## Section 2 S&T Policy at Stake

In the previous section, we reviewed various challenges revealed by the earthquake in various fields, and responses based on the damages and influences caused by the GEJE. Can the cutting-edge S&T, which Japan has been proud of, meet the expectations of the Japanese public when responding to earthquakes?

In this section, we will discuss the change in the Japanese public's feelings toward S&T in Japan with regards to the GEJE, based on the following polls: 1) the "Monthly Opinion Poll[1]" conducted by the National Institute of Science and Technology Policy (NISTEP) before the earthquake, in order to observe the Japanese public's thoughts on S&T in Japan; 2) the "Opinion Poll on S&T" conducted after the earthquake, in July and December of 2011 by the institute by visits and interviews, and 3) "Public Opinion Poll on S&T and Society" conducted by the Cabinet Office, Government of Japan (surveyed in January 2010). We will study the challenges revealed by the earthquake in regard to the S&T policies, considering the changes in the Japanese public's awareness of S&T.

### 1 Change in the Public Awareness of S&T

#### (1) Public trust in scientists and engineers

The Japanese public has relied on and trusted S&T to a high degree until now. This is suggested by the high rate (75.1%) of affirmative answers to the question "Emerging social issues will be solved by further development of S&T" in the "Public Opinion Poll on S&T and Society" (surveyed in January 2010) and the high rate (approximately 80% before the earthquake) of the Japanese public, who considered scientists opinions "trustworthy" or "rather trustworthy" in the "Monthly Opinion Poll" conducted by the National Institute of S&T Policy.

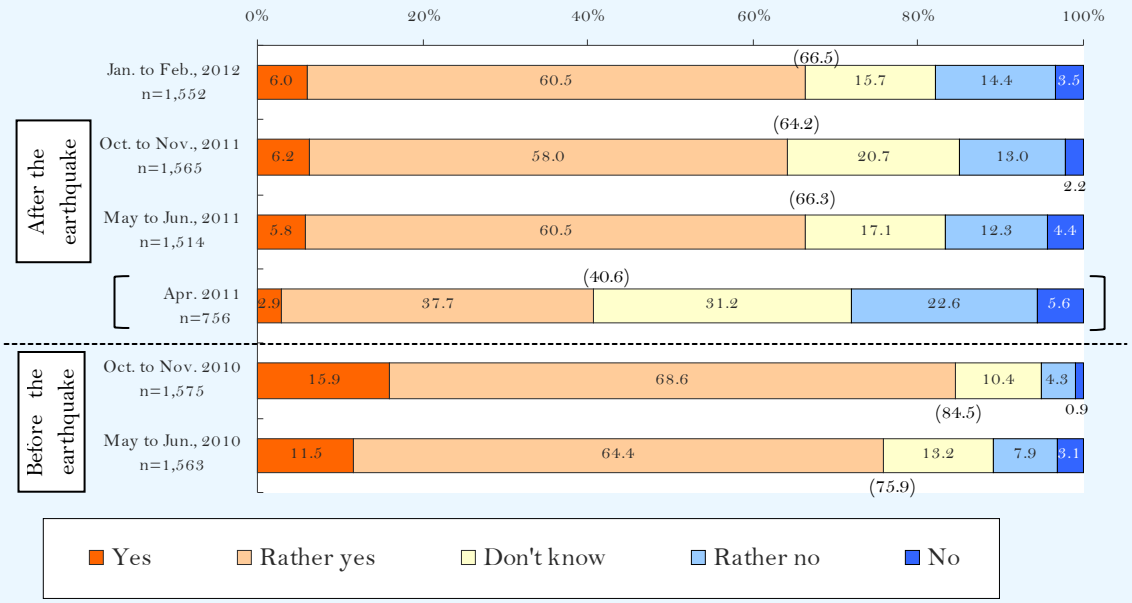
However, it should be borne in mind that the earthquake/tsunami and the nuclear energy power plant accidents have decreased the Japanese public's confidence in scientists and engineers. According to the survey conducted by the NISTEP, 12 to 15% of the respondents answered "Yes" to the question "Do you find scientists' statements trustworthy?" before the earthquake, whereas after the earthquake the rate went down to approximately 6%, or less than half. The rate of affirmative answers after the earthquake, such as "Rather yes" accounted for approximately 65% of answers, no less than 10% or more compared with the rate before the earthquake[2] which used to be 76 to 85% (Figure 1-1-16).

1 The "Monthly Opinion Poll" targeted monitors who registered in an Internet survey company, was conducted at the end of every month from November 2009 through March 2012, and basically kept same questions to answer through the Internet. There are groups of males and females aged 10 through their 60s, and 60 people or more from each group (720 or more in total).

2 Although direct comparison may not make sense since questions used are different, the rate of people who answered "Strongly agree" or "Rather agree" with the comment "Scientists' statements are trustworthy" has dropped to approximately 40% in 2011 April Poll.

Figure 1-1-16 / The Japanese Public's Confidence in Scientists.

Question: Do you find scientists' statements trustworthy?




Note: 1. The question asked in the poll was "Do you find scientists' statements trustworthy?" (except the poll in April 2011). There were five options, out of which respondents could only choose one: "Yes," "Rather yes," "Rather no," "No" and "Don't know."

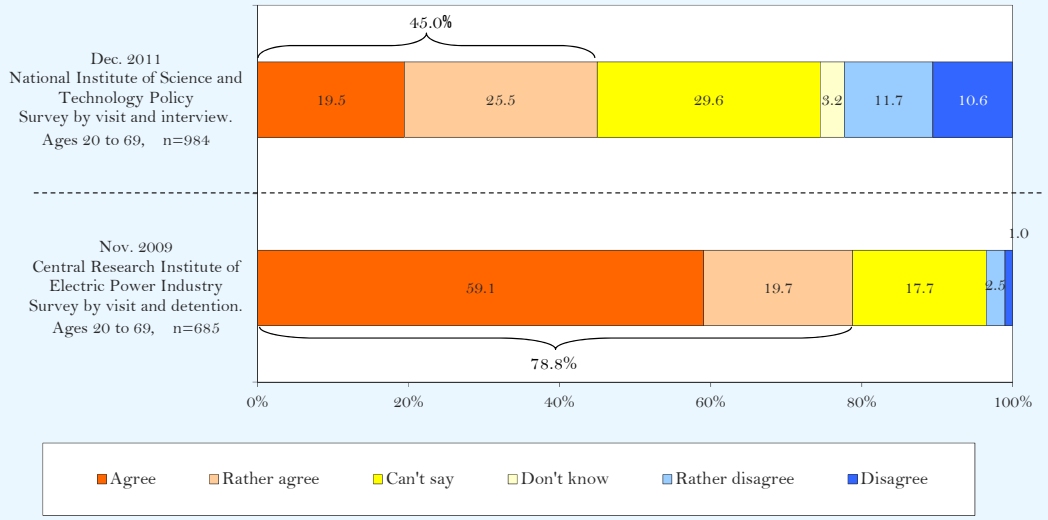
2. In the 2011 April poll, there was an additional question: "What is your opinion on the following statements? Select the answer closest to your opinion" followed by two sentences: "Scientists' statements are trustworthy" and "Engineers' statements are trustworthy" to answer with one from next five options: "Strongly agree," "Rather agree," "Rather disagree," "Strongly disagree" and "Don't know." Therefore, it is not appropriate to compare the 2011 April poll directly with other polls.

Source: "Monthly Opinion Poll" NISTEP

The decrease in the public's confidence in scientists will presumably influence whether people will support experts' decisions on "direction of R&D in S&T." Although the methodology and targets of the polls are distinct, the rate of respondents who answered "Agree" to the statement "It's better for trained and experienced experts to determine the direction of R&D in S&T," went dramatically down to 19.5 % after the earthquake, approximately one third of 59.1% scored before the disaster. The rate of supportive answers, including "Rather agree," has also significantly decreased to 45.0% after the earthquake--down from 78.8% before the earthquake (Figure 1-1-17).

Figure 1-1-17 / Is it better for experts to determine the direction of R&D in S&T?

Question: What is your opinion on the following statement regarding S&T?
It's better for trained and experienced experts to determine the direction of R&D in S&T.



