- Establish EDP funds based on contribution amount of greenhouse gases: **To be fair**, regions and countries with more carbon emissions have an obligation to take more responsibility.However, because there are differences in national conditions(population and policy),they often fail to meet their responsibilities. Thus we think, countries that have emitted more greenhouse gases should **pay more** to the EDP fund set up by the United Nations;
- Play the guiding role of economic subsidies: EDP can obtain **different subsidies** when they migrate to different countries, which will cause EDP to change the destination.We could use this policy to encourage EDP immigrate to countries with large areas,few people and welcoming immigration policy;

(2) **Publicity:** It is very essential to promote the idea of a community of Shared future , equality and mutual assistance for mankind actively which will help EDP integrate into new communities, be free from discrimination and protect the human rights of EDP;

(3) **Negotiate agreements and set rules:** The United Nations can negotiate among its member states on the issue of migration caused by climate change, **formulating agreements on the response to EDP**, which can change the attitude of some countries in dealing with EDP problem and encourage them to make positive policies;

(4) **Zoning :** From the perspective of enhancing cultural transmission and cultural retention, we can place EDP from different countries in different regions according to the appropriate ratio of men and women and age structure, and provide them with certain resources.

6.3 Policy implications and improvements

The policy has three beneficial effects:

- It fully respects the rights of the EDP
- To some extent, it guarantees fairness among countries
- It raises the possibility of cultural preservation

Potential adverse effect	Improvement	Category of Policy
1.Zoning may result a problem that one country include another. 2.When territory does not exist, does the state exist at the legal level.	Establishing a National EDP fund: Countries in climate risk could Establish their own fund with the help of The united nations.The fund is used to buy land to meet the country's immigration needs.	Subsidy
Legal definition of EDP	Determine EDP's International Status：The United nations could write relevant legal documents specifying whether EDP is a refugee or an immigrant.	Regulation
Some countries can benefit from climate warming.But it is difficult to determine the international responsibilities they should bear	Encourage cooperation： Encourage countries which benefit from climate warming to reach agreement or cooperation with victim countries。	
Ignore environmental protection	Strengthen the promotion of environmental protection	Publicity
Different languages make it difficult for EDP to integrate into local communities, and zoning make this worse.	Language and cultural education for EDP： Propose a plan to teach EDP Language and survival skills.	Zoning
Zoning makes it easier for EDPs to be isolated and become a vulnerable group.	Establish local organizations to protect EDP's rights： Establish organizations in each EDP resettlement area to provide Legal consulting services for EDP and help cultural preservation.	

Table.6 Policy implications and improvements

Of course, our policy has many adverse effects and shortcomings at the same time.After analyzing the potential impact of our policies, we put forward improvements of the policy in following table.

