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An Overview of the 11th Foresight Survey in Japan

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Abstract

The purpose of the 11th Foresight survey in Japan is to provide basic information that contributes to the consideration in Science and Technology (S&T) innovation policy and strategy formation, including the 6th S&T Basic Plan in 2021–2025. The prospective period is about 30 years until 2050, and the target year is 2040. This survey consists of 4 parts: horizon scanning as part 1, visioning as part 2, Delphi survey as part 3 and scenario planning as part 4. For the vision, many opinions were given at the workshop, but as a characteristic tendency, the importance of recognizing humanity due to the spread of science and technology and the importance of connection with people were required. For the image of society in 2040, a society was proposed in which there is no difference between reality and imagination, and there is no feeling of loneliness. In addition, a wide range of hobbies has been proposed as a result from the spread of virtual space technology that can be enjoyed by anyone of any age; and a safe society proposed where dementia can be understood in advance. In this way, a society image was proposed in which the issues that are already prominent at present are overcome. For Delphi survey, it was conducted to reveal the importance, international competitiveness, and prospects for implementation of the topics. There were 5,352 respondents from the industry, academia, and government. The priority was placed on support for problems such as the reduction in population and the ultra-aging society, as well as the recent and frequent climate-related disasters, preventive medicine use, weather disaster support, and lifestyle or work support robots. With regard to the prospect of realizing this, it was shown that 90% of S&T topics can be realized by 2035. In addition, the feature of this survey is that the vision and the results of the Delphi survey were linked, and the priorities for realization were examined in the workshop specifically by the forecast and the backcast. This work was more popular and effective than the participants imagined.

Keywords

science and technology; foresight; Delphi survey; S&T basic plan

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1. Introduction

The formulation of S&T policy requires dialogue with various stakeholders, and it is important to incorporate opinions from various perspectives. When deciding on S&T policy, many things should be considered, such as promotion of S&T projects, education content and research at higher education institutions, human resource development, industry-academia collaboration, international cooperation, based on national comprehensive policies. Policy decision is desirable to collect opinions and ideas from as many people as possible and guide the optimal strategy. However, scientifically creating the decision is a difficult task for many cases. Especially, predicting future development is one of the most difficult issues in government.

Foresight to create the future is a method adopted by many government agencies because it is an evidence-based instrument that includes qualitative and quantitative elements such as expert panels, hearings, scenario creation, and Delphi survey. The National Institute of S&T Policy (NSTEP) has carried out Foresight survey every five years since 197l in Japan and the purpose of this survey is to contribute to the formulation of the National S&T strategy basic plan development policy within 5 years (Cabinet office, 2020; Science council of Japan, 2020). However, due to changes in national economic conditions and social conditions, survey methods have become diversified. Initially, there was only the Delphi survey available, which mainly focused on technology prediction, but in recent years, scenario creation became an important element for future development (NISTEP, 2005).

The 11th Foresight survey consists of 4 parts, including scanning (detecting weak signal), future image of society, future of S&T and scenario planning, as shown in Fig. 1. The prospective future period was the approximately 30-year period from 2020 to 2050, and the target year was set on 2040 (NISTEP, 2019).

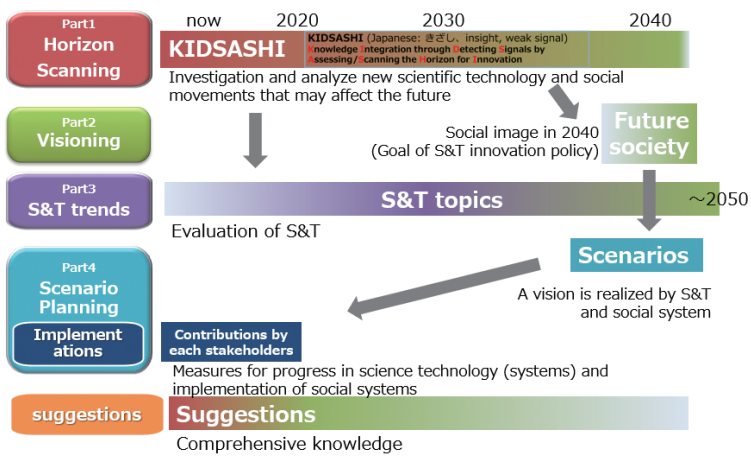

Fig.1 The structure of the 11th foresight survey

2. Horizon Scanning

Early understanding of events that will affect the future is essential for promoting S&T policy. Therefore, it is necessary to investigate the current situation and grasp the trends (OECD, 2020; Government UK, 2020).