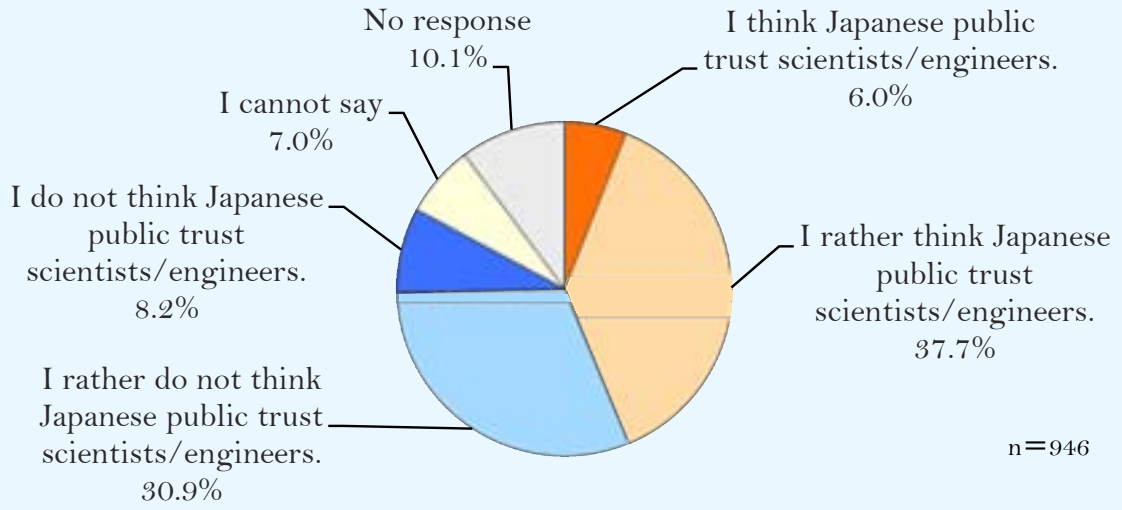

Note: 1. The poll conducted by the Central Research Institute of Electric Power Industry (CRIEPI) targets residents in Greater Tokyo Area (Saitama Prefecture, Chiba Prefecture, Tokyo, Kanagawa Prefecture), whereas the poll conducted by the NISTEP targets citizens nationwide. Note that both polls use random sampling methods to pick survey respondents. The figure shows the result of answers from people whose age is from 20 to 69.
2. In both polls, the answer "Don't know" is not available on the survey slip. As for visit and interview survey, however, an answer "Don't know" was given during the interview by researchers.

Source: "Survey on Public Awareness of S&T" NISTEP (conducted in December 2011)
"Survey on Public Awareness on the Use and Safety of S&T" CRIEPI (conducted in November 2009)

On the other hand, regarding the question "What do you think about the Japanese public's confidence in statements by scientists/engineers?" asked to experts after the earthquake, approximately 44% of them responded either "I think Japanese public trust scientists/engineers" or "I rather think Japanese public trust scientists/engineers." This rate is higher than the rates of "I do not think Japanese public trust scientists/engineers" or "I rather do not think Japanese public trust scientists/engineers" (approximately 39%) (Figure 1-1-18). It seems that experts in general are not fully aware that the Japanese public's confidence in scientists/engineers has decreased, and there is a sharp increase in the number of Japanese, who believe that "experts alone should not determine the direction of R&D in S&T."

Figure 1-1-18 / The Japanese public's confidence in scientists/engineers after the earthquake (experts' perception)

Question: What do you think about the Japanese public's confidence in messages from scientists/engineers after the GEJE?
Select the answer closest to your opinion.



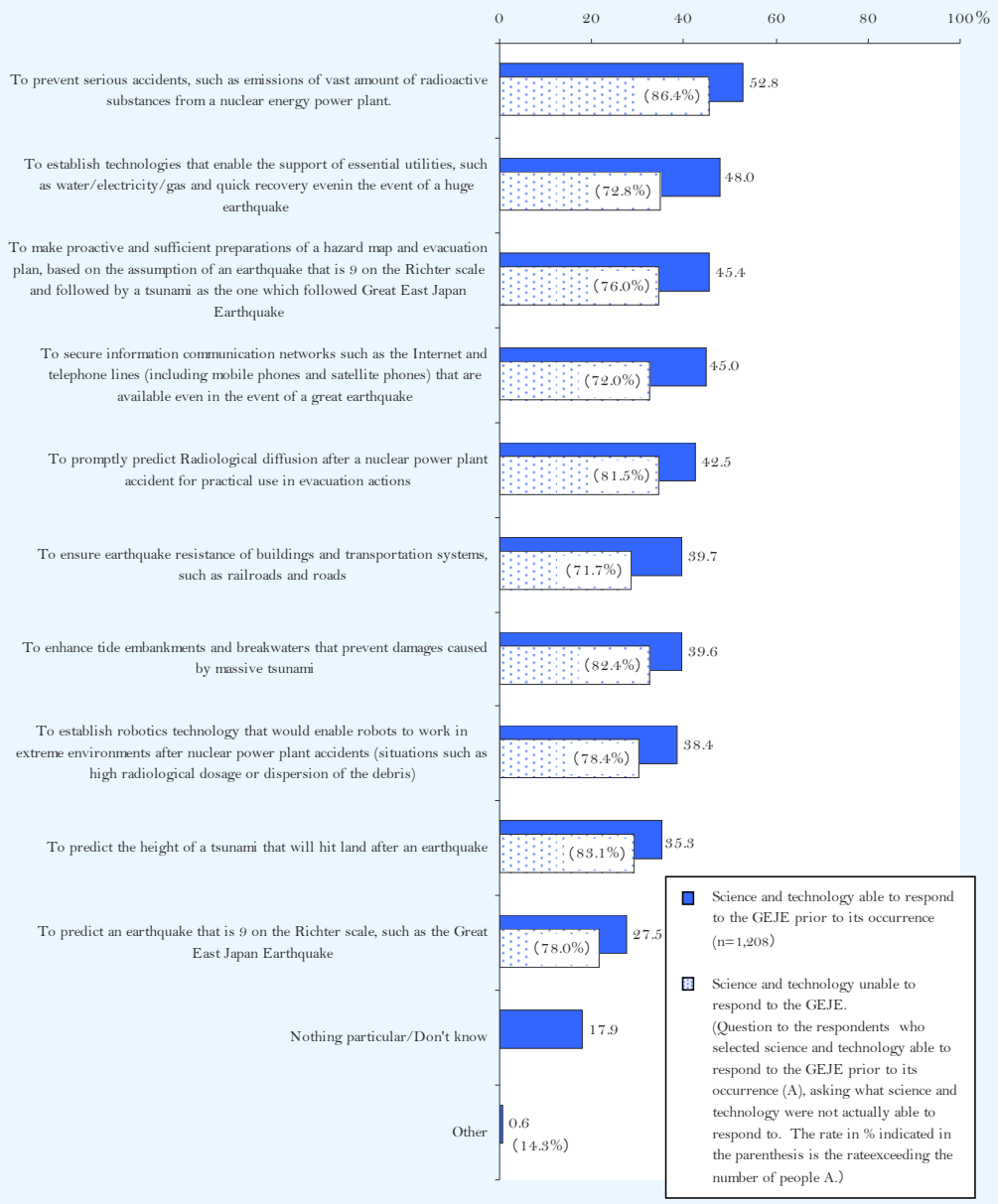

Note: This survey was conducted by the National Institute of Science and Technology Policy through the use of its network, "Science and Technology Expert Network". The Institute targeted 1,735 experts: researchers, engineers or managers from industry, public research institutions and academia. The Institute asked them to reply through the Internet and received answers from 946 respondents (at 1st round) and 796 people (at 2nd round).
Source: "Survey of S&T experts regarding the GEJE (1st edition)" NISTEP (conducted in July 2011)

(2) Public expectations and anxieties regarding S&T

Let us now discuss why the Japanese public's confidence in scientists/engineers has decreased.

