Ministry of the Environment, Japan Global Environment Research Fund
Strategic R&D Area Project

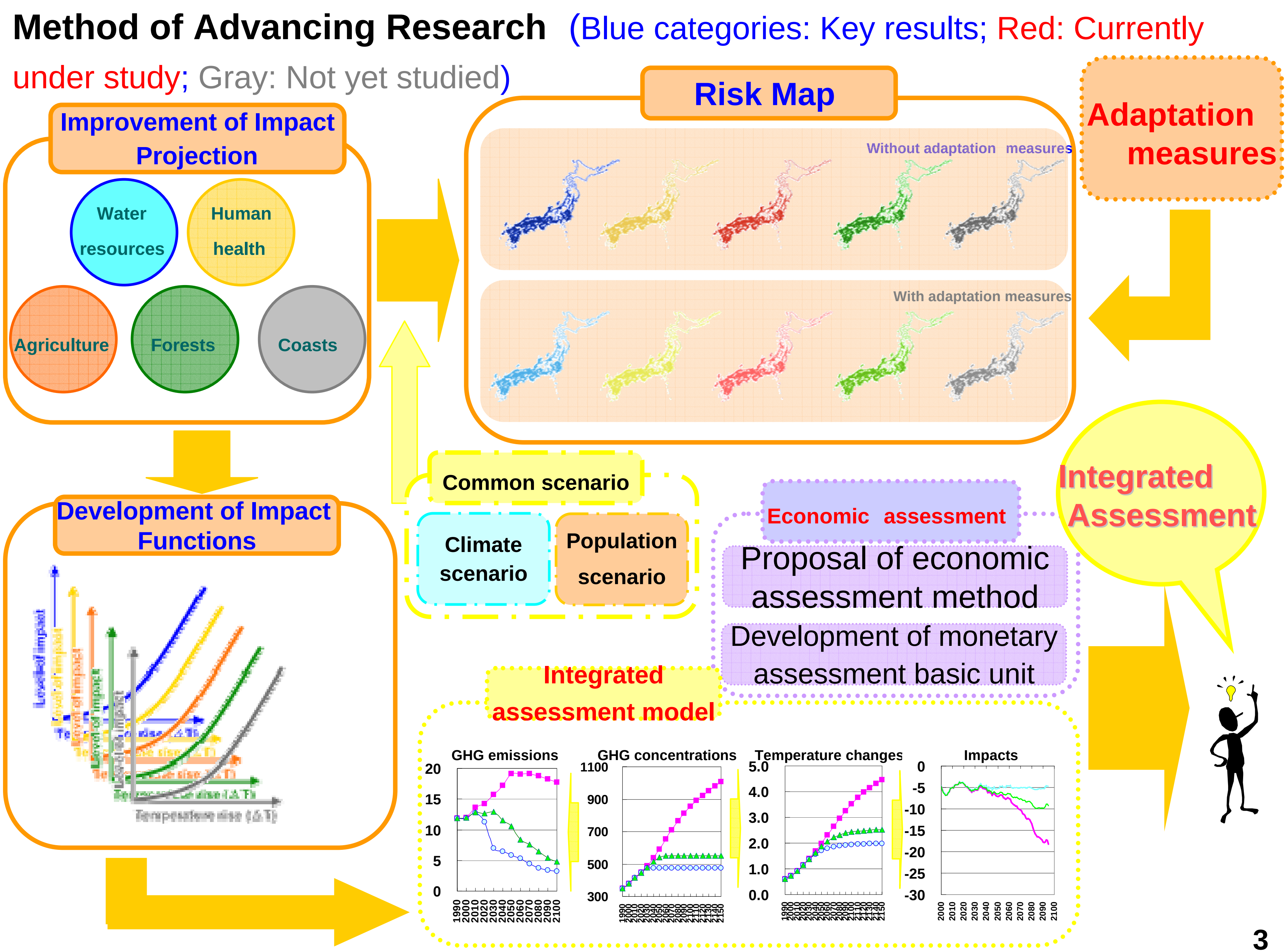
S-4 Comprehensive assessment of climate change impacts to determine the dangerous level of global warming and to determine appropriate stabilization target of atmospheric GHG concentration

- Project for Comprehensive Projection of Climate Change Impacts -

Ibaraki University, National Institute for Environmental Studies, Tohoku University, National Institute for Rural Engineering, The University of Tokyo, National Institute for Land and Infrastructure Management, University of Tsukuba, National Institute for Infectious Diseases, National Institute for Agro-Environmental Sciences, Japan International Research Center for Agricultural Sciences, Forestry and Forest Products Research Institute, Kyushu University, Meijo University, Mitsubishi Research Institute, Inc.