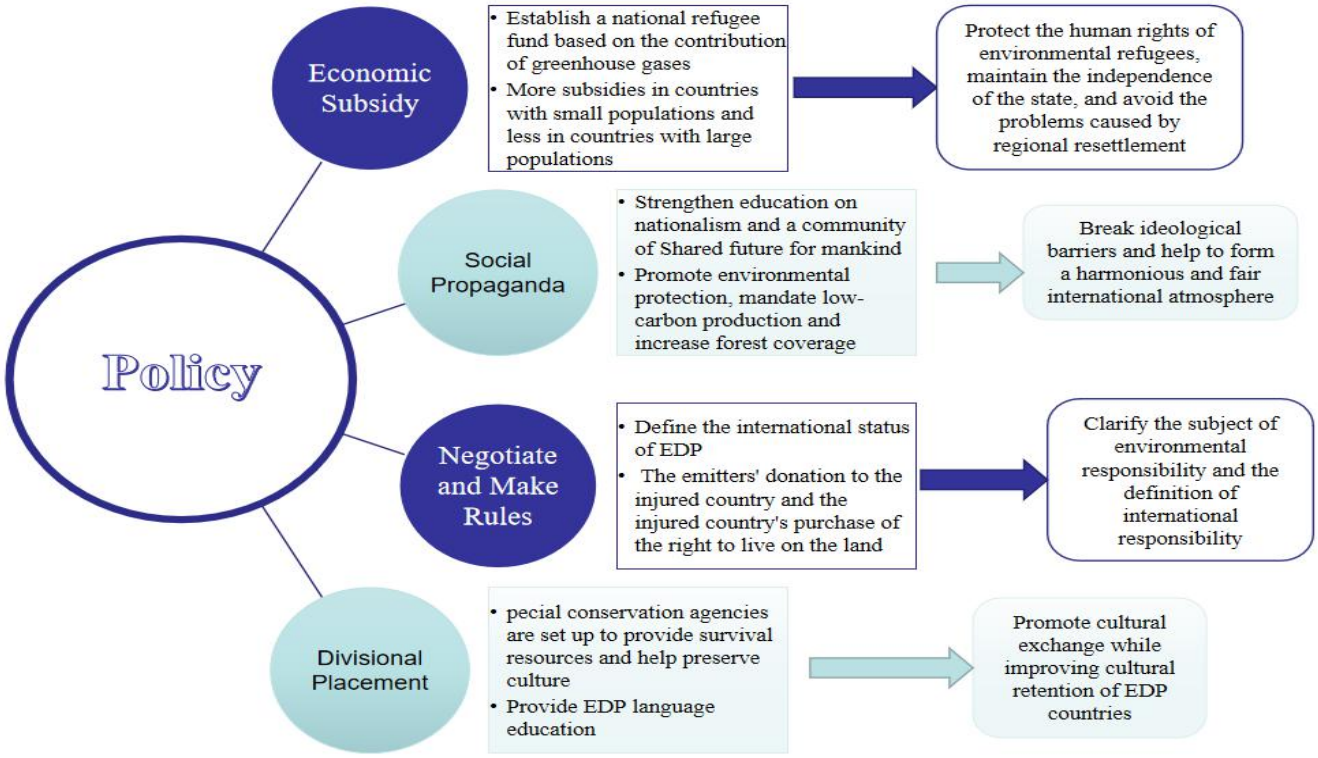

Figure.14 The details and functions of the policy

6.4 Innovation

Traditional policies may be effective in dealing with these problems.However, the future is changeable, and we are also advocating more innovative assistance programs for environmental refugees.

- **Developing Antarctica:** as the global climate warms, ice cover in Antarctica is decreasing.Countries such as Australia and New Zealand, which are the main entrants, are under greater pressure.So we are thinking about collaborating to develop the available areas of Antarctica in order to prepare for more environmental refugees in the future;
- **Mars settlement:** earth may face more environmental problems in the future.We think that developing and emigrating to Mars might have an unexpected effect on solving the problem of environmental refugees;
- **New islands:** in the case of the Maldives, high-risk countries can choose to build roads in shallow water, which costs a lot.The country may need more economic aid;
- **Floating city:** Belgian architect Vincent Callebaut designed the floating city "home of the water lily", which is self-sufficient in solar, wind, tidal and other renewable energy technologies.
- **Separation wall:** the government can build reinforced flood walls around the island to protect the city

7 Stability and Sensitivity

From the overall effect of the model, it is suitable not only for the environment and region of EDP, but also for most areas related to refugees, that is, our model has a relatively broad applicability. After establishing an EDP prediction model and referring to data from many fields, this paper draws the relationship between EDP flows. We use them to study the number of such relationships and the impact of evaluation objects. The results obtained are reasonable. Therefore our model is practical and reliable.

Our model does not rely on certain data. When the original data changes, our model results will change to new data corresponding to the actual. Whether we add some data to the model or delete some data from the model, the model's results will not show large fluctuations, which indicates that our model has good stability and sensitivity.
Based on this assumption, we considered the time for transfer preparation. Time affects both EDP receiving countries and EDP exporting countries. For the spread of culture. From our point of view of the new results, although the cultural retention rate of each EDP receiving location will change after increasing the size of EDP, the change in its relative influence is small, indicating that our model has a good Sensitivity.

