Research Plan for

the Centre for Environmental Creation

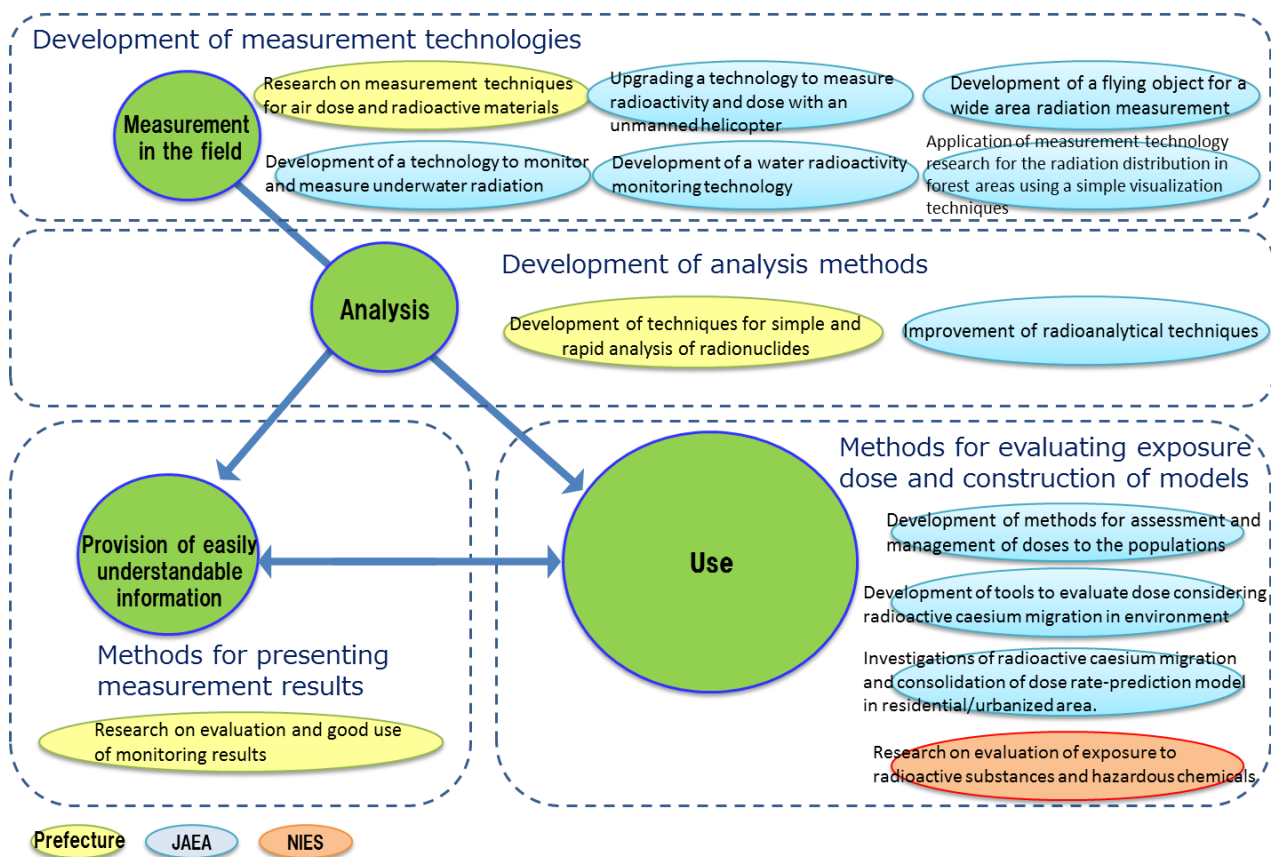## (*Provisional Translation*)

Contents

I Radiation Measurement

Relationship among research and development activities in the Radiation Measurement Division

| 1. Development of analysis methods | [Fukushima Prefecture, JAEA] |

① **Development of methods for simple and rapid analysis of radionuclides**

For present contamination status by radionuclides released into the environment from the Fukushima Daiichi Nuclear Power Plant accident, the main subject of investigation has been contamination with ^{134}caesium and ^{137}caesium. Contamination with ^{90}strontium, tritium, plutonium, etc., has yet to be sufficiently clarified, as the analysis for these nuclides is both complicated and time-consuming. Existing analysis techniques will be improved by simplification, acceleration and automation, and rapid and precise alternative analysis methods will also be developed.

▶▶▶ Application of outcomes

Improved and newly-developed methods will contribute to the rapid analysis of such nuclides and help provide information for the safety and peace of mind of prefectural inhabitants.

【Fukushima Prefecture】

② **Upgrading of radioanalytical techniques**

Development of simple and rapid analytical techniques is planned with regards to the quantification of ^{90}strontium and organically bound tritium (OBT) in environmental samples.

^{90}strontium analysis based on mass spectrometry, techniques for eliminating isobaric interferences, and for enhancing sensitivity, etc. will also be developed. For OBT, automatization and speed up of combustion water recovery techniques will also be developed for the analysis of non-exchangeable organically bound tritium (NE-OBT), which is a key contributor from the perspective of internal dosimetry.

The behavior of ^{90}strontium and tritium in the environment differs from that of ^{137}caesium. The developed techniques can be thus usefully utilized for environmental monitoring of these nuclides in various flora and fauna, with an emphasis on agricultural and marine products.

▶▶▶Application of outcomes

The developed techniques can be utilized for quantifying radioactivity in various samples, including marine products. Provision of information on these activities promotes the safety and serves to reassure, residents of Fukushima prefecture.

【JAEA】

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2. Development of measurement technologies	[Fukushima Prefecture, JAEA]

① **Research on measurement technologies for air dose and radioactive materials**

In the current circumstances, whereby air dose must be measured in the high-dose areas and over a wide ranging area, requiring techniques which enable stable, high-precision measurements, continuous measurement techniques by an automatic system will be developed, to save human resources, etc. These will be accompanied by visualization techniques to present measurement results visually, to contribute to efforts to reduce exposure dose and the burden of work for radiation measurement workers.

Technologies and methods for measuring radionuclides that may be released into the environment as a result of the ongoing reactor decommissioning work at Fukushima Daiichi Nuclear Power Plant, i.e., tritium and ^{85}krypton, will be developed. This process will take the particular circumstances of Fukushima Prefecture, e.g., high background doses, into consideration.

▶▶▶ Application of outcomes

The technologies and methods developed will enable detailed and precise monitoring responsive to the needs of the people and municipalities of Fukushima Prefecture. Prompt information provision on the environmental effects of decommissioning work will contribute to ensuring the safety and peace of mind of prefectural inhabitants.

【Fukushima Prefecture】

② **Upgrading a technology for measuring radioactivity and dose with an unmanned helicopter**

A radiation measurement system using a large unmanned helicopter for pesticide spraying or a smaller device called a multicopter will be developed and optimized. Analysis methods for estimating radionuclide settling distributions in forests and mountainous regions will be developed, and measurement technologies with mapping will be enhanced.

