

As mentioned before, the GEJE has revealed the limitations and negative aspects of the S&T that the modern civilization is based upon. The lessons that we have learned through the earthquake are 1) that even the most developed society faces the risks and crises of natural disasters and accidents, and 2) that all of us must cooperate and create a society that can minimize the damage caused by these crises in order to quickly recover from them.

At the "World Economic Forum Annual Meeting" (known as the Davos Forum) in January 2012, multiple symposiums on natural disaster risks were held, and Prime Minister Noda (via satellite) and former Prime Minister Kan joined in from Japan to exchange their thoughts with key governments and business leaders. The report "Global Risks 2012," published by the forum, featured special articles on the GEJE. The articles showed that the international community had recognized the impacts to the economy and society caused by natural disasters exceeding expectations, as well as the necessity to prepare for such impacts.

The report described the impact to the automotive manufactures in Detroit caused by the disaster's damage to auto parts manufactures in Japan as an example, and pointed out how vulnerability in the world economy had affected advanced interdependence. In conclusion, the report emphasized that flexibility and resilience were required to take measures against natural disasters. And, on May 10, 2012, the G-Science academies stated that "Building Resilience to Disasters of Natural and Technological Origin" was one of the policy challenges that should be discussed by world leaders, including G8 summits. Building a society that is rich in resilience and can quickly recover from disasters is a global challenge which includes Japan and its experiences in the GEJE.

As for the society that Japan should aim at as a goal after the earthquake, this chapter will introduce a "Robust and Resilient Society" that can prevent or minimize the impacts and damages due to various risks and crises that human beings face, such as natural disasters and accidents, climate changes and global warming, energy problems, food shortage problems, cyber crimes, pandemics, and so forth, so that societies can promptly recover, and can make progress even further. In addition, this chapter will give an overview on the necessary contributions that S&T are expected to make to build such a society. Then, this chapter will introduce some examples of efforts for advanced STI (science, technology and innovation; the same shall apply hereafter), aiming at overcoming the various challenges revealed by the earthquake, and provide future direction of the policy in order to further promote such STI.

Section 1 Rebuilding the Society and the Role of S&T after the GEJE

According to the "Survey of Level of Happiness of Young People" conducted by the Cabinet Office of the Japanese Government immediately after the earthquake, many young people in their 20s and 30s claimed a change in their sense of values related to happiness. The survey revealed that their viewed life as being triggered by the earthquake, regardless of whether they lived in the damage area or not, because of the psychological shock caused by seeing how daily life can be destroyed in seconds and because of

their anxiety that a similar disaster could happen anywhere at anytime.

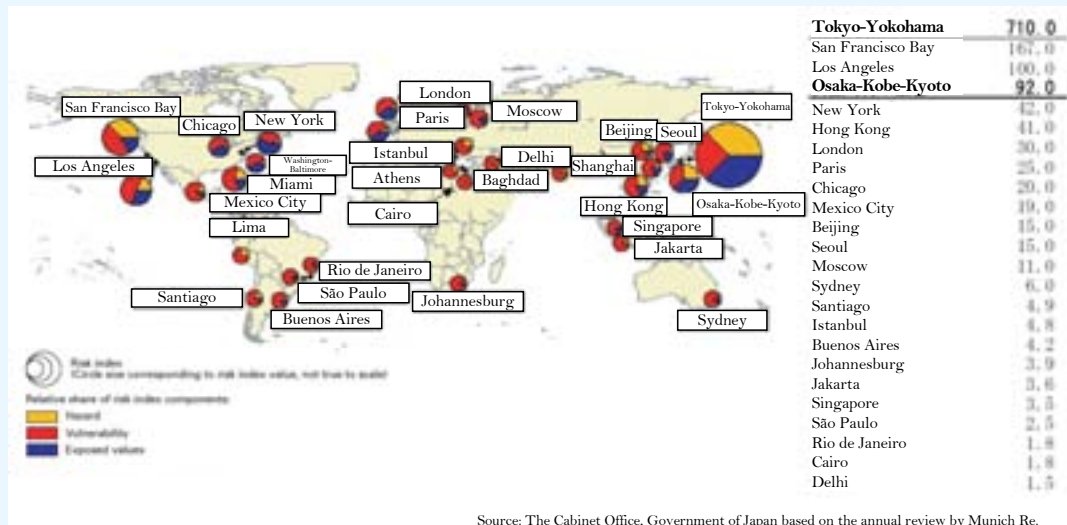
The question here is, what sort of society does the Japanese public expect, in terms of the goals of reconstruction and revival from the earthquake?, and how are they supposed to experience changes in their values and views of life after going through the GEJE? What kind of roles do they expect S&T to play in establishing such a society?

