SCIENCE FOR RESILIENCE

NIED 防災科研

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NIED INTEGRATED REPORT 2021

SCIENCE FOR RESILIENCE

Earthquake, tsunami, volcanoes, violent winds, heavy rains,
snowstorms, floods, and landslides are
natural threats that will always exist.
However, at NIED, we believe that disasters can be reduced.
Therefore, we are constantly developing technologies and strategies
to prepare for and respond to disasters.
With better prediction, smarter prevention, and faster restoration,
we aim to protect lives and livelihoods for a sustainable future.

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NIED's commitment toward our identity.

Disasters caused by natural threats are not only limited to the moment when the disaster occurs, but also have the long-term impacts. In order to sustain Japan into the future, it will be necessary to establish society with resilience for resiliently overcoming disasters. To this end, NIED promotes comprehensive research and development for every kind of natural disaster (all hazards) for each stage (all phases) of before and after occurrence of disaster and pledges to support the lives and livelihoods of all people with our branding identity: "Science for Resilience".

Meaning of the NIED logo

The two blocks in blue and red respectively represent the before and after phases of a disaster, which express NIED's commitment to conduct research and development for all phases of disaster. The blue color used for pre-disaster symbolizes the prediction and prevention of disaster through the accumulation of wisdom. The red color representing post-disaster symbolizes the response and recovery for tackling a disaster with passion. The grey color at bottom represents the research that forms the basis and foundation for creating trust. The white "resilience curve" that runs across from left to right indicates the capability to overcome disasters for a better future.

Co-creating Resilience with Everyone

Since FY2019, NIED has issued Integrated Report to communicate research initiatives and results comprehensibly, get public understanding and set the stage for co-creation.

NIED promotes various types of research to save the nation from catastrophic national crises that are expected to strike in the first half of the 21st Century and achieve sustainable development. Since FY2016, NIED has promoted R&D based on the 4th mid-to-long term plan, which spans seven years, aiming to create a "highly resilient society where each person has a basic level of disaster risk reduction (DRR)."

In the first four years of this plan, NIED focused on research and development based on social needs and a basic structure as a core institute for innovation, focusing on research based on societal needs. In the latter three years from FY2020, we have adopted "co-creation" as a keyword for promoting R&D in science and technology for DRR. In FY2021, "I-Resilience Corporation" was established through joint investment with private companies, and the "research into social wish-discovery" through co-creation and collaboration between industry-academia-government-private sectors was launched. This report will communicate research initiatives and results to provide the impetus for everybody to think and act toward realizing a "highly resilient society where each person has a basic level of disaster risk reduction."

NIED INTEGRATED REPORT 2021

[Fiscal year] April 1, 2021 - March 31, 2022
(including activities and other results after April 2022)

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For detailed reports of NIED's operations, evaluation, and finances, please refer to the following:
https://www.bosai.go.jp/introduction/open/
We welcome your comments and suggestions on this report:
Nied-ir@bosai.go.jp

Promoting “Co-Creation” of science and techn we will work together with all to build a resilie

NIED aims to create innovations in DRR science and technology in collaboration with the private sector, universities and research institutes, municipality and government officials, and citizens. Through co-creation between industry-academia-government-private sectors and NIED, we will promote research and development that will bring about social change and contribute to the realization of a resilient society.

Aiming for trans-disciplinary innovation in science and technology for DRR

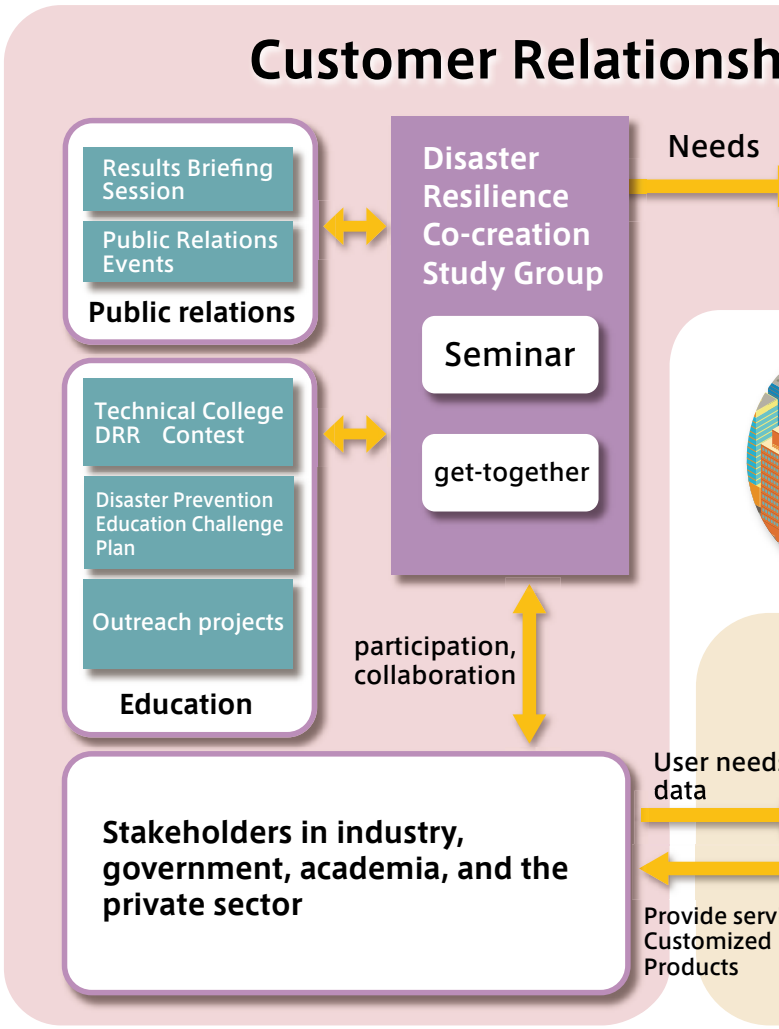
Under its 4th mid-to-long term plan running from FY2016, NIED designated the first four years as the 1st phase and had been building a system for generating research results through conducting “research that meets the actual needs of society” and “effective research that makes changes in a society.” By doing so, NIED has been creating “Information Products” that lead to everyone’s action for DRR.

As part of this, NIED coordinates the “Data use and application council for resilience “(DEKATSU) which aims to develop a system for the use and application of observation equipment and data owned by corporations and other bodies. To further promote these activities during the 2nd phase of the 4th mid-to-long term plan, which had three years left to run, NIED established the” Headquarters of Innovation Co-Creation.”

Realization of a resilient society by promoting co-creation

The field of science and technology for DRR is composed of many academic disciplines and is a domain that strongly requires the implementation of research results into society. “Co-creation” is necessary to make the results of science and technology for DRR utilized and to deliver research results needed by the various stakeholders who make up societies.

NIED, as a “core institute for innovation in science and technology for DRR”, promotes co-creation through the Headquarters of Innovation Co-Creation, headed by the President. While sharing its enormous observational data sets, large-scale experimental facilities, and research results, NIED further strengthens and develops partnerships with collaborating parties in the industry, academia, government, and citizens to promote science and technology innovation for DRR.

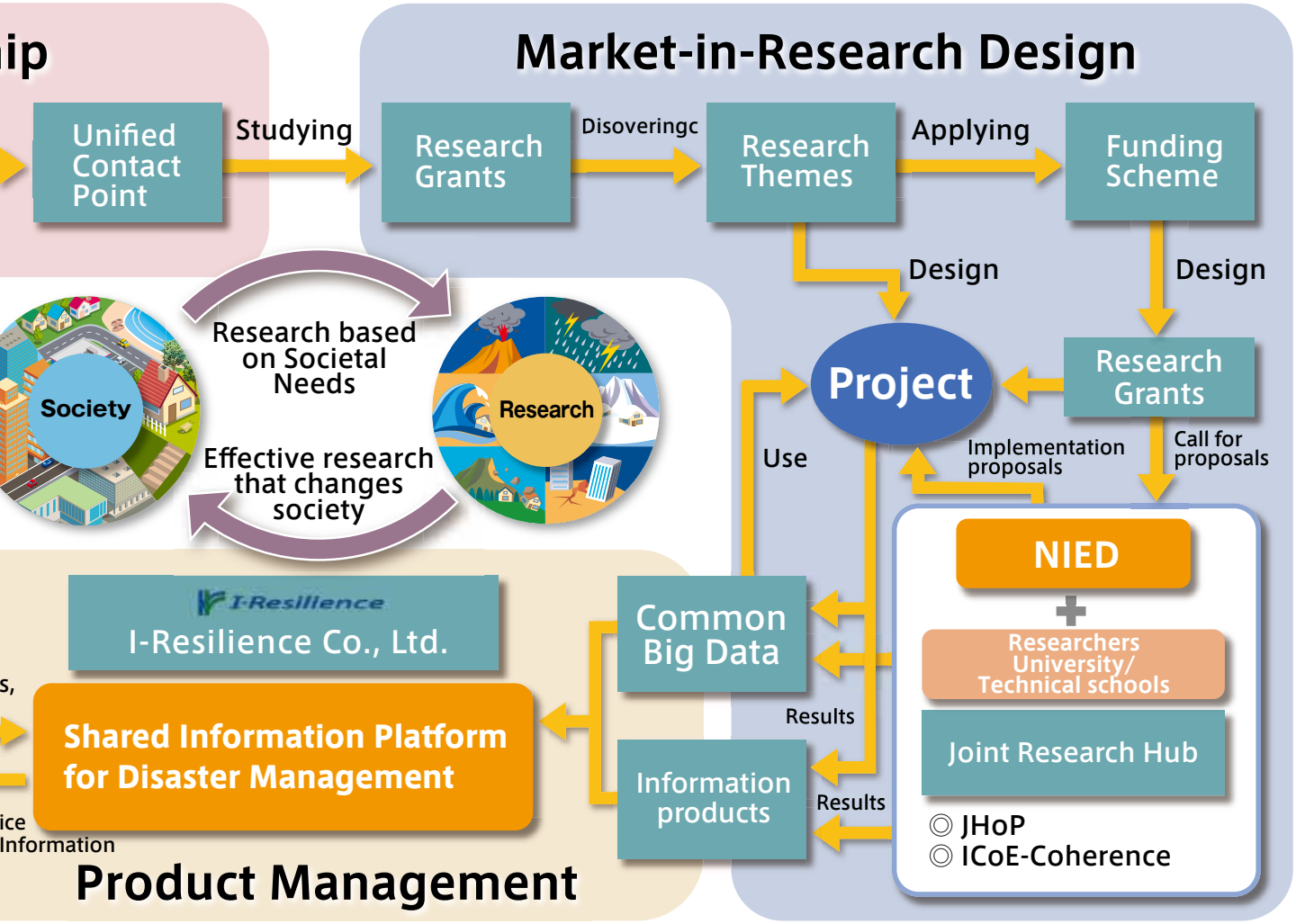


In March 2022, NIED concluded a basic agreement with Tohoku University to promote collaboration and cooperation. Under this basic agreement, both parties have been promoting the formation of an “international academic research center” based on the “consilience” of both institutions, as well as research to improve resilience for accurate prediction of increasingly complex disasters, minimization of the damage, early recovery, and build back better, social implementation, and human resource development to take these initiatives.

Furthermore, as a new initiative of NIED, the “Research Group for Co-Creating Disaster Resilience” was established in April 2022. This group aims to create the seeds for co-creation between industry-academia-government-private sectors to improve disaster resilience, cultivate future growth, improve business continuity management in companies, local governments, and communities, and create new businesses related to DRR. (See also pp. 17-18)

ology for DRR, nt society.

System for Co-Creation sought by NIED



Published the book "Realization of a Resilient Society: Beyond the Imminent National Catastrophic Crises"

NIED and NTT (Nippon Telegraph and Telephone Corporation) established the "Study Group for Creating a Resilient Society" and held a total of five workshops from March 11, 2021, where members discussed how DRR knowledge, science, and technology can contribute to the realization of a "resilient society" that can save the nation from catastrophic national crises. The results of these discussions, which also led to the NIED's ideal vision and the 5th mid-to-long term plan, were compiled into a book and published in April 2022 as "Realization of a Resilient Society: Beyond the Imminent National Catastrophic Crises".

Written and edited by Study Group for Creating a "Resilient Society" + TAKASHIMA Yuya (Novelist, Science Fiction Review)

Established "I-Resilience Corporation" as a joint venture with private companies

The "Act on Vitalizing the Creation of Science, Technology, and Innovation" was revised in 2020 to allow the National Research and Development Agency, such as NIED, to invest in venture companies. Considering this, NIED established "I-Resilience Corporation" in November 2021 in collaboration with private companies to promote the social implementation of research results.

NIED, as a national research institute, is responsible for research, developments, and verification, while I-Resilience Corporation is responsible for social implementation by developing, commercializing, marketing, and providing services based on the research results to meet user needs. In this way, NIED aims to deliver the results of its activities as "information products" that lead to actions by society and businesses sustainably and promptly to meet the needs of stakeholders in the industry, academia, government, and the private sector.

NIED utilizes “Digital Twin” and “Consilience” to meet the new challenges of disaster risk reduction.

Coordination among response organizations is essential as disasters become more widespread.

In these days, natural disasters become more wide spread where the Disaster Relief Act is applied to more than 100 municipalities in a single catastrophe. In the 26 years from 1995 to 2020, the Disaster Relief Act was applied 122 times to 1,858 municipalities. 241 municipalities were affected by the 2011 Great East Japan Earthquake, and 390 municipalities were affected by Typhoon Hagibis (No. 19) in 2019, as compared to 54 municipalities in the 2004 Niigata Chuetsu Earthquake, the most significant number before 2010s. It is Japan’s new DRR challenge how to respond to and overcome such large-scale disasters where multiple prefectures were hit simultaneously.

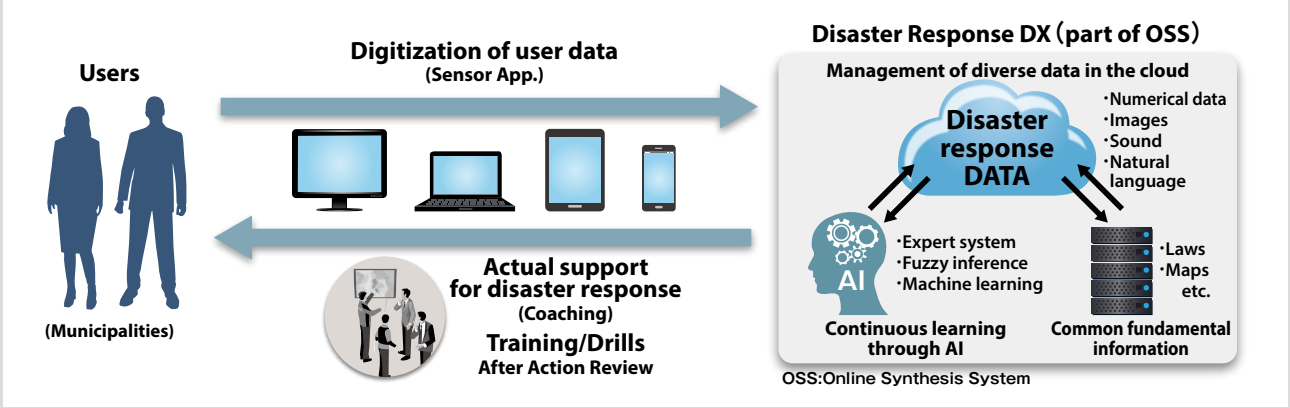
According to the Basic Act on Disaster Control Measures , DRR has been the primary responsibility of municipalities. However, once the Disaster Relief Act is applied to municipalities, the relevant prefectural governors are to take charge of disaster response, and municipalities are responsible for a part of or assistance in disaster response operations. With large-scale disasters hitting multiple prefectures, the national government should take the lead to coordinate the activities of prefectures and municipalities for effective disaster response. In the case of the Nankai Trough Earthquake that is predicted to occur in the first half of this century, where 707 municipalities would be hit simultaneously, it will be necessary to have a system of nationwide coordination to respond to this catastrophic disaster covering a wide area on the Pacific side of western Japan. In this regard, the national government, prefectures, and municipalities must coordinate their respective roles in response to disasters.

Utilizing Digital Twin will Enhance Disaster Response Capabilities of municipalities.

Municipalities are the interface with disaster victims, regardless of the size of the disaster, and their response capacity needs to be enhanced. However, their response vary widely across municipalities in terms of their mechanisms and capabilities. We are trying to resolve these differences through DX.

As a part of the national Disaster Response DX, NIED has established a system to support activities of municipalities, especially those responsible for interfacing with disaster victims, named as the Emergency Response DX. It is a unique point of Emergency Response DX that an ideal disaster response model will be built on a “cloud” where municipalities can participate in this system for responses at the time of real disasters as well as training and exercises. Since amendments in disaster-related laws and regulations are constantly updated in these clouds, time and cost required for municipalities can be drastically reduced.

Disaster response training in a cloud can also contribute to capacity building of people work at municipalities. By utilizing digital twin technology to develop and simulate a high-performance virtual space that can copy reality, it is possible to conduct realistic training for disasters. This digital twin will enable municipalities to continuously improve their disaster response capabilities and serve as a fundamental environment that will open new frontiers in the field of DRR research.



DRR research should be based on "consilience" that integrates natural and social sciences.

Today, "consilience" is positioned as a keyword representing the frontier of DRR research. Traditionally, DRR research has been conducted primarily based on the physical laws of natural phenomena that cause disasters. However, science from the perspective of recovery process from both physical damage and psychological/economic damage should be streamlined to ultimately enhance resilience of our nation.

To understand resilience, knowledge from social sciences is required in addition to natural sciences. In 2020, the Basic Act on Science and Technology was revised and replaced with the Basic Act on Science, Technology and Innovation (promulgated in June 2020 and enforced in April 2021), allowing research on social phenomena together with natural phenomena as science. Since disasters are a mixture of natural and social phenomena, DRR research should be a fusion of natural and social sciences. In other words, DRR science and technology must be based on consilience of DRR.

NIED's mission is to continue to enhance resilience from multiple perspectives.

The main focus of NIED's fourth Mid-to-Long Term Plan is "co-creation" and "Information Products". Regarding "co-creation," we have worked with many stakeholders in many research projects to realize co-creation; starting with the Innovation Hub for Meteorological Disaster Mitigation Project, the Tokyo Metropolitan Resilience Project, the launch of the Headquarters of Innovation Co-Creation in 2020, and the launch of I-Resilience Corporation in 2021 with the investment from NIED. In the area of "Information Products," we have developed a system to provide visualization via internet of comprehensive DRR process; natural phenomena, disaster prevention measures, and disaster response processes. A variety of disaster information was organized based on GIS (Geographic Information System) and mashed up each research result as layers.

NIED mission remains to improve resilience at multiple levels through science and technology innovation with the latest findings and knowledge.

HAYASHI Haruo

HAYASHI Haruo, President
National Research Institute for Earth Science and Disaster Resilience

NIED provides society with “information products” leading to each individual’s actions.

NIED not only observes and analyzes disasters in a scientific and technological manner but also works on research designed to provide society with information products, which lead to the actions of each individual. Our research objects include all types of natural hazards in all phases of disaster prediction, prevention, response, and recovery/reconstruction.

NIED’s value creation model links science with society.

The value that NIED produces is the creation of information products leading to the actions of everyone. The five steps to achieve this are shown in the figure on the right. Data from observation and experiments are modeled (identify and define the characteristics of events) to create information products that will be delivered to stakeholders to lead everyone’s actions.

Using feedback to improve quality.

This value creation model is a system that takes in feedback from behavior to experiments/observation, through which it clarifies issues to be solved in terms of social implementation as well as scientific and technological innovation. This two-way process enhances the quality of the respective steps for resolving these issues.

Definition of “Information Products”

The integration and processing of observation and experimental data, etc., with geospatial information, making it easier to use in accordance with user needs.

“Information Products” is a generic term for value-added information created by combining observation data, experimental data, and other information, as well as systems, information sites, and information services that provide such information, mainly as geospatial information.

NIED promotes the creation and utilization of information products based on the results of its research and development and publishes on the web those products that contribute to the creation of scientific and technological innovations and to the solution of social issues. NIED has also established an “Information Products Policy” for the provision of information products to external organizations and for the creation, provision, and distribution of information products that process data and information from external organizations.