"The degree to which S&T was believed to have been able to prevent damages using high level of S&T in Japan, but was not able to when the earthquake hit" was one of the questions asked in the "Survey on Public Awareness of S&T" conducted by NISTEP in December 2011. According to the results, regarding the items such as "Prevention of serious accidents such as emission of vast amount of radioactive substances from a nuclear energy power plant", it seems that a fairly large amount of the Japanese public feel that it was possible to have taken measures in advance, but not once the earthquake hit, these results suggest that many Japanese understand that the power of S&T could not be leveraged well enough to take measures against severe accidents in advance, and prevent expansion of damages after the accident, in regard to the nuclear energy power plant accident (Figure 1-1-19).

Figure 1-1-19 / S&T that was not useful when the GEJE hit




Note: 1. The introduction to the poll "This poll aims to examine whether S&T were useful when the Great East Japan Earthquake hit." was followed by the next two questions: (1) "Select all items you think Japan's level of S&T could have responded to before the earthquake hit" and (2) "Among the items you have selected, select all items that you think S&T were not able to support when the earthquake actually hit." Therefore in the second question, the number of people who selected such choice in the first question (A) is used as a denominator of corresponding choice in the second question.

2. The rate (%) shown in the horizontal graph filled with dots is the percentage of respondents of the blue bar behind.

Source: The "Opinion Poll on S&T" NISTEP (conducted in December 2011)

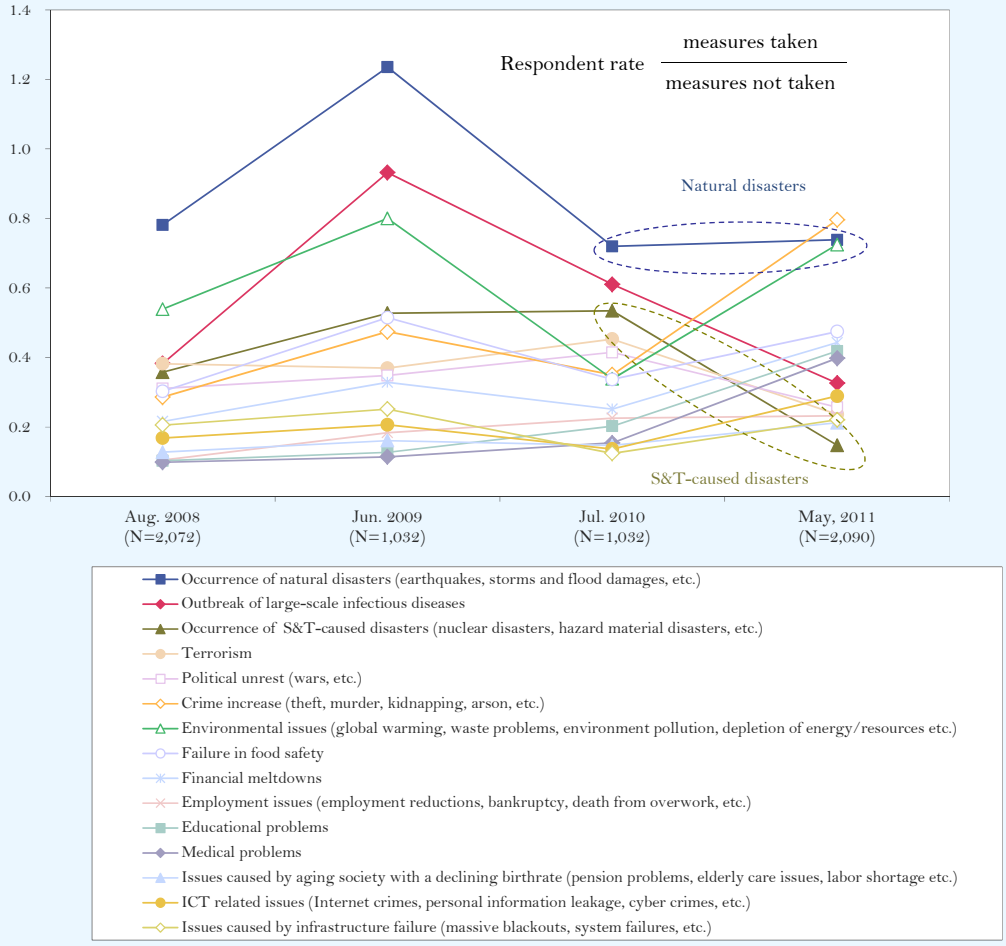
According to an online survey, "Opinion Poll on Citizen's Sense on Risk," conducted by the Mitsubishi Research Institute, Inc. in May 2011, the evaluation rate on measures against S&T disasters, such as nuclear power plant disasters, has significantly decreased, while the evaluation rate on measures against natural disasters by the government and local governments are almost the same before and after the

earthquake. These survey results suggest that the Japanese public is not satisfied with the response of the national government and local governments to the nuclear energy power plant accident (Figure 1-1-20).

As discussed above, many of the Japanese public do not think that S&T in Japan responded well to the actual challenges--especially to the nuclear energy power plant accident--during the unprecedented disaster, and in that respect, it can be said that S&T do not meet the Japanese public's expectations very well.

Figure 1-1-20 / On regular preparation/measures of the government and local governments against threats

Question: Do you think that the government and local governments take measures as regular preparation (measures/preparation in during normal period) against threats?




Note: 1. The survey is conducted through the Internet, targeting those who are registered to an Internet research company as a monitor using same set of questions once every year since August 2010. The target at the survey conducted in May 2011 after the earthquake was men and women of 20 years of age or older and live in Japan, and the number of valid responses was 2,090 (1,045 from men, 1,045 from women). The sampling method is designed to distribute the respondent attributes similar to the demographics in Japan, but the detailed attributes (occupation, educational background, etc.) depend on the attribute of the actual monitors registered to the research company.

2. In the survey, the first question was "Do you think that the government and local governments take measures as regular preparation (measures/preparation in during normal period) against threats?" followed by another question to ask them to select from "(Rather) Yes", "(Rather) No", "Don't know" regarding each threat. The rate in the figure was calculated by dividing the number of respondents who replied "(Rather) Yes" by the number of respondents who replied "(Rather) No."

Source: "Opinion Poll after the GEJE – Results of Opinion Polls of Citizen's Sense on Risk" the Mitsubishi Research Institute (July 13, 2011)

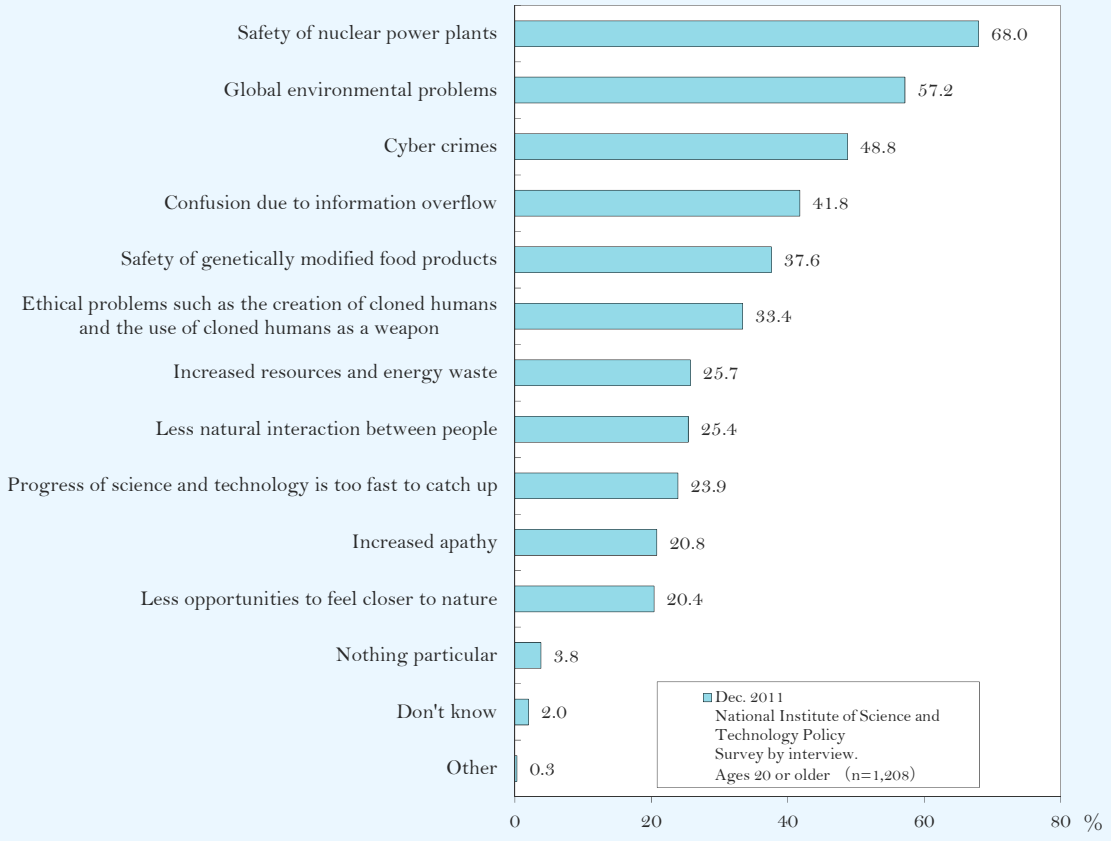
After the earthquake, some matters have increased the public's anxiety in regard to development of S&T. According to the "Public Opinion Poll on S&T and Society" conducted by the Cabinet Office, Government of Japan (surveyed in January 2010), as the answer to the question about what makes people anxious about the development of S&T, even before the earthquake, many people listed the following:

