Moonshot R&D MILLENNIA* Program

*Multifaceted investigation challenge for new normal initiatives program

“Research on Post-Anthropocentric Values, Behavioural Styles, Science and Technology”

Initiative Report

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Brainstorming Team “Team Post-Anthropocene”

Team Leader:
Hajime AKIYAMA
(Assistant Professor, Faculty of Humanities and Social Sciences, University of Tsukuba)

Sub Leader:
Syun-ichi URAYAMA
(Assistant Professor, Life and Environmental Sciences, University of Tsukuba)

Team Members:

Ayataro WADA
(Representative Director, ARARE STUDIO Ltd.)

Takuto YAMAGUCHI
(Representative Director, ARARE STUDIO Ltd.)

Mio OMURA
(Director, ARARE STUDIO Ltd.)

Kazane ITOI
(4th year student, College of Social Sciences, University of Tsukuba)

Mayuko TAKEHARA
(2nd year student, Doctoral Program in Geosciences, University of Tsukuba)

Thomas SAVAGE
(4th year student, College of Agro-Biological Resource Sciences, University of Tsukuba)

Hiroyuki MIZUMOTO
(Teacher, Nara Prefectural Kokusai High School)

Kiyokazu UJIIE
(Associate Professor, Faculty of Life and Environmental Sciences, University of Tsukuba)

Maki EGUCHI
(Assistant Professor, Faculty of Humanities and Social Sciences, University of Tsukuba)

Masanori TOYOFUKU
(Associate Professor, Faculty of Life and Environmental Sciences, University of Tsukuba)

Daisuke HAGIWARA
(Associate Professor, Faculty of Life and Environmental Sciences, University of Tsukuba)

Yusuke HIRAI
(Associate Professor, Faculty of Human Sciences, University of Tsukuba)

Rie TAKATA
(Research Administrator, Faculty of Life and Environmental Sciences, University of Tsukuba)

Ai SAITO
(Research Administrator, Faculty of Humanities and Social Sciences, University of Tsukuba)

Shoko SAGOSHI
(Research Administrator, Faculty of Human Sciences, University of Tsukuba)

Naoki NAGATA
(Senior Research Administrator, Research Administration/Management Office,
University of Tsukuba)

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I. Concept

1. Proposed MS Goal

1.1 Proposed MS Goal title

"Realising a Smart Earth by 2050"

1.2 Vision for 2050 society

This team proposes realising a Smart Earth (SE) by 2050. In this report, an SE is defined as a sustainable earth that is created by reconfiguring the relationship between the natural environment and society through the effective use of science and technology.

Until recently, society did not sufficiently consider its impact on nature, and shortsighted anthropocentrism, which only focuses on the interests of the current generation of humans, has determined the way to use science and technology. Thus, humans have placed tremendous burden on earth, and environmental issues have become more serious. In other words, we are now in the Anthropocene age, where humans have the dominant influence on geology. Therefore, for earth to be habitable for future generations, we need a society that can think about, and tolerate, the use of science and technology with a long-term perspective.

Thus, to overcome the environmental and social issues humans are facing today, we will realise a post-Anthropocene era, with a natural environment and society that will make earth sustainable by 2050. The concrete vision of the society will be clarified through the Mini Smart Earths (Mini SEs), which are a multipurpose platform for testing not only scientific but also social technologies to enhance sustainability after 2030.

Figure I-1: Team Post-Anthropocene's Image of 2050

For example, this team envisions an SE that focuses on human spirituality, social systems, and material cycles. For human spirituality, the well-being of the relational self will be realised. For the social system, a small community where people can proactively participate is envisioned. For material cycles, biotechnology will be utilised. In the Mini SE, we will verify the validity of this concept; analyse the desirable states of science, technology, and human society; and realise the SE as a sustainable planet in 2050.

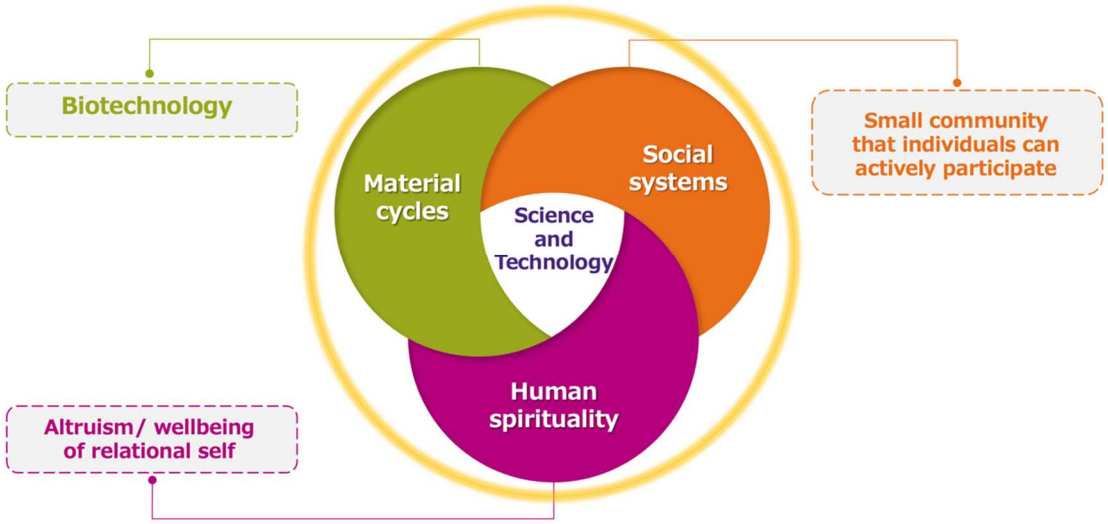

Figure I-2: Team Post-Anthropocene's Vision for 2050

2. Targets

Scene of achievement in 2050

A sustainable earth that is created by reconfiguring the relationship between the natural environment and society through the effective use of science and technology is realised.

What will be achieved in 2030

The Japanese government establishes various types of Mini SEs and operates them as a platform. Proposals of the technologies and social systems required for each Mini SE will be sought through the MS R&D system.

Figure I-3: Image of Mini SE in 2030

3. Background

3.1 Why now?

Christophe Bonneuil and Jean-Baptiste Fressoz, French scholars of the history of science, technology, and the environment, point out that “The Anthropocene is characterized by the fact that ‘the human imprint on the global environment has now become so large and active that it rivals some of the great forces of Nature in its impact on the functioning of the Earth system,’” referring to the work of atmospheric chemist Paul Crutzen and others [1]. Scientifically, the Intergovernmental Panel on Climate Change (IPCC) has assessed that there is a greater than 95% probability that human activities are affecting the planet [2]. Humanity’s footprint on earth’s environment can be seen in the changes in the composition of earth’s atmosphere and greenhouse gases (i.e., climate change) since the invention of the steam engine; the general destruction of earth’s ecosystems (biosphere) (i.e., collapse of biodiversity); and the changes in the biogeoscientific cycles of water, nitrogen, and phosphate [3]. In pursuit of prosperity, humans are destroying the global environment, and thus, humans are receiving retaliation from nature.

Climate change and COVID-19 are concrete examples of nature’s retaliation against human beings occurring behind the scenes of human prosperity. That is to say, it can be said that pathogens

have infected humans through the development of areas where humans have never lived before and that infection has become a serious problem because of the increase in population density on account of human prosperity [4]. To survive on the planet in a stable manner in the future, it is necessary for humans to urgently envision a new, post-Anthropocene science, technology, and society rather than the conventional science, technology, and society that have placed excessive burden on earth.

Environmental issues have become a matter of great social concern today. It is noteworthy that young people have responded to Greta Thunberg's call for action on environmental issues, and it is possible that more young people will take environmental issues seriously in the future. In the international community, the Sustainable Development Goals (SDGs) were adopted by the United Nations in 2015 and are now being discussed in schools around the world.

These issues are important not only from the perspective of social demands but also from the perspective of Japan’s international contribution through science and technology. In the future, competition among states for energy and food will intensify, and international tensions are likely to become more serious. For Japan to take the lead in the field of science and technology and contribute to the international community, it is necessary to promote the development of science and technology as soon as possible.[1]

The SE needs to be realised with a long-term vision through national-level research and development programs. This is because the consent of the people in Japan and all over the world over a long period is necessary to realise an SE. In addition, the most important point of this concept is that it does not aim to develop a particular technology but rather to develop technology that will serve as a bridge among many existing technologies with its social value and visions.

Note that no other state is conducting a project similar to this one that aims for the realisation of an SE. Artificial ecosystems, such as the Biospheres 2 and 3,[2] International Space Station, moonbase, and development of Mars, are all designed with the immediate habitation of humans in mind and therefore have different foundations from this project, which emphasises the circulation of the natural environment. The reason this project is based on the circulation of the environment and this project places human beings within it is that this team believes that considering the immediate effects on human beings will not benefit humans in the end. Rather, placing the environment at the centre will benefit humans from a long-term perspective. Particularly in Japan, humans have a history of believing in 8 million gods and of living in awe of nature while striving for coprosperity and coexistence with nature, which makes it possible to relativise humans when compared with Western countries.[3] Based on this background, Japan can globally disseminate post-Anthropocene science, technology, and society.

