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New Home Plan: Right EDP's Rights

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Abstract: The well-founded concerns that the number of EDP fleeing untenable environmental conditions may grow exponentially as the world experiences the effects of climate change makes it highly urgent to develop strategies to prevent environmental migration and the conflict which may be related to it. This article looks at this issue from both aspects of human rights and culture preservation with New Home Plan (NHP), a sophisticated and generalized model established. Based on NASA data, this article forecasts the sea level before 2100 and predicts the total population and cultural value affected by the crisis while establishing models to characterize the dynamic impact of the rising sea level crisis on these countries. Containing Timing of Intervention Model (TIM) and Optimal Destination Matching (ODM), NHP applies indicators in economy, culture, geography and environmental contribution to select destination whilst attaching importance to human rights and timeliness. To check the robustness of the model, the authors conducted a simulation comparing situations with NHP and without it, the result of which indicates the exercise of NHP can better preserve culture and higher relocation efficiency.

Keywords: Sea Level Rise; EDP; New Home Plan; AHP

1. Introduction

Global warming causes fatal sea level rise in 21th century. The protection and relocation of environmental displaced persons (EDP) become a global concern. To address this situation, the scope of this issue was first studied. By predicting sea level rise, countries that may output EDP in the next 100 years were identified. Based on researches conducted by UNESCO, etc., the value of culture was estimated[1].

New Home Plan was established to assist EDP to relocate successfully, protect their life and human rights, and preserve their culture. NHP also raises suggestions to UN about when, why and how to step into the complicated issues of EDP. New Home Plan consists of Timing of Intervention Model (TIM) and Optimal Destination Matching (ODM).

Finally, New Home Plan and a situation without our proposal were evaluated, whose results reasonably indicates that it is imperative to let UN engage in as a supporter and supervisor at least when tipping point arrives if EDP's rights and culture are expected to be well-protected.

2. Assumptions

To better quantify the problem, our model is based on several assumptions that hold true in most cases or are indisputably satisfactory under government regulation.

Assumption 1 *After 2020, the rising rate of sea level is fixed at 3.6 mm per year.*

Assumption 2 *The EDP mentioned in this article only refers to people displaced by rising sea levels.*

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Assumption 3 *EDP becomes a citizen of destination country after the relocation, its regime no longer exists.*

Assumption 4 *The destination country must accept if all the conditions are met.*

Assumption 5 *EDP are rendered as no capability of relocating themselves.*

3. Scope of the issue

3.1 People at risk

To estimate how many EDP exist, first the sea level rise to year 2100 is predicted by NASA. The result shows that upon 2050 the sea level will be 172.5 mm higher than in 2000[2]. Assuming that the sea level rise rate is constant at 3.2mm per year, in 2100, the sea level will excess 352.3 mm. So, island nations with average altitude less than one meter are on the verge of destruction.

Then the sea-level-rise world map within year 2100 is simulated to determine the nations being affected. Area covered in blue indicates an altitude less than 4 meters. From 2019 to 2100, the blue area along the coast will gradually spread into the inland.