This section will discuss the post-earthquake society that the Japanese public wishes for, and provide an overview of the expected roles of S&T and the direction of the policy in order to build such a society.

(The post-earthquake society that the Japanese public wishes for)

According to the natural hazard risk index for megacities, Japan faces an extraordinarily higher risk of natural disasters compared to other developed countries. With the drastic change in progress of earthquake-resistant technologies and global economic development nowadays, it is a matter of great importance that Japan needs to consider in order to maintain a robust industrial infrastructure, and to maintain and improve economic value (Figure 1-2-1). Even after FY2011, Japan has endured severe damages caused by the following events: the eruption of Mt. Kirishima (Shinmoedake) in late January of 2011, Typhoon No. 6 (Typhoon Ma-on) on June 20, in Kinki/Shikoku, Typhoon No. 12 (Typhoon Roke) from August 29 through September 7 in Kinki/Shikoku, Typhoon No. 15 (Tropical Storm Talas) from September 15 through 22 in Kanto/Chubu/Kinki, heavy rain in Niigata/Fukushima from July 27 through 30, heavy snow from November 2011 through March 2012, and the tornado on May 6, 2012, in Tsukuba City in Ibaraki Prefecture—all in addition to the damages caused by the GEJE. It is obvious that the risk of natural hazards in Japan, such as earthquakes and typhoons, is extraordinarily high compared to other countries. For example, the incidence of hazards in Japan are among the highest worldwide (e.g. number of M6.0 or greater earthquakes is approximately 20%) and are extremely high, considering that Japan only makes up 0.25 % of the world's land mass. If Japan's economy which accounts for 8.6 % of world GDP would stagnate for a long time due to a large-scale, large-area disaster, such as the March 2011 earthquake, the impact to the global economy and industries could be tremendous (Figure 1-2-2).

Figure 1-2-1/ A natural-hazard risk index for megacities



Source: The Cabinet Office, Government of Japan based on the annual review by Munich Re.

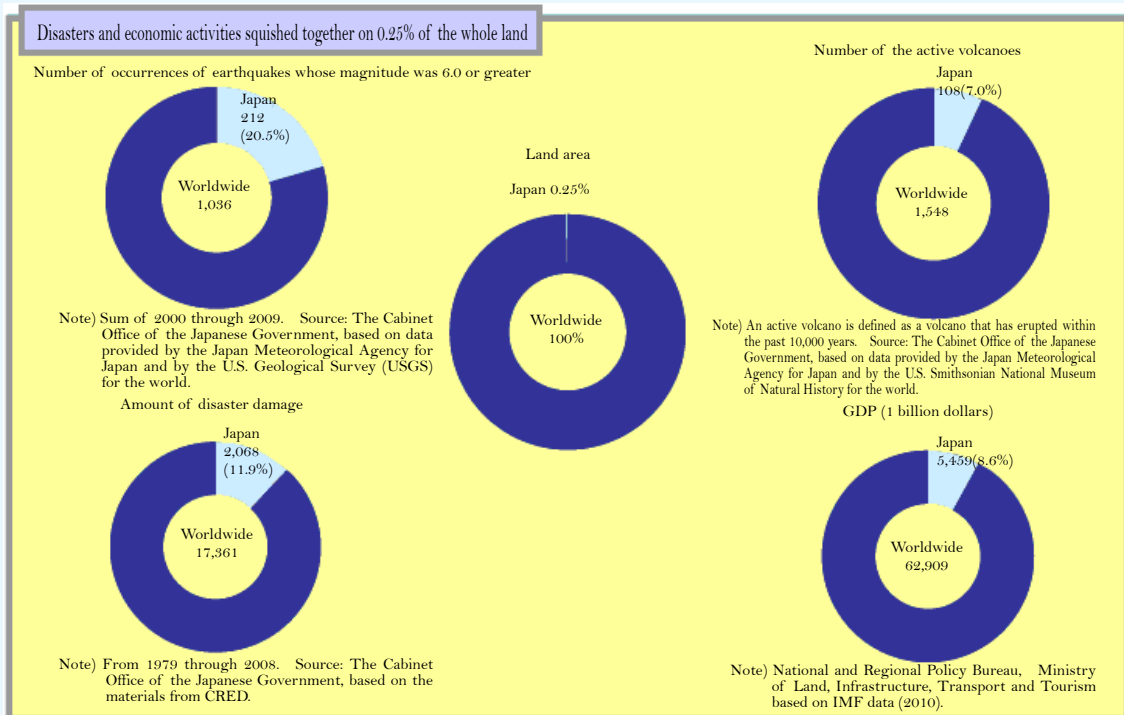
Note: According to "The natural hazard index for megacities" published by Munich Re in March 2003, the risks in Tokyo and Yokohama were reported to be extremely high among the 50 megacities around the world.