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[1] As shown by the current status of vaccine development for COVID-19, Japan’s science and technology are in a difficult position in international competition with other countries.

[2] For the Biosphere 2 project, see this report II. 3. For the Biosphere 3, refer to [5].

[3] For more on the role of animism in Japanese society and culture, refer to [6].

3.2 Social significance

The essence of this project is that earth will become sustainable. The SE, which is to be realised in 2050, is oriented toward reconfiguration of the relationship between the natural environment and society by utilising new science and technology. The concept of Anthropocene, named and characterised by scientists, is used to criticise the fact that anthropocentrism started the destruction of nature and ecosystems at the end of the 18th century, that the “great acceleration” occurred after 1945, and that it advanced to a new stage around the year 2000. At the same time, it is considered a conceptual device for fundamentally questioning the modern thinking of dualism: nature/human. To overcome the challenges of the Anthropocene, it is necessary to recognise the limitations of the modern progressive view of history and to think about a society created by human beings in the same dimension as nature.

3.3 Action outline

To achieve this MS goal, several actors have roles to play. The first is the role of researchers. The development of new science and technology is indispensable as a medium in reconfiguring the relationship between the natural environment and society. Therefore, researchers in technology and the natural sciences need to create new science and technology that will contribute to the sustainability of earth. In addition to this, researchers in the humanities and social sciences also play a significant role in order to relativise current society, which embodies anthropocentric thinking, to envision society fundamentally from the level of drafting the constitution, and to guide specific concepts in policies and institutions. It is also necessary to communicate with citizens using many forms of media, including educational activities, to realise this vision.

Second is the role of industry. We need to collaborate with the business sector so that industry can promote business models that not only ensure profits but also emphasise sustainability. Industry’s support is necessary to promote technological development.

Third is the role of the state. It is necessary to implement regulatory and subsidy policies to promote sustainability-oriented industries. We also need to actively encourage global companies and other countries to follow suit.

Fourth is the role of the international community. Cooperation of the nations of the world and the United Nations (UN) is essential for the realisation of the SE. While the Japanese government takes the lead, it is necessary to build international consensus for the SE at international conferences to promote science and technology. In recent years, there has been an increase in political commitment from countries around the world to address environmental issues,[4] and Japan needs to seize the

[4] Led by the president of the United States in April 2021, states are announcing targets to be achieved regarding measures to deal with environmental issues. See [7].

opportunity and take the lead in SE. Furthermore, to realise Mini SEs by 2030, the UN should take the lead and consider borrowing territory to conduct various experiments, and sufficient political commitment is important.

Fifth is the role of local and global civil society. The transformation of society is essential toward creating the SE. To this end, it is important to foster a new sense of values among many citizens through discussions on the outcomes of Mini SEs. Continuous education is essential for future generations to understand and internalise the new values. In addition to this, communication in civil society and mutual communication between humans and the natural environment will contribute to the formation of a sense of values for future citizens. We need to actively reach out to civil society, be understood by it, and use the crowdfunding mechanism to gain understanding, and bring about changes, in science, technology, and society.

4. Benefits for industry and society

1) Expansion of the scope of participation in decision making and its limitations

To realise a desirable society in which interests are appropriately coordinated, it is important that stakeholders be appropriately involved in decision making. In human society, there was a long period when a few people, such as monarchs and aristocrats, monopolised decision-making power. With the development of democracy, the number of actors who can be involved in decision making has gradually expanded. At least theoretically and normatively, in many parts of the world, it is difficult for any particular subject to unilaterally decide others' lives today.[5]

Can future generations be involved in decision making? Future generations will be greatly influenced by the decisions we make today. Nevertheless, those generations can never be involved in our decision making. This is because they do not yet exist in the present and cannot express their will. Therefore, we who live in the present have to be "despots" to the future generations, whether we like it or not. We, who make decisions today, may be tyrants to future generations.

2) Human altruism and the socioeconomic system

What kind of tyrant should we be? We should be as virtuous as possible. People living in the present age should act such that it is sympathetic and considerate of future generations who cannot speak up. In this project, we focus on altruism and the well-being of the relational self.[6] Traditionally, economics and other academic disciplines have been built on the premise that people are rational and

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[5] It should be pointed out that there are many areas where it is questionable whether individual opinions are being adequately heard in practice.

[6] Although the concept of altruism is generally used, altruism is a concept that separates the "self" from the "other," and there is a question of whether "egoism" and "altruism" can be clearly separated. Therefore, this team has also introduced the concept of well-being of the relational self. For more information on the well-being of the relational self, see [8], [9].

selfish economic beings. On the other hand, the results of recent economic experiments have pointed out the existence of an altruistic aspect to human decision making.[7]

3) The state of altruism in contemporary Japanese society and the possibility of industrialising "sustainability"

What is the nature of altruism among the citizens living in Japanese society today? In this section, we would like to discuss the results of a social survey conducted as part of this project.[8]

(1) The nature of altruism

First, we examine the nature of altruism. In the survey we conducted, the targets of altruistic behaviour were classified into four categories: family, friends, strangers, and the environment, and 28 types of behaviour, seven for each category, were presented. The specific questions were based on Oda et al. (2013) [11], and questions on the environment were added based on Johnston et al. (2001) [12]. An example of the actual questionnaire is shown in Figure I-4. The obtained behavioral frequency data were classified using the latent class model,[9] and the patterns of occurrence of the behavioral type frequencies were reduced to four.

We analysed this estimated result from several angles. Figure I-5 shows the probability patterns of the frequency of each behavioural type. PATTERN1 has a relatively high frequency of altruistic behaviour. In the sample of this study, 25.0% of the respondents were estimated to fall into this category. The frequency of altruistic behavior toward family (FAM) and friends (FRI) is high. However, the frequency of altruistic behavior toward others (OTH) and the environment (ENV) is also relatively high among the four patterns. However, it can be said that the more distant the relationship with the target the more the frequency of altruistic behaviour tends to vary.

PATTERN2 is a pattern wherein the frequency of altruistic behavior is rather low. It was estimated that 32.1% of the respondents in the sample fell into this category. In terms of the frequency of altruistic behaviour toward family and friends, “Occasionally” was the most common response, but the percentages of “Almost never” and “Never” were high and varied. In terms of altruistic behaviour toward others and the environment, the percentage of “Rarely” was the highest.

PATTERN3 is the pattern with the lowest frequency of altruistic behaviour. It was estimated that 12.3% of the respondents in the sample fell into this category. For other people and the environment with whom there is little relationship, the ratio is concentrated in “Never,” and the variation is small. In the case of behaviour toward family and friends, the ratio of “Never” is relatively high, but the ratio of higher frequency is also high.

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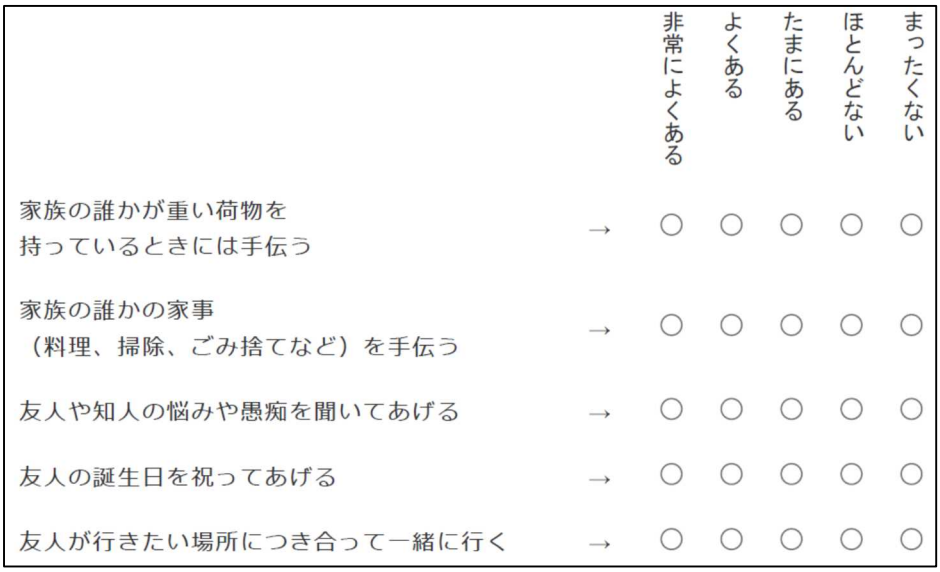
[7] For example, refer to [10].
[8] For more details on this survey, please refer to the Supplementary Chapter of this report.
[9] For more information on latent class models, see, for example, [13].

PATTERN4 is a pattern in which the frequency of altruistic behaviour is moderate. It was estimated that 30.6% of the respondents in the sample fell into this category. Regardless of the relationship, the ratio of “Occasionally” is the largest for almost all behaviour types. The frequency tends to increase slightly for family members.