"KIDSASHI (Knowledge Integration through Detecting Signals by Assessing Scanning the Horizon for Innovation)" has been a steady and continuous horizon scanning method as a new approach to S&T prediction activities since 2016. This system is to understand various phenomena related to S&T that are currently occurring. It automatically collects the news sent from 300 domestic organizations (universities, research institutes, companies, etc.) every day and summarizes it as data.

Through this activity, the other purpose is to detect weak signals that will have a great impact on society in the future. KIDSASHI is able to create an overview of monthly changes in collected news releases and short reports that capture new signs of S&T, and post them on our dedicated website. By publishing news on the web based on the collected data, it is possible to obtain more information and opinions related to the news from users. These two-way activities are also necessary to promote S&T policies more efficiently (NISTEP, 2018).

3. Visioning

In the 1970s, Japan was in an era of high growth, and the government was investing in research in many fields with the goal of catching up with the developed countries. However, a different future image is predicted now such as an aging society and a declining birthrate. In particular, since the government is expected to reduce tax income, some indicators are needed to efficiently allocate the limited budget in promoting S&T. It is necessary to study the future image of society, to avoid the problems that may occur in that society by avoiding them now, and to consider measures to realize a better society. Therefore, a workshop was held to examine the ideal image of society and what issues should be considered, and the purpose of drawing a final vision for the future.

3.1. Making vision by workshop

In January 2018, we held a vision workshop in which 96 people involved in S&T and related sectors participated in order to envision a society aimed toward 2040. Participants were divided into 10 groups for consideration. In forming the group, attributes such as specialized fields, industry-academia-government divisions, and gender were made diverse.

In the study, after sharing possible future possibilities, the participants proposed multiple social images, aggregated and grouped them to extract the ideal social image. Next, we examined the degree of involvement of the image of society in S&T and feasibility, and wrote down the S&T and elements other than S&T (social systems, etc.) that contribute to the realization of an ideal image of society.

3.2. Results of future vision

The ideal social image obtained from the group discussion was classified according to the content, and the keywords were summarized as Humanity, Inclusion, Sustainability, and Curiosity as shown in Fig. 2.

The keyword "Humanity" describes human life style, society and human beings, automation, Japanese, culture, happiness, and a society image that enhances the value of the community. "Inclusion" pictures a society in which people with different characteristics understand individual characteristics and their respective values and progress through connection. "Sustainability" depicts a society in which resources, energy, food, environment, circulation, disaster countermeasures, and civic activities are emphasized.

"Curiosity" gives the image of a society in which the expansion of the activity space is emphasized as well as the spirit of inquiry is depicted. Overall the essential conditions for human beings to live, such as energy and food, are met, and equal treatment is ensured for everyone to live happily. In addition, activities of individuals and communities aiming at better life are being respected; in the society frontier development by curiosity is important.

Discussions on Sustainable Development Goals (SDGs) have been considered in Japan, and similar results have been obtained in the ministry's vision review. From these, we can find a common vision of a happy way of life, food and energy security, and a disaster-resistant society.