Research System and Objectives

- **Results for the first three years of the Project for Comprehensive Projection of Climate Change Impacts (Ministry of the Environment, Global Environment Research Fund S-4, 2005-2009)**
- **Research system**
  - Project leader: Nobuo MIMURA, Ibaraki University
  - Research period: Period I (2005-2007) + Period II (2008-2009)
  - Number of subthemes: Seven; Number of participating research institutions: 20 (2007); Number of participating researchers: 44 (2007)
- **Targeted fields: Water resources, forests, agriculture, coastal zones, human health**
- **Objectives of the research project**
  - To obtain quantitative knowledge on climate change impacts in key fields such as water resources, forests, agriculture, coastal zones, and human health in the Asian region including Japan, targeting the period up to the end of the present century while focusing on the period up to around 2050.
  - To comprehensively grasp the impacts on Japan and elucidate the relationships with the level of global warming.



Method of Advancing Research (Blue categories: Key results; Red: Currently under study; Gray: Not yet studied)
Improvement of Impact Projection
Water resources
Human health
Agriculture
Forests
Coasts
Risk Map
Without adaptation measures
With adaptation measures
Adaptation measures
Development of Impact Functions
Common scenario
Climate scenario
Population scenario
Economic assessment
Proposal of economic assessment method
Development of monetary assessment basic unit
Integrated Assessment
Integrated assessment model
GHG emissions
GHG concentrations
Temperature changes
Impacts

Information Presented in This Report

- The development of quantitative assessment methods by field and projection of the impacts on Japan are described, together with risk maps (nationwide as well as regional assessments) that show the level of and regional distribution of the impacts.

- Comprehensive studies are described on the increasing impacts on Japan when global warming proceeds under various climate scenarios, using climate change impact functions that have been developed to show the relationship between the progress of global warming and impact levels.

Impacts on Water Resources: The frequency and intensity of torrential downpours will increase, flood damage will expand, and landslide disasters and dam sedimentation will worsen. The costs of water supply purification will rise due to increased turbid runoff during periods without rainfall. On the other hand, decreases in snow water resources will cause shortages of agricultural water at the time of plowing and irrigation of fields on the Pacific side of the Tohoku region, and the risk of water shortages will increase in various regions including southern Kyushu and Okinawa due to changes in precipitation.

1. Floods

(a) The frequency of torrential downpours that occur once every 50 years is projected to increase to every 30 years by around 2030 (result using MIROC climate scenario). While changes in the frequency and intensity of torrential downpours due to global warming vary according to the region, the frequency and intensity of torrential downpours in the Pacific coast and mountainous regions will

become high and the flood risk will increase.

(b) The damage caused by floods resulting from more frequent torrential downpours due to global warming will be approximately 1 trillion yen annually (damage caused if the frequency of torrential downpours that currently occur once every 100 years increases to around once every 50 years).

2. Slope disasters

- The danger of slope collapse due to torrential downpours will become evident in areas closer to the outskirts of cities, with heightened risk seen especially in the environs of urban areas in the Chugoku and Tohoku regions.

3. Sedimentation

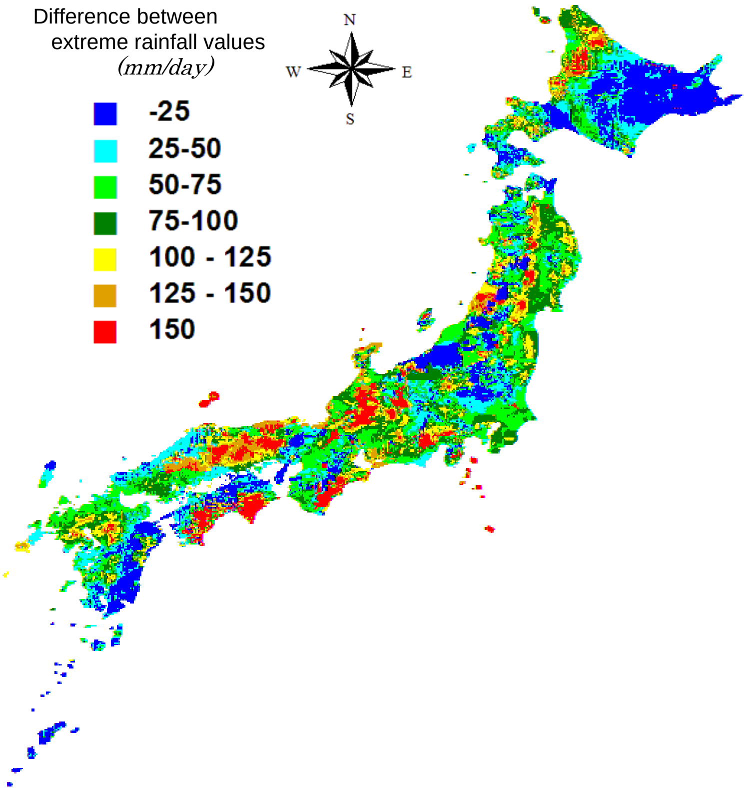
- Areas with large increases in sedimentation will expand along the Median Tectonic Line. In particular, there are concerns over increased sedimentation in the area from the Northern Alps to the Southern Alps.