		非常によくある	よくある	たまにある	ほとんどない	まったくない
家族の誰かが重い荷物を持っているときには手伝う	→	○	○	○	○	○
家族の誰かの家事（料理、掃除、ごみ捨てなど）を手伝う	→	○	○	○	○	○
友人や知人の悩みや愚痴を聞いてあげる	→	○	○	○	○	○
友人の誕生日を祝ってあげる	→	○	○	○	○	○
友人が行きたい場所につき合って一緒に行く	→	○	○	○	○	○

	Very frequently	Often	Occasionally	Rarely	Never
Help a family member when they are carrying heavy baggage					
Help a family member with housework (cooking, cleaning, garbage disposal, etc.)					
Listen to your friends when they have problems or complaints					
Wishing friends happy birthdays					
Accompanying friends to a place they want to go					

Figure I-4: Examples of questions about altruistic behaviour types in the original Japanese and translated versions

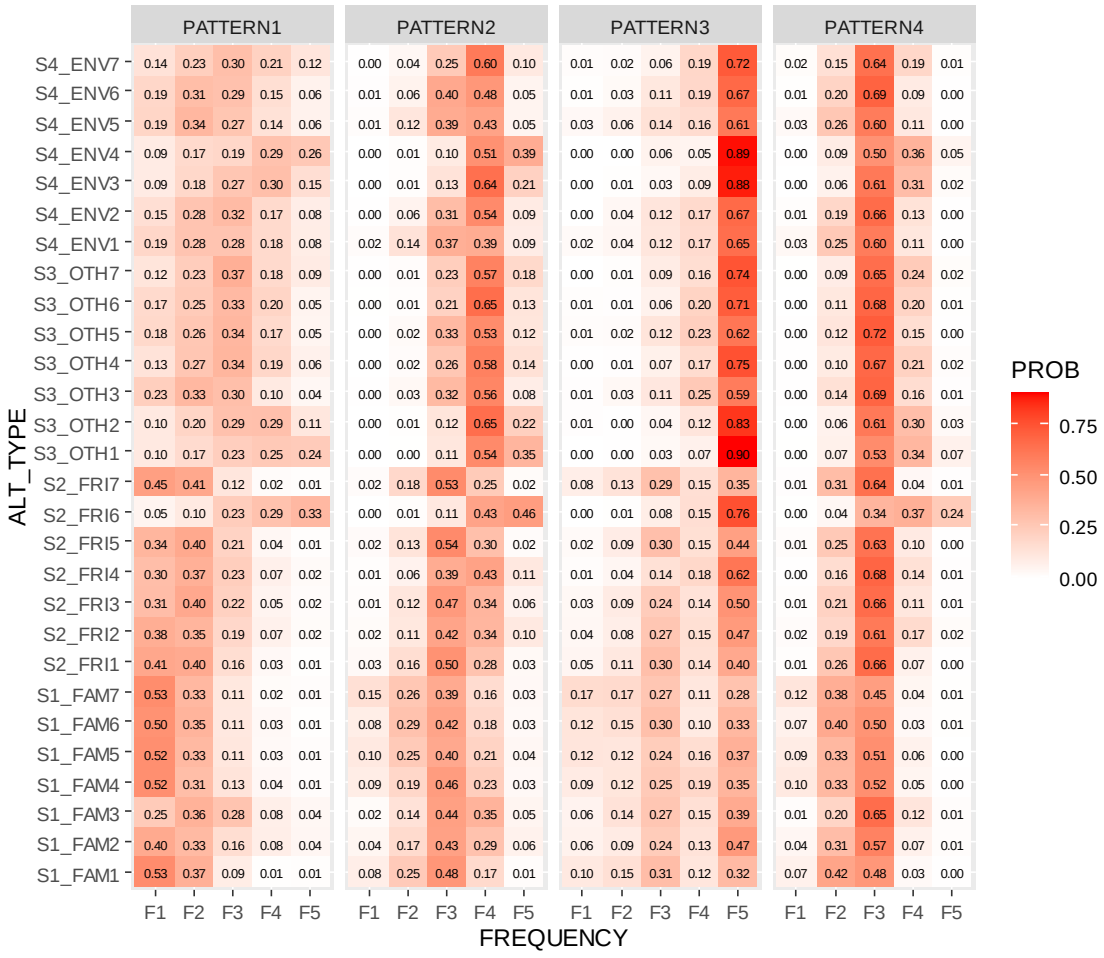


Figure I-5: Patterns of frequency occurrence probabilities for altruistic behaviour types

Note 1: The vertical axis (ALT_TYPE) is the type of behaviour, and the horizontal axis (FREQUENCY) is the frequency of each type of behaviour in each class. F1 to F5 on the horizontal axis correspond to “Very frequently,” “Often,” “Occasionally,” “Rarely,” and “Never,” respectively.

Note 2: The numbers in the cells are estimates of the probability of having the relevant frequency for each type of behaviour.

Figure I-6 shows the estimated probabilities of the four altruistic behaviour patterns found in Figure I-5 for each sex and age group. In terms of gender, the ratio of PATTERN3 and PATTERN2 is higher in males, indicating that they are less likely to engage in altruistic behaviour. In terms of age, the probability of the occurrence of PATTERN1, which has more altruistic behaviour, is higher in the younger age group, and the probability of the occurrence of PATTERN4 and PATTERN2, which have moderate characteristics, is higher in the older age group. On the other hand, the probability of PATTERN4, which has less altruistic behaviour, is also higher in the younger age group. This suggests that there are various patterns of altruistic behaviour in the younger generation.