- Global environment (50.7 %)
- Safety of genetically modified food products and nuclear power generation etc. (50.2 %)
- Cyber crimes (43.8 %)
- Ethical problems, such as the creation of cloned humans and the use of cloned humans as a weapon (42.3 %)

Meanwhile, as the answer to the question about what makes people anxious about development of S&T after the earthquake, the rate of people who listed "safety of nuclear power generation" was 68.0 %, which was the highest rate, followed by "Global environment problems" (50.7 %), and "Cyber crimes" (43.8 %) (Figure 1-1-21). Also, the rate of people who selected "Information overflows make me confused" exceeded 40 % (41.8 %), which is assumed to be influenced by the fact that inconsistent messages from various experts were broadcasted and published regarding the status of the nuclear reactor that caused the accident and the effects of radiation after the earthquake on health.

Figure 1-1-21 / Fields, in which anxiety level toward S&T increased since last year (before the earthquake).

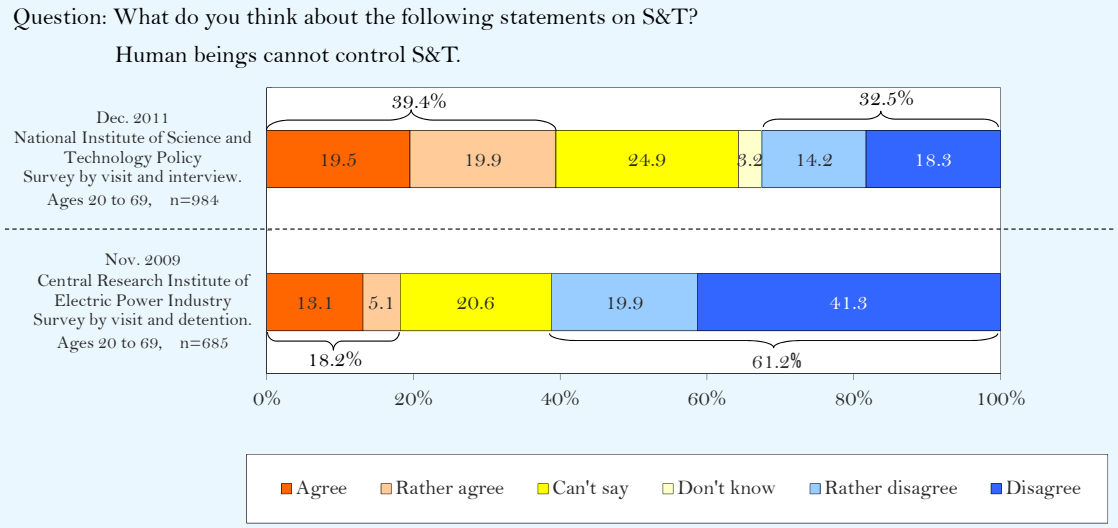
Question: Is there anything that made you feel increased anxiety due to development in S&T compared to last December? Select all applicable items from the list below.




Source: "Opinion Poll on S&T" NISTEP (conducted in December 2011)

Moreover, although the target and method of surveys were not same, over 60 % (61.2 %) of people disagreed with the opinion "Human beings cannot control S&T" before the earthquake, the rate went down to approximately 30 % (32.5 %) after the earthquake (Figure 1-1-22). It may be due to witnessing the earthquake, tsunami and nuclear energy power plant accidents that were far beyond previous expectations, that caused the Japanese public to once again realize the possibilities as well as the limitations of S&T, and they no longer easily believe that "human beings can control S&T." Or, as discussed above, it can be interpreted as the indication of a growing anxiety among the Japanese public toward development of S&T after the earthquake.

Figure 1-1-22 / Can't human beings control S&T?




Note: 1. The poll conducted by CRIEPI targets residents in Greater Tokyo Area (Saitama Prefecture, Chiba Prefecture, Tokyo, Kanagawa Prefecture), whereas the poll conducted by the NISTEP targets citizens nationwide. Note that both polls use random sampling methods to pick survey respondents. The figure shows the result of answers from people whose age is from 20 to 69.

2. In both polls, the answer "Don't know" is not available on the survey slip. As for visit and interview survey, however, an answer "Don't know" was given during the interview by researchers.

Source: "Survey on public Awareness of S&T" NISTEP, (conducted in December 2011)
"Survey on Public Awareness on the Use and Safety of S&T" CRIEPI (conducted in November 2009)

As discussed above, based on the results of opinion polls from the Japanese public, people are losing confidence in experts who are involved in S&T. That is because 1) S&T in Japan could not sufficiently solve the actual problems that arose during the disaster, and from that perspective, did not meet the Japanese public's expectation of safety 2) anxiety about developments in S&T is increasing and 3) the possibilities and limitations of S&T were once again recognized during this unprecedented disaster. Finally, as mentioned before, there is an increase in the number of respondents who think that society cannot let only the experts determine the direction of R&D in S&T.

In the future, it is necessary to communicate with the Japanese public in an honest and sincere way and to form policies in the areas of S&T that are based on a mutual understanding when responding to risks and uncertainties of S&T. In the meantime, it is also necessary to establish a system that allows the Japanese public to be involved, to a reasonable extent, in the formulation processes of S&T.

## 2 S&T Policy Issues Raised after the GEJE

As discussed in the previous section, the GEJE has revealed risks and uncertainties that S&T possess and their limits, such as the inability of predicting massive earthquakes and tsunamis, as well as insufficient assumptions that led to the nuclear energy power plant accident, and unsatisfactory support by S&T to prevent further damage after the accidents. Many of the Japanese public were forced to once again realize that S&T has not only the bright, but the dark side, too. And, after the earthquake, the Japanese public has changed their perspectives on S&T, for example, there is increased anxiety caused by the development of S&T and less confidence in experts.

Today, development of S&T has brought various benefits, such as increased convenience in our daily lives and the development and growth of the economy in human society. The progress of science has significantly expanded our intelligence, helping us to discover and understand various phenomena ranging from the foundation of space to the rise of life, and has provided us with an intellectually and culturally rich daily lifestyle.. On the other hand, the progress of S&T has brought various threats such as the development of weapons of mass destruction, environmental disruption, global warming and so forth. Thus, even today's most advanced S&T cannot predict or anticipate all natural phenomena accurately.

The GEJE highlighted the following questions in regard to these risks and uncertainties and the limits that S&T possess: "Didn't the government and experts consider sharing information with the Japanese public very well?" and "As a result, couldn't many of the Japanese public could not recognize those enough?" and clearly showed how these issues relate to entire polices of S&T as described below.

(Issue no. 1: Advance measures against risks and risk communication were not sufficient.)

Among the issues related to entire polices of S&T revealed by the GEJE, the first one is that advanced and sufficient measures were not taken based on 1) an understanding of the risks and uncertainties, and the limits of S&T, 2) assuming disasters and accidents as well as the damages caused by them, and 3) recognizing the possibility of unexpected incidents. This resulted in poor promotion of these measures and in a failure to share these risks with society.