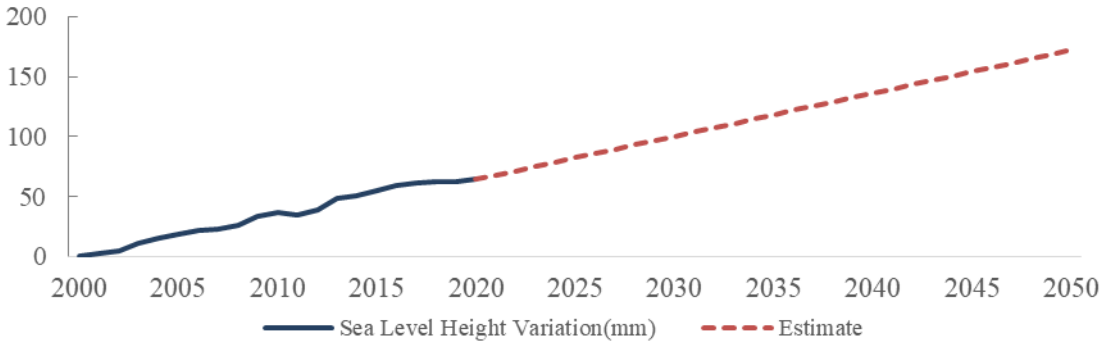

Figure 1. Sea level rising prediction**.**

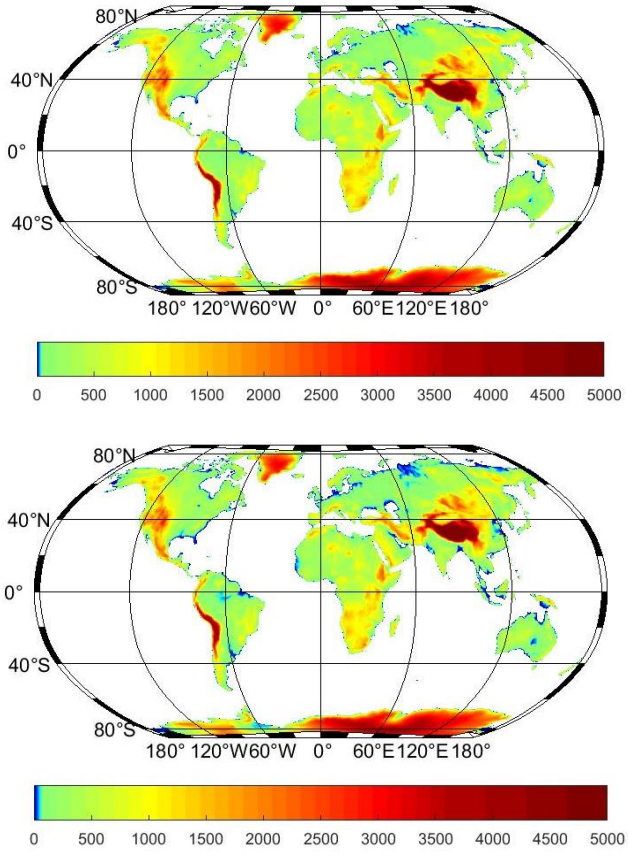

Figure 2. Areas at risk in 2019 and 2100**.**

	Average Elevation(cm)	Population(thousand)
The Republic of Palau	77	21
The Republic of Nauru	45	10.89
The Republic of The FiJi Islands	130	890.00
The Kingdom of Tonga	82	106.40
Federated States of Micronesia	79	540.00
The Republic of Maldives	54	530
Tuvalu	150	10.70
The Republic of Kiribati	200	120.00
The Republic of Marshall Island	300	61.96

Table 1. Information of island nations

Excluding the inland basins and islands that belong to other countries without crisis, 10 island nations are determined as victim nations, whose citizens are recognized as EDP in total 2.291 million.

3.2 Tipping point

Tipping point is defined as the moment when the island nation become inhospitable. r_i, the ratio of population density to GDP per capita at time i, is chosen as measurement here.

With the rise of sea level, the area of islands is shirking, so the residents are forced to move to higher places, which eventually leads to a surge in population density. Eqn (1) is to demonstrate this relationship:

$$r = \frac{\rho_t}{Per\ capita\ GDP} = \frac{R}{S} \times \frac{1}{Per\ capita\ GDP} = \frac{R}{G(\omega t)} \times \frac{1}{Per\ capita} \quad (1)$$

S stands for projected area of an island nation; $G(\omega t)$ indicates the relation function of sea level rising rate and time.

To clearly quantify the dynamic process of increasing population density as the sea level rises, the shape of the island is simplified to a cone, and the height of the cone will gradually decrease. So the ratio of the land projected area after to the before is equal to the ratio of the heights, then the land area at time i is computed.

