Provisional translation

A White Paper on Science and Technology, 2011
- Overview -

■ Nature of this document

Annual report on government policy measures that have been implemented to promote science and technology; submitted to the National Diet as stipulated in Article 8 of the Science and Technology Basic Law

■ Overall structure

Part 1 **Toward a Robust and Resilient Society ~Lessons from the GEJE~**

The Great East Japan Earthquake(GEJE) inflicted unprecedented damage on Japan. The Japanese people are taking a very severe look at science and technology. They wonder if science and technology could not have at least somewhat lessened the damage from the earthquake and tsunami that left almost 20,000 people missing or dead. They wonder if the nuclear accident could not have been prevented, and they worry about its impact on their health. Indeed, the situation of science and technology is being questioned.

Based on the problems and lessons raised by the GEJE, everyone involved in science and technology is reconsidering the situation of science and technology. And aiming to build a robust and resilient society that can prevent or minimize influence and damage from the various problems humanity faces, recover quickly, and carry on with further development is seen as a necessity.

This year's white paper reveals various issues and lessons gleaned from the GEJE, and it provides implications for the science and technology innovation policy in terms of forming "a Robust and Resilient Society"

Part 2 **Measures that have been implemented to promote science and technology**

-On the basis of the 4th Science and Technology Basic Plan, measures taken by the government in FY 2011 are reported.

June 2012
Ministry of Education, Culture, Sports, Science and Technology

Part 1　Toward a Robust and Resilient Society ~Lessons from the GEJE~

introduction

Chapter 1　Review of the Response to the GEJE

○The review revealed various problems and lessons by examining the course of countermeasures to the GEJE and Fukushima nuclear power plant (NPP) accident.
○The review investigates how public awareness on S&T in Japan changed after the GEJE and provides an overview of the issues considered in the formulation of the S&T policy.

Section 1　Impact of the GEJE and Responses to it
1　The impact of the Great East Japan Earthquake
2　Responses to the Great East Japan Earthquake and issues raised
• The Great East Japan Earthquake as a whole
• Tokyo Electric Power Co. Fukushima　nuclear power plant accident
Section 2　Science and Technology Policy at Stake
1　Change in the public awareness of science and technology
2　Science and technology policy issues raised after the GEJE

Chapter 2　Reform of science, technology, and innovation policies towards the building of a robust and resilient society

○In this chapter,
・the role of S&T in achieving a robust and resilient society is outlined. This role can mitigate the impact of various problems, aid in rapid recovery, and sustain development.
・we present our stance of encouraging innovation to overcome social challenges and our effort to renew public trust in S&T (by promoting risk communication and creating guidelines on the use of scientific advice in policy making).

Section 1　Rebuilding the Society and the Role of Science and Technology after the GEJE
Section 2　Examples of S&T Innovation to Overcome the Problems
1　Advanced efforts for achieving tasks
2　R&D contribution to the recovery and reconstruction of businesses in disaster-hit areas
Section 3　Future Improvements to the Science and Technology Innovation Policy
~to Overcome the Problems Caused by the GEJE~
1　Promotion of Science and Technology　innovation in response to social needs
2　Toward renewing society's trust in Science and Technology

Column:　Science and technology policy history as seen in the White Paper on Science and Technology: 50 volumes of White Papers

Conclusion

Chapter 1 Review of the response to the Great East Japan Earthquake

Section 1 Impact of the Great East Japan Earthquake and response to it

1 Impact of the Great East Japan Earthquake

○ The 2011 off the Pacific Coast of Tohoku Earthquake and tsunami
The huge earthquake and tsunami with its epicenter off the Sanriku coast that occurred on March 11, 2011, caused **serious human and material damage centered on the Tohoku region and across a wide swath of Japan from Hokkaido to the Kanto area**

○ Fukushima nuclear power plant accident
→ Massive emission of radioactive material led to **orders for the evacuation of people living nearby and restrictions on the shipping and consumption of food**
→ **Harmful rumors in many parts of Japan**
→ **Planned power outages and restrictions on power use** Etc.

Overview of and state of damage from the 2011 off the Pacific Coast of Tohoku Earthquake

○ Date :	March 11, 2011 (Fri.) 14:46
○ Epicenter :	Off the coast of Sanriku, depth 24 km
○ Earthquake size :	Magnitude 9.0
○ Tsunami :	Over 40 m (runup height in Iwate Prefecture)
○ Aftershocks :	661 (through March 31, 2012)
○ Area flooded :	561 km^2 (approximate)
○ Deaths :	15,854 (as of March 28, 2012)
○ Power outage :	About 8.71 million homes (entire Tohoku region, part of Kanto region)
○ Water outage :	about 2.3 million homes (entire Tohoku region, part of Kanto region)

○ The Great East Japan Earthquake did serious damage to Japanese society, the economy, and science and technology infrastructure

(Japanese society and economy overall)
- Real GDP : The January–March and April–June 2011 quarters both posted negative quarter-on-quarter growth
- Estimated amount of economic damage : 16.9 trillion yen (not including damage from the nuclear power plant accident; June 24, 2011, Cabinet Office announcement)

(Agriculture, forestry, and fisheries)
- Amount of damage related to agriculture, forestry, and fisheries : 2.4268 trillion yen (as of March 5, 2012)

(Manufacturing)
- industrial production index (seasonally adjusted) : Down 16.2 percent: in March 2011 (compared with February 2011)
- Four-wheeled vehicles produced : Declined 60 percent in April 2011 (compared with April 2010)

(Tourism)
- Foreign visitors to Japan : Decreased by about 60 percent in April 2011 (compared with April 2010)

(Science and technology infrastructure)
- Research facilities and equipment : 177 universities and 34 independent administrative agencies/national examination and research centers suffered damage
  The FY 2011 supplemental budget allocated 119.1 billion to repair such damaged facilities and equipment
- Foreign researchers : Departures from Japan were notable immediately after the earthquake, but most returned after a few months.

Japan faces a situation in which a number of unprecedented difficult problems arose simultaneously.

2 Responses to the GEJE and issues involved

(1) Responses to the GEJE as a whole and issues involved

1) Government responses

(Measures for recovery and victim support)
- Headquarters for Emergency Disaster Response was established for response immediately after the earthquake

(Initiatives on reconstruction)
- Passage of the Basic Act on Reconstruction from the Great East Japan Earthquake (June 20, 2011)
  → Setting of Basic Guideline for Reconstruction in response to the Great East Japan Earthquake (July 29, 2011)
- Launching of the Reconstruction Agency (February 10, 2012)

(Budgetary provisions for recovery and reconstruction)
- The first supplemental budget (about 4 trillion yen) was quickly appropriated after the earthquake. Three additional supplemental budgets were subsequently compiled.