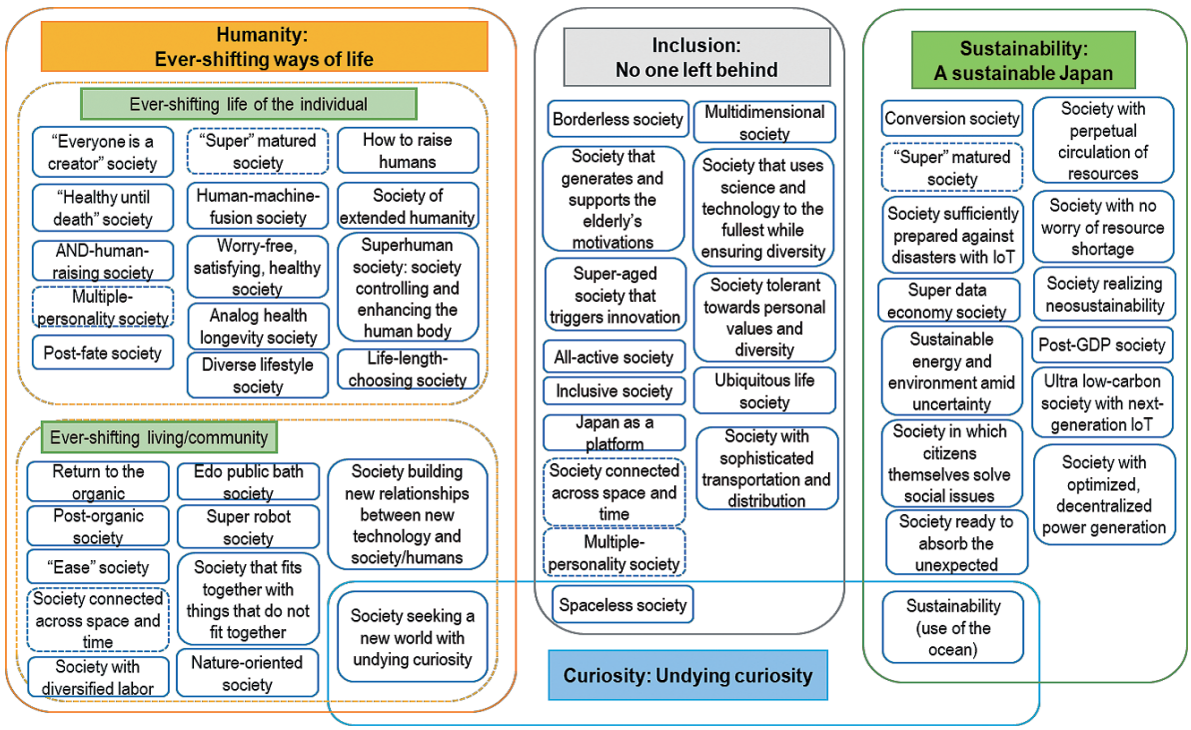

Fig. 2 Summary of future vision

4. Delphi Survey

4.1. Design of Delphi survey

This is a questionnaire to obtain a medium- and long-term outlook for S&T development. The characteristics of the Delphi method is to increases the convergence precision of the opinions from multiple specialists through a repeated questionnaire note.

As the Delphi survey covers all S&T issues, seven fields are shown in Table 1 and the investigation was conducted by means of a subcommittee composed of ten experts from each field. A total of 702 S&T research and development topics were set to be realized by 2050. The survey setting procedure is shown in Table2, question items were set in regard to priority, international competitiveness, achievement outlook, and policy phases for realization.

Table 1 Areas, fields and number of topics

Areas	Fields	Topics
Health, medical and life sciences	① Medicine ② Medical device development ③ Senescent and noninfectious diseases ④ Brain science ⑤ Health crisis management ⑥ Information and health ⑦ Social medicine	96
Agriculture, forestry & fisheries and food biotechnology	① Production ecology systems ② Food ecology system ③ Resource ecology systems ④ System infrastructure ⑤ Next generation biotechnology ⑥ Biomass ⑦ Safety, relief, health ⑧ Community and energy	97
Environment, resources and energy	① Energy conversion ② Energy system ③ Resource development, reduce, reuse and recycling ④ Water ⑤ Global warming ⑥ Environmental conservation ⑦ Risk management	106
ICT, analytics and services	① Future social design ② Data science and AI ③ Computer systems ④ IoT and robotics ⑤ Network and infrastructure ⑥ Security and privacy ⑦ Service science ⑧ Industry, business and business applications ⑨ Policy and institutional design ⑩ Social implementation ⑪ Interaction	107
Materials device process	① Materials and substances ② Processes and manufacturing ③ Computational data science ④ Advanced measurement and analysis methods ⑤ Application device system (ICT · nanotechnology field) ⑥ Application device system (environment and energy fields) ⑦ Application device system (infrastructure · mobility field) ⑧ Application device system (life · biotechnology field)	101
City, architecture, civil works and traffic	① Land development and conservation ② Architecture ③ Social infrastructure ④ Urban environment ⑤ Construction production systems ⑥ Transportation systems ⑦ Road, rail, marine and aviation ⑧ Disaster prevention and mitigation technology ⑨ Disaster prevention and mitigation information	95
Space-marine and earth science foundation	① Space ② Ocean ③ Earth ④ Earth observation and prediction ⑤ Calculation, mathematical science and information science ⑥ Elementary particle, nuclear, accelerator-particle ⑦ Beam applications: synchrotron radiation ⑧ Beam applications: neutronmuon charged particles, etc. ⑨ Light and quantum technology	100

