EDP placement model based on Python data prediction

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Abstract. In recent years, with the adverse impact of rising sea level become increasingly significant, the issue on environmentally displaced persons (EDPs) and their unique culture has emerged into our vision. Resulting from adverse impact of rising sea level, the EDPs will not only lose their resident, but also will lose their unique culture. To effectively deal with the problem, we have established two models in python, aimed at predicting the growth of sea levels and the number of EDPs, and resettling the EDPs. In order to better optimize our model and reflect the significance of relevant factor indicators in the model, we conducted a sensitivity analysis and analyzed the sensitivity factors and rationality of the model in this paper. In the end, we come to a conclusion of the strength and weakness of our model. It will provide constructive opinions for the UN to promote the research on global climate change, protect the atmospheric environment, assist island countries and protect their unique culture.

1. Introduction
Firstly, based on certain climatological knowledge and geographic information, we establish a sea level growth prediction model. Next, by applying the GIS-based method of flooding area and the per capita area of coastal areas to build a model for predicting the number of EDPs, we predict that the sea level around Maldives will rise at a rate of 3 mm per year, and the world will have 6 million EDPs in 2050.

Secondly, we consider 6 factors as the indexes to evaluate the decision on EDPs’ resettlement, establish a dynamic programming model for EDPs’ resettlement decisions. It will help EDPs decide which country is the most suitable choice from various aspects. The example of this model shows that Australia's acceptance of Fiji and Canada's acceptance of the Maldives will be a win-win decision. Through the model, policies are proposed to protect the culture of EDPs and promote the integration of EDPs into society, guaranteeing the basic rights of EDPs in law, education, and society.

Finally, in order to better optimize our model and reflect the significance of relevant factor indicators in the model, we conducted a sensitivity analysis and analyzed the sensitivity factors and rationality of the model in this paper.

In the end, we conclude the strength and weakness of our model. It will provide constructive opinions for the UN to promote the research on global climate change, protect the atmospheric environment, assist island countries and protect their unique culture. Furthermore, it can spread humanitarian spirit.
2. Background
After the Industrial Revolution, carbon dioxide emissions increased for a time, and the formation of the global greenhouse effect was caused by the release of these harmful gases into the atmosphere 0. In recent years, with the increasing international awareness of environmental protection, countries have paid great attention to carbon dioxide emissions. However, this still cannot quickly reverse the greenhouse effect that has been generated. Eventually, some coastal cities are at risk of being submerged. As a result, some people living in these coastal cities have become refugees—environmentally displaced persons.

The resettlement of these environmentally displaced persons is an extremely complex issue, not a simple population transfer. The issue of human rights as the subject of conduct and the carrier of culture, as well as the issue of state responsibility, should also be considered.

In sum, if the national and international legal system can’t effectively deal with, will probably lead cause of poverty, large-scale illegal immigration, money to deal with immigration issues and other issues involving climate lack of basic human rights and the protection of public order in his country, which for remote, low-lying small island states This is especially the case for the residents [2].Therefore, how to balance these many issues and take reasonable measures to enable the environmentally displaced persons to get the best resettlement and the best protection of the culture of the environmentally displaced persons, so that countries can be convinced is a major issue facing the international community [3].

3. Model

3.1. An analysis the people at risk

3.1.1. Assumption and symbol definition
(1) Temperature is affected only by carbon dioxide concentration.
(2) Regional altitude is not affected by plate movement.

| Variable | Definition |
|----------|------------|
| $\alpha$ | $5.59 \times 10^{-4}$ |
| $\beta$  | $8.69 \times 10^{-3}$ |
| $c_0$    | $270 \times 10^{-6}$ |
| $a$      | $1.81 \text{w/m}^2$ |
| $b$      | $2.95 \text{w/m}^2$ |
| $t$      | The ordinal number since 1850. |
| $\mu$    | 0.00593 |
| $\lambda$| 0.0114 |
| $K$      | The thermal diffusion coefficient of the ocean, and its value range is 0.5-3.0. |
| $E_n$    | Elevation of the nth submerged area |
| $A_n$    | Elevation of the nth inundated area |
| $M$      | Number of connected submergence units |
| $f(t)$   | The per capita area of coastal areas in the t year after 1980. |

