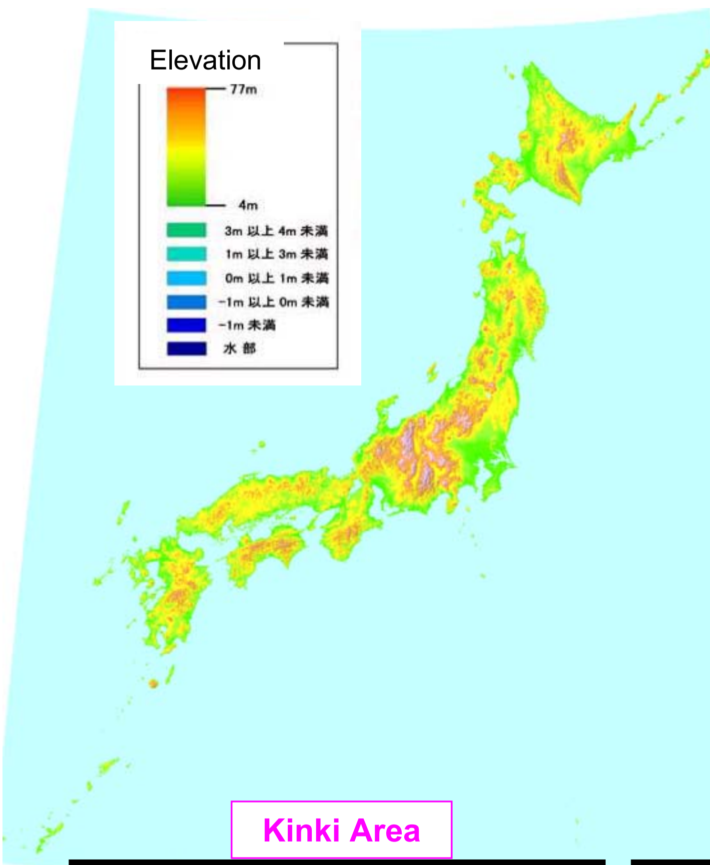
# Reference

# Japan – vulnerable to climate change



**About 50% of population and about 75% of property exist on about 10% of national land lower than river water levels during flooding.**




**Topographical, geological, & meteorological characteristics of Japan**

(i) Land:
A north-south stretch of land extending over a length of 2000 km

(ii) Four main islands:
Four main islands are separated from one another by straits. There are also numerous small islands.

(iii) Backbone mountain range:
Mountains run at the middle of the land.

(iv) Tectonic lines:
Median and Itoigawa-Shizuoka Tectonic Lines run from north to south.

(v) Plains:
Narrow plains are located along shorelines.

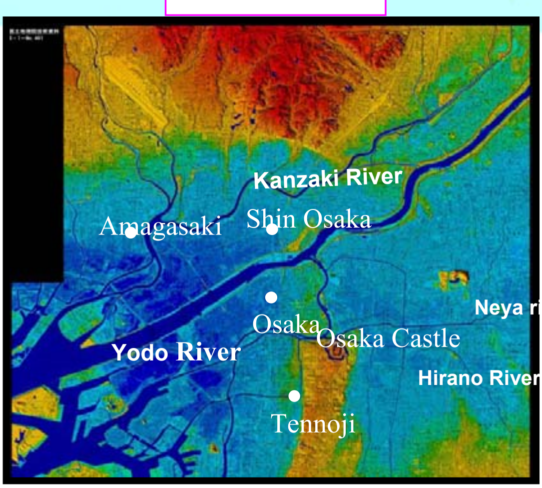
(vi) Weak soils:
Most large cities are located on weak soils.

(vii) Earthquakes:
About 10% of world's earthquakes occur in Japan.

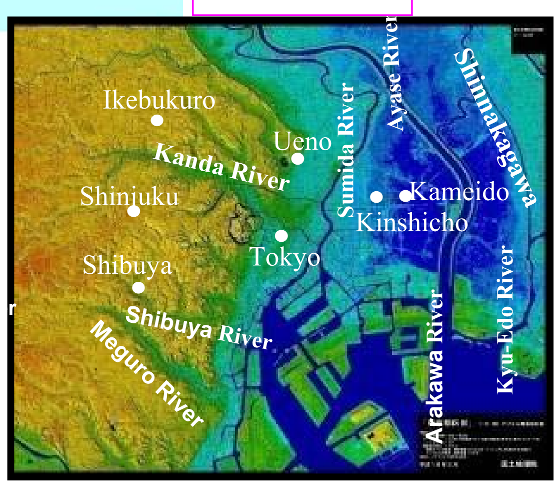
(viii) Heavy rains:
Japan is on the eastern edge of Monsoon Asian and is faced with the threats of heavy rains and typhoons. Rivers flow on steep slopes.

(ix) Snow cover:
Sixty percent of land is located in snowy and cold areas.