4. Snow water resources

- As a result of global warming, snow water resources will decrease in areas along the Japan Sea side from Hokuriku to Tohoku. Moreover, there is a possibility of shortages in the agricultural water supply during the time of plowing and irrigation of fields in the rice-producing areas along the Pacific side due to decreases in snowmelt water.

5. Water demand

- In Hokkaido and the east coast of the Tohoku region, the balance of water supply and demand will become tighter compared with the present condition, with strains in water resources becoming particularly evident in southern Kyushu and in Okinawa.



Difference between daily rainfall (mm/day) of torrential downpours occurring once every 30 years compared with once every 50 years (change in torrential downpours around 2030 estimated from present statistical values)

Impacts on Forests: **Forests in Japan will suffer severe consequences as a result of rises in temperature and changes in rainfall due to global warming. The distribution of suitable habitats for Siebold's beech *(Fagus crenata)* forests, dwarf bamboo *(Sasa kurilensis),* Japanese stone pine *(Pinus pumila),* and *Abies shikokiana* will sharply decrease, and from around the middle of the century the Shirakami mountain range will no longer be a suitable habitat for beech forest. There will also be increased risk of pine wilt damage, with a temperature rise of 1 to 2° C resulting in the area of risk expanding to the northern tip of Honshu, where such damage has not yet occurred.**

1. Distribution of suitable habitats for beech (*Fagus crenata*) forests (See figure at right.)

(a) Nationwide, suitable habitats will decrease to 65-44% (2031-2050) and 31-7% (2081-2100) compared with the present. In western Japan, and the Pacific side of Honshu, the Japanese beech will become vulnerable.

(b) The distribution of suitable habitats for beech forests, which currently occupy 77% of the Shirakami mountain range (a World Heritage Site), will shrink to 44.3-2.9% in 2031-2050 and from 3.4-0.0% in 2081-2100.

(c) The speed of the northward advance of global warming in Hokkaido is 10-50 km/100 years, whereas the rate of migration of Japanese beech is 1-2 km/100 years (the past maximum value in Honshu is 23.3 km/100 years). Therefore, the migration of Japanese beech cannot keep pace with the temperature rise.

2. Pine wilt

- With a 1-2° C temperature rise, the area of risk will expand even to the plains of Aomori Prefecture, where there is currently no damage from this disease. If the temperature rise exceeds 2° C, there is a possibility that devastating damage will occur in the Japanese red pine *(Pinus densiflora)* forestry zone and *matsutake* mushroom production area in the inland part of Iwate Prefecture.

3. Distribution of suitable habitats for dwarf bamboo (*Sasa kurilensis*)

- Compared with the present, suitable habitats will decrease to 54-45% (2031-2050). *Sasa kurilensis* will become vulnerable on Sado Island.

4. Mountain wetlands

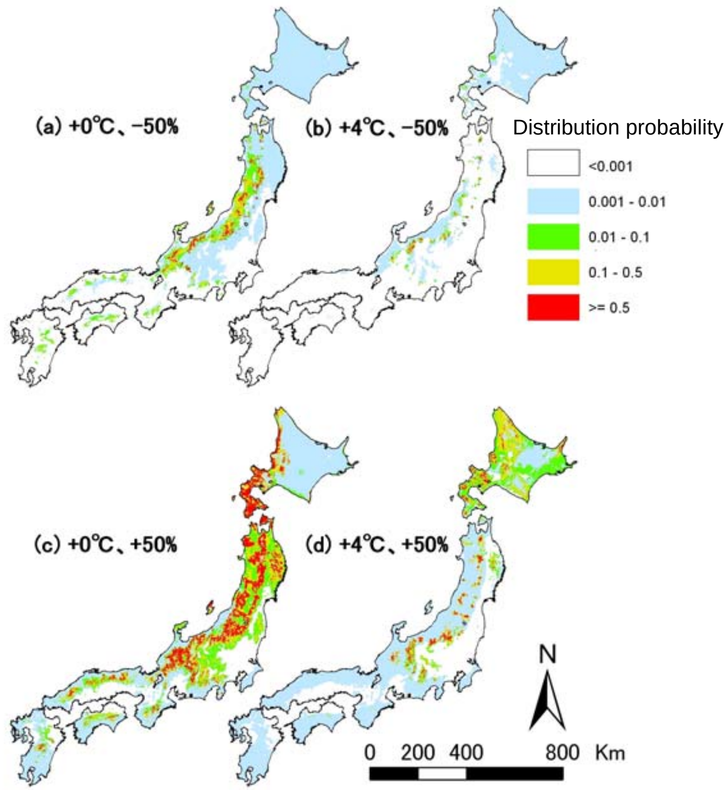
- The wetland in the summit area of Mt. Hiragatake on the boundary between Gunma and Niigata prefectures has shrunk by approximately 10% in area during the 30 years from 1971 to 2000 due to the decrease in snow and is becoming dry.