3.1.2. Model construction Model 1 Sea level growth and EDPS quantity prediction model. As we all know, greenhouse gas has a close relationship with sea level rise, and sea level rise will cause some residents of coastal areas to lose their homes. [4] About the future there will be a number of environmental problems of displaced persons. By analyzing the carbon dioxide concentration and temperature, the relationship between radiation, the relationship between temperature and sea level
rise, and then the relationship with the submerged area of sea level, determine the area of a flooded area, finally, the following model is established based on the relationship between per capita land area and population. [5]

(1) CO2 concentration prediction model:
\[ C(t) = c_0 \exp[\alpha t \sqrt{\beta t}] \]

(2) Greenhouse effect radiative forcing prediction model:
\[ F(t) = a + b \ln(C(t)/270) \]

Among them, \(a, b\) can be adjusted according to the actual concentration of dioxide and the amount of radiative forcing under the greenhouse effect.

(3) Temperature prediction model
\[ T(t) = \mu \ln(\lambda C(t)/270) - 0.5 \]

Among them, this model treats the 1980 temperature rise as zero, for better comparison and calculation relative to the 1980 temperature rise.

(4) Sea level rise prediction model:
\[ Z(t) = [4.13 + 2.65F(t)/T(t)]^{0.223} \]

(5) Forecast model of flooded area:
\[ S(t+\Delta t) - \sum_{i=1}^{n} E_i (\Delta Z - \Delta A) = 0 \]
\[ \Delta Z = Z(t) - Z(t-1) \]
\[ S(t) = \begin{cases} S_0 & t = 0 \\ \sum_{i=1}^{n} E_i & t \geq 1 \end{cases} \]

(6) EDP population prediction model:
\[ P(t) = \frac{S(t)}{f(t)} \]

Result 1:
Taking Maldives, a country facing greater inundation threats, as an example, by fitting the sea level growth model to actual Maldivian sea level data, the final result obtained in this article is as follows:

The overall trend of sea level elevation in the Maldives is increasing. Although the sea level dropped in some years, it rebounded a few years later. According to the results of the model, the sea level in the Maldives is rising at a rate of about 3mm per year, and the average altitude of the Maldives country is 1.2m. It is expected that at this speed, it will be completely submerged in about 2400. At this time, the world will increase more than 500000 environmental displaced persons. If the difference between the predicted sea level and the actual sea level is considered to be a maximum of 5 cm, then the Maldives may be submerged in advance. The final analysis shows that there will be 60 million environmentally displaced persons in the world by 2050.

3.2. The decision of EDP resettling

3.2.1. Model construction. Considering the human rights of the EDPs and individual choice, we choose 4 factors to decide. Which country is the best one to receive EDPs. This model will consider 2 aspect: the one is protecting the EDPs’ human rights and providing them with the enough resource to support their livings. The other is reduce the press of the receiving country in economy and resource.
3.2.2. Assumption and symbol definition. An aid country only accepts EDPs from one country, and EDPs from one country only go to one aid country to resettle. The EDPs are unified under the responsibility of their own country, and they will make arrangements for relocating from their capital as an international refugee to the capital of the assisting country.

| Variable | Definition |
|----------|------------|
| $x_i$    | The country $i$ of the EDPs  |
| $y_j$    | The country $j$ to receive the EDPs  |
| $z_{ij}$ | $z_{ij}$ is dummy variables, if $j$ receive $j$, then $z_{ij}=1$, or $z_{ij}=0$.  |
| $d_{ij}$ | The distance between country $i$ and country $j$.  |
| $m_{ij}$ | The language fitting index |
| $e_{ij}$ | The CO$_2$ emissions index |
| $n_{ij}$ | The population density index *
| $p_{ij}$ | The GDP per capita index |
| $r_{ij}$ | The overall inclusiveness index |

The factor index
Considered the pressure will grow up increasingly, if one country decides to receive the EDPs, so we propose this country receive the only one country of EDPs. In this part, the country will be named as aid country, which decides to receive the EDPs.

The distance $D=(d_{ij})_{i,j}$: $d_{ij}$ is the symbol of the distance between country $i$ and country $j$. The weight of this indicator is $\theta$.

The language fitting index $M=(m_{ij})_{i,j}$: if the EDPs resettle in a new country, the communication between them and the local should be a vital one to be considered. The weight of this indicator is $\eta$.