**Kinki Area**




**Kanto Area**

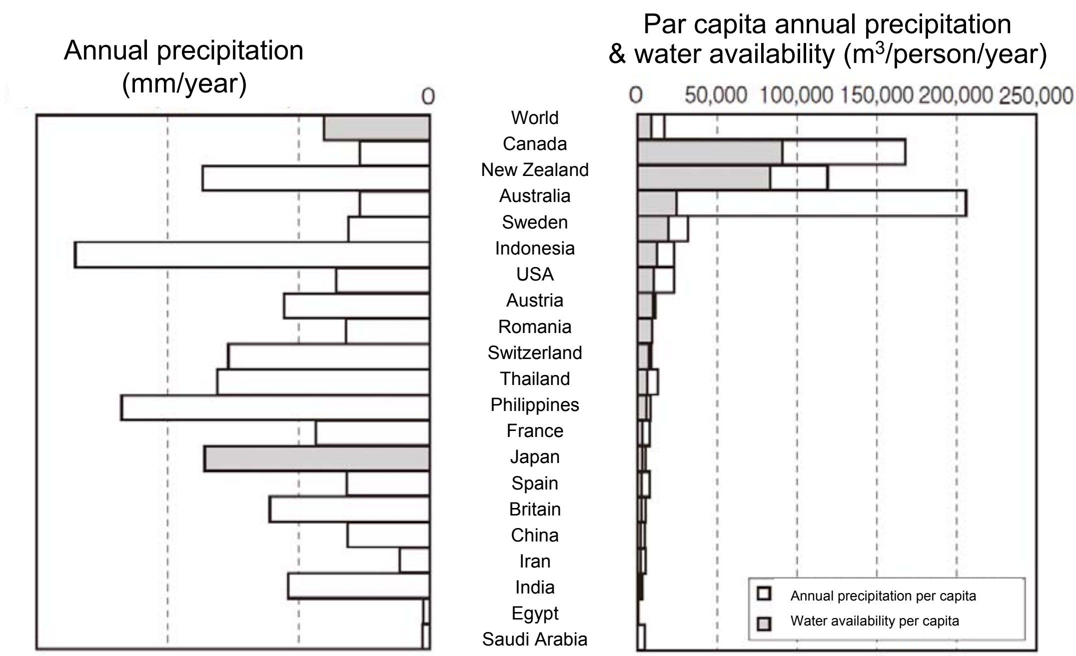



Source: Prepared by the Geographical Survey Institute

# Per capita precipitation

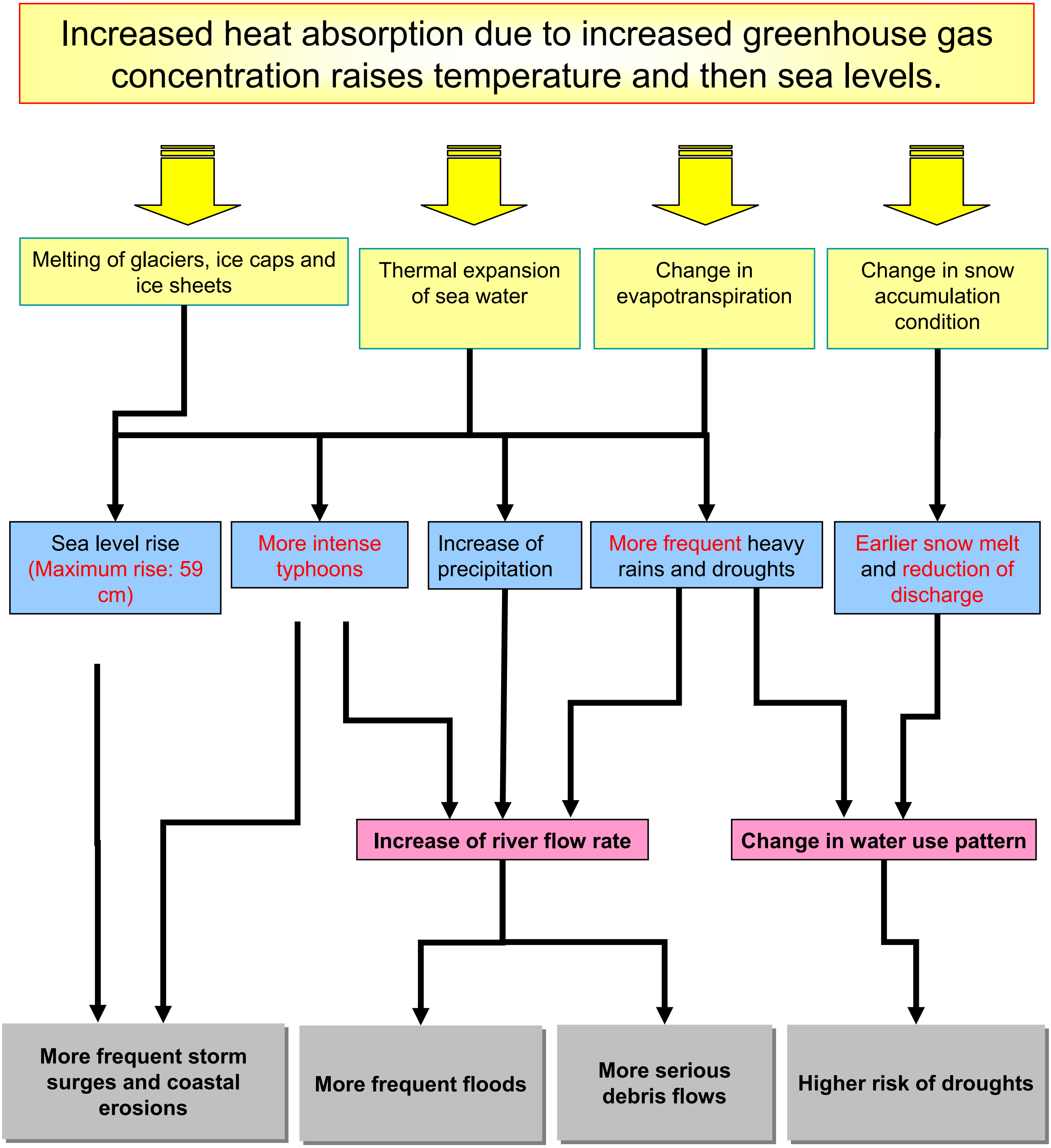
**Policy Report pp.3-7**
**I. Common Recognition**

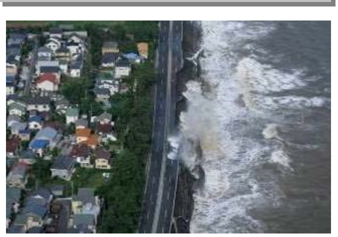
- **Mean annual precipitation**:1,700mm
  **Double** of world land area average (810mm)
- **Per capita annual precipitation**: 5,100$m^3$
  **1/3** of world's per capita annual precipitation (16,800$m^3$)




Note: 1. The figures are crated by MLIT Water Resources Division based on "Aquastat" published by FAO.
2. The population of Japan is based on the 2000 National Census published by the Statistics Bureau of the Ministry of Internal Affairs and Communications. The mean precipitations and water resources are the average between 1971-2000 based on research done by MLIT Water Resources Division.

Source: Water Resources in Japan 2007 -- for secure and safe use of water --


Increased heat absorption due to increased greenhouse gas concentration raises temperature and then sea levels.
Melting of glaciers, ice caps and ice sheets
Thermal expansion of sea water
Change in evapotranspiration
Change in snow accumulation condition
Sea level rise (Maximum rise: 59 cm)
More intense typhoons
Increase of precipitation
More frequent heavy rains and droughts
Earlier snow melt and reduction of discharge
Increase of river flow rate
Change in water use pattern
More frequent storm surges and coastal erosions
More frequent floods
More serious debris flows
Higher risk of droughts



# Climate changes in IPCC AR4

**Policy Report pp.8-12**
**II-1. IPCC**

## Theme 1　Results of monitoring of climate change and its impacts

-Rises of global average air and ocean temperatures and of average global sea level attest to the warming of climate system.
-Global average surface temperature rose by 0.74℃ in the last 100 years.
-Sea level rose in synch with global warming.

## Theme 2　Cause of climate change

-The rise of global average surface temperature since the mid-20th century is highly likely to be attributable to the increase of man-made greenhouse gases.

## Theme 3　Expected climate change and its potential impacts

-A growth-oriented scenario highly dependent upon fossil energy sources will result in a rise of 4℃ in global average surface temperature and a rise of 0.26 to 0.59 m in sea level at the end of the 21st century according to the best available predictions.
-Frequency of heavy rains is highly likely to continue increasing.
-Intensity of tropical cyclones is highly likely to increase.
-Increases of frequencies and intensities of extraordinary meteorological phenomena, and the rise of sea level are expected to have adverse impacts on the nature and human system.
Asia
-Possibility of using freshwater will be reduced by 2050 in central, southern, eastern and south-eastern Asia, in large river basins in particular.
-Risk of inundation by floodwaters from rivers and the sea will increase in the megadelta areas in southern, eastern and south-eastern Asia.

## Theme 4　Options for adaptation and mitigation

-More effective adaptation measures than at present are required for reducing the vulnerability to climate change.
-Regardless of the scale of mitigation, additional adaptation measures will be necessary in 10 to 20 years.

## Theme 5　Long-term perspective

-Neither adaptation nor mitigation alone is sufficient. They can, however, significantly reduce the risks of climate change by complementing each other.
-Adaptation is necessary both in the short term and longer term to address impacts resulting from the warming
-Unmitigated climate change would, in the long term, be likely to exceed the capacity of natural, managed and human systems to adapt.
-Many impacts can be avoided, reduced or delayed by mitigation.



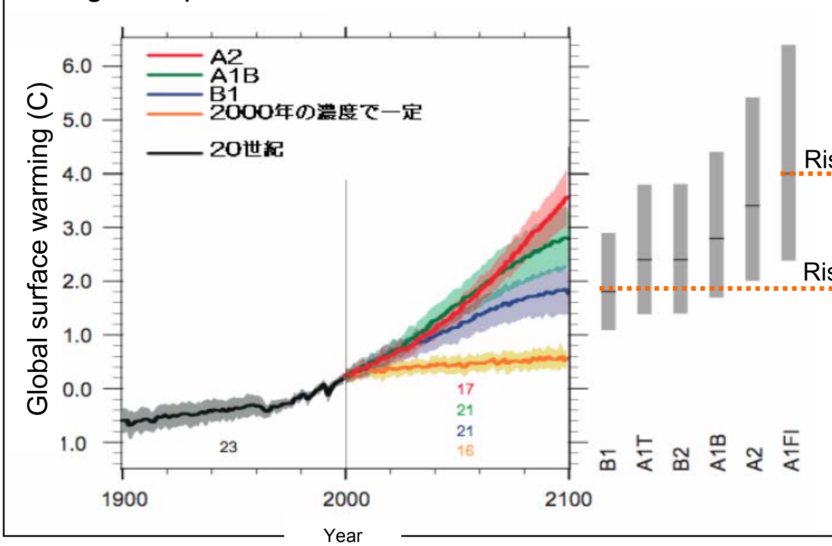
Source: IPCC AR4 Synthesis Report

# Climate changes in IPCC AR4

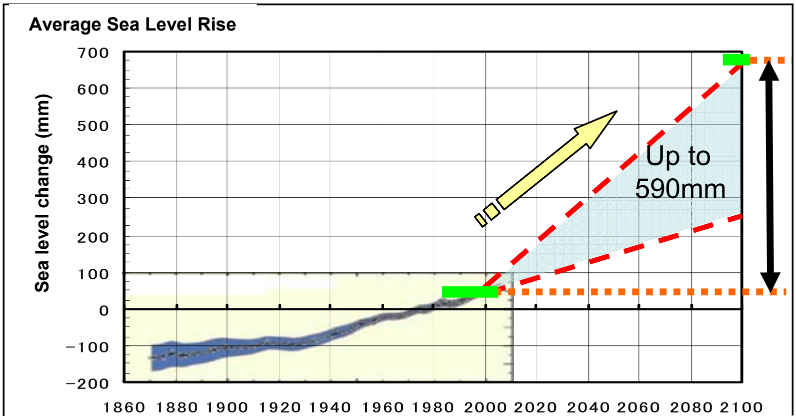


-Global average surface temperature is expected to rise by 1.8 to 4.0℃ in 100 years' time from now.
-Global average sea level is expected to rise by 18 to 59 cm in 100years' time from now.
-Global warming and sea level rise will continue over several centuries even if green house gas emissions are controlled.

## Average temperature




Source: IPCC AR4 WG1 (Working Group 1) Summary for Policymakers (Japan Meteorological Agency)
-Solid lines indicate rises of global average surface temperature in each scenario identified using multiple models.
-Shaded areas indicate the range of standard deviations of average annual temperature for each model.



