Evaluation of the EDPs’ Cultural Assimilation Based on Epidemic Model

Shubai Chen¹, and Shuo Sun²

College of Computer and Information Science, Southwest University, Chongqing, 400700, China
E-mail: chansuba@email.swu.edu.cn gmqss3690@email.swu.edu.cn

Abstract. In recent UN resolutions, EDPs are defined as refugees. Based on the systematic effects caused by EDPs, we propose an optimization model to predict the number of EDPs and protect the traditional culture of EDPs. Based on the basis of our proposed model, we can demonstrate the importance of the policy proposed based on our model.

Firstly, we use climate phenomena such as sea-level rise and soil desertification to determine the countries at risk. Kiribati and Mongolia are studied in our model. We propose to use the power-law distribution to calculate the number of EDPs in the countries at risk. Through the qualitative analysis, it shows that “national collective migration to countries with similar cultural backgrounds” can effectively reduce the risk of cultural loss.

Secondly, in terms of cultural protection, we use SIS and SEIR infectious disease models to simulate the process of cultural assimilation and budget the time needed for cultural assimilation of EDPs. We also revised the policy according to the index of refugee and the speed of cultural assimilation. (1) international organizations should give appropriate economic assistance to the recipient countries. (2) the recipient country should take strong cultural protection measures when EDPs start to migrate. (3) the recipient country should try its best to provide jobs to EDP without harming the interests of its own people.

Finally, we proposed an optimization model to verify that when the policy is implemented, the cultural protection has been greatly improved. By comparing with the natural state of the policy not adopted, the importance of the optimization model of human rights and cultural protection based on EDPs proposed by us is illustrated.

1. Introduction

1.1. Problem Analysis
Researchers have identified several island nations, such as The Maldives, Tuvalu, Kiribati, and The Marshall Islands, as being at risk of completely disappearing due to rising sea levels. Not only do these environmentally displaced persons (EDPs) need to relocate, but there is also risk of losing a unique culture, language, and way of life.

In this paper, we aimed to solve the following problems:

(i) Analyze the increasingly serious EDPs problems from the number of people at risk and the risk of cultural loss.

(ii) Model the potential impact of proposed policies and analyze the model and propose improvement policies.

(iii) State the importance of the proposed policy.
1.2. Assumptions
(i) Ignore how long it takes refugees to move.
(ii) The ethnic population of refugees will not change for a certain period of time.
(iii) Refugees are identical in body and mind and will not die in the process of transfer.
(iv) Cultural assimilation takes place within a closed system.
(v) Culture in refugee-receiving country tends to assimilate the EDPs culture.
(vi) Because traditional cultures are adaptive, assimilated cultures have a chance to recover.

2. Analysis of People under Risk and Culture Loss

2.1. Number of People under Risk

2.1.1. The Total Number of EDPs
Extreme environmental changes are happening around us. Its rapid changes and significant influence are far beyond the imagination of most people in the industrialized world. According to the statistics from the World Health Organization, about 300000 people die every year because of the climate change; The “Right to Survive Report” released by Oxfam in May 2009 predicts that by 2015, the number of people affected by the global environmental crisis will increase by 54% and to total number of 375 million; by 2050, it is estimated that 200 million people will become EDPs. The Figure1 illustrate the environmental refugees ranges from 1990 to 2018.

2.1.2. Estimated Number of EDPs in Various Countries
Hans Roslyn, a Swedish doctor and statistician, divides the world’s income level into four levels, among which the high-income level is “32 dollars or more per day” (> 11680dollars/year). At present, only one billion people in the world are above this income level. Therefore, the number of people in the high-income level should be removed from the EDPs, because they have the ability to migrate to developed countries and meet the living standards of developed countries.
Figure 1. Environmental refugees from 1990 to 2018