4.2. Results

4.2.1. Overview of respondents

This survey with questionnaire was conducted during 4 months in 2019. The answers were obtained from 5,352 experts in Japan. The attributes of the respondents are shown in Fig. 3.

4.2.2. High importance of each field

The examples of high-priority topics among all the 702 are shown in Table 3. When looking at the achievement outlook for the topics, 97% can be achieved from a S&T perspective by 2035 (technical environment is prepared for achieving expected performance) and 87% can be achieved socially (the realized technology will be in a usable state for products and services). There were 23 topics to be realized from an S&T perspective, including brain science, biological memory, nuclear power, nuclear fusion, resource extraction, reuse, space science, and space development, etc. Of them, 11 topics fell in the

Table 2 Survey questions for all topics

Items	Contents	Answers
Importance (single answer)	Current importance of topic for Japan to achieve the desired state of society 30 years from now	very high(+2), high(+1), neither high nor low(0), low(-1), very low(-2)
International competitiveness (single answer)	Japan current international competitiveness in terms of the topic	very high(+2), high(+1), neither high nor low(0), low(-1), very low(-2)
Prospect of scientific/ technological realization (single answer)	Time by which scientifically/ technologically realized somewhere in the world, not excluding Japan	already realized, by 2025, 2026 to 2030, 2031 to 2035, 2036 to 2040, 2041 to 2045, 2046 to 2050, 2051 or later, It won't be realized, No idea
Policy means for scientific/technologic al realization (multiple answers allowed)	Policy means called for to scientifically/technologically realize the vision	development/securing of human resources, increased R&D budgets, research platform establishment, domestic collaboration, international collaboration/standardization, establishment of legal regulations, addressing ethical concerns, other
Prospect of social realization (single answer)	Time by which the vision will be socially realized in Japan, following its scientific/technological realization somewhere in the world, not excluding Japan	already realized, by 2025, 2026 to 2030, 2031 to 2035, 2036 to 2040, 2041 to 2045, 2046 to 2050, 2051 or later, It won't be realized, No idea
Policy means for social realization (multiple answers allowed)	Policy means called for to socially realize the vision in Japan	development/securing of human resources, support for business/project, establishment of business/ project environment, domestic collaboration, international collaboration/standardization, establishment of legal regulations, addressing ethical/legal/social concerns, other