Examples of NIED’s information products

bosai Xview

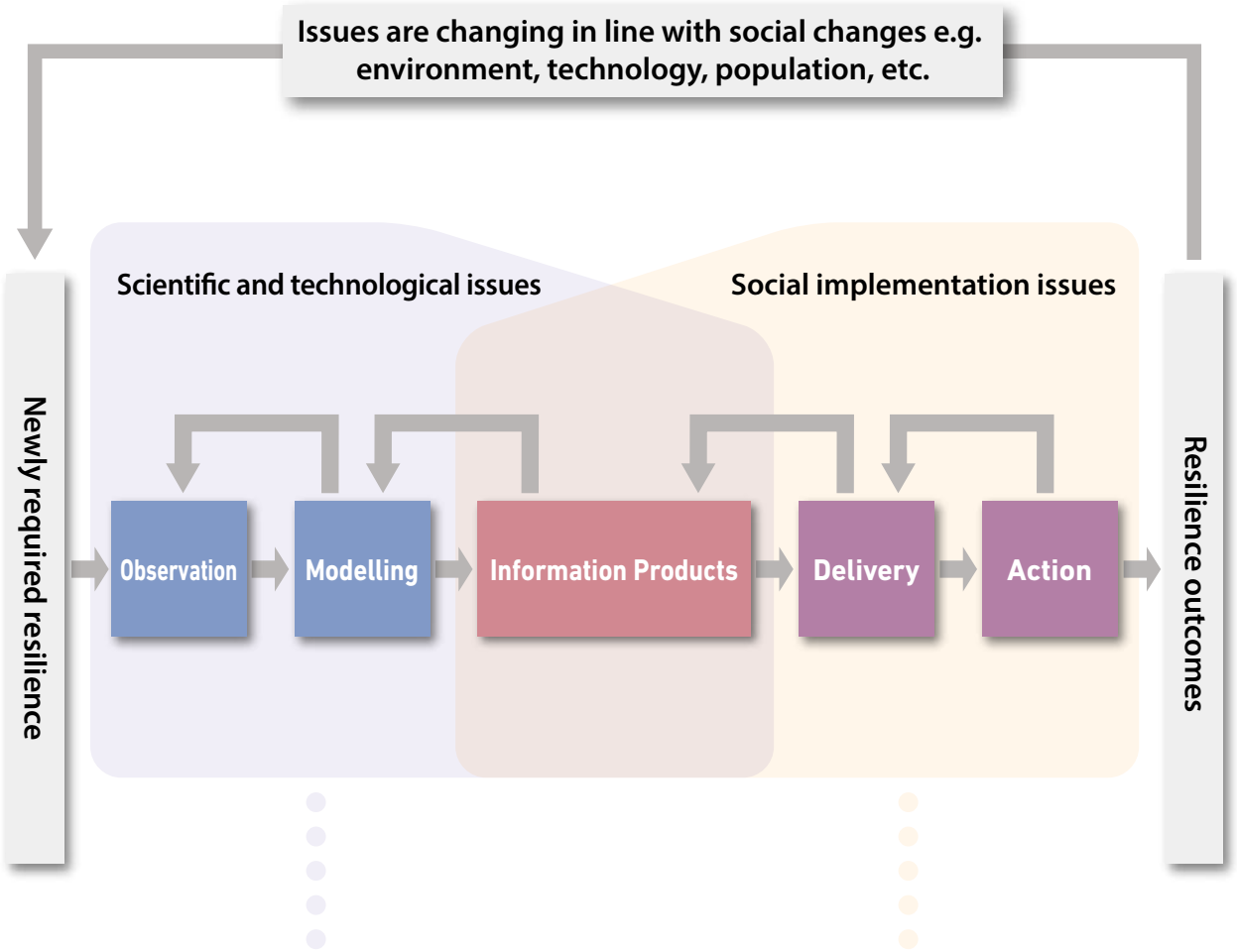
Bosai Xview

Bosai Xview Bosai (pronounced “bosai cross view” is a system that looks beyond (view) a disaster by overlaying (cross) all disaster information, including occurrence, progress, recovery, past records, and future projections.
https://xview.bosai.go.jp/

雪おろシグナル Snow Load Alert

YukioroSignal (Snow Load Alert)

“YukioroSignal” (Snow Load Alert), which shows the distribution of snow weight on a map to help people make decisions about removing snow from roofs. It has been developed to help reduce accidents during roof snow removal, which causes casualties every year.
https://seppyo.bosai.go.jp/snow-weight-japan/



Scientific and technological issues

Comprehensive research on "all hazards × all phases".

NIED is a unique organization in the world that conducts comprehensive research across all phases from prediction and prevention to response and recovery encompassing all natural hazards. We implement a wide range of R&D to create high-quality information products by combining natural science, engineering, and social science, for example, an observation network for earthquakes, tsunamis, and volcanoes, Monitoring of Waves on Land and Seafloor (MOWLAS) that covers all land in Japan, and the Shared Information Platform for Disaster Management (SIP4D), a platform that can deliver disaster information between the government, municipalities, private companies, and the others.

Social implementation issues

Providing information products for appropriate "actions".

Providing information products for appropriate "actions". For information products to lead to "action" for overcoming disasters, it is vital to clarify user needs. It is also necessary to ensure that such information products are utilized by users. Therefore, NIED is engaged in R&D for creating high-quality information products that support decision-making at the site of disaster as well as their delivery methods.

NIED implements nine initiatives regarding technology for DRR to realize a society with

As a National Research and Development Agency, NIED, leading Japan in science and technology for disaster risk reduction (DRR), is required to maximize the R&D results, i.e. realization of "a society with high resilience by empowering each individual to have basic ability of DRR".
In the 4th mid-to-long-term plan, we established the following two objectives to promote the actualization of the value creation model.

Activities as a core institute for innovation

NIED plays a core role to implement six initiatives to realize the value creation model in cooperation with diverse organizations such as the governments, municipalities, private companies, universities, and research institutes.

Promotion of co-creation by industry, government, academia, and the private sector

As a core institute for science and technology for DRR, NIED is promoting cooperation with municipalities and private companies (such as infrastructure companies with needs for reducing disaster damage and securing business continuity) on disaster risk reduction and mitigation.

Dissemination of Research Results/Application of Intellectual Properties

By investigating the needs of governments and municipalities on DRR, NIED implements initiatives to reflect these needs in R&D. We are also committed to effective information delivery of our research results and acquisition and licensing of high-quality patent rights.

Promotion of basic research and fundamental R&D

As a driving force for innovation, NIED promotes observation research on hazards, experimental research using world's largest class facilities, and empirical research toward the disaster response and recovery/reconstruction, as well as R&D on technologies to become the nucleus for simulation that integrates the above-mentioned research activities and utilization of the information.

Observation and Prediction of Disasters

We are conducting strategic advanced research for earthquake and tsunami prediction technology, research on mega-earthquake generation process, and research regarding multi-disciplinary evaluation of volcanic activities.

science and high resilience.

4th Mid-to-Long Term Plan [From FY 2016 to FY 2022]

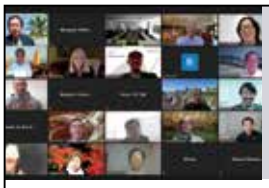
This IR Report mainly introduces best practices of NIED for "strengthening of function as a core institute for innovation in science and technology for DRR". For more details regarding "Promoting basic research and foundational R&D regarding science and technology for disaster resilience", please refer to NIED's brochure (https://www.bosai.go.jp/ introduction/abstract.html) * Japanese only

Fundamental Observation Network, Advanced Research Facilities, Information Distribution Infrastructure

NIED maintains establishment/stable operation of the fundamental observation network and effective/efficient and safe operation of the advanced research facilities. In addition, we construct information platform regarding science and technology for DRR and disaster information, and promote sharing it with external research institutes including industries.

Contribution to Disaster Management Practice at National Government

As a designated public corporation according to the Basic Act on Disaster Management, after a disaster has occurred, NIED delivers information promptly based on science and technology for DRR to relevant organizations, provides assistance at the disaster site, and strengthens cooperation with the government and municipalities.



International Collaboration

As a core institute for innovation in science and technology for DRR of Japan, NIED promotes joint research with foreign organizations and international cooperation through the delivery of information. In light of international needs, we will pursue overseas deployment of Japan's science and technology for DRR.

Human Resource Development

To contribute to the improvement of entire nation's DRR literacy and to the securing of safety and security, NIED promotes researchers and works on municipalities, school education and leaders of local disaster management teams to support fostering of wide range of human resources and enhancing their qualifications.

Reduction of Disaster Risk

NIED conducts development of prediction technologies for water-related disasters based on multi-sensing, combined research on grasping degree of risk for changing snow and ice disasters and their whole area prediction, research regarding hazard risk assessment, and research regarding disaster countermeasures based on utilization of information.

Enhancement of the Resilience of Social Infrastructures

NIED conducts earthquake disaster mitigation research using research infrastructure as 3-D Full-Scale Earthquake Testing Facility "E-Defense".

TOP PRACTICE REPORT

Activities as a core institute for innovation

“Co-creation” evolves disaster risk reduction.

TOP PRACTICE REPORT

Activities as a core institute for innovation

As initiatives based on the 4th mid-to-long term plan, this section introduces specific application results for information products generated through the value creation model, as well as initiatives for co-creation.

TOP PRACTICE REPORT 01

Promotion of co-creation between industry-academia-government-private sectors

NIED promotes research into social wish discovery based on co-creating diverse organizations and disciplines.

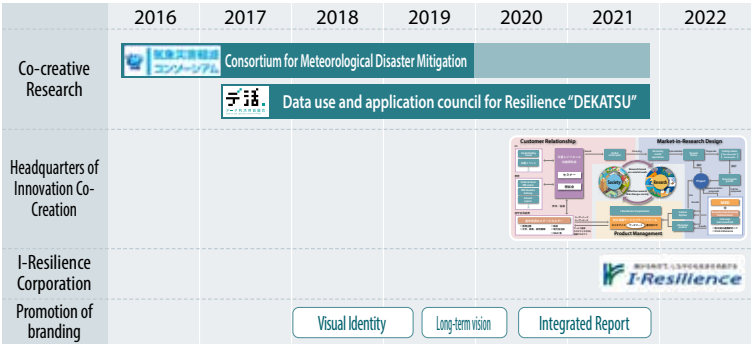
Collaboration across organizations and research fields is indispensable to foresee future large-scale national-level disasters and to protect people's lives. NIED promotes co-creation between industry-academia-government-private sectors and fosters research into social wish discovery that will bring innovation to disaster risk reduction (DRR) in Japan.
Discover society's latent needs for science and technology while keeping abreast of changes in the social and natural environment.

"Discover society's latent needs for science and technology while keeping abreast of changes in the social and natural environment."

Co-creation to improve disaster resilience.

NIED, as a core institute for innovation in DRR science and technology in Japan, shares its vast amount of observational data, large experimental facilities, and outstanding research results in the field of DRR science and technology while further strengthening and developing partnerships with industry, academia, government, and private sector stakeholders to promote innovation in DRR science and technology. -The NIED is promoting "co-creation" by establishing a system to continuously promote innovations in disaster prevention science and technology by further strengthening and developing partnerships with industry, academia, and the private sector.Specific examples include the Consortium for Meteorological Disaster Mitigation which was implemented from 2016 to 2020, and "DEKATSU" (Data use and application council for Resilience "DEKATSU"), which discusses issues that should be addressed to strengthen the resilience of the metropolitan area and Japan. Also, in 2020, it established the Headquarters of Innovation Co-Creation and has been working on a variety of initiatives, including the promotion of branding, such as establishing an identity to promote co-creation and investing in "I-Resilience Corporation," a corporate joint venture which provides information products and services related to DRR.

Progress of the Promotion of Co-Creation



Bottom-up innovation through inter-organizational and inter-disciplinary collaboration.

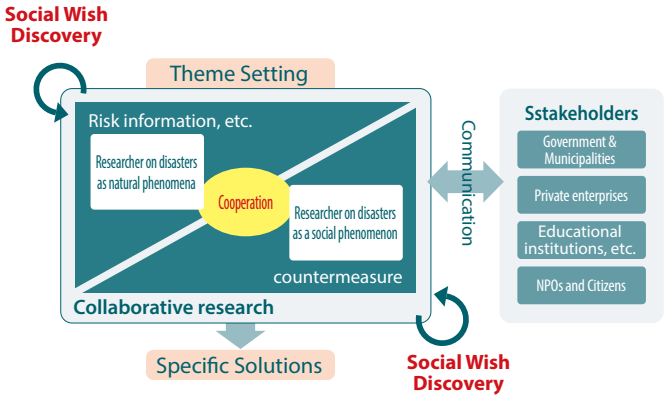
DRR science and technology is a field in which research results are strongly required to contribute to society. To achieve results, it is necessary to know the community itself well and to provide research results that are truly desired by the various stakeholders that make up society. For this reason, NIED has launched the " Research into Social Wish-Discovery for Improving Disaster Resilience," an open, collaborative research project to identify the "social wishes" that society truly needs to create and effectively utilize science and technology to improve society's resilience against disasters in FY2021.

Social wishes are the latent needs of society that lie behind the needs of individuals and individual companies and organizations. Once the actual needs of the people who make up society are clarified, this will guide research to create and effectively utilize superior science and technology to help reduce disaster risk.

To create science and valuable technology for DRR, knowledge of disasters' natural and social aspects is indispensable. Thus, approaches from both the natural sciences and the humanities/social sciences play an important role. Therefore, in this project, researchers who view disasters as "natural" phenomena and those who view them as "social" phenomena will team up and will not be limited to the knowledge and technologies of NIED but will also include researchers from universities, other research institutes, technical colleges, private companies, and other organizations.

Research into social wish discovery through public solicitation

Each research team has gained new insights through needs assessments, and some groups use the results as a springboard to move on to the following research phase. Team building across disciplines and organizations is a catalyst for new co-creation. NIED is working to create an environment for co-creation in this way and is promoting research that has the potential to bring about bottom-up innovation in the field of DRR.



Research into social wish-discovery for improving disaster resilience 2021 List of adopted projects

1	Geospatial Information System for Epidemiology Overlaid with Disaster-Related Information to Improve Resilience in the COVID-19 Pandemic (Principal Investigator: KITAJIMA Masaaki, Division of Environmental Engineering, Faculty of Engineering, Hokkaido University)	2	Development of an interactive system to check and improve the effectiveness of business continuity plans for small and medium enterprises (Principal Investigator: KOYAMA Maki, River Basin Research Center, Gifu University)
3	Prediction of the Mental Health Support Needs among Residents in the Area affected by Large-Scale Flooding (Principal Investigator: TOMITA Hiroaki, Department of Disaster Psychiatry, International Research Institute of Disaster Science, Tohoku University)	4	Verification of the Effectiveness of Supply-demand Adjustment Using Information on Damage Forecasts of Weather Disasters in Open Field Vegetables (Principal Investigator: SUGAHARA Koji, National Agriculture and Food Research Organization, Institute of Vegetable and Floriculture Science)
5	Problem-solving practical research on social implementation of school evacuation and security planning (Principal Investigator: SATO Takeshi, International Research Institute of Disaster Science, Tohoku University)	6	CPS4D Verification of decision-making support for imminent disasters using information products (Principal investigator: NAGATA Shozo, Faculty of Social Safety, Kansai University)
7	Research on effective use of real-time disaster information to mitigate damage to small and medium enterprises (Principal Investigator: NISHIKAWA Satoru, Disaster Mitigation Research Center, Nagoya University)	8	Application and improvement of online hazard map to private school shelter area in Shinjuku (Principal Investigator: TSUBOUCHI Akiko, Biomedical Research Core Facilities, Juntendo University Graduate School of Medicine)
9	Appropriate residential land selection behavior Research into social wish-discovery expectations regarding the use of disaster hazard maps (Principal Investigator: TADA Yutaka, Department of Creative Technology Engineering, Anan National College of Technology)	10	Social scientific research and study for social implementation of snow sliding coating technology for safe, secure, and comfortable living (Principal investigator: KAMIJO Toshio, Tsuruoka National College of Technology, Department of Creative Engineering)

Proposals adopted in FY2021: Case Study 1

Verification of the Effectiveness of Supply-demand Adjustment Using Information on Damage Forecasts of Weather Disasters in Open Field Vegetables

- **Principal Investigator: SUGAHARA Koji**
  (National Agriculture and Food Research Organization, Institute of Vegetable and Floriculture Science)
- **NIED's collaborators**
  BORJIGIN Habura (Disaster Information Research Division) ,
  TAGUCHI Hitoshi (Disaster Information Research Division)

In order to stabilize the balance between supply and demand of open-field vegetables, we examined the effectiveness of using information on forecasted damage from weather disasters in adjusting supply and demand. Open-field vegetables such as cabbage and lettuce are easily affected by weather and have the problem that the balance between demand and supply is easily disrupted. For this reason, the National Agriculture and Food Research Organization (NARO) has been developing a "precise production forecasting system" using weather data so that producers and buyers of open-field vegetables can adjust supply and demand in advance to stabilize their production. However, the system has not yet provided a disaster response for estimating and forecasting damage caused by sudden weather disasters. Therefore, we devised a method to evaluate and predict damage to open-air vegetables caused by weather disasters (especially flooding damage) by linking with the "damage situation analysis and sharing system" based on observation data from satellites, Etc., developed by the NIED DRR, and hypothesized that "if the damage situation of open-air vegetables is known approximately one month before the shipping time, it may be possible to adjust the supply and demand of production quantities in advance. Based on the hypothesis that "if the status of damage to open field vegetables is known approximately one month before the shipping season, it may be possible to adjust the supply and demand of shipments in advance," interviews were conducted with producers and buyers to verify the economic effects of reducing damage risks. Based on the interviews, if buyers could obtain information on the estimated yield loss of the affected production area at least one month before the scheduled shipment, they could use the lead time to procure most of the demand from other production areas and significantly reduce sales loss. With forecast information available at least two weeks in advance, it is possible to procure up to half of the volume demanded. Based on the results of this study, efforts are currently underway to develop a practical shipment forecasting system that incorporates information on damage forecasts from weather disasters.

Proposals adopted in FY2021: Case Study 2

Appropriate residential land selection behavior Research into social wish-discovery regarding the use of disaster hazard maps

- **Principal Investigator: TADA Yutaka**
  (Department of Creative Technology Engineering, Anan National College of Technology)
- **NIED's collaborators**
  SHIOZAKI Yuto (Disaster Resilience Research Division),
  SUZUKI Shingo (Disaster Resilience Research Division)

We have organized the basic concept of hazard maps so that consumers can select and purchase residential land appropriately based on comprehensive disaster risk information. When concluding a contract for the purchase or sale of residential land, building lot and building traders are required to explain flood risks in advance using flood hazard maps. However, the current flood hazard maps are based on the assumption that they are to be used in the event of a disaster (evacuation behavior) and indicate the maximum expected depth of inundation, so they do not provide sufficient information for consumers and building lot and building traders to use them in selecting residential land. Therefore, we investigated the actual situation through questionnaires and interviews with consumers and building lots and building traders, and found the following: - Safety assessment of residential areas is not consistent among building lots and building traders even if the depth of inundation is the same; - Consumers cannot accurately assess safety based on flood hazard map inundation depth alone, and cannot establish correct evacuation routes in the event of a disaster; - Consumers are not aware that flood hazard map inundation depth is not sufficient to assess the safety of residential areas; and - Consumers are not aware that flood hazard map inundation depth is not sufficient to assess the safety of residential areas. Consumers do not evaluate safety based on inundation depth but on the cost of the residential area (safer = more expensive), etc. Based on these results, we have developed a basic concept for using hazard maps in selecting a residential area. Based on the needs identified by the survey, we are currently working on a prototype application that can be effectively used for residential land selection.

TOP PRACTICE REPORT 02

Fundamental Observation Networks

The use of data from fundamental observation networks that provide real-time earthquake and tsunami information is expanding.

The observation network "MOWLAS*1" is deployed over land and sea areas throughout Japan to report the occurrence of earthquakes and tsunamis as soon as possible. The data from this observation network, which captures earthquakes and tsunamis that affect the Japanese archipelago, including the anticipated Nankai Trough Earthquake, is widely used by the government, municipalities, private companies, and other organizations.

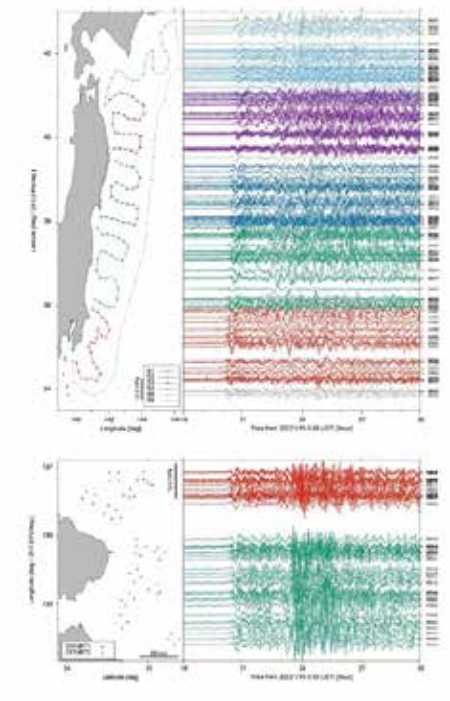
*1: Monitoring of Waves on Land and Seafloor

NIED's observation networks observed ocean bottom pressure changes during the Tonga eruption.