On the assumption of the same population, it is easy to get the population density at time i. At the same time, that GDP per capita is assumed to decline in proportion to the shrinking island area. So:

$$r_i = \frac{\beta_i}{GDP_i} = \frac{R}{Projected\ Area_i} \times \frac{1}{GDP_i}$$

$$\frac{Projected_i}{Projected_0} = \frac{Height_i}{Height_0}$$

When r reached 0.08, the island should become an environmental hotspot and needs the help of the international community; when r is above 1, it is a tipping point and requires the compulsory intervention of UN or other international organizations; when the sea level rises above the island height, the island sinks.

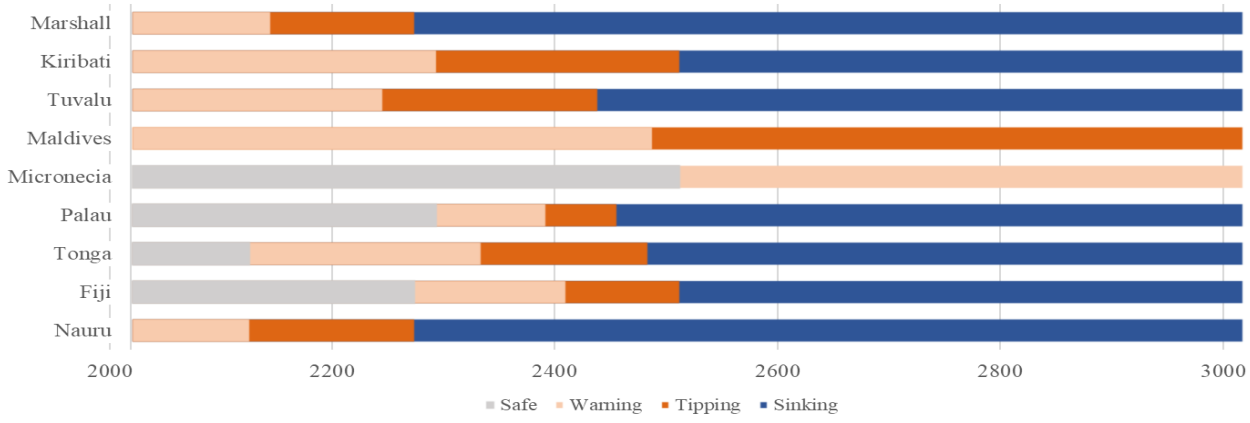

Figure 3. Tipping Point prediction.

3.3 Culture at risk

In the island nations of the Pacific Ocean and the Indian Ocean, intangible cultural heritage far from modern civilization is stored. If these cultural treasures are assimilated and eventually disappear, it will cause a catastrophe to human civilization.

4. Policy proposal: New Home Plan

New Home Plan consists of Timing of Intervention Model (TIM) and Optimal Destination Matching (ODM).

TIM focuses on the timing point starting to relocate, while ODM inclines to select an ultimate new home for EDP, which ensure that the interests of EDP would be optimized. The construction of ODM takes *adaption*, *culture and economy* into consideration, showing our concerns for both of the human right of EDP and the interest of host nations[3].

4.1 Timing of Intervention Model (TIM)

The timing model is built up to instruct UN, or other international groups when to intervene into the issue. With the rising sea level, part of residents of island nations would begin to realize that they need to be relocated elsewhere while others cherish their root. When 75% of the residents are willing to migrate, international organizations can start to offer assistance. UN respect their choice, willingness and freedom of migrating[4]. Not until the moment when this island is completely inhospitable, UN will not take action on people who are unwilling to leave.

So, the timing of intervention model is as Eqn (2):

$$T = \min(t_{willingness}, t_{tipping}) + C \tag{2}$$

C indicates the relocation time, anywhere between 3 to 24 months.