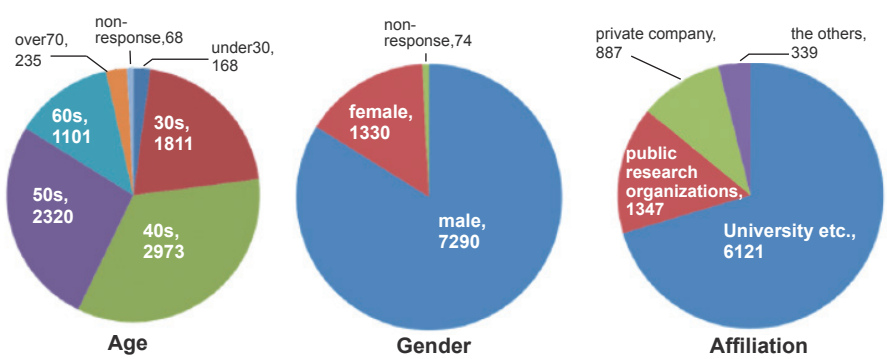

Fig. 3 Respondents in the 11th delphi survey

Table 3 High priority topics in each field

Technology topic example	Importance	Inter′ competitiveness	Tech. realization	Social realization
The prevention, cure for exercise functional decline accompanied with the aging	1.56	0.55	2028	2030
The agriculture robot which substitutes between people	1.35	0.56	2026	2029
The longer life that is exchange-free for electric cars and low-cost rechargeable battery	1.48	0.98	2029	2032
Techniques such as AI, IoT, robot improving the cancellation that is short of productivity of the agriculture, a labor shortage, leading figures radically	1.57	0.27	2029	2031
The high volume high output battery which has performance of (a flying range is equivalent to 500km at current size, weight if it is a car) output density 1kW/kg or more energy density 1kWh/kg or more	1.5	0.91	2030	2032
The Nondestructive Inspection technology which I can use on the site to plan reliability improvement and the burden reduction of check, the diagnosis of the infrastructure	1.53	0.8	2025	2026
Pressure degree evaluation to find the volcano which there is not in the way that it seems to erupt next for all active volcanoes in Japan or I do it	1.51	0.91	2031	2033

environment /resource/energy field. Most of the topics can be realized socially within a period of five years in terms of S&T realization.

4.2.3. Importance and international competitiveness

All the 702 topics were summarized, and a comparison of importance vs international competitiveness is shown in Fig. 4. Most of the topics have a correlation between importance and international competitiveness, and their international strength is high, except for areas including ICT, analytics and service science. In particular, the international competitiveness of topics related to the use of data, considered to be something that will greatly move society forward, such as lifestyle big data or urban-related data, is close to 0, and there is an issue in regard to strengthening competition.

On the other hand, climate forecasts and risk evaluation topics rank first in terms of international competitiveness within the agriculture and fisheries, food, and biotechnology fields, while the secondary batteries for automobile topic ranks second for international competitiveness within the environment, resource, and energy fields.

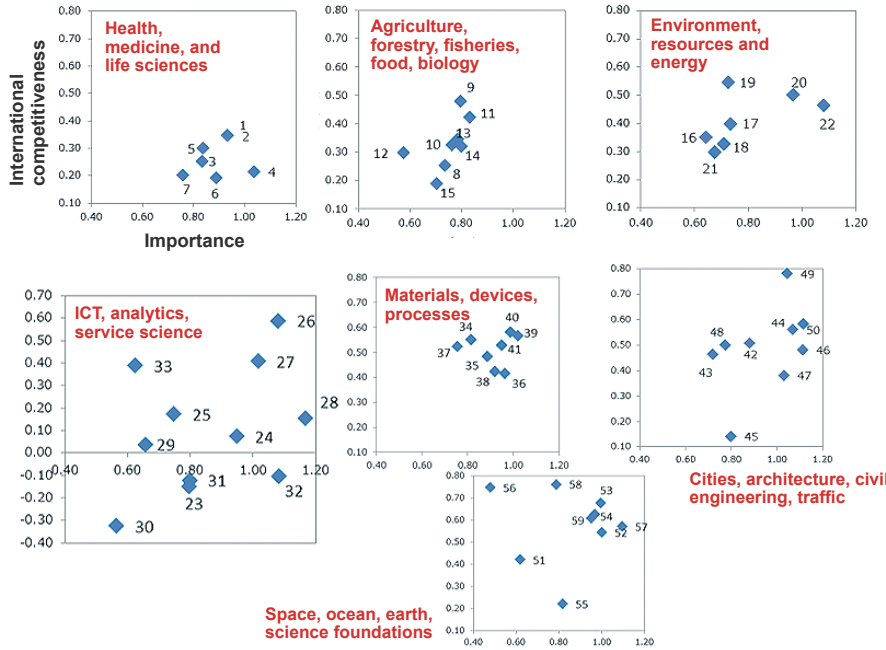

Fig. 4 Comparison of importance and international competitiveness

5. Scenario Planning

The scenario method is well known as a successful example of the international oil company Royal Dutch Shell (NISTEP. 2018). At present, it is practiced at various scales, ranging from countries, regions, industries to companies, involving various stakeholders and experts (Schoemaker, 1995; Amer. 2013; Shell Scenario, 2020). In today's world and business environment where the sense of values is diversified, and uncertainty and change are rapidly changing, the scenario method (scenario planning) is drawing attention as one of the best practices for shared vision and long-term strategy formulation.