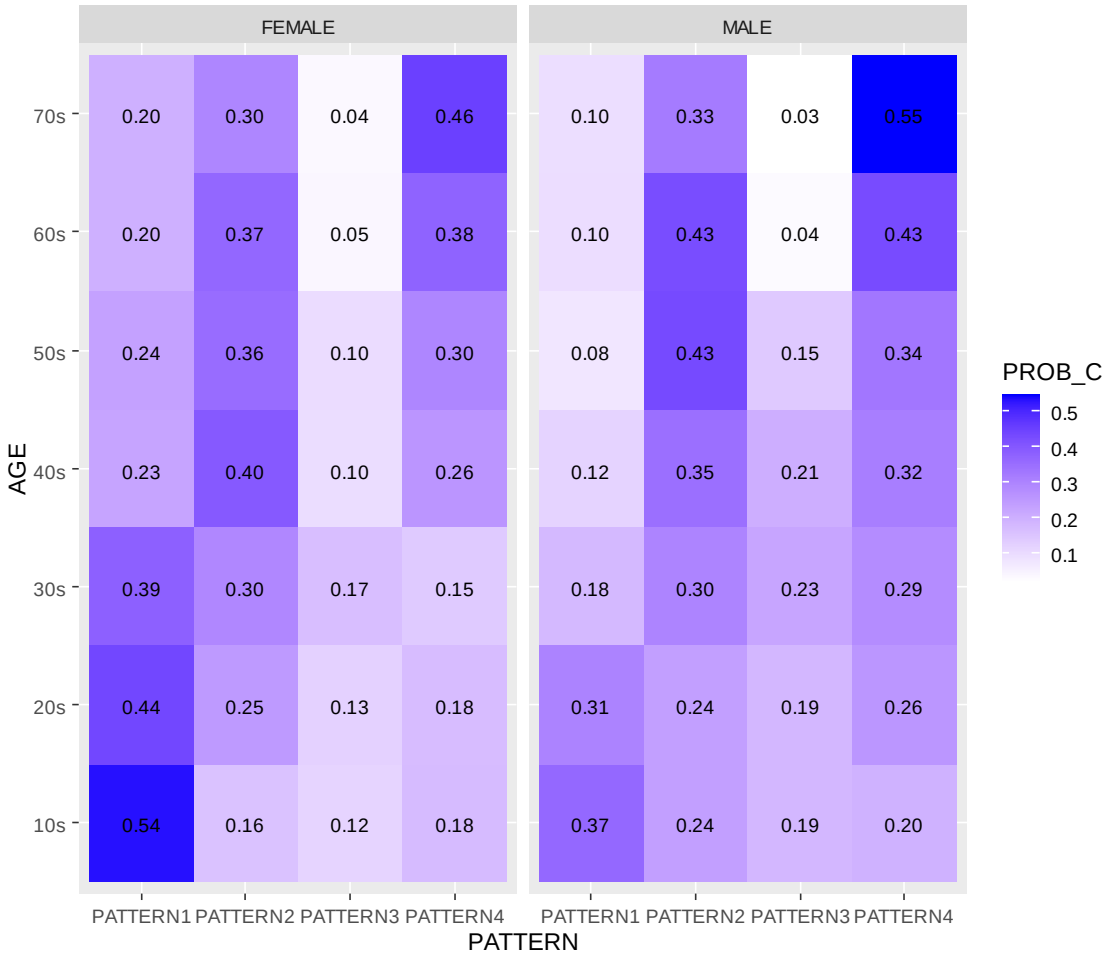


Figure I-6: Probability of occurrence of behavioural patterns by gender and age

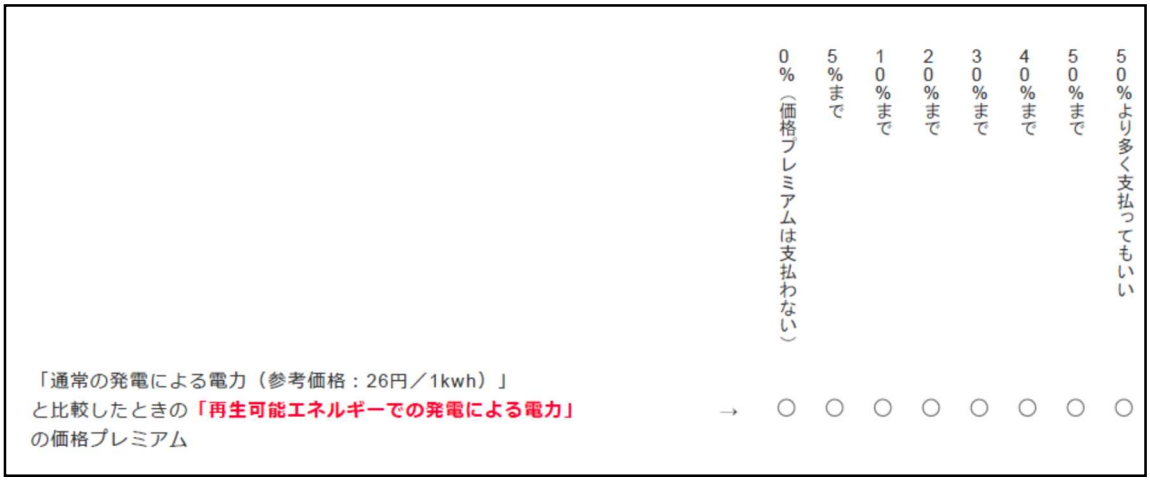
Note 1: The vertical axis (AGE) indicates the age, and the horizontal axis (PATTERN) indicates the four patterns in the probability of occurrence of altruistic behaviour type frequencies.

Note 2: The values in the cells are the probability of occurrence of each pattern by gender and age.

(2) How much will citizens be willing to pay for “sustainability”?

The Mini SEs proposed in this project will provide a multipurpose platform for demonstrating and testing scientific and social technologies to enhance sustainability by 2030. We expect some of the technologies will be used, and the SE will be realised by 2050.

In order for the technologies to be widely used in society, they need to be acceptable not only in terms of sustainability but also in terms of cost. Therefore, we would like to examine the degree to which sustainability-conscious products can be accepted. In this survey, we asked how much of a price premium people would be willing to pay for some specific sustainability-conscious products when compared to other products. This section introduces electricity from renewable energy sources as a case study. An example of the questionnaire is shown in Figure I-7.



	0% (No price premium paid)	Up to 5%	Up to 10%	Up to 20%	Up to 30%	Up to 40%	Up to 50%	More than 50%
Price premium for "electricity generated from renewable energy sources" when compared to "electricity generated from normal sources (Reference price: 26 JPY/1kwh)"								

Figure I-7: Example of a question in a price premium survey for a sustainability-conscious product in the original Japanese and translated versions

Figure I-8 shows the relationship between the amount of the price premium and the ratio of selection of electricity generated from renewable energy sources by calculating the cumulative ratio of price premium values by gender and age based on the responses to Figure I-7. The vertical axis shows the selection ratio, which is the ratio of renewable energy electricity selected at the price premium shown on the horizontal axis.

It can be seen that about 40% of citizens in their 20s to 40s are willing to pay a price premium, and about 60% of citizens in older age groups are willing to pay a price premium.[10] On the other hand,

[10] Tully and Winer (2014), by a meta-analysis of previous studies, point out that about 60% of consumers are willing to pay a price premium for sustainability-conscious products, and this is consistent with the

as the price premium increases, the choice ratio decreases, and when the price premium is about 50%, the choice probability drops to around 5%.

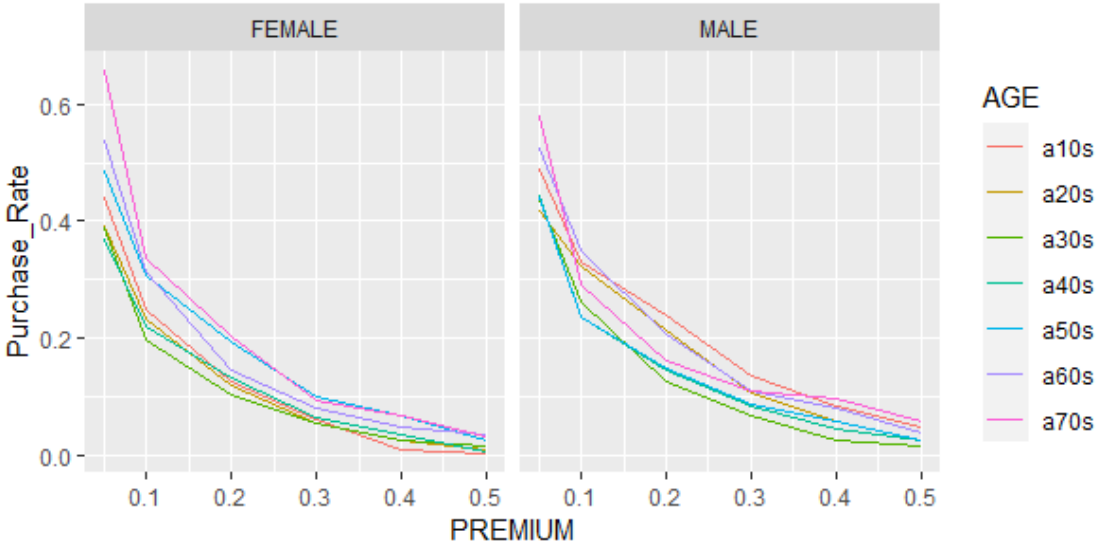


Figure I-8: Price premium and selection ratio for electricity from renewable energy sources

Note 1: The horizontal axis (PREMIUM) shows the price premium (ratio) for electricity from renewable energy sources when compared to electricity from conventional energy sources. The vertical axis (Purchase_Rate) shows the rate at which electricity from renewable energy sources is selected.

Note 2: The legend (AGE) indicates the age.

In order to examine the attitude toward a price premium for sustainability-conscious products in more detail, this report analyses the impact on the price premium using an interval regression model with demographic factors such as income and the presence of children, in addition to gender and age, and the altruism of the respondents discussed in the previous section as explanatory variables. For altruism, the frequency of altruistic behaviour toward family, friends, strangers, and the environment was evaluated on a 5-point scale (1: Never–5: Very frequently), and the average value for each individual was calculated as the altruism score. The higher the value the stronger is the altruism.

Table I-9 shows the estimation results of the model. Looking at the effect of age (AGE), there is a tendency for the premium to increase by 0.13% for each additional year of age. In terms of gender (GENDER), the price premium is significantly higher for males than for females, with an increase of 6.5%. However, the coefficient of the crossover effect between gender and age is significantly negative, suggesting that the difference in price premiums by gender narrows as age increases and that women will have a higher price premium after the age of about 60. On the other hand, the coefficient estimates

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results of this study. See [14].

for income (INCOME) and the presence or absence of children (CHLD) are small, and their effects on the price premium cannot be confirmed.

As for the impact of altruism, the results suggest that altruism toward family (ALTRUISM_FAM) has a significant negative impact. There is a possibility of avoiding financial burden in order to take care of family members. On the other hand, altruism toward others (ALTRUISM_OTH) and the environment (ALTRUISM_ENV) has a significant positive impact. In particular, an increase of one in altruism toward the environment is associated with a 6% increase in the price premium, which is very influential.

Thus, citizens' evaluations of sustainability-conscious products are complicated. As age increases, the price premium also increases, but on the other hand, we did not find a relationship with income. In addition, the relationship with altruism was somewhat complex: the relationship with altruism toward family members was negatively correlated, while it was strongly positively correlated with altruism toward others and the environment, where the relationship is relatively weak.

Characteristic	Beta	95% CI[1]	p-value
GENDER			
FEMALE	—	—	
MALE	5.7	1.7, 9.7	0.005
AGE2	0.13	0.07, 0.19	<0.001
INCOME	0.00	0.00, 0.00	0.7
CHLD			
HAVE	—	—	
NOT_HAVE	0.49	-1.2, 2.2	0.6
ALTRUISM_FAM	-1.4	-2.5, -0.24	0.018
ALTRUISM_FRI	0.83	-0.65, 2.3	0.3
ALTRUISM_OTH	1.4	-0.06, 2.8	0.061
ALTRUISM_ENV	6.2	4.9, 7.5	<0.001
GENDER * AGE2			
MALE * AGE2	-0.10	-0.17, -0.02	0.015

[1] CI = Confidence Interval

Table I-9 Factors influencing the price premium for electricity from renewable energy sources

Note 1: Estimation results using the maximum likelihood estimation method of the interval regression

model.

Note 2: Coefficients (Beta) indicate the value of the price premium (%) that changes when each explanatory variable increases by one unit.

4) Prospects for changes in social and industrial structures

Currently, labeling systems for carbon emissions, animal welfare, fair trade, and sustainability of resource use are being used in society. In addition, the market for plant-based meats (meat-like foods made from plant-based ingredients) is expanding rapidly around the world. This is because people are reflecting on the high environmental impact of meat consumption and that the young generation is more concerned about the lives of animals.[11, 12]

These can be said to be adjustments in consumption behaviour that take into account social values. The analysis in the previous section also suggests that altruistic motivation has a significant impact on the purchase behaviour of sustainability-conscious products. Furthermore, investment principles that emphasise corporate social responsibility, such as environment, social, and corporate governance (ESG) investment, are becoming more common. These movements can be seen as an expression of the altruistic nature of people. However, as we saw in the previous section, the nature of altruism is complex. In today's economic system, which is based on the premise of rational and selfish economic people, it is inherently difficult to manifest altruistic behaviour. Humans need to be given information and choices in an appropriate manner.