It was based on an index derived by multiplying the following information for each city and area;

- (1) Hazard probability: Risk of earthquakes, windstorms, floods and other hazards (volcanic eruptions, bush fires and frost)
- (2) Vulnerability: Three components to be examined are the predominant form of residential construction, building density, and standards of preparedness/safeguards.
- (3) Exposed economic values: The index related to the magnitude of economic impact as based on the household and economic level of each city.

Source: White Paper on Disaster Management, FY2004

Figure 1-2-2 / Disasters and activities compressed together on the limited land



Source: Reference material of "Proposal to Build a Land Tolerant to Disasters," the Committee for the Protection of Land and the Prevention of Disasters of the Policy Subcommittee in the National Land Council (July 2011)

Meanwhile, the Council on Competitiveness-Nippon (COCN¹) defines a "resilient economy" as an economy that possesses "flexibility and robustness that enable society to quickly recover and function as a whole even when some portions of certain functions, such as social systems or operations, stop due to actual risk" (resilience). The COCN states the importance of measures to strengthen competitiveness within the nation and business sectors and the importance of preparation against natural disasters and accidents, including global warming and energy problems², food problems³, cyber crimes⁴, and pandemics⁵ by establishing resilience between the social system and business management as part of a comprehensive business strategy⁶.

Column
1-4

A society that the U.S. is shifting toward in response to 9/11

Being heavily affected by 9/11 that occurred in 2001, the Department of Homeland Security (DHS) was established in the U.S. This organization was built by combining 22 related, yet separate federal departments and agencies, and its core missions are to prevent terrorism and enhance security, secure and manage their borders, enforce and administer their immigration laws, safeguard and secure cyberspace, and ensure resilience to disasters. "The Science and Technology Directorate" is established under the DHS, and is responsible for R&D related to anti-terrorism and other information securities that the U.S. recently makes numerous efforts to support, including various security guarantees against infectious diseases. At a symposium⁷ held in Tokyo after the Great East Japan Earthquake, Dr. Norman P. Neureiter, who used to work as an Assistant for International Affairs to the President's Science Adviser in the White House Office of Science and Technology and Science and Technology Adviser to the U.S. Secretary of State, and has lived in Japan, stated that the common key word was to prevent, protect from, mitigate, respond to and overcome all incidents—to be resilient, that was to realize the recovery capacity to survive under difficult circumstances and especially that resilience would be the core of all preparations. As pointed out response to natural disasters was (partially omitted) the same as a response to anti-terrorism in terms of the necessity of organized reconstruction, and the saving of lives and treating of victims.

Meanwhile, the Council on Competitiveness (COC⁸), a private bipartisan organization, mainly comprised of U.S. industry sectors, universities and labor unions submitted a report titled "Transform. The Resilient Economy: Integrating Competitiveness and Security" in June 2007. In response to the 9/11 shock, the COC introduced a concept that the national security shall be also the challenge in national competitiveness."

The report points out the following:

- The level of risks that companies and nations are facing is increasing due to globalization, complexity in technologies, interdependency, terrorism, variability in climate and energy, and epidemic risks.
- The interrelationship between risks is also further increasing.
- There is a possibility that a functional failure occurring in a certain area could affect other multiple areas. The report states "The capability to respond to new risks, anticipate interaction between various kinds of risks, and recover from functional failure will be the competitive differentiator of a company and a nation in the 21st century." The report also mentions that the nation should focus not only on national security and protection but on risk management and resilience based on the fact that any impregnable defensive line still possesses an essential flaw and that all fences and firewalls can be broken. In the report, "resilience"⁹ is defined as the capacity to predict, mitigate the influence from, and quickly recover from risks, and "resilience" shall be the ultimate goal for both a secured economy and competitive businesses.

The report contains the following points: there is an infinite number of scenarios of function failure for companies, but the number of results is limited. In other words, it does not matter what causes down time, whether it is a power outage, flood, strike or terrorist attack. The goal is to become agile and flexible in order to mitigate risk and manage its influence, rather than to focus on the cause.

Acquiring "resilience" against risks is surely a critical goal for achieving creditworthiness and competitiveness among individual organizations and companies and it is also important for the construction of a society that can very well tolerate environmental changes, and can be robust and resilient. Finally, it is important for the enhancement of national security and competitiveness as well.

¹ The Council on Competitiveness-Nippon (COCN) was established in 2006 by volunteers in the business sector who are deeply interested in strengthening Japan's competitiveness in industries.

² The Great East Japan Earthquake revealed the vulnerability of Japan's energy system against the risks because of planned power outage and restrictions on power usage due to the shutdown of large-scaled power generation facilities such as nuclear power plants and thermal power plants.