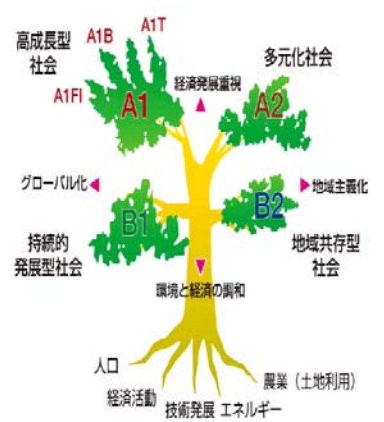

Source: The figure was created by MLIT River Bureau based on IPCC AR4 WG1 Report.

Rises of average temperature and sea level at the end of the 21st century

| | Society achieving both global environmental protection and economic development | Society achieving high economic growth dependent on fossil energy sources |
|---|---|---|
| Temperature rise | About 1.8℃ (from 1.1℃to2.9℃) | About4．0℃ (from2.4℃to6.4℃) |
| Sea level rise | 18～38cm | 26～59cm |

Source: IPCC AR4 WG1 Report

Basic Concept of Emission Scenarios




A1High-growth World Scenario"
A1FI:Emphasis on fossil fuels
A1T : Emphasis on energy resources other than fossil
A1B :Emphasis on a balance across all sources
A2. Heterogeneous Society Scenario
B1. Continuously Developing Society Scenario
B2 Regional Pluralism Society Scenario

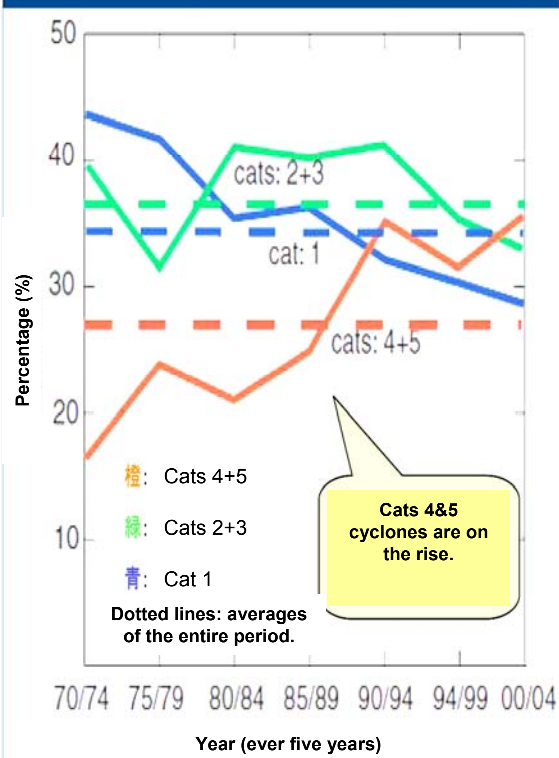
Source: IPCC AR4 Synthesis Report
As of Dec. 17, 2007

# Climate changes in IPCC AR4



-Over the past three decades, the percentage of strong tropical cyclones has become larger.
-Tropical cyclones of Categories 4 and 5 generated over the Western Atlantic Ocean as well as those generated over other major oceans have increased.
-In addition, it is predicted that the strength of tropical cyclones will continue to increase.

## Percentage of tropical cyclones by category




*Categories 1-5 shows the intensity of tropical cyclones with category 5 the strongest.

## No. & % of categories 4&5 tropical cyclones

| Oceans | Period | | | |
|---|---|---|---|---|
| | 1975-1989 | | 1990-2004 | |
| | No. | % | No. | % |
| E. Pacific | 36 | 25 | 49 | 35 |
| W. Pacific | 85 | 25 | 116 | 41 |
| N. Pacific | 16 | 20 | 25 | 25 |
| SW. Pacific | 10 | 12 | 22 | 28 |
| N. Indian | 1 | 8 | 7 | 25 |
| S. Indian | 23 | 18 | 50 | 34 |

Source: IPCC AR4 WG1 Report

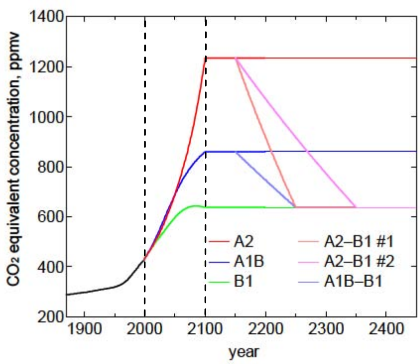
# Climate changes in IPCC AR4

**Policy Report pp.8-12**
**II-1. IPCC**

## IPCC Fourth Assessment Report Working Group I

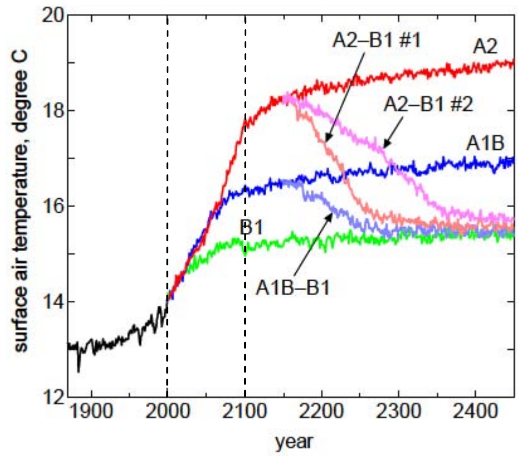
-Even if radioactive forcing becomes stable by 2100 as in Scenario B1 or A1B, the global average temperature is expected to rise by about 0.5℃ by 2200.
- If radioactive forcing becomes stable as in Scenario A1B, sea level is expected to rise by 0.3 to 0.8 meter (compared with that from 1980 to 1999) due solely to thermal expansion. Because it takes time for heat transfer into the deep sea, thermal expansion is expected to continue for centuries to come.
- $CO_2$ emitted in the pastor to be emitted in the future by human activities contributes to rises in global temperature and sea level for thousands of years to come, considering the time scale necessary to remove such gas from the atmosphere.

**Examples of Projected Long-term Impacts of climate change**

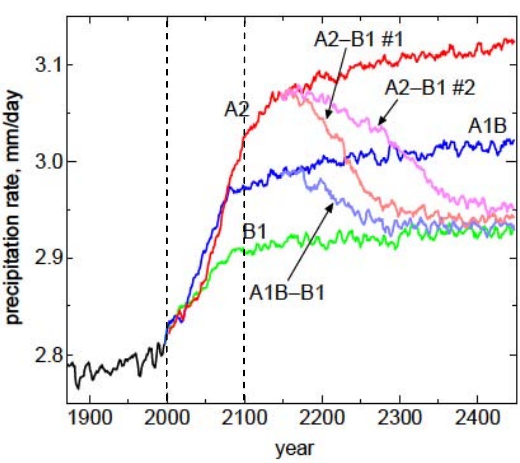



Scenario of Green Gas Concentration
(equivalent $CO_2$ concentration ) Used in Predictive Calculation

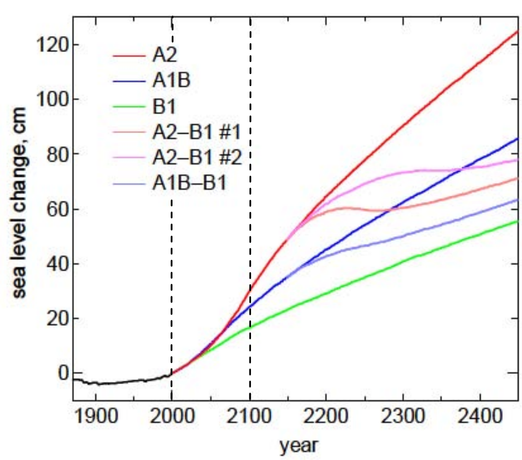
Projected Global Average Temperature Rise




Projected Global Average Precipitation



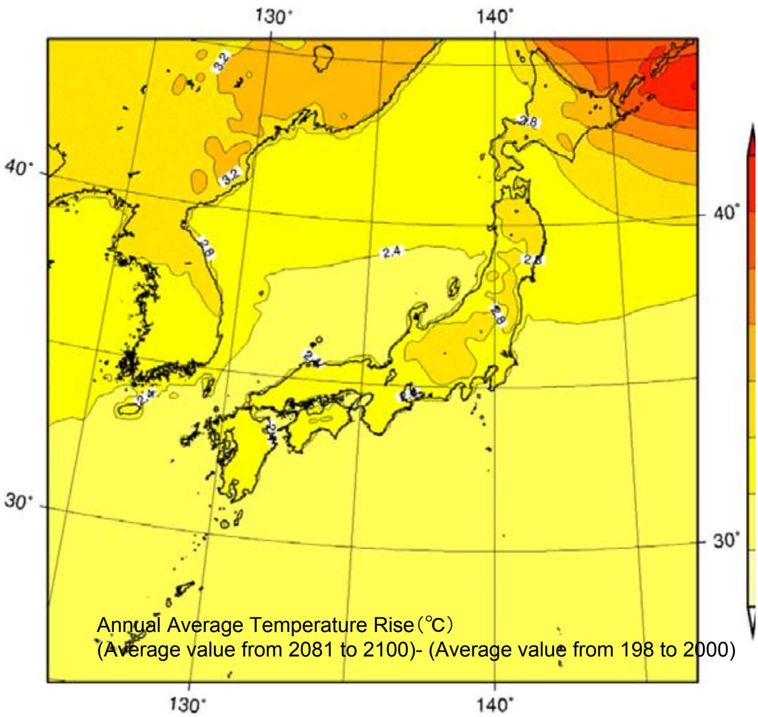

Diagnosis Result of Sea Level Rise due to Thermal Expansion



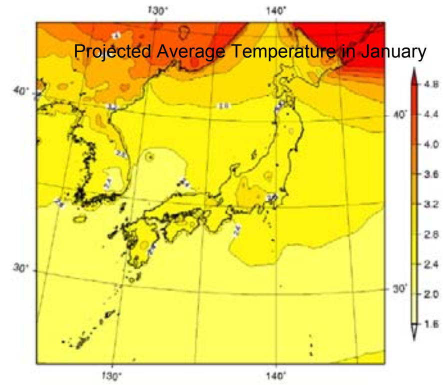

Source: Report on “Development of Super High Resolution Global and Regional Climate Models” under the research project of “Sustainable Coexistence of Human, Nature and the Earth” produced by the Central Research Institute of Electric Power Industry

