Future resettlement of environmentally displaced persons

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Abstract. With the development of human economy and society, there has been climate warming, sea level rise, resulting in many environmental displaced people. Their placement will become a serious problem in the future. In response to the increasing number of EDPs caused by sea level rise, first, we established a dangerous population prediction model, estimated the number of dangerous people over time by predicting sea level height, and established a cultural loss model to estimate EDP migration by quantifying cultural indicators. The problem of cultural loss in the process. Then, in order to effectively solve the problem and protect the human rights and culture of EDP, we have established a tripartite game model and concluded that the United Nations should have the right to speak on this issue and make a unified deployment for each country.

1. Introduction

1.1. Background
As a result of global warming, melting of polar glaciers, and thermal expansion of upper seawater, the issue of global sea level rising is becoming increasingly severe. Currently, researchers have identified several island nations, including the Maldives, Tuvalu, Kiribati and the Marshall Islands, as being at risk of disappearing completely due to rising sea levels. When the land of the island nation disappears, the people on the island become environmentally displaced persons (EDP), which not only needs to be relocated, but also risks losing their unique culture, language and way of life. There are many considerations and questions to consider on this issue, not only to determine how to move a certain number of people around the world, but also to recognize that these people are rights holders and the last living representatives of their unique culture. It needs to be considered from various aspects such as human rights, cultural protection, and time changes.

1.2. Our Work
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Then, in order to effectively solve the problem and protect the human rights and culture of EDP, we have established a tripartite game model and concluded that the United Nations should have the right to speak on this issue and make a unified deployment for each country.
2. Prediction Model of People at Risk
For EDPs, in order to better assess the climate risks facing island nations, the first thing we need to evaluate is the scope of the issue. Firstly, we build a fitting model of sea level data to predict the number of people who may be face risk from rising sea levels. Here, we takes Maldives as an example, collects its sea level observation data from 1880 to 2020 and establishes a prediction model.

Based on the observed data, we perform time series stationarity test on it. The time series and autocorrelation diagram of the time series are shown in Figure1 and Figure2.

![Figure 1. Time series](image1)

![Figure 2. Autocorrelation graph](image2)

It can be seen from the image that the sea level height sequence has a clear increasing trend, and by observing the autocorrelation graph, it indicates that the autocorrelation coefficient is located above the zero axis for a long time. Therefore, the series have strong instability.

Based on its unevenness, we use random dynamic fitting to fit the sequence.
Figure 3. Random dynamic fitting

Random dynamic fitting’s multiple R-squared is 0.9798, residual standard error is 4.79, which demonstrate that the average annual sea level rise is 2-4.6mm. Random dynamic model decomposes sea level height into four parts.

\[ Y(t) = T(t) + S(t) + I(t) \]

\[ T(t) = At + B \]

\[ S(t) = \sum_{i=1}^{k} \left[ a_i \cos \left( \frac{2\pi}{T_i} t \right) + b_i \sin \left( \frac{2\pi}{T_i} t \right) \right] \]

In the formula above, \( Y(t) \) represents the sea level sequence, \( T(t) \) represents the long-term trend of the sequence, \( C(t) \) represents residual random sequence, \( I(t) \) represents a white noise sequence, \( a_i, b_i \) represents the coefficient corresponding to the period \( T_i \).

After getting sea level forecast data, we use this as a basis to estimate the number of people who may face risk. The height of the sea level is \( H_s \), and the altitude of the area is \( h_a \). When \( H_s = h_a \), we define this area as a risk region. The number of people at risk in this area is

\[ M = \rho \cdot S \]

Among them, \( \rho \) is the population density and \( S \) is the new seawater coverage area.

At the same time, we also need to consider that some regions will suffer unexpected ecological disasters. For example, a major tsunami taking out a nuclear power plant and causing enough other significant damage that a more heavily inhabited nation may become uninhabitable. At this time, we need to conduct further expansion assessments. Considering that the ecological environment of some small countries is very fragile, it is difficult to withstand large ecological disasters. And it is in the predicament of sea level rise, so it is a wise method to include them in the risk population in advance, so we not only need to consider the country’s resistance to ecological disasters, we define an ecological resistance indicator:
There, $F$ is the anti-risk ability of the area, $F_1$, $F_2$, and $F_3$ are the basic settings, the anti-risk ability of economic development and land cover. All three have a role in fighting risk to a certain extent.

Combined with the sea level rise in the region, we can give priority to countries with weak ability to fight risks, and their numbers can be calculated by formula 5.

3. Policy Report: Individual, Nations or UN?

When we are considering policy making, we must see the conflict between idealism and realism in the migration process. As individuals, people have the right to choose to go to any country by themselves, but as countries, they will consider whether to accept immigrants from the perspective of practical interests. If the accepted immigration is good for them (such as increasing national reputation, bringing in labor, etc.), they will accept immigration. Otherwise, many countries will refuse to accept immigration due to the economic costs of immigration. In order to describe this process in more detail, we have established a dynamic game model.