³ Japan, whose food self-sufficiency rate is extremely low, faces the issue that it could not secure enough food if global food crisis would occur while food prices are soaring in the world because of increase in the world population, expansion of biofuels, and worse production condition of agricultural products due to the global warming and frequent abnormal weathers.

⁴ In FY2011, Japan realized the vulnerability in information security with the incidents such as leak of legislator's mail addresses in addition to a series of uncovered cyber attacks against major companies and government and municipal offices.

⁵ In 2009, a pandemic flu (A/H1N1) broke out globally, and over 14,000 people worldwide were killed by influenza infection and 198 people were killed in Japan (according to a summary as of March 20, 2010 by the Office Headquarters for Pandemic Influenza Counter-measures). Japanese society also faces vulnerability in terms of infection control measures since it would take one and half to two years to produce influenza vaccine for all people with the current method using an egg culture if worldwide pandemic of infectious disease breaks out.

⁶ Source: "The Resilient Economy Workshop – Establishment of a Robust Resilient Social System and Industry," Council on Competitiveness-Nippon

⁷ JST symposium "Science and Technology for Social Security," held on December 8, 2011.

⁸ Council on Competitiveness, established in 1986. The council has provided proposals to strengthen competitiveness of U.S. industries such as "Innovate America" (known as Palmisano Report) in its history, and influences to U.S. government's policy making.

⁹ According to the definition by the Center for Resilience at Ohio State University, "resilience" is the capacity of a system to survive, adapt, and grow in the face of unforeseen changes, even catastrophic incidents. It also states that a resilient enterprise is well aware of risks, flexible and agile.

Japan needs to build a society that is strong and capable of recovery (so called "a robust and resilient society¹⁾") in order to maintain its strong industrial infrastructure and to prevent the degradation of Japan's economic value.

Obviously the demand for such a society comes not only from the industrial and economic but also from other communities, too.

Results from opinion polls conducted by prefectures after the earthquake also imply that the earthquake has triggered citizens' demand for the government to treat the earthquake as an opportunity to improve measures to protect from disasters. According to the responses to the 16 questions related to demands/needs for prefectural governments in the results of opinion polls conducted by 31 prefectures²⁾ after the earthquake, the citizens' demands for enhanced "measures to protect from disasters" increase in most questions. Particularly in Tokyo, in FY2011, the demand for the disaster protection measures scored highest, even exceeding the public safety measures that had been rated as No.1 for the previous seven consecutive years (Figure 1-2-3). There was also a significant increase in demands/needs for disaster protection measures in Ibaraki Prefecture, Tochigi Prefecture, Saitama Prefecture, Chiba Prefecture, and Kanagawa Prefecture. Also in western Japan, when the people in Toyama Prefecture were asked the measures and policies that required further efforts from the government, the reply with "enhancement of disaster protection/crisis management" soared to fifth from 13th in the previous year, and in Nara Prefecture a matter of disaster protection measures was ranked high as important but not implemented sufficiently. Increase in the anxiety and fear of a disaster occurring and the ratio of people preparing for disasters were also observed. In addition, demands for "food safety" measures increased in five prefectures (Ibaraki Prefecture, Tochigi Prefecture, Saitama Prefecture, Chiba Prefecture, and Kanagawa Prefecture). With the exception of Tokyo³⁾, among six prefectures that conducted the opinion polls in the Kanto area, there were concerns about radioactivity impacts to food due to the nuclear energy power plant accidents.

Also, the results of opinion polls that prefectures conducted after the earthquake show trends of increased anxiety in regard to disasters and disaster protection consciousness and demands for a secured society able to endure disasters through disaster protection measures.

As shown above, Japan needs to build a "Robust and Resilient Society" that can prevent or minimize the impacts and damages caused by various problems, including natural disasters and accidents, such as climate change and global warming, energy problems, food security, cyber crimes, pandemics, and so forth, so that Japanese society can promptly recover, and progress even further.