4.1.1 Willingness time

A translation matrix is first built to measure the probability of altering willingness.

$$Q_{ij}^{\rho_t} = \begin{matrix} \\ No \\ Slight \\ Strong \end{matrix} \begin{matrix} \begin{matrix} No\ willingness & Slight\ Willingness \end{matrix} \\ \begin{bmatrix} 1-\lambda_1\rho_t & \lambda_1\rho_t \\ 0 & 1-\lambda_2\rho_t \\ 0 & 0 \end{bmatrix} \end{matrix} \begin{matrix} \\ \\ \\ Strong\ Willingness \end{matrix}$$

$$\begin{matrix} \\ No \\ Slight \\ Strong \end{matrix} \begin{bmatrix} 0 \\ \lambda_2\rho_t \\ 1 \end{bmatrix} \tag{d}$$

To discuss all the details in TIM, firstly it is assumed that, within one year the number of residents who transferred from *No to Slight* and *Slight to Strong* complies with poisson distribution:

$$p(k_1) = \frac{e^{-\lambda}\lambda^{k_1}}{k_1!}, p(k_2) = \frac{e^{-\mu}\mu^{k_2}}{k_2!}$$

$$E(k_1) = \lambda, E(k_2) = \mu$$

Furthermore, the expectation number of people who transferred their willingness has positive correlation with the increasing population density $\rho_{(t)}$, so:

$$\lambda_1 = \frac{\lambda}{\rho_{(0)}}, \lambda_2 = \frac{\mu}{\rho_{(0)}}$$

Among it, $\rho_{(0)}$ stands for the population density at time 0.

The element in position (i,j) indicates the probability that residents' willingness transfers from state i to state j. For example, element (1,1) means that residents' willingness transfers from *No* to *No* (which means stay the same) is of the possibility of $1-\lambda_1\rho_t$. Element (1,2) shows that the possibility of willingness transfers from *No* to *Slight* is $\lambda_1\rho_t$. Element (3,3) indicates that possibility that willingness stay at *Strong* is 1, which means it is a recurrent state.

Next, a will vector is developed to describe the number of residents who have no, slight and strong willingness respectively.

$$X_{(0)} = [a, b, 1-a-b]R = [aR, bR, (1-a-b)R]$$

Among the vector, $X_{(0)}$ means the number of residents at time 0; $a, b, 1-a-b$ are proportion of no, slight and strong willingness at time 0; while R stands for the total population.

After one year at time 1, based on our translation matrix:

$$X_{(1)} = X_{(0)}Q_{ij}^{\rho_{(0)}}$$

Accordingly:

$$X_{(t)} = X_{(t-1)}Q_{ij}^{\rho(t-1)}$$

So, the transitions from time 0 to time t can be illustrated as:

$$X_{(t)} = X_{(0)} \prod_{i=0}^{t} Q^{\rho(i)}$$

Therefore, the number of residents who have strong willingness to move is:

$$Strong = X_{(t)}\begin{bmatrix}0\\0\\1\end{bmatrix} = X_{(0)}\prod_{i=0}^{t} Q^{\rho(i)}\begin{bmatrix}0\\0\\1\end{bmatrix}$$

Because of complicity of calculating people who have strong will willingness, we choose to calculate people with no and slight willingness:

$$No = R\left[a\prod_{i=0}^{n-1}(1-\lambda_1\rho_i)\right]$$

$$Slightly = R\left\{a\lambda_1\sum_{i=0}^{n-1}\rho_i\left[\prod_{j=0}^{i=1}(1-\lambda_1\rho_i)\prod_{k=i+1}^{n-1-i}(1-\lambda_2\rho_k)\right] + b\prod_{i=0}^{n-1}(1-\lambda_2\rho_i)\right\}$$

$$Strong = R - No - Slightly$$

And it is the time that people of strong intention has occupied 95% of the total UN take action.

$$\frac{Strong}{R} \geqslant 95\% \tag{3}$$

Eqn(3) is determined as Key Function, and t can be solved through to get the willingness time.

4.1.2 Tipping point

Although the individual choices of the local people were taken into account, when the island nation becomes completely uninhabitable is the tipping point, and the UN will come forward to assist local government a forced evacuation.

The moment when the r reaches 1 we can get our tipping point.

$$\begin{cases} r = 1 \\ t = Tipping\ Point \end{cases}$$

4.2 Optimal destination matching

First of all, the relocation of the victim nations as a unit is believed to score the highest in their survival and cultural preservation of EDP. This model is for UN to evaluate different countries who prepare to receive EDP, in order to match the optimal destination for victim nations.