5. Distribution of suitable habitats for Japanese stone pine

- Suitable habitats will decrease to 49-56% (2031-2050) and 31-14% (2081-2100) compared with the present. In the Tohoku region, the Japanese stone pine will become virtually extinct, with suitable habitats decreasing to 14-6% (2031-2050) and 9-0% (2081-2100) compared with the present.

6. Distribution of suitable habitats for *Abies shikokiana*

- Compared with the present, suitable habitats will decrease to 48-26% (2031-2050) and 23-13% (2081-2100). Suitable habitats will completely disappear in Shikoku.



Projection of changes in beech forest distribution probability in the case of uniform changes in temperature and precipitation throughout Japan compared with the present condition

Impacts on Agriculture: Rice yields will increase in northern Japan, while yields in the southwest of the country from the Kinki region westward will be roughly the same as at present or slightly lower. Agriculture will be significantly affected by deteriorations in rice quality; a northward shift in areas suitable for the cultivation of other cereals, fruit trees, etc.; and decreases in their yields. If climate change coincides with such factors as rising demand due to population growth and soaring prices due to speculation and diversion to biofuel, there may be impacts on the supply of food to Japan as well.

1. Rice yields in Japan (See figure at right.)

(a) Yields around **2050** (**2046-2065**) will increase by **26%** in Hokkaido and **13%** in Tohoku, and decrease by **5%** in the Kinki and Shikoku regions compared with the present (**1979-2003** average).

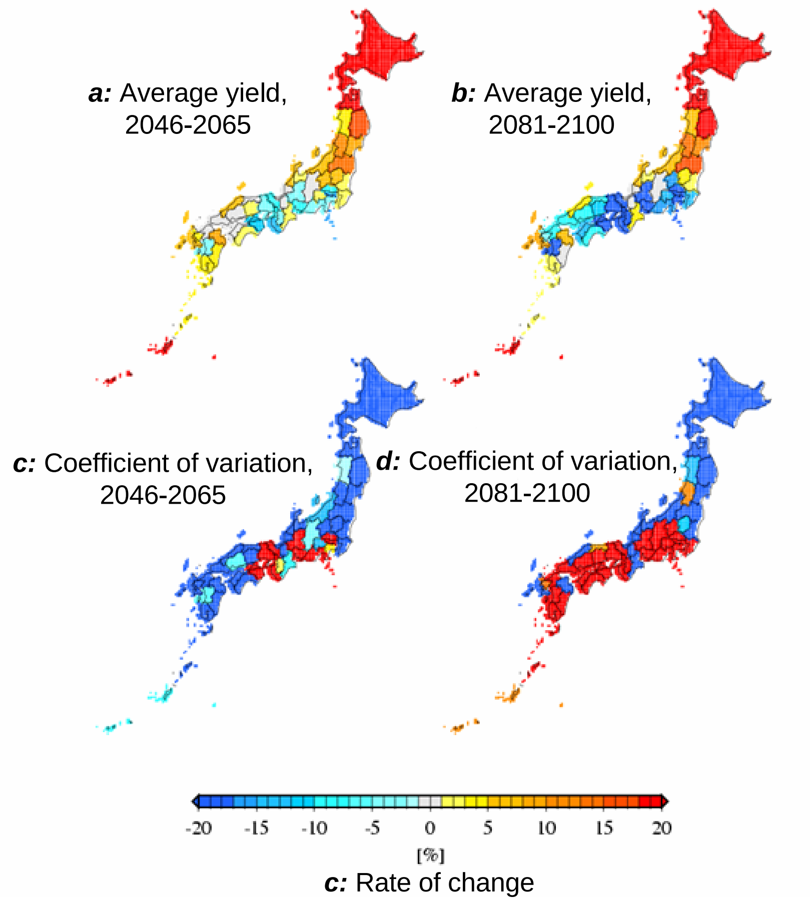
(b) This trend will become more pronounced in **2081-2100**, with the area of decreased yield expanding to Shikoku and Kyushu.

- The transplanting time is assumed to be the same as at present.
- The assessment considers only impacts arising from **three** types of weather-related environmental change: temperature, solar radiation, and atmospheric CO2 concentration.
- Assessment of snowmelt water resources and the impacts of vermin is a future task.
- In the area centering on western Japan, a trend toward greater year-by-year changes in yield can be seen.