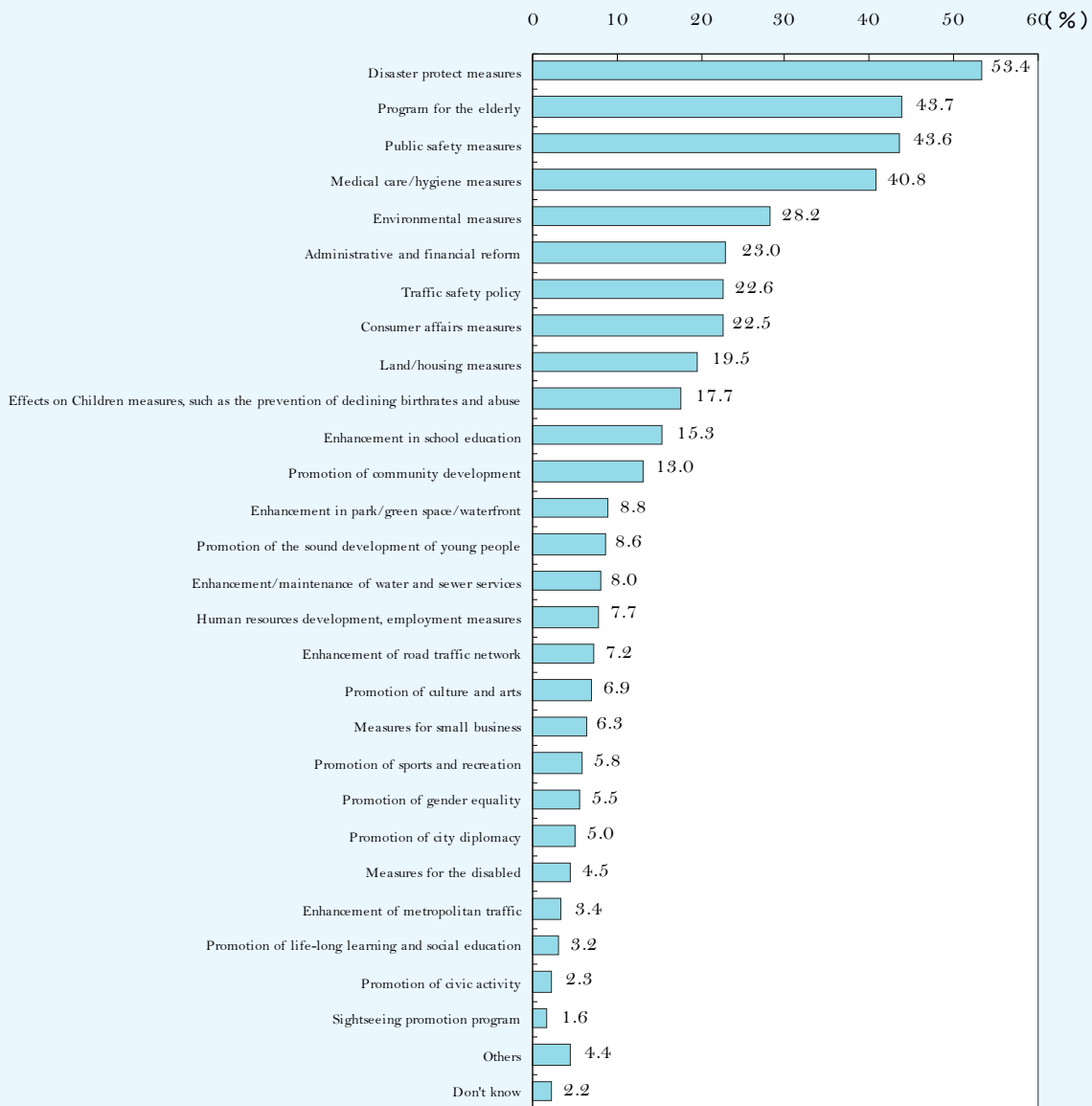
¹ In this white paper, a "Robust and Resilient Society" is defined as a society that can prevent or minimize the impacts or damages caused by natural disasters and accidents, as well as various problems that human beings face, such as climate change and global warming, energy problems, food security, cybercrimes, pandemics, and so forth, so that they can promptly recover, and progress even further.

² The data extracted only from the prefectures that published the poll results as of the end of March 2012. Note that three damaged prefectures (Iwate Prefecture, Miyagi Prefecture, and Fukushima Prefecture) did not conduct polls after the earthquake.

³ The poll conducted by Tokyo does not include the item "food safety measures" in the selections of answers to the questions about "requirement to metropolitan government."

Figure 1-2-3 / Demand to the metropolitan government (what citizens of Tokyo expect Tokyo metropolitan government to make special effort for)

Question: Considering the overall metropolitan government in the future, on which items listed below do you want to receive the most focus?
Choose up to five items that you want Tokyo to give special attention.



Note: The Tokyo Metropolitan Government conducted this survey by sampling 3,000 people with a two-stage stratified random sampling of the case based on the Basic Resident Register, targeting males and females aged 20 or older who live in Tokyo and visiting sampled people individually from August 19 through September 4, 2011 in order to understand inhabitant's sense about Tokyo and the area in which they live, and to measure the leverage for future metropolitan government operation by understanding the options and demands of the metropolitan government. The number of the valid replies (n number) was 2,009.