▶▶▶ Application of outcomes

Data on radioactive material transfer and wide area measurements will be disseminated, to serve as information to reassure citizens of the prefecture of their safety.

③　Development of a flying machine for wide-area radiation measurement

Radiation measurement technologies using an unmanned airplane created in 2014 by JAXA will be developed. Such technologies will enable detailed radiation measurement over a wide area over short time periods. With such technologies for radiation measurement from above, it will be possible to observe radiation in areas which are difficult to access, such as forests and mountainous areas.

▶▶▶　Application of outcomes

　　Measurement data on forests and mountainous area will be provided as a form of information to assure inhabitants of the prefecture of their safety.

【JAEA】

④　Development of technologies for monitoring and measurement of underwater radiation

Plastic Scintillation Fiber (PSF) detector technologies will be applied to measurement of radioactivity on the bottoms of ponds/lakes to develop an evaluation method with gamma-ray spectra and a method for measuring a three dimensional radioactive material distribution. A Remote Operation Vehicle (ROV) will be applied to measurement of underwater radioactive materials on the bottoms of dams and estuaries.

▶▶▶　Application of outcomes

The technologies will be used to measure radioactivity on the bottom of, and within, waterways contaminated due to the nuclear power plant accident, and information on the measurement results will be provided to inhabitants of the prefecture.

【JAEA】

⑤　Development of water radioactivity monitoring technologies

As part of the reconstruction and environmental restoration activities in Fukushima prefecture, a water radioactivity monitoring system capable of *in-situ*, rapid, highly accurate, and continuous measurement will be developed to obtain the quantities of ^{137}caesium and ^{134}caesium in water samples from storage reservoirs, agricultural water, mountain runoff and seepage from Interim Storage Facilities, in order to secure the safety of local inhabitants and to assure them of this safety, as well as for agricultural workers. Continual measurement of radioactivity in waterways will be carried out for analysis and evaluation of the transport of radioactive contaminants in the environment.

▶▶▶　Application of outcomes

　These technologies will enable rapid analysis of such transport so that related information can be provided for the safety and reassurance of inhabitants of Fukushima prefecture.

【JAEA】

⑥　Research in technologies for measurement of radiation distributions in forest areas using a simple visualization technique

Technologies are needed both to measure air dose rate distributions over wide areas and short time periods of follow-up monitoring, and to compare the air dose rate before and after decontamination. Technologies to clearly present measurement results of concern to inhabitants are also needed.

However, there are difficulties involved with research into application of walking survey techniques to measurement of air dose rate in forest areas in mountains regions, due to the difficulty of ascertaining positional information which would best inform environmental recovery.

▶▶▶ Application of outcomes

These technologies will help facilitate the generation and dissemination of monitoring results for the safety and reassurance of inhabitants of Fukushima Prefecture.

【JAEA】

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3. Methods for presenting measurement results　　　　　　[Fukushima Prefecture]

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① **Research on evaluation and best use of monitoring results**

Information based on the enormous volumes of data generated in the course of monitoring activities should be provided for the inhabitants of the prefecture in an easily-understandable and appicable manner. For this purpose, methods for presenting such information, e.g., by creating a radiation dose distribution map, will be studied. This will produce a database useful for evaluating the effect of the nuclear plant accident in terms of exposure dose, and changes in that effect since the accident. Methods for evaluating and applying the results of monitoring of environmental radiation will be considered.

▶▶▶ Application of outcomes

Research results will be used to ensure the safety and peace of mind of prefectural inhabitants.

【Fukushima Prefecture】

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4. Development of methods and models for evaluation of exposure dose [JAEA, NIES]

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① **Investigations into radioactive caesium migration, and dose rate-prediction models for residential/urban areas**

Fundamental data used for evaluating radioactive caesium migration and dose rate-prediction models will be merged by comprehensive/detailed investigations into radioactive caesium distribution and dose rate distribution, as well as temporal changes in such distributions in residential/urban areas. The dose rate-prediction model will be improved as appropriate by combining the factors to control the dose rate, such as meteorological conditions.

▶▶▶ Application of outcomes

A dose rate-prediction tool will be provided for the safety and reassurance of local inhabitants.

【JAEA】

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② **Development of methods for assessment and management of radiation doses to the population**

Approaches and models for assessing the radiation doses to the populations living in the areas contaminated due to the Fukushima Daiichi Nuclear Power Station (1F) accident will be developed. On the basis of those approaches and models, the radiation doses to the

populations and the effectiveness of protective actions will be assessed retrospectively, considering the improvement of emergency response actions, following the Fukushima 1F accident. In addition, the effectiveness of medium- and long-term exposure protective actions in terms of population doses will be analyzed in order to optimize those actions described for environmental restoration in the affected areas.

▶▶▶ Application of outcomes

Information concerning the radiation doses and relevant issues will be provided for the inhabitants to ensure the safety and attendant peace of mind in their daily lives.

【JAEA】

③ Development of tools for evaluating radiation doses, taking radiocaesium migration in the environment into consideration

Tools for evaluating external and internal radiation doses, taking into consideration the spatial distributions of radioactive caesium in soils and water, the topography, forest distributions, the radioactivity transfer to plants, etc. based on investigations and simulations of radioactive caesium migration, will be developed.

▶▶▶ Application of outcomes

Tools for evaluating radiation doses will be produced to ensure the safety and provide reassurance to inhabitants.

【JAEA】

④ Research on evaluation of exposures to radioactive substances and hazardous chemicals

To provide information that will serve to minimize exposures to radiation and hazardous chemicals in the event of a disaster by improving our understanding of the exposure sources and pathways, a model for estimating exposure to radioactive substances (mainly radioactive caesium) originating from the Fukushima Daiichi Nuclear Power Plant accident as well as hazardous chemicals will be developed. Environmental measurements will also be conducted to reduce exposure doses.

▶▶▶ Application of outcomes

The model and its parameters for evaluation of the exposure to chemicals will be disseminated and made available for the protection of human health in the event of a disaster.