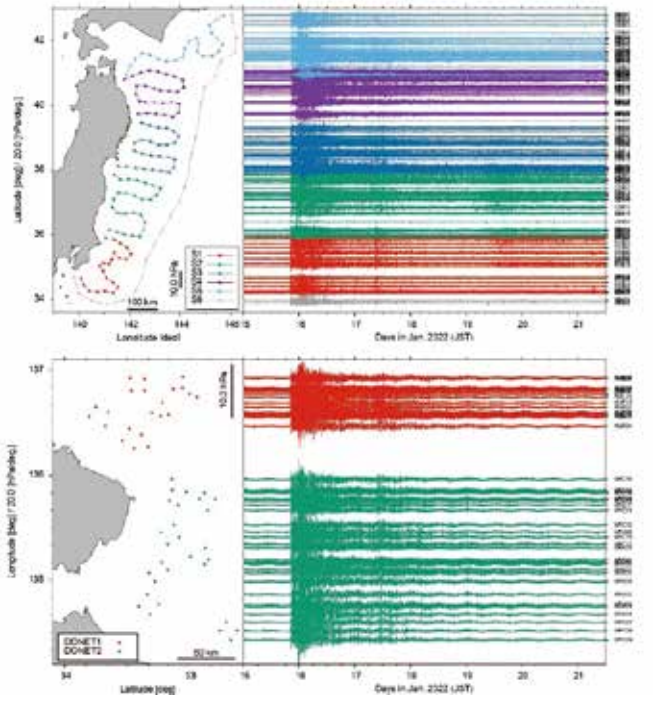
On January 15, 2022, at around 1:00 pm (Japan time), a large-scale eruption occurred at the Hunga Tonga-Hunga Ha'apai volcano near the Tonga Islands (according to Japan Meteorological Agency). The eruption caused an ocean bottom pressure disturbance on the seafloor, which was captured by NIED's seafloor observation networks, S-net (Seafloor observation network for earthquakes and tsunamis along the Japan Trench) and DONET (Dense Oceanfloor Network System for Earthquakes and Tsunamis).

This ocean bottom pressure disturbance was observed by the ocean bottom pressure gauges at all the observation stations of S-net and DONET from after 8:00 pm on the same day of the eruption, and it was observed that the arrival time was earlier in the southern area, that there was an ocean bottom pressure disturbance with a shorter period than the initial movement at around 11:00 pm, and that the ocean bottom pressure disturbance was caused by atmospheric pressure changes that circled the earth on the 17th. These ocean bottom pressure disturbances continued from January 20 to 21, and the maximum observed ocean bottom pressure disturbance was about a dozen hPa (single amplitude).

Tsunamis are generated not only by earthquakes in coastal areas but also by earthquakes and eruptions in remote areas. Fundamental observation networks are highly useful in understanding such unique events through real-time continuous observation, leading to the advancement of earthquake and tsunami DRR and academic research.



Records of ocean observation network pressure gauge and maps of observation stations for 12 hours from 6:00 pm on January 15 (including observation stations for which no data were used). Bandpass filter of 120-1800 sec is applied to all of them. Colors are changed for each subsystem.
(Upper) S-net (Lower) DONET



Overall view of ocean bottom pressure change and map of observation stations (including some observation stations for which data were not used). Both with 120-1800 sec bandpass filter applied. The horizontal axis is the date, indicating that it took about 5 days to return to the original noise level.
(Upper) S-net (Lower) DONET

Use of MOWLAS observation data and related information products is expanding year by year to various stakeholders.

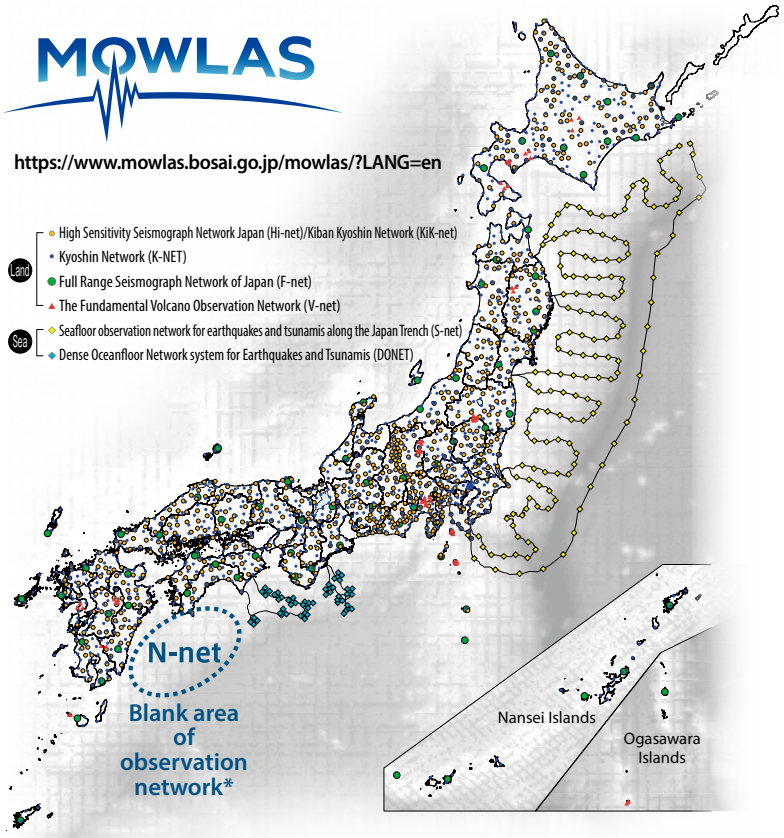
For general public
Through its "Kyoshin Monitor", NIED transmits information on current seismic shaking in Japan observed by MOWLAS. This information is also sent out on Yahoo! JAPAN and "MDA Situational Indication Linkages", a system for displaying various maritime conditions operated by the Japan Coast Guard.

For private companies
Railroad operators, telecommunication companies, electric power companies, etc. use the observation data, and the NPO Japanese Geopark Network has been providing the "NIED Quake map!" and "NIED Quake monitor!" to monitor seismic activity in your neighborhood.

For government institutions
Observation data is utilized as the basic data for creating the "National Seismic Hazard Maps for Japan" by the Headquarters for Earthquake Research Promotion. It is also used by the JMA for earthquake early warnings, tsunami information, seismic intensity information, hypocenter determination and volcanic observation. In March 2020, data from S6 (sub-system installed to the east of the Japan Trench) was added, which marked the start of the application of observation data for the whole of S-net.

For municipalities
NIED transmits data from seafloor observation networks to Wakayama/Mie/Chiba Prefectures, to allow immediate tsunami prediction.

For Researchers
NIED contributes to greater understanding of seismic/tsunami/phenomena and volcanic activity.



*Nankai Trough Seafloor Observation Network for Earthquakes and Tsunamis (N-net) is under construction in the ocean area (off Kochi Prefecture to Hyuga-nada) where no observation network has been established in the anticipated seismic source region of the Nankai Trough Earthquake.

From our stakeholders — **Joint development of Shinkansen train earthquake early detection system using ocean seismographs.**

Dr. SUZUKI Hiroto
Disaster Prevention Research Laboratory,
JR East Research and Development Center,
East Japan Railway Company

For the Shinkansen train, which runs at high speed, one of the most important safety measures is to decelerate and stop the train as quickly as possible in the event of an earthquake. On the JR East Japan Railway Company's shinkansen train, we have installed our own seismographs along the tracks, inland, and in coastal areas such as the Pacific Ocean. We have also developed and implemented early detection method for earthquakes that may cause damage to trains and structures.

Starting in November 2017, we have introduced observation information from S-net operated by NIED into our Shinkansen Early Earthquake Detection System in step-by-step manner, in addition to observation information from our own seismographs. This has further enhanced the speed of earthquake detection and the safety of the Shinkansen train by using ocean seismographs to quickly detect earthquakes that occurred under the Pacific Ocean floor between Kanto and Hokkaido, and promptly decelerate and stop the Shinkansen trains. In fact, there have been cases where the use of S-net has reduced the time required to detect earthquakes compared to using only our own seismographs, which has helped to ensure the safe operation of Shinkansen trains.

It is difficult for a single private company to install seismographs to the ocean floor, and we believe that it is one of our missions as railroad specialists to utilize DRR information from outside the company, such as this case, for safe operation of the railroad.

TOP PRACTICE REPORT 03

Advanced Research Facilities

Promotion of industry-academia-government cooperation and co-creating through the use of experimental facilities that realistically reproduce hazards.

For research and development of DRR for large-scale disasters, experiments that realistically reproduce hazards are indispensable. NIED has one of the largest experimental facilities in the world. As a user-oriented and open facility, we are committed to the development of DRR science and technology through collaboration and co-creation between industry-academia-government by promoting the utilization of the facilities.

Reproduction of museum exhibition facilities

Public experiments were conducted on the functional maintenance performance of indoor spaces.

In FY2021, E-Defense conducted two series of open experiments on "functional maintenance performance in indoor spaces": the first series reproduced a museum exhibition facility in collaboration with the National Institutes for Cultural Heritage and the Tokyo National Museum; the second series reproduced an office space, a residential space, and a server floor space. The earthquake ground motions used in the experiments were simulated based on the assumption of a M7-class earthquake directly under Tokyo Bay, and earthquake data obtained from MeSO-net, an earthquake observation network deployed at approximately 300 locations in the Tokyo metropolitan area. The experimental results will be used to establish and standardize a verification system for functional maintenance performance.

Miki (Hyogo)

Reproducing all kinds of seismic motion in 3-D [E-Defense] (3-D Full-Scale Earthquake Testing Facility)

The world's largest experimental facility (shaking table 20m x 15m)can reproduce the ground motions such as the Great Hanshin-Awaji Earthquake and Great East Japan Earthquake of intensity 7 . Capable of realistically reproducing seismic motion including long-period ground motion and huge motion induced by near-field earthquake, E-Defense is utilized to evaluate seismic performance of residential houses and industrial infrastructures and to verify countermeasure technologies.

https://www.bosai.go.jp/e/facilities/edefense.html

[Number of contracts in FY2021: 6]

Large-scale shaking table test on seismic reinforcement of joints along water pipeline (Taisei Kiko Co., Ltd. etc.)

Performance can be verified in a one-of-a-kind experimental facility that can realistically reproduce hazards.

Reproduction and observation of "extreme conditions" caused by hazards are essential for research and development of DRR science and technology. NIED has one of the world's largest experimental facilities for advanced research facilities for earthquakes, heavy rainfall, and snow and ice. Through the observation of realistic data that cannot be obtained in smaller facilities, we promote co-creation between industry, academia, and government, as well as utilization by private companies and manufacturers. Center for Advanced Research Facility was established to promote user-oriented utilization of experimental facilities and to implement science and technology in society through standardization of methods for evaluating the performance of buildings and other structures.

Tsukuba (Ibaraki)

Generating realistic heavy rain. [Large-scale Rainfall Simulator]

This rainfall experimental facility has one of the largest surface areas for sprinkling water in the world. The facility can control rain from misty rain to torrential rain of 300 mm per hour in 10-minute increments, and is widely utilized by both government organizations and private companies for research on landslides and flooding, as well as for verification experiments using drones and automated driving technologies.

https://www.bosai.go.jp/e/facilities/rainfall.html

[Number of contracts in FY2021: 8]

Research on the improvement of external sensing systems for the creation of autonomous vehicles that can operate during disasters toward the establishment of a resilient society (TIER IV, Inc., etc.)

Tsukuba (Ibaraki)

Verifying seismic performance of full-scale structures [Large-scale Earthquake Simulator]

This large-scale facility is used not only for academic research, but also for various full-scale seismic experiments on houses, water tanks, and others using the world-leading large-scale 1D shaking table (14.5m x 15m). It is possible to ascertain the damage that would be caused by an earthquake on the scale of the Great Hanshin-Awaji Earthquake.

https://www.bosai.go.jp/e/facilities/earthquake.html

[Number of contracts in FY2021: 8]

Research on evaluation of seismic response of wooden frame houses with sliding foundations Tokyo University of Science, etc. *New applications are not currently being accepted.

Shinjo (Yamagata)

Reproducing near natural snow crystals [Cryospheric Environment Simulator]

The only experimental facility in the world capable of reproducing near natural crystal shaped snow even in mid-summer. We elucidate snow and ice phenomena, and verify the effectiveness of disaster countermeasures regarding roof snow, snow accretion, blizzards, and avalanches.

https://www.bosai.go.jp/e/facilities/environment.html

[Number of contracts in FY2021: 17]

Evaluation of snow accretion characteristics on electric wire (Central Research Institute of Electric Power Industry, etc.)

From our stakeholders **Verifying drone safety in adverse weather conditions in a full-scale experiment.**

Dr. NAKABO Yoshihiro

Team Leader,
Dependable Systems Research Team,
Industrial CPS Research Center,
National Institute of Advanced
Industrial Science and Technology

Today, automation and autonomy such as robotization, are advancing in all industrial fields, but safety is an issue that needs to be addressed when these technologies are implemented in society. The Dependable Team studies evaluation, standards, and performance verification methods for such systems, and is working on the verification of IoT sensors in and automated driving and drones under adverse weather conditions using Large-scale Rainfall Simulator.

In recent years, torrential rains occur frequently. In order to evaluate the function of the drone's onboard sensors in such an environment, it is highly effective to have a large facility that is large enough to actually fly the drone and reproduce various types of rainfall. In addition, I believe that this collaboration is very meaningful because we will be able to obtain knowledge from weather experts at NIED during the experiment, and because drones are expected to be used during disasters. The knowledge gained from this experiment will be used to standardize drone testing and evaluation methods. I would also like to actively engage in joint research with the NIED, which will be triggered by the new findings.

TOP PRACTICE REPORT 04

Information Distribution Infrastructure

Realization of prompt and effective disaster management by sharing and using information beyond the framework of organizations.

During disasters, a wide variety of information is shared, including the extent of damage, evacuation status, recovery support situation, and analysis results of observational data from each organization collected by the government, municipalities, and infrastructure companies. NIED has formulated a system for aggregating information that transcends the boundaries of agencies and organizations, and for sharing it in an easy-to-use form.

With the revision of Basic Plan for Disaster Risk Reduction, SIP4D was incorporated into this plan.

On May 25, 2021, the Basic Plan for Disaster Risk Reduction established by the government was revised, and in addition to the Information Support Team (ISUT), the use of SIP4D (Shared Information Platform for Disaster Management) was specified in the Basic Plan for Disaster Risk Reduction.

SIP4D is a system that collects information necessary for disaster response from various sources, converts it into an easy-to-use format that can be shared appropriately by related organizations, and provides it quickly. In FY2020, a demonstration of the conjunction between prefectures and SIP4D was carried out. In FY2021, many prefectures began to study and develop SIP4D conjunction, and in the heavy rain events in August of the same year, evacuation center information was directly shared from prefectural disaster management information systems that had already been connected to SIP4D and provided to the disaster site as integrated information.

SIP4D has been adopted as a national disaster response system for social implementation. In the future, further efforts will be made to develop an integrated disaster management information system for the Cabinet Office and a data infrastructure and system for the entire country by the Digital Agency. In addition, SIP4D won the R&D 100 Awards, referred to as the "Academy Awards of Innovation," in 2021.

Basic Plan for Disaster Risk Reduction describes the use of SIP4D and ISUT.

Part 2: Management common to each disaster
Chapter I: Disaster prevention
Section 6: Preparation for prompt and smooth disaster emergency response and recovery/rehabilitation.

2. Collection and communication of information and development of an emergency response system

In order to share information, the national government (including the Cabinet Office), public organizations, and municipalities shall strive to aggregate DRR information that should be shared across all institutions into a common system (Integrated Disaster Management Information System) and SIP4D (Shared Information Platform for Disaster Management).

Chapter II: Disaster emergency measures
Section 2: Collection and communication of information and establishment of activities system

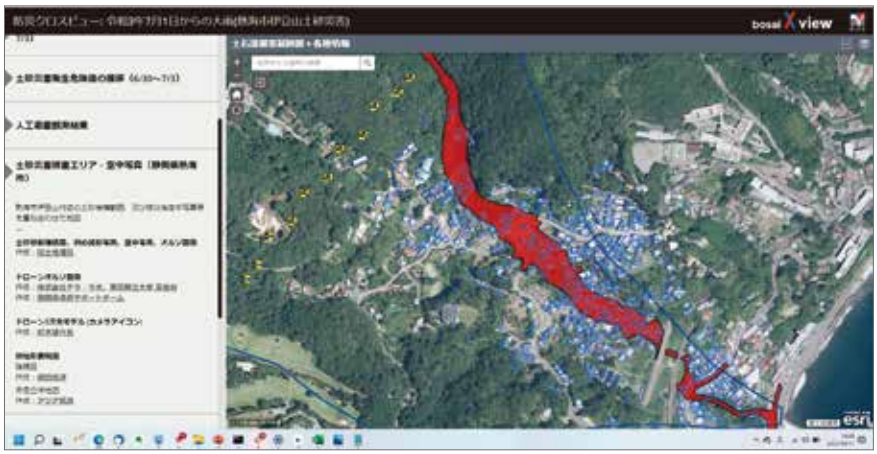
6. Activities system of the country

(3) Dispatch of staff
In the event that large-scale damage is anticipated, the national government [(including the Cabinet Office) shall immediately dispatch a Cabinet Office survey team by helicopter, etc., as necessary, to promptly grasp the extent of damage and provide support to the affected municipalities. At that time, the national government (Cabinet Office) shall dispatch ISUT (Information Support Team) consisting of the national government (Cabinet Office) and National Research Institute for Earth Science and Disaster Resilience, etc., to assist municipalities in disaster response by using SIP4D to collect and organize disaster information and provide it on a map. When dispatching staff, the health management of dispatched staff and the wearing of masks, etc., should be thoroughly implemented.

NIED is enhancing real-time delivery of information via “bosaiXview”.

NIED operates "bosaiXview” (pronounced “bosai cross view”), which provides information on hazards and risks, forecasts and estimates, disaster occurrence, recovery status, and past disaster records in an overlaid form when there is a threat of a disaster or when a disaster occurs (the site was renamed from NIED Crisis Response Site in 2021). As of March 31, 2022, 39 sites (10 for earthquakes, 21 for wind and flood disasters, 6 for volcanic eruptions, and 2 for snow and ice disasters) had been established. We are studying the possibility of detecting the occurrence of disasters by mashing up (superimposing) a wide variety of disaster-related information on a map and expressing it as a disaster dynamic that combines natural dynamics with social dynamics.

In 2021, NIED opened “bosaiXview” for the landslide disaster in Atami-city, Shizuoka, caused by heavy rainfall from July 1, heavy rainfall in August, and volcanic activity at Mt. Aso.



Aerial view of the area of landslide damage near Mt. Izu, Atami, Shizuoka, caused by heavy rainfall since July 1, 2021. Combination of the extent of sediment accumulation near Mt. Izu, and post-disaster aerial photographs.
© NTT InfraNet

This chart shows the estimated population and number of buildings in the inundation area after the heavy rainfall in August 2021. Inundated buildings are extracted by overlaying building data with inundation areas estimated by JAXA’s radar satellite ALOS-2. Then, the results of the total number of inundated buildings (number of inundated buildings), the percentage of total buildings (percentage of inundated buildings), population, population over 65 years old, and number of households are mapped for each municipality.

2021 Mt. Aso volcano DRR map, which shows eruption phenomena that are expected to likely occur in the future based on the past volcanic activities of Mt. Aso and the expected damage area in the event of an eruption.

TOP PRACTICE REPORT 05

Contribution to Disaster Management Practice at National Government

SIP4D and ISUT, which are specified in the Basic Plan for Disaster Risk Reduction, provide support for information aggregation and other activities by the government.

With the SIP4D (Shared Information Platform for Disaster Management) developed by NIED and the ISUT (Information Support Team) dispatched jointly by NIED and the Cabinet Office specified in the Basic Plan for Disaster Risk Reduction, the contribution to disaster management is steadily progressing. We also cooperate in drills organized by the Cabinet Office and municipalities from the study stage, and are working to unify situational awareness through the use of SIP4D and ISUT.

NIED's contributions spreading to municipalities nationwide.

NIED's SIP4D (See page 23 and 24 for details) is being connected to prefectural disaster information systems. In addition to the prefectures that have already been linked, there are also prefectures that are specifically considering the linkage, numbering more than 30. Now that the use of SIP4D has been included in the Basic Plan for Disaster Risk Reduction, we will be working with more and more prefectures in the future.

In FY2021, NIED conducted and supported 12 disaster investigations, including one in Shizuoka and other prefectures (See page right). Information provision and cooperation with the national and municipalities amounted to 892 cases. In many cases, long-term cooperative relationships have been established through agreements with municipalities and other organizations. A total of 329 agreements have been concluded since FY2016, when the 4th mid-to-long term plan began.

■Number of prefectures interconnected prefectural disaster information systems and SIP4D

More than 30

*Including those under consideration

■Number of agreements with municipalities, etc.

329 cases

(total number of cases in fiscal years 2016-2021)

■Conducting and supporting disaster investigations, etc.

12 cases (FY2021)

■Provision of information and cooperation with national government and local municipalities, etc.

892 cases (FY2021)

Examples of collaboration partners: Tokyo Fire Department, Setagaya Ward (Tokyo), Higashimatsushima City (Miyagi), Kamaishi City (Iwate), Kobayashi City (Miyazaki), Chiba Prefecture, Minamiashigara City (Kanagawa), Shimanto Town (Kochi), Ibaraki Prefecture, Fujisawa City (Kanagawa), Wakayama Prefecture, Owase City (Mie), Wakayama Prefecture, Chubu Electric Power Co. Inc, Japan Agency for Marine-Earth Science and Technology, Nagareyama City (Chiba), Tokushima Prefecture, Tokushima University, Mount Fuji Research Institute Yamanashi Prefectural Government, Miyazaki Prefecture, Niseko Town (Hokkaido), Kutchan Town (Hokkaido), Otari Village (Nagano), Hakuba Village (Nagano)

NIED participated in disaster drills (in Tokyo, Chubu, Kinki, Shikoku, and Kyushu regions) organized by the Cabinet Office and disaster drills of municipalities and other organizations from the study stage, contributing to the support of map utilization.