8 Strengths and Weakness

8.1 Strengths

After establishing the EDP prediction model, we used AHP to calculate the impact of each assessment object. In addition, in order to ensure the stability of the model, we cycle the calculation process and weight each evaluation object according to the determined weighted occurrence rate. We then use our model to re-evaluate all of the appraisals to give an effective policy-making strategy.
When analyzing the transfer of EDP, we generalize the model to different fields, rather than confining the model to one field, so that the model has higher reliability and a wider range of applications. In addition, after establishing the EDP prediction based on GA-BPNN, we solved the problem from different angles, and thus fully described our model from other angles.
Finally, we have some new ideas. For example, in terms of culture, we feel that people are cultures, and people are carriers and communicators of cultures. We think through this idea, then we can build an epidemic disease model (SEIR) to solve. We can try to make more people understand our culture, that is, the infected. The viewpoint of the model is relatively new.

8.2 Weakness

In terms of data statistics, due to resource constraints and lack of statistical techniques, sometimes our model is not accurate enough, so there may be errors in the results.
Since there are many evaluation objects in our EDP evaluation, if all the evaluation objects are zero, the transfer graph will be quite confusing and difficult to study. The results of many evaluation objects are close to the evaluation indicators set in our model, thereby reducing the persuasiveness of our model results.

References

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[2] Xie xiaoyu, zhu tingting. Research on comprehensive evaluation of urban cultural soft power -- based on the analysis of Beijing's cultural soft power development [J]. Price theory and practice, 2019 (10) : 149-152.
[3] Liu benying, luo yong, huang zhonggan. Study on WeChat rumor propagation based on improved SEIR model [J]. Journal of wenzhou university (natural science edition), 2019,40 (04) : 14-19.
[4] Lu yalan. Research on international law protection of climate refugees [D]. Chongqing university, 2015.
[5] The World Bank Report. (2018, March 19). Climate Change Could Force Over 140-Million to Migration Within Countries by 2050. Retrieved from:https://www.worldbank.org/en/news/press-release/2018/03/19/climate-change-could-force-over-140-million-to-migrate-within-countries-by-2050-world-bank-report.

Appendix

1.GM（1,1） MATLAB code

```
y=[3.201
8.414
13.481
9.648
19.001
14.335
20.653
16.134
12.284
22.478
]
n=length(y);
yy=ones(n,1);
yy(1)=y(1);
for i=2:n
    yy(i)=yy(i-1)+y(i)
end
B=ones(n-1,2);
for i=1:(n-1)
    B(i,1)=-(yy(i)+yy(i+1))/2;
    B(i,2)=1;
end
BT=B';
for j=1:(n-1)
    YN(j)=y(j+1);
end
YN=YN';
A=inv(BT*B)*BT*YN;
a=A(1);
u=A(2);
t=u/a;
t_test=4;
i=1:t_test+n;
yys(i+1)=(y(1)-t).*exp(-a.*i)+t;
yys(1)=y(1);
for j=n+t_test:-1:2
    ys(j)=yys(j)-yys(j-1);
end
x=1:n;
xs=2:n+t_test;
yn=ys(2:n+t_test);
plot(x,y,'^r',xs,yn,'*-b');
det=0;
for i=2:n
    det=det+abs(yn(i)-y(i));
end
det=det/(n-1);
```

```
disp(['Percent absolute error：',num2str(det),'%']);
      disp(['predict：',num2str(ys(n+1:n+t_test))]);
```

