Implementations of Nuclear Climate Justice Reflecting the IPCC Sixth Assessment Report (AR6) Keeping 1.5 °C: Honorable Nobel Prize in Physics for Carbon Neutrality

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1. Introduction

The Sixth Assessment Report (AR6) of the United Nations (UN) Intergovernmental Panel on Climate Change (IPCC) showed the keeping of 1.5 ^oC increasing as the important point [1]. Following the mood of global climate interests, the Nobel Prize in Physics 2021 was awarded in climate change problem seeking the carbon neutrality [2]. Therefore, reasonably, it is studied that the social evolutions for the energy transition incorporated with the energy mix are focused on the non-carbon emitted nuclear energy development reducing the fossil fuels such as coal and oil. There is the analogy of the mutation-based evolutions of life with quantitative calculations for the behavior of a society in Fig. 1.

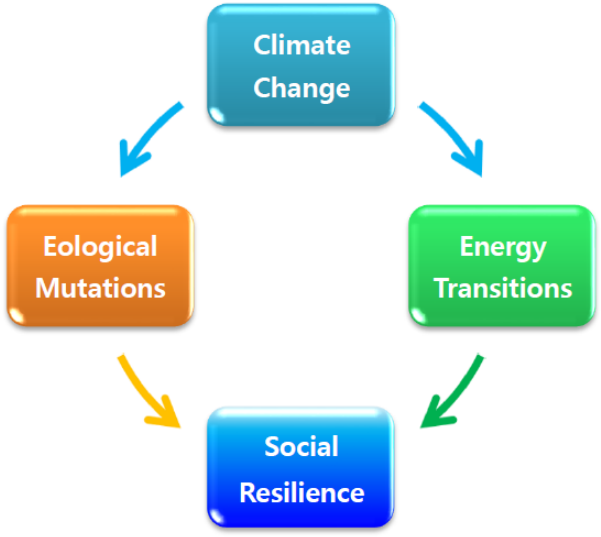


Fig. 1. Analogy between ecological evolutions and energy transitions as the specific links for conclusions to this study from climate change to social resilience.

This could be the specific links for conclusions to this study from climate change to social resilience. Present society has been reformed by non-contacted communications like the social networking service (SNS) under the pandemic situation, which have been dominant methods in visual and audio transportations between individuals.

By the statistics, the early stage of the COVID-19 in Seoul, Korea, showed the confirmed patient was very low. The list of confirmed patients in Seoul for two years is given in Table 1 [3]. The periodically and the accumulated patient number increases gradually and the central government has made administrative guidance of the social distance where it shortens business hours and enforces empty seats. There are some studies for infectious disease impact [4-6].

Table I: List of confirmed patients in Seoul, Korea [3].

Date	Patient	Accumulated
2020/01/25	1	0
2020/03/01	5	87
2020/05/01	1	634
2020/07/01	9	1,322
2020/09/01	103	4,018
2020/11/01	45	6,057
2021/01/01	363	19,393
2021/03/01	92	28,331
2021/05/01	195	38,031
2021/07/01	333	50,319
2021/09/01	665	80,016
2021/11/01	646	120,237
2022/01/01	1,464	226,691

For the key point of study, Fig. 2 shows the ecological evolutions by mutations in which the mutation-based evolution is progressed. According to literatures, the evolution game theory (EGT) papers mimicked the ecological phenomena for application into the nonlinear social mechanism [7,8]. Furthermore, the system dynamics (SD) was applied to EGT [9] where the SD is used for the modeling of the scientific and technological analysis in social matters [10].

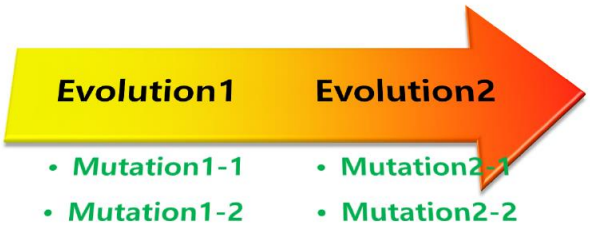


Fig. 2. Ecological evolutions incorporated with mutations.

2. Methods

Making use of the characteristics of the climate resilience for cooling the weather, the gene's behaviors are utilized as mutations and evolutions. The procedure of the study is shown in Fig. 3 where the climate change is the first cause factor in this investigation. This infers the mutation of Hardy-Weinberg Principle and the evolutionary game of Bishop-Cannings Theorem. After then, the modeling is constructed by the SD and the resilience by energy mix is analyzed.