Source: "Public Opinion Poll on Metropolitan Citizens Life," Tokyo Metropolitan Government (conducted in August 2011)

(Expectation from S&T for the Robust and Resilient Society)

The next question is what kind of roles S&T can play to build such a society.

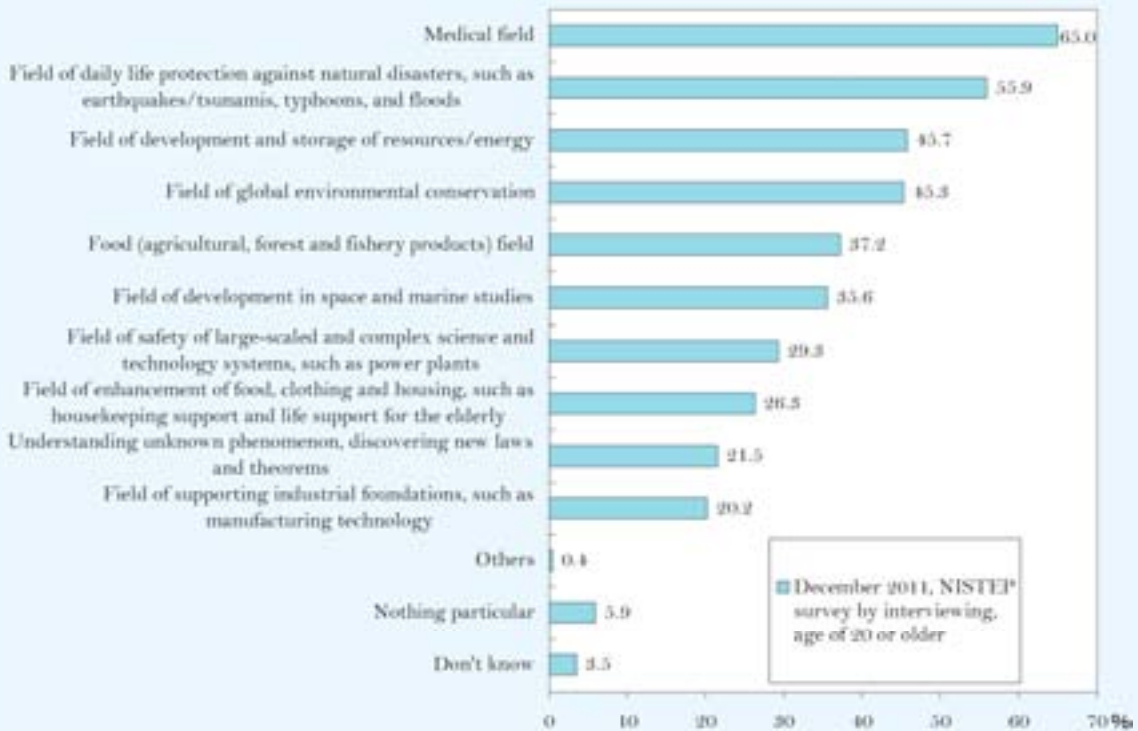
As described in Section 2 of the previous chapter, according to the opinion poll conducted after the earthquake by the National Institute of Science and Technology Policy, although the Japanese public's expectation from S&T to achieve social targets had decreased after the earthquake, the rate is still over

60%. The public felt the areas that S&T should contribute to were: 1. The medical field, 2. The global environment conservation field, and 3. The resources/energy field. These fields were rated high both before and after the earthquake, with increased expectations of the resources/energy field (increase by 10.3 points) and industrial infrastructure field such as manufacturing technologies (increase by 12.9 points) in particular¹.

The medical field, the field to protect daily life against natural disasters, the resources/energy field, and the global environment conservation field were the highest-rated fields where development/improvement of S&T was expected to progress faster than before the earthquake. In response to the earthquake in particular, there are increasing expectations for development/improvement in the disaster protection field against natural disasters, and further developments in S&T to support them is desired (Figure 1-2-4).

Figure 1-2-4 / The field where expectations of development and enhancement have increased compared to a year ago (before the earthquake).

Question: Among the following fields, please choose all of the areas (if any) where you expect more development and improvement as compared to last December:



Source: The opinion poll that the National Institute of Science and Technology Policy conducted in December 2011)

The earthquake has raised the expectation of contributions by S&T in regard to "solutions in resources/energy problem," "prediction of natural disaster/mitigation of damage," "global environment conservation," and "improvement in environmental purification technology" among various social targets (Figure 1-2-5).