There is a status quo bias in human judgments toward the clarity of the outcomes of various technologies from a scientific perspective and a strong tendency to be risk averse in behavioural change. Technologies with uncertain effects are unlikely to be adopted. In addition, in decision making by consensus, objective evidence that can persuade the majority is more significant. If the effects of scientific and social technologies that improve sustainability can be quantitatively clarified, it will be easier for society to support such technologies.

When people make decisions as voters, consumers, or investors, the evidence provided by the Mini SEs proposed in this project is expected to encourage the emergence of altruistic motives. There is a saying in Japanese: "A poor woman's single light persisted longer than a rich man's million lights." Without mass support, politics will not work, and industry cannot be established. If consumers start to prefer more sustainable products, companies will respond to the demand trend and shift to sustainable management. Investors will also be encouraged to do so. It is hoped that the various insights gained from the Mini SE will reveal human altruism and enhance and promote the SE of the planet.

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[11] In Japan, the young generation places importance on the lives of food-producing animals such as chickens and cows, as shown by the surveys conducted in this project. Please refer to the Supplementary Chapter for details.

[12] For more information on the status of Plant Based Meats and cultured meat, see [15].

II. Analysis

1. Essential scientific/social components

Mini SEs, which are the starting point of the SE, are a test site for creating a pseudo-other earth as a quasi-enclosed space and creating a world that *internalises the limits of earth's environment*. The realisation of Mini SEs is a *creation of new society* for humankind, which is fundamentally different from the development of already inhabited areas, which has been done many times in history. Among a wide range of challenges expected to be faced in achieving this goal, the following two initiatives are important:

1. Establishment of social consensus and support for the creation and operation of Mini SEs.
2. Establishment of technologies that enable sustainable and comfortable living in Mini SEs.

1. In order to realise the idea of Mini SEs, it is necessary to establish a social consensus and support for the creation and operation of the Mini SEs. In addition, it is desirable to place Mini SEs outside the existing national framework. For example, it may be necessary to lease a part of the territory of a state to the UN and to guarantee a high degree of freedom, such as a "special zone" that exists in Japan, which is not bound by Japanese restrictions in terms of the legal system.[13]
2. These efforts will involve a very wide range of science and technology research areas and will require technological development with different objectives from those of conventional science, which has been pursued to *increase competitiveness*. For this purpose, an organisation independent of the conventional science policy system (e.g., Japan Mini SEs Organisation) should be established. Of the national revenue, 0.1% will be allocated to this organisation until 2050, and the decision on the use of the budget and the election of the head of the organisation will be based on direct deliberative democracy with public participation. The organisation will manage Mini SEs and the Mini SE Research Institute and will promote the development of related technologies with the world through its funding function. In principle, all results will be the common property of humankind.

2. Science and technology map

In order to create a better world that *internalises the limits of earth's environment*, it is important to conduct research and development in the three areas of demonstrating altruism, energy, and material production. In addition to these, there are a wide range of other R&D elements, such as the use of cyberspace (MS Goal 1), the sharing of fundamental ideas that bring peace of mind, educational

[13] According to Article 3 of the Convention on the Privileges and Immunities of the United Nations, the properties of the UN are inviolable. This principle applies to the UN headquarters in New York.

methods that enhance altruism, a policymaking system that reflects responsibility for the future, a material cycle monitoring system (MS Goal 4), and artificial intelligence (AI) (MS Goal 3).

[1. Demonstrating altruism] Support by genuine artificial intelligence

Human cognition and lifespan are factors that limit the exercise of altruism in global issues and the distant future, and decision support by *genuine AI* that transcends the limitation will enable humans to exercise a wider range of altruism. Based on the *development of AI that follows the process of human growth from child to adult*, which began in the 2010s, it will be necessary to develop genuine *artificial general intelligence (AGI)*, which can respond in the same way as humans. At present, AI can only function in a *narrow range* specialised for specific tasks, and the development of AGI has not been realised [16].

We need to develop AGI that has no cognitive or lifespan limitations and that can support human decision making to overcome the limited time of human life. In addition, AGI will assist humans from the rational side, such as recommendations on Mini SEs and balancing the SE, as well as from the emotional side, as a good partner to talk like an elder. Currently, there are attempts to develop AGI, but no breakthroughs have been achieved. For example, as deep learning technology, which is the basis of AGI, was developed by mimicking the human brain's neural system (neural network),[14] the biological elements of *self-reproduction* and *natural selection* could be incorporated to mimic human growth.

[2. Material production] Material production by biotechnology

Artifacts that support a comfortable life will be produced biologically in small units such as households. We will need biotechnology for the public to produce what we want, when we want it, as much as we want, and to process it freely.

Artifacts that we see around us today, such as plastics, cause enormous amounts of waste. They are produced in places where they can be produced cheaply because of globalisation, and they are carried to where they are used, which requires energy. After they are used, they are disposed. Material circulation is important in Mini SEs, and such artificial materials cannot be used.

The cyclical nature of living things, their ability to produce a variety of materials, and human care for them makes cyclical material production possible. For example, bioplastics,[15] spider silk, bio-ink, bio-carbon fiber, and bio-fuel, which are currently being developed in various R&D programs, can be obtained by cultivating the microorganisms that produce them at home. This includes technology for highly efficient biological fixation of solar energy using biofuel-producing green algae and plants instead of non-recyclable solar panels.

[14] For more information on the relationship between deep learning and neural networks, see [17].
[15] For the current situation regarding bioplastics, see [18].

Food production is also an important component of material production and is being addressed in MS Goal 5: “Creation of the industry that enables sustainable global food supply by exploiting unused biological resources by 2050.”[16]

[3. Energy] Environment-conscious society

The only sustainable energy source is sunlight, and the energy consumption of society will be autonomously controlled so that it does not exceed that limit. In addition to the improvement of the efficiency of energy fixation and the development of energy-saving technologies, technologies to “link” the amount of remaining available energy with the level of activity in society need to be developed.

As stated in *Net Zero by 2050: A Roadmap for the Global Energy Sector*, published by the International Energy Agency (IEA) [20], new development of oil fields will not be allowed in the future. Although the proven reserves of fossil fuels are being extended with the development of drilling technology, oil will surely be depleted in a few hundred years. The depletion of fossil resources will lead to a sharp rise in energy prices, which will inevitably reduce the level of activity in society, but it may also encourage unsustainable deforestation and the use of nuclear energy.

We need to build a system that can visualise the various forms of energy in a unified manner and verify their origins. By linking this system to the economic system, a society that recognises environmental limits can be built. For example, a common unit such as the calorie is treated as an E-coin, and E-coins are produced when biomass and biofuels are produced. E-coins are lost when they are consumed by cars and other vehicles. E-coin technology facilitates social activities to be within the maximum of E-coins. Furthermore, this E-coin technology includes a mechanism to eliminate unsustainable logging by verifying where and how each E-coin was produced through blockchain technology.

3. Japan’s position in overseas trends

An example of an experiment aimed at designing an environment in which people can live by an artificially material circulation system is Biosphere 2, which was built in Arizona, US, in 1991 (Biosphere 1 refers to earth). In this experiment, eight men and women lived self-sufficient lives for 2 years in a 1.27-hectare facility with oceans, deserts, tropical rain forests, and fields. The facility was a closed system where material circulation was isolated from the outside world, and gas leakage was less than 10%. However, the oxygen concentration continued to drop from the beginning of the experiment, and oxygen was introduced during the experiment. In addition, N_2O gas was emitted at an extremely high level, which was an unexpected development. Furthermore, it is said that living in a closed system forced the participants to undergo a great deal of mental stress [21], [22]. Although a

[16] In addition, the possibility of realising a *bio-liberal* social system using biotechnology has been discussed [19], and there are useful suggestions for envisioning a post-Anthropocene social system.

certain degree of self-sufficiency was achieved in the closed system, energy was in fact supplied inexhaustibly from the outside, and the sustainability of the system was questionable. Although scientific data that can be used in the future were accumulated, the experiments in Biosphere 2 have shown us how difficult it is to maintain the material cycle in our daily lives and have illustrated the difficulty of solving the problems we are facing on earth today. The Mini SEs and SE, unlike Biosphere 2, are aimed at building a recycling-oriented society, including the energy issue. Therefore, the actions aim to shift to a better society to realise a truly sustainable environment.