In the evaluation process, *economic status*, *social culture*, *and geographical factors* were chosen as indicators. *Environmental contribution* is taken as a penalty term, and when the host nation has done more damaging to the environment, there will be a greater possibility of accepting EDP.

4.2.1 Indicators details

Economic Status (***ES***)

Per Capita GDP. With higher per capita GDP, the destination country would possess more fiscal power to settle down EDP. To achieve dimensionless and normalization, the economic indicator is established as Eqn (4):

$$Economic\ Indictor = \frac{Per\ capita\ GDP_i - \min}{\max - \min} \tag{4}$$

Social Culture (***SC***)

Linguistic Proximity. With higher linguistic proximity, the languages of EDP can be protected more easily. This indicator is defined as the degree of language similarity. Firstly, a five-dimensional state vector is established as Eqn (5). If the victim nation and the host nation meet one of the states, we assign 1 to the element and 0 to the rest. Furthermore, the similarity value vector is applied to weight the linguistic proximity indicator Eqn (5).

$$State\ vector = \begin{bmatrix} Different\ Family\ Trees \\ Different\ Branches \\ Same\ Branch \\ Same\ Subrance \\ Same\ Language \end{bmatrix} \tag{5}$$

$$Proximity\ vector = [\alpha_1\ \ \alpha_2\ \ \alpha_3\ \ \alpha_4\ \ \alpha_5] \tag{6}$$

$$Linguistic\ Proximity = Proximity\ vector \times State\ vector \tag{7}$$

Religious Inclusiveness. Similarly, a relationship vector Eqn (8) is to demonstrate five different correlations between the EDP's religion and religion of the host nation. Then, the inclusive vector is built to give the varied weight, which forms religious inclusiveness indicator Eqn (10).

$$\mathrm{Re}lationship\ vector = \begin{bmatrix} Complete\ Confrontation \\ Slight\ Confrontation \\ No\ Confrontation \\ Slightly\ the\ same \\ Exactly\ the\ same \end{bmatrix} \tag{8}$$

$$Inclusive\ vector = [\beta_1\ \ \beta_2\ \ \beta_3\ \ \beta_4\ \ \beta_5] \tag{9}$$

$$Religious\ Inclusiveness = \mathrm{Re}lationship\ vector \times Inclusive\ vector \tag{10}$$

Race. It is deemed that the sense of identity between the same race or the same color excess interracial groups. Therefore, the race indicator, a dummy variable, is defined as Eqn (11):

$$Race\ Indicator = \begin{cases} 0, & for\ not\ in\ the\ same\ race \\ 1, & for\ in\ the\ same\ race \end{cases} \tag{11}$$

Geographical Factors (***GF***)

Terrain. Whether the victim nation and the host nation are of the same terrain influences their accommodation and cultural preservation. It is assumed that all the EDP from island nations will migrate to region along the coast, in order to protect their unique techniques and culture heritage.

$$Terrain\ Indicator = \begin{cases} 0, & for\ not\ in\ the\ same\ terrain \\ 1, & for\ in\ the\ same\ terrain \end{cases} \tag{12}$$

Climate Alikeness. Analogously, Climate Coordinate System is constructed to describe the climate alikeness between the victim nation and the host nation. According to the climate types of the two countries, two points are determined in the coordinate system, and the euclid distance between the two climate reflects the differences. In order to assimilate the indicator and normalization, the indicator is adjusted as Eqn (13):

$$Climate\ Alikeness = 1 - \frac{Climate\ Euclid\ Distance}{Diagonal\ Length} \tag{13}$$

Environmental Contribution (***EC***)

National Carbon Emission. It is believed the catastrophe happened upon the victim nations should be blamed on countries who release massive carbon dioxide to the environment to some degree. To give a penalty, the Carbon Indicator is set up as Eqn (14):

$$Carbon\ Indicator = \frac{Carbon\ Emission_i - \min}{\max - \min} \tag{14}$$

EDP Saturation. Apart from the rights of EDP, the host nation's welfare is also taken into consideration. To maintain the ideal population density of host nations, a EDP saturation indicator is amended. If the host country has accepted certain number of EDP, then it will have no further obligation to receive more.