2. Global food situation

(a) The rate of growth in output of major cereals by the U.S. will decrease up to the **2030**s due to climate change. Although the impact on the supply of food to Japan will be small during this period, the rate of growth in the supply of corn will decrease.

(b) If climate change coincides with rising demand due to population growth, soaring prices due to speculation and diversion to biofuel, etc., there is a possibility of unexpected impacts on the supply of food to Japan as well.



Results of estimation of changes in rice yield using MIROC climate scenario
a, b: Average yield; *c, d:* Rate of change in coefficient of variation of yields during 20-year period (ratio of standard deviation to average value). The rate of change is defined as the ratio of the difference between the values during the target period (2046-2065 or 2081-2100) and the present value (1979-2003) to the present value.

Impacts on Coastal Zones: **Due to rising sea levels and increasing storm surges, flood damage to vulnerable areas and populations will increase even when current shore protection measures are taken into consideration. The risk of flooding will be particularly high in semi-enclosed sea areas such as the Seto Inland Sea, and land areas bordering the inner parts of Japan's three major bays that were reclaimed long ago as well as their environs. Moreover, rising sea levels will weaken river embankments due to the expansion of brackish waters, and increase the risk of liquefaction in coastal zones.**

1. Flooding due to storm surges

(a) Inner parts of Japan's three major bays and western Japan (Chugoku, Shikoku, and Kyushu regions)

Area and population affected in **2000**: **20,000 ha, 290,000** people

Area and population affected in **2030**: **29,000 ha, 520,000** people

Area and population affected in **2100**: **58,000 ha, 1,370,000** people

(b) The areas and populations affected by storm-surge flooding in western Japan will be greater in semi-enclosed sea areas such as the Seto Inland Sea, inlets, etc.

(c) The risk of storm-surge flooding is particularly high in land areas bordering the inner parts of Japan's three major bays that were reclaimed long ago as well as their environs.

2. River embankments

Brackish waters in rivers will expand due to rising sea levels, resulting in a weakening of river embankments.

3. Risk of liquefaction

Rising sea levels and extreme rainfall events will raise groundwater levels and expand the size of areas subject to ground disaster due to liquefaction at the time of earthquakes.

4. Slope disaster risk (Fukuoka Prefecture)

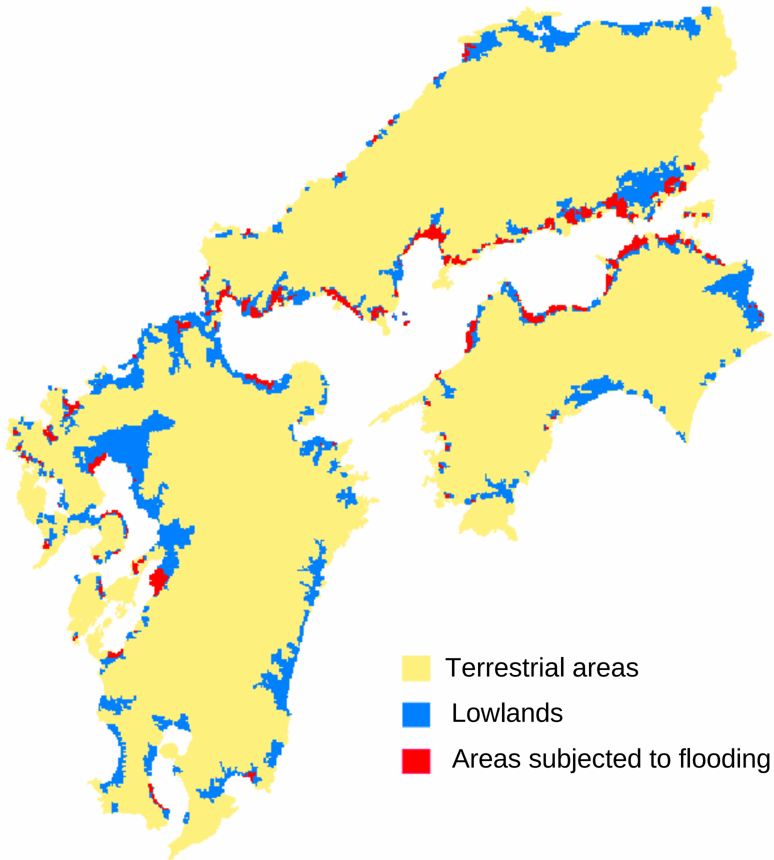
Current rainfall condition: Loss of 36 billion yen/year

Rainfall condition in 2050 resulting from global warming: Loss of 61.43 billion yen/year

5. Loss of recreation value of sand beaches and tidal flats

Sand beaches: Approx. 12,000 yen/m^2. The value of sand beaches lost by a 30 cm sea level rise will be about 1.3 trillion yen.