【NIES】

Ⅱ Decontamination and contaminated waste disposal
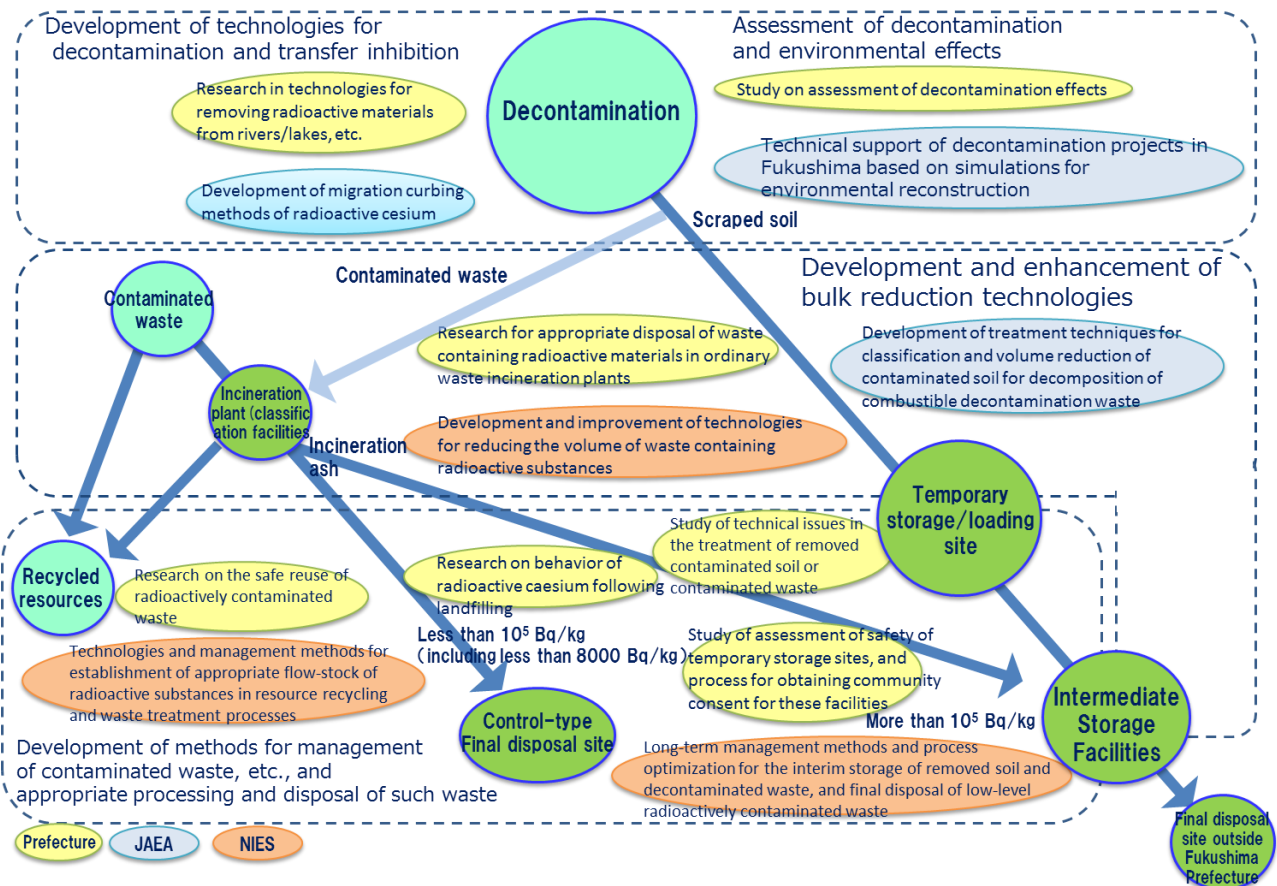
Relationship among research areas in the Decontamination/Contaminated Waste Disposal Division

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1. Development of technologies for decontamination and transfer inhibition

[Fukushima Prefecture, JAEA]

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① **Study of decontamination technologies for rivers and lakes.**

The areas in which people live have been given priority in decontamination initiatives so far, but minimal decontamination has been carried out in rivers and lakes. It is necessary to study technical aspects of the decontamination of rivers and lakes so as to effectively address the problems that may occur when considering the various circumstances particular to rivers and lakes in Fukushima Prefecture with regards to the effect of radioactive materials. Knowledge on relevant technologies in Japan and from overseas will be collected and organized and the technologies to be used will be developed by means of demonstration tests. Effective decontamination methods applicable to particular problems will be studied.

▶▶▶ Application of outcomes

The developed technologies will be used to expedite the recovery of the environment and the decontamination work to ensure the safety and peace of mind of prefectural inhabitants.

② **Development of methods for curbing migration of radioactive caesium**

Through a comparative study of various methods for curbing radioactive caesium migration in fine soil particles by the surface runoff from the slopes, migration curbing methods appropriate to the relevant conditions or situation will be proposed in terms of their features and usefulness. In addition, from the point of view of effectiveness and efficiency, a quantitative comparison of the methods for curbing the migration of radioactive caesium which is transported in fine soil particles by water flow in small streams, such as agricultural waterways for rice paddy fields, will be conducted. Migration curbing methods appropriate for the conditions or situation will be proposed.

▶▶▶ Application of outcomes

Effective methods for curving the migration of radioactive materials transported in fine soil particles will be proposed to reduce possible exposure doses, and ensure inhabitant safety and peace of mind. The reconstruction of the agricultural industry will be facilitated by proposing the methods for reducing the exposure to, and concentrations of, radioactive caesium in irrigation water.

【JAEA】

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2. Assessment of effect of decontamination, and assessment of effect on the environment
   [Fukushima Prefecture, JAEA]

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① **Study of evaluation of decontamination effectiveness**

To make good use of the advanced knowledge acquired from experiences in Fukushima prefecture, the measures taken by municipalities in the areas where people live, including decontamination, in terms of applied method/technology, site, time, cost, air dose rate reduction effect, and maintenance of decontamination effect, will be systematically reviewed and a comprehensive evaluation conducted.

▶▶▶ Application of outcomes

Information on the status of environmental recovery of Fukushima Prefecture will be provided to the inhabitants to contribute to their peace of mind.

【Fukushima Prefecture】

② **Technical support for decontamination in Fukushima based on simulations for environmental reconstruction**
   - Application of the Restoration Support System for Environment (RESET) on decontamination evaluation –

In order to support the effective and efficient implementation of decontamination by national and local governments; decontamination effects will be checked; risk communication to support the return of evacuees provided; predictive estimation to identify appropriate decontamination areas and methods conducted; and the present and ongoing effectiveness of decontamination evaluated using RESET.

►►► Application of outcomes

This support will expedite the completion of decontamination projects and environmental reconstruction, which in turn will ensure the safety and be a source of relief for returnees.

【JAEA】

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3. Development and enhancement of bulk reduction technologies

[Fukushima Prefecture, JAEA, NIES]

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① **Study of proper treatment of radioactively contaminated waste at municipal solid waste incinerators**

Burning conditions, etc., under which the migration of radioactive caesium into bottom ash/fly ash can be controlled will be studied by means of demonstration tests in a municipal solid waste incinerator. The elution characteristics of radioactive caesium from the bottom ash/fly ash will be studied, and technologies developed to remove or make insoluble radioactive caesium.

In addition, treatment methods using bag filter fabric will be studied, and the most appropriate method identified.

►►► Application of outcomes

The outcome of this research will enable the safe and proper disposal of incineration ash, and allay associated inhabitant anxieties.

【Fukushima Prefecture】

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② **Development of techniques for treatment of contaminated soil and combustible decontamination wastes for classification and volume reduction**

Soil/waste treatment systems to classify and efficiently reduce volumes to the extent possible will be developed and proposed to the government as candidate treatment systems at Interim Storage Facilities in Fukushima prefecture. Feasible soil applications following treatment by such systems will also be proposed to the government. These tasks will be coordinated and implemented with government-funded projects.