By analyzing the global averaged sea level anomalies Figure 2 from 2005 to 2019, we finally identified several countries in need of migration. Taking Maldives as an example, the average altitude of the country is 1.2 meters, and 80% of the country’s territory is not higher than one meter. Research shows that Maldives may no longer be suitable for human survival due to sea-level rise when 50 years later. Therefore, Maldives should complete the migration.
of the national population within 50 years. The United Nations predicts that the number of Maldives population will reach 575,584 by 2070. The average GDP of the Maldives given by the World Bank is 10,223.64 US dollars. The Maldives is a developing country, and the ratio of per capita income to GDP of developing countries is about 0.4, thus, the per capita income of Maldives is about 4,089.456 yuan. The studies from Pareto, an Italian economist, illustrated that the statistical distribution of personal income conforms to the power-law distribution, and proposed that 20% of the people in the society hold 80% of the wealth, namely Pareto’s law. Based on this, the income distribution map of Maldives can be calculated according to the future population (n) and per capita GDP (gdp), which is illustrated in Figure.3.

\[
\frac{\int_1^{0.2n} b x^n dx}{\int_1^n b x^a dx} = 0.8 \\
\int_0^n b x^a dx = 0.4 n gdp \\
y = b x^a
\]

![Image](image.png)

Figure 3. High-income Bracket in Malaysia

Based on the model, it can be concluded that there are 13,630 people in high-income level in Maldives, so the number of EDPs in Maldives should be 561,954, and the number of people to be relocated each year should be 11,240.

The data of Tuvalu, Kiribati, Mongolia and other countries are substituted into the model and the Table 1 is obtained.

2.2. The Risk of Loss Culture

Human is the fundamental carrier of culture. The individual migration or extremely limited number of migration of immigrants from a certain cultural area make the traditional culture carried by them lack of systematization. And in the process of migration, its original cultural background information is
constantly declining and

Table 1. EDPs in Several Country

| Country  | High Income Population | Total Forecast Population | Total numbers of EDPs |
|----------|------------------------|---------------------------|-----------------------|
| Maldives | 13,630                 | 575,584                   | 561,954               |
| Tuvalu   | 77                     | 16,309                    | 16,232                |
| Kiribati | 620                    | 209,956                   | 209,336               |
| Mongolia | 42,100                 | 34,536,345                | 3,494,245             |

it is difficult to aggregate and reproduce the original form of its culture in the place of immigration. Therefore, only when the whole country moves to a country with similar cultural background can effectively reduce the risk of cultural loss.

Tuvalu, the world’s first country to be submerged by sea water, proposed the similar solution in 2000: moving the country into New Zealand in batches. New Zealand and Tuvalu have the same language, the same religion, close geographical distance, and both belong to Oceania island countries. Moreover, they both have similar living customs and culture. Thus, the collective migration to New Zealand can reduce cultural conflicts and protect Tuvalu culture to the greatest extent.

3. Policies for Cultural Protection

Refugee-receiving country should establish cultural reserves for EDPs from the same country. The refugee-receiving country has the obligation to set up an area for EDPs to live in to protect their original culture. In this way, EDPs living in the region can be more exposed to people in their original countries, thus reducing the risk of cultural assimilation in the countries where the original culture is funded. However, refugee-receiving country should not restrict the scope of EDPs’ activities, and should also help some of them who are unwilling to live in cultural reserves.

4. Cultural Assimilation Based on SIS and SEIR Model

In chapter 3, our team proposed some policies to address EDPs’ human rights and cultural preservation, in consideration of immigration countries. In this section, we model the risk of cultural disappearance and assimilation according to the migration speed of EDPs. With the help of SIS infectious disease model, we propose that in addition to the relevant cultural protection measures, we should also conduct artificial intervention on cultural protection at key time points to reduce the speed of cultural assimilation.