2.1.GA-BPNN main program MATLAB code

```
clc;
clear all;
close all;
global BitLength
global boundsbegin
global boundsend
bounds=[-2 2];
precision=0.0001;
boundsbegin=bounds(:,1);
boundsend=bounds(:,2);
BitLength=ceil(log2((boundsend-boundsbegin)' ./ precision));
popsize=50;
Generationnmax=12;
pcrossover=0.90;
pmutation=0.09;
population=round(rand(popsize,BitLength));
[Fitvalue,cumsump]=fitnessfun(population);
Generation=1;
while Generation<Generationnmax+1
    for j=1:2:popsize
        seln=selection(population,cumsump);
        scro=crossover(population,seln,pcrossover);
        scnew(j,:)=scro(1,:);
        scnew(j+1,:)=scro(2,:);
        smnew(j,:)=mutation(scnew(j,:),pmutation);
        smnew(j+1,:)=mutation(scnew(j+1,:),pmutation);
    end
    population=smnew;
    [Fitvalue,cumsump]=fitnessfun(population);
    [fmax,nmax]=max(Fitvalue);
    fmean=mean(Fitvalue);
    ymax(Generation)=fmax;
    ymean(Generation)=fmean;
    x=transform2to10(population(nmax,:));
  xx=boundsbegin+x*(boundsend-boundsbegin)/(power((boundsend),BitLength)-1);
    xmax(Generation)=xx;
    Generation=Generation+1;
end
Generation=Generation-1;
Bestpopulation=xx;
Besttargetfunvalue=targetfun(xx);
figure(1);
hand1=plot(1:Generation,ymax);
set(hand1,'linestyle','-','linewidth',1.8,'marker','*','markersize',6)
hold on;
hand2=plot(1:Generation,ymean);
set(hand2,'color','r','linestyle','-','linewidth',1.8,...
'marker','h','markersize',6)
```

```
xlabel('Evolutionary algebra');ylabel('Maximum / average fitness');xlim([1 Generationnmax]);
legend('Maximum fitness ',' Average fitness');
box off;hold off;
disp(['Optimal x value:' num2str(Bestpopulation)]);
disp(['Function maximum:' num2str(Besttargetfunvalue)]);
```

2.2.Subroutine: New population cross operation

```
function scro=crossover(population,seln,pc);
BitLength=size(population,2);
pcc=IfCroIfMut(pc);
if pcc==1
    chb=round(rand*(BitLength-2))+1;
    scro(1,:)=[population(seln(1),1:chb) population(seln(2),chb+1:BitLength)];
    scro(2,:)=[population(seln(2),1:chb) population(seln(1),chb+1:BitLength)];
else
    scro(1,:)=population(seln(1),:);
    scro(2,:)=population(seln(2),:);
end
```

2.3.Subroutine: Calculating fitness function

```
function [Fitvalue,cumsump]=fitnessfun(population);
global BitLength
global boundsbegin
global boundsend
popsize=size(population,1);
for i=1:popsize
    x=transform2to10(population(i,:));
xx=boundsbegin+x*(boundsend-boundsbegin)/(power((boundsend),BitLength)-1);
    Fitvalue(i)=targetfun(xx);
end
Fitvalue=Fitvalue'+230;
fsum=sum(Fitvalue);
Pperpopulation=Fitvalue/fsum;
cumsump(1)=Pperpopulation(1);
for i=2:popsize
    cumsump(i)=cumsump(i-1)+Pperpopulation(i);
end
cumsump=cumsump';
```

2.4.Subroutine: Determine whether genetic operations need to be crossed or mutated

```
function pcc=IfCroIfMut(mutORcro);
test(1:100)=0;
l=round(100*mutORcro);
test(1:l)=1;
n=round(rand*99)+1;
pcc=test(n);
```

2.5.Subroutine: New population mutation operation

```
function snnew=mutation(snew,pmutation);
BitLength=size(snew,2);
snnew=snew;
pmm=IfCroIfMut(pmutation);
```

```
if pmm==1
    chb=round(rand*(BitLength-1))+1;
    snnew(chb)=abs(snew(chb)-1);
end
```

2.6.Subroutine: New population selection operation

```
function seln=selection(population,cumsump);
%从种群中选择两个个体
for i=1:2
    r=rand;   %产生一个随机数
    prand=cumsump-r;
    j=1;
    while prand(j)<0
        j=j+1;
    end
    seln(i)=j; %选中个体的序号
end
```

2.7.Subroutine: fitness function

```
function y=targetfun(x);
y=200*exp(-0.05*x).*sin(x);
```