For combustible decontamination wastes, such as tree branches and leaves, non-incineration decomposition techniques involving only low risks of radioactive caesium release will be developed to reduce waste volumes and inhabitant concerns.

►►► Application of outcomes

Various impacts associated with the final disposal project can be mitigated by reducing volumes of contaminated soil and wastes to be disposed.

【JAEA】

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③ **Development and improvement of technologies for reducing the volumes of wastes containing radioactive substances**

To achieve appropriate treatment of contaminated wastes and early restoration of the environment, the behavior of radioactive Cs in temporary intermediate treatment facilities, etc., in Special Decontamination Areas will be investigated, and methods developed for controlling the behavior to facilitate the safe operation of those facilities.

Methods for the appropriate maintenance and dismantling of those waste treatment facilities will be developed and proposed. Technologies for reducing the volumes of the final disposal wastes will be developed and improved in conjunction and cooperation with demonstration projects being carried out by the national government and other concerned parties.

▶▶▶ Application of outcomes

The outcomes of these activities will contribute to the early appropriate treatment of contaminated wastes, reduction of the volumes of final disposal wastes, and the safe maintenance and dismantling of treatment facilities.

【NIES】

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4. Development of methods for management of contaminated wastes and appropriate treatment and disposal of such wastes   [Fukushima Prefecture, NIES]

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① **Study for appropriate treatment of wastes containing radioactive materials at municipal solid waste incinerators**

In order to store removed soil and contaminated wastes produced as a result of decontamination in temporary storage sites, and also to appropriately treat and dispose of the soil/contaminated wastes, technical issues such as the manner of storage, methods for their removal from temporary storage sites, and methods for their effective use such as their employment as cover soil will be considered by demonstrating the relevant existing techniques and appropriate new technologies to implement these measures will be developed.

▶▶▶ Application of outcomes

The outcomes of this study will contribute to ensuring the safety and peace of mind of concerned inhabitants.

【Fukushima Prefecture】

② **Safety assessment of temporary storage sites and consensus building among citizens regarding facility installation**

In order to deal with local anxieties regarding temporary storage sites, a safety assessment method for these sites in Fukushima prefecture with regards to protection from radiation will be established.

In addition, in order to facilitate a prompt and appropriate ongoing response for any such future cases, know-how and information on community approaches, and site costs and specifications with regards to construction, etc. will be collated and systematized. Processes for obtaining community consent will also be considered.

▶▶▶ Application of outcomes

The outcomes of the study will contribute to the mitigation of inhabitant anxieties, and be applied in the event of similar future cases.

【Fukushima Prefecture】

③ **Research on the behavior of radioactive caesium after landfilling of waste**

In order to facilitate the safe and appropriate long term management of disposal sites for

contaminated wastes, the long-term behavior of radioactive caesium in the disposal sites in which caesium-contaminated wastes are landfilled will be evaluated and studied.

In addition, improved technologies for maintaining and managing the disposal sites, predicting changes of their properties due to leachates from those sites, and predicting and adjusting for their stable management will be considered and developed.

▶▶▶ Application of outcomes

The outcomes of this study will be useful in mitigating inhabitant anxieties, and will contribute to the safe and appropriate long-term maintenance and management of those sites.

【Fukushima Prefecture】

④　**Research for safe reuse of radioactively contaminated waste**

In dealing with radioactively contaminated wastes produced in Fukushima prefecture, it is feasible and appropriate to use such wastes which are minimally contaminated by radiation as recycled resources. Towards this purpose, we will study the transfer and accumulation of radiation when such wastes are used as recycled resources. The long-term safety and effects of such wastes on human living environments will also be elucidated and assessed.

▶▶▶ Application of outcomes

The outcomes will enable the reuse of these wastes and contribute to the formation of a material-cycle society.

【Fukushima Prefecture】

⑤　**Technologies and management methods for establishing the appropriate flow-stock of radioactive substances in resource recycling and waste treatment processes**

To prevent long-term human exposures to radioactive Cs associated with flows of contaminated materials in the anthroposphere, research into the behavior of radioactive Cs will be conducted, and methods for long-term prediction of that behavior developed. Technologies and methodologies for the appropriate management of radioactive substances, including their storage, transport, and recycling, and extending to attendant issues such as the dismantling and disposal of contaminated wastes will be developed and proposed.

▶▶▶ Application of outcomes

The outcomes from these initiatives will contribute to facilitating the long-term prevention of radiation exposure in humans, which could be associated with recycling and disposal of contaminated materials, promote appropriate treatment of contaminated wastes tailored to their flows, and promote early restoration of the environment.

【NIES】

⑥　**Long-term management methods and process improvement for the interim storage of removed soils and decontamination wastes, as well as the final disposal of contaminated wastes with low levels of radioactivity**

We will draw up recommendations for technologies and systems to improve and promote the safe, long-term management of final disposal sites for specified municipal/industrial solid

wastes and designated waste, and for the interim storage processes for removed soil and decontamination wastes. The associated basic technologies and evaluation methods will be developed.

▶▶▶ Application of outcomes

The outcomes will contribute to proper final disposal and long-term maintenance of contaminated wastes with low levels of radioactivity by local governments and other entities, and to the construction and appropriate long-term management at national/local Interim Storage Facilities.