# Climate changes over Japan

**Policy Report pp.13-16**
**II-2. Climate Change Reports**

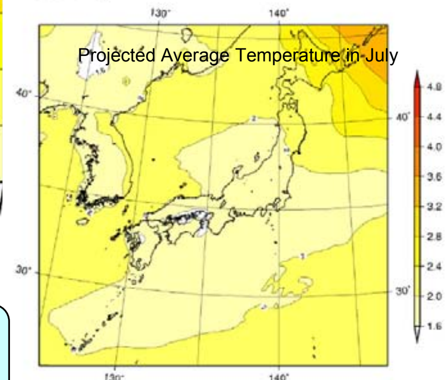


Annual Average Temperature Rise（℃）
(Average value from 2081 to 2100)- (Average value from 198 to 2000)



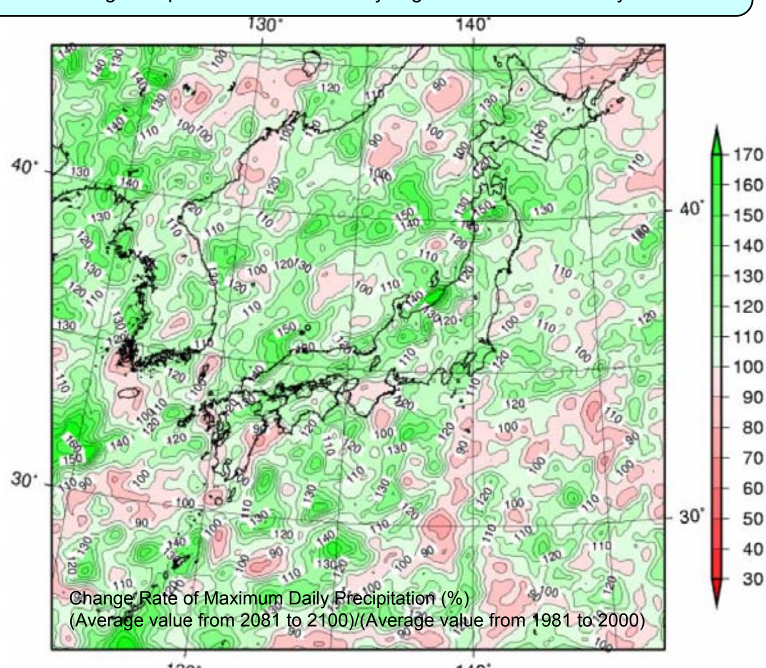
Projected Average Temperature in January

(f) 7 月

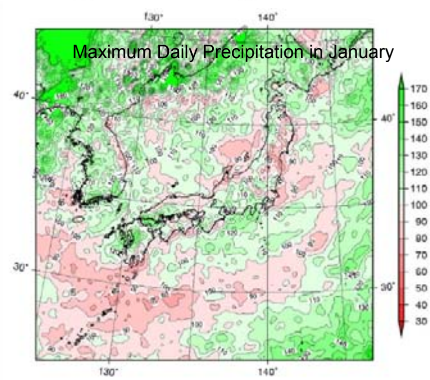


Projected Average Temperature in July

-The annual average temperature is expected to rise 2 to 3℃(and 4 ℃ in some areas of Hokkaido).
-The average temperature rise in January is greater than that in July.

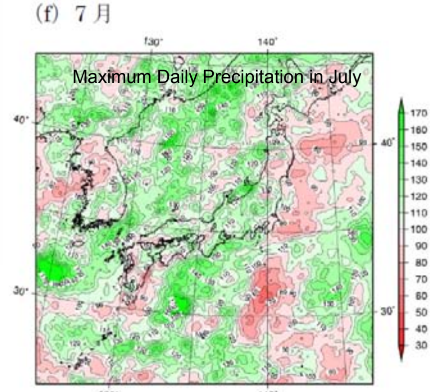


Change Rate of Maximum Daily Precipitation (%)
(Average value from 2081 to 2100)/(Average value from 1981 to 2000)



Maximum Daily Precipitation in January

(f) 7 月



Maximum Daily Precipitation in July

-The maximum daily precipitation tends to increase up to 1.5 times across the country
-The maximum daily precipitation in July is expected to increase in almost all regions.

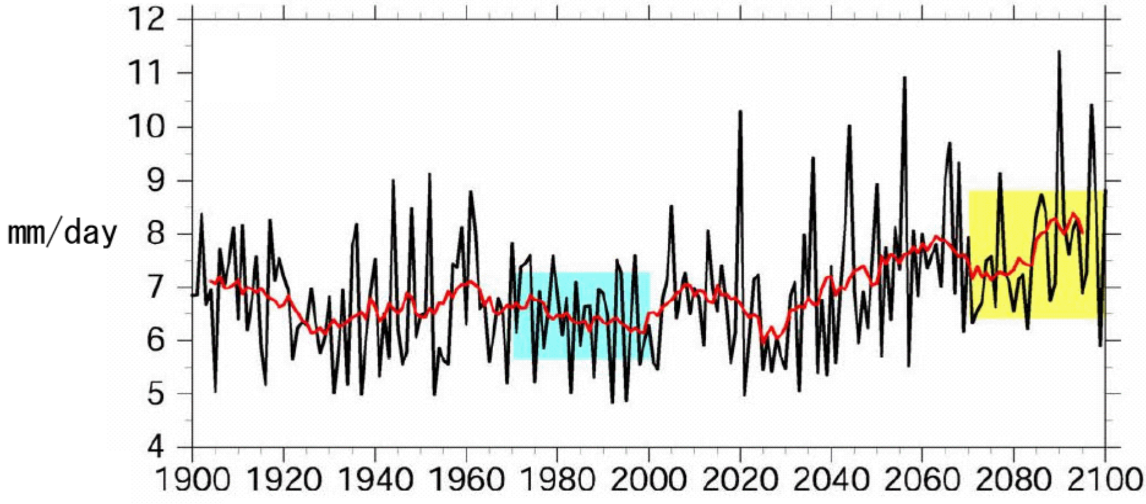
Source: Source: “*Chikyu-ondanka ndanka Yosoku-joho* (Global Warming Projections) Volume 6” by Japan Metrological Agency: Projection using RCM20 (Scenario A2)

# Climate changes over Japan

Policy Report pp.13-16
II-2. Climate Change Reports

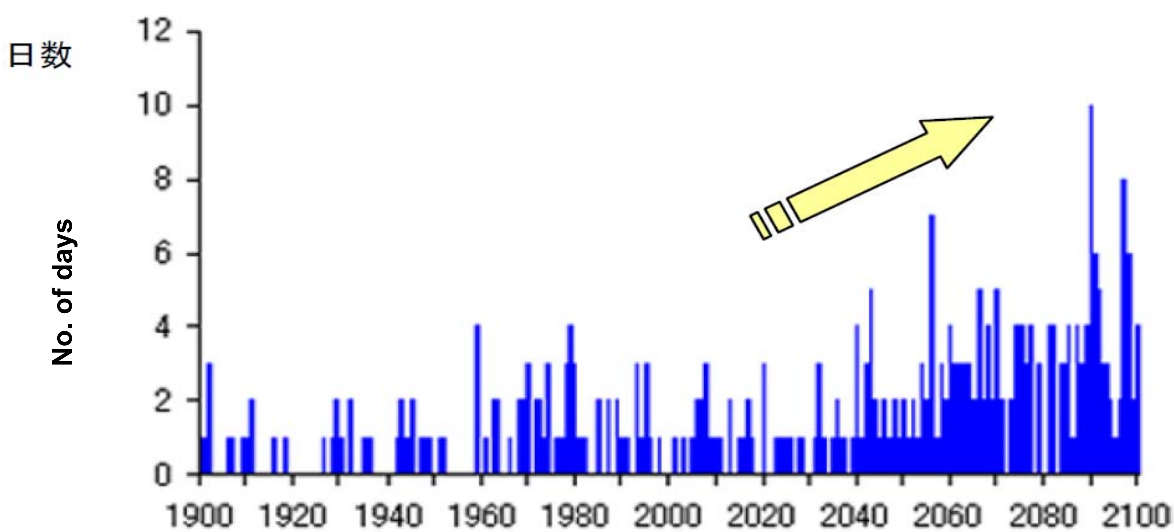
- With rainfall increasing, the range of variation is also expected to increase. The number of days with no rainfall is also expected to increase.
-The possibility of droughts is expected to increase, while that of large floods is also expected to increase.