NIED assisted at disaster sites as a member of ISUT. Also created common situation maps in cooperation with multiple organizations.

In FY2021, NIED staff were dispatched to the disaster sites three times as a member of ISUT.

A total of 74 staff were dispatched to Atami City, Shizuoka and other locations during the heavy rains from July 1, a total of 46 staff went to Saga Prefecture during the heavy rains from August 11, and a total of 3 staff went to the disaster sites of the earthquake off Fukushima Prefecture in March 2022 to provide support by aggregating and sharing information to SIP4D and provide information products. ISUT-SITE, which visualizes information circulated in SIP4D, is used as a common viewer in local disaster management HQs, and has spread to the point where it can be operated by each organization itself, rather than by NIED.

In addition, in the case of heavy rainfall in Atami City, multiple organizations including ISUT collaborated to create a common situation map (a map of damage to houses in the river basin) for rescue and recovery activities in Izuyama area, which was used for various purposes by multiple organizations.

Utilization of a map provided by ISUT, at Shizuoka Prefectural Office (heavy rain from July 1, 2021)

Creation and utilization of a common situation map (map of damage to houses in the river basin)

- Drone photography: Ministry of Land, Infrastructure, Transport and Tourism (MLIT)
- Reading and confirmation: Shizuoka Prefecture (Civil engineering)
- Planning: Shizuoka Prefecture (Risk management), ISUT, Geospatial Information Authority of Japan (GSI)
- Mapping: GSI
- Sharing: ISUT

Past use cases

Grasp of damage: Shizuoka Prefecture, etc.	Damage to infrastructure: MLIT, etc.
Rescue plan: Emergency Fire Response Teams, Japan Self-Defense Forces, etc.	Explanatory material for inspection: Cabinet Office, Shizuoka Prefecture.
Building damage certification survey plan: Atami City, Shizuoka Prefecture, Cabinet Office, etc.	

Support at the Saga Prefectural Office (heavy rain from August 11, 2021)

TOP PRACTICE REPORT 06

Dissemination of Research Results and Utilization of Intellectual Property

Research results on hazard and risk are provided as information products.

NIED is committed to providing DRR information in a form of KATA (form of essence) that is easy for everyone to understand by developing, maintaining, and providing information products based on its research results on hazard and risk information such as earthquakes, tsunamis, and the damage caused by these events.

"J-SHIS"*1, which provides earthquake hazard information covering the entire country with the aim of mitigating disasters

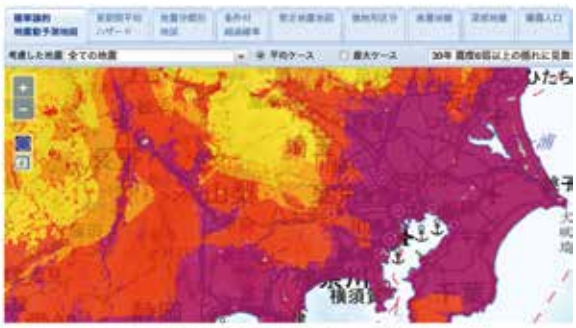
"J-SHIS" (https://www.j-shis.bosai.go.jp) is a web service developed as a nationwide "earthquake hazard station" to contribute to earthquake DRR. The "J-SHIS Portal" provides information on how to use J-SHIS and basic hazard information, the "J-SHIS Map" is a nationwide earthquake hazard map, the "J-SHIS API" is for application developers, and the "J-SHIS Labs" introduces experimental content.

J-SHIS Map consists of a "Probabilistic Seismic Motion Prediction Map" that predicts the long-term probability of earthquakes and strong ground motions, and a "Seismic Motion Prediction Map with Faults at the Sources" based on a scenario for a specific earthquake, and is updated regularly. In the process of creating these maps, a vast amount of information on source fault and underground structure modeling is processed. This information is valuable for understanding earthquake hazard assessment and for utilizing hazard information. Therefore, "J-SHIS" is positioned as a "common information base for seismic hazard" by also publishing the data on which the maps are based.

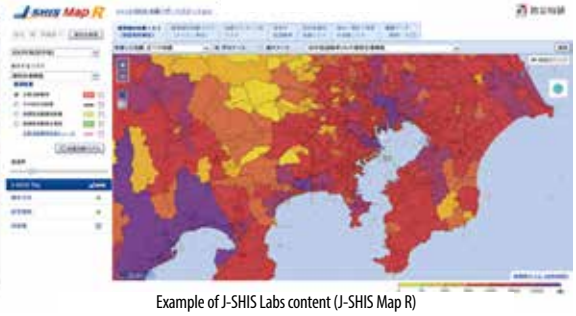
In addition, we are working to enhance new content, such as "J-SHIS Map R," which predicts damage to buildings and human casualties in the event of a strong quake, and the "Earthquake Hazard Chart," which allows users to identify an area delimited by a mesh and view various information from the J-SHIS Map in one place.

*1: Japan Seismic Hazard Information Station

Top page of J-SHIS Portal


Example of J-SHIS Map display (displayed enlarging the tabs)

Example of mobile application using J-SHIS API (Moshi Yure)



Example of J-SHIS Labs content (J-SHIS Map R)

"J-THIS"*2, the first system in Japan to provide probabilistic tsunami hazard information

The tsunami hazard station "J-THIS" (https://www.j-this.bosai.go.jp) is a web service developed with the aim of effectively utilizing diverse tsunami hazard information, and began operation in February 2020. By taking into account the various giant earthquakes that are expected to occur along the Nankai Trough and cause tsunamis, the probability of being hit by a tsunami above a certain height within the next 30 years (30-year exceedance probability) is evaluated for each location along the coast. (a, b)

Selecting a coastal location will display the hazard curve (the relationship between tsunami height and 30-year probability of exceedance) for that location. (c)

It also displays the top five wave source fault models and their tsunami heights at that location. (d)

J-THIS is being improved in reference to user needs, and is also equipped with a function for directly downloading numerical tsunami hazard assessment data and a function for importing the data into a user's own system (Web API function) to promote the use of information that contributes to tsunami DRR.

*2: Japan Tsunami Hazard Information Station

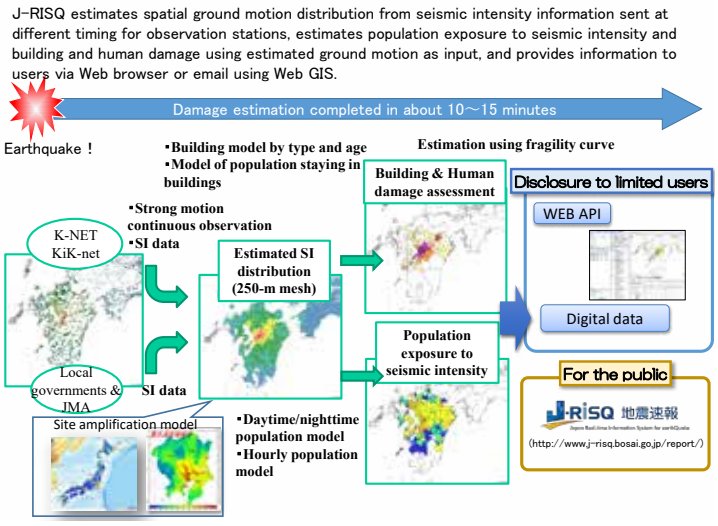
"J-RISQ"*3, which estimates the damage immediately after a major earthquake occurs for all of Japan

When a major earthquake strikes, it is extremely important to quickly assess the damage and quickly link it to disaster response. "J-RISQ" (https://www.j-risq.bosai.go.jp/), a real-time earthquake damage estimation system, has been developed for the purpose of contributing to such a response.

First, the distribution of seismic intensity is estimated from data received from more than 5,000 observation stations nationwide from NIED's strong-motion seismic network (K-NET and KiK-net), local governments, and the Japan Meteorological Agency, taking into account the ease with which the earthquake shakes. The system then estimates the population that may have been exposed to that seismic intensity, as well as building damage and human casualties from the distribution of buildings and population and the degree of shaking, approximately 10 minutes after the earthquake, and provides the results on the web. This system released the results of estimated damage of buildings for the first time in 2016 Kumamoto Earthquake.

This system can be used for disaster response by government ministries and agencies, police, fire departments, and local governments, as well as for business continuity planning (BCP) and District Continuity Plan (DCP) in the private sector, thereby helping to strengthen society's DRR ability. We will continue our efforts in both research on information utilization and system development/improvement in collaboration with SIP4D and the Hazard and Risk Experiment Consortium.

*3: Japan Real-time System for earthQuake damage information



TOP PRACTICE REPORT 07 International Collaboration

Facing global challenges, NIED contributes to improving international DRR and resilience.

NIED conducts joint research and collaborations with domestic and international stakeholders and is also engaged in global issues such as coherence between disaster risk reduction (DRR) and SDGs and climate change adaptation. The Institute also contributes to DRR-related international cooperation and human resource development by utilizing the research results.

International contribution through promoting Japan Hub of Disaster Resilience Partners' activities.

The Japan Hub of Disaster Resilience Partners (JHoP; Chair: HAYASHI, Haruo, President, NIED) is a network-based research body on DRR consisting of 16 organizations including universities, research centers, and business entities in Japan and is working closely with the Science Council of Japan.

JHoP established the 18th IRDR ICoE (International Center of Excellence) in the world in 2021 as a Japanese research center to promote international integrated research on disaster risk in collaboration with overseas organizations under the framework of Integrated Research on Disaster Risk (IRDR), which is a decade-long research program co-sponsored by the International Science Council (ISC) and UN Office for Disaster Risk Reduction (UNDRR). The name, ICoE-Coherence, is derived from the aim of promoting coherence among DRR, SDGs, and climate change adaptation. ICoE-Coherence has promoted international disaster risk research in collaboration with overseas institutions and has co-hosted a workshop with ICoE-Taipei in 2021-22.

As the secretariat of JHoP, NIED is working to establish research collaboration on global issues and to strengthen the international network for integrated research on disaster risk.

IRIDeS, Tohoku U.
ERI, U.Tokyo
CIDIR, U.Tokyo
EDITORIA, U. Tokyo
GRIPS SciREX
NHDR, Niigata U.
DMRC, Nagoya U.
DPRI, Kyoto U.
WENDI, Kyoto U.
KUDRC, Kyushu U.
R²EC, Tsukuba U.
National Research Institute for Earth Science and Disaster Resilience (NIED)
JAMSTEC (MAT)
ICHARM
DRI
JBP

16 institutions participating in JHoP

Improving disaster resilience through international joint research in diverse fields

NIED is engaged in international research not only with research institutes and universities but also with private companies. NIED has concluded a memorandum of cooperation with Environmental Systems Research Institute, INC. (ESRI) of the United States, which possesses advanced knowledge, tools, and data in Geographic Information Systems (GIS) for joint research, personnel exchange, and human resource development. Both continue to cooperate in further developing NIED's information products, such as BosaiXview, that incorporate the technologies of Esri.

President Dangermond of Esri and NIED President Hayashi signing the memorandum of cooperation.

Promoting initiatives that contribute to BBB in disaster-affected areas overseas.

Build Back Better (BBB), which was proposed in the Sendai Framework for DRR, is the concept of strengthening resilience after a disaster in preparation for the next disaster. NIED also promotes various international initiatives, including cooperation with the Republic of Croatia. Interview with Dražen Hrastić, Ambassador Extraordinary and Plenipotentiary of the Embassy of the Republic of Croatia in Japan.

At E-Defense

H.E. DRAŽEN HRASTIĆ,
Ambassador of the Republic of Croatia to Japan

"We hope to deepen cooperation with NIED to strengthen disaster resilience."

Two devastating earthquakes hit Croatia in 2020, which made us realize that we were not well prepared for such disasters. In response to our request to Japan for knowledge sharing toward Build Back Better (BBB), a webinar series began in February 2021, and President Dr. HAYASHI gave us an insightful lecture and advice.

NIED has the world's best experimental facilities and vast expertise, profound knowledge, and experts in various disaster preparedness and resilience areas. Visiting the headquarters and E-Defense by myself, I am convinced that collaboration between NIED and our counterparts will strengthen disaster resilience in Croatia and our neighboring countries where more disasters have occurred.

In addition to exchanging experiences and expertise with our expert communities through various symposia, we hope to find a common interest in research activities and projects using NIED facilities and send Croatian experts to NIED. We would also like to bring NIED experts to Croatia to assess and identify gaps in our preparedness and resilience activities. In the context of climate change, floods and landslides occur more frequently and more significantly than before, which could be other areas of our collaboration.

Strengthening international dissemination and contributing to the sharing of research results and human resource development.

It is essential to disseminate the results of disaster research internationally and share them with people worldwide. NIED organized a "Resilience in Tokyo Metropolitan Area" session at the Tsukuba Conference in 2021. Young researchers and business executives presented their efforts to realize a disaster-resilient society through cutting-edge DRR research and technology.

TSUKUBA CONFERENCE
For Future Shapers
2021

Hosted a hybrid session at NIED's Wadachi Memorial Hall and via online

TOP PRACTICE REPORT 08

Human Resource Development

NIED is actively developing human resources through the Collaborative Graduate School system degree program.

NIED is proactively participating in the University of Tsukuba's degree program run by the Resilience Research and Education Promotion Consortium through the Collaborative Graduate School system, and is working to foster young researchers who will play a leading role in DRR in the future.

NIED participates in the University of Tsukuba's graduate degree program through the Collaborative Graduate School system.

NIED has joined the "Resilience Research and Education Promotion Consortium" established in 2017 by the University of Tsukuba and 11 companies and research institutions in Tsukuba City and the surrounding area, and is implementing a new degree program, "Doctoral Program in Risk and Resilience Engineering" at the University of Tsukuba Graduate School starting in 2020. The consortium is an organization that aims to develop human resources with the research and practical skills to flexibly respond to unforeseen events and changes in circumstances in modern society, and to maintain, provide, and recover the social functions required.

NIED has signed an agreement* with the University of Tsukuba to participate in this program on a proactive and sustainable basis. As of October 2022, three NIED researchers and four students (including two working students) are pursuing degrees through this program. Through this program, we are striving to develop high-end human resources with doctoral degrees who will play a key role in realizing a resilient society through their advanced knowledge and skills.

* Collaboration agreement in education research between the University of Tsukuba and the Collaborative Graduate School established in the Resilience Research and Education Promotion Consortium

Risk and Resilience Engineering Degree Program

Disaster risk and resilience theory

KATA (form of essence) covering various types of natural disasters, the lecture will provide an overview from individual disaster risk assessment to disaster response technologies to improve resilience. Specifically, the course will provide an overview of earthquake and tsunami disasters (risk assessment, disaster control measures, observation technology, and simulation technology), volcanic and ground disasters (risk assessment and disaster control measures), and wind, flood, and snow/ice disasters (risk assessment, disaster control measures, and information sharing/utilization technology), as well as comprehensive strategies to improve resilience. The course will also provide comprehensive strategies to improve resilience, including practical examples of how such strategies have been implemented in times of peace and disasters.

Backing up young people to obtain degrees.

Through the Collaborative Graduate School system with the University of Tsukuba, young employees of NIED are enrolled in the University of Tsukuba's Graduate School of Risk and Resilience Engineering, where they are pursuing their degrees as students in the Risk and Resilience Engineering Degree Program. NIED fully supports this degree program by allowing students to complete it as part of their work at the institute.

Efforts are also underway to utilize NIED's resources, such as its large experimental facilities, for research at the University of Tsukuba's graduate school. One of NIED's human resource development policies is to strengthen its research capabilities through collaboration and cooperation with institutions of higher education.

KOJIMA Jun

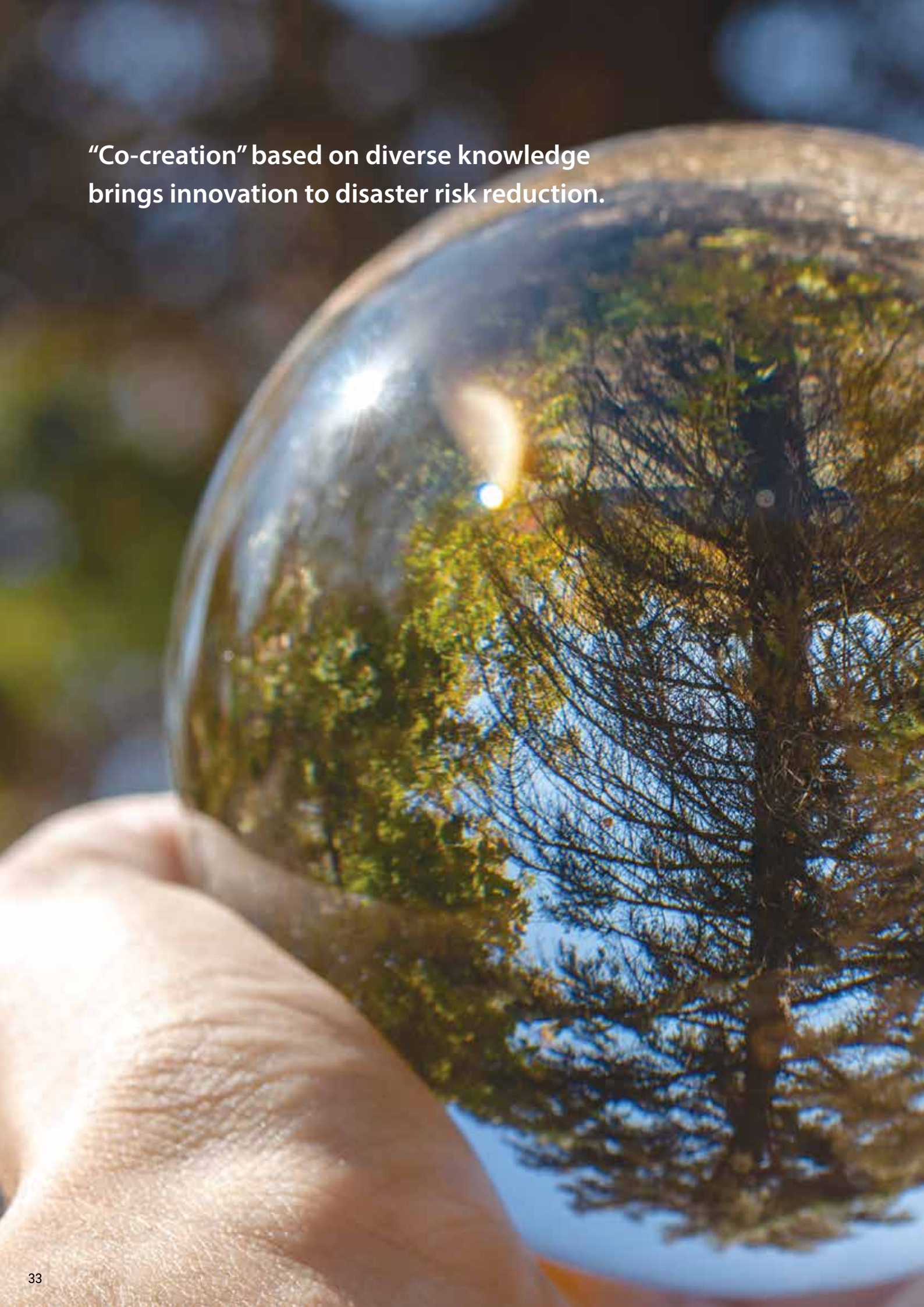
Technical Staff,
Earthquake Disaster Mitigation Research Division,
2nd year of Master's Programs in Risk and Resilience Engineering
Degree Programs in Systems and Information Engineering (Postdoctoral Program),
Graduate School of Science and Technology,
University of Tsukuba

As a student, I majored in aerospace engineering and conducted research on simulation of space structures. I am taking advantage of the Collaborative Graduate School to obtain a degree in DRR and enhance my expertise while utilizing my structural knowledge. In graduate school, I am currently involved in research to evaluate the risk of collapse and damage to buildings when they are subjected to earthquake ground motion. I think it is a very good environment to enhance my expertise because my daily work is linked to my research at the graduate school, and I am surrounded by knowledgeable specialists like the faculty members at NIED. I also find it attractive that I can be involved in various fields of research by acquiring one specialty. Of course there are difficulties in balancing graduate school research and work, but I feel that the greatest advantage of the Collaborative Graduate School is that I can earn my degree while working.

OGUCHI Akira

2nd year of Master's Programs in Risk and Resilience Engineering
Degree Programs in Systems and Information Engineering (Pre-doctoral Program),
Graduate School of Science and Technology,
University of Tsukuba

I majored in geotechnical engineering as an undergraduate and at the same time was interested in cutting-edge research fields such as DX and AI. I entered the University of Tsukuba Graduate School as an environment where I could engage in research that utilizes both of these fields, and I am taking advantage of the Collaborative Graduate School. Currently, I am conducting research to quantitatively assess the risk of slope failure using IoT and AI in order to improve resilience. I am using the Large-scale Rainfall Simulator for my research, and I feel that the Collaborative Graduate School is very fortunate to be able to conduct full-scale experiments using the resources of the NIED. In addition, the Collaborative Graduate School provides us with opportunities to experience research in a variety of fields, such as sensing. I would like to continue to be involved in research that is useful to society, focusing on the fusion of DRR, DX, and AI.



“Co-creation” based on diverse knowledge brings innovation to disaster risk reduction.