The CO$_2$ emissions index $E=(e_{ij})_{i,j}$: take into consideration the reasons for some EDPs’ displacements, the impact caused by them is small, but global warming resulted from more greenhouse gases emitted by some other countries, affecting small island countries. The weight of this indicator is $\epsilon$.

The population density index $N=(n_{ij})_{i,j}$: Taking into account the limited land carrying capacity of each country, in order to minimize the land load of the aid country, population density is an important factor in decision-making. The weight of this indicator is $\varphi$.

The GDP per capita index $P=(p_{ij})_{i,j}$: It is well known that the economy is an important factor in the development of a country. Therefore, according to the per capita GDP data of the World Bank Organization, this item is taken as one of the decision-making factors and given a certain weight. The weight of this indicator is $\omega$.

The overall inclusiveness index $R=(r_{ij})_{i,j}$: In order to protect the basic human rights and development opportunities of EDPs, and to provide certain conditions for the protection of the country's culture. Therefore, comprehensive inclusive indicators are used to measure the degree of acceptance of EDP and their culture by the aid country. The weight of this indicator is $\xi$.

Model 1
We build following model:

$$\max Q = (\eta M + \varepsilon E + \omega P + \xi R - \varphi N - \theta D)\cdot Z$$

subject to:

$$\sum_{j=1}^{I} z_{ij} \leq 1$$

$$\sum_{j=1}^{I} z_{ij} = 1$$

$$i \leq j$$

Model solving
Step 1: The index different weights assignment
Assign weight values to the above six indicators based on the data and hierarchy analysis [6]

\[
\begin{align*}
\eta &= 5\% \\
\varepsilon &= 15\% \\
\varphi &= 30\% \\
\omega &= 30\% \\
\xi &= 20\% \\
\theta &= 10\%
\end{align*}
\]

Step 2: Matrix normalization of raw data
Normalize the corresponding values of the six indicators according to the mean standard deviation mode:

Set the original data matrix of m evaluation indicators to n evaluation objects (assistance countries) as \( A = (a_{ij})_{m \times n} \), normalize it to get \( R = (r_{ij})_{m \times n} \), and use the larger value as an excellent indicator (such as GDP per capita), and their normalization formula:

\[
r_{ij} = \frac{a_{ij} - \min \{a_{ij}\}}{\max \{a_{ij}\} - \min \{a_{ij}\}}
\]

For smaller targets (such as population density), their normalization formula:

\[
r_{ij} = \frac{\max \{a_{ij}\} - a_{ij}}{\max \{a_{ij}\} - \min \{a_{ij}\}}
\]

Step 3: Model solving
In order to test the model, Maldives and Fiji were selected as the two EDPs countries x1 and x2 respectively. According to certain environmental science reports and economic statistics reports, the United States, Canada, the United Kingdom, France, Germany, Italy, Switzerland, China, Japan, South Korea, Singapore, Australia, and New Zealand are assisting countries. Assign values to the above variables based on Google Maps, World Bank statistics, United Nation Datas Retrieval System., and overall inclusiveness indicators from Ipsos statistics and it will be calculated using Simulated Annealing algorithm.

Result 1:
If there is only one EDPs country, then \( i = 1 \). The aid countries from Asia, Europe, North America and Oceania. The result as follows:

After comprehensive consideration of various aspects, the results show that if a climate disaster occurs and the Maldives is flooded, the most suitable country to assist Maldives is Australia, followed by Canada and the United States. Such a result is mainly due to the high degree of inclusiveness of these three countries, which is very conducive to EDPs to protect their own culture and is least likely to be discriminated against. Secondly, these three countries have the advantages of vast land and material resources. Due to the lower population density, after accepting EDPs, these aid countries can reduce the pressure on land competition and personnel competition. This is more conducive to protecting the human rights and development rights of EDPs and Cultural protection. Lastly, these countries have strong economic strength and can provide some help to EDPs while ensuring that their economies are less affected.
As the same result of Maldives, the most suitable choice for Fiji is Australia. For the one hand, Australia is closer than any other country. For the other hand, Australia’s economy is flourishing and developing at a stable speed, with the more load and less population. The most main factor contributes to this result is that the overall inclusiveness index is higher among the 13 countries. What’s more, America, Canada and China will be suitable. Furthermore, it is the aid country’s responsibility to provide the EDPs with help in various aspects.