[1. Demonstrating altruism] Support by genuine artificial intelligence

Science and technology are a double-edged sword, so even if it is a useful technology, it will eventually be harmful to earth and people unless it is used in the right way. The right way to use technology here refers to a way of using it that does not place an excessive burden on earth. Unless each individual changes his or her consciousness and behaviour, it will be difficult to overcome the Anthropocene, and it will be difficult to realise a truly sustainable earth simply by developing technology because the same mistakes as in the Anthropocene may be repeated in the future. In fact, despite the fact that many people are already concerned about environmental issues, and various activities have been carried out so far, the fact that earth faces serious environmental issues has not been changed, which shows how difficult it is to change the behaviour of each individual. This team believes that people's behaviour based on spirituality is the key to transitioning to a post-Anthropocene social system, and we have been discussing whether we can provide the scientific and technological support necessary to nurture spirituality and lead to behavioural change. Although we have had some success in trying to change mindsets by holding workshops using board games, it seems rare that the results actually lead to behavioural change.[17]

Based on this background, Mini SEs aim to create a society where altruism is nurtured, and well-being of the relational self is realised. However, considering the fact that mental stress was a problem in Biosphere 2, how to cultivate a healthy mind is an important issue. Recent research has focused not only on reason but also on emotions in terms of humans' ability to overcome the Anthropocene in making the right decisions [23]. On the other hand, current AI development has focused on how to make logical decisions quickly and accurately. Therefore, we are developing AI that can understand emotions. By incorporating emotions into AI, it will be able to take care of our mental health with a good understanding of human beings in the future. Furthermore, it will be able to enhance humans' empathy by taking on the role of sharing the experiences of humans across generations.

[17] On 13 May 2021, we held a workshop at Nara Prefectural Kokusai High School, and around 200 students participated.

Additionally, by expressing data about non-human organisms and the environment as the *personality* of the AI, communication between humans and other organisms and the environment will become possible. In order to achieve this, we will establish a technology that can reproduce (virtual) individuals from genome information and evolve them like living organisms in order to integrate AI and living beings. With the development of bioinformatics, it has become possible to predict the structure of individual proteins and their metabolism, but even bacteria have not succeeded in reproducing the movement, shape, and metabolism of individual proteins from genome information alone. On the other hand, DNA information is easy to obtain, and if the technology to reconstruct organisms from it is developed, it can be used not only in the virtual world but also in the real world in synthetic biology, digital breeding, ecosystem conservation, and medicine. In the digital world, time can also be accelerated, which can greatly accelerate the speed of research and development.

Furthermore, by developing technologies that allow machines to operate based on genome information, we will take the integration of organisms and machines one step further and build unprecedented coexistence. Since ancient times, Japan has had a deep-rooted culture of animism, in which non-human nature is worshiped and personified, which provides a cultural foundation for the development of AI technology that appeals to emotions. Japan has already developed a robot that appeals to emotions (Mental Commit Robot) and has proposed robot therapy using it. In addition to psychological and physiological effects, robot therapy has also been shown to have social effects, such as improvement of communication [24]. By advancing this technology, we can build a society where people can share their emotions with AI not only in the field of nursing and medical care but also on a daily basis and can facilitate human relationships and communication, including support for decision making and altruism from a perspective that is not hindered by human limitations. Compared to the West, Japanese people have a culture that values cooperation, and they are willing to sacrifice themselves for the sake of the group,[18] which makes them more suitable than other countries for programming the abovementioned AI.

[2. Material production] Material production by biotechnology

Japan has traditionally been strong in fermentation and brewing technology using microorganisms and is at the top level in the world. The technology cultivated there has been linked to the production of foodstuffs, pharmaceuticals, useful compounds, and useful enzymes, and the microbial stocks obtained in the process are among the best in the world, some of which are available as libraries [25]. It is fresh in our minds that Japan has succeeded in cultivating the microorganism that holds the secret of the birth of eukaryotic organisms ahead of the rest of the world, which was

[18] Interview with Dr. Ken TAKAI, Director-General, Institute for Extra-cutting-edge Science and Technology Avant-garde Research, Japan Agency for Marine-Earth Science and Technology (5 March 2021).

counted as one of the top 10 most important news items in *Science* in 2019 [26]. This kind of cultivation and screening is the result of Japanese people's unique perseverance, and it is a Japanese strongpoint. The discovery of Ivermectin-producing bacteria by Dr. Satoshi OMURA (Nobel Laureate in Physiology or Medicine) can also be cited as an achievement of this kind. In Japanese academia, microbiology belongs to either the agricultural or the medical sciences, and the educational backgrounds are very different from those of other countries, where microbiology belongs to basic biology. In the agricultural sciences, there are microbiologists who are highly interested in environmental issues in Japan because they study a wide range of subjects, including environmental issues, which is advantageous in that a climate has been created for the environmental biotechnology industry to mature in the future.

[3. Energy] Environment-conscious society

The most significant problem in the field of energy is that modern society has built a negative spiral with no future prospects, in which the legacy of the past, namely oil, is used, and CO_2 is released from it, causing global warming. A feature of the Anthropocene is the inscription of human activities on the geological strata, and as a result of the impact of the human influence on earth, the melting of ice floes, mass extinction of coral reefs, and the frequent occurrence of enormous disasters have taken place and are accelerating. In order to overcome this problem and stabilise earth's ecosystem, we need to stop global warming, and we need to be aware that we are at a crossroads [27]. Carbon neutrality has been mentioned as one direction to stop global warming, and although the goal has been set on a global scale, it is limited to the development of particular technologies, and there is very little research and development related to material cycles.

Biotechnology is an effective technology in the Mini SE to connect the issue of global warming and material cycle. Ecosystems essentially use light energy to fix CO_2 and drive the material cycle within the range of the fixed CO_2. By linking light energy and CO_2 fixation once again, we are planning to completely use light energy for material production and restore earth's material cycle, which has been greatly imbalanced. Biotechnology is one of Japan's strengths, and even in a country where resources are scarce, the biotechnology industry has great potential and is expected to bring about the fifth Industrial Revolution [28].

As for the production of renewable energy and materials using light, Japan is leading the world in research on algae, but issues remain in terms of growth rate and stabilisation. The greatest weakness of photosynthetic organisms is their relatively slow growth rate, but the technological infrastructure to improve this has been established through genome editing technology and synthetic biology. Furthermore, genetic recombination technology has made it possible for fast-growing *Escherichia coli* to have the ability to fix CO_2 [29], and the possibility of producing useful substances from CO_2 is emerging. It is also possible to obtain electricity directly from microorganisms (extracellular electron

transfer), which is being studied worldwide as an alternative energy source. Although there is still a problem with the amount of energy that can be produced at present, it is an extremely attractive seed technology in that it can generate electricity by inserting electrodes into the soil at any location, and a system to supply electricity using activated sludge has been developed in Japan [30]. In the first place, cells are constantly producing energy and storing it as adenosine triphosphate (ATP), but if we can change our way of thinking and use ATP as a power source, it could lead to the development of innovative technologies. In Japan, the application of ATP to pump muscle tissue has already been studied [31], and we can expect the development of alternative energy in a broader sense.

The realisation of the abovementioned technologies and the establishment of a system that allows each individual to produce their own energy will transform the social structure and provide the basis for building a society that is resilient to natural disasters.

Virtual reality (VR) will be also used as a place to build Mini SEs by operating the science, technology, and AI described so far. Mini SEs aim to create a society where the well-being of the relational self is realised, where people's thoughts extend beyond people. In order to build such a society, we will use VR to cultivate people's spirituality and as a place to experience social systems, science, and technology. Some Mini SEs are used as parallel worlds and try to establish an environment-conscious society by encouraging change of mindset and behaviour change while reflecting the experience in VR to the real world. Although projects to coexist with nature using science and technology have been carried out in Japan, when they are carried out in the physical world, they cannot be easily redone and cannot respond flexibly to the ever-changing environment and social conditions. In this respect, the use of VR is advantageous for research in that it allows us to experience a different world while maintaining our current lives, to understand the issues and effects of physical SE, and to be able to start over and manipulate time.

In order to make advanced use of VR, it is first necessary to collect precise data based on the real world. The Mini SE can be tested while moving back and forth between the digital and physical worlds. It may seem that a mere simulation would be sufficient for a virtual Mini SE, but since human behaviour involves many uncertainties and is extremely difficult to simulate, we will complete the Mini SE by incorporating actual people into the VR. Since people of any nationality, age, etc., can participate in VR, it is easier to recruit diverse participants than in physical social experiments, and it is easier to analyse the impact of people on the Mini SE.

To date, VR has received attention mainly in the entertainment industry, and Japan has a history of leading the world in the gaming industry and has been an early adopter of VR with the development of PlayStation VR in 2016. In addition, the Virtual Reality Society in Japan was established in 1996, and preparations have been made to analyse the social needs and impacts of VR. Currently, the use of

VR is also being actively considered in the medical field and is being used for surgery, treatment, and even simulated experience of schizophrenia [32]. The use of such VR technology as a social experiment is different from existing VR research and development, and the interaction between the virtual Mini SE and the people who use it will evolve the concept and reality of VR and lead to the development of basic science fields such as cognitive science.

III. Plan for Realization

1. Area and field of challenging R&D, research subject for realization of the Goals

The following points are important in realising a sustainable earth created by reconfiguring the relationship between the natural environment and society through the medium of science and technology.

(1) With the issue of climate change in mind, the use of buried energy should be reduced to *almost zero*, and the use of solar energy should be maximised.
(2) Redefine the ideal state of the natural environment using futuristic thinking, and incorporate the data derived from this into the premise of all problem solving.
(3) Design a social system that allows for future-oriented administration, and develop laws, norms, and education to support this system.