5.1. Basic scenario making based on summary of vision and Delphi survey

This study is the final part of the survey, and based on the future image of S&T (702 S&T topics) and the future image of society (50 social images) obtained so far. The basic scenario was created by holding a workshop to incorporate many opinions and viewpoints from various fields.

Based on the target year of this survey 2040, it set up the two axes of "individual/society" and "intangible/tangible" assuming "the next society realized by Society 5.0". Therefore, the axis set up for summarizing S&T topics and the future society is shown in Fig. 5.

This axis is not one for setting conditions to draw multiple future images, but one for classifying social images. The "individual/society" axis was set as a classification axis to identify changes in individuals (Humanity, Curiosity) or the society (Inclusion, Sustainability) as mentioned in the examination of social image. As for the "intangible/tangible" axis, as described above, classifies the efforts of Society 5.0 having progressed to form a unique society in which virtual space (cyber space) is confronted with real space (physical space). Regarding the classification of "individuals" and "society", the social image of individuals is classified as "individual", and the social image of the society in which those individuals live is classified as "society". Also, regarding the classification of "intangible" and "tangible", those that cannot be touched

such as spirit and values are classified as “intangible”, and those that can be touched such as body and things are classified as “tangible”. The summary of viewpoints of future society is shown in Fig.5.

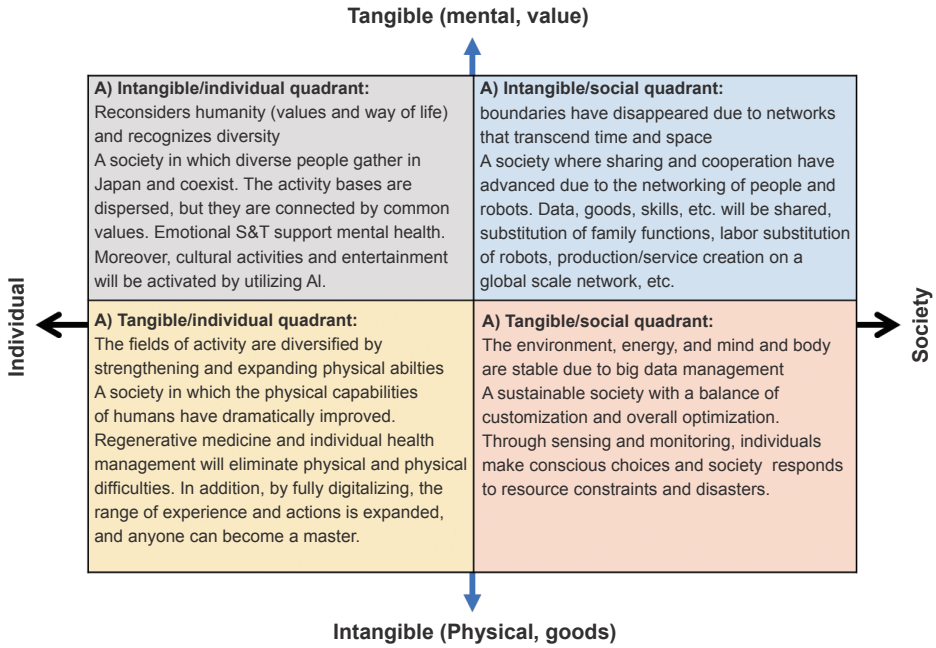

Fig. 5 The viewpoints of future society development

5.2. Up-dating scenario by workshop

The workshop was employed to share the vision and add more ideas, and to understand the relationship between the future society and S&T drawn from the vision.