(Initiatives on policy review and verification in light of the earthquake)
- Central Disaster Management Council: Revision of the Basic Disaster Management Plan and review of earthquake and tsunami forecasts and damage forecasts
- Council for Science and Technology Policy: Review of the Fourth Science and Technology Basic Plan

2) Issues raised by the GEJE and responses to it (the earthquake and tsunami)

(i) Various problems made clear by observation of the earthquake and tsunami damage and the direction of future countermeasures

< Problems in terms of science and technology >

× **The limits of the prediction methods of the past**
- **The largest recorded earthquakes** (the largest class of earthquakes that may have occurred in the past) such as **the Jogan Earthquake and the Keicho Earthquake were not adequately considered**
- **The largest theoretically possible earthquake** (the largest earthquake that could occur in theory) **was not considered either**
- Measurement data and basic knowledge that formed the basis for estimates were inadequate, and earthquake models were limited.

○ **The government failed to predict the occurrence of a mega earthquake**
○ **The actual damage from the earthquake and tsunami was much greater than the predictions** used as the premises for countermeasures.

< Problems with the transmission of information >

○ Method used to provide **the tsunami warnings immediately after the earthquake**
  • The first tsunami warning underestimated the size of the earthquake.
  • It is even possible that the initial information slowed evacuation and led to greater damage
○ **Updated tsunami warning information did not reach residents.**

× Accurate tsunami predictions could not be quickly made in order to update the tsunami warning, because of problems with the measurement range of seismographs.
× Evacuation information could not be transmitted because of interruptions in communications lines, drastic increase in communication volume, and power outages that prevented the use of equipment.

Issue ; Construction of information and telecommunications infrastructure that is robust against disasters

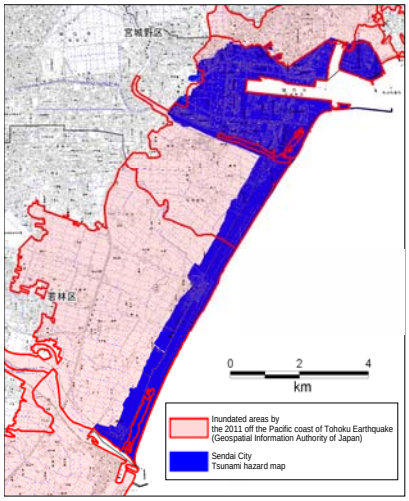
< Problems with measures on disaster management >

× **Measures for widespread and complex disasters were inadequate**

× Overreliance on coastal protection facilities (seawalls, breakwaters, etc.)
The limits of physical countermeasures against disaster
- The large seawall in the Taro area of Miyako City
  (the so-called Great Wall of Taro)

× **It is even possible that the gap between hazard maps based on conventional predictions and the actual extent of flooding may have caused greater damage**

Tsunami Hazard Map, Sendai City
Estimated and Actual Flooded Area



Source: White Paper on Disaster Management 2011

< Problems related to discussions of risk in society and fostering an awareness of disaster management >

- The everyday preparation and instant decisions of each individual person decided life or death
- Although the public has always lived with the risk of natural disasters, overconfidence in science and technology may have led people to forget the lessons of the past and their fear of nature, dulling their preparation for risks and crises.

The importance of shared risk awareness through everyday **disaster management education** and **risk communication**

< Direction for and issues to be considered in future counter-earthquake and tsunami measures >

○ Reviewing the anticipated earthquakes and tsunamis for disaster management measures

- **The largest classes of earthquakes and tsunamis in light of all possibilities should be anticipated.**
- In that case, it is important to **base estimates on scientific knowledge** including analysis of historical documents, study of tsunami deposits, and surveys of coastal topography.
- It needs the **development of research that integrates various knowledge from different fields such as seismology, geology, archeology and history**.
- At the same time, it is necessary **to fully take into account the uncertainty in and limitation of predicting natural phenomena**

○ Measures to mitigate damage from tsunamis and earthquake shaking

- It is necessary to **estimate two levels of tsunamis**, and develop measures to mitigate damage for both of them.
  - ☆ **The largest class of tsunami, which occurs at an extremely low frequency, but which causes enormous damage when it does**
    ⇒ **Disaster mitigation by evacuation**
  - ☆ **Tsunamis that occur frequently and cause extensive damage even though they are not high**
    ⇒ Continued mitigation through **physical countermeasures** (ex. embankments)
- Enhanced and improved information and telecommunication systems to accurately transmit disaster information
  Strengthened earthquake resistance of large-scale structures against long-period ground motions

○ Improved disaster management ability through government assistance, cooperation, and self-help

- Urban renewal that **links "hardware"** (disaster prevention facilities, etc.) **and "software"** (disaster prevention training, etc.) **measures**
- **Enhanced measures on risk communication** (measures for people who will not evacuate, etc.)

(ii) Discussion in the Japanese and international science and technology communities

○ Varied study in Japanese communities such as academic societies and related conferences
○ Holding of international symposiums

(2) Responses to the Tokyo Electric Power Co. Fukushima nuclear power plant(NPP) accident

1) Accident overview and development

- Total loss of power including AC and DC power, the impairment of cooling capability, uncovered nuclear fuel and core meltdowns occurring
- Explosion of reactor buildings believed to be caused by leaking hydrogen
- Dispersal of radioactive material from inside the reactor over a large area

⇩

- Declaration of nuclear emergency situation and occurrence of an specified event stipulated in Articles 10 and 15 of the Act on Special Measures Concerning Nuclear Emergency Preparedness
- Order for citizens to evacuate
- Establishment of the Government-TEPCO integrated Response Office
- Publication of the "Roadmap towards Restoration from the Accident at Fukushima Daiichi Nuclear Power Station" by TEPCO
- Confirmation of the achievement of "Steps 1 and 2" under the roadmap

2) Issues raised through responses to the accident and investigation and verification

(i) Indications of accident investigation and verification activities

○ Report of Japanese government to the IAEA

- The Government compiled a 28 lessons learned by the accident to that date for the June 2011 IAEA Ministerial Conference (June Report)
- The Government compiled another report adding the situation since the June Report for the September 2011 IAEA Board of Governors Meeting and General Meeting (September Report)

○ Interim report of the government's Investigation Committee on accident, etc.