【NIES】

Ⅲ Environmental dynamics
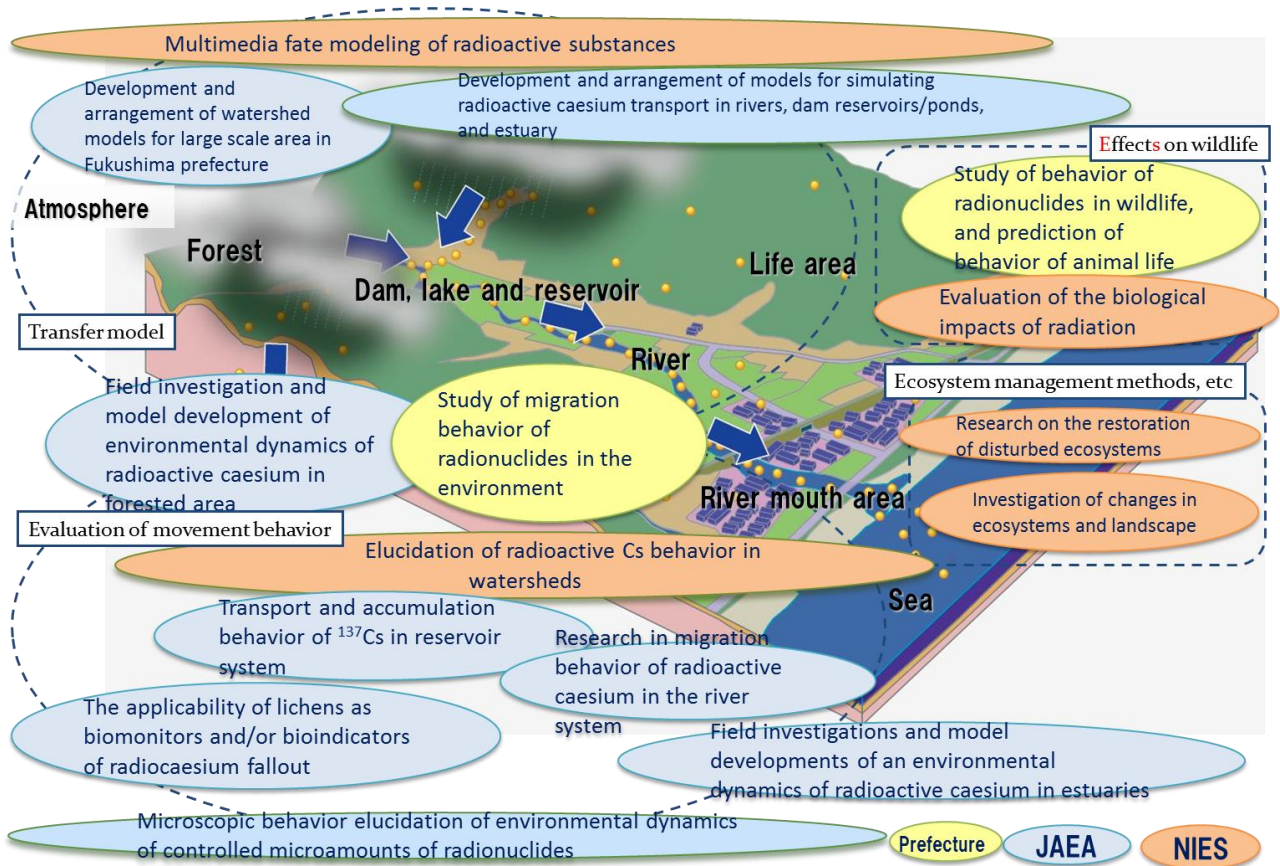
Relationship among research areas in the Environmental Dynamics Division

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| 1. Evaluation of movement behavior | [Fukushima Prefecture, JAEA, NIES] |

① <mark>**Study of migration behavior of radionuclides in the environment**</mark>

Water in rivers and lakes is widely used as supply water, agricultural water, etc. and is indispensable for lifestyles and economic activities. Therefore, it is important that such water can be used safely.

The migration of radionuclides in rivers and lakes, and the runoff characteristics of such nuclides according to the particular characteristics of rivers and differences in land use, will be studied. The sites associated with the accumulation of radionuclides, the timescales, temporal changes of such accumulation, etc., will be quantitatively predicted, using a TODAM model. The results will be compared with those from other models to select and improve model suitability adapted to the particular topography of the prefecture.

▶▶▶ Application of outcomes

The outcomes will contribute to formalizing measures for the safe use of river water.

【Fukushima Prefecture】

Main objectives of the investigation and model development are as follows;:

・ To develop models of the environmental dynamics of radioactive caesium in forest areas, taking into consideration differences in physical and geographic conditions (e.g., weather, vegetation, topographic and soil conditions), based on the field data

・ To estimate the outflow of radioactive caesium associated with soil loss and surface runoff in forest areas, and acquire relevant data for numerical analysis

・To develop evaluation methods for environmental dynamics of radioactive caesium in forest areas.

▶▶▶ Application of outcomes

Investigation and development outcomes will contribute to the formulation of policies and implementation of processes for the revitalization of forests and the forestry industry by elucidating the environmental dynamics of radioactive caesium in forest areas, in particular by allowing the prediction of its biogeochemical cycle in such areas.

【JAEA】

To elucidate the transport and accumulation processes of radioactive caesium in river systems, concentrations in river water, riverbeds and floodplains, etc., should be monitored. Parameters established on the basis of the obtained data will be used in stock-flow analysis of radioactive caesium at the watershed scale, and distributions predicted.

▶▶▶ Application of outcomes

To ensure the safety and peace of mind of the inhabitants of Fukushima Prefecture, the outcomes of this research will help predict the external radiation exposure dose for riverside residents, and radioactive caesium concentrations in agricultural products by way of irrigation water from rivers.

【JAEA】

The main objectives of this study are to reconstruct the history of local ^{137}caesium deposition using the distribution of ^{137}caesium in water and sediments, to elucidate the manner in which water reservoir sediments have been affected by the Fukushima Daiichi Nuclear Power Plant accident, and to obtain environmental data for validation of the modelling and simulation of sediment transport and deposition of ^{137}caesium in reservoirs.

▶▶▶ Application of outcomes

The results of this study will facilitate the quantitative evaluation of ^{137}caesium transport and concentrations ofs ^{137}caesium in irrigation waters, which information will contribute to ensuring the safety of concerned inhabitants and the recovery of agriculture from radioactive contamination.

【JAEA】

⑤ Field investigation and model development on environmental dynamics of radioactive caesium in estuaries

Main objectives of the investigation and model development are as follows:

・To develop models of environmental dynamics of radioactive caesium in estuaries, taking into consideration criteria under various conditions (e.g., seawater, topographic features of seafloor, and flows), based on field data

・To develop methods for evaluating environmental dynamics of radioactive caesium in estuaries

▶▶▶ Application of outcomes

The results of this investigation and model development will contribute to evaluating transportation and deposition processes of radioactive caesium in estuaries, and decision-making for the revitalization of marine product industries.

【JAEA】

⑥ Elucidation of the behavior of extremely small amounts of radionuclides on environmental dynamics

To elucidate the reaction mechanism of extremely small amounts of radioactive caesium, and model the environmental dynamics of radioactive caesium, relevant basic data will be evaluated by desorption and leaching tests. These tests will be conducted on various samples of environmental soil, water and organic matter. Measurement methods for such materials will be established.

▶▶▶ Application of outcomes

The outcomes will help improve the accuracy of quantitative prediction tools for radioactive caesium concentrations in irrigation waters and seas for the recovery of agriculture and fisheries.

【JAEA】

⑦ Use of lichens as biomonitors and/or bioindicators of radioactive caesium fallout

The purpose of this study is to establish a method for estimating the initial amount of fallout and radioactive plumes by investigating the radioactive caesium activity concentration in lichens. The following have been investigated: (1) Relationships between radioactive caesium activity and concentrations in lichens and ground soil radioactive caesium deposition; (2) Temporal variations in radioactive caesium activity and concentration in lichens; and (3) The influence of growing direction of lichens and habitat altitudes on effects.

▶▶▶ Application of outcomes

It is suggested that the results of this research be used for predicting the behavior of radionuclides in the environment, and estimating radionuclide fallout amounts on the basis of measurement of radionuclide plumes.