As stated in the report from the expert panels in the Central Disaster Management Council and the Interim Report of the Government's Accident Investigation Committee, the GEJE taught an important lesson on how to be prepared for an event that is "of a scale that vastly exceeded pre-disaster assumptions," or an "beyond all assumptions" event that we never thought could have occurred, and then these risks and uncertainties become obvious.

In regard to advanced measures against risks, the Expert Panel's Report from the Central Disaster Management Council states, "While gravely acknowledging the fact that this disaster event caused damage greatly exceeding the pre-disaster damage estimate, the former principles for hazard assumption need to be fundamentally reviewed and thorough reviews be conducted for all procedures from selection of earthquakes and tsunamis for hazard assumption through to development of individual measures, so that the disaster management measures be rebuilt in their entirety." In concrete terms, as detailed in the previous section 2 (1), the report points out that "when conducting earthquake and tsunami hazard assumptions in the future, the largest-possible mega earthquakes and tsunamis should be considered from every possible

angle," and by sufficiently considering the great uncertainties of natural disasters and the limitations of our assumptions, as well as the need to reexamine previous assumptions.

Moreover, the mid-term report by the Government Accident Investigation Committee states, "the need for a transformation (a paradigm shift) in the basic framework for disaster preparedness and countermeasures for a huge system that risks tremendous damage if an accident occurs." It is required to change the framework (paradigm) of fundamental ideas on the disaster protection of large systems that could be severely damaged once an accident happens," and in concrete terms, the report points out the following:

1) Even though the probabilistic frequency of an event of that scale is assessed to be low, it is nevertheless predicted that if one were to strike, the extent of the damage would be enormous. This indicates the need for a new risk awareness regime under which the required measures would be developed, and the possibility of damage would not be ignored.

2) Developing measures to respond to the possibility of a multidimensional disaster will surely be important.

3) Importance of all-encompassing perspective.

In particular, the "Adverse effect of specialization and division of professional expertise" is related to the lack of all-encompassing perspective mentioned in 3) above, and is pointed out as the reason why sufficient measures were not taken against the tsunami in advance. This is a challenge from the perspectives of S&T and to the issues surrounding safety regulations such as "limitation of voluntary safety initiatives" and "insufficient organizational capabilities of regulatory bodies."

Namely, the report states "A division of labor is needed to raise expertise in specialized fields, and dividing fields of expertise into smaller units boosts knowledge and technology," but at the same time "There can be a negative side to this, however — the high degree of specialization does not encourage consideration of issues that extend across various fields of expertise productively, and as a result the various groups may not do everything necessary in order to elevate the safety in totality." This would be accomplished by experts sharing issues beyond their area of expertise with each other and by friendly competition.

It is also pointed out that another major problem was that the government and other experts neither published appropriate information in a timely manner, nor proactively shared that information with the public. In other words, there was a lack of "risk communication" based on the risks, uncertainties, and limits that S&T possess. The distribution of information, particularly in a disaster or accident, can directly affect lives and health of the residents or their evacuation activities. We can conclude that the risk-communication was too poor to meet society's demands and that it failed to provide information verified by S&T in an easy manner in such emergencies as the GEJE.

In concrete terms, as mentioned in the previous section 2 (1), it was pointed out that 1) there were issues around the communication system, such as having a tsunami warning that is tied into evacuation activities when a tsunami hits, 2) the Japanese public, who received the information, were not aware of the possibility of an unusually large tsunami that exceeded their expectations, and 3) sharing the sense of risk through disaster education was insufficient. Moreover, in regard to the response to the TEPCO Fukushima NPS accident, as mentioned in the previous section 2 (2), it was pointed out that 1) there is

not necessarily enough communication of accurate and clear information in a timely manner, and 2) the disclosure of information without enough risk prospect made the Japanese public even more concerned.

In the article "Critical Issues on S&T for a Safe and Secure Society" established by the S&T Committee for a Safe and Secure Society of the Subdivision on R&D Planning and Evaluation of Council for Science and Technology, it is pointed out that it is required to inform the public about scientific and objective facts in a clear, courteous and accurate manner, and to interact for a better understanding of issues (risk communication). It is essential to provide the society with timely and accurate information and to interact sufficiently, even under normal circumstances, for smooth risk communication in case of an emergency.

Meanwhile, in its mid-term report, the Government Accident Investigation Committee points out that "presenting risk information in the public sphere" has some difficulties, because "if one attempts to make improvements to raise safety levels higher, the paradoxical result is the negation of the validity of past practices. The mid-term report states, however, that "it is necessary to make effort toward creating social conditions where difficult-to-convey risk information can be presented, and people are allowed to make reasonable choices based on the facts," since modern society needs to face risks, because absolutely safety does not exist. To establish such a society, it is important for both the government and experts, as well as various members of society to make efforts to face risks even under normal circumstances, in order to improve mutual understanding through bidirectional communication with society, and to establish an agreement as to how society can prepare for risks.

Column 1-2

## Limitations of science and risk communication (Dr. Satoko Oki, assistant professor, Earthquake Research Institute, The University of Tokyo)

Courtesy of Dr. Satoko Oki, assistant professor, Earthquake Research Institute, The University of Tokyo

Dr. Satoko Oki, assistant professor at the Earthquake Research Institute, The University of Tokyo, has been involved in outreach activities of seismology since before the GEJE. Dr. Oki has continuously sought an ideal relationship between science and society through various practices on seismology and society after the earthquake. We interviewed her about the seismology and risk communication.

Since I was appointed as an assistant professor of the Outreach and Public Relations Office at the Earthquake Research Institute, The University of Tokyo, I have been involved in research/public relations outreach activities with a policy that aims "To resolve too many expectations and to correct the misunderstandings over earthquake prediction." People may think that the next big earthquake may be predicted somehow and so they may not be victims, but prediction of any earthquakes is far beyond realization. Before the earthquake, I thought that we could resolve over-expectation and misunderstandings over earthquake prediction, by having communication emphasized on the seismology as the "earth science" aspects of seismology rather than on the “prediction” aspects of seismology. But now, I feel that this was not necessarily sufficient.

Today's school education highlights too many of the positive aspects of science. But, when science cannot meet these expectations, it causes catastrophic public relations disaster, as we've seen in the aftermath of the GEJE. We are partially responsible for not cautioning the public to "not believe in perfect information from the scientific fields." And I feel that another problem was the fact that the education in Japan has not touched upon the limitations of current science. Therefore, the researchers involved in science should not underestimate the limitations of science. After the Great Hanshin-Awaji Earthquake, we expressed the difficulty of "earthquake prediction" to accurately predict "Time," "Place" and "Magnitude" of an earthquake, and instead we have been trying to provide information such as long-term evaluation of possible earthquakes or hazard maps to be better used for people’s motivation for disaster prevention. In that course, ironically, evaluation models in seismology had been consolidated into one in the end. At a symposium during the fall meeting of the Seismological Society of Japan, held in the fall of 2011, the majority of the retrospectives in regard to the long-term evaluation were "We've lost the spirit of criticism." I reflect on this loss seriously as having doubts is the basis of any researcher's nature.

As a result of the earthquake, I myself really understand how responsible science is for insufficient communication about the limitations of seismology, which in turn caused "excess expectations." I really regret that we could not efficiently articulate the possibility of an event beyond all assumptions For example, many people were harmed at the evacuation sites which they fled to for safety. A lot of children were killed at a school which was designated as a shelter. We scientists and other people who are supposed to publish information, must seriously realize that the lives of many people were in danger due to the use of tsunami warnings and/or hazard maps that were based on people’s confidence in the information given to them from scientific fields.

After the earthquake, I realized another big hurdle. Surely, technologies and systems for emergency responses to earthquakes have made great progress recently. However, a fundamental issue is that even improvements in alarm accuracy may not necessarily convince people to undertake disaster protection activities. Every Japanese understands that Japan has been suffering from earthquakes and is aware of the risks caused by tsunamis associated with earthquakes. But often the furniture is not fixed, houses lack proper reinforcements. People seem unable to take action even though they have information and knowledge. I couldn't find an answer to solve this problem, but I feel a possible solution in the disaster protection education taught to children. As with subsidies from MEXT, I have worked on a disaster prevention education project at a pilot school, and children act independently from their own experiences, maybe because their experience is limited, and are able to act practically using correct but limited information and knowledge. For example, the phenomenal case of professor Toshitaka Katada at Gunma University and Kamaishi City is very well known, and at the school in Tokyo, where we worked together before the earthquake, children instantly secured themselves. I believe that it is not only physical matters such as embankments, but also mental measures such as proper education that were proven to be effective. I think that risk communication in seismology is realized only when we can publish information that lets people take action with an understanding that there are limitations to science.