Tidal flats: Approx. 10,000 yen/m^2. An economic loss of up to about 5 trillion yen can be expected assuming tidal flats throughout Japan are impacted by sea level rise.



Areas of storm-surge flooding projected in western Japan under 2100 climate conditions

Impacts on Human Health: **Threats to human health due to global warming will increase. With rising temperatures, especially the daily maximum temperature, the mortality risk due to heat stress and the incidence of heatstroke will drastically increase. In particular, the risk to people of advanced age will become greater. The occurrence of atmospheric pollution (photochemical oxidants) due to changes in weather will increase. The potential distribution range of vector mosquitoes for infectious diseases (dengue, malaria, and Japanese encephalitis) will also expand.**

1. Heat stress mortality risk

- With rising temperatures, the probability of mortality due to heat stress will increase to about double even in prefectures whose changes are small, and by fivefold or more in prefectures with large changes.

2. Heatstroke

- The incidence of heatstroke will drastically increase as the daily maximum temperature becomes higher. In the summer of 2007, a steep increase in cases was seen in people aged 65 years or older on days when the temperature exceeded 35° C.

3. Atmospheric pollution risk

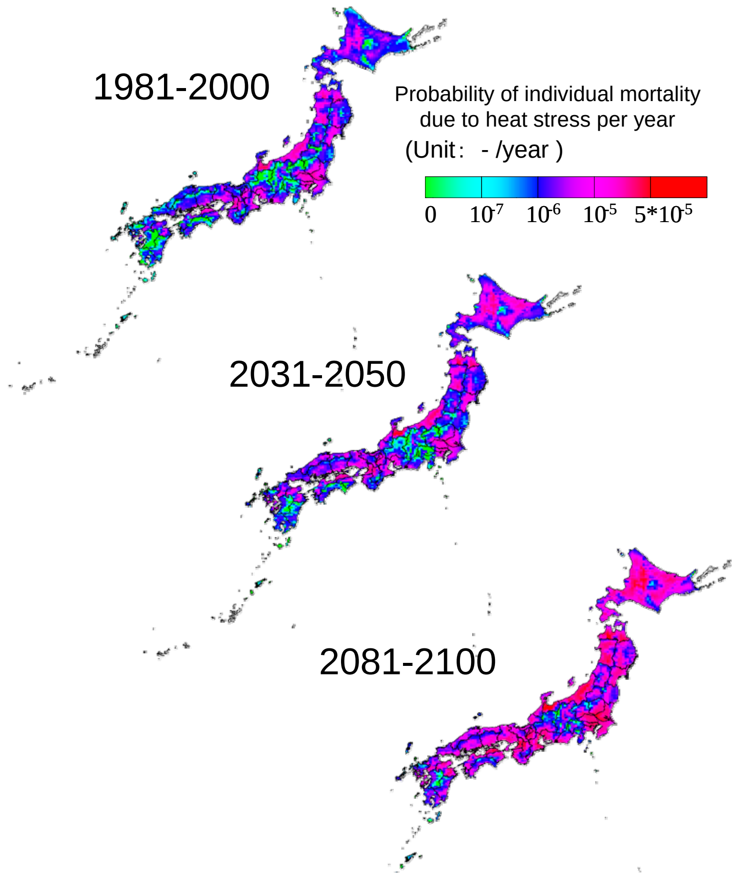
- Accompanying changes in weather due to global warming, higher concentrations of photochemical oxidants and consequent increases in mortality are expected. Compared with the increasing occurrence of transboundary photochemical oxidant pollution, however, the impact will be small.

4. Infectious diseases: Dengue, malaria, and Japanese encephalitis

(**a**) The potential distribution range of the yellow fever mosquito *(Aedes aegypti),* a vector for dengue, will expand to a wide area encompassing the southern part and the eastern and western coastlines of Kyushu, Kochi Prefecture, the southern part of the Kii Peninsula, Shizuoka Prefecture, Kanagawa Prefecture, and the southern part of Chiba Prefecture by 2100.

(**b**) The distribution range of the Asian tiger mosquito *(Aedes albopictus)* has now reached Iwate and Akita prefectures, and by 2100 it will expand to the whole of the Tohoku region and part of Hokkaido.

(**c**) Under Japan's present medical system, the possibility of a new malaria epidemic due to global warming is low.