In the 1st generation of a dominant gene G, the gene frequency of G is described as [11,12],

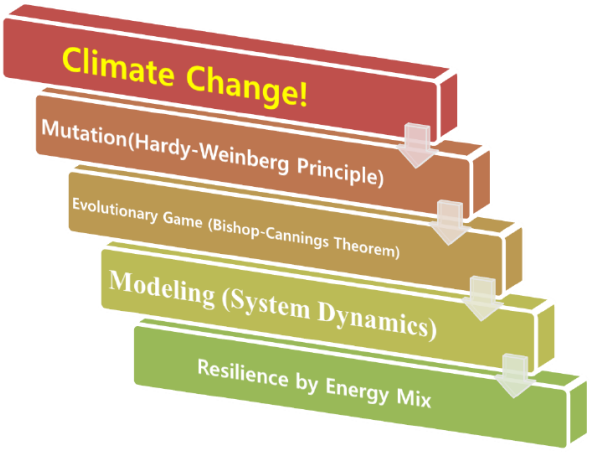


Fig. 3. The procedure of the study.

$$\alpha + \beta = k \tag{1}$$

where α and β are the genotype frequency. As the 2nd generation's gene frequencies, the dominant gene G is described as,

$$k^2 + kh \tag{2}$$

So, the implications of evolutions and game theory, EGT is applied to this study which was created by John Maynard Smith and George R. Price for the gaming algorithms [13]. The mathematical descriptions for the quantifications are performed by Parker and Thompson which is as follows [14],

$$p(s) = \frac{e^{-s/W}}{W} \tag{3}$$

where the specific value is W. If the generation's gene frequencies are broken, it could be written by a form as follows,

$$as^2 + bs \approx as^2 \tag{4}$$

So, the equation (5) can be written as,

$$p(s) = \frac{e^{-(as^2)/W}}{W} \tag{5}$$

by integrating between 0 and c, using,

$$p(c) = \frac{1}{W}\sqrt{\frac{\pi}{4a}}\, erf\left(\sqrt{\frac{a}{W}}\, c\right) \approx \frac{c}{2W}\sqrt{\frac{\pi}{W}} \tag{6}$$

Then, the SD modeling can be constructed in the form of simplified equation as,

$$p(c) \approx \frac{c}{W^{2/3}} \tag{7}$$

So, c is the designed period and V is the random number for meaning the gene quantity in the mutation-evolution formula. So, it is shown mathematically in SD form as,

$$Output = f(t_0) + f(t_1) + f(t_2) + \cdots + f(T) = \int_0^T f(t)dt \tag{8}$$

$$f(t_i) = \frac{C}{W^{2/3}} \approx Rational\ number\ form \tag{9}$$

Fig. 4 shows the SD modeling in which the SD presented as follows as the rational number form.

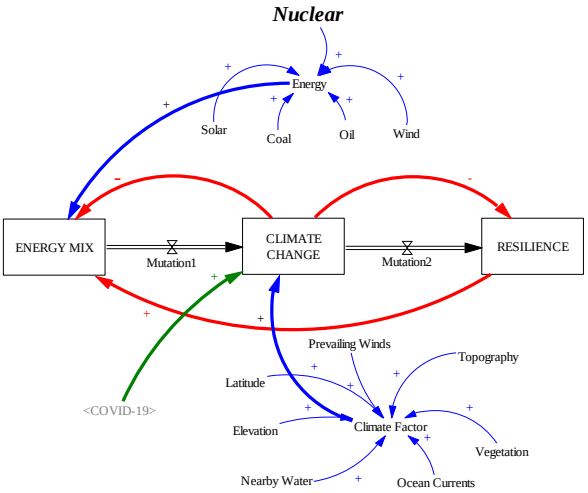


Fig. 4. SD modeling.

Mutation2 / CLIMATE CHANGE; Initial Value = 1.0 (10)

Fig. 5 has the causes tree for climate change where event flows are shown by networking.