In order to make these visions of the future of science and technology, the natural environment, and society possible, it is essential to develop from the national level to a global effort and to mobilise the wisdom of all people on earth. In the Mini SEs, we will examine various elemental technologies, systems, and ideas and make the best choices to realise a leap forward to a new earth, the "Smart Earth," which will not be an extension of the current Earth.

(1) Non-use of buried energy and maximisation of solar energy

Since the Industrial Revolution, the use of buried energy such as coal and oil has been increasing at an accelerated rate. This places a heavy burden on the global environment due to the retention of greenhouse gases and is threatening the survival of humankind on the planet. If all of these energy sources could be replaced by alternative energy sources, it would be a direct solution to the problems, and we would be able to chart a course toward a sustainable future for the planet. As the numerical targets for greenhouse gas reduction are being fought over by countries approximately 1%, zero use by 2050 will be extremely difficult to achieve if we rely on the current logic. Therefore, the achievement of the target will require the incorporation of large-scale technologies, and the biotechnology strategy will be an important research area as a promising option.

All of the materials that support today's affluent lifestyles are dependent on chemical products. This *chemistry* uses a lot of buried energy in the production process and generates a large amount of waste, which makes it a good target for reducing the environmental impact. Biomass energy and biotechnology will assist to make all materials on earth to be derived from biomass. Biomass and biofuels from solar energy, which is the bottleneck of environmental capacity in the SE, needs to be revolutionised and made more efficient. On the other hand, the affluent life is positioned by the disruptive technology that enables the production of any material required on earth by using

microorganisms and plants.

(2) Redefinition of the natural environment guided by futuristic thinking

When examining the role of science and technology in the state of the natural environment, the degree to which the natural environment can remain *natural* depends on the quantitative and qualitative perspectives of energy and materials required in the SE. From the current perspective, one concrete example is the balance between the necessary installation of solar panels and environmental destruction. On the other hand, the possibility that all the environment and ecosystems on earth will be managed by science and technology should also be considered, and the Mini SEs will examine a new way of thinking about the natural environment and science and technology based on a futuristic way of thinking that is not bound by current thinking and stereotypes. This will include research areas related to the connection between nature and spirit as well as areas related to countermeasures against unexperienced infectious diseases, which requires a redefinition of the natural environment.

(3) Future-oriented society

The current environmental issues have occurred because society has expanded with competition and growth, and the use of buried energy and the destruction of the environment could not be stopped. In the SE, it is essential to have a social system that enables decision making with the utmost respect for the rights that should be guaranteed to future generations. To achieve this, we need to consider an administrative system that gives more discretion to the generation that has many possibilities in the *future*. In addition, action for passing earth on to future generations in a better state is altruism for future generations, and it is necessary to utilise AI technology and build an educational system to spread this new value to many citizens and encourage them to change their behaviour.

2. Direction of R&D for realization of goals

There are some milestones in 2030, 2040 and 2050.

2030: Mini SEs will be established in various forms to begin examining the technologies and social systems necessary for a new earth. The Mini SEs will be established in 10 locations in Japan, where the technologies developed in other MS goals can be verified, and projects in MS R&D work together to realise the SE.

2040: The verification of technologies and social systems in the Mini SEs will be promoted, and the core elements to the achievement of the SE will be selected. Mini SEs can be built not only in Japan but also in other states, and a pathway for global problem solving will be provided.

2050: Technologies and social systems that should be installed in the SE will be selected, and a truly sustainable earth that does not use buried energy will be achieved. To achieve this goal, research and development to further accelerate the biotechnology strategy is promoted. The achievement of SE will also demonstrate the effectiveness of the verification in Mini SEs in implementing new science and technology and social systems. As a result, the Mini SEs will function as an effective scheme as a means of solving further global-scale problems.

3. International cooperation

Since this goal is oriented toward global transformation, international cooperation is essential. In the field of science and technology, it is necessary to promote international joint research in the three areas of demonstrating altruism, material production, and energy. It is necessary to collaborate not only with academia but also with businesses. International collaboration in the humanities and social sciences is also necessary; when the SE is established in 2050, society should be constructed on the basis of diverse philosophies, ideas, and religions on a global scale. Therefore, international comparative research of thought and society based on the progress of science and technology is necessary.[19]

In order to realise the SE, it is necessary to collaborate with other governments and for the Japanese government to lead the world in cooperation with other countries. For this purpose, leadership in the UN is important. Japan has the experience of mainstreaming the concept of "human security" through the UN[20] and needs to use this experience as a basis for taking leadership in the SE. In one case, a research institute and a venture company presented their project at the UN in the presence of the UN Deputy Secretary-General. A research group at the Massachusetts Institute of Technology (MIT) and a venture company, OCEANIX, made a joint presentation on the concept of a floating city at sea, in cooperation with the United Nations Human Settlements Programme (UN-Habitat) [35]. It is also important for non-governmental actors to work with the UN and reach out to the international community.

4. Interdisciplinary cooperation

In order to realise SE, it is also necessary to collaborate with people other than those in academia.

First, dialogue with local governments and civil society is necessary. Change in social behaviour is necessary to realise this goal, and it will not be effective unless the sense of necessity to change society is shared among citizens. In addition, in order to realise the physical Mini SEs in 2030, a place is needed, and the understanding of local governments and civil society is important. This team

[19] For more information on environmental thought and religion, see [33].
[20] For more on the mainstreaming of "human security" and Japan's foreign policy, see [34].

has already exchanged opinions with the City of Tsukuba regarding the Mini SEs concept.[21] It is important to increase the number of local governments that share our philosophy and to create a space for dialogue with civil society in order to establish Mini SEs in 2030 and realise the SE in 2050.

Secondly, cooperation with the education sector is essential. It is important for children, who will be the future leaders of the world, to be encouraged to think together about the vision of society and the role of science and technology. This team conducted workshops for high school and university students to discuss the importance of the environment and to exchange opinions on the visions.[22] Through this kind of practice, it is necessary for many people to discuss the sense of values that are necessary to realise the SE.

5. ELSI (Ethical, Legal, Social Issues)

(1) Expected issues

At present, there are many ethical, legal, and social issues to face in realising the SE. As for ethical issues, it can be pointed out that there may be problems with humans' intervention with the environment in relation to the use of biotechnology. For example, there is a negative view of genetic modification from the perspective of bioethics [36]. Also in society, there are ethical problems with the emphasis on altruism. Considering the history that the development of liberalism has evolved through the liberation of the individual from the group, there can be criticism of emphasising altruism. This is especially the case in Japan, where in the past, education was given to put the group before the individual, and this has been denied after World War II[23]. Some people may see similarities between this education, which emphasises group and altruism in the sense that the interests of others can be prioritised over those of the individual, and some may be critical of this.

As for legal issues, legal restrictions on the use of biotechnology can be mentioned. For example, genetic modification is currently restricted by the Cartagena Act on the Conservation of Biological Diversity through the Regulation of the Use of Genetically Modified Organisms (Cartagena Act) in Japan, and there is the possibility that genetic modification that conflicts with current regulations may be necessary. As a matter of society, there is the issue of how to overcome state sovereignty from the

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[21] Interview was held in 27 April 2021.

[22] The "Post-Anthropocene" course was offered at the University of Tsukuba from April to May 2021, with 72 participants from a variety of colleges. On 13 May 2021, a workshop was held at Nara Prefectural Kokusai High School with about 200 participants.

[23] In Japan, from the late 19th century until the end of the war in 1945, the Imperial Rescript on Education, which served as the basis for education, emphasised the desirability of serving the group and the nation rather than respecting the individual. In addition, the Constitution of the Empire of Japan, promulgated in 1889, stated that human rights would be recognised as a benefit of the emperor. Reflecting on this, the Constitution of Japan, promulgated in 1946, and the Basic Act of Education, enacted after the war, included the concept of respect for the individual. Article 13 of the constitution and Article 2 of the Basic Act of Education stipulate respect for the individual.

perspective of international law. At present, each country has its own sovereignty[24], and each country can adopt different policies. Therefore, the SE cannot be realised by Japan or the UN alone. From the perspective of domestic law, the issue of "altruism," which was also mentioned as an ethical issue, becomes an issue. Respect for the individual is enshrined in Article 13 of the Japanese Constitution and is one of the most important articles of the constitution, especially as it was created as a reflection of World War II. Emphasising "altruism" may interfere with the independence of the individual, and therefore, various legal problems can be expected under the current Japanese law.

One of the social issues is that it is difficult to share the awareness of the issues necessary to realise the SE. There is the possibility that society will point out its aversion to human intervention to the natural environment. In addition, social opposition is expected because the realisation of a new society may conflict with the current norm of respect for the individual.

It was found in the survey conducted in this project that the social image sought by citizens is diverse. Figure III-1 shows the results of the best–worst scaling[25] of the degree of importance placed on various social images.

The overall trend is that the correction of inequality and wealth imbalance (S7) and acceptance of diversity in lifestyle (S6) are the most important. On the other hand, the rejection of the behaviour change promotion by the behavioral score system (S6) is strong, regardless of gender or age. It is possible that a strong sense of rejection exists for systems that exogenously promote some kind of behaviour change. Emphasis on the development of resources in space and the oceans is also generally low.