【JAEA】

⑧ Elucidation of the behavior of radioactive caesium in watersheds

The behavior of radioactive caesium in the watersheds of major rivers and dams will be studied, and biological monitoring conducted at such locations in the Hamadori region of Fukushima Prefecture to analyze the stocks and flows of radioactive caesium at the watershed scale and elucidate transfer and accumulation properties of radioactive caesium in forests and freshwater ecosystems, including those areas with high levels of radioactive caesium deposition.

▶▶▶ Application of outcomes

The outcomes of this study will facilitate the establishment of systems for strategic environmental assessment to conduct wide-area decontamination works, and the construction of models for predicting the behavior of radioactive caesium with the aim of reducing the risks of both external and internal radiation exposures.

【NIES】

| 2. Transfer model | [Fukushima Prefecture, JAEA, NIES] |

① **Study of migration behavior of radionuclides in the environment (same as the above)**

Refer to Evaluation of movement behavior in Environmental Dynamics.

【Fukushima Prefecture】

② **Field investigation and model development on the environmental dynamics of radioactive caesium in forest areas (same as the above)**

Refer to Evaluation of movement behavior in Environmental Dynamics.

【JAEA】

③ **Development and provision of models for simulating radioactive caesium transport in rivers, dam reservoirs/ponds, and estuaries**

Systems to predict the behavior of sediments and radioactive caesium discharge/deposition from/in water systems, with an emphasis on rivers, and taking in dam reservoir/ponds, and estuaries, in river basins near the Fukushima Daiichi Nuclear Power Plant will be developed. Systems ranging from one-dimensional to three-dimensional models will be developed and provided to appropriately simulate ongoing changes based on the temporal and spatial conditions.

▶▶▶ Application of outcomes

Quantitative prediction tools for radioactive caesium concentrations in irrigation waters and seas will be provided for the recovery of agriculture and fisheries. Air dose prediction tools will also be provided to contribute to the safety and peace of mind of prefectural inhabitants.

【JAEA】

④ **Development and coordination of watershed models for large scale area in Fukushima prefecture**

Models based on the Soil and Caesium Transport (SACT) model to simulate the migration processes of sediment-absorbed radioactive caesium, with an emphasis on soil detachment by rain drop and surface water, subsequent sediment transport, and eventual inflow to rivers, will be developed. On the basis of field survey data, the transport and dyanmics of radioactive caesium in forests will be predicted.

►►► Application of outcomes

Quantitative prediction tools for radioactive caesium concentrations in irrigation waters and seas for the recovery of agriculture and fisheries, and air dose prediction tools to contribute to the safety and peace of mind of prefectural inhabitants will be proposed and provided.

【JAEA】

⑤　**Multimedia fate modeling of radioactive substances**

To predict changes in the spatiotemporal distribution of radioactive substances in Fukushima prefecture and surrounding regions, the behaviors of radioactive substances in the environment, including the atmosphere, land, and ocean, will be studied by multimedia fate modeling.

►►► Application of outcomes

The outcomes will be useful in the fate prediction of radioactive substances in the atmospheric, terrestrial (including freshwater), and coastal environments and the assessment of various countermeasures.

【NIES】

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3. Effects on wildlife [Fukushima Prefecture, NIES]

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①　**Study of behavior of radionuclides in wildlife, and prediction of behavior of animal life**

In order to expedite the lifting of prohibitions on shipment of wild animals, and alleviate inhabitant anxieties, the behavior of radionuclides, including radioactive caesium *in vivo* in wild animals, and the migration of such nuclides between wild animals via the food chain, will be studied.

In addition, the behavior of wild animals, including their eating habits, will be studied, a requirement to clarify circumstances in the food chain, predict yearly and seasonal behaviors of such animals, and changes in the muscular concentrations of radionuclides.

►►► Application of outcomes

The outcomes will help anticipate and accelerate the lifting of the prohibition on the shipment of wild animals..

They will be used as basic data in studying internal exposures in the human body, to ensure the safety and peace of mind of the inhabitants of the prefecture.

【Fukushima Prefecture】

③　**Evaluation of the biological impacts of radiation**

Methods for evaluating the impacts of radiation originating from the radioactive substances

released into the environment on both wild and experimental organisms at the genetic, cellular and organism level, will be developed. These methods will be used to conduct site evaluations.

►►► Application of outcomes

The outcomes will be useful to ensure the safety of the inhabitants of Fukushima prefecture by providing them with information based on scientific evidence regarding the biological impacts of radiation.

【NIES】

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4. Ecosystem management methods, etc. [NIES]

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① **Study on changes in ecosystems and landscape**

Changes in biological distributions and landscape structure as a result of factors other than radiation (e.g. evacuation of the human population) will be studied by conducting biota surveys and using remote sensing to monitor the land cover in regions that include the districts to which evacuees may not currently return.

►►► Application of outcomes

The outcomes may be helpful to facilitate the return of evacuees to their homes by providing scientific information on biological and ecological aspects of their districts.

【NIES】

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② **Research for the restoration of disturbed ecosystems**

Ecosystem models that reflect the natural history of the region will be developed to examine strategies for restoring ecosystems disturbed by the evacuation of the human population and decontamination in relation to the Fukushima Daiichi Nuclear Power Plant accident. On the basis of such models, strategies for preventing threats with their origin in ecosystems and for conserving the biodiversity on a region-wide scale will be formulated.

►►► Application of outcomes

The outcomes will be useful for reconstruction initiatives in providing information on methods for managing disturbed ecosystems.

