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How to build disaster-resilient cities and societies for making people happy

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ABSTRACT

The current disaster approaches and strategies have failed. Our society is also vulnerable to COVID-19 pandemics and natural disasters. This paper surveys the conventional disaster governance regimes and examines whether a sustainable and resilient society against natural and human-induced disasters can be built. This paper aims to shed light on resilient city and country building from the perspective of disaster prevention. Current disaster strategies must be updated in order to mitigate the cost of disaster events and to make people happy. This paper quantifies the scores of the COVID-19 policies for strengthening disaster prevention technology.

1. Introduction

According to National Centers for Environmental Information in the US, overall damages/costs of 308 weather and climate disasters since 1980 in the US reached or exceeded $1 billion [1]. The total cost of these 308 events exceeds $2.085 trillion in the US alone [1]. Globally, damage costs and disaster losses do not even show any improvement each year. This fact shows the current disaster approaches and strategies have failed. This paper aims to shed light on resilient city and country building from the perspective of disaster prevention using sustainable technologies to make people happy.

This paper surveys the disaster mitigation technology from the viewpoint of the initial governance regimes against natural disasters. Currently, about 3 billion people live in seismically active areas, and about 750,000 people have been killed by earthquakes and associated tsunamis in the past 20 years [2]. The COVID-19 pandemic caused 6, 351,754 deaths in the world as of June 27, 2022 according to the Worldometers over 2 years.

This fact shows that current medical technology and disaster-resilient science and engineering technologies reveal their weaknesses. The resilient technology for cities and societies should be urgently updated. The information technology is not enough to reduce the risk of disasters.

Disaster preparedness plays a key role in reducing the number of deaths killed by earthquakes. In Japan, the building standard law has been tightened in order to reduce the damage caused by earthquakes. Great Hanshin-Awaji Earthquake in 1995 with 6.9 on the moment magnitude scale caused 88% of crushing 4831 deaths, due to collapse of houses and furniture [3]. As of 2018, the earthquake resistance rate or the seismic retrofitting rate is about 87% for houses and about 89% for buildings used by many people for mitigating crushing deaths [4]. The Tōhoku earthquake and tsunami in 2011 with magnitude 9.0–9.1 (Mw) undersea megathrust earthquake caused more than 20,000 deaths or went missing where more than 90% of deaths were from drowning during the tsunami. The building standard law alone could not prevent drowning.

In many countries, the first 72 h (3 days) after a disaster has been referred to as a vacuum of authority without outside assistance from governments. Local and federal governments advocate for 72 h of self-reliance [5]. In other words, individuals and their neighborhoods need to be prepared to mutually assist each other during these critical hours without external supports.

In Japan, residents are told to plan for a minimum of one week without external assistance since the government aims to restore power in at least 7 days instead of the first 72 h [6].

This paper proposes sustainable and resilient technologies against a variety of natural disasters in order to enhance self-reliance in the long term and examines whether the current technologies can achieve the goal or not.

As far as we know, no attempt has been made to use sustainable and resilient technologies to increase long-term self-reliance against disasters from the viewpoint of governance regimes.

In the United States in December 2021, tornadoes struck six states, causing devastating damage. "Beyond expectations" is a keyword that has always been used to describe catastrophic damage in the world. We should not use the keyword as an excuse for experts to fail in disaster management.

This paper uses a single metric for scoring and evaluating individual

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COVID-19 policies in the world in order to reveal the best policy with sorted scores [7–9]; Takefuji 2022). The single metric is scored based on the population mortality rate: the number of COVID-19 deaths per population [9]. The higher the number of deaths, the more unhappy people become. The smaller the score, the better the policy. This paper will reveal the best policy against the COVID-19 in the world.

Current disaster approaches and strategies are failing: the COVID-19 pandemic is a natural disaster. This paper will address what COVID-19 policies are best suited to learn about disaster prevention and what we should do to prepare for a severe disaster environment in the future.

2. COVID-19 pandemic

The COVID-19 pandemic caused 6,615,451 deaths in the world as of Nov. 13, 2022 according to the Worldometers. The COVID-19 pandemic has been dramatically changing our lifestyle by lockdowns, social distance, hand-washing, mask-wearing, and no-kissing and no-hugging. Our society reveals its weakness against the COVID-19 pandemic. Many policymakers are stubborn and may not be flexible or adaptable enough to update their policies against the COVID-19 pandemic.

This paper presents a scoring tool based on the single metric for evaluating individual policies against the COVID-19 pandemic. The single metric is based on the population mortality rate: the number of COVID-19 deaths per population. The lower the score, the better the policy. The larger the score, the more the unhappy people.