One of the excitements within all research, including seismology, is the capability to predict the near future. That's why people rely on science and lose trust if it fails. I'm sensing that we researchers must remember that society tends to expect "prediction" by science when we are involved in scientific activities.

(Issue no. 2: The government and society were not sufficiently provided with the scientific knowledge by experts)

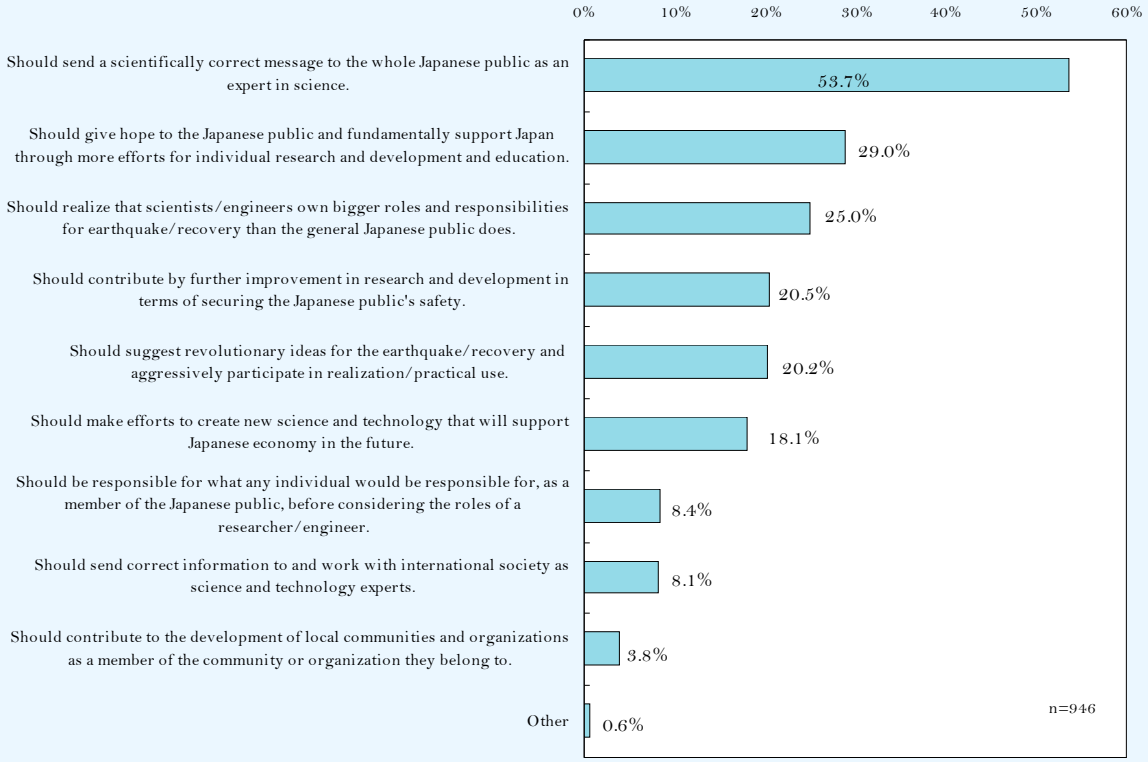
The second issue that the earthquake taught the entire field of S&T is, as discussed in the previous section 2 (2), the matter of how experts provide scientific knowledge to the government and society, that is, the matter related to how experts should make scientific suggestions. At the GEJE, the government was required to make prompt political decisions and to execute them on a scientific basis, and the S&T community was required to provide scientific knowledge consolidated by gathering expertise from various fields of reference in order to inform these political decisions. In the realty, however, the S&T community did not provide scientific knowledge by consolidating their expertise, and prompt political decisions based on such knowledge was not distributed to society.

In regard to this matter, the Science Council of Japan (SCJ) published a Statement of the Executive Board "Recovery from the Great East Japan Earthquake and Responsibilities of Science Council of Japan" on September 22, 2011. The statement reviews six months of the council's activities after the GEJE, and suggests that it is necessary to newly establish relationships with the government and a broad range of society. It finds that "Appropriate advice and suggestions were required by the government through the consolidation of scientists' wisdom and knowledge in the aftermath of unprecedented complex disasters," and further states that "Individual statements of specialized knowledge from individual scientists cannot result in appropriate advice; scientists are responsible both to society and the government."

More than 50 % of scientists believe "they should deliver scientifically correct information to society as experts in the fields of S&T" and that this is the primary role that scientists and engineers should play in an earthquake and its recovery (Figure 1-1-23). Moreover, in the Statement of the Executive Board of the Science Council of Japan mentioned above, it is concluded that the science community is required to build comprehensive knowledge through comprehensive and neutral investigations based on a variety of expertise, and should provide advice and suggestions to society and the government.

Figure 1-1-23 / Roles that scientists and engineers should play in an earthquake/recovery (responses from experts)

Question: It is said that the nation-wide efforts are required for the earthquake and its recovery. What do you think about the roles that scientists and engineers specifically need to play? Select items closest to your opinion (select up to two items).



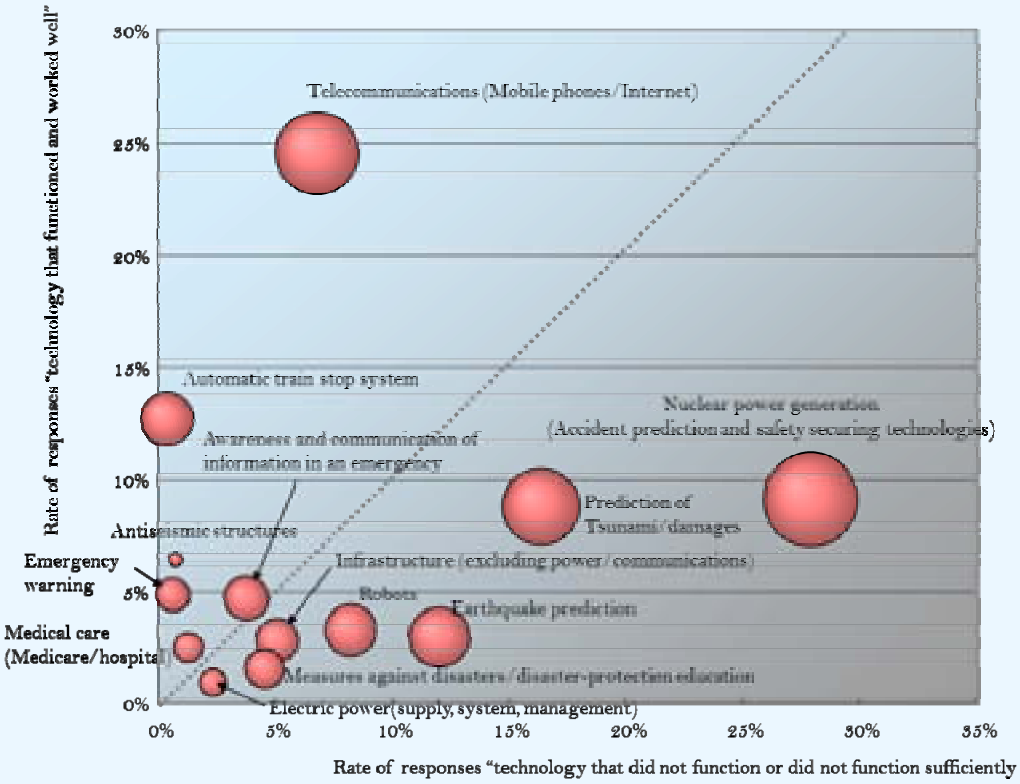

Note: Same as the note in the Figure 1-1-18.
Source: "Survey of S&T experts regarding the GEJE (1st edition)" NISTEP (conducted in July 2011)

(Issue no. 3: Advance measures against risks and risk communication were not sufficient.)