【NIES】

Ⅳ Environmental creation
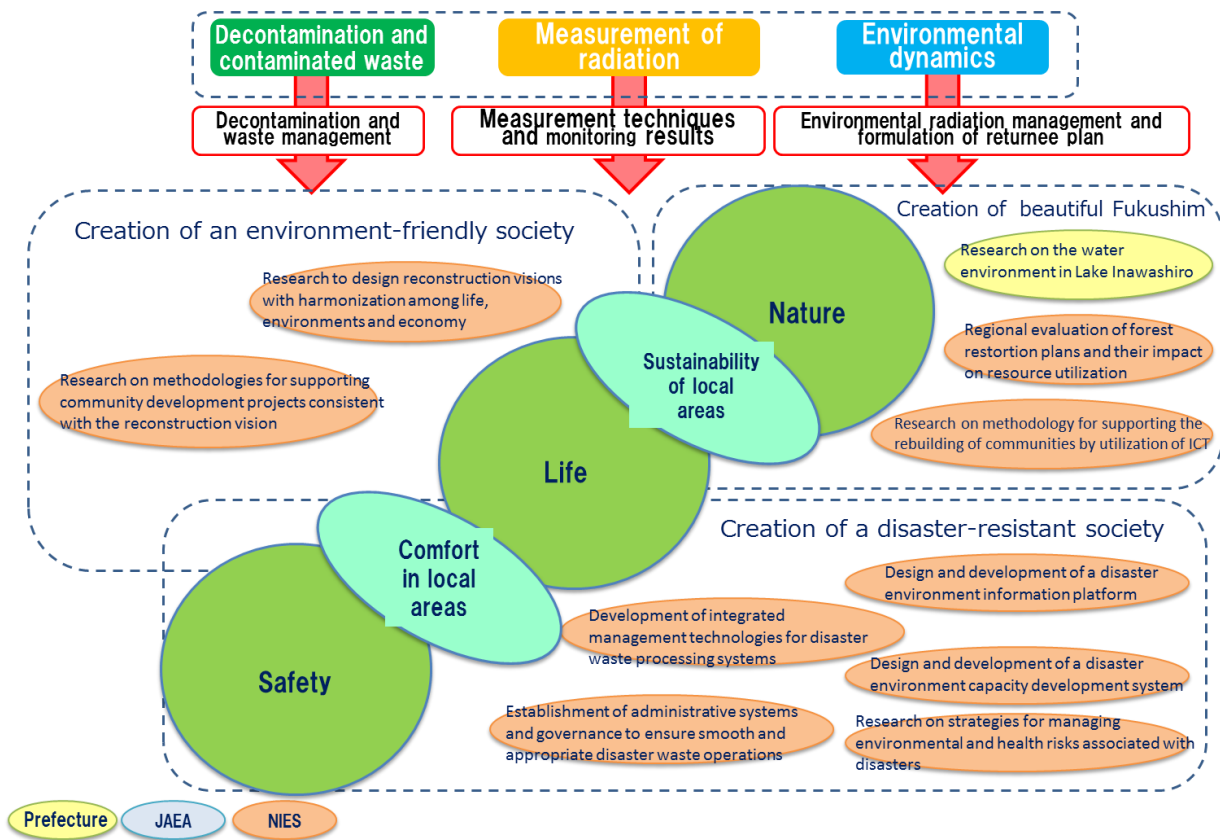
Relationship among research areas in the Environmental Creation Division

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1. Creation of environment-friendly society [NIES]

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①　**Research for designing reconstruction visions with harmonization among life, environments and economy**

The medium- to long-term development of Fukushima prefecture and its constituent municipalities will be accelerated by furthering decontamination and environmental restoration, implementing policies based on visions for the region which address the mitigation of, and adaptation to, climate change, and dealing with the issues of depopulation and an aging society. In this context, integrated assessment models for the quantitative design of future visions with consideration to the return of evacuees, community development, economic growth and employment, low carbonization of energy, and other factors, will be developed. These models will be applied to Fukushima prefecture and its municipalities, and by these means, medium- to long-term visions and roadmaps for the forthcoming 10–30 years will be proposed and disseminated.

▶▶▶ Application of outcomes

The outcomes will facilitate the reconstruction of affected municipalities by proposing

future visions and scenarios with harmonization among life, environments, community renovation and economic development.

<div align="right">【NIES】</div>

② **Research on methods for supporting community development projects consistent with reconstruction visions**

Sustainable reconstruction and restoration of communities requires a design for municipality-level project master plans integrated with the Innovation Coast Vision and other key projects being implemented in Fukushima prefecture. In this research, models for supporting urban development projects through aggregation of energy-related industries in conjunction with siting plans for an LNG terminal in the northern part of the Hamadori region will be developed. More specifically, a support platform that enables local stakeholders to evaluate the impact of a spatial and energy system design for the target district on lifestyles, economy and the environment over the medium- to long-term through analysis of energy costs and environmental loads, will be provided.

▶▶▶ Application of outcomes

The outcomes will be useful to provide support to local stakeholders in formulating urban and agricultural system plans integrated with energy systems.

<div align="right">【NIES】</div>

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2. Creation of disaster-resilient society   [NIES]

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① **Development of integrated management technologies for disaster-related waste treatment systems**

To establish technological systems for disaster-related waste treatment that make it possible to better respond to future disasters, data on waste treatment systems after the Great East Japan Earthquake disaster will be studied, and recommendations for such systems from both technological and system perspectives will be made to improve disaster environment management in preparation for future disasters.

Recommendations for the utilization of disaster-related waste and industrial by-products in the reconstruction following a major disaster, and for distributed household sewage treatment systems to be used when disasters arise, will be provided. Furthermore, a standard system for treating disaster-related wastes will be proposed for Asian countries as an integrated management technology, to be disseminated internationally.

▶▶▶ Application of outcomes

The outcomes will contribute to the creation of concepts, technical guidelines and manuals for disaster-related wastes treatment systems both in Japan and overseas.

<div align="right">【NIES】</div>

② **Establishment of administrative systems and governance to ensure smooth and appropriate operations of disaster-related wastes**

To support the development of administrative systems for disaster-related waste treatment

better equipped for the advent of future disasters, relevant data from past disasters, including the Fukushima Daiichi Nuclear Power Plant accident will be analyzed from the perspective of procurement and allocation of personnel, materials and equipment, funds and information, and from the perspective of planning, systems and risk communication most required for the management of such processes. Administrative systems and the associated governance required to ensure the smooth and appropriate treatment of disaster-related waste will be studied. The outcomes of this study will be useful in formulating and implementing policies related to disaster-related wastes treatment both in Japan and overseas and will also be made internationally available.

▶▶▶ Application of outcomes

The outcomes will contribute to the construction of robust administrative systems by offering policies and management methods for the smooth and appropriate processing of disaster-related wastes.

【NIES】

③ **Research on strategies for managing environmental and health risks associated with disasters**

The Great East Japan Earthquake revealed that Japan has only insufficient measures in place for managing the environmental and health risks posed by disasters. To address this issue, the objectives of disaster-related risk management will be considered. Capabilities with regards to rapid exploratory analysis in case of a disaster, and systems for managing the risks in its aftermath, will be studied. On the basis of the research results, methods for the prompt and appropriate management of various risks associated with disasters will be proposed. The purpose of the research is to utilize the experience of Fukushima to reconstruct a society to be better equipped against disasters.

▶▶▶ Application of outcomes

The outcomes will contribute to the formulation of disaster-related risk management strategies, and to the building of a society capable of withstanding disasters, taking advantage of the experience of Fukushima.

【NIES】

④ **Design and development of an environmental information platform for times of disaster**

An information platform to consolidate environmental disaster prevention and mitigation capabilities of Japan will be designed and developed. Knowledge that will contribute to effective disaster response will be acquired and disseminated. Operations analysis and other methods will be used to examine the relationship between information and disaster response operations, such as incident action plans for disaster-related wastes. Means of information management and their improvement of environmental management capacities in preparation for future disasters will be considered. Experiences and know-how acquired from Fukushima will be disseminated.

►►► Application of outcomes

The outcomes will contribute to the construction of an information platform for use in the event of future disasters.

【NIES】

⑤ Design and development of an environmental capacity development system for times of disaster

The human resources and capacities required on the ground in an environment in which a disaster has occurred will be identified, and a program for effective training of such human resources will be developed and implemented. An environmental information platform and training program for times of disaster designed to create a network linking universities, research institutes, local government, private industry, researchers and practitioners involved in the fields of disaster and environment, will be used, with the aim of establishing a new disaster-stricken environment study field by integrating and organizing various relevant areas of knowledge and information.