The scoring tools such as scorecovid for scoring individual policies in the world with sorted scored and hiscovid for scoring a time-series score by country are presented. In other words, scorecovid can reveal the best policy in the world and hiscovid allows users to find when policymakers made their mistakes against the pandemic.

We are also facing up to global warming and climate change under the COVID-19 pandemic. We have to solve two critical problems simultaneously. The COVID-19 pandemic and global warming issues. The important question is whether we can build a resilient society with sustainability against natural and human-induced disasters.

3. Resilient technology

The state-of-the-art sustainable technologies may allow us to build the resilient society. In order to live or survive, food, water and fuel are needed in normal or harsh environments. Food is chemical energy that humans derive from their food and molecular oxygen through the process of cellular respiration. Water is essential for the human body to function. Fuel is used to generate electricity regardless of weather conditions.

In other words, this paper examines whether a sustainable and resilient society against natural and human-induced disasters can be built by using the state-of-the-art sustainable technologies.

According to the American Red Cross, 15 basic supplies are listed as minimum needs, with water, food, and flashlights with batteries being priorities. Therefore, this paper examines sustainable technologies for sustainable food, water, and fuel for power generation.

In other words, this paper will examine whether the sustainable technologies for sustainable protein alternatives, water and fuel respectively can transform our society to a resilient society against natural and human-induced disasters.

Sustainable protein alternatives for food, sustainable water, and sustainable electric power will be investigated in terms of a vacuum of authority for the first 72 h or 7 days without outside assistance from the government as self-reliance.

Three sustainable technologies on protein production, water production, electric power production will be introduced to be able to survive during the harsh environment. We must understand that each of us must assume a harsh environment with no external support from the government, no transportation, no power, no water, and no food. In the following three Sections, we will examine these three perspectives on food-water-power in a hypothetical harsh environment.

4. Sustainable protein alternatives

With the advanced progress in the sustainable technology, sustainable protein alternatives are introduced [10]. Alternative protein can be produced by plant or microbe. In microbe-based protein production, fermentation plays a key role in producing edible protein. There are three fermentations: traditional fermentation, biomass fermentation, and precision fermentation respectively [11]. Animal-free dairy protein can be produced by fermentation in microflora. To improve the real production, companies are focusing on fermentation for animal-free meat, eggs, and dairy respectively [10]. Animal-free dairy protein is made by fermentation in microflora rather than the typical extraction of protein from bovine milk [11].

The latest bioprocessing system by Solar Foods can produce 1 kg of protein-rich edible powder "Solein" per day only by solar power electricity [12]. Solein is made by growing a microbe in liquid in a fermentation tank. It's similar to the process used in breweries where Solar Foods' microbe eats only hydrogen bubbles, carbon dioxide, nutrients and vitamins. Pilot production cost is $5-$6 per kilogram of 100% protein as of Jan. 2020.

Without killing animals, we can consume protein alternatives instead of animal meats.

To summarize the sustainable technology on food productions, sustainable protein alternatives for producing animal-free meat, eggs, and dairy respectively can build a decentralized society instead of our centralized society as long as we can capture air and water with sustainable power generation technology. Sustainable protein alternatives can transform our society to a sustainable and resilient against natural disasters regardless of weather conditions. Food can be generated even in isolated homes in harsh environments.

5. Sustainable water

An atmospheric water generator (AWG) is a device that extracts water from humid ambient air. MOFs (metal organic frameworks) based on an aluminum play a key role in harvesting water from air [13,14]. Wentao reported that daily rates as high as 90 L of water per kilogram of MOF can be achieved in the regions where the air is rich in water, while a remarkable 7–20 L of water per kilogram of MOF can be achieved in some of the driest deserts of the world [15]. MOF-303 costs just $3 per kilogram [13]. MOF-303 is expected to harvest 8–10 L per kilogram of MOF per day.

Without centralized water supply public system, using MOFs allows us to harvest water from air for household use. Sustainable water technologies can transform our society to a resilient society against natural disasters. Water can be generated even in isolated homes in harsh environments.

6. Sustainable electric power

Solar power and wind power are popular as sustainable electric power. However, they are intermittent. California's wildfires hampered solar energy production in September 2020. The U.S. Energy Information Administration stated that in the first two weeks of September 2020, average solar generation in the California Independent System Operator, which covers 90% of utility-scale solar capacity in the state, declined nearly 30% from the July average [16].