4.1. SIS Model

(i) Model assumption

The region during the spread of the disease is regarded as a closed system, so the total number of people N is unchanged, and the population is divided into Susceptible and Infectious. The proportion of the population in the time stamp t is S(t) and I(t). The proportion of Infectious patients cured per day to the total number of Infectious patients is γ. The working principle of this model is shown in the figure4.
(ii) **Model Establishment**

The differential equations for \( S(t) \), \( I(t) \) is defined as follows:

\[
\begin{align*}
\frac{dS}{dt} &= -r \beta S \frac{I}{N} + \gamma I \\
\frac{dI}{dt} &= r \beta S \frac{I}{N} - \gamma I 
\end{align*}
\]

4.2. **SEIR Model**

(i) **Model assumption**

The region during the spread of the disease is regarded as a closed system, so the total population \( N \) is unchanged, the population is classified as Susceptible, Infectious, Exposed and Recovered, and the proportion of people in time stamp \( t \) is \( S(t) \), \( I(t) \), \( E(t) \) and \( R(t) \). Each of these Susceptible is likely to become Exposed with probability of \( \beta \), and Exposed with probability of \( \sigma \) to become Infectious. Infectious agents can be Recovered after treatment. The working principle of this model is shown in the Figure5.

(ii) **Model Establishment**

The differential equations for \( S(t) \), \( I(t) \) is defined as follows:

\[
\begin{align*}
\frac{dS}{dt} &= \mu N - \nu S - \frac{\beta SI}{N} \\
\frac{dE}{dt} &= \beta SI - \nu E - \sigma E \\
\frac{dI}{dt} &= \sigma E - \gamma I - \nu I \\
\frac{dR}{dt} &= \gamma I - \nu R
\end{align*}
\]
4.3. Cultural Assimilation Model

In the model of cultural assimilation, we simulate the process of cultural assimilation with the spreading process of the SIS infectious disease model. We assume that the EDPs from the same country move into the same part of the refugee receiving countries in batches every year. Therefore, this area is regarded as a closed system in the SIS model of infectious diseases. The traditional culture of EDPs is regarded as Susceptible, while the culture of EDPs has been regarded as Infectious by an assimilated culture. In the process of cultural assimilation, due to the adaptability and clustering of traditional culture, the assimilated part may recover. Since cultural assimilation is a difficult problem to quantify, in order to simplify the model, the total number of EDPs is used in this example to replace the traditional culture, and the number of people who accept the local culture is used as the assimilated part of the culture. Since the number of first-year arrivals is small and easily assimilated, the EDPs arriving in the refugee receiving countries in the first year is the initial number of infections. Our team made the following modifications to the SIS model. The recovery factor was the probability of Infectious being cured /gamma, that is, the national population that EDPs came into contact with while living in the refugee receiving countries. Taking into account both the immigration plan and the local population, the revised formula is:

$$\gamma = \frac{\text{newEDPs}}{\text{totalEDPs}}$$
$$\beta = \frac{\text{totalEDPs}}{\text{population of refugee receiving countries}}$$

The diagram6 simulates the process of cultural assimilation in terms of number of people.

4.4. Policy Analysis

4.4.1. Recipient countries should anticipate and prepare for the EDP issue in advance and actively seek through negotiations the annual MIGRATION PROGRAM in a given

(a) (b)

Figure 6. Evolution of cultural Assimilation. White represents traditional culture of EDPs, red represents assimilated culture of EDPs.

region. The process of cultural assimilation is influenced by the surrounding environment. As EDPs from the same country increase in the refugee receiving countries, the rate of cultural assimilation will slow down. In this model, we simulate this process by increasing the recovery coefficient of $\gamma$ year by year, that is, due to the self-adaptability of culture, the assimilated part can be restored to traditional culture. In this paper, we take EDPs from Mongolia and EDPs from Kiribati as examples to calculate the year when the rate of cultural assimilation turned a turning point. It is worth noting that since the country to be immigrated from Mongolia is China, and the neighboring province of Inner Mongolia is of the same origin as Mongolia, the population of Inner Mongolia is added to the total population of EDPs from Mongolia to calculate the assimilation process of Chinese civilization to nomadic civilization. The cultural assimilation process of EDPs from Mongolia and EDPs from Kiribati is shown in the Figure7:
4.4.2. The sponsoring country shall establish cultural protection areas for EDPs from the same country. In the figure above (there is a hyperlink here), the rate of cultural assimilation in Mongolia accelerated in about 100 years with the coefficient of recovery unchanged, and accelerated in about 200 years after the coefficient of recovery was corrected. When the speed of cultural assimilation reaches an inflection point, it proves that the current cultural protection measures are no longer applicable. Therefore, manual intervention should be carried out again at this point, such as the establishment of cultural protection areas. In this cultural conservation intervention, we used the SEIR infectious disease model. In the SEIR Infectious disease model, the probability of an infection from the Infectious state becoming exposed in the Susceptible state is constant under natural conditions, but in the real world we can often reduce this probability. For example, by isolating the source of the infection. The process of cultural assimilation is similar to the spread of infectious diseases. When the speed of assimilation reaches an inflection point, we will isolate the source of infection for those who are in the Susceptible state. In other words, we will set up