- A Government accident investigation was established in order to probe the causes of the accident through neutral investigation and verification and to provide policy advice to prevent the spread of damage and a reoccurrence of the accident
- Interim report compiled in December
- The Ministry of Education, Culture, Sports, Science and Technology published the "Interim Report on Verification of the Results of Efforts on Recovery and Reconstruction from the Great East Japan Earthquake (First Report)," which included information on the nuclear accident
- Outside the Government, an investigatory committee was established in the National Diet, and private-sector organizations and the scientific community also carried out investigation and verification of the accident

(ii) Various issues that occurred after the accident

○ An overview of policies carried out by the Government that have a significant relationship to science and technology
○ Extraction of issues currently raised from among those policies

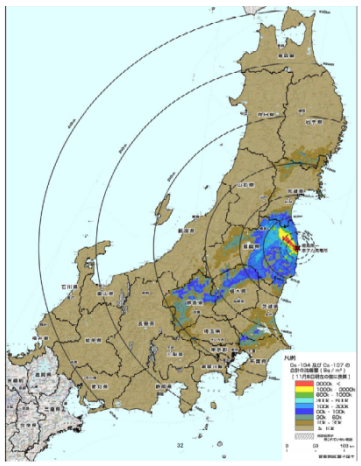
a) Establishment and lifting of evacuation zones

- ○ The scope of the evacuation has expanded since the issuing of the first evacuation order on March 11. From late April onwards, a caution zone, planned evacuation zone, prepared emergency evacuation area, and specific spots recommended for evacuation have been designated.
- ○ On September 30, the prepared emergency evacuation area designation was canceled. In light of the completion of Step 2, the caution zone designation was canceled for some municipalities, while new evacuation order areas (prepared evacuation order cancelation zone, residential restriction zone, difficult to return zone) were designated.
  → Common issues for these zones are ensuring the safety and peace of mind of residents, thorough decontamination, and concern for children

b) Planning and implementation of radiation monitoring

- ○ A number of problems arose during the implementation of emergency monitoring.
- ○ In July, the Monitoring Coordination Meeting was established, and the "Comprehensive Monitoring Strategy" was set and revised. Relevant organizations began monitoring activity.
- ○ Impacts were spread through dispersal of radioactive material from the accident and distribution of contaminants.
  → Because the accident spread over a wide area, appropriate monitoring and decontamination are necessary.
- ○ About SPEEDI, various issues including the method of information provision were highlighted. Both, the government and Diet investigation committees are conducting investigations.

The total deposition of Cs-134 and Cs-137 on the ground surface as a result of the nuclear accident



Source: Ministry of Education, Culture, Sports, Science and Technology

c) Effect of radiation on human health

- ○ Implementation of emergency exposure screening and the long-term "Prefectural Resident Health Management Survey"
- ○ Compilation of the "Report of the Working Group on Risk Management Concerning low-level radiation exposure," which summarizes Japanese and international scientific knowledge on low dose exposure
  → It is necessary to carry out transparent risk communication that makes confirmed scientific facts easy to understand and is based on awareness that voluntary public participation is essential.

d) Promotion of decontamination

- ○ Large scale decontamination carried out based on the Act on Special Measures concerning Environmental Contamination the Handling of Pollution by Radioactive Materials. Model pilot projects to establish decontamination technology and preliminary decontamination carried out in parallel.
  → It is necessary to communicate work methods and precautions, and to be able to obtain the advice and guidance of experts.
  → Establishment and operation of facilities for the interim storage of decontaminated soil are necessary, and research and development on technology to control the volume of decontaminated soil are needed.

e) Securing food safety

- ○ Implementation of shipping restrictions, tougher inspections, and improved inspection equipment in response to the detection of radioactivity exceeding provisional limits in some foods
- ○ Review of standards for allowable inclusion of radioactive cesium in foods
  → Along with risk communication, efforts to implement effective measures are necessary.

f) Risk communication

- ○ Appropriate information regarding the development of the accident was not transmitted at the appropriate time. Additionally, expert opinion sometimes differed due to different fields of expertise, etc.
- ○ A series of incidents occurred that showed spreading anxiety regarding radiation and radioactivity.

How to explain specialized information quickly without losing accuracy and in a way that recipients can understand, and especially how to respond to public doubts and concerns when expert opinion differs, are major issues.

g) Response for mitigating the effects of the NPP accident and decommissioning of the Fukushima Daiichi NPP

- ○ Moving towards resolution of the accident, confirmation of Step 1 and Step 2 of Tokyo Electric Power Company's "Roadmap towards Restoration from the Accident at Fukushima Daiichi Nuclear Power Station"
- ○ Moving towards decommissioning, creation of a medium to long term roadmap and a research and development plan

→ Because this is a long term effort and is technically difficult, collection of knowledge from Japan, other countries, and industry, along with securing and developing human resources development , are necessary.

h) Information provision for the international society

- ○ Japan's situation was explained through reports on the accident made to the IAEA Ministerial Conference on Nuclear Safety (June 2011) and IAEA General Conference (September 2011).

→ Along with confirming that the accident had a significant international impact, quickly overcoming the accident is an international responsibility and mission.

3) Reviewing the nuclear safety regulation system

- ○ Along with carrying out safety assessments based on new procedures with reference to stress tests, implementation of emergency safety measures including short-term measures such as placement of vehicle mounted generators and pumper trucks, and medium to long term measures such as establishment of seawalls
- ○ In order to restore trust in nuclear safety administration and improve its functioning, establishment of a "Nuclear Regulatory Agency," and submission of bills to the Diet, including amendment of the Nuclear Reactor Regulation Act and the Act on Special Measures Concerning Nuclear Emergency Preparedness

- Thorough implementation of a culture of safety is a shared issue that cuts across from resolution of the accident to future strengthening of safeguards

4) Reviewing the energy policy

- ○ Energy and Environment Council completely revised the Basic Energy Plan and indicated a move in the direction of reducing dependence on nuclear energy and converting to a decentralized energy system
- ○ Along with setting an "Innovative Energy and Environment Strategy" targeting summer 2012, implementation of deliberations on a new policy outline for nuclear power in the Atomic Energy Commission

It is important to base the means by which research and development on technology that will have a significant impact on society on a broad range of opinions from all levels of society. In that case, however, how experts can scientifically evaluate utility and risk and convey the results to the public in an easy to understand way and ensuring the reliability of that evaluation are important elements in order for the discussion to make effective progress.

1 Changes in the Public Awareness of Science and Technology

(1) Public Trust in Scientists and Engineers

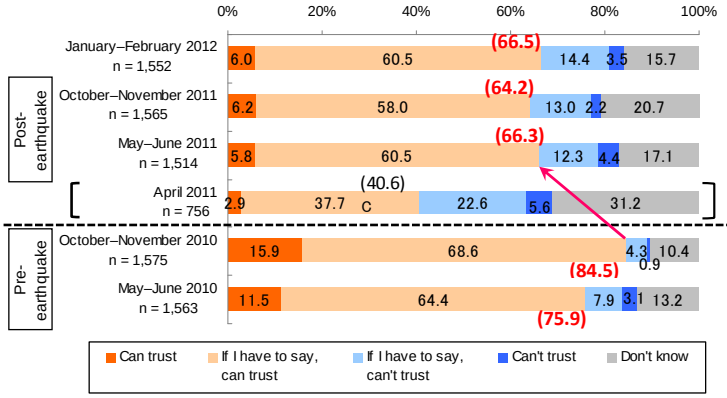
○ The public placed high expectations and great trust in science and technology

○ The earthquake, tsunami, and nuclear accident have **diminished the public's trust in scientists**

The percentage of people responding that they "Can trust" or "If I have to say, can trust" what scientists say has dropped by 10 percentage points since the earthquake (76–85% → around 65%).