5.2.1. Scenario development of future society

The workshop included an additional study on social factors and scrutinized related S&T issues, and compiled a basic scenario as shown in Fig.6.

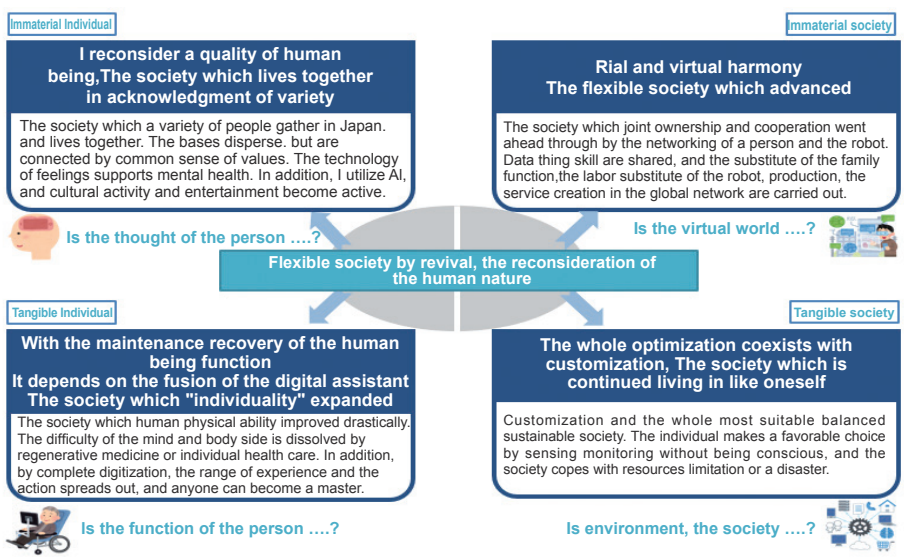

Fig.6 Summary of future society

5.2.2. Understanding the relationship between future image of society and S&T

The workshop carried out the work of studying the necessary technology in view of the future from the present (forecast) and the future society (backcast). In fact, understanding how there is a difference between these two results is an important point in scenario development. Looking at the relationship between the image of society and S&T topics, 470 of the 702 S&T topics were associated with the image of society.

Seven fields were set in the Delphi survey (① health/ medical/ life science, ② agriculture/ forestry/ fisheries/ food/biotechnology, ③ environment/resource/energy, ④ ICT/ analytics service, ⑤ material/ device/ process, ⑥ city/ architecture/ civil engineering/ transportation, and ⑦ Space, ocean, earth, and science base), more than half of the S&T topics were linked to the image of society as shown in Fig. 7.

In the study of social origin, 60% to 90% of the results were related to the image of society in the fields of health/ medical/ life science, agriculture/ forestry/ fishery/ food biotechnology, environment/ resource/ energy. On the other hand, in examining the starting point of S&T, more than 50% results were only in the fields of ICT, analytics, and services, and there were no fields with a particularly high ratio, and in general, all fields were uniformly linked to the image of society.

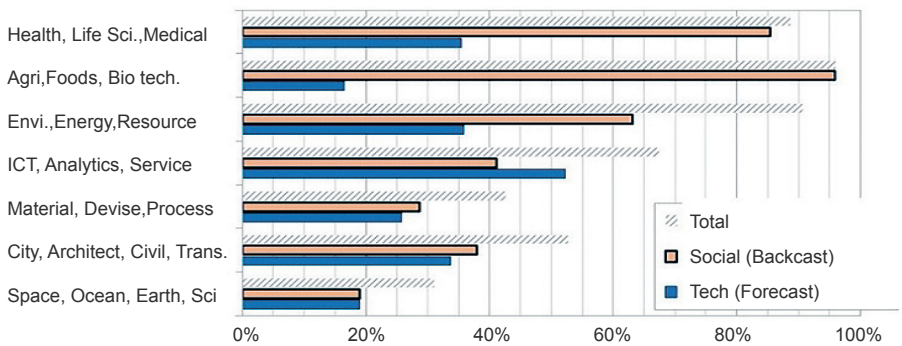

Fig. 7 The ratio of relationship between future society and S&T topics

5.3. Making scenario by society and S&T

One example of scenario based on future society A (as Fig. 6) and Delphi survey results with consideration for realization is shown in Fig. 8.