FUNDAMENTALS

Promotion of Basic Research and Fundamental R&D

We introduce the aspirations and research results of our researchers who engage in basic research and fundamental R&D through interviews with them.

Interview with a researcher who challenges disasters ❶

“Community promotion and avalanche clarification. Two thoughts unite to co-create the rules for DRR.”

YAMAGUCHI Satoru

Principal Chief Researcher, Snow and Ice Research Division

Research Theme: Efforts to improve the attractiveness of the community through avalanche research

Survey at Niseko Ski Resort

Screen of Niseko avalanche-related information provision system

"NISEKO Rules" co-created by the local community and NIED

In Niseko, Hokkaido, which is attracting attention as an example of an inbound success, one of the popular reasons for enjoying powder snow is backcountry skiing, which is done off-piste. The "NISEKO Rules", which have been in place since the early 2000s, make it possible to ski in an environment that is more avalanche-prone than a groomed ski area. The rules are enforced through the judgment of the local staff, who know the local snow well, and are able to determine whether off-piste skiing is allowed or not based on their own experience. With the recent increase in the number of inbound visitors to Niseko, there was a growing demand for a scientific basis for these decisions. At the same time, there were moves to resolve issues related to human resource development and organizational structure for the continued operation of the "NISEKO Rules", and NIED, which conducts avalanche research in Niseko, joined the council to discuss these issues. Since then, NIED, which promotes avalanche research, and the local community, which aims to revitalize tourism resources, have synchronized their efforts to continuously upgrade the "NISEKO Rules".

A case in which local empirical rules for avalanche forecasting and the scientific methods of NIED were linked to solve the problems of both.

- Conventional safety management based on empirical rules of local experts ("NISEKO Rules") and NIED's scientific methods (observation monitoring, numerical modeling) has been combined as avalanche accident prevention measures in the Niseko area (Kutchan Town and Niseko Town).
- NIED provided "Niseko avalanche-related information provision system" that "visualized" empirical rules using objective data to ski resort personnel, contributing to the establishment of a continuous safety management system based on scientific evidence.

Issues in the Niseko Area

NIED:
Further cooperation from ski resorts and other local communities to adovance avalanche forecasting research

Kutchan Town, Niseko Town:
Human resource development to ensure the continued operation of "NISEKO rules"

Trust relationship with key persons

NIED formed a relationship of trust with local experts through daily exchange of information, etc. Through conversations with local experts and others, NIED realized the potential of using research results to solve local issues, and began to consider ways to resolve these issues.

Start of local cooperation

Study with local officials

NIED listened carefully to the content of local experts' empirical rules and needs related to avalanche forecasting (information on wind direction and speed, snowdrifts distribution, etc.), and discussed the target and content of cooperation together with ski resort officials. People involved shared the image that sustained safety management through this initiative will lead to improved status as a "safe ski resort".

Cooperation agreement

Establish Niseko avalanche-related information provision system

- NIED visualized empirical rules using objective data and provided current and forecast information to ski resort personnel.
- Avalanche forecasting using current and forecasted information by ski resort personnel became possible, and it enabled advanced gate management, which incorporated scientific information into the existing empirical rules, establishing a continuous safety management system.

The goal is to make empirical rules scientifically visible and to universalize the rules.

Our first effort was to "visualize" the scientific thinking behind the empirical rules of local staff. After working together with the staff to observe and discuss what information was needed to determine avalanche danger, it became clear that the criteria for determining avalanche danger might lie in the snowdrifts and stabilization process. We began measuring wind direction, wind speed, and temperature at six key locations, and by using NIED's simulation technology, we were able to visualize the wind conditions over the entire mountain area and where and how much snowdrifts develop. Besides, we have recently combined weather forecasting modeling and simulation technology to predict avalanche occurrence several hours in advance, making visible the information necessary to determine the degree of danger.

Such visualization of scientific evidence helps to universalize the rules of risk judgment, which had relied on individuals, and to train successor as facilitators. Facilitators need to know the snow in their area, as the properties of snow vary from region to region. By standardizing and universalizing not only the mechanism of avalanches, but also the training of facilitators who can identify the degree of danger, we aim to create rules that can be applied to ski resorts around the world.

Co-creation with social science to further advance "NISEKO Rules".

Co-creating with local staff members often leads to the discovery of scientific information that we researchers are unaware of, or the importance of natural phenomena that we have ignored. Such discoveries suggest the possibility of developing into challenging research that has not yet been undertaken worldwide.

On the other hand, one of the challenges is how to convey information in an easy-to-understand way for inbound and other tourists, in addition to disseminating information in the form of specialized figures and graphs. To solve this problem, we need the insight of social science as well as science, and it is very meaningful to study the "NISEKO Rules" and universalize them at NIED, where natural science and social science can collaborate. We will continue to work together with local residents to create indicators and establish information dissemination that will enable skiers to think and make decisions on their own, rather than simply issuing a decision on whether or not they can ski.

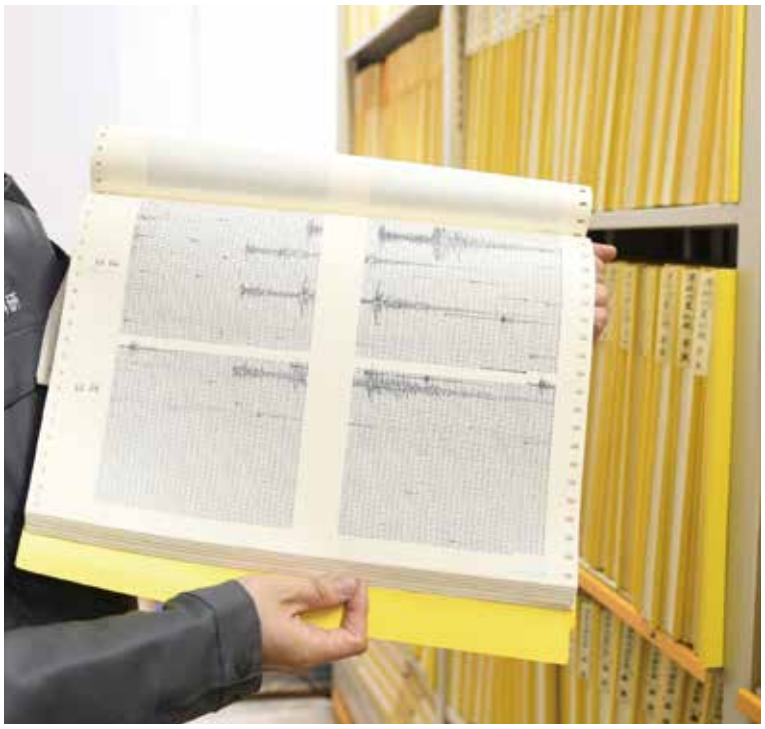
Interview with a researcher who challenges disasters 2

MATSUZAWA Takanori
Chief Researcher, Network Center for Earthquake, Tsunami and Volcano

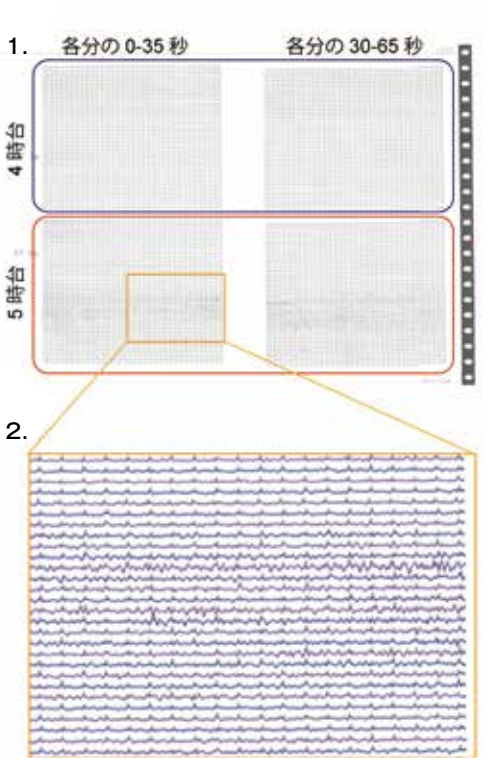
Research Theme: Slow earthquakes probed by paper seismographic record

Slow earthquakes (tectonic tremors) found in the paper seismographic records.

In terms of seismographic observations, all signals other than earthquake shakings are noise. To obtain correct observation results, it is necessary to exclude various types of noise, such as vehicle traffic and construction work near observation stations. NIED has stored seismograms recorded by pen recorders since the late 1970s by the NIED Kanto-Tokai observation network, and digital observation data from the High Sensitivity Seismograph Network (Hi-net), which began operation in 2000. When my supervisor, Dr. Kazushige Obara (now at the University of Tokyo), visually checked the Hi-net records, he came across a strange waveform different from the known noise. What was discovered through this analysis was tectonic tremors, a type of slow earthquake. This discovery triggered a worldwide review of seismographic records, which led to the discovery of slow earthquakes in many regions and eventually to the discovery of a universal characteristic in the relation between slow earthquakes and large earthquakes. Currently, continuous data from Hi-net operations are stored as digital records, but this project aims to digitize past analog records so that they can be handled on a computer, and to apply more long-term data to the recent analysis methods, thereby contributing to the study of slow earthquakes, which are still largely unexplained.



Examples of analog waveform record files and records stored at NIED.



1. Example of a paper record of a period confi rmed tectonic tremors, a type of slow earthquake.
The record is divided into four blocks: top, bottom, left, and right..

2. Digitized data (blue and purple lines) are displayed on top of the original image.
The orange line frame in (1) is enlarged.

The challenge of digitizing paper seismograph records is noise removal

Paper seismographic records are scanned for analysis to create image files, which are then digitized into waveform data. When the digitized results are overwritten on the images, it can be confirmed that the data is consistent with the original waveform. We can confirm from the frequency characteristics of this data that it is the same characteristics as the tectonic tremor we are currently observing.

Since it would take a great deal of time to manually convert several days' worth of waveforms into data while discriminating noise, we are currently developing a program to automate the process.

The difficulty lies in discriminating the noise. One of the characteristics of slow earthquakes is that the signal is so minute that it is difficult to distinguish it from other noise. In addition, there are ink stains and notes on the recording paper, and since the recording device of seismograms was designed to insert tick marks every second, these marks are mixed in with the seismic waveforms. The biggest problem in the automatic digitization of analog data is removing these noises and accurately extracting the signal of slow earthquakes.

More accurate numerical simulation of slow earthquakes.

Numerical simulations have shown that slow earthquakes are observed in areas around large earthquakes and are predicted to occur at shorter intervals as a large earthquake approaches. However, to confirm the accuracy of the prediction, it is necessary to verify the forecast on a scale of several decades, at least. In the future, we intend to verify the validity of numerical simulations of large earthquakes and slow earthquakes based on long-term slow earthquake data, including analysis of paper recordings, and to improve our prediction capability by further increasing the accuracy of our modeling.

This effort has been made possible because NIED has preserved the waveform data of earthquakes it has observed over the years. We believe that NIED plays a vital role in elucidating slow earthquakes.

“Quantify and visualize individual’s resilience capacity to overcome disasters.”

MATSUKAWA Anna
Research Fellow, Disaster Resilience Research Division

Research Theme: Development of a scale for basic level of disaster risk reduction

Designed basic level of DDR as a scale of DRR literacy.

Following the Great Hanshin-Awaji Earthquake in 1995, the Ministry of Education, Science, Sports and Culture at that time proposed safety education for children to enhance their zest for life. The curriculum, now organized as “DRR literacy,” is included in the government course guidelines and consists of three components: “the ability to understand disasters,” “the ability to prepare for disasters,” and “the ability to take action in an emergency“.

In our research, using the theory of DRR literacy, we developed a scale called basic level of DRR and designed a scale to measure DRR capability throughout Japan. In order to know the invisible abilities of individuals, we need a theoretical concept and a scale as a prerequisite. The knowledge of DRR, preparedness at normal times, and the ability to make appropriate decisions in the event of a disaster are called “basic level of DDR,” and each ability is quantified to develop a versatile measure of resilience on an individual basis to make the abilities visible.

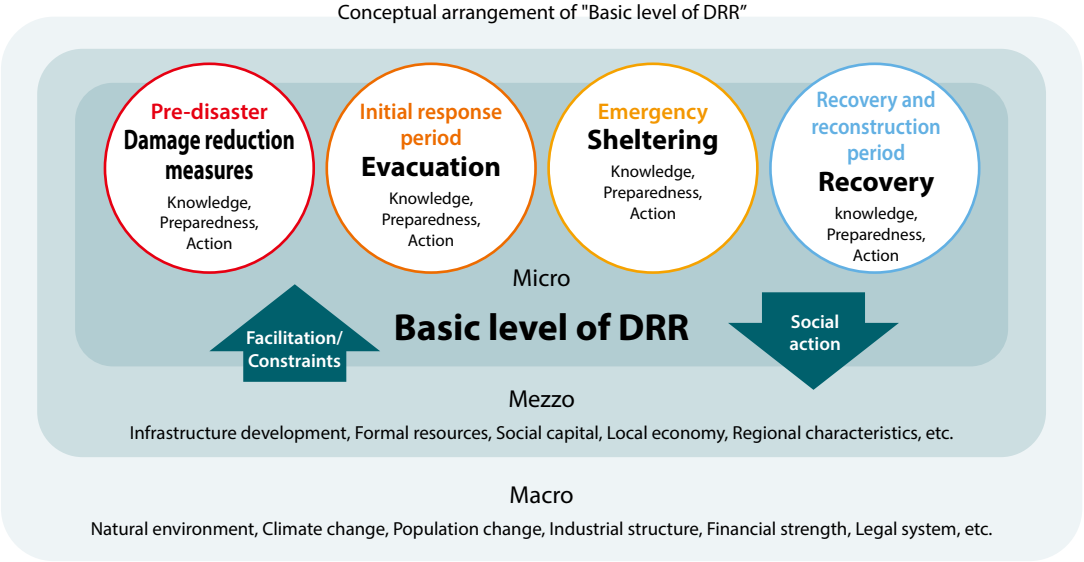
We are currently collecting and analyzing information to measure basic level of DDR, including individual-based DRR knowledge and preparedness status. The survey targets individuals, but by taking an average, we can measure the DRR capacity of a region. If we conduct the survey on an ongoing basis throughout Japan, we will be able to make comparisons between regions and identify changes over time, as well as the long-term effects of DRR efforts.

Promotion of a tool that will attract more attention from people and communities to DRR.

DRR awareness and action are not easily spread among people who are busy in their daily lives. In this situation, we hope that the basic level of DRR will help individuals to measure their own ability to respond to disasters, to understand the state of the community in which they live, and to become more aware of the importance of DRR. DRR efforts are meaningless unless they are sustained. In reality, however, in many cases, people's DRR awareness is raised after a major disaster, but then their activities are curtailed during normal times, and the challenge is how to find the meaning of DRR and maintain motivation. We hope that the basic level of DRR will be utilized as a standard to show, for example, that a community's DRR has increased, that our municipality's DRR is higher than that of our neighbors, or that we can be confident that our DRR activities are correct, thereby motivating individuals and communities to maintain their motivation.

Theoretical Framework: DRR Literacy

Conceptual arrangement of "Basic level of DRR"



Fusing science, engineering, and social science to tackle the challenges of DRR.

I originally majored in crime prevention from a social science perspective, researching what kind of community activities by residents would enhance social capital*. Later, when I became involved in research on disaster prevention following the Great East Japan Earthquake, I learned about the realities of people such as the disabled and elderly who were left out of DRR and suffered unreasonably, and I became keenly aware of the problem that individuals and communities should become more resilient. In DRR research, it is essential to consider not only the mechanism of a disaster, but also how society and people can respond to such a phenomenon. In this respect, I believe that NIED is one of the best institutions in Japan that can relate both the knowledge that has been cultivated in the fields of science and engineering and the social scientific perspective.

*Social capital: A concept that describes the importance of human ties,trustworthiness, and cooperative relationships in a community.

“Estimate flood hazard levels by predicting river discharge increase based on seismic noise”

SHAKTI P. C.
Storm, Flood and Landslide Research Division
Research Fellow

Research Theme: Estimation of river discharge in mountain river basins using Hi-net data

Utilize seismic observation network to know the danger of flooding etc. in rivers.

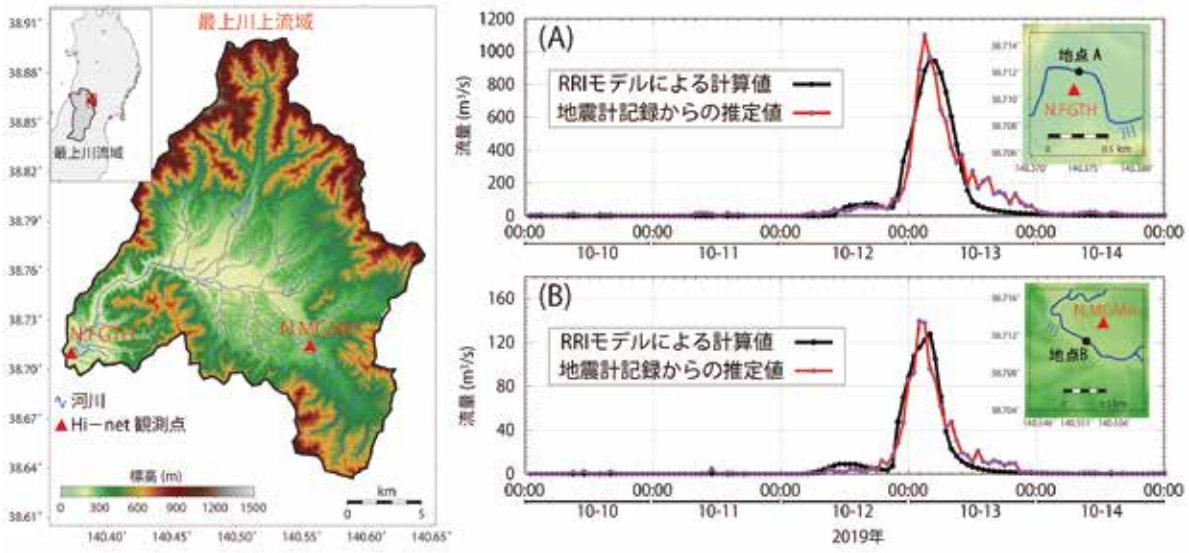
A sudden increase in river discharge in any tributary of a basin may lead to a severe disaster in downstream of the basin in the form of flash flooding. This phenomenon is more common in mountainous areas, especially in small river basins, where flooding can occur within a short period of time after rainfall. Although it is important to assemble comprehensive data to estimate the flood disaster level in such downstream section, direct measurement of river discharge in mountainous areas is highly challenging and not economically feasible due to complex topographies and their remoteness. On the other hand, previous studies have reported that seismic noise excited by river flow can be detected at seismic stations and that the noise power is highly correlated with the river discharge data.

In this study, we have worked to establish a method for predicting river discharge in mountainous river basins using noise data recorded by seismometers. NIED has constructed a high-density, High Sensitivity Seismograph Network (Hi-net) covering ungauged mountainous river basins in Japan at approximately 20 km intervals, and operates and manages about 800 seismic stations throughout the country. If we can predict discharge of nearby rivers during heavy rain events from these seismic stations, it will be very important information for the appropriate forecasting of flood disasters in Japan.

Using observations and calculations to clarify the relationship between seismometer noise and river discharge.

It was already known that seismographs could observe noise correlated with water levels and flow rates in mountain rivers. However, since hydrologic and seismic observation networks are designed and installed for very different purposes, and there may be several independent river systems within a relatively small area of a given mountainous river basin. Thus, when seismic and hydrologic stations are far apart, a large uncertainty in the relationship between river flow and noise is inevitable, and this has hindered research.

This research aimed to clear this problem by combining observation and simulation. First, using the Rainfall-Runoff Inundation (RRI) model that can calculate river flow rate from rainfall flow rate, we numerically calculated the flow rate at the point on the river closest to Hi-net station and compared the calculated flow rate with seismograph record. We have verified that the flow rates calculated from the model matched the actual observed flow rates, and it was confirmed that the observed and calculated flow rates are generally consistent with past flood events. In addition, we were able to identify the frequency band of noise that best represents the increase or decrease in flow rate. I pursue this research in close collaboration with Kaoru Sawazaki, Research Fellow at Network Center for Earthquake, Tsunami and Volcano, who specializes in earthquake observation and its data processing.



Comparison of flow rate estimated from Hi-net noise records and calculated flow rate by RRI model in the Mogami River basin

Challenging to pursue new research ideas with a background in meteorology and hydrology.

Hi-net stations can provide information in real-time, while hydrologists are always looking for real-time data. This research has the potential to be used by anyone in the future for rapid analysis of flood disaster forecasting, as data on river runoff forecasting is made available as open source by NIED.

In the fields of meteorology and hydrology, I have been involved in a variety of research projects, including cross-departmental and international projects. This research is also interdisciplinary between hydrology and seismology and is based on creativity, investigation, and innovation. I will continue to consider new research ideas in meteorology and hydrology or in multidisciplinary fields, and will actively collaborate with national and international research institutions.