$$EDP\ Saturation = 1 - \frac{Accepted\ EDP}{Admissive\ EDP}$$

Optimal Matching Process

First we build up an indicator vector containing four imperative aspects in the evaluation, and to aggregate all the indicators above, we apply AHP to determine the weights:

$$IV = [EC\ \ ES\ \ SC\ \ GF]$$

$$Q = [\lambda_1\ \lambda_2\ \lambda_3\ \lambda_4] = [0.15\ 0.48\ 0.27\ 0.10]$$

So the final evaluation grade s is calculated by Eqn (15):

$$s = Q^T IV \tag{15}$$

Consequently, the optimal destination for a victim nation is the one who are assessed with highest. As we've already take EDP saturation into consideration, there's little possibility that two victim nations have the same optimal destination.

	Nauru	Fiji	Tonga	Palau	Micronesia	Maldives	Tuvalu	Kiribati	Marshall
λ_1	0.18	0.012	0.012	0.013	0.017	0.113	0.139	0.143	0.001
λ_2	0.36	0.2	0.4	0.6	0.44	0.18	0.68	0.32	0.001

Table 4. Poisson parameters

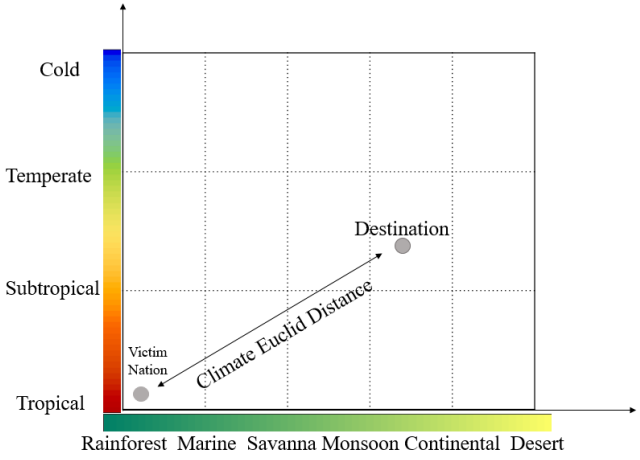

Figure 4. Climate alikeness coordinate system.

5. Policy evaluation

5.1 Relocating: NHP

5.1.1 Intervention time

According to our Time Intervention Model (TIM), the circumstances of 9 island nations are simulated, both the willingness transferring status and sinking time.

Next, based on the investigation of UNHCR, the distribution of people's transferring will in 9 countries is simulated to obtain the parameters in translation matrix.

By solving their key functions we can get the $t_{willingness}$ when 60%, 75% and 95% people agree to move. Along with the tipping point of these nations calculated before, the intervention time is computed.

5.1.2 Optimal destinations for EDP

Based on UN database as well as our ODM model, we obtain the optimal host country who get the highest score while capable of acceptance for 9 island nations[5].

5.2 Relocating: Without NHP

5.2.1 Relocating time

Without an international organization or government's help, it is assumed that residents leave gradually in accordance with the rising sea level. Situations in 9 nations are simulated respectively based on NASA data and UN reports. After fitting the willingness shifting distribution, we obtained data on the number of people on the island over time:

Also, we forecasted the moment when all the residents are relocated through our simulation, all of which are later than UN intervention time in NHP.

5.2.2 Destinations for EDP

It is believed that without the assistance of any international organization, residents will only consider distance when they endeavor to relocate. Therefore, it is deemed that the residents' migration nation will be an even distribution related to distance. Based on data from Google Earth, the distribution shows island nations in Oceania mainly relocate in New Zealand while Asian nation chooses Bhutan most. The concentrated destination countries that don't take economic status into consideration may result in intense resources for EDP and low degree of culture protection[6-8].