Projected changes in average rainfall during summer (June-August) in Japan




Source: Presentation at a water resources symposium entitled the “World Water Day – climate change-induced water issues”

The number of days of heavy rains with a daily precipitation of more than 100 mm is expected to increase from about three up to about ten per annum.



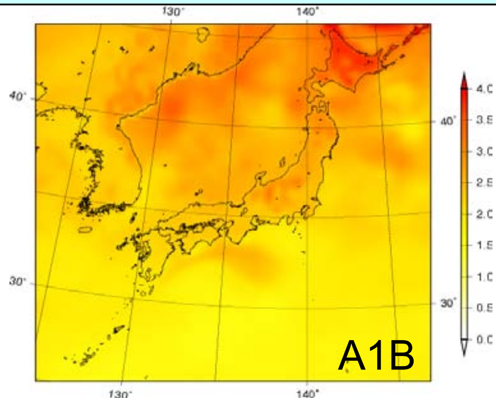

Projected number of days with heavy rainfall in summer
(daily precipitation of more than 100 mm)



Source: The figure is created based on “*Ijo-kisho (Extreme Climate)* Report 2005” published by Japan Meteorological Agency.

**Temperature increase in winter (Dec. to March)**

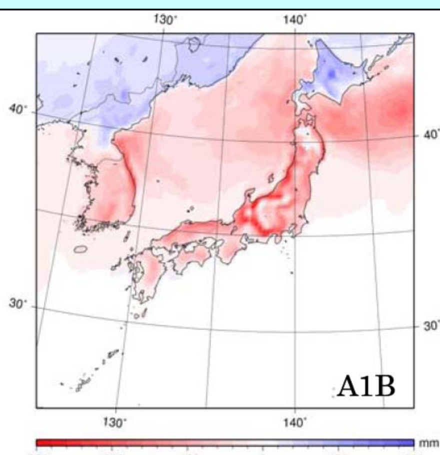
- Warmer at higher latitudes
- Over 3℃ in Hokkaido, 2-3℃ in eastern to western Japan based on A1B scenario




Projected through comparison of average winter-period temperatures between the current climate (1981-2000) and future climate (2081-2100) based on the CRCM model.

## Change in snowfall

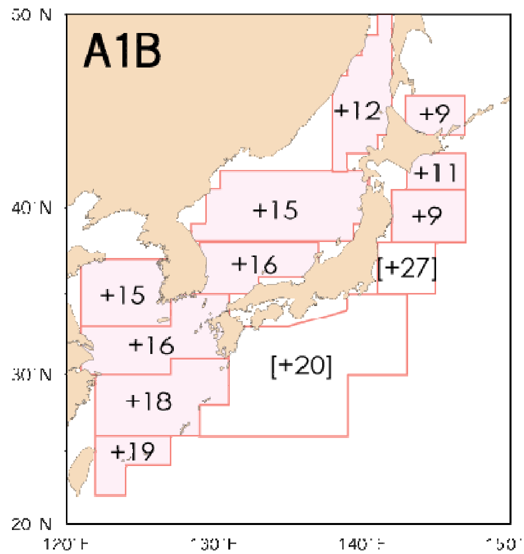
- Snowfall is projected to decrease throughout Japan except Hokkaido, but increase in higher elevation areas in Hokkaido.




Projected through comparison of average winter-period snowfall between the current climate (1981-2000) and future climate (2081-2100) based on the CRCM model (Snowfall was converted to rainfall).

## Change in annual average sea level

- Annual rising rate of 0.09-0.19m during the 100-year period (1981-2100) based on A1B scenario.
- The rising rate is calculated based on thermal expansion and ocean current changes. The effect of ice sheet melting is not included.



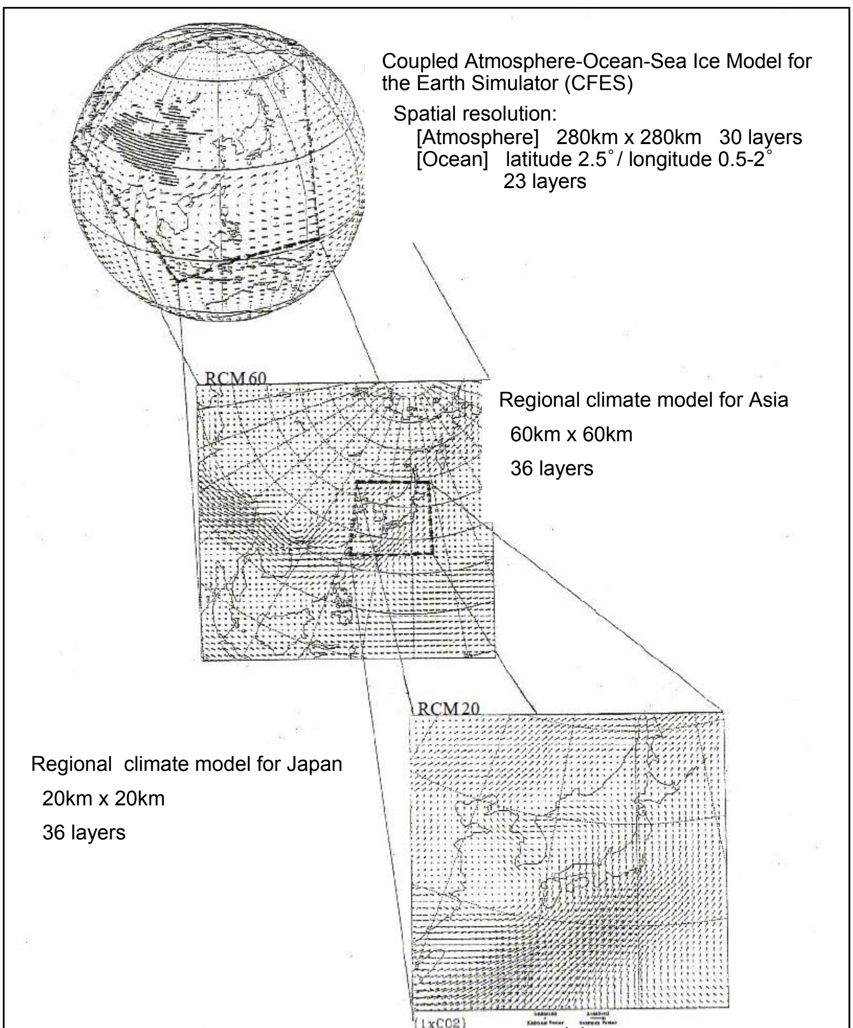

The rising rate was projected based on change in sea level rise during the 100-year period (1981-2100) simulated using the NPOGCM model. The bracketed rising rates requires caution when used because of their high uncertainties in long-term projection.

Source: "*Chikyu-ondanka ndanka Yosoku-joho* (Global Warming Projections) Volume 7" by Japan Metrological Agency

Recently developed simulation models enable more detailed regional climate predictions.

## Regional Climate Models

| | GCM20 (General Circulation Model) | RCM20 (Regional Climate Model) |
|---|---|---|
| Areas to be Calculated | Entire globe | Japan and surrounding areas |
| Horizontal Resolution | About 20 km<br>Number of meshes 1920 x 9960 | About 20 km<br>Number of meshes 129 x 129 |
| Number of Vertical Layers | 60 layers | 36 layers |
| Lateral Boundary Conditions | N/A, as this is a global scale mode. | Climate model for Asia |