“E-Defense Research Challenge for the Reliable Resilience of Our Society”

TABATA Kentaro

Earthquake Disaster Mitigation Research Division
Deputy Manager / Principal Chief Researcher

Research Theme: Developing regional resilience through research with E-Defense

Focus from individual structures to regional spaces; expand research views to establish reliable resilience.

My colleagues and I are working on earthquake engineering research and development through the "E-Defense" experimentation. E-Defense is one of the world's largest 3D shake-table facilities for observing the collapse behavior of a full-scale structure. It started operation in 2005, 10 years after the 1995 Great Hanshin-Awaji Earthquake, which caused devastating damage to many buildings and infrastructure systems.

In the first phase after the start of its operation, we conducted experimental research to clarify the collapse mechanism of structures and evaluate current or new technologies, and developed numerical simulation technology to reproduce the behavior observed in E-Defense experiments to analyze the damage process in detail.

In the next phase, our research focus expanded to include the continuity of the structure's functions. Each structure has a function, such as residence, office, hospital, and school. We carried out the experiments to assess the functional continuity and collapse margin of the structures that can survive even after a large earthquake.

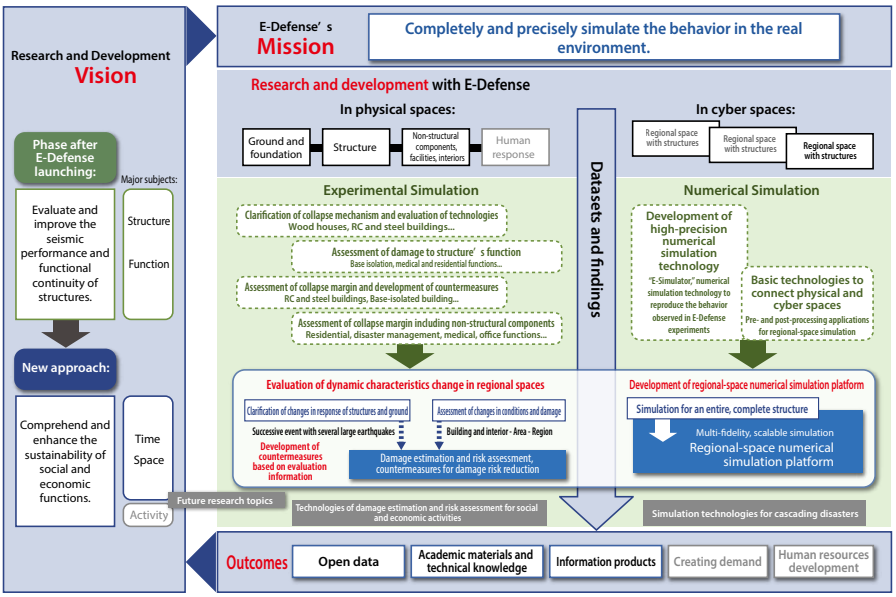
Based on the research results and outcomes through the E-Defense experiments, we will implement the research and development that contribute to the resilience evaluation with the assessment of the impact of large earthquakes in "regional spaces," under the new vision "Toward the creation of technologies to comprehend and enhance the sustainability of social and economic functions" in order to establish a resilient society that can reliably continue our activities after an earthquake.

Identify changes in regional spaces; reveal damage and risks from disasters.

In order to expand the research themes to regional spaces, it is also important to clarify the effects on the "groups of buildings" that interact through the ground, such as damage to underground structures and infrastructure connections, changes in ground conditions, and the influence of adjacent buildings and facilities. We will conduct E-Defense tests and demonstrate the effect of the ground in the period after a large earthquake occurs, such as the Nankai Trough Earthquake.

We will also develop the technologies for recognizing the conditions from "spatial data" acquired by visual and acoustic monitoring, for example, so as to effectively identify changes in regional spaces. Through the development based on the data obtained from E-Defense experiments and others, we will promote the research to introduce various spatial information, covering the inside of a building, the surrounding area, and even the regional area, into the damage estimation and risk assessment.

Furthermore, to provide wide-area, reasonable information for resilience evaluation, we will establish the "regional-space-applicable" numerical simulation platform with the core technology "E-Simulator," which can reproduce the behavior observed in E-Defense experiments, and the cyberspace model of a regional space containing various information of buildings and ground conditions and monitoring data.



Promote E-Defense globally for research on reliable resilience.

NIED creates and provides various information products to secure our sustainable lives against natural disasters; we are working on developing technologies for valuable information of resilience evaluation. Establishing reliable resilience against earthquake disasters is a common goal in countries with high seismic activity, and the unique datasets obtained from E-Defense experiments and findings based on them should be shared not only in Japan but globally. Under the new vision, we will continue to communicate with researchers and engineers in order to co-create our "global ideas" and promote their implementation through E-Defense experiments in collaboration with them.

NIED conducts basic research to provide the driving force for promoting co-creation in science and technology for Disaster Risk Reduction (DRR).

NIED conducts basic research for all hazards, including earthquakes, tsunamis, volcanic eruptions, strong wind, torrential rain, heavy snow, and landslides, as well as science and technology for DRR spanning all of the phases before and after disasters. Results are presented in numerous papers by researchers, receiving positive feedback from various parties along with the efforts in society.

Including numerous awards, NIED's research activities have received wide-ranging recognition.

"FY2020 Japan Association for Earthquake Engineering Distinguished Achievement Award"

NAKAMURA Hiromitsu, Deputy Manager of the Multi-hazard Risk Assessment Research Division, has received the 2020 Japan Association for Earthquake Engineering Distinguished Achievement for his contributions to further enhance the activities of the Japan Association for Earthquake Engineering through his overall planning and management of the Executive Vice President for the two years from June 2018 to May 2020.

"FY2020 Japan Society Snow Engineering Technology Award"

HIRASHIMA Hiroyuki, Chief Researcher of the Snow and Ice Research Division, and SANO Hiroaki, Research Fellow of the DRR Research Division, received the 2020 Japan Society Snow Engineering Technology Award for the development and operation of the "YukioroSignal" (Snow Load Alert), which they worked on together with IYOBE Tsutomu of JR East, Professor KAWASHIMA Katsuhisa of Niigata University and Associate Professor MOTOYA Ken of Akita University. The award was given in recognition of the development and operation of the "YukioroSignal."

SIP4D Received 2021 R&D100 Award

SIP4D (Shared Information Platform for Disaster Management), which NIED and Hitachi, Ltd., have jointly developed, received the R&D100 Award. It is the most prestigious international award in science and technology sponsored by R&D Magazine, Inc. of the United States. It recognizes new products, technologies, and technologically significant materials that have been put to practical use. (For more information on SIP4D, see p. 23.)

The 20th Japan Railway Award, Japan Railway Grand Prize

NIED and East Japan Railway Company, Tokai Railway Company, West Japan Railway Company, Railway Technical Research Institute, and JAMSTEC received the 20th Japan Railway Grand Prize of the Japan Railway Award. The award was given in recognition of the "Development and Introduction of the World's First Earthquake Early Warning System for Shinkansen Lines Using Ocean Bottom Seismographs and Its Effectiveness - Toward Enhancing Shinkansen Safety against Earthquakes" for its significant contribution to public understanding and interest in railroads and the development of railroads.

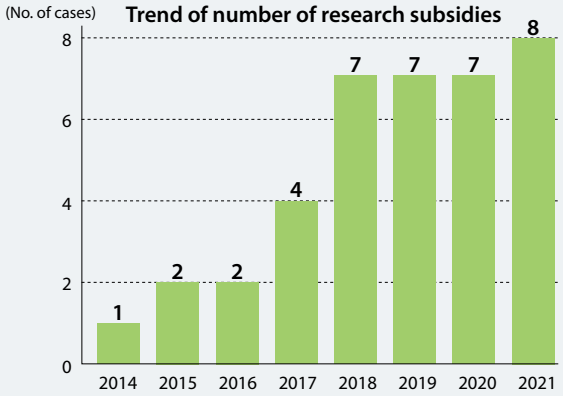
2021 Young Scientist Award at the Fall Meeting of the Community Safety Society of Japan.

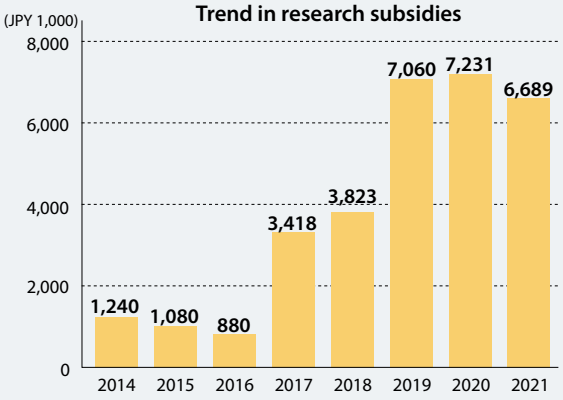
IKEDA Masaki, Technical Staff in the Disaster Resilience Research Division, received the Young Scientists Award at the 2021 Fall Meeting of the Institute of Social Safety Science (ISSS). The paper's subject is Analysis of Current Disaster Prevention Education Materials Developed in Japan: The Future of Disaster Prevention Education in relation to the Courses of Study

NIED publishes many research results, including those attained through research subsidies.

Research subsidies

While NIED's research is primarily supported by operation cost funds from the government, commission income, and Grants-in-Aid for Scientific Research (KAKENHI p.53), research grants from non-governmental bodies are also an essential financial pillar. NIED also promotes various kinds of research through grants from the Taisei Foundation and the SECOM Science and Technology Foundation.

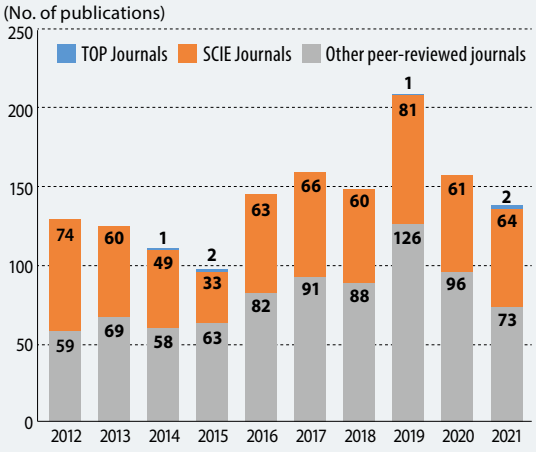




Number of academic papers presented

Every researcher at NIED publishes at least one paper every year.
As NIED approaches the final year of the 4th med-to-long term plan, we will consolidate research results and transmit R&D results required by society. In FY2021, 139 papers were published, reflecting the lively research activities. In addition, many papers have been published in prominent international journals, significantly contributing to knowledge creation.

Definition in this integrated report	
TOP Journals	Authoritative scientific journals such as Nature, Science, with stringent peer review, and which are said to only include only one tenth of a submitted paper.
SCIE Journals	Highly credible and strictly selected journals compiled in Web of Science
Other peer-reviewed journals	Journals not included in TOP/SCIE journals, mainly compilations of academic papers.



Create an environment where young researchers and other researchers can actively participate.

Chief Researcher KUBO Hisahiko (Earthquake, Tsunami, and Volcano Research Network Center) has been selected by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) for the "Seismic Survey Research Project Using Information Science (STAR-E Project)," which aims to develop the entire field of "Information Science x Seismology" including training young researchers for the next generation through efforts to promote collaboration between the fields of information science and seismology. In addition, the adoption rate*1 of Grant-in-Aid for Scientific Research in FY2021 by the research institution to which the researcher belongs ranked 7th in Japan (43.1%) and 1st among National Research and Development Agencies (national average: 27.9%). As part of our efforts to create an environment in which young researchers can play an active role, we will continue to provide young researchers with opportunities to actively apply for external funding while encouraging academic research by individual researchers and striving to create a resilient society through the creation of superior DRR science and technology.

*1 For institutions with 50 or more new applications

NIED continues to evolve, both as a core DRR institute for science and technology for DRR and as a hub for co-creation.

Leaning lessons from many past disasters in Japan and in order to rebound from coming disasters, NIED has expanded the scope of its research to encompass hazard prediction to prevention, response and recovery. In future, NIED will continue to lead the development of science and technology for disaster risk reduction (DRR) through cross-disciplinary co-creation between natural sciences, engineering and social science.

1959 Ise Bay Typhoon

The Ise Bay Typhoon can legitimately be described as Japan's worst flooding disaster in history, causing catastrophic damage including 5,098 fatalities/ missing persons, 40,862 houses destroyed or washed away, 113,068 partially destroyed houses and 363,611 inundated houses.

Jan. 1963 – Showa 38 Heavy Snow –
Apr. 1963 National Research Center for Disaster Prevention (NRCDP) established as a national research institute under the jurisdiction of the Science and Technology Agency [Ginza, Tokyo]
Jun. 1964 – Niigata Earthquake –
Dec. 1964 Institute of Snow and Ice Studies established [Nagaoka]
Aug. 1965 Marine Observation Tower completed [Hiratsuka]
Jun. 1967 Strong Motion Earthquake Observation Council established
Jun. 1967 Hiratsuka branch established
Oct. 1969 Shinjo branch established
Jun. 1970 Large-scale Earthquake Simulator completed (The first research facility in Tsukuba Science City)
Mar. 1973 Iwatsuki Crustal Activity Observatory completed
Mar. 1974 Large-scale Rainfall Simulator completed
Apr. 1978 HQs of NRCDP moved from Tokyo to Tsukuba Science City
Mar. 1984 Kanto and Tokai Crustal Activity Observation Network formed
Mar. 1988 Doppler Radar completed
Jun. 1990 Institute's name changed to "National Research Institute for Earth Science and Disaster Prevention"

As a National Research Institute

1963 Research institute established

Triggered by the damage inflicted by the Ise Bay Typhoon, National Research Center for Disaster Prevention (NRCDP), the predecessor to NIED, was established as an institute for researching science and technology for DRR.

Mar. 1996 Sagami-Bay Sea Bottom Earthquake Observatory completed
Jun. 1996 Operation of K-NET (Kyoshin Network) started
Mar. 1997 Cryospheric Environment Simulator completed [Shinjo]
Apr. 1997 Construction of Hi-net (High Sensitivity Seismograph Network Japan), KiK-net (Kiban Kyoshin Network), and F-net (Full Range Seismograph Network of Japan) started
Mar. 2000 Multi-parameter radar system completed
Jan. 2001 Jurisdiction of NIED changed to MEXT after reorganization of the ministries

1995 Southern Hyogo Prefecture Earthquake (Great Hanshin-Awaji Earthquake)

In response to the Great Hanshin-Awaji Earthquake, as a new initiative in the fields of natural science and engineering, NIED began construction of the fundamental earthquake observation network and the E-Defense (3-D Full-Scale Earthquake Testing Facility).

E-Defense
(3-D Full-Scale Earthquake Testing Facility)

2011 Great East Japan Earthquake

Following the Great East Japan Earthquake disaster triggered by the 2011 off the Pacific Coast of Tōhoku Earthquake, NIED constructed Seafloor observation network for earthquakes and tsunamis along the Japan Trench (S-net).

Ocean area from off the coast of Hokkaido to Boso Peninsula

Observation units of S-net

Apr. 2001 Independent Administrative Agency NIED established
Earthquake Disaster Mitigation Research Center (EDM) transferred to NIED from RIKEN [Miki]
The 1st mid-term objectives and plan launched
Oct. 2002 Kawasaki Laboratory established as an additional branch of EDM [Kawasaki]
Apr. 2003 EDM moved to Kobe
Oct. 2004 Hyogo Earthquake Engineering Research Center [Miki]
Apr. 2005 Operation of Three-Dimensional Full-Scale Earthquake Testing Facility (E-Defense) started [Miki]

As an Independent Administrative Agency

Apr. 2006 The 2nd mid-term objectives and plan launched
Mar. 2007 Kawasaki Laboratory closed down
Mar. 2008 Marine Observation Tower at Hiratsuka Experiment Station closed down
Apr. 2010 Operation of V-net (The Fundamental Volcano Observation Network) started
Mar. 2011 EDM closed down
Apr. 2011 The 3rd mid-term objectives and plan launched
Aug. 2011 Construction of S-net (Seafloor observation network for earthquakes and tsunamis along the Japan Trench) started
Apr. 2013 Snow and Ice Research Center reorganized (Shinjo branch changed to Shinjo Cryospheric Environment Laboratory)
Sep. 2014 — Mt. Ontake erupted —
Oct. 2014 Research Center for Reinforcement of Resilient Function established

Apr. 2015 Institute's name changed to National Research Institute for Earth Science and Disaster Resilience
Apr. 2016 - The 4th mid- and long-term objectives and plan launched
- Innovation Center for Meteorological Disaster Mitigation established
- Center for Integrated Volcano Research established
- DONET (Dense Oceanfloor Network system for Earthquakes and Tsunamis) transferred to NIED from JAMSTEC
Apr. 2017 Research Center for Enhancing Metropolitan Resilience established
Nov. 2017 Integrated operation of Monitoring of Waves on Land and Seafloor (MOWLAS) began
Apr. 2018 SIP Program Management Office established
Dec. 2018 Research Center for National Disaster Resilience established
Feb. 2019 - Construction of Nankai Trough Seafloor Observation Network for Earthquakes and Tsunamis (N-net) started
- Announcemnt of NIED's Identity
Apr. 2019 Headquarters of Nankai Trough Seafloor Observation Network for Earthquakes and Tsunamis established
Jul. 2020 Headquarters of Innovation Co-Creation established
Nov. 2021 I-Resilience Corporation established as a joint venture company

As a National Research and Development Agency

2016 Kumamoto Earthquake

At the Kumamoto Earthquake Onsite Disaster Management Headquarters, the Shared Information Platform for Disaster Management (SIP4D) was used for the first time ever by utilizing the results of R&D for DRR in the field of social science. These activities subsequently led into ISUT (Information Support Team).

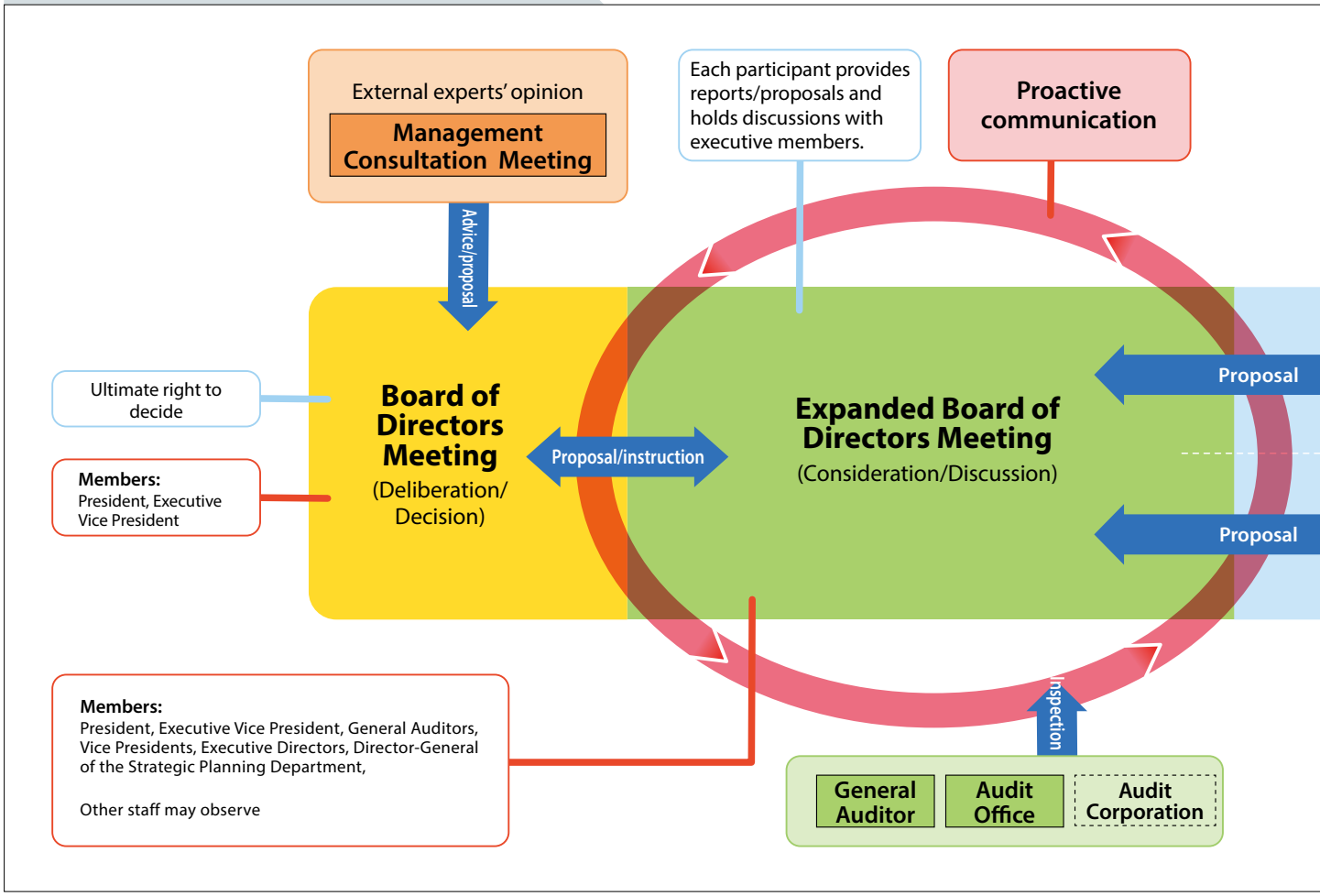
Governance and compliance for NIED

NIED is one of the National Research and Development Agencies whose purpose is to improve science and technology by conducting primary research and fundamental research and development on DRR science and technology following the seven-year mid-to-long-term goals set by the competent minister (Minister of Education, Culture, Sports, Science and Technology). Under the decision-making system of the President, whom the competent minister appoints, an Executive Vice President assists the President, and a General Auditor, whom the same minister appoints, audits the corporation's operations. Internal controls are established as part of governance under this structure, whereby under the President, duties are conducted observing laws and ordinances based on the mid-to-long term goals and under systems put in place for efficiently and effectively achieving NIED's mission as a national research and development agency.