Year	Nauru	Fiji	Tonga	Palau	Micronesia	Maldives	Tuvalu	Kiribati	Marshall
TW(60%)	2020	2152	2058	2146	2455	2094	2020	2020	2226
TW(75%)	2039	2188	2075	2177	2546	2115	2041	2055	2230
TW(95%)	2066	2257	--	2225	2765	2163	2081	2096	2236
Warning	--	2275	2127	2295	2513	--	--	--	--
Tipping	2127	2411	2335	2393	3019	2489	2247	2295	2146
Sinking	2275	2513	2485	2457	--	3019	2440	2513	2275

Table 5. Intervention time

Optimal Host Nation	
Palau→ Trinidad and Tobago	Maldives→ Singapore
Nauru → Australia	Tuvalu→ USA
Fiji → Australia	Kiribati→ New Zealand
Tonga→ USA	Marshall Island → UK
Micronesia→ Australia	

Table 6. Optimal host nation

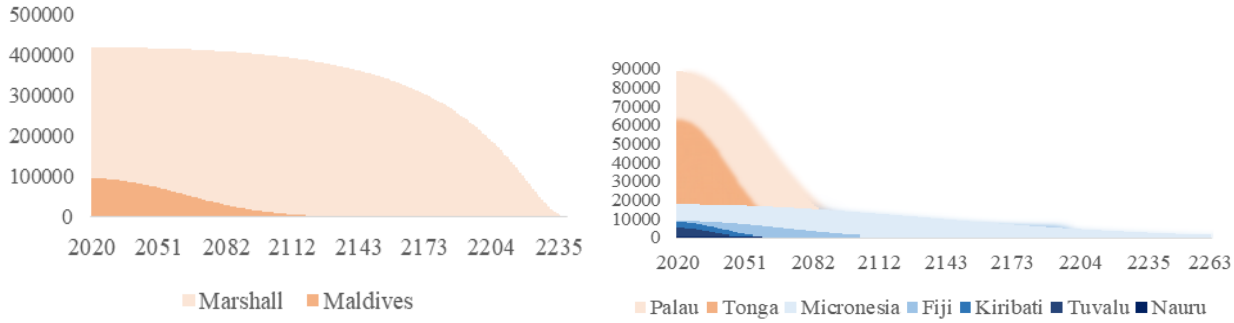

Figure 5. Residents flow.

	Relocation Year	NHP
Palau	2156	2177
Nauru	2059	2039
Fiji	2193	2188
Tonga	2101	2075
Micronesia	2493	2230
Maldives	2171	2115
Tuvalu	2082	2041
Kiribati	2097	2055
Marshall Island	2240	2230

Table 7. Relocation year

Population	Australia	New Zealand	Papua New Guinea	Solomon Islands	Vanuatu	Population	Australia	New Zealand	Papua New Guinea	Solomon Islands	Vanuatu
Palau	2975	8225	1400	2975	5425	Tuvalu	2955.25	2482.41	2364.20	1536.73	1359.41
Nauru	2472.05	3708.07	1483.23	1606.83	1606.83	Kiribati	437.04	437.04	288.61	206.15	206.15
Fiji	1725.41	1083.40	1845.79	1083.40	642.01	Marshall	15433.16	16124.20	10595.90	8753.14	11056.59
Tonga	1277.31	741.66	1236.10	906.47	700.46	Total	28106.47	33980.65	19742.81	17581.59	21661.47
Micronesia	831.26	1178.88	528.98	513.87	665.01	Tuvalu	2955.25	2482.41	2364.20	1536.73	1359.41

Population	Bangladesh	Bhutan	India	Nepal	Pakistan	Sri Lanka
Maldives	95156.25	117031.25	12031.25	92968.75	76562.5	26250

Table 8&9. Results

6. Conclusions

This article focuses on the sea-rising issue from both the aspect of human rights and culture preservation and proposed New Home Plan (NHP) containing Timing of Intervention Model (TIM) and Optimal Destination Matching (ODM). It concerns about economic status, culture similarities, geographic status and environmental contribution to select destination whilst attaching importance to human rights and timeliness. In our simulation of relocation circumstances, the robust result that NHP outperforms in dimensions of economy, timing and culture convinces us that UN's role in EDP issue is indispensable.

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