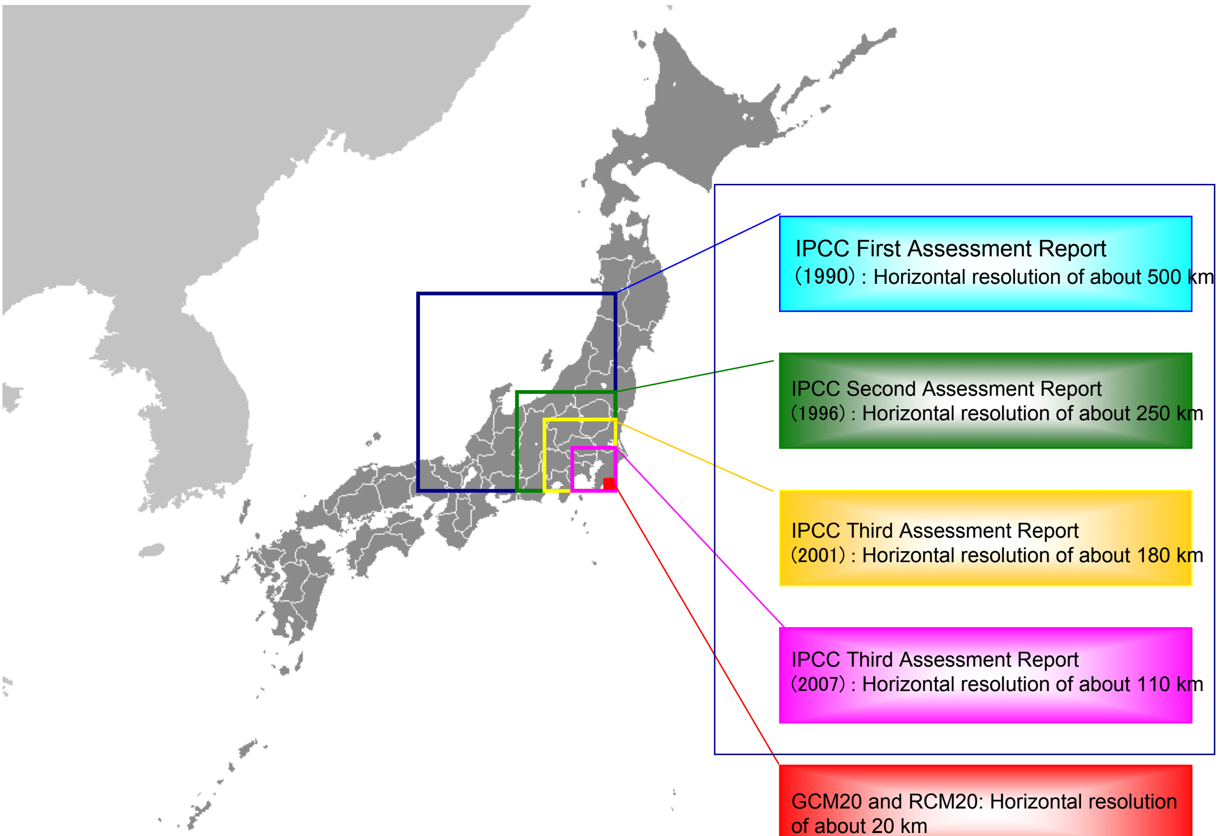

**Concept of boundary conditions of RCM20**

Source: The figure is created based on "*Ijo-kisho (Extreme Climate)* Report 2005" published by Japan Meteorological Agency.

# Regional Climate Models (RCM20 & GCM20)



The resolution of climate change prediction models has been improved year by year.




The figure only shows relative mesh sizes, not actual mesh locations.

Prepared by the River Bureau

Projecting climate changes

↓

Projecting the increases of disaster risks

-Predicting the increase of floods in each basin
-Evaluating the decrease of safety level in each basin

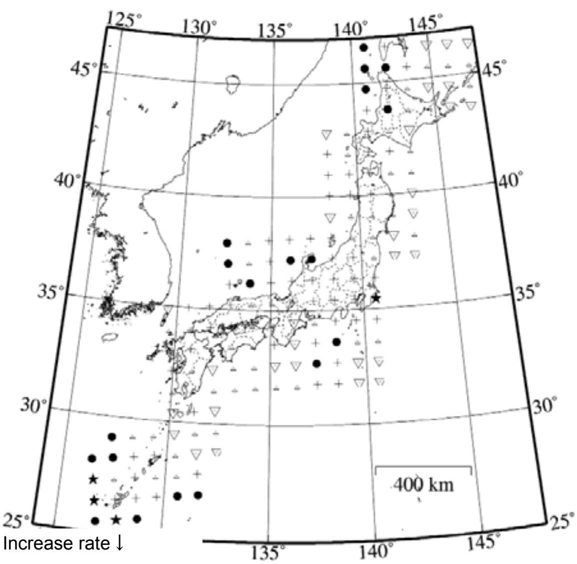
↓

Re-defining the goal

# Rainfall projection based on RCM 20

**Policy Report pp.17-22**
**II-3. Increased External Forces**

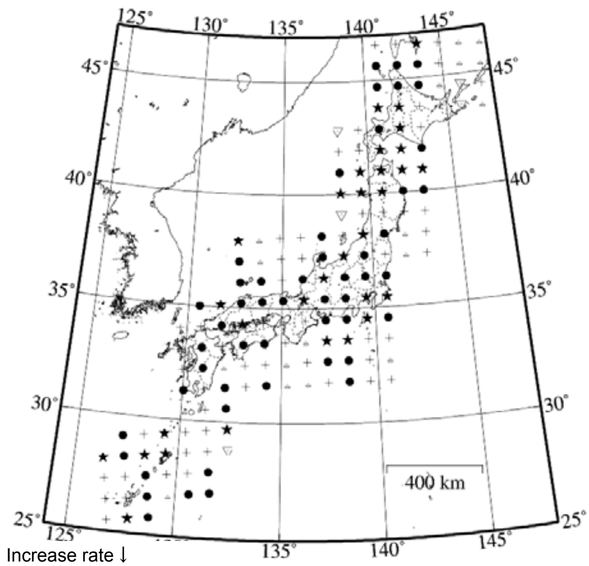
-Maximum daily precipitation is projected to increase in the next 100 years.
-The increase may be more evident in the second half of the next 100 years than in the first.
-In most regions, the increase may be 1.1 to 1.2 times in 50 years and 1.2 to 1.4 times in 100 years.




Increase rate ↓

変化率 ▽～80% -:80～100% +:100～120% ●120～140% ★140%～

Fig. Change in 1/100 Maximum Daily Precipitation
(Increase rate = 50 years later / Current)




Increase rate ↓

変化率 ▽～80% -:80～100% +:100～120% ●120～140% ★140%～

Fig. Change in 1/100 Maximum Daily Precipitation
(Increase rate = 100 years later / Current)

Projection results using RCM20 (Scenario A2)

Source: Kazunori Wada, Katsuhiko Murase, Yosuke Tomizawa, “Changes in Rainfall Characteristics due to Global Warming and Flood/Drought Risk Assessment,” *Doboku-gakkai-ronbunshu* (a journal published by the Japan Society of Civil Engineers), No. 796

# Future rainfall increase & decrease in flood control safety

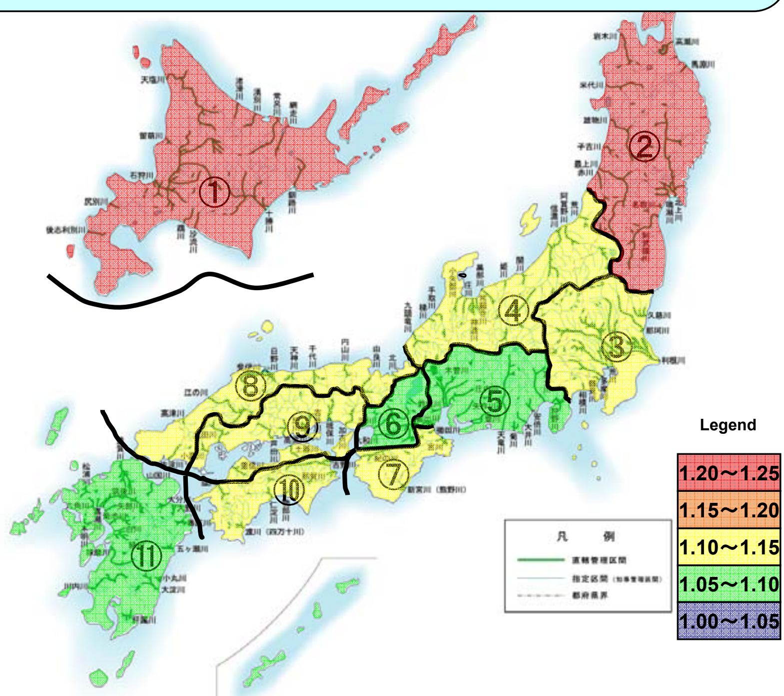
**Policy Report pp.17-22**
**II-3. Increased External Forces**