- $E_g$: Efforts made by resettlement countries in accepting EDPs, such as the cost in approving EDPs and the cost of investing in resettlement.
- $C(i)$: EDPs' individual efforts in immigration. It is used to measure the subjective initiative of EDPs in the face of disasters, including the ability of information to be found in supply. We assume that $C(i)$ increases with the increase of the individual’s efforts, and because of the increasing marginal cost, $C(i)' > 0$.
- $prob_g$, $prob_1$, $prob_u$: Represents three probability functions jointly determined by government input $E_g$, individual efforts $C_i$, and United Nations efforts $E_u$ in resettlement. $prob_g$, $prob_1$, $prob_u$ represents the probability of resettlement success.
- $m_g$, $m_i$, $m_u$: Represents the benefits obtained by the three after the successful immigration. In order to simplify the calculation of the model here, we do not consider the specific size of $m$, only the probability of obtaining $m$.

In the course of the game, we assume that the game participants (the United Nations, resettlement countries, and immigrants) have common knowledge, that is, they have the same knowledge of the rules and processes of the entire game and their respective winning values under different decisions. In addition, this model also assumes that the game process is incomplete, which is reflected in the cost function $C(i)$ of the victims (also can be considered as their own level of effort $i$ is only known to them personally, central government and local the government cannot observe.

Through calculation, we can get a summary of the expected returns of all parties in the game:

| Participant       | Decision variable | Return value                                      |
|-------------------|-------------------|--------------------------------------------------|
| UN                | $E_u, P$          | $H_u = prob_u \cdot prob_1 \cdot prob_g \cdot (m_u - p) + p - E_u$ |
| Resettlement country | $E_g$            | $H_g = prob_u \cdot prob_1 \cdot prob_g \cdot (m_g - p) + p - E_g$ |
| Immigration       | $i$               | $H_i = prob_u \cdot prob_1 \cdot prob_g \cdot m_i - C(i)$ |

Calculate $\frac{\partial^2 H_g}{\partial E_g^2}$ and $\frac{\partial^2 H_i}{\partial E_i^2}$, the result is as follows.
Here \( \text{prob}^n \leq 0 \), which represents the decreasing probability margin of success, and according to the assumption, \( \text{prob}^s, \text{prob}^a, H_g, P \) are all positive values, \( \frac{\partial^2 H_g}{\partial E^2_g} \leq 0 \), \( \frac{\partial^2 H_i}{\partial E^2_i} \leq 0 \).

From the process of solving the game equilibrium state, it can be seen that as long as the sub-game equilibrium exists between the receiving country and the EDPs, an equilibrium solution exists in the entire game process. From equations (6) and (7), it can be seen that the expected return function of the receiving country and EDPs has a concave shape. According to the "Nash equilibrium point existence theory", it can be seen that this subgame has an equilibrium state, so there is equilibrium in the entire three-party game solution. Through backward induction, the equilibrium solution between the individual and the receiving country can be obtained first, and then the equilibrium solution for the United Nations can be obtained.

Next, we need to fully differentiate the expected returns of individuals and governments.

\[
\frac{\partial^2 H_g}{\partial E^2_g} = \text{prob}^s \cdot \text{prob}^n \cdot \text{prob}^a (H_g + P) \tag{6}
\]

\[
\frac{\partial^2 H_i}{\partial E^2_i} = \text{prob}^s \cdot \text{prob}^n \cdot \text{prob}^a (H_i - E(i)^n) \tag{7}
\]

Observing Equation (8), the first term on the right is the first-order partial derivative of the expected return function of the local government on the input variable \( E_g \). In equilibrium, this value is 0; the second term on the right is a positive value. Although increasing the efforts of the victims will increase their return value, due to the existence of opportunism, the victims will not actively increase their investment. Similarly, the government will not actively increase their investment funds to resettle the victims.

It can be seen that in the case where the United Nations only provides financial support, neither the government nor the individuals can reach their optimal choices, because the receiving country will not take the initiative to undertake more obligations to receive EDPs, invest more costs, and the EDPs will not take the initiative to go to provide information and supplies. Therefore, in order to maximize the interests of EDPs and recipient countries, the country’s own policies cannot be adopted. An organization that transcends the country needs to perform responsibility allocation and unified scheduling, that is, the United Nations. Therefore, we believe that when deciding who has the right to decide where the EDPs go, the United Nations should be called to coordinate the countries.

4. Conclusion
By using dynamic random fitting of 140 years of sea level data from 1880 to 2020, the annual rise of sea level is 2-4.6mm. Some of the world’s island nations are at risk of disappearing. On the question of how to relocate the environmentally displaced, The United Nations will be responsible for resettlement of EDPs. From our tripartite game model, we can see that when we give the right of choice to individuals or separate countries, we will not be able to maximize the interests of both parties due to opportunism. Therefore, the policy that UN is responsible for coordinated and unified arrangements can avoid the above situation and make each party agree on the principle of EDPs’ resettlement.
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