![Figure 7](image1.png)

![Figure 7](image2.png)

![Figure 7](image3.png)

![Figure 7](image4.png)

Figure 7. a: cultural assimilation process in Mongolia (constant coefficient of recovery); b: cultural assimilation process of Mongolia (recovery coefficient increases year by year); c: cultural assimilation process in Kiribati (constant recovery coefficient); d: the process of cultural assimilation in Kiribati (the recovery coefficient increases year by year);

a cultural protection zone for EDPs, which can slow down the intensity of cultural assimilation. In the Figure8, we made a comparison between intervening at an inflection point and not intervening at all.
4.5. Policy Improvement

- The Refugee receiving countries should carry out stronger cultural protection measures when the EDPs began to immigrate.

In the early years of the migration program, the culture was easier to be assimilated because EDPs from the same country were smaller. Strong protection at this point in time is equivalent to reducing the number of initial infections in the SIS model.

- The Refugee receiving countries should provide as many jobs as possible to improve the ability of the EDPs to combat cultural assimilation without harming its own people.

5. The Importance of Culture Protection

In this section, an explanation of the importance of implementing our proposed policies will be shown based on our analysis.

- The Refugee receiving countries should carry out stronger cultural protection measures when the EDPs began to immigrate.

In our SIS based cultural assimilation model, the number of Infectious agents in time stamp $t = 0$ will greatly affect the speed and breadth of cultural assimilation. As shown in the following figures, figure (a) shows the initial Infectious population of $4,187$, which means the number of EDPs immigrants in the first year, and figure (b) shows the initial Infectious population of $100$ (assuming), and the turning point of cultural assimilation is delayed by $50$ years. Therefore, in the first year of the migration program, cultural protection measures for EDPs will greatly affect the rate of cultural assimilation, which is shown in Figure 9 (b).

Figure 8. Comparison between Intervening at an Inflection Point and Not Intervening at All.

Figure 9. Cultural Assimilation of the Kiribati residents (under different Infectious Population)
The Refugee receiving countries should help the EDPs immigrate to the same area. If EDPs immigrants were scattered throughout the refugee receiving countries, the traditional culture of the EDPs would quickly be assimilated. For example, the plan for Kiribati migration to Australia is carried out under that Kiribati residents are randomly resettled throughout Australia. Due to the impact of local culture, it is difficult for dispersed people to stick to their traditional culture. Therefore, we adjusted the proposed model in chapter 3 to study the cultural assimilation of EDPs of immigrants in each year. The initial number of assimilation corresponds to the initial number of infection in the SIS infectious disease model, which is 1 person. As the total number of EDPs decreased, we amplified the rate of erosion of local culture in equal proportion. The result is that traditional EDPs culture can be fully assimilated in only 40 years. Therefore, it is extremely necessary to adopt the measures to protect local culture put forward in chapter 2 and chapter 4 which is shown in Figure 10.

![Figure 10. Cultural Assimilation of The Kiribati residents (Without Protection)](image)

6. Conclusion
In this paper, a novel optimization model for cultural protection is proposed which not only simulates the process of cultural assimilation but also improves the importance of cultural protection policies.

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