Public trust in scientists

Question: Do you feel you can trust what scientists say?

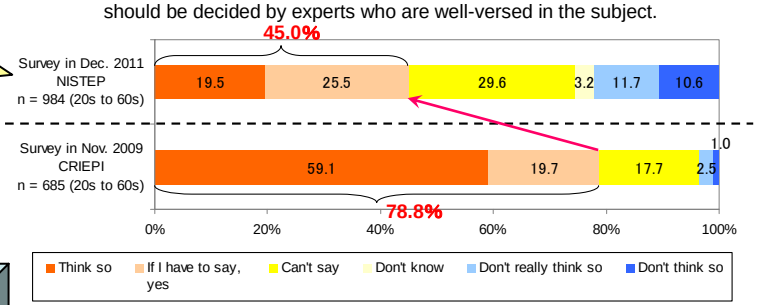


Source: National Institute of Science and Technology Policy, "Monthly Opinion Poll"

The percentage of people who feel that experts should decide the "direction of science and technology research and development" has fallen sharply, from 78.8% before the earthquake to 45.0% after.

Should experts decide the direction of S&T ?

Question: What do you think of the following opinion regarding science and technology?
The direction of research and development in science and technology should be decided by experts who are well-versed in the subject.



Sources: NISTEP, "Survey on Public Awareness of Science & Technology" (carried out December 2011)
CRIEPI, "Survey on Public Awareness on the Use and Safety of science and technology" (carried out November 2009)

○ **Few members of the public want to trust experts** with the direction of research and development

A **crisis of trust and confidence in experts** in science and technology

(2) Public expectations and anxiety regarding science and technology

○ Many people considers that **the Japanese science and technology could not cope with the serious accidents** such as the release of large amounts of radioactive materials from nuclear power plant **though they believed that it could solve the problem before the earthquake**.
(Source: NISTEP, "Survey on Public Awareness of Science & Technology " [carried out December 2011])

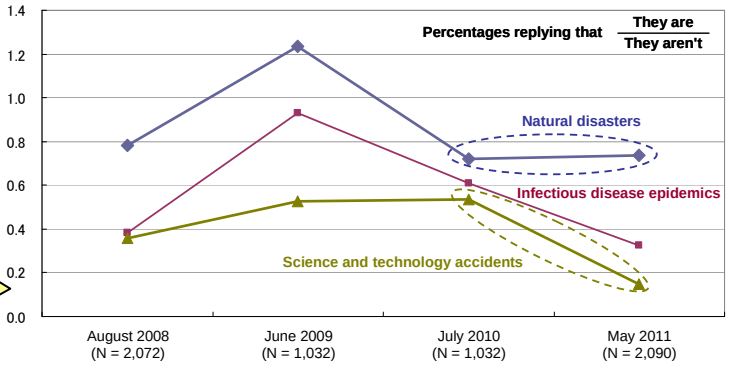
○ The public **believes that regarding the nuclear accident, Japan's science and technology prowess was not adequately utilized**
- In measures against severe accidents before Fukushima or in measures to prevent the damage from spreading after the accident began

○ **The science and technology did not adequately meet the public's expectations**.

The reputations of the national and local governments concerning measures against nuclear disaster and other science and technology accidents fell sharply after the earthquake.

Regarding current national and local governments measures against threats

Question: Do you think that the national and local governments are currently taking measures (everyday measures and preparations) to prepare against threats?



Source: MRI, "Opinion Poll after the Great East Japan Earthquake (1): Risk Awareness of Citizens" (July 13, 2011)

○ Anxiety concerning the development of science and technology matters of high anxiety before the earthquake
- Global environmental problems
- Safety of genetically modified food products and nuclear power generation
- Cyber crime, such as cyber-terrorism and unauthorized access

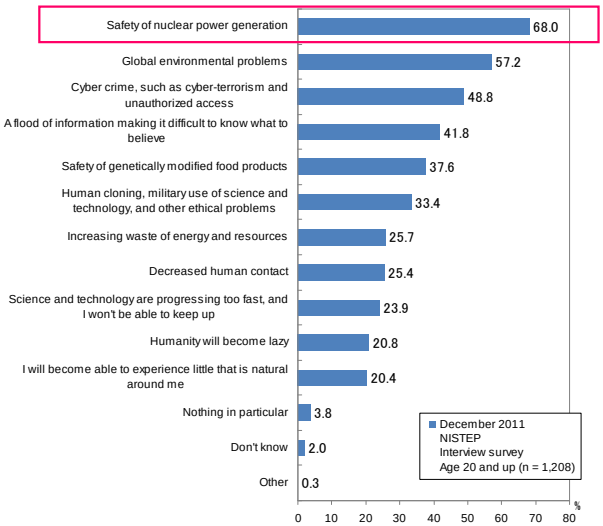
○ Meanwhile, the most common response is **"Safety of nuclear power generation"**, as **a matter of increased anxiety after the earthquake**.

○ The percentage of the public that believes that humanity can control science and technology has fallen.
(Before earthquake: 60 percent
→ after earthquake: 30 percent)

Background of the public's **loss of trust in experts**
- When the earthquake occurred, **science and technology did not adequately meet the public expectations**
- **Increased concern** along with the development of science and technology.
- After the earthquake, **the public recognized the potential of science and technology and its risks and uncertainties** again

Areas in which anxiety concerning science and technology has increased since the earthquake

Question: Compared with the time around last December, do you feel more anxiety regarding the development of science and technology? Choose any of the following if you feel increased anxiety concerning them.



Source: NISTEP, "Survey on Public Awareness of Science & Technology " (carried out December 2011)

2 S&T Policy Issues Raised after the GEJE

○ The GEJE exposed the following problems:
- **Risks and uncertainties involved in S&T have not been seriously considered** with regard to the provision of information **by the government and experts for the public**.
- As a result, most of the **public did not have an adequate understanding of the situation**.

This highlighted the following issues for science and technology as a whole.