Future rainfall amounts were predicted as a median value of

Average rainfall in 2080-2099 period
Average rainfall in 1979-1998 period

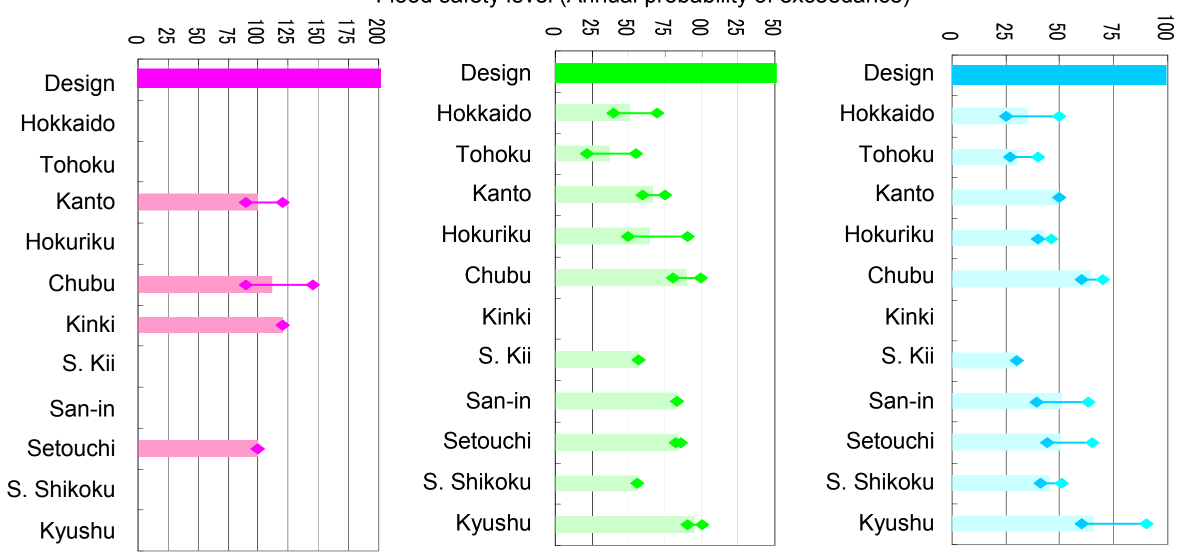
The above equation was obtained based on the maximum daily precipitation in the year at each survey point identified in GCM20 (A1B scenario).

| | | |
|---|---|---|
| ① | Hokkaido | 1.24 |
| ② | Tohoku | 1.22 |
| ③ | Kanto | 1.11 |
| ④ | Hokuriku | 1.14 |
| ⑤ | Chubu | 1.06 |
| ⑥ | Kinki | 1.07 |
| ⑦ | Southern Kii | 1.13 |
| ⑧ | San-in | 1.11 |
| ⑨ | Setouchi | 1.10 |
| ⑩ | Southern Shikoku | 1.11 |
| ⑪ | Kyushu | 1.07 |




Based on changes in annual maximum daily precipitation in each region (listed in the table above), the decreases in safety level were estimated in 82 river systems and charted by region (horizontal scale) and current safety level (vertical scale).

Flood safety level (Annual probability of exceedance)



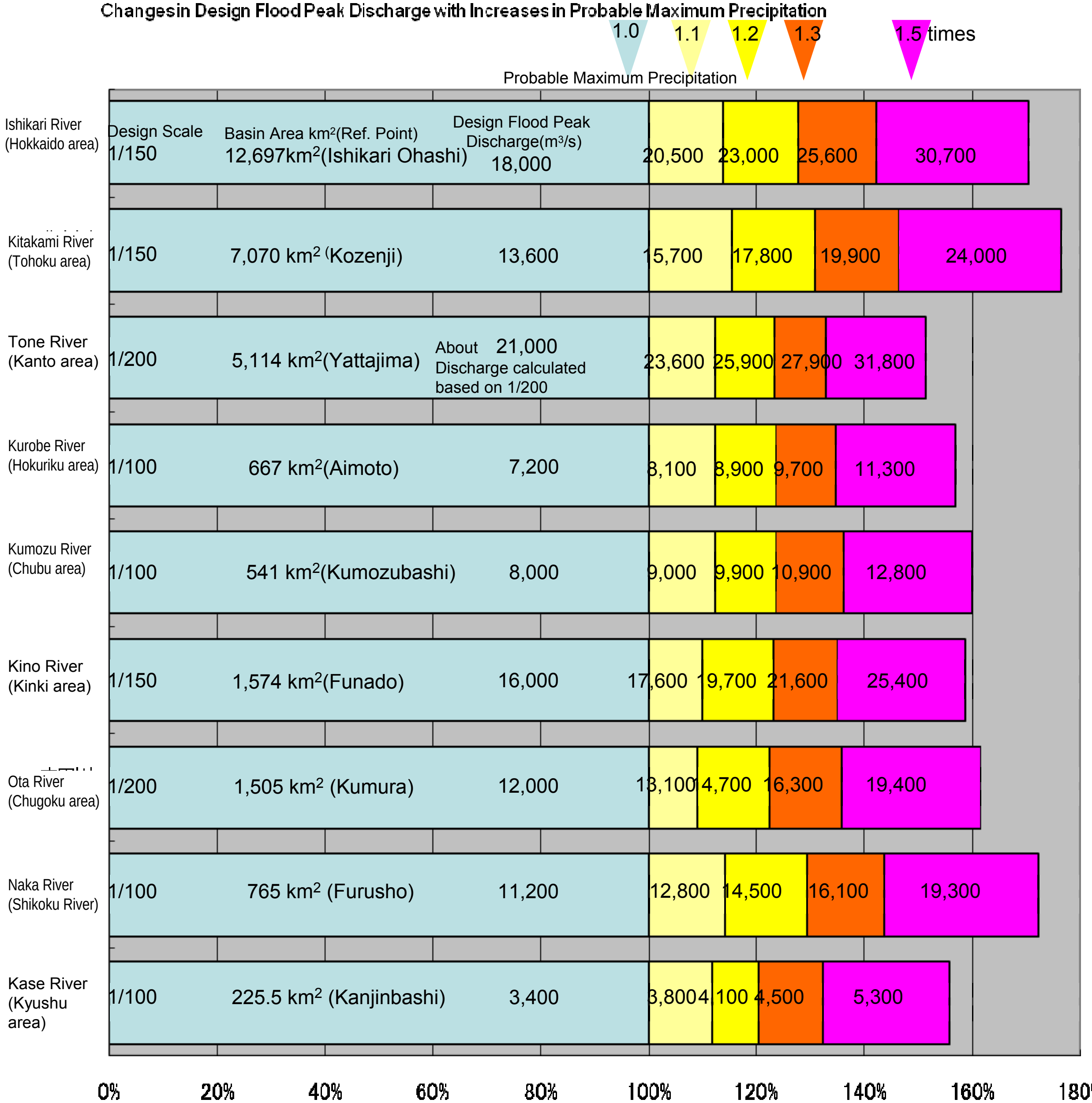

Note: The circled numbers were the number of river systems used for the estimation.

# Global warming impacts on design flood peak discharge

**Policy Report pp.17-22**
**II-3. Increased External Forces**

According to various prediction results, precipitation is expected to increase up to 1.2 times in most regions. In some regions, it is expected to increase 1.3 to 1.5 times.
Using nine class-A rivers that adapt daily-based probable maximum precipitation (PMP), the peak discharge was calculated assuming the probable maximum precipitation will increase (1) 1.1 times, (2) 1.2 times, (3) 1.3 times, and (4) 1.5 times.

Changesin Design Flood Peak Discharge with Increases in Probable Maximum Precipitation




*Assuming that the probable maximum precipitation will increase 1.1 to 1.5 times, the peak discharge was calculated based on the discharge simulation models prepared when the basic policies were established.

Prepared by the River Bureau

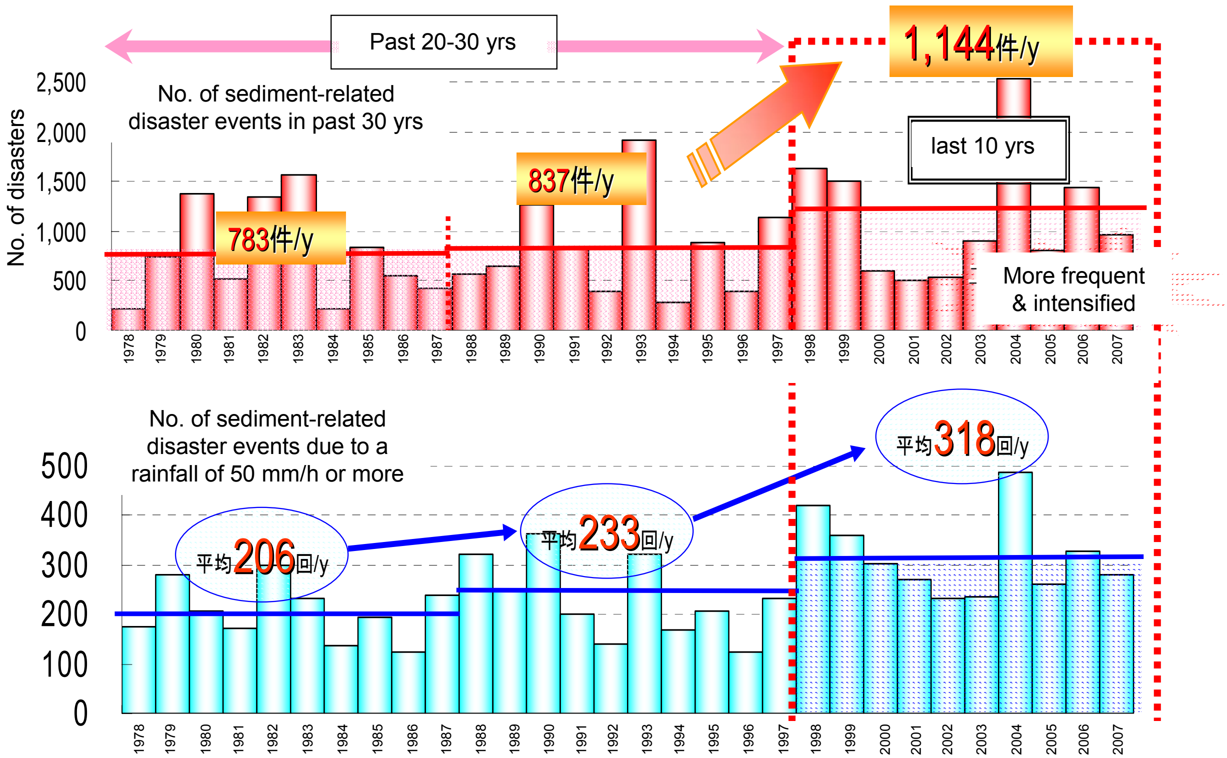
# Increasing trend in number and intensity of sediment-related disasters