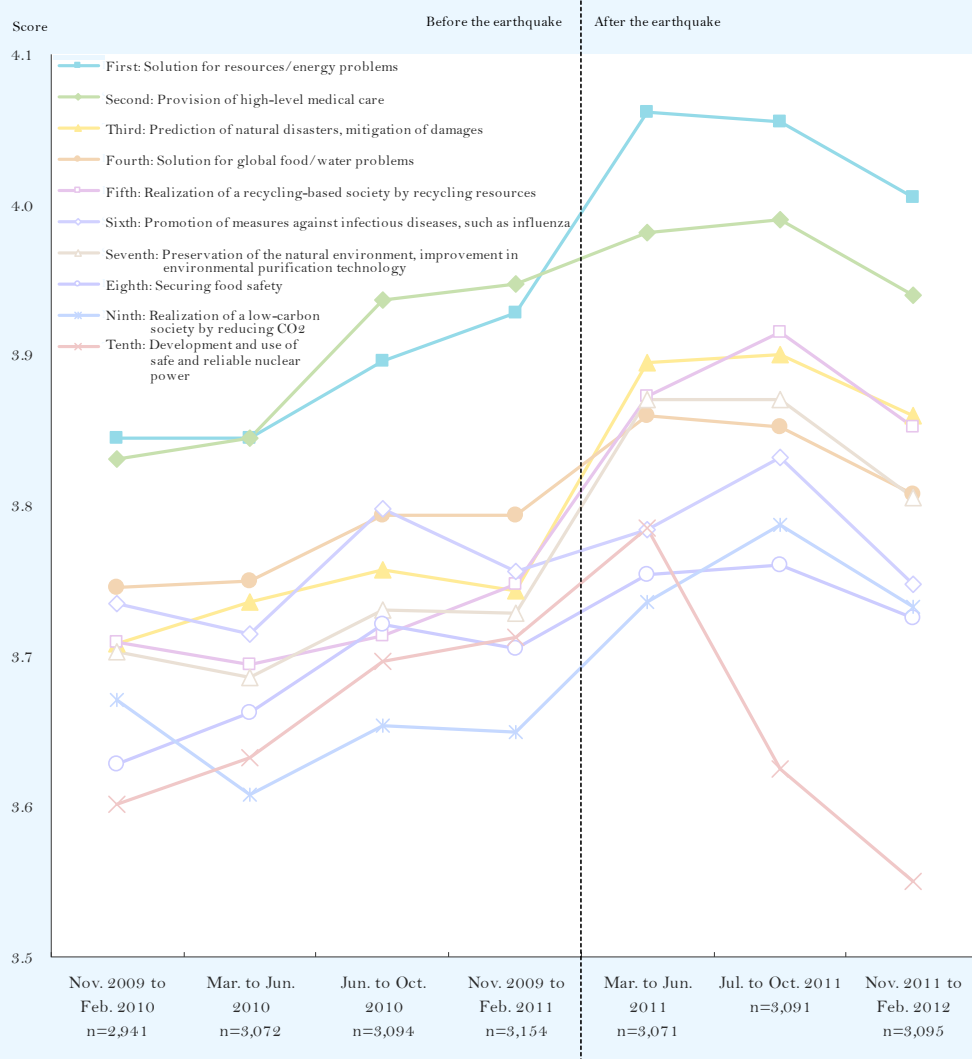
In this regard, experts' opinions greatly vary in answering the question "What sort of future

¹ Comparison between "Public Opinion Poll on S&T and Society" conducted by the Cabinet Office, Government of Japan in January 2010 and "Opinion poll on Science and Technology" conducted by National Institute of Science and Technology Policy in July 2011.

contribution S&T can make for reconstruction and revival from the GEJE, improvement in safety, and establishment of a society that is robust against disasters." Table 1-2-6 shows that summary of actual responses related to the following fields related to the challenges revealed by the earthquake:

- Earthquake/Tsunami prediction and disaster protection measures,
- Energy development,
- Decontamination of a radioactive substance,
- Enhancement in information systems and information/telecommunications infrastructure, and
- Risk assessment and risk communication.

Figure 1-2-5 / Social targets that S&T is expected to contribute to solve/understand (up to 10th)



Note: 1. The task is to choose one from five grades to express the level of expectation for each target. 1 (not expect) – 3 (somewhat expect) – 5 (strongly expect)
 2. A total of 21 targets were shown in the survey, and the figure shows the targets whose average rate for the whole survey term are within the top 10.