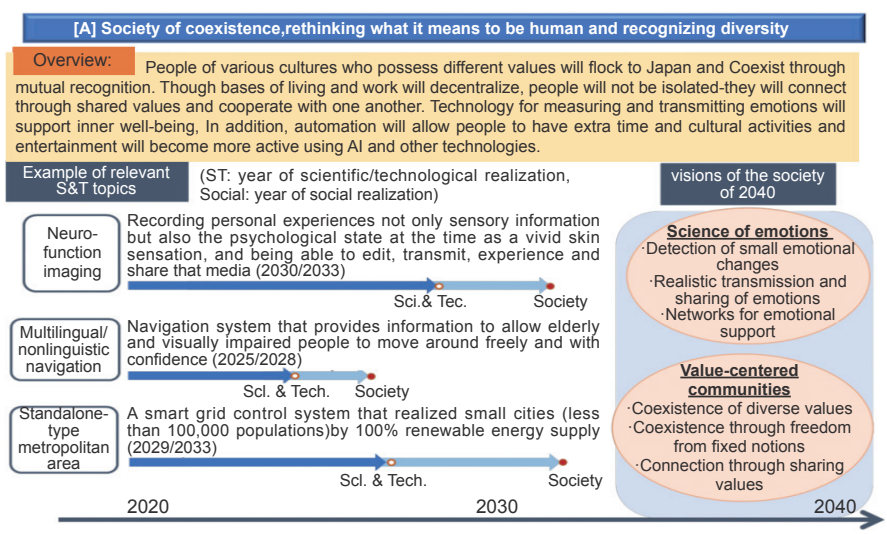

Fig. 8 Example of basic scenario based on vision and delphi survey

Based on this scenario, avoiding future risk is an issue getting seriously challenging, and a big concern is the risk of separation among communities due to opposition/ indifference. This is a key S&T topic. Also, creating opportunities for exposure to different cultures/values and generating shared experiences among communities is important. Securing infrastructure maintenance cost for the sustainable use of services is one of the priority issues as well.

6. Summary and Discussion

This article introduced an overview of the 11th Foresight survey. The survey consists of 4 parts and this article introduced only part of the results. 2040 was set as the target year for the whole survey.

To make a vision, many opinions were given at the workshop, but as a characteristic tendency against the spread of science and technology, "recognizing humanity" and "connection with people" were found to be important. For the image of society in 2040, a society was proposed in which there is no difference between reality and imagination, and there is no feeling of loneliness. In addition, a wide range of hobbies has been proposed due to the spread of virtual space technology that can be enjoyed by anyone of any age, and a safe society was proposed where dementia can be understood in advance. In this way, a society image was proposed in which the issues that are already prominent at present are overcome.

According to the results of this Delphi survey, the year difference between technology realization and social dissemination tends to be closer than in the previous survey. It can be said that this is because many of the topics that were selected in this survey were closer to practical use than those in the previous survey. In addition, the feature of this survey is that the vision and the results of the Delphi survey were linked, and the priorities for realization were examined in the workshop specifically by the forecast and the backcast. This work was more popular and effective than the participants imagined.

NISTEP has been holding Foresight surveys for 11 times so far (NISTEP, 2010; NISTEP,2015). At the beginning of the Foresight project, a survey specialized in technology was conducted, but from the 8th survey, the system and social background have been taken into consideration. Since then, the design has been changing each time based on the social background. For this time, the vision and S&T workshops were held several times, and it was a quantitative and qualitative survey incorporating the opinions of various stakeholders (NISTEP, 2019b).

This is largely influenced by the social background in which factors other than technology, such as social ethics and legislation for disseminating new technologies, are becoming more important in technological development (COCN, 2020).

In Japan, as faced with aging society, human resource development issues are also major challenges. Creating a scenario for a better society is a great challenge and difficult, but many stakeholders considered that technology foresight is efficient because it is an activity that also serves as consensus.

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