►►► Application of outcomes

The outcomes will contribute to the building of a society capable of a resilient response to future disasters by developing human and other resources on the ground in disaster-stricken environments.

【NIES】

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3. Creation of a beautiful Fukushima [Fukushima Prefecture, NIES]

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① Research in the water environment of Lake Inawashiro

As the water of Lake Inawashiro has recently been neutralized in terms of chemical property, the natural purification function characteristic of the lake has been compromised. COD has risen and the coliform count has exceeded the relevant environmental standard, with a contingent deterioration in the water quality.

The mechanism of neutralization of the lake water and the causes of pollution load will be comprehensively elucidated. By these means, knowledge on the causes of water pollution will be acquired, and effective methods for improving the water quality studied.

►►► Application of outcomes

The neutralization mechanism and causes of pollution load will be elucidated to contribute to the recovery of optimal water quality in Japan.

【Fukushima Prefecture】

② Evaluation of regional forest restoration plans and their impact on resource utilization

Forestry is an important local industry of Fukushima prefecture. To facilitate the recovery of this industry and the utilization of woody biomass, it is necessary to study forest material cycles and ecosystems, and predict biomass supply and demand. Forest ecosystem models for evaluating biogeochemical dynamics, and woody biomass utilization models that cover

all aspects from production to distribution, consumption and disposal, will be developed. These models will be used to evaluate the impacts of high-value-added, high-efficiency forest management and timber/biomass utilization on the environment in Fukushima Prefecture, and examine methods of utilizing forest resources in harmony with the lives of the inhabitants of Fukushima.

►►► Application of outcomes

    The outcomes will help promote management of forest environments in harmony with the lives of the inhabitants of Fukushima.

<div align="right">【NIES】</div>

③   **Research on methods for supporting the reconstruction of communities by utilization of ICT (Information and Communications Technology)**

Effective implementation of reconstruction policies and the maintenance and restoration of community bonds depends on a multifaceted evaluation of the effectiveness of such policies in the region by using integrated evaluation systems that incorporate livelihood support and various aspects of everyday life, environment and comfort. For this research, an information sharing system that utilizes ICT to enable an instant, interactive exchange of information with inhabitants of Shinchi Town, will be constructed, and methods for supporting the everyday lives of the inhabitants to facilitate the recovery of communities and address a wide range of needs of local communities, will be developed.

►►► Application of outcomes

    These outcomes will help support community lives in line with local characteristics and the various needs of local inhabitants.

<div align="right">【NIES】</div>

prefecture **JAEA** **NIES**

Radiation Measurement

Development of methods and models for evaluation of exposure dose
- Development of tools to evaluate dose considering radiocesium migration in environment
- Development of methods for assessment and management of doses to the populations
- Research on evaluation of exposure to radioactive substances and hazardous chemicals
- Investigations of radiocaesium migration and consolidation of dose rate-prediction model in residential/urbanized area.

Development of analysis methods
- Methods for simple and rapid analysis of radioactive nuclides
- Improvement of radioanalytical techniques

→ Monitoring by each engine

Methods for Presenting measurement results
- Evaluation and good use of monitoring results

Development of measurement technologies
- Technologies of measurement of air dose and radioactive materials
- Upgrading a technology for measuring radioactivity and dose with an unmanned helicopter
- Development of a flying object for a wide area radiation measurement
  - Application of measurement technology research for the radiation distribution in the forest area using a simple visualization technique
- Development of a technology monitoring and measuring under water radiation
- Development of a water radioactivity monitoring technology

Measurement technologies, good use of monitoring results

Decontamination and contaminated waste disposal

Development of technologies for decontamination and transfer inhibition
- Decontamination technologies for rivers and lakes
- Development of migration curbing methods of radioactive cesium
- Assessment of effect of decontamination, and Assessment of effect on the environment
- Evaluation of decontamination effectiveness
- Technical support of decontamination projects in Fukushima based on simulations for environmental reconstruction

Development and enhancement of bulk reduction technologies
- Proper treatment of waste containing radioactive material at municipal soil waste incinerator
- Development of treatment techniques for classification and volume reduction of contaminated soil and for decomposition of combustible decontamination waste
- Development and improvement of technologies for reducing the volume of waste containing radioactive substances

Development of methods for management of contaminated waste, etc., and appropriate processing and disposal of such waste
- Safety assessment of temporary storage sites and consensus building among citizens
- Appropriate treatment of waste containing radioactive materials at municipal solid waste incinerators
- Behavior of radioactive caesium after waste disposal by landfill
- Safe reuse of waste contaminated with radioactive materials
- Technologies and management methods for establishment of appropriate flow-stock of radioactive substances in resource recycling and waste treatment processes
- Long-term management methods and optimization of processes for the interim storage of removed soil and decontaminated waste, and final disposal of low-level radioactively contaminated waste

Exchange of information Sharing knowledge

Environmental dynamics

Evaluation of movement behavior
- Transport and accumulation behavior of Cs in reservoir system
- migration behavior of Cs in the river
- The applicability of lichens as biomonitors and/or bioindicators of radiocaesium fallout
- Migration behavior in the environment
- Elucidation of radioactive Cs behavior in watersheds
- Field investigations and model developments of an environmental dynamics of Cs in the estuary
- Microscopic behavior elucidation of microamount radionuclide controlled an environmental dynamics
- Field investigation and model development of an environmental dynamics of Cs in forested area

Transfer model
- Development and arrangement of watershed models for large scale area in Fukushima prefecture
- Development and arrangement of models for simulating Cs transport in rivers, dam reservoirs/ponds, and estuary
- Multimedia fate modeling of radioactive substances

Effect on wildlife
- Behavior of radioactive nuclides in wildlife, and prediction of behavior of animal life
- Evaluation of the biological impacts of radiation

Ecosystem management methods, etc.
- Investigation of changes in ecosystems and landscape
- Research on the restoration of disturbed ecosystems

Used for decontamination and waste control

Used for environmental radiation management and preparation of resident return plans

Environmental creation

Creation of environment-friendly society
- Research on methodologies for supporting community development projects consistent with the vision for reconstruction
- Research to design visions for reconstruction with harmonization among life, environments and economy

Creation of beautiful Fukushima
- Research on methodology for supporting the rebuilding of communities by utilization of ICT
- Regional evaluation of forest restoration plans and its impact on resource utilization
- the water environment in Lake Inawashiro

Creation of disaster-resistant society
- Establishment of administrative systems and governance to ensure smooth and appropriate operations of disaster waste
- Development of integrated management technologies for disaster waste processing systems
- Research on strategies for managing environmental and health risks associated with disasters
- Design and development of a disaster environment information platform
- Design and development of a disaster environment capacity development system

Support for rehabilitation and reconstruction of disaster-stricken area | Creation of disaster-resistant society based on lessons learned from the Great East Japan Earthquake

Schematic diagram of cooperation in research among the three organizations