The third issue revealed by the GEJE, is a question of whether or not the outcomes of Japanese S&T, which tremendous money was invested in, worked well against disasters and accidents, and whether the R&D were aimed at real problems.

As mentioned before, as for the GEJE, many members of the Japanese public and many experts think that S&T was not able to respond to the actual problems, such as accident prediction in nuclear energy power plants or safety-securing technology and earthquake/tsunami prediction technology; therefore, they were not able to prevent the severe accidents that took place, including the nuclear energy power plant accident in particular (Figure 1-1-24).

Figure 1-1-24 / Technologies and measures that worked/ did not work in the GEJE




Note: 1. Same as the note in the Figure 1-1-18.

2. The survey includes a question (Q4-1) "Write down any aspects of S&T you think worked better than expected when the earthquake hit (example of S&T whose R&D results worked well, instances where systems of S&T functioned well in an emergency) (Multiple answers acceptable. Do not exceed 250 characters)" and question (Q4-2) "What did not function and which assumptions were not accurate in regard to the earthquake? As a result, what should R&D do you think be focused on in the future, to strengthen measures against disasters and to support recovery? Write down concrete examples (Multiple answers acceptable. Do not exceed 250 characters).

3. This figure shows the calculated rate at which each mentioned technology had an over all valid response after selecting the technologies that were frequently mentioned as answers in a free descriptive form to the questions labeled "technology that functioned and worked well" (Q4-1) and "technology that did not function or did not function sufficiently" technology (Q4-2). The rate of answers "technology that did not function or did not function sufficiently" is on the horizontal axis and "technology that functioned and worked well" on the vertical axis, and the size of each circle represents the total number of answers.

Source: MEXT, based on the results from " Survey of S&T experts regarding the GEJE (1st edition)" NISTEP (conducted in July 2011)

They point out the issue that Japanese S&T are prone to be less integrated considering the cases in which they were actually applied at disaster/accident sites, for example 1) the emergency power supply at the Fukushima Daiichi NPS that expected to have worked even under unpredictable circumstances, did not work, and 2) the initial measurements inside the nuclear reactor building were done by robots made, not in Japan, but overseas. These examples clearly show how facilities and equipment developed for an emergency situation were not able to work at all when they were most needed, and when disasters or accidents occurred.

Column 1-3

## Use of robots at the nuclear energy power plant accident site

The robots that work for rescue and operation in severe environments, were expected to play an active role at the accident site of the Fukushima Daiichi NPS, where workers could not enter due to extremely high radiation. In the fifth urgent proposal submitted on April 13, 2011, the Science Council of Japan (SCJ) announced their policy to actively support practical use of robot technology as measures against accidents. Moreover, on March 31, 2011, scientists and engineers involved in cutting-edge robot technologies got together from robot-related academic societies/academic conferences, and the "Robotics Task Force for Anti-Disaster" was promptly formed[1]. However, Japanese robot technologies were seldom used, except for unmanned constructions, because they did not meet the needs at the site. The disaster-prevention monitoring robot was developed by MEXT for gathering information around the facility in case of a disaster at the nuclear power facility, But it was not used at the site covered with debris (as of March 2012). The Japan Atomic Energy Agency (JAEA) also developed a robot for remote collection of radiation-dose data at nuclear power accident sites. This robot, however, was not ready for immediate use since the cost for continuous maintenance was not budgeted after finishing the prototyping in 2001, due to lack of users who would develop it for practical application. In the "Survey of S&T experts regarding the GEJE (1st edition)" that targeted academic expert by NISTEP, the survey collected various options such as 1) criticism against the direction of Japanese R&D of robots which avoided the tough challenges of practical application and maintenance systems after development, and 2) the difference in technology levels and efforts made for development between the US, where robots able work in disaster situations are sold as a product and in Japan, where robots are still only used at the laboratory level.

On the other hand, the International Rescue System Institute (NPO) established in response to The Great Hanshin-Awaji Earthquake, Chiba institute of Technology and Tohoku University started to modify a rescue robot "Quince" on March 17, 2011. "Quince" is a High-Speed Search Robots in Confined Space, and is superior in running performance against debris and stairs. But its use inside reactor buildings was outside of the scope of R&D, and serious modifications were required for the robot to be used at the nuclear power plant accident site. Taking various requests from TEPCO, it was modified to support the evaluation of radiation-resistant performance and wired-communications required inside the reactor building. Since June 2011, it has climbed up steep stairs that a U.S. robot had a difficulty with, and it worked very well to measure doses in the reactor building. The robot for measures against nuclear power disaster by JAEA was not used immediately, but was used to measure doses inside the reactor building after necessary modifications. Besides these, the unmanned construction technology that was practically used to remove rocks at Mt. Fugen at Unzen was also used in a practical manner to remove debris from inside of the reactor building, and for debris removal work at the upper section of the building.

It is necessary not only to improve functionality, but also to establish and manage operation systems in order to make the robot work practically at emergency disaster sites, particularly under actual severe conditions, such as the nuclear power disaster. Based on the understanding that "It became clear that unmanned systems, as measures against disasters in Japan, had issues such as the lack of flexibility to support various types of disaster sites, maneuverability to promptly and continuously locate within the site, and durability against severe environments as compared to technologies in the U.S. and Europe." In March, 2012, METI started a "Research and development project of unmanned systems to disaster" in order to develop a robot that can support operations for human beings at the places, where radiation doses are high, thus making it hard for humans to work. Improving the reliability of Japanese robots will now be urgent, "so that they can be used at disaster sites" not only through the individual R&D of robots, but also by enhancing the system to conduct operation practices and allow repair/maintenance under normal circumstances from a long-term perspective. It will also be necessary to establish an operation system that includes a control system in emergency situations, including cooperation with organizations, so as to respond to disasters with valuable knowledge gained from actual sites.

(Summary of issues in whole S&T)

We have discussed concrete issues of the entire field of S&T revealed by the GEJE. The most serious issues in regard to the earthquake are 1) most scientists did not expect an earthquake/tsunami of such

[1] A voluntary group is to get together to exchange information and opinions on technical issues to make robot technology efficiently practical and to consider a policy of applications and operations aiming at reconstruction/recovery from the disaster due to the earthquake, tsunami and nuclear power plant accident. The group also cooperates with other groups at academic societies/academic conferences, for example, the Science Council of Japan and industrial societies that are involved in robot technologies in Japan.

magnitude, 2) when the impermissible nuclear energy power plant accident occurred, the measures to prevent damage expansion were not sufficient, and finally, 3) those involved in S&T, government officials and expert groups face an extremely important issue: "The Japanese public lost confidence in the policies of S&T, and in experts who did not handle real-world risks and issues" as was made clear by the various issues revealed through responses in the aftermath of the disaster (refer to Figure 1-1-16, Figure 1-1-17).

Especially in terms of the response to the nuclear energy power plant accident, insufficient communication of timely and accurate information by the government and inconsistent opinions among experts resulted in loss of confidence in the government and scientific experts. The S&T community is expected to consolidate expertise from its various fields with the government, for making of political decisions, while the government has to make practically prompt political decisions using such scientific knowledge, and must communicate these decisions to the Japanese public in a clear manner, even if the experts' opinions are not unanimous. When such cases arise in the future, the major challenges for the government are to make decisions in an objective and fair manner, and to clearly explain to the Japanese public, why such decisions were made in order to regain the public's confidence. In order to overcome such challenges, it is necessary to continuously investigate the way in which scientific knowledge is collected and the way in which such information is put to practical use.

With regard to the GEJE, 1) the possibility of massive earthquakes that were 9.0 on the Richter scale was not considered, 2) damage to the nuclear energy power plant was not expected and, thus, a critical accident could not have been prevented, and 3) robots made in Japan initially could not be used at the nuclear energy power plant accident site, except in some cases, in which the facts showed that S&T in Japan could not necessarily work to solve various problems as society expected. As previously mentioned, this is one supposed reason as to why the Japanese public lost confidence in experts. From now on, it is extremely important for researchers and policy makers to reestablish S&T policies in order to understand social demands well, to efficiently deploy the outcomes of S&T to society and to help solve various problems within society.