[First issue: Insufficient response to risks such as risk evaluation and risk communication]

× **In light of the risks and uncertainties of science and technology**, when predicting disasters, accidents, and damages from them, **the government did not recognize the possibility of unexpected events, and did not take sufficient measures against them.**

⇒Earthquakes and tsunamis
- Direction for **drastic rethinking of the way to set assumptions and of overall disaster management measures** (Central Disaster Management Council)
- Anticipating earthquakes and tsunamis that **fully considers the great uncertainty in natural phenomena and the limits of prediction**

⇒Nuclear accidents
- The need for **transformation in the basic framework for disaster preparedness and countermeasures for a huge system**

In concrete terms, (Investigation Committee on the Accident)
1) **Renewed risk awareness** and the taking of necessary measures
2) The necessity of formulating disaster prevention programs that **assume complex disasters**
3) **The importance of having an all-encompassing perspective**
→ Adverse effects of specialization and sectoral subdivisions

× **Inadequate risk communication during emergencies**
- During the nuclear accident, risks were not explained in easy to understand terms, and a risk outlook was not provided
- Issues with disaster information regarding evacuation provided by the government to residents

× **Inadequate risk communication in ordinary times**
- **There are difficulties in presenting risk information to society.**

However, since there is no such thing as absolute safety, **it is necessary to work towards building a society that faces up to risks on an everyday basis and can make rational choices about them** (Investigation Committee on the Accident)

[Second issue: Inappropriate provision of scientific knowledge by experts]

× Government → Rational **policy decisions based on scientific knowledge** and **its transmission to the public were both insufficient**
× Science and technology community → **Provision of scientific knowledge gathering expertise from various fields** for reference by government decision makers **was inappropriate**

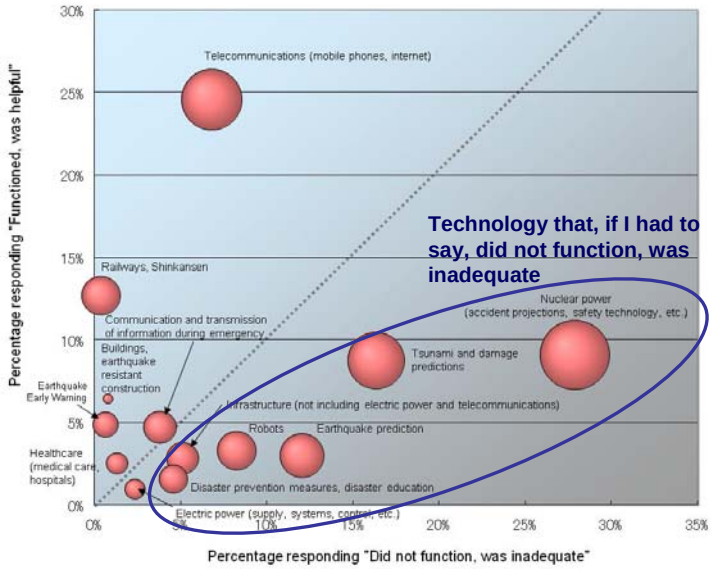
(Statement of the Executive Committee of Science Council of Japan,
"Reconstruction after the Great East Japan Earthquake and the duty of the Science Council of Japan" [September 22, 2011]

• **Study of means of gathering and utilizing scientific knowledge is necessary** so that objective and fair policy decisions can be made quickly even when expert opinion differs and cannot be summarized.

[Third issue: Lack of a system utilizing R&D results to cope with actual issues]

× The fruits of Japanese research and development in which so much had been invested did not live up to expectations when disaster and accident occurred
  - Technology for projecting nuclear power plant accidents and ensuring safety
  - Technology for forecasting earthquakes and tsunamis
  - Robot for use in search and rescue Etc.

Technologies that functioned or did not function when the earthquake occurred



Note: For this figure, common free responses regarding technology that "Functioned, was helpful" and technology that "Did not function, was inadequate" were selected, and the percentage of valid responses accounted for by each technology was extracted.
Source: Prepared by MEXT based on NISTEP, "Survey regarding the GEJE by S&T Experts (1st)," (carried out July 2011)

[Summary of issues for science and technology policy as a whole]

○ **The most serious issue raised after the GEJE was that public trust in the S&T policy and experts declined** because of the lack of countermeasures for risks and actual problems.

○ However, **the public expectations of the development of science and technology remains high**.

○ It is now important to not only **recover the public's trust by reviewing and reconstructing the S&T policy**, but also **promote S&T in response to social needs**.

Chapter 2 Reform of science, technology, and innovation policies towards the building of a robust and resilient society

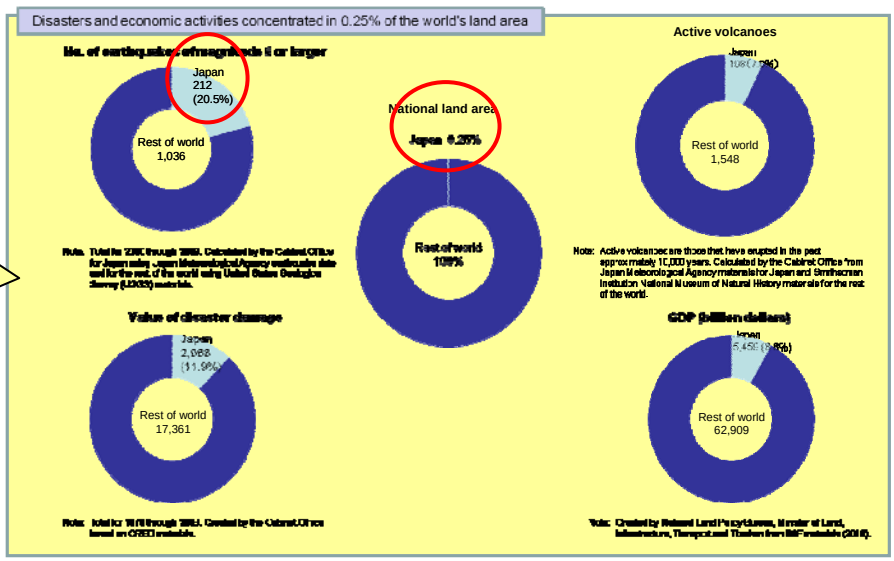
Section 1 The ideal society that Japan should aim for and the proper form for science and technology after the earthquake

< The society desired by the public after the earthquake >

○ Japan's **risks stand out** among developed countries

Examples: Since 2011, besides the Great East Japan Earthquake, Japan has suffered extensive damage from the eruption of the Shinmoedake volcano, typhoons, torrential rain, blizzards, and tornados.

Japan's percentage of disasters (about 20% of the world's earthquakes of at least magnitude 6) is very high compared with its land area (0.25% of world land area).



Source: Disaster Prevention National land Development Committee, Policy Subcommittee, National Land Development Council, "Advice on developing national land resilient to disasters" reference materials (July 2011)

○ In addition to natural disasters, Japan **faces various dangers**, such as energy issues, cyber-terrorism, and infectious diseases.

○ A report published by the Davos Forum points out the need to prepare robustness and resilience versus natural disasters and other risks.