NASA has developed a new technology that can convert the greenhouse gas carbon dioxide (C02) into fuel by using solar-powered, thin-film devices [17]. Xu H. et al. discovered the efficient conversion from CO2 to ethanol [18]. The household refrigerator-sized unit can produce 20 L of gasoline per week [13,14]. Ethanol has five times higher volumetric energy density (6.7 kWh/L) than hydrogen (1.3 kWh/L) and can be used safely in fuel cells for power generation. Theoretically, the

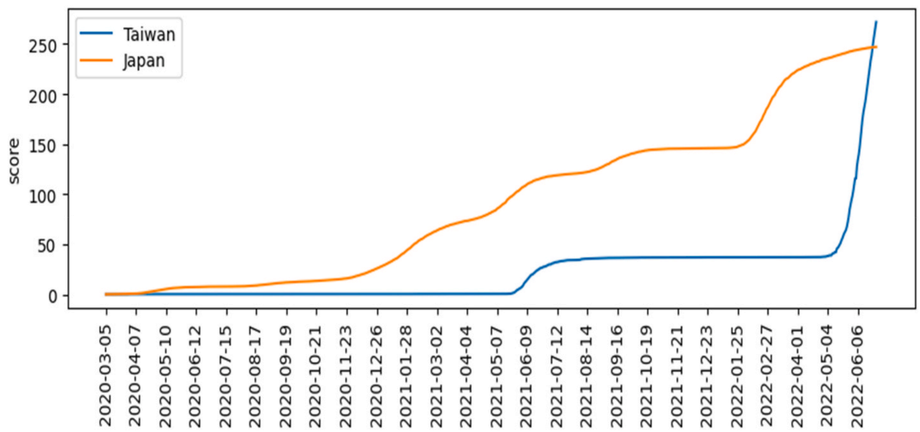

Fig. 1. Time-series scores of Taiwan and Japan with hiscovid.

efficiency of an ethanol fuel cell should be 96%, but in practice at the highest power density it is only 30%.

To summarize the sustainable fuel technology, capturing air can produce 20 L per day with a household refrigerator-sized conversion unit. Produced fuel can generate electricity by fuel cells or combustion engines. Using produced fuel from air can be considered CO2 zero emissions. Electric power can be generated even in isolated homes in harsh environments.

7. Discussion

We showed that three sustainable technologies for producing food, water, and electric power respectively can be used in the harsh environment. A new COVID-19 issue has been added in the conventional harsh environment.

Many policies against COVID-19 rely heavily on pharmacological approaches. Vaccines are initially successfully used to mitigate pandemics. However, resurgences have been observed in many vaccinated countries.

The scorecovid tool is for scoring individual COVID-19 policies in the world to reveal the best policy in the world [9]. Scores are calculated by dividing the number of COVID-19 deaths by the population in millions.

Policymakers must understand when they made mistakes in COVID-19 policies. The hiscovid tool for scoring time-series scores by country can reveal when policies made mistakes in Taiwan and Japan. Fig. 1 shows that Taiwan made two mistakes: the first one between May and June 2021 and the second one in May 2022. The first incident in Taiwan was caused by the failure to test airline crew members and their families for COVID-19. The second incident in Taiwan was caused by lifting quarantine regulations. Fig. 1 shows that Japan made mistakes several times. Two flat graphs were observed in Taiwan, one from the start of the pandemic to May 2021 and the other from July 2021 to May 2022. The flat graphs indicate that the COVID-19 pandemic was successfully suppressed by the test-isolation policy in Taiwan.

Effectiveness of digital fences against COVID-19 were reported [7,8] where the test-isolation policy was used. The test-isolation policy adopted by Taiwan was the best policy against the COVID-19 pandemic until May 2022 [8,9]. The test-isolation policy is to test and identify infected individuals at an early stage and to isolate them from uninfected people during the quarantine period. However, in June 2022, Taiwan's score became the third-best because of lifting COVID-19 regulations.

Harvey revealed that current vaccines do not respond well to current variants due to spike mutations and immune escape [19].

Decentralization in our society means isolations between individuals. Isolations can be achieved by digital fences. The goal of the digital fences is to test infected individuals at an early stage and isolate asymptomatic and pre-symptomatic carriers from uninfected people during the quarantine period for mitigating the pandemic.

8. Conclusion

By using the proposed sustainable and resilient technologies for producing food, water and fuel respectively, the resilient society can be built in terms of a vacuum of authority for the first 72 h or 7 days without outside assistance from the government as self-reliance. The resilient society will be robust against natural disasters or hazards by enhancing self-reliance which is the world's first attempt. The sustainable technologies can also reduce carbon dioxide by transforming CO2 to protein alternatives or fuels. According to the recent studies on sustainable technology, the production cost will be reduced dramatically in the near future for real household use. This paper shows that a society by using the state-of-the-art sustainable technologies for producing protein alternatives, water and fuel respectively will be sustainable and resilient against natural and human-induced disasters. Isolation on COVID-19 can be realized by digital fencing. The effectiveness of digital fences is proven by data. Resilient strategy revealed the better performance on mitigating the COVID-19 pandemic.