4. Extension

4.1. Sensitivity analysis

In the second model to decide country, six factors were selected as indicators for decision-making. The weight of these six decision indicators is the key to decision making. Taking Maldives as an example, statistics from 13 countries collected from various official websites:

| country | d_{ij} | m_{ij} | e_{ij} | n_{ij} | p_{ij} | r_{ij} |
|---------|-------|-------|-------|-------|-------|-------|
| US      | 14314.41 | 2      | 5254279 | 36     | 62794.60 | 54     |
| CA      | 13830.13 | 2      | 537193  | 4      | 46233    | 55     |
| UK      | 8509.97  | 2      | 419820  | 275    | 42943.90 | 35     |
| FR      | 8286.16  | 2      | 303276  | 122    | 41463.60 | 46     |
| DE      | 7638.46  | 3      | 71983   | 237    | 47603    | 20     |
| IT      | 7318.02  | 2      | 320411  | 205    | 34483.20 | 22     |
| CH      | 7858.62  | 2      | 35306   | 216    | 82796.50 | 38     |
| NZ      | 11312.60 | 2      | 34664   | 19     | 41945.3  | 40     |
| AU      | 9039.68  | 2      | 361262  | 3      | 57373.70 | 44     |
| CN      | 5796.05  | 1      | 10291927| 148    | 9770.8   | 10     |
| JP      | 7579.04  | 1      | 1214048 | 347    | 39290    | -6     |
| SK      | 6521.63  | 1      | 587156  | 530    | 31362.80 | 9      |
| SG      | 3368.80  | 2      | 56373   | 7953   | 64581.9  | 15     |

Table 1. The index of impact on decision.

The following picture is from part 2, which display the possibility of the different decision made by Maldives based on unchanged index weights.

Figure 3. The possibility of the different decision made by Maldives based on unchanged index weights.

A preliminary analysis of the indicator values shows that the values of the 13 indexes m_{ij} are very close, so they have little impact on decision making. Because the current transportation technology is developed, the distance has little effect on the decision of the model also. In contrast, there is a big gap between different countries of n_{ij}, e_{ij} and r_{ij}, so n_{ij} are used as a sensitivity indicator. e_{ij} and r_{ij} are
used as uncertain factors for analysis. In the initial conditions, the weight of $n_{ij}$ is 20%, the weight of $e_{ij}$ is 15% and the weight of $r_{ij}$ is 20%. It means: $\phi = 20\%$, $\epsilon = 15\%$, $\xi = 20\%$.

4.1.1. Change the weight of $e_{ij}$

After changing I: $\phi = 15\%$, $\epsilon = 20\%$, $\xi = 20\%$

After changing II: $\phi = 10\%$, $\epsilon = 25\%$, $\xi = 20\%$

In the case of a small change in the weight of $e_{ij}$, the final result does not change much, especially the three countries with the highest possibility of selection. After a large change, the final result showed more obvious differences.

5. Conclusions

5.1. Strength

In the EDP population prediction model, by correlating carbon dioxide concentration with sea level rise and the number of EDPs, the model can be used to observe the direct impact of carbon dioxide concentration on the amount of EDP. In cultural loss risk rating model, the risk of cultural loss is decomposed into multiple indicators that can be quantified. The proposed fuzzy comprehensive evaluation method better represents the uncertainty relationship between various indicators, and the analytic hierarchy process has cleverly solved the subject of the index weight problem.

In the model, from the perspective of human rights, national responsibility and cultural protection, national morality and obligations, the economic environment and cultural environment of the aid country, it has good practical significance and consideration multifaceted on the issue of resettlement of EDPs.

5.2. Future work

Although the model in this paper considers the influence of economy, politics, law and culture, some details are not well done due to the limitation of time. For example, although this paper believes that talents are the main body of culture, if the environmental displaced people unconsciously inherit culture, even if they are treated friendly by the international community, their culture may face a crisis. In order to expand this detail, we use python to reflect the impact of human consciousness on cultural.
However, there is no policy to encourage EDP to protect their culture consciously. Considering the abandonment and inheritance of culture, this paper also does not stipulate the compulsory obligation of cultural inheritance. In addition, the resettlement model proposed in this paper does not take batch migration into consideration, and EDP group can only move to one country. Therefore, there are many things to consider in the future.

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