Initiatives and operations for governance

NIED puts in place and operates a system for implementing management under which Strategic Planning Department, General Affairs Department, Basic research divisions, and Fundamental R&D centers are established. Headquarters and offices under the President's direct supervision are also established under this system. (refer to the organizational diagram on P60). Furthermore, in addition to holding a regular board of directors meeting/expanded board of directors meeting, NIED also convenes management consultation meetings with external experts and liaison coordination meetings to coordinate items related to business operations and various committees for deliberating matters of high importance. In addition, the "Opinion Exchange between the President and Staff" is held for interactive communication between the President and staff. Budget allocation hearings are held to promote various projects, thereby ensuring appropriate management.

Initiatives and operations for governance at NIED



Internal Control and Compliance Initiatives

Under the President's leadership, NIED's direction and mission are thoroughly communicated and unified, and awareness is raised to maximize the research and development results. In addition, through the expanded board of directors' meeting, the status of the execution of the institute's operations is monitored, and intentions and instructions regarding internal control and compliance initiatives are shared. In addition to identifying and flexibly addressing risks in organizational processes, internal audits and General Auditor audits are conducted, and advice is provided to the President and others on business operations.

Promotion of Health Management

- Declaration of promotion of health management in January 2021
- Appointment of health promotion leaders in each department and regular meetings
- Enhancing training to improve health literacy

Realization of a comfortable work environment

- Institutionalization of teleworking
- Establishment of remote working and meetings such as web conferencing
- Promotion of paperless conferences and development of systems for this purpose
- Review of work procedures, efficiency improvement, and countermeasures against the decline in camaraderie and cooperativeness.

Promotion of Branding

- Develop public relations and branding promotion plan
- Create integrated report
- Strengthen internal branding

Promotion of "visualization"

- Utilize time and attendance management systems, safety confirmation systems, financial accounting systems, business support systems, etc.
- Promote visualization of budget execution, budget allocation policies, individual schedules, etc.
- Started full-scale operation of NISE (Researcher Information System), which is helpful for visualization of research achievements.

Effective promotion of risk management and compliance

- Implementation of the PDCA cycle based on the risk management plan
- Review and enhancement of prevention plan for unauthorized use of public research funds
- Implementation of organizational conflict of interest management
- Establishment of an ethical review system for research involving human subjects
- Performance of periodic compliance awareness-raising activities such as training and awareness surveys

Each department
(Consideration/ Coordination/ Preparation of draft)

- Strategic Planning Department
- General Affairs Department
- Basic research divisions
- Fundamental R&D centers

Liaison and Coordination Meeting
(Consideration/Coordination/ Preparation of draft)

Each committee
(Consideration/ Coordination/ Preparation of draft)

- Risk Management Committee
- Crisis Management Exploratory Committee
- Personnel Committee
- Health and Safety Committee
- Contract Review Committee
- The 5th mid-to-long-term plan examination committee

Taking into consideration of important matters for operational administration based on relevant regulations of each committee to make recommendations based on the results. Functions as secretariat in response to draft plans from each section.

Board of Directors Meetings and Expanded Board of Directors Meetings
held regularly to hold deliberations and make decisions for essential items related to basic operational policy and business execution, as well as for crucial matters requiring decisions by management. Furthermore, an Expanded Board of Directors Meeting is held for an in-depth discussion on items placed on the agenda at Board of Directors Meetings and for significant matters regarding the management of NIED.

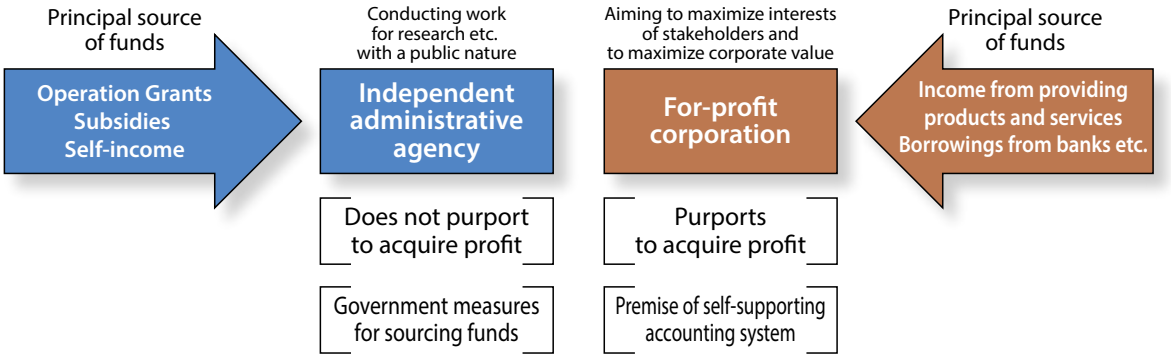
Management Consultation Meeting
By convening management consultation meetings composed of external experts, NIED can obtain exterior recommendations and proposals from objective, specialist, and wide-ranging perspectives. As well as using these to grasp operational business issues and to deliberate solutions,NIED is committed to bringing a higher level of efficiency and transparency of operations.

Liaison and Coordination Meeting
This meeting is held monthly to share awareness of issues among administrative and research divisions. We use it to communicate and coordinate the smooth execution of the Institute's work necessary to achieve the mid-to-long term plan and to share and exchange views on NIED's future role and awareness of issues to improve our work.

Accounting system for independent administrative agency

Accounting different to a for-profit enterprise, emphasizing publicness.

A national research and development agency is an independent administrative agency that carries out business/work with a public element, does not pursue profit as an objective, and does not presuppose a self-supporting accounting system such as that of a for-profit enterprise such as a joint-stock corporation. Thus, while in principle it conforms to corporate accounting principles, its accounting differs to that of a for-profit enterprise.



Formulating a system for profit and loss equilibrium

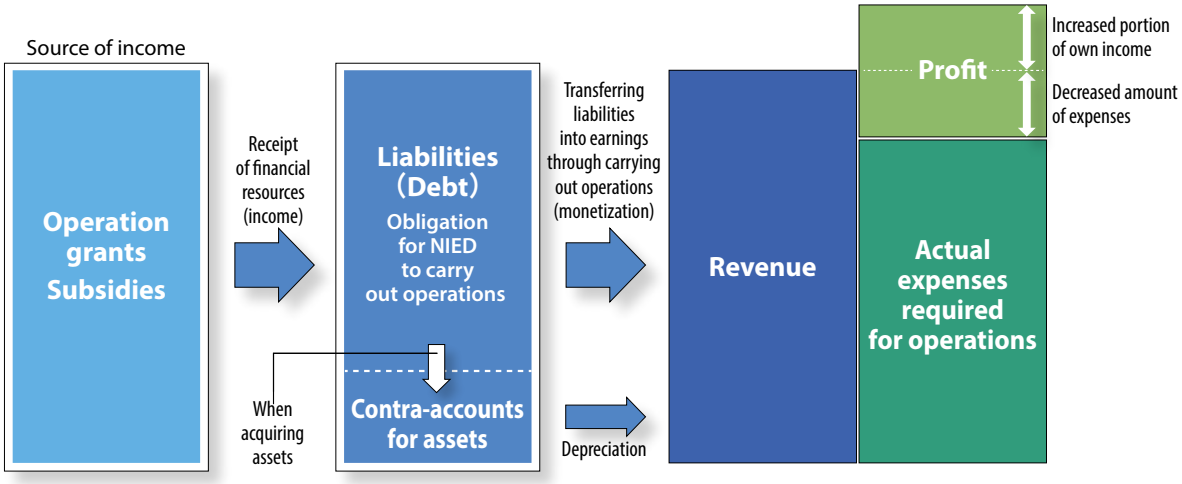
Due to the fact that National and Research Development Agencies are public in nature and do not aim to turn a profit and do not presuppose a self-supporting accounting system, in terms of the relationship between financing measures such as operation grants and subsidies, in principle a system is formulated to ensure profit and loss equilibrium.

For example, when operation grants or subsidies are received, NIED deems that it has borne the responsibility to implement a project, and books this as a liability (debt). Then, by implementing projects using these as a financial source, it is deemed that the obligation has been fulfilled, and accounting is processed to transfer liabilities into earnings.

Similarly, in cases where NIED has acquired assets using operation grants and subsidies as a financial source, these are transferred to contra-accounts for assets, and by taking away the same amount consequent upon depreciation costs and transferring liabilities into earnings, profit and loss are balanced out.

In addition, in cases where costs have been curtailed through increased self-income and management efforts including cost reduction, profit will be generated. A portion of the profit approved by Minister of Education, Culture, Sports, Science and Technology can be used in the next fiscal year onward.

Accounting flow for independent administrative agency

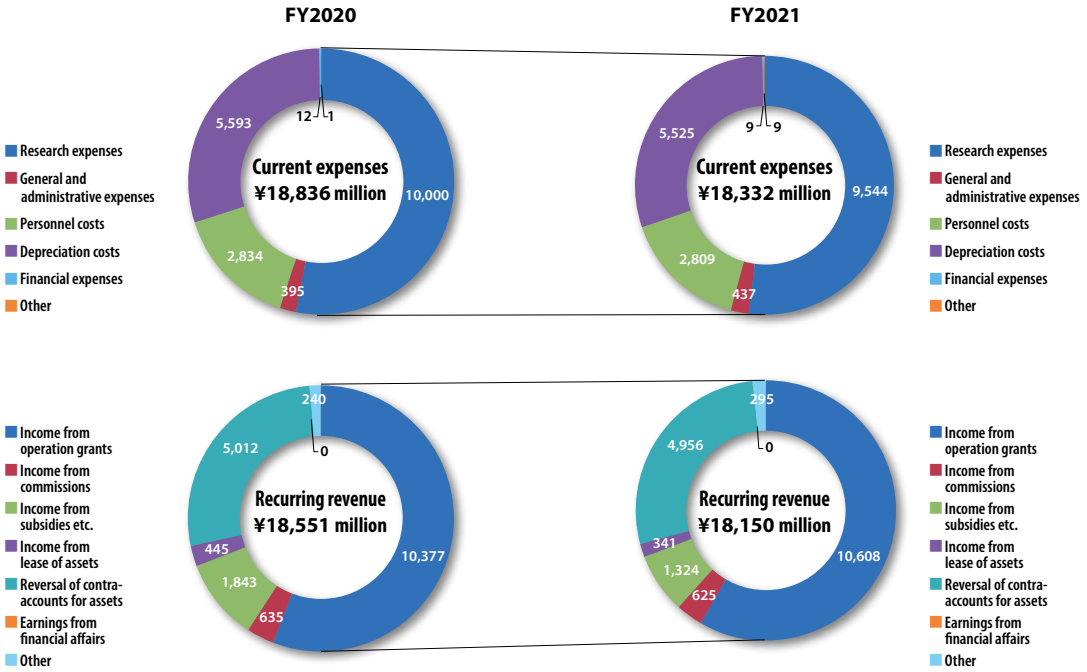


Transition of costs and earnings

Below is a comparison of costs and earnings for FY2020 and FY2021.

In expenses, there was a decrease of ¥504 million from the end of the previous fiscal year to ¥18.33 billion. This was mainly due to a decrease in research expenses, which was caused by the completion of measures for aging facilities at the Tsukuba HQs and the renewal of the earthquake and volcano observation networks in 2020, etc.

In terms of revenue, it amounted to ¥18.15 billion, a decrease of ¥410 million from the end of the previous fiscal year. This was mainly due to a decrease in facility expense revenues as a result of a decrease in expenditures financed by subsidies for facility maintenance.



State of affairs of major costs (FY2021)

NIED demarcates projects using three segments - "promotion of R&D", "formation of a core institution", "corporate common" – and numerical values booked on financial statements are disclosed as segment units.

Promotion of R&D (¥4.58 billion)

The following nine projects are in the scope of these costs.

- Advanced earthquake and tsunami forecasting technologies project
- Research on mega earthquake generation process
- Research on multidisciplinary evaluation of volcanic activity
- Research and development to enhance the resilience of social infrastructure
- Developing technology to predict water-related disasters based on multi-sensing
- Research on combining risk monitoring and forecasting technologies for mitigation of increasingly diverse snow disaster
- Research on hazard and risk assessment
- Research for the effective creation, distribution, and usage/application technologies of disaster information
- Research on the scientific clarification of disaster processes and effective disaster management

Formation of a core institute (¥ 12.86 billion)

The following six initiatives are in the scope of these costs, for expediting the strengthening of NIED's function as a core institute for innovation in science and technology for DRR.

- Promotion of industry-academia-government cooperation as a core institute.
- Operation/promotion of joint usage of observation networks/experimental facilities/information foundation
- Contribution to DRR governance
- International leverage of R&D
- Human resource development
- Dissemination of R&D results/facilitating use of intellectual property

Corporate Common (¥892 million)

Administrative departments including General Affairs Department are in the scope of these costs.

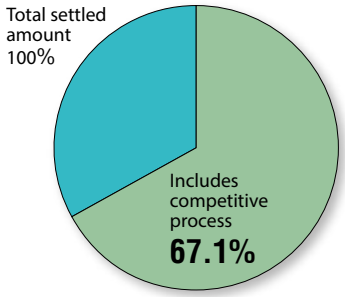
Main income sources (FY2021)

In addition to operation grant from the government, NIED is operated through income from commissions and income from leasing facilities, as well as self-income including income from patents.

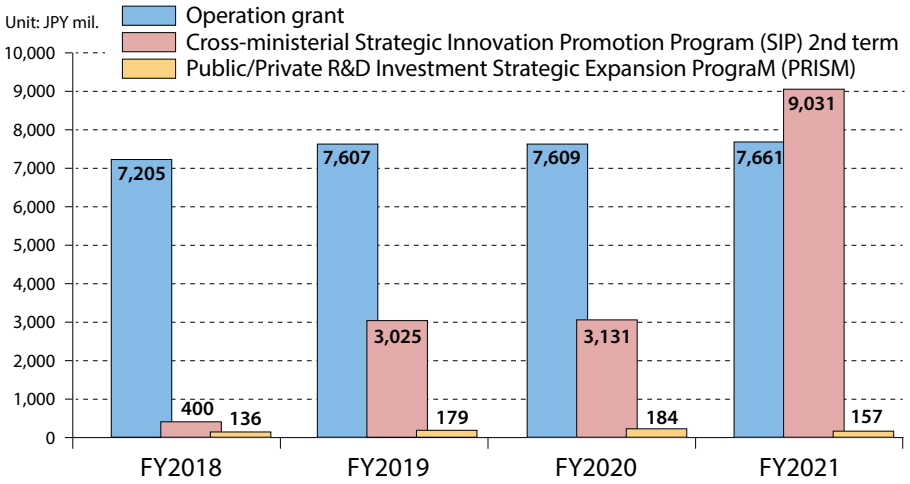
The majority of income from commissions comes from funds acquired following a competitive process

The bulk of income from commissions for FY2021 was obtained through competitive processes screened by government agencies, fund distribution organizations, and foundations. The ration of income obtained through competitive processes is 67.1%.

Ratio of income from commissions obtained through competitive process



Transition of operation grant

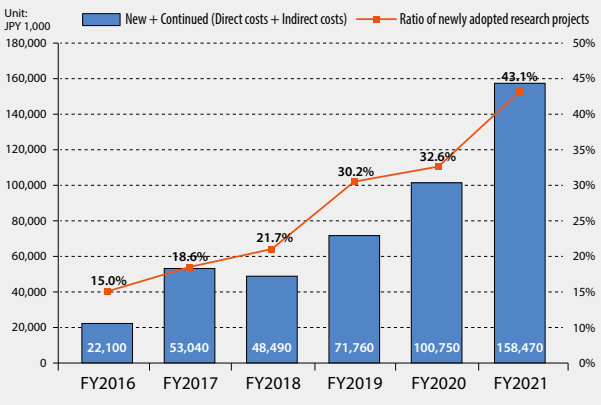


Regarding "KAKENHI" that are not shown on financial statements

Grants-in-Aid for Scientific Research (KAKENHI) are "competitive research funds" aimed at developing research, provided by Ministry of Education, Culture, Sports, Science and Technology (MEXT) to foster original and pioneering research.

KAKENHI do not show up on financial statements due to being processed as deposits received. Since FY2016, NIED has been deeply committed to acquiring KAKENHI under the mid-to-long term plan. NIED's ranking for number of research projects adopted is going up every year, as is the ratio of newly adopted projects. (See page 46)

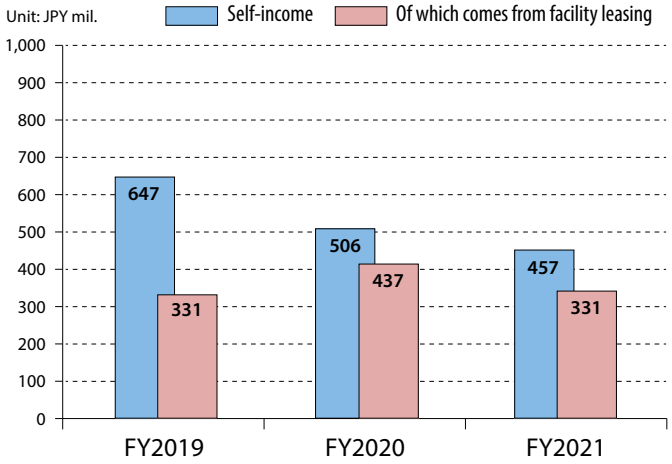
Transition of amount of KAKENHI acquired



Majority of self-income is made up of income from leasing facilities.

The majority of NIED's self-income comes almost entirely from the leasing of facilities.

Transition of self-income together with income from leasing facilities



* In FY2021, rental income was low because NIED conducted its own experiments at E-Defense.
*In FY2019, there was less lease income as an experimental facility due to the major renovation of E-Defense.

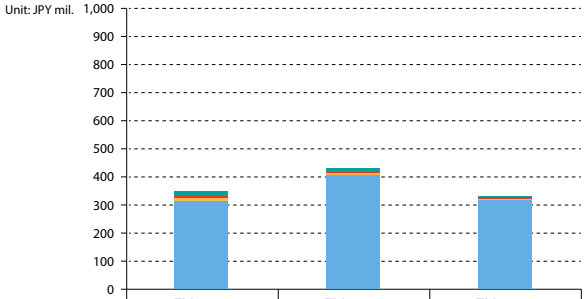
Income from leasing facilities

NIED promotes the use and application of its advanced research facilities.

In terms of leasing income by facility, E-Defense (three-dimensional full-scale earthquake testing facility) acquires the most amount of self-income, playing an instrumental role in assessing housing and industrial infrastructure. NIED is similarly actively promoting the use and application of other facilities.

E-Defense (Hyogo)

Transition of leasing income by facility



	FY2019	FY2020	FY2021
Cryospheric Environment Simulator	17	8	2
Large-scale Rainfall Simulator	3	4	5
Large-scale Earthquake Simulator	7	8	4
E-Defense	303	417	319
Total	JPY 331 mil.	JPY 437 mil.	JPY 330 mil.

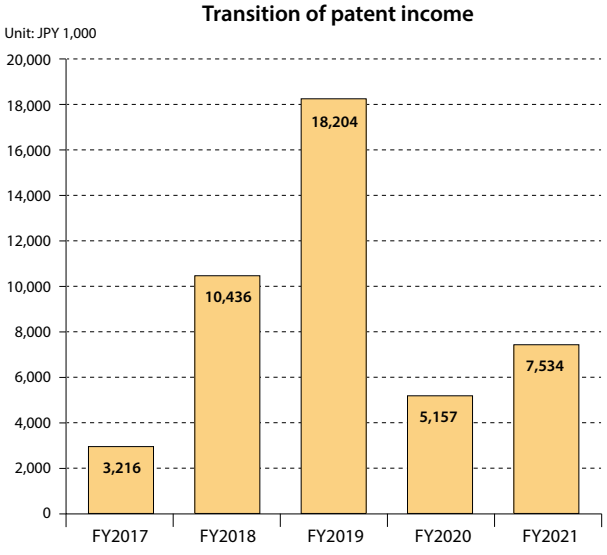
* In FY2021, rental income was low because NIED conducted its own experiments at E-Defense.
* In FY2019, there was less lease income as an experimental facility due to the major renovation of E-Defense.
* Related to rounding off of fractions, total amount does not match total income from leasing facilities.

Patent Income

NIED promotes the utilization of research results and steadily generate patent-related income.

In recent years, NIED has been steadily generating patent-related income. This is mainly due to the fact that our patents on microtremor observation and real-time seismic intensity measurement are being utilized by several private companies.