Next, we examine the differences in the mean scores by gender and age. Resource recycling (S5) is emphasised by the older generation (generally those in their 50s and above) but not by the younger generation. The importance of active resource development (S2) is also low for women across all age groups, but for men, there is a large difference by age group, with the older generation placing less importance on it. The older generations place more importance on the fairness of the economic system (S3).

[24] See UN Charter, Article 2, Section 4.
[25] For more on best–worst scaling, see [37].

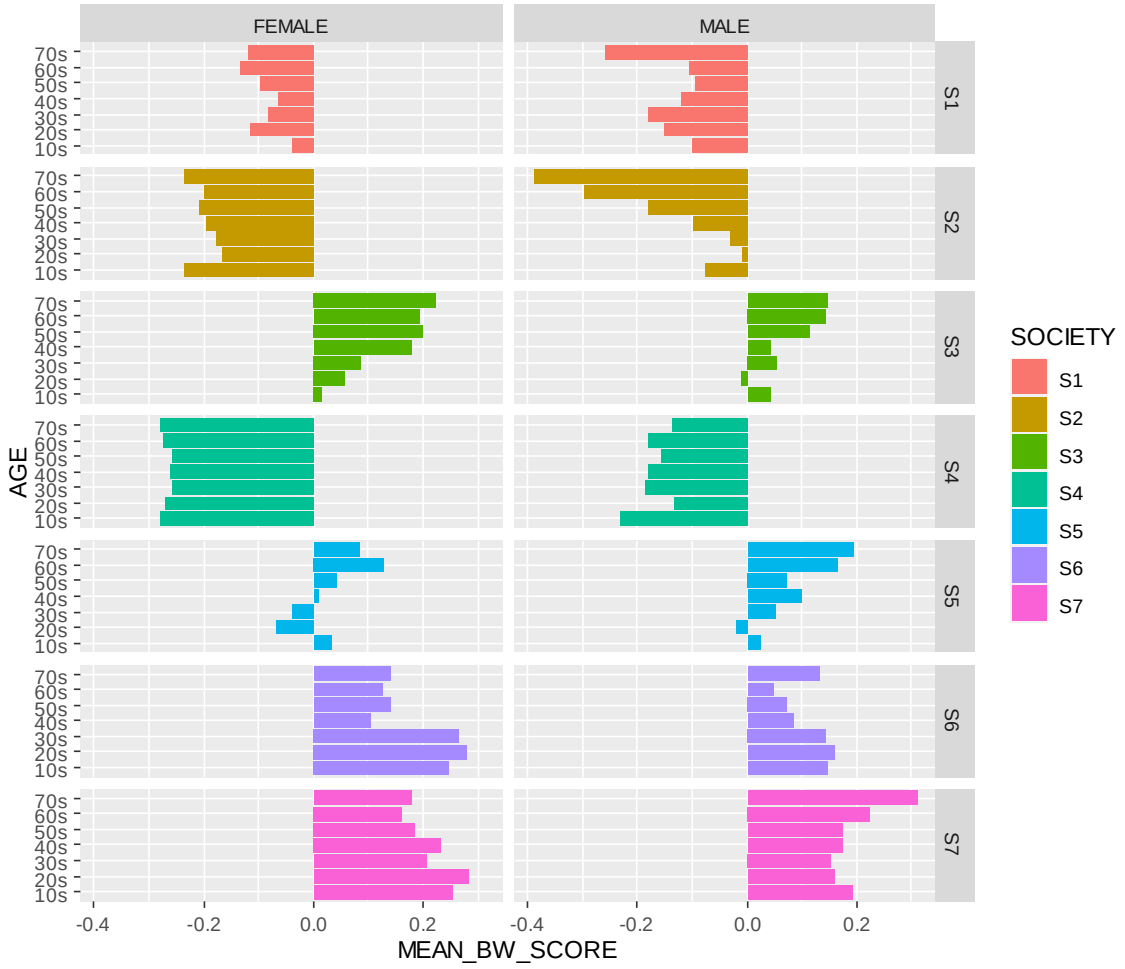

Figure III-1 Mean standardised best–worst scores for social image by gender and age

Note 1: The horizontal axis (MEAN_BW_SCORE) shows the mean value of the standardised best–worst score. The higher the value, the more importance is attached to the relevant social image. The vertical axis (AGE) shows the age of the respondents in 10-year increments.

Note 2: The legend (SOCIETY) indicates the social image as follows: S1 (the right to a better life is extended to species other than humans), S2 (aggressive resource development, including space and oceans, is being promoted), S3 (resource recycling with emphasis on material recycling is promoted), S4 (socially desirable behavioural changes are promoted through the introduction of a behavioural score system), S5 (an economic system that emphasises fairness and sustainability over efficiency has been introduced), S6 (individual lifestyles and principles are mutually recognised), and S7 (problems of inequality and imbalance of wealth among people have been solved).

In summary, the older generation tends to avoid aggressive resource development, emphasises resource recycling, and emphasises a fair and sustainable economic system. The younger generation,

on the other hand, emphasises resource recycling and diversity of lifestyles and beliefs, and this tendency is particularly pronounced among women. However, these are only broad trends based on gender and age, and there is a great deal of variation among individuals. There is a need to reconcile this diversity of thought.

(2) Solutions to issues

However, as has already been mentioned, the SE needs to be realised given the current state of the planet. An important question in responding to the ethical issues is whether the ethical issues at present are important issues that should be considered even if they narrow down the possibilities for future human beings. As humans feel the mystery of life, it is inevitable that technologies related to the foundation of life will be controversial. However, in order to leave possibilities for the future, it is important to consider the possibility of human intervention with the natural environment in order to achieve the greater good.[26] It is necessary to consider the possibility of human intervention on the environment on the premise of a scientific analysis of the impact of human intervention on the natural environment.

In order to overcome the legal issues, different solutions exist for the international legal issue of state sovereignty and the legal regulations on human intervention with the natural environment and the "altruism" in society. With regard to the international legal issue, the persuasion of many states is a possible solution to realising the SE within the premise of national sovereignty.[27] At the climate summit hosted by the president of the United States in April 2021, many states announced their greenhouse gas reduction targets in rapid succession, and this trend can create momentum to build cooperative relationships beyond the national framework[28]. By adopting a strategy similar to that of "human security" mentioned above, the Japanese government can take the lead in building a global consensus. By leading other countries and reaching a consensus at the international level, the SE can be achieved while maintaining the foundation of national sovereignty. As for the issue of domestic legislation, by overcoming the following social issues, the legislators elected by the people will recognise the necessity of realisation of the SE, and legislation to promote the SE will be facilitated.

To overcome social problems, communication with citizens is necessary. In the area of human intervention with the natural environment, activities to distribute seedlings for home gardens are underway to make society understand genome editing [40]. It is necessary to promote an understanding of science and technology by sharing the technology of modifying nature with the public. As for the

[26] To examine this issue, it is necessary to consider intergenerational justice [38].

[27] Note that there is also an idea to change the current system of sovereign states and envision a single world federation. If the world federation is realised, and the world federation works on the SE, political commitment to the SE can be observed. For more information on the World Federation movement, see [39].

[28] See [7] for targets to be achieved by each country.

new society, it is necessary to share a new way of thinking that corrects the individualism based on modern constitutionalism.[29] Although this extremely significant issue will drastically change the foundation of the conventional way of thinking about society, it needs to be considered in order to preserve the possibilities for the future. Through continuous discussion, we must examine ways of being that society can accept.

Because of these efforts, the need for the SE will be recognised, and the ELSI should be overcome by 2050.

[29] For a discussion focusing on the constitution in particular, see [41].

IV. Conclusion

This study concluded that Mini SEs in 2030 and an SE in 2050 are necessary to preserve earth for future generations. There was a lot of discussion to reach this conclusion. There were many difficulties because our team had a diverse group of members, and the discussions were conducted *in between* various positions and assumptions. Throughout the discussions, we had to realise the differences in positions, such as "social science/natural science" and "academia/creative designers." It was not easy to overcome these differences. There were also various discussions on how to think about "nature/science and technology," "nature/human," "past/future," and "West/East."

What we learned from the team's discussions was the importance of maintaining a relationship of *trust* and discussing the *in between*, even if we have different views. By discussing the *in between*, we can relativise our respective positions. Relativising oneself is painful, and it takes time to come up with an answer. However, by building *trust* and continuing dialogue, we were able to see the importance of the *in between*.[30] This team has envisioned the ideal of 2050. This ideal, however, is not something that we, the people of 2021, should force upon the future generation; it is something that the people of 2050 should consider. It is up to the people living in 2050 to think about it, and leaving possibilities for 2050 is what we can do in 2021. The future lies in the *in between*, where we have hope for the future but do not offer an absolute future. It is the SE is that realises *in between*.

The SE will be realised in 2050, but our focus goes beyond 2050. The SE in 2050 is a basis for children in 2100 and 2150 to live on earth. We are sure that the concept of the SE will become the foundation for the smiles of the children who will live in 2150.

[30] Kohei Saito points out that trust and mutual assistance are important to overcome the Anthropocene [42].

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