Source: "Monthly Opinion Poll," National Institute of Science and Technology Policy

Table 1-2-6: Contributions from S&T to reconstruction and revival after the earthquake, improvement in safety, and establishment of a social infrastructure which is robust against disasters (major examples of answers)

- (Field of earthquake/tsunami prediction and disaster protection measures)
- It is necessary to focus on earthquakes whose occurrence probability was supposed to be low, and to reexamine the expected wave height of a potential tsunami by historical examination and modification of wave source models for tsunami predictive simulations. In the area where no historical record is available, it is required to understand tsunami history by identifying the silt layer by a boring exploration.
 - Based on the fact that some natural disasters caused by earthquakes/tsunamis and cloudbursts are extraordinary in scale, it is essential to develop hardware for disaster protection measures and to implement comprehensive S&T that promote cooperation among human systems that can practically use the developed hardware in the social system.
 - There is an academic approach from the perspective of fluid dynamics and structural mechanics regarding load to the building structure by tsunami. It is valuable to review any system that is robust against damages by earthquakes and tsunamis, regarding not only power generation but also power facility including power distribution without too much sticking to seismic criterions of each facility from the civil engineering standpoint.
- (Field of energy development)
- It is required to take essential measures to save energy and develop distributed natural energy.
 - It is important to develop new energy to replace nuclear power, especially developing technologies of energy storage to achieve the reconstruction and revival of the Japanese economy through efficient energy usage.
 - Japan should contribute to the development of renewable energy by utilizing the vast amount of submarine resources and recyclable marine energies around Japan.
 - To focus on S&T to pursue safety, sustainability and environmental harmony not just to pursue added-value or economic efficiency as the ultimate goal.
- (Field of enhancement in information system and information/telecommunication infrastructure)
- The study of information system can contribute as a foundation to all of the following: practical use of mobile phones for information exchange at disaster occurrence, re-enhancement of its infrastructure, supply-chain management for agile supply of materials, and a smart grid for energy conversion.
 - Understanding and archiving the information on risks that can affect some regions, including private company jurisdiction areas, and building an information system that organically links the archived information to simulations in various ways.
 - Enhancement and expansion of information and communication facilities to promptly and accurately provide damage information. It is necessary to establish measures against disasters by building wireless communication infrastructure, including Japan-wide satellite communications.
- (Field of decontamination of radioactive substances)
- Technology to decontaminate ground that has been polluted by a radioactive substance.
 - Concentration removal of radioactive pollutants by bio-leaching method.
 - It is necessary to establish an efficient method to decontaminate a residual radioactive substance, and to expand phytoremediation technology to recover polluted farm land and to establish an information service to secure food safety and distribution..
- (Field of risk assessment and risk communication)
- We should establish a method and system to evaluate the scale of disasters, the expected damages, the necessity of measures and the assessment of risk that could be caused by taking no measures. It should be based on cases in the past in an objective and fair way independent from any specific intentions.
 - A social consensus to accept risk assessment and cost to reduce risk is required first because a social infrastructure tolerant against disasters is useless when no disaster occurs. It is also necessary for society to understand that it is impossible to build a 100% secure social infrastructure, even with such scientific and technological investment. There are some S&T available that are effective at this stage which can achieve social consensus in an objective way.

Note: Same as Figure 1-1-18.

Source: MEXT based on the results from "Survey regarding the Great East Japan Earthquake by S&T experts," National Institute of Science and Technology Policy (conducted in July and September 2011)

In the 4th Basic Plan revised to reflect to the effects of the earthquake, the following goals are listed as ones the nation should aim at in the mid-term to long-term future. Responses to various social targets revealed by the earthquake are strongly required.

- The nation must achieve reconstruction and revival from the disaster and realize sustainable growth and social development into the future.
- The nation must realize a safe, affluent and high-quality life for the Japanese public.

At the same time, the Basic Plan states that the government will promote and focus on new efforts that practically use STI, such as leveraging the individual characteristics and heritage of local communities in order to help foster the priorities of the Tohoku region and the Kanto region's coastal zones which suffered catastrophic damage from the earthquake. The nation must also establish a system to support local communities, so they can independently implement STI that leverages local strengths and characteristics to restore damaged areas.

From the discussions above, it may be concluded that S&T are expected to contribute to the protection of citizens' daily lives from natural disasters (disaster protection) and to the understanding/achieving of social targets revealed by the earthquake, such as resources and energy problems for a "robust and resilient society."

Future generations will need to remember the issues and severe lessons we have learned from the hard experiences of the GEJE that killed many people, in order to build a foundation for a disaster tolerant society. The government is strongly required to deeply consider the issues and to accept the lessons learned from the earthquake, and to remember its essential role, which is to protect the lives and properties of the Japanese public from disasters and grave accidents. The government is also strongly required to contribute to and overcome the various challenges revealed by the earthquake. It must use S&T to build a robust and resilient society that can tolerate the risks of natural disasters to prevent the unfortunate calamities of such a grave accident from ever occurring again. Sharing such lessons with other countries, as well as establishing procedures for overcoming various challenges will contribute to the recovery and rebirth of damaged areas in Japan, while helping to develop STI that solve the various problems faced by other nations throughout the world.