In regard to many of the issues discussed thus for, the government has internally examined its operations from various aspects. For example, the Council for Science and Technology of MEXT declared "View of Future Investigation of Science and Technology Policies based on the GEJE" at the 36th general meeting on May 31, 2011, and discussed the five aspects listed below in order to devotedly review the GEJE, and to aim at a more comprehensive promotion of S&T, which Japan relies upon as its foundation, by considering its contributions for overcoming national crisis, and for the recovery and construction of social infrastructure that is resistant to environmental changes:

1. S&T review of the GEJE,
2. Interdisciplinary research and cooperation between fields to solve problems,
3. Practical use of the outcomes of R&D in an appropriate and efficient manner,
4. Communication with society, and
5. Contribution to recovery and rebirth, and future improvements in safety.

At a general meeting of the council (38th, on February 29, 2012), the Council summarized fundamental points and issues that the council would need to further discuss based on the reports on the investigation status from each subdivision belonging to the council (Table 1-1-25). Each subdivision is to further

review the GEJE from the perspectives of S&T and to proceed with the investigation of a comprehensive promotion policy of S&T.

Table 1-1-25 / Fundamental points at issues in regard to "Perspectives in investigation on S&T based on the GEJE"

(* Council status at each subdivision and options from council members are organized based on the chairperson.)

Perspective 1: Review in terms of S&T on the GEJE

1) Necessity to sufficiently recognize social demands

- There is a possibility that researchers may not sufficiently recognize social demands due to lack of interaction between the general public and specialized groups of scientists. The researchers should not only make efforts to deepen science and develop S&T, but also to proactively learn from society in various ways and to improve social literacy.
- Those conducting research with mandates from the Japanese public and public funds should understand its meaning well and shall be occasionally accountable to society for the value of their research.
- It is necessary to train various talented human resources who will support the future of Japan and its society's demands.

2) Review of previous policy on making efforts for earthquake/disaster prevention

- It is necessary to thoroughly examine why we were not able to consider the possibility of a great earthquake. What was insufficient in the previous efforts we made in the circumstances where research systems were always required to be reviewed? (It is necessary to be cautious when asking for funds in order to avoid being accused of "the phoenix trick") It might be necessary to strengthen comprehensive and interdisciplinary efforts by involving not only experts directly related to earthquake and disaster prevention, but also to human and social science fields.
- Pursuit of what is really required to protect the lives and properties of the Japanese public. The feedback given by ordinary people should be taken in and carefully examined.

3) Necessity of S&T systematization in Japan

- S&T in Japan is prone to be biased toward the development of element technologies, and less focused on systematization that considers actual application within society, which may result in the fruits of S&T not being linked with problems and solutions or not being implemented into society.
  Example) Robot shock

Perspective 2: Interdisciplinary research and cooperation between fields to solve problems

1) Political action as a way to solve problems

- It may be necessary to establish a political system to promote interdisciplinary research and cooperation between various fields of science in order to solve problems.

2) Expectation for talented people to support interdisciplinary research and cooperation between fields

- It may be necessary to make efforts to let students and young researchers develop various views and ideals of society.

Perspective 3: Practical use of the outcomes of research and its development in an appropriate and efficient manner

1) Understanding social needs to reflect themes in research

- It may be necessary to strengthen efforts to discover social needs at some phases, to determine research themes by cooperating with users, researchers in application fields, and researchers in the areas of the humanities/sociology in a broad and active manner, and to then reflect the results of the theme.

Perspective 4: Communication with society

1) Expectation of scientific advice

- It may be necessary to clearly define how experts' advice on S&T relates to the government's decision making. It is important to gather a wide range of scientists' opinions. If experts' opinions are inconsistent, it is necessary to establish a process to consolidate various opinions into multiple political options, propose them, and make political decisions based upon them.

2) Expectation of risk communication

- Based on an understanding of the limitations and uncertainties of S&T, the government should communicate with society about these risks. It is important not to mislead the public by making them believe that "earthquake prediction" is possible or that "risk free" outcomes are achievable.
- What kind of efforts should be made to improve confidence in S&T? We must strengthen mutual communication with society and properly judge the balance of social gain and loss (benefits and risks) in S&T. It may be necessary to improve risk literacy among the Japanese public and to improve the social literacy of researchers.

Perspective 5: Contribution to recovery, rebirth and improvements in safety

1) Expectations that R&D realize a secured society and improve disaster prevention capabilities

- What sort of efforts should we make in R&D by focusing on safety and reliability and how can R&D establish a social infrastructure resistant to disasters?

2) Recovery support by research institutions

- What sort of efforts should we make to have the results from research institutions and talented people further help recovery in damaged areas?

Source: Council for Science and Technology (CST) General meeting, Material 3-2-3 (38th, on February 29, 2012)

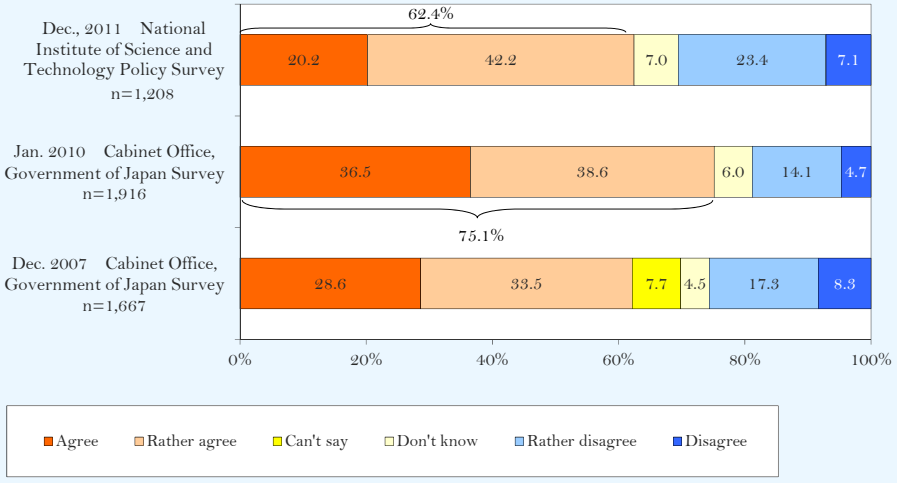
The GEJE made us realize that forces of nature can easily destroy modern civilization or claim valuable human lives. It has also forced us to face the limitations of S&T; even though they improve our daily lives, there is some vulnerability in any social or economic system. As discussed in this chapter, the challenges that the earthquake presented to various fields of S&T and the way it affected the policies of S&T were hard to learn, but extremely important.

Although the rate decreased after the earthquake, over 60 % of the Japanese public still believe that developments in S&T can solve emerging social problems, which clearly indicates that the expectations of development in S&T are still high even after the earthquake (Figure 1-1-26). Although the fruits of research from previous S&T did not necessarily satisfy the Japanese public in the aftermath of the earthquake and tsunami far beyond expectations, S&T did contribute to the prevention of further damages. For example, Earthquake Early Warning technology instructed a Tohoku Shinkansen to make an emergency stop and helped to prevent further damage. Furthermore, some bridges were able to avoid fatal damage thanks to seismic strengthening technology. It is also true that Japan has developed the ability to better resist natural disasters by continuous progress of flood control technology, such as river bank constructions, and the launch of AMeDAS[1] and weather satellites.

From now on, the government must make efforts to promote S&T that is accountable to the public's expectations. S&T are the driving force for Japan's reconstruction, for its revival in the aftermath of the earthquake and for its sustainable growth in the future. Finally, S&T must make efforts to regain the confidence of the Japanese public through devoted responses to the various problems revealed by the earthquake.

Figure 1-1-26 / Expectation of the Japanese public toward development in S&T

Question: What do you think about the following statement regarding S&T?
Further development in S&T will solve emerging social problems such as resource/energy problems, environmental problems, water/food problems and infectious disease problems.




Source: "Opinion Poll on S&T" NISTEP (conducted in December 2011) and "Public Opinion Poll on S&T and Society" Cabinet Office, Government of Japan

[1] AMeDAS stands for Automated Meteorological Data Acquisition System meaning "local weather meteoroidal system". Currently there are approximately 1,300 meteorological stations to measure precipitation nationwide.