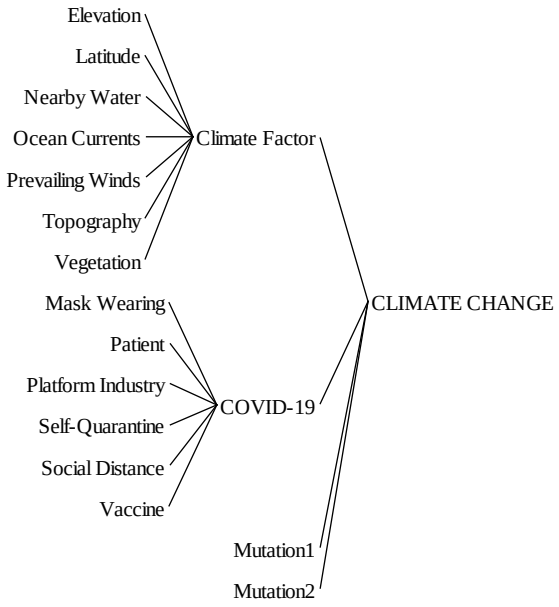
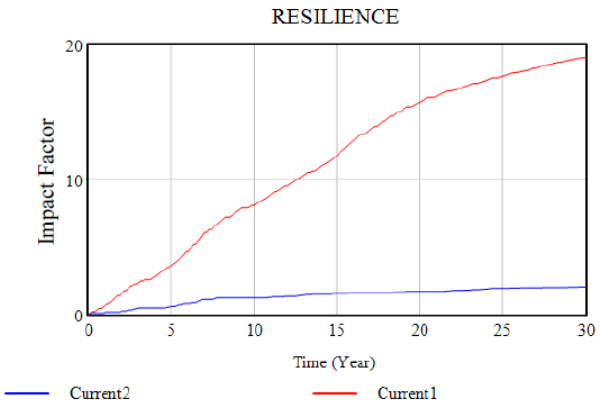


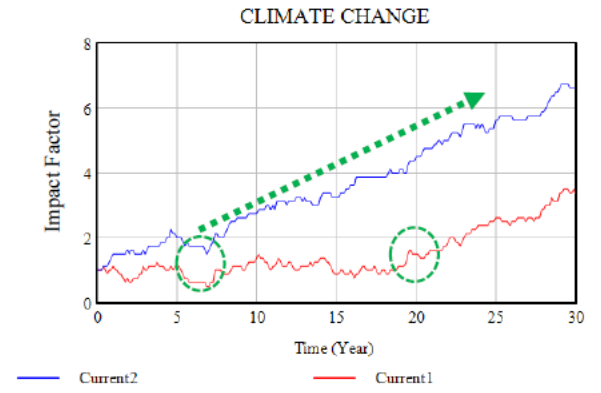
Fig. 5. Causes tree for the modeling.

3. Results

In the modeling, the RESILIENCE is related to CLIMATE CHANGE as the impact of RESILIENCE shows the rapid increase of the early period in Fig. 6 where there are two kinds of cases for comparisons by the modulations of mutation pairs in Table 2.



(a)



(b)

Fig. 6. Results for Climate Change by mutation pairs (a) RESILIENCE and (b) CLIMATE CHANGE.

Table II: List of mutation pairs.

Pair	Variable	Content
1	Mutation1	if then else(random 0 1 () < 0.7, 1, 0)
	Mutation2	if then else(random 0 1 () < 0.8, 1, 0)
2	Mutation1	if then else(random 0 1 () < 0.2, 1, 0)
	Mutation2	if then else(random 0 1 () < 0.2, 1, 0)

For the case of Current 1, in the later period, the slope of RESILIENCE is lower due to the impact of the CLIMATE CHANGE being higher. There is the slope change time around the 20th years in Current 1. Otherwise, the current 2 case has the different value in results. The RESILIENCE is lower when the CLIMATE CHANGE increases significantly. So, it is imaginable that the climate resilience is very effective when the climate change is not severer. Table 3 shows the list of currents.

Table III: List of Currents.

Current	Pair	Remark
1	1	The slope of RESILIENCE is lower due to the impact of the CLIMATE CHANGE being higher in the later period. The climate resilience is very effective when the climate change is not severer in the desirable society of keeping the carbon emission controls.
2	2	The RESILIENCE is lower when the CLIMATE CHANGE increases highly, which could be the case of the extremely fossil fuels consumed society.

4. Conclusions

As the present climate change induced pandemic era, the non-carbon emitted nuclear energy has been focused as the indispensable energy source among energy-mixed resources. In this work, the possible situations are classified as three cases where the lowest impact one is shown as the plausible trend. Some important points could be described as follows,

- Climate justice could be made by the resilience aspect.
- Mutation-evolution-based game theory is modeled for the social variables.
- Complex algorithm has been used for carbon neutrally modeling.
- Nuclear energy is one of mitigation methods for global warming disasters.

Considering of energy's significant factors in the climate variations, the fossil fuel of oil and coal could increase the carbon in the environment. So, the relation between atmospheric warming and non-carbon emitted energy can show the strategy to mitigate global warming where the quantitative values are obtained by the complex algorithm. So, this work can find out how much the social endeavor of pandemic treatment and climate variation would impact our lives. The nuclear energy can be a role of game changer as climate justice.

Acknowledgments

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