○ The Council on Competitiveness-Nippon also pointed out the importance of a society with "the flexible resilience to enable the functioning of society as a whole to recover quickly even if some functions of society or business halt when a risk materializes" (resilient economy).

○ An increasing number of residents want improved disaster and crisis management (prefectural opinion survey)

Example: In Tokyo Prefecture's "Requests of the Metropolitan Government," disaster management measures was number one in FY 2011, surpassing public safety measures, which had led for seven straight years

It is necessary to build a tough society with the ability to recover quickly (a robust and resilient society)

< Expectations for science and technology towards building a robust and resilient society >

○ Development in the healthcare, management of natural disasters, energy, and environment fields is desired (National Institute of Science and Technology Policy survey).

○ **Expectations for solutions from science and technology for issues exposed by the earthquake**

○ Japan needs to **share the lessons it learned** from the earthquake **with the rest of the world** and **transmit ways to overcome various problems to the world**

Science and technology that not only contribute to reconstruction and recovery of Japan and the stricken area, but also help solve global problems

Section 2　Examples of S&T Innovation to Overcome the Problems

○ Expectations are rising for S&T to make a contribution to social issues such as energy issues and mitigation of damage from natural disasters because of the earthquake. Promotion of S&T innovation with a view towards enabling it to include a steady contribution to solving social issues is needed.
○ In addition, initiatives based on the Fourth Basic Plan that contribute to the realization of a society that is robust against disasters and has great resilience is necessary.

1　Advanced efforts for achieving tasks

(1) Examples of responses to earthquakes and tsunamis

• Upgrade of the Earthquake Early Warning System (Japan Meteorological Agency, etc.)

Developed by National Research Institute for Earth Science and Disaster Prevention , etc. (Operating since 2007)

Utilized for emergency stops on other railways as well

→ Earthquake occurs →

Emergency stopping of the Tohoku Shinkansen traveling at high speed and other trains, preventing derailment

Issues raised, such as prediction accuracy, mistaken reports when there are multiple earthquakes → Software upgrade (– August 2011)

• Upgrade of the Tsunami Warning System (Japan Meteorological Agency)

Proper form for tsunami warnings

After collection of the many issues made clear by the earthquake and the setting of a direction for development, opinions were solicited → Changes so that evacuation activities are not hindered

Tsunami warning accuracy

Promotion of technical development so that the warnings themselves are more accurate

• Creation of information-collection and decision-making support systems to ensure sound operations in case of any unexpected disasters (Tokyo Institute of Technology, etc.)

Development of a system that quickly gathers information under the adverse conditions immediately following a disaster and supports disaster response by local governments → Enables local governments to:
1) Decentralize data storage
2) Perform administrative work by proxy
Etc.

By the wide-range cooperation of the local governments

(2) Examples of responses to issues caused by the Tokyo Electric Power Co. Fukushima nuclear power plant accident

• Utilize S&T for environmental monitoring (Ministry of Education, Culture, Sports, Science and Technology, etc.)

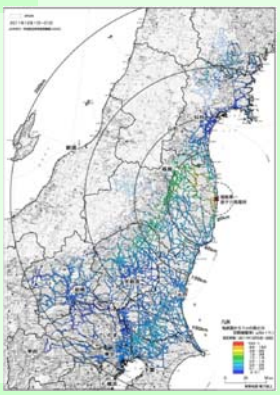
Development of new methods of environmental monitoring (use of aircraft, etc.)

Implementation of large-scale environmental monitoring through the "Survey on the distribution of radioactive material emitted by the Tokyo Electric Power Co. Fukushima Daiichi nuclear power plant accident," which comprises over 400 researchers from more than 100 universities and other research organs

Surveillance of environmental radiation level by newly developed vehicle-mounted radiation measurement system in and around Fukushima Prefecture

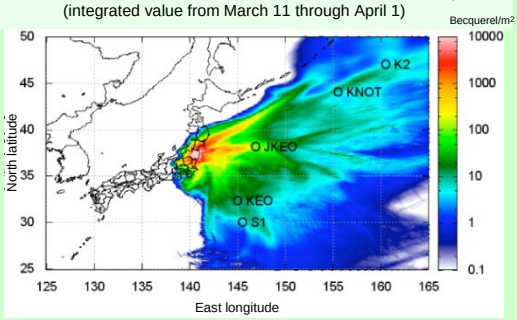
→ Understanding air doses

Results of measurement of air doses through a mobile survey



- **Simulation of marine pollution (Japan Agency for Marine-Earth Science and Technology, etc.)**

Results of simulation of the distribution of cesium-137 in the atmosphere (integrated value from March 11 through April 1)



- Water from the northwestern Pacific Ocean is sampled and cesium-137, etc., is measured
- Simulation of the distribution of contaminated water through a model that takes the movement of seawater into account and simulation of the distribution of radioactive material through a model of atmospheric particles

The simulations suggested distribution above 40 degrees north latitude through atmospheric particles

- **Decontamination using zeolites, etc. (Japan Atomic Energy Agency, various academic societies, etc.)**

Decontamination work by local residents → Safe, sure, low cost → Summarizing the guidelines (Ministry of the Environment)

R&D on decontamination methods

Water pollution through radioactive material → Need to reduce volume → Database creation and disclosure

R&D on substances that absorb radioactive materials and technology for handling them

Decontamination in a pool

- **In response to a tighter electricity supply-demand balance after the GEJE, efforts to expand the use of renewable energy**

Initiatives on expanding use of renewable energy in light of constraints on power supplies following the earthquake (Kitakyushu City, etc.)

Local conservation location

Adjustment of power supply-demand

Homes, offices, etc.

Large storage batteries

- Adoption of renewable energy
- Achievement of energy conservation
- Stable energy supply

Collaboration among industry, academia, and government

Potential large reductions in carbon dioxide emissions

2 Examples of initiatives of R&D contribution to the recovery and reconstruction of businesses in disaster-hit areas

(1) Examples of implementation of existing R&D results

- **Biotreatment of spilled oil by Bark Compost (Oita Industrial Research Institute and Japan Science and Technology Agency)**

Regeneration of seawater is essential to reconstruction in tsunami-stricken areas

In order to develop a method for disposal of oil washed ashore by the tsunami, experimentation with the insertion of the oil into compost for decomposition and disposal

- Most of the oil decomposed, and compost was obtained
- Only one-third as much carbon dioxide was released compared to incineration

Left photo: Microorganisms that decompose oil
Right photo: Heavy oil bioprocessing experiment at Ofunato Bay

- **Improvement of the marine environment by the micro bubble technique (Tokuyama College of Technology and Japan Science and Technology Agency)**

The tsunami worsened water quality, leading two red tides and shellfish poisoning