Without using the keyword "beyond expectations," preparedness plays an important role in disaster management. The proposed ideas will be examined in Japan through smart city and super-city projects.

The technology such as test-isolation strategy can play a key role in mitigating the COVID-19 pandemic. Two scoring tools such as scorecovid and hiscovid can reveal the best policy and mistakes by policymakers. Scoring tools are used for poorly scored countries to learn good strategies from countries with excellent scores.

Research involving human participants and/or animals

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Yoshiyasu Takefuji: Writing – original draft, Visualization, Supervision, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

References

[1] NOAA, Billion-dollar weather and climate disasters. https://www.ncdc.noaa.gov/billions/, 2021.
[2] Robert Glasser, How can we make earthquakes less deadly?. https://reliefweb.int/report/world/how-can-we-make-earthquakes-less-deadly, 2016.
[3] Ronni Alexander, Security in the context of our everyday lives: lessons from the great hanshin-A waji earthquake, Kobe Univ. law Rev. 30 (1996) 1–28, https://doi.org/10.24546/00166963.
[4] MLIT, Seismic retrofitting of houses and buildings. https://www.mlit.go.jp/jutakukentiku/house/jutakukentiku_house_fr_000043.html, 2021.
[5] FEMA, Community and family preparedness. https://www.energy.gov/sites/prod/files/FEMA-Good_Ideas_Book_0.pdf, 2021.
[6] Tokyo, Let's get prepared disaster preparedness actions. https://www.bousai.metro.tokyo.lg.jp/book/pdf/en/02_Lets_Get_Prepared.pdf, 2021.
[7] Y. Takefuji, Correspond. N Engl. J .Med. 384 (2021) (2021) e66, https://doi.org/10.1056/NEJMc2101280.
[8] Y. Takefuji, Analysis of Digital Fences against COVID-19, Health Technol, 2021, https://doi.org/10.1007/s12553-021-00597-9, 2021.
[9] Y. Takefuji, SCORECOVID: A Python Package Index for Scoring the Individual Policies against COVID-19, Healthcare Analytics, 2021, https://doi.org/10.1016/j.health.2021.100005, 2021.
[10] Y. Takefuji, Sustainable protein alternatives, Trends Food Sci. Technol. 2020 (2020), https://doi.org/10.1016/j.tifs.2020.11.012.
[11] Fermentation, The good food institute, introduction to a pillar of the alternative protein industry. https://www.gfi.org/files/fermentation/INN-Fermentation-SOTIR-2020-0910.pdf, 2020.
[12] B. Molitor, et al., Power-to-protein: converting renewable electric power and carbon dioxide into single cell protein with a two-stage bioprocess, Energy Environ. Sci. (2019) (2019), https://doi.org/10.1039/c9ee02381j.
[13] R.F. Service, Crystalline Nets Harvest Water from Desert Air, Turn Carbon Dioxide into Liquid Fuel, 2019, https://doi.org/10.1126/science.aaz3733.
[14] R.F. Service, This former playwright aims to turn solar and wind power into gasoline. https://www.sciencemag.org/news/2019/07/former-playwright-aims-turn-solar-and-wind-power-gasoline, 2019.
[15] Xu Wentao, et al., Metal–organic frameworks for water harvesting from air, anywhere, anytime, ACS Cent. Sci. 6 (8) (2020) 1348–1354, https://doi.org/10.1021/acscentsci.0c00678, 2020.
[16] H. Aranya, et al., Wildfire smoke slashes solar energy production in California. https://www.reuters.com/article/us-usa-wildfires-solar/wildfire-smoke-slashes-solar-energy-production-in-california-idUSKBN26L31P, 2020.
[17] NASA, Solar powered carbon dioxide (CO2) conversion. https://ntts-prod.s3.amazonaws.com/t2p/prod/t2media/tops/pdf/TOP2-160.pdf, 2020.
[18] H. Xu, et al., Highly selective electrocatalytic CO_2 reduction to ethanol by metallic clusters dynamically formed from atomically dispersed copper, Nat. Energy 5 (2020) (2020) 623–632, https://doi.org/10.1038/s41560-020-0666-x.
[19] W.T. Harvey, A.M. Carabelli, B. Jackson, et al., SARS-CoV-2 variants, spike mutations and immune escape, Nat. Rev. Microbiol. 19 (2021) (2021) 409–424, https://doi.org/10.1038/s41579-021-00573-0.

Further reading

[20] Reid Kathryn, 2011 Japan earthquake and tsunami: facts, FAQs, and how to help. https://www.worldvision.org/disaster-relief-news-stories/2011-japan-earthquake-and-tsunami-facts, 2019.
[21] Angie Szumlinski, Herd immunity. https://www.healthcapusa.com/blog/herd-immunity-2/, 2021.