Transition of patent income



Balance Sheet

A balance sheet is a report displaying all owned assets, liabilities, and the balance of net assets, to clarify the financial condition of a corporate body at the end of the accounting period,

①Assets are the basic assets for conducting business. The balance at the end of FY2021 was ¥75.48 billion, an increase of ¥1.223 billion from the end of the previous fiscal year. Although research assets decreased due to depreciation, cash and deposits increased due to the carry-over of a portion of the subsidy program for operating expenses to the next fiscal year, which ensured flexible business execution to achieve higher results in accordance with the progress of research and development.

②Liabilities are yet unadministered portions of projects among sources of funds conferred for implementing projects (debts), and obligations to provide other parties with a specified amount of assets or services. For NIED, these are principally the balance carried forward to the following fiscal year from conferred operating expense grants and subsidies due to factors including the ensuring of flexible project execution conducive to higher results as a function of progress of R&D, and contra accounts for assets booked under the system of profit and loss equilibrium. The balance at the end of FY2021 was 39,632 million yen, an increase of ¥4,019 million from the end of the previous fiscal year. This is mainly due to the fact that a portion of the subsidies for operation expenses granted was carried over to the next fiscal year.

③Net assets are the sum total of the amount of investment provided by investors and the income resulting from activities by the organization. For NIED, these are principally the investment (contribution in kind) received from the state in FY2001 when research institutes shifted to independent administrative corporations, and capital surplus that was booked as the equivalent amount deemed to constitute the financial basis among acquired fixed assets. The balance at the end of FY2021 was ¥35,848 million, a decrease of ¥2,795 million from the end of the previous fiscal year. Although there was an increase due to the acquisition of research assets maintained with subsidies for facility maintenance, the balance has turned to a decrease due to depreciation of the maintained research assets.

Balance Sheet (Indicates financial situation as of settlement day (3/31))

(Unit: JPY1,000)

	FY2020	FY2021	Increase (Decrease)
1. Assets	74,256,740	75,479,642	1,222,902
Ⅰ Current Assets	6,750,289	10,902,725	4,152,436
Cash and deposits	6,439,427	10,631,269	4,191,843
Uncompleted commissioned research disbursements	14,956	17,818	2,862
Prepayment	4,714	4,650	(64)
Prepaid expenses	1,444	12,575	11,131
Account receivable	209,490	164,660	(44,830)
Contra-accounts for bonus reserves	80,258	71,753	(8,505)
Ⅱ Fixed Assets	67,506,451	64,576,916	(2,929,534)
1. Tangible fixed assets	66,562,276	63,661,521	(2,900,755)
Buildings	10,445,116	9,837,092	(608,023)
Structures	20,385,399	16,542,609	(3,842,789)
Machinery	7,490,956	5,754,078	(1,736,878)
Motor vehicles and transport equipment	4,535	3,468	(1,067)
Tools, equipment and fixtures	5,844,345	4,742,861	(1,101,484)
Land	17,839,565	17,839,565	0
Construction in progress	4,552,361	8,941,847	4,389,487
(Depreciation amount for current term)	8,378,517	8,361,682	(16,835)
(Impairment loss for current term)	0	0	0
2. Intangible fixed assets	321,683	288,554	(33,129)
Patent rights	11,480	11,320	(160)
(Depreciation amount for current term)	2,184	2,600	416
(Impairment loss for current term)	0	0	0
Trademark rights	6,163	7,317	1,154
(Depreciation amount for current term)	732	876	144
(Impairment loss for current term)	0	0	0
Telephone subscription right	5,244	4,916	(329)
Software	207,220	232,291	25,072
(Depreciation amount for current term)	161,858	148,766	(13,091)
(Impairment loss for current term)	0	0	0
Intellectual property rights in progress	11,947	11,794	(153)
Software in progress	79,629	20,917	(58,712)
3. Investments, other assets	622,492	626,841	4,350
Shares of affiliate	0	16,328	16,328
Deposits	3,300	3,300	0
(Depreciation amount for current term)	0	0	0
Money on deposit	104	74	(30)
Contra-liabilities for retirement benefit reserves	619,088	607,139	(11,949)

	FY2020	FY2021	Increase (Decrease)
2. Liabilities	35,613,454	39,631,709	4,018,254
Ⅰ Current liabilities	7,068,300	11,200,063	4,131,762
Operating expenses grants liabilities	1,961,123	7,580,709	5,619,586
Received facilities costs	10,671	13,317	2,646
Received subsidies etc.	30,115	9,625	(20,490)
Received donations	11,456	22,398	10,942
Arrears	4,566,680	3,032,717	(1,533,964)
Advance received	30,312	66,872	36,561
Withholdings	47,250	72,332	25,082
Bonus allowances	80,258	71,753	(8,505)
Short-term lease debt	330,435	330,340	(95)
Ⅱ Fixed liabilities	28,545,154	28,431,646	(113,508)
Contra-accounts for assets	27,176,026	27,336,397	160,370
Assets funded by operational grants	2,338,856	2,282,264	(56,593)
Encumbrance for assets-subsidy for operation	15,353,509	12,474,405	(2,879,104)
Encumbrance for assets donated	4,908,241	3,609,053	(1,299,188)
Assets funded by donations	23,059	28,827	5,768
Construction in progress funded by operational grants	1,911	8,473	6,563
Construction in progress funded by subsidies for facilities	0	809	809
Construction in progress funded by donations	4,550,450	8,932,566	4,382,115
Reserves for retirement benefits	619,088	607,139	(11,949)
Long-term deposited donations	0	10,000	10,000
Long-term lease debts	750,040	478,111	(271,930)
3. Net Assets	38,643,285	35,847,933	(2,795,352)
Ⅰ Capital stick			
Government investment	58,902,885	58,902,885	0
Ⅱ Capital surplus	(21,100,368)	(23,713,031)	(2,612,663)
Capital surplus	63,105,242	63,484,030	378,788
Accumulated amount for other administration costs	(84,205,610)	(87,197,061)	(2,991,451)
Accumulated depreciation amount	(75,533,793)	(78,302,002)	(2,768,209)
Accumulated impairment loss	(285,670)	(261,090)	24,580
Accumulated difference in retired and disposed assets	(8,386,147)	(8,633,969)	(247,822)
Ⅲ Retained earnings	840,768	658,079	(182,689)
Reserve fund carried over from the previous mid-term objectives period	541,264	433,349	(107,915)
Reserves	471,656	299,504	(172,152)
Unappropriated retained earnings (minus is total loss for current period)	(172,152)	(74,775)	97,377

Account Statement for Administration Costs

The account statement for administration cost is a report showing results of work (output information) with "administrative cost" (= cost required to achieve work results) as comparative information, from the perspective of providing information pursuant to the appropriate assessment of the work of an independent administrative corporation.

In addition to costs on the profit and loss statement, other administrative costs that are also included and which do not show up on the account statement are costs for depreciation amount for depreciable assets processed in accordance with "No.87 Account processing for equivalent amount of costs related to specific assets" (*).

(*) No.87 Account processing for equivalent amount of costs related to specific assets

With respect to depreciable assets held by an independent administrative agency that are identified as those for which no revenue is expected to be earned from their depreciation, the amount equivalent to the depreciation of such assets shall not be charged to expense in the profit and loss statement, but shall be reduced from capital surplus.

Account statement for administrative costs (From April 1, 2021 to March 31, 2022) (Unit: JPY)

Ⅰ Costs on Profit and Loss Statement		
Research expenses	17,422,167,412	
General and administrative expenses	891,621,307	
Financial expenses	9,304,017	
Miscellaneous losses	9,308,983	
Total costs on Profit and Loss Statement		18,332,401,719
Ⅱ Other Administrative Costs		
Depreciation amount	2,989,278,454	
Sales and retirement difference amount	2,172,887	
Total other administrative costs		2,991,451,341
Ⅲ Administrative costs		21,323,853,060

Statement of Income

The Profit and Loss Statement is a report indicating expenses for research activities (costs) and the financial sources required to fund them (revenue), in order to clarify the operational circumstances for the accounting period (April 1st to March 31st).

① Current expenses were ¥18.33 billion, down ¥504 million from the end of the previous fiscal year. This was mainly due to a decrease in business consignment expenses, etc., financed by subsidies for facility maintenance.

② Recurring revenues totaled ¥18.15 billion, down ¥401 million from the end of the previous fiscal year. This was mainly due to a decrease in revenues from facility expenses, which accompanied a decrease in expenditures financed by subsidies for facility maintenance.

Statement of Income (to clarify operational circumstances for the relevant FY) (Unit: JPY1,000)

	FY2020	FY2021	Increase (Decrease)
1. Current expenses	18,835,600	18,332,402	(503,199)
Research expenses	17,952,402	17,422,167	(530,234)
Personnel expenses	2,280,177	2,277,165	(3,012)
Business consignment expenses	7,906,982	7,372,548	(534,434)
Communications expenses	923,673	963,936	40,263
Depreciation	5,562,310	5,499,774	(62,537)
Provision for bonuses	65,107	58,690	(6,417)
Retirement benefit expenses	44,940	42,663	(2,277)
Expenses	1,169,212	1,207,391	38,179
General and administrative expenses	869,644	891,621	21,977
Personnel expenses	391,810	413,690	21,879
Business consignment expenses	181,559	169,677	(11,882)
Communications expenses	2,842	3,177	335
Taxes and dues	42,423	68,447	26,024
Depreciation	30,940	24,872	(6,068)
Provision for bonuses	15,151	13,063	(2,088)
Retirement benefit expenses	37,159	3,357	(33,802)
Expenses	167,760	195,340	27,580
Financial expenses	12,142	9,304	(2,838)
Interest paid	12,142	8,982	(3,160)
Loss on valuation of shares of subsidiaries and associates	0	322	322
Miscellaneous losses	1,413	9,309	7,896

	FY2020	FY2021	Increase (Decrease)
2. Recurring revenue	18,551,023	18,149,712	(401,310)
Revenue from operating expense grants	10,376,708	10,607,788	231,080
Government commissioned income	274,710	293,443	18,733
Other commissioned income	360,536	331,907	(28,628)
Subsidies for facilities	403,272	35,080	(368,192)
Revenue from subsidies etc.	1,439,468	1,288,889	(150,578)
Revenue from donations	283	317	34
Revenue related to contra-accounts for bonus reserves	80,258	71,753	(8,505)
Revenue related to contra-accounts for retirement benefit reserves	82,099	46,020	(36,079)
Reversal of contra-accounts for assets	5,011,937	4,956,324	(55,613)
Property leasing income	444,810	340,987	(103,823)
Miscellaneous income	76,944	177,205	100,261
(Recurring profit (Loss))	(284,578)	(182,689)	101,888
3. Current net income (Loss)	(284,578)	(182,689)	101,888
4. Reversal of reserve fund carried over from the previous mid-term objectives period	112,426	107,915	(4,511)
5. Current gross income (Loss)	(172,152)	(74,775)	97,377

For a deeper understanding of NIED's activities.

KEYWORD 1

"Disaster"

Phenomena that occur at the intersection of hazards (natural phenomena) and the disaster resilience of society.

The word "disaster" tends to conjure up a threat from actual hazards (natural phenomena) such as earthquakes, tsunami, volcanos, violent winds, torrential rains, snowstorms, typhoons, landslides and so on. However, the amount of damage that these hazards cause (becoming a disaster) depends enormously on the level of disaster resilience of society. This is why NIED promotes research on both hazards and the disaster resilience of society.

Even for the same hazard (natural phenomena), the amount of damage differs greatly depending on the disaster resilience of society.

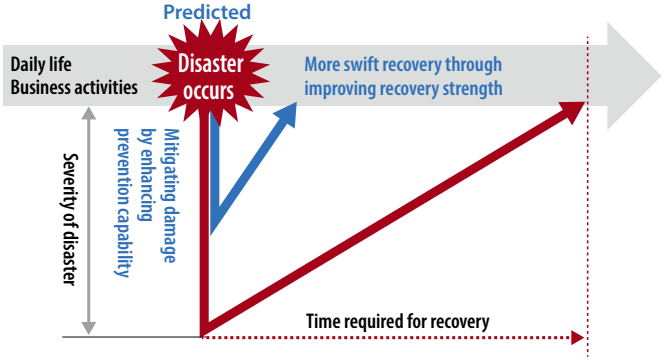
Damage is sustained when the hazard overwhelms the disaster resilience of society. The scale of the "disaster" largely depends on the disaster resilience of society.

KEYWORD 2

"Resilience"

Comprehensive resilience encompassing prediction/prevention capabilities with recovery strength.

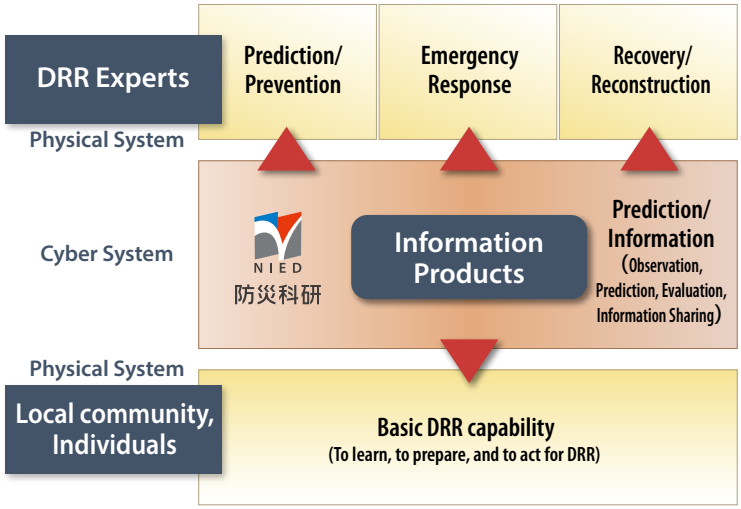
In order that livelihoods are not devastated by the threat of natural hazards, it is vital to approach disasters both from the aspect of "damage prevention and mitigation to the absolute minimum (prevention capability)", and "swift recovery" after the disaster has occurred (recovery strength). The comprehensive actions will enhance "resilience".



CONCEPT VISUAL 1

Cyber-Physical System of DRR domain for Society 5.0

Japan aims to realize Society 5.0 under the 5th Period Basic Plan for Science and Technology, and NIED is deliberating the ideal state of the DRR domain there. Society 5.0 is a world where the information realm (Cyber) and the physical realm (Physical) are melded to a high degree. For DRR in the physical realm, communities of experts each involved in prevention, emergency response, and recovery/reconstruction play an instrumental role in overcoming disasters as a physical force. In the cyber realm, creating information products tailored to various aspects will combine the four physical capabilities with the aim of realizing an overall resilient society.

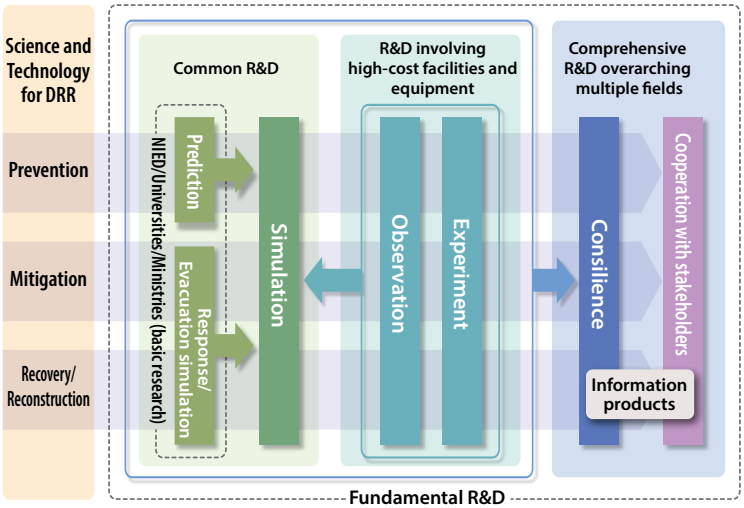


CONCEPT VISUAL 2

R&D for DRR science and technology

Science and Technology for DRR refers to that conducive to preventing disasters before they occur (prevention), mitigating the damage (emergency response), and expediting recovery/ reconstruction from disasters.

- Common R&D: In addition to fundamental research in specialized fields, research aimed at simulations of entire disasters by combining common technologies and date including AI, GIS, and big data.
- R&D involving high-cost facilities and equipment: Research using one-of-a-kind facilities/equipment, utilizing the foundational observation networks and cutting-edge experimental facilities.
- Comprehensive R&D overarching multiple fields: R&D through multi-lateral cooperation spanning multiple domains with all stakeholders for co-creation.



OVERVIEW [Institute Information]

Facts

Institute name	**National Research Institute for Earth Science and Disaster Resilience**
Abbreviation	**NIED**
Board members	**President** **HAYASHI Haruo**
	Executive Vice President **ANDO Yoshiaki**
	General Auditor **SATO Takeshi, JINNO Norie (part-time)**
Employees	**341 (including 168 researchers, 173 clerical staff)** * As of March 31st 2022
Annual budget	**7.66 billion yen (Operation grant)** * FY2021
Jurisdiction	**Ministry of Education, Culture, Sports, Science and Technology (MEXT)**

NIED HQs and Research Centers

Snow and Ice Research Center
(Nagaoka, Niigata Prefecture)

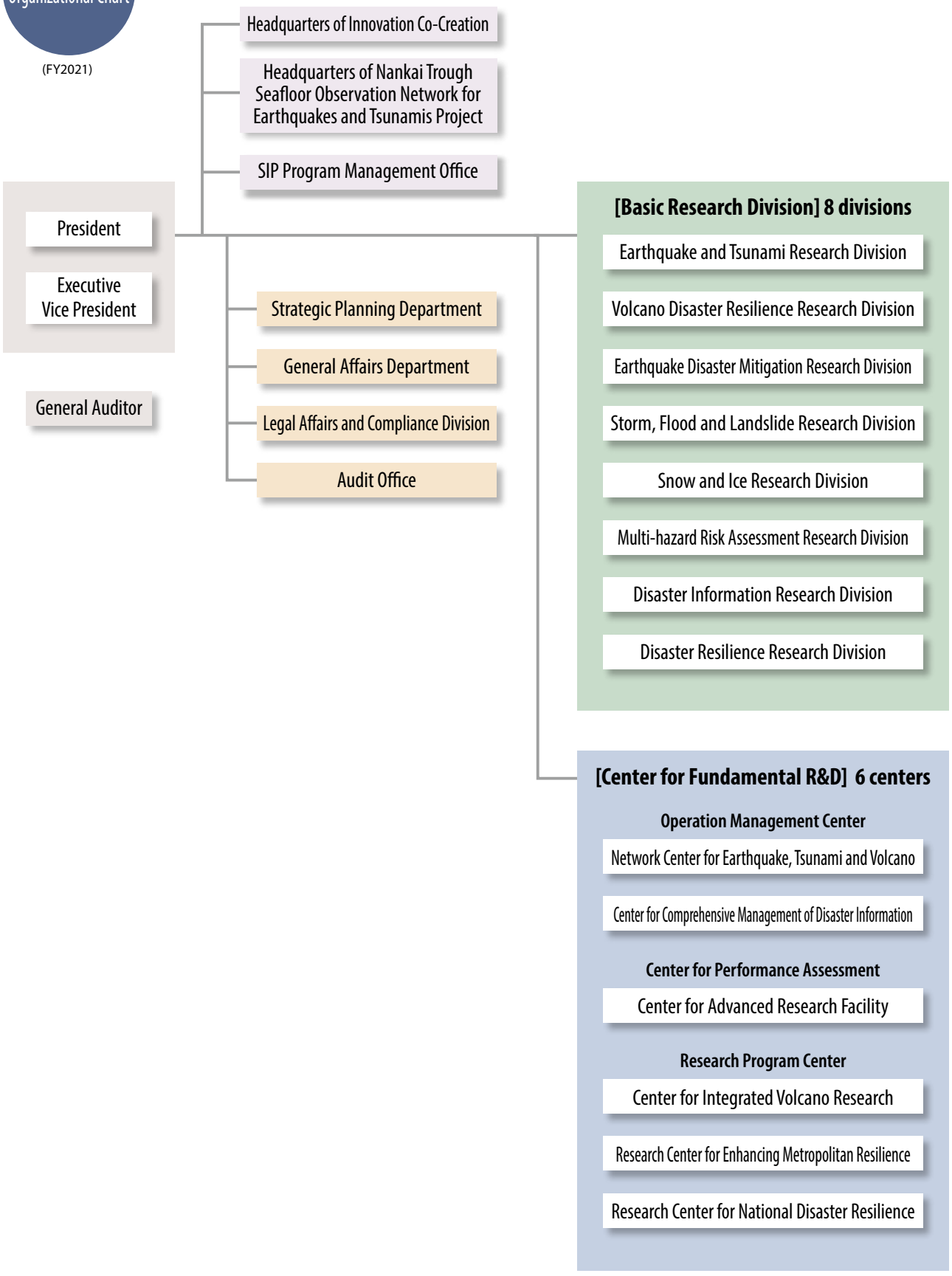
Snow and Ice Research Center, Shinjo Cryospheric Environment Laboratory
(Shinjo, Yamagata Prefecture)

Hyogo Earthquake Engineering Research Center
(Miki, Hyogo Prefecture)

Tsukuba HQs
(Tsukuba, Ibaraki Prefecture)

Organizational Chart

(FY2021)



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SCIENCE FOR RESILIENCE

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