2.8.Subroutine: Convert a binary number to a decimal number

```
function x=transform2to10(Population);
BitLength=size(Population,2);
x=Population(BitLength);
for i=1:BitLength-1
    x=x+Population(BitLength-i)*power(2,i);
end
```

3.Culture SEIR Simulation model

```
turtles-own[
  state
  initial-xcor
  initial-ycor
  exposed-start
  received?
  cured?
]

globals[remain-hospital-segregation-area]

to setup
  clear-all
  reset-ticks
  create-turtles population[
```

```
    set shape "circle"
    set initial-xcor (random-xcor * 0.95)
    set initial-ycor (random-ycor * 0.95)
    setxy initial-xcor initial-ycor
    set received? 0
    become-susceptible
  ]
  ask n-of initial-infectious-num turtles[
    become-exposed
  ]
  set remain-hospital-segregation-area hospital-patient-segregation-area
end


to go
  ask turtles [
    move-turltes
    spread
    transform
  ]
  received-and-cured
  tick
end


to received-and-cured
  let current-time ticks
  if current-time >= (receive-cure-response-time + latent-time)[
      ask n-of remain-hospital-segregation-area patches [
      if receive-rate >= random-float 1[
        let agents turtles-here
        if count agents > 0[
          ask one-of agents[
            if state = 2 and received? = 0 [
                if remain-hospital-segregation-area > 0 [
                  set remain-hospital-segregation-area (remain-hospital-segregation-area - 1)
                  set received? 1
                  recovery
                ]
            ]
          ]
        ]
       ]
      ]

    let has-infected-not-cure turtles with [state = 2 and received? = 1 and cured? = 0]
    let num count has-infected-not-cure

    if num > 0 [
      ask has-infected-not-cure [
        recovery
      ]
```

```
      ]
   ]
end


to move-turltes
   ifelse human-flow-range = 0[
      fd 0
   ][


   if random-float 1 < 0.2[
      set heading random 360
   ]
   ifelse (distancexy initial-xcor initial-ycor) < human-flow-range
   [
      fd 1
   ][
      facexy initial-xcor initial-ycor
      fd 1
      ]
   ]
end


to spread
   let touch-agents other turtles-here
   if count touch-agents >= 1[
      if (state = 1 or state = 2) and received? = 0 [
         ask touch-agents with [state = 0][infect-turtles]
      ]
   ]
end


to transform
   if state = 1[
      let current-ticks ticks
      if current-ticks - exposed-start >= latent-time[
         if transform-rate >= random-float 1 [become-infected]
      ]
   ]
end


to recovery
   if state = 2 and recovery-rate >= random-float 1 [
      become-recovered
   ]
end


to infect-turtles
   if infection-rate >= random-float 1[
      become-exposed
```

```
  ]
end

to become-susceptible
  set state 0
  set color green
end

to become-exposed
  set state 1
  set color yellow
  set exposed-start ticks
end

to become-infected
  set state 2
  set color red
  set cured? 0
end

to become-recovered
  set state 3
  set color blue
  set cured? 1
end
```

4. EDP Flow https://flowmap.blue/ image

4.1 Location csv

```
id,name,lat,lon
1,Maldives,0.549767,73.21496
2,Tuvalu,-8.5176265738,179.1996346212
3,Kiribati,1.46667,173.03333
4,Marshall Islands,7.11667,171.06667
5,Sydney,-33.868,151.21
6,Brisbane,-27.469,153.0235
7,Adelaide,-34.9274,138.5999
8,Perth,-31.9527,115.8605
9,Canberra,-35.2819,149.1289
10,Melbourne,-37.8142,144.9632
```

4.2Flow CSV

```
origin,dest,count
1,5,42
1,6,56
1,7,74
1,8,46
1,9,45
1,10,64
2,5,34
```

2,6,23
2,7,12
2,8,34
2,9,45
2,10,54
3,5,23
3,6,34
3,7,54
3,8,34
3,9,23
3,10,53
4,5,35
4,6,35
4,7,43
4,8,52
4,9,23
4,10,43