↓

In order to cleanse the water quality and improve the environment for aquaculture businesses, microbubble generation equipment that increases dissolved oxygen in the water was set up, and an experimental oyster bed was created

↓

The oysters grew twice as large as usual, enabling a decrease in cultivation time

Large oyster that grew in a bed generated with microbubbles

(2) Construction of R&D bases

○ Implementation of the Construction of bases that will perform R&D meeting social needs in order to revive industry and provide employment in the stricken area

◎ Fukushima renewable energy research base (provisional name)
Actors : National Institute of Advanced Industrial Science and Technology (Ministry of Economy, Trade and Industry, etc.)
Objective : Promotion of industrial concentration related to renewable energy
Details : Construction of a base for advanced research and development on renewable energy

◎ Tohoku Medical Megabank project Tohoku Medical-Megabank Organization Initiative
Actors : Tohoku University, etc. (Ministry of Internal Affairs and Communications, Ministry of Health, Labour and Welfare, Ministry of Education, Culture, Sports, Science and Technology, etc.)
Objective : Improvement of the health of residents in the stricken area and creation of new industry
Details : Implementation of an initiative to rebuild healthcare in the stricken area and develop a base for personalized medicine and other next-generation healthcare in Tohoku

◎ R&D base for medical/welfare equipment and medicine industry Development of a research and development hub for medical welfare equipment and the drug discovery industry in Fukushima Prefecture
Actors : Fukushima Prefecture (Ministry of Economy, Trade and Industry, etc.)
Objective : Improvement of the health, welfare, and lives of Fukushima Prefecture residents and creation of new industry and jobs
Details : Implementation of development using some funds from the Fukushima Prefecture Nuclear Disaster Reconstruction Fund of a R&D base for medicine and medical equipment centered on Fukushima Medical University

◎ R&D base for radiation and decontamination
Actors : Fukushima Prefecture (Ministry of Education, Culture, Sports, Science and Technology)
Objective : Maintenance and improvement of the health of Fukushima Prefecture residents
Details : Implementation using some funds from the Fukushima Prefecture Nuclear Disaster Reconstruction Fund of development of a R&D base on radiology and advanced diagnosis and a R&D base that will carry out development of decontamination technology

Radiopharmaceutical manufacturing facility

A class on decontamination work in Fukushima Prefecture

◎ R&D base to strengthen disaster-resistance of the information and communications network Development of a research and development hub to increase the robustness of information and communications networks versus disasters
Actors : National Institute of Information and Communications Technology (Ministry of Internal Affairs and Communications)
Objective : Building a new international base for R&D innovation in the information and communications field with collaboration among industry, academia, and government
Details : Implementation of R&D and demonstration experiments to strengthen disaster-resistance of the information and communications networks

◎ Tohoku Marine Science Center
Actor : Tohoku University, etc. (Ministry of Education, Culture, Sports, Science and Technology)
Objective : Restoration of fishing grounds off the coast of Tohoku, reconstruction and revival of industry and villages in harbor areas
Details : Construction of a base comprising multiple organizations, implementation of research studies on marine ecosystems, and technology development that will lead to creation of new industry

Section 3 Future Improvements to the S&T Innovation Policy ~to Overcome the Problems Caused by the GEJE~

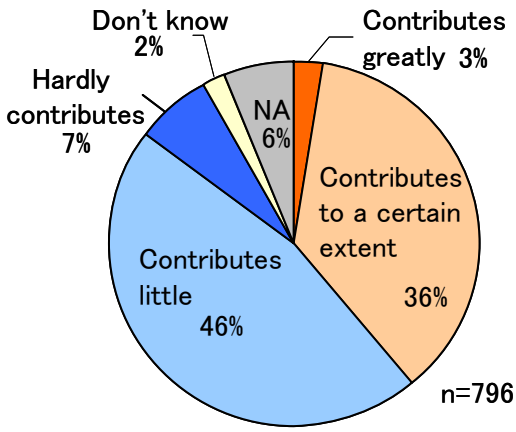
1 Promotion of S&T innovation in response to social needs

(1) In order to promote productive R&D

○ Most experts are aware of **the third issue (R&D findings were not always responsive to real world issues)** raised by the GEJE

Over 50 percent of experts responded that findings "Hardly contributes" or "Contributes little" to solving problems.

Do R&D results contribute to solutions for social problems?



Source : NISTEP "Survey regarding the GEJE by S&T experts (2nd ed.) " (Sept. FY2011)

< Reasons findings not contribute to solving problems >

○There is a Gap between the experts and society
○**Inadequate understanding of and research on social needs**
○S&T in Japan **is not systematically organized and does not provide applicable solutions** Etc.

< Necessary initiatives >

In order for R&D findings to be appropriately and effectively utilized, 1) through 3) are necessary

1) **Timely discovery of urgent social issues**
2) **Overall S&T management** suited to mission oriented research and development
3) **Efficient and effective implementation of R&D results**

In order to carry out 1) through 3) effectively,
- Researchers **must collaborate across organizations and fields**
- Collaboration must begin **at the topic-raising or planning stage**, not the application stage

The Fourth Basic Plan includes initiatives such as:
- **Foundation of Innovation Strategy Council (provisional name)**
- Strengthening "knowledge" networks among industry, university and government
- Establishment of "places" for industry-university-government collaboration

(2) Aiming for the collection of knowledge from different fields in order to overcome social issues

To address the issues, integrated academic knowledge including that on social sciences and humanities is required; however…

○ In Japan, **there is not active coordination and integration between the fields of social sciences, humanities, and natural sciences**

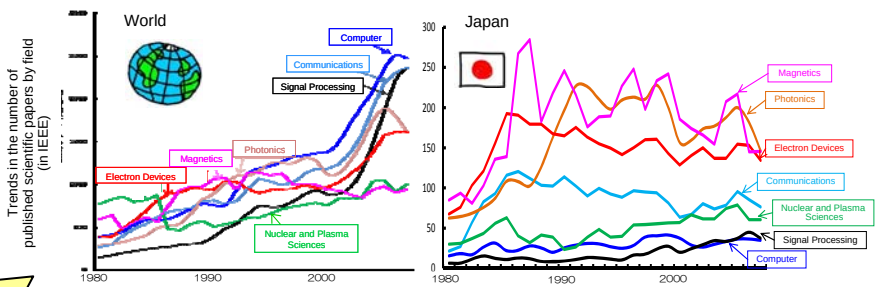
- In Japan, most research accords with traditional academic disciplines, because it does not have mechanisms for interdisciplinary ad hoc initiatives in response to the needs of industry

○ **In Japan**, it seems **that R&D does not respond to changes in the industrial system and social needs**

Looking at numbers of IEEE papers published worldwide,
- 1990s: electronics was the most popular field
- 2000s: Information and telecommunications was the most popular field

However
- electronics is still the most popular field in Japan

Incongruence between R&D development and the changes in the Japanese industrial system



Worldwide, papers in the information and communication field increased rapidly during the 2000s.