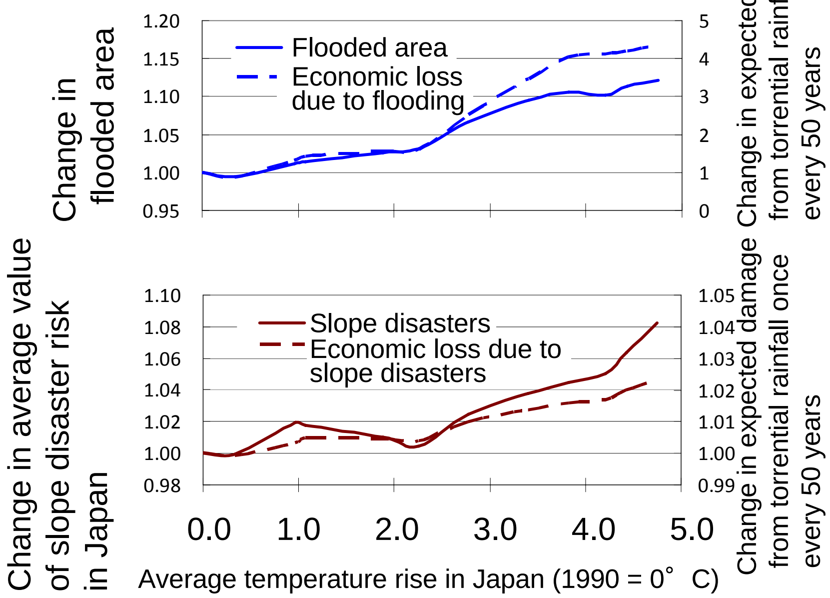


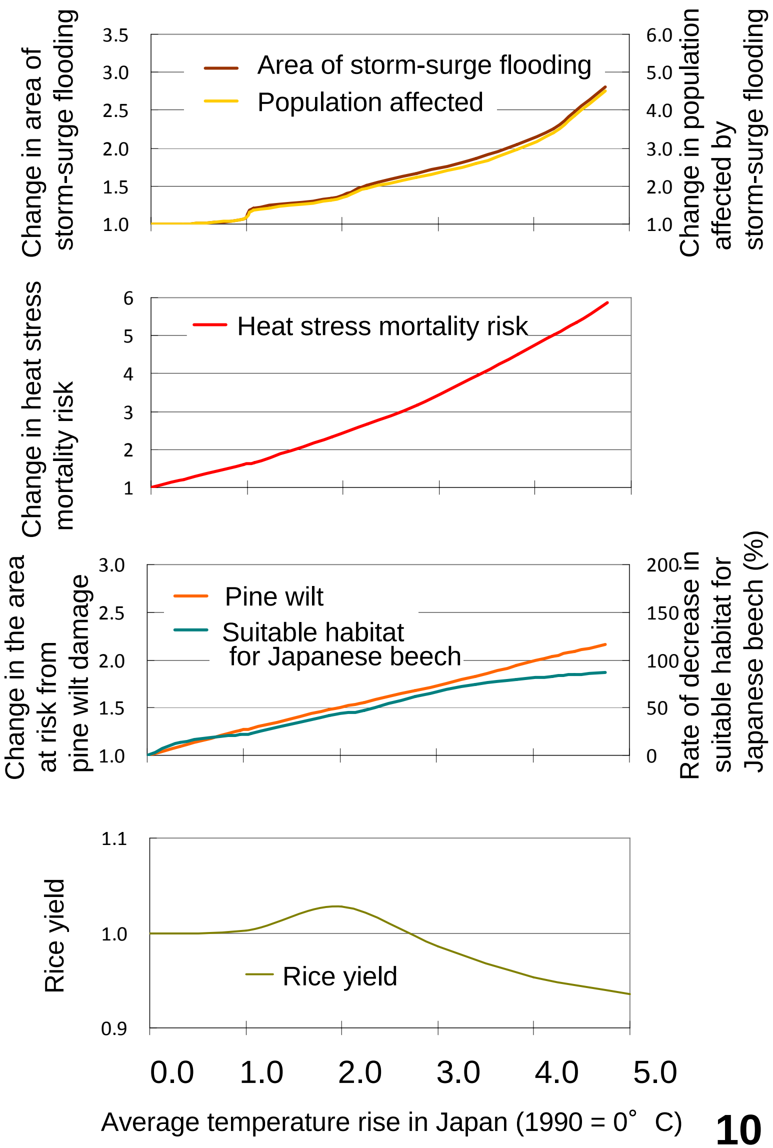
Probability of a person dying from heat stress during a given year

Climate Change Impact Functions

Unified multifield impact assessments were performed and the results were assessed in an integrated manner.

- **Using multiple detailed impact assessment models targeted at various fields, multiple simulations were performed while altering key factors such as temperature, precipitation, etc. by sensitivity analysis, and climate change impact functions obtained by mean aggregation of the output by region were developed and implemented in the integrated assessment model.**





Integrated Assessment of Impacts by Field

The latest knowledge with unprecedented comprehensiveness concerning the dangerous level of global warming is now available.