In Japan, the number of papers in the electronics and electrical field remained high, and there was no major change in other fields.

< Impediments >

○ **University majors and academic societies are narrowly fragmented in vertically divided fields**, so there are **few opportunities for interaction** with researchers from other fields.

○ **Integrated fields where it is difficult to publish** papers are difficult to evaluate and **have no hope of new budget allocations.**

○ With specialization increasing, **there are few people** who can do mission oriented research and development that gathers knowledge from outside fields.

○ **Some researchers** have little interest in other fields and **do not even see a need for collaboration.** Etc.

< Examples of initiatives needed in order to promote interdisciplinary collaboration and integration >

○**Research in the fields of the social sciences and humanities should be used to understand humans, society, and the economy**

(Building mechanisms for collaboration and integration and venues for interaction)
- **Creation of top down projects** that support mission oriented interdisciplinary collaboration and integration
- **Creation of special programs to encourage** interdisciplinary and integrated research **as a matter of policy**

(Reform of research evaluation and budget allocation mechanisms)
- **Evaluation standards** of integrated research
- **Creation of incentive mechanisms** through special funds

(Human resources development and utilization)
- Development of personnel with perceptiveness regarding society, flexible thinking, comprehensive vision, and a cosmopolitan sensibility
- Implementation of university and graduate school research and educational programs that integrate the natural science with the humanities and social sciences

(Fulfillment of the social responsibility among researchers = Change in thinking)

○ **In order to promote productive innovation**, it is essential to **construct a system that can promptly respond to rapidly changing social needs and issues**

○ **Various policy-related efforts are required**, such as the establishment of a program for **integrated research**, reforms in the research evaluation process and funding system, and cultivation of effective human resources to conduct the integrated research and evaluation.

2 Towards renewing society's trust in science and technology

(1) The development of science and technology accompanied by risks

○ The progress of science and technology along with its deepening relationship with society **creates more complicated problems related to its risks and uncertainties**

○ The policy issues government faces are becoming more complex and highly complicated

Mechanisms to through which scientific advices can be provided need to be developed, and more serious efforts for risk management are necessary

Examples of matters where the risks and uncertainties of science and technology are considered problematic

- Aircraft, railway, and automobile accidents
- Reliability of scientific evidence in courts (unjust accusation based on false DNA test, etc.)
- Drug and vaccine side effects, difficult surgery
- Safety of the development of space technology (rocket launches, etc.)
- Impact of radiation exposure on the human
- Impact of genetically engineered crops on ecosystems and the human
- Safety of nuclear power plants
- Prediction of earthquakes and volcanic eruptions

Etc.

(2) The appropriate system for a new policy making

1) System of providing scientific advice to the government

USA:
Advisors (Assistant to the President for Science and Technology, President's Committee of Advisors on Science and Technology, National Academies, etc.) give advise the government on issues related to science and technology.

UK:
There are Government Chief Scientific Advisors, the Royal Society, etc. (On the occasion of the Fukushima nuclear accident, Scientific Advisory Group was organized and provided with appropriate advice.)

- **Transparency and openness** → The scientific advice should be made publicly available, and scientific advisors are free to publish and present their results
- **Independence and neutrality** → Advisors should be free from political interference. They should avoid conflicts of interest.
- **Separation of scientific advice and policy making** → "Science is only part of the evidence that Government must consider in developing policy."

In Japan

○ **Scientific advice that can appropriately construct integrative knowledge for social responsibility of scientists is needed** (Science Council of Japan, "Reconstruction from the Great East Japan Earthquake and the responsibility of the Science Council of Japan")

○ **Development of mechanisms to appropriately provide experts' scientific advice is necessary** (Expert panel for the promotion of science, technology, and innovation policies)

2) Facing the risks: The necessity of various initiatives on risk

(i) Risk communication

○ A process for stakeholders such as citizens, industry, and government **to build mutual understanding** by sharing **accurate information regarding risks and uncertainties** (including when they are unclear),

→ **It is necessary to gain society's agreement for the application of science and technology which is accompanied by risks**

< Important factors in risk communication >

○ **Fostering trust between senders and recipients** by sincerely **disclosing the limits of current risk assessment** is essential.
○ **The media play an important role** linking the two sides.
○ It is necessary to **improve national risk literacy** through accurate and appropriate risk communication, **so that individuals can take the initiative in the judgment of risks**.

(ii) Promotion of "science for safety" and development of the method for "evaluation of the social impact of advanced technology":
Based on the advice of the Science Council of Japan

a) Science for safety: To evaluated, the risks caused by the application of new technology (food, drugs, environment, etc.)
○ A bridge scientific knowledge for its reflection in regulatory measures when that knowledge is used, etc.
○ Promotion of science that supports the development of the method for risk management and policy making related the safety of the society
→ **Coordination so that the fruits of science and technology can contribute to the public**

b) Evaluation of the social impact of advanced technology
○ Prediction of the various social impacts of advanced technology at an early stage in its development
○ Evaluation of social impact of advanced technology in order to support the discussion and decision making on technology
→ **Increases opportunities for the public to express opinions and participate in debates on science and technology**
→ **Scientists and engineers listen to the demands of society**

The Fourth Science and Technology Basic Plan
○ The national government shall **promote regulatory science** in order to set evaluation guidelines and standards with a basis in scientific rationality with socioeconomic consideration
○ Along with **discussing the suitable system for technology assessment in Japan,**… when making policy decisions, the national government shall promote efforts to **share the results of technology assessments to obtain mutual understanding with the public.**

(iii) Overcoming further issues raised after the disaster
○ Risk communication
(risk awareness depends on one's position)
○ Analysis of the cost benefit performance before the application of new technology
○ **Communication on the occasion of emergencies (crisis communication)**

Even "safety" does not necessarily mean "peace of mind"

Coordination with humanities and social sciences is important

→ Consideration of the roles of **experts, government, journalism**, etc . at usual condition, is necessary.

Including serious problems which appear at emergencies such as Tsunami-tendenko, triage, etc.

While promoting the development of science and technology to overcome various disasters and vulnerabilities, we should strengthen the development of a robust and resilient society that nurtures the dreams and hopes of the people

Column:
Science and technology policy history as seen in the White Paper on Science and Technology: 50 volumes of White Papers

An overview of the White Paper on Science and Technology with socioeconomic changes in Japan during past 50 volumes are provided because this year's publication makes 50 volumes of White Papers on Science and Technology,

Part 2 Measures taken to promote science and technology

○ Summary in accordance with the structure of the Fourth Science and Technology Basic Plan