1. **Although the level of impact and rate of increase vary according to the field, impacts will also appear in Japan even with a relatively low temperature rise.**
   - Even with a temperature rise of about 1°C, natural systems including forests will be subjected to significant impacts. The risks of flood and landslide disasters will become extremely high due to increased torrential downpours if the temperature rise exceeds 2°C, and the population affected by storm-surge flooding will exceed 1.7 times the present level. In the field of agriculture, if the temperature rise exceeds 2.6°C, areas suitable for cultivation of particular crops will move northward and the CO_2 fertilization effect will be cancelled out.

     In the field of health, increasing impacts of heat stress will appear even from the time of a small temperature rise.
2. **While impact levels and rates of increase will vary by region, there are especially vulnerable regions for each field.**
3. **The most advanced methodologies have been developed in order to provide comprehensive knowledge concerning the dangerous level of global warming.**

Flooding: The area subjected to flooding and amount of damage will gradually increase as the temperature rises up to about 2°C, and will show a more pronounced increasing trend at temperatures exceeding 2°C.

Slope disasters: The impact of slope disasters exhibits a similar trend to the impact of flooding.

Distribution of suitable habitats for Japanese beech forests: A decrease in suitable habitats of around 30% will be seen with a temperature rise of about 1.5°C, followed by decreases of around 50% and 80% with temperature rises of about 2.5°C and 4.0°C, respectively.

Area subjected to pine wilt damage: The impact of climate change will be large, similarly to the case of Japanese beech forests. The area of pine wilt will expand by around 1.3 times with a temperature rise of about 1.2°C, increasing to around 1.5 times at about 2°C and around double at about 4°C.

Rice yield: Productivity will improve until the rise in temperature reaches about 2°C, and will show a decreasing tendency thereafter. A decrease in overall yield compared with the present level will not be seen until the temperature rises by about 2.6°C.

Storm-surge flooding: With a temperature rise of about 2°C, the area of storm-surge flooding will expand by around 1.4 times and the affected population by around 1.7 times. With a temperature rise of about 3°C, the area of storm-surge flooding will expand by around 1.7 times, while at about 4°C, the affected population will expand to around 3.2 times compared with the present levels.

Heat stress mortality risk: A trend of exponential increase is seen as the temperature rises.

Summary of the Present Research (1) – Overall

1. While impact levels and rates of increase will vary by region, there are especially vulnerable regions for each field.

A number of risk maps have been presented showing the regional distribution of climate change impacts in five fields: water resources, forests, agriculture, coastal zones, and human health. In these fields, a wide range of impacts will appear such as increases in flood and landslide disasters, northward migration and decline of forests, impacts on rice production, increases in storm surge disasters as well as the risk of liquefaction in coastal zones, increases in the number of heatstroke cases, and increases in the potential risk of infectious diseases. Moreover, while there are regional differences, some of the impacts will be extremely severe when the country is examined as a whole.

2. Although the level of impact and rate of increase vary according to the field, Japan will also experience significant impacts even with a relatively low temperature rise.

Climate change impact functions elucidating the relationships between temperature rise and the concurrent levels of impact have been developed and utilized to comprehensively study how the impacts on Japan will intensify under a climate scenario in which global warming progresses up to 2100. The results show that even with a relatively low temperature rise, severe impacts will also appear in Japan.

3. In view of the fact that the impacts of climate change have been appearing in various fields in recent years, the immediate planning of appropriate adaptation measures is necessary.

Studies have been conducted on the formulation of adaptation measures necessary to control these adverse impacts, and the direction of measures to be taken in each field.

Summary of the Present Research (2) – Findings by Field

Impacts on Water Resources: The frequency and intensity of torrential downpours will increase, flood damage will expand, and landslide disasters and dam sedimentation will worsen. The costs of water supply purification will rise due to increased turbid runoff during periods without rainfall. On the other hand, decreases in snow water resources will cause shortages of agricultural water at the time of plowing and irrigation of fields on the Pacific side of the Tohoku region, and the risk of water shortages will increase in various regions including southern Kyushu and Okinawa due to changes in precipitation.

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Impacts on Human Health: Threats to human health due to global warming will increase. With rising temperatures, especially the daily maximum temperature, the mortality risk due to heat stress and the incidence of heatstroke will drastically increase. In particular, the risk to people of advanced age will become greater. The occurrence of atmospheric pollution (photochemical oxidants) due to changes in weather will increase. The potential distribution range of vector mosquitoes for infectious diseases (dengue, malaria, and Japanese encephalitis) will also expand.

Future Research Tasks

1. Impact assessment using stabilization scenarios
2. Studies on integrated assessment methods
   - ✓ Studies on how to integrate and assess the results of multifield impact assessments
   - ✓ Strengthening of economic assessment
3. Impact assessment taking adaptation into consideration
4. Uncertainty analysis
5. Support for formulation, planning, and implementation of adaptation measures
6. Assessment of impacts in the Asia-Pacific region

Contacts

Report website: http://www-cger.nies.go.jp/climate/rrpj-impact-s4report.html

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