**Policy Report pp.17-22**
**II-3. Increased External Forces**

-An average of 921 sediment-related disasters in the past 30 years.*

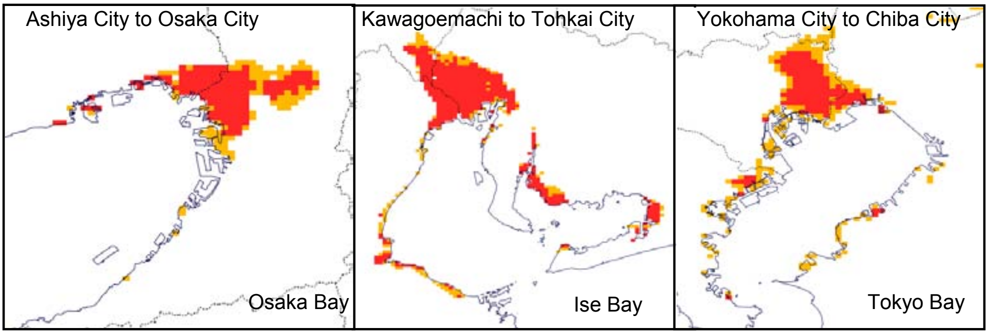
-An increasing trend in number and intensity of sediment-related disasters due to more variable climate.

-More frequent and intensified sediment-related disasters if global warming progress as IPCC has projected.




(*The number excludes pyroclastic flows during 1992-1996 due to the Unzenfugendake eruption. The numbers of debris flows and landslides during 1978-1982 were estimated by the Land Conservation Division of the Sabo Department, MLIT.)

## Increases of below-sea-level areas in three large bay areas (Tokyo Bay, Ise Bay and Osaka Bay)




**Areas with flood risks due to storm surges will increase**

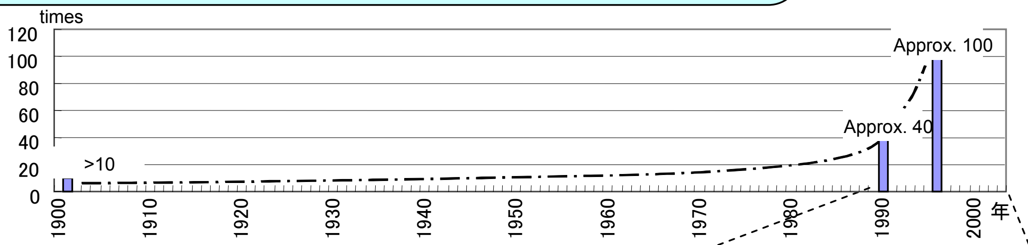
| | Present | After sea level rise | Rate of increase |
|---|---|---|---|
| Area (km$^2$) | 559 | 861 | 1.5 |
| Population (in tens of thousands of people) | 388 | 576 | 1.5 |

*Prepared by the River Bureau based on the national land-use digital information.
*Shown are the areas at elevations lower than sea level shown in a three-dimensional mesh (1 km x 1 km). Total area and population are based on three-dimensional data.
*No areas of surfaces of rivers or lakes are included.
*A premium of 60% is applied to the potential flood risk area and to the population vulnerable to flood risk in the case with a one-meter rise of sea level.

## Increase of inundation risks due to storm surges

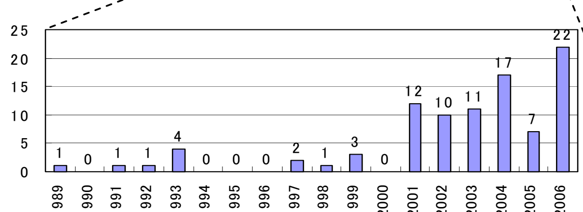
-St. Mark's Square in Venice was flooded with water less than ten times a year at the beginning of the 20th century. Ground settlement and climate change later caused the frequency to increase to about 40 times a year by 1990 and to as many as 100 times a year in 1996.
- There is also a report of 250 times of inundation a year in 2006.

*At present, it is not clear whether the increase of inundation risk is attributable to global warming or not but there may be a possibility




Annual frequency of inundation of St Mark's Square in Venice, Italy (Graph prepared based on the Economics of Climate Change by Stern Review.)

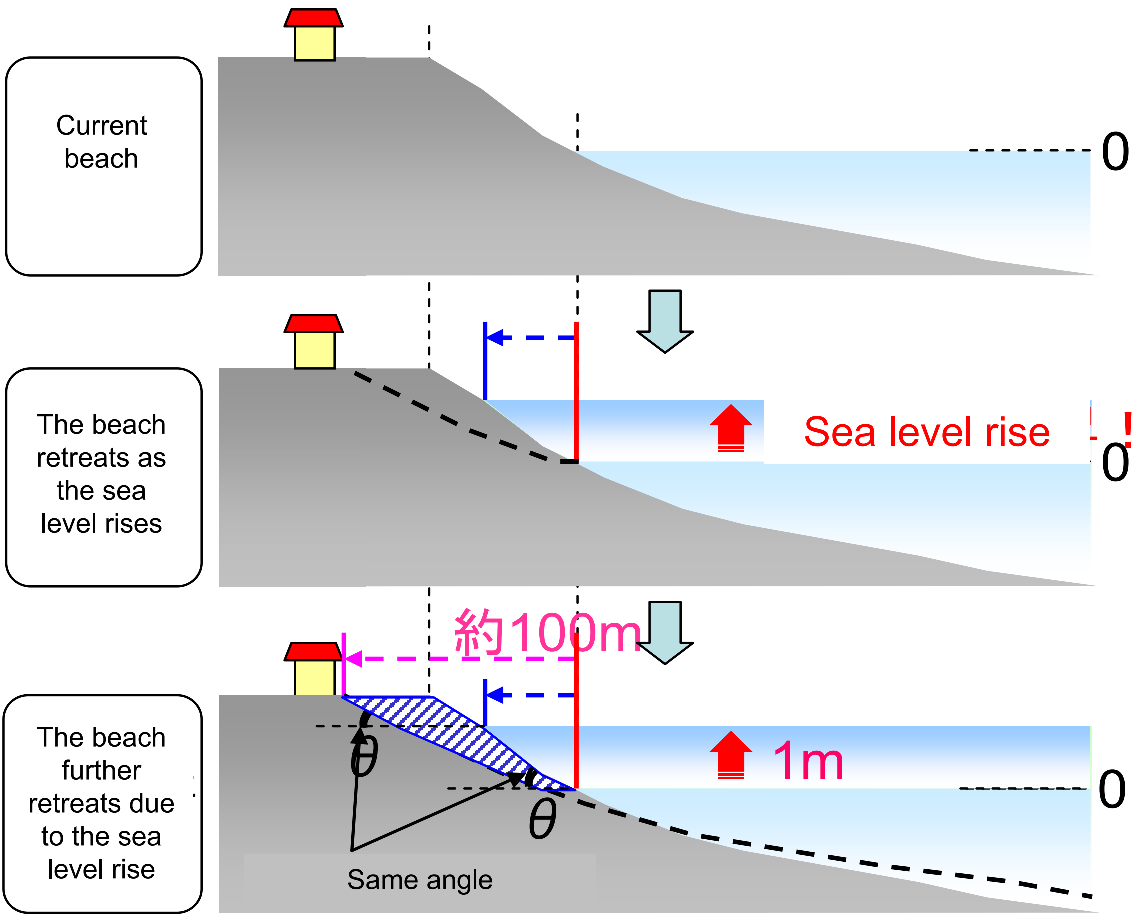
The corridor of Itsukushima Shrine in Hiroshima was inundated in water less than five times a year in the 1990s. It was flooded about ten times a year in the 2000s. The frequency was 22 times a year in 2006 and is still increasing.




Annual frequency of inundation of the corridor of Itsukushima Shrine in Hiroshima (Graph prepared by the Chugoku Regional Development Bureau based on a diary of Itsukushima Shrine.)

# Further coastal erosion

-With sea level rise, the beach tries to achieve a stable gradient, so the shoreline retreats by a margin larger than the sea level rise.
-With a one-meter rise of sea level, beach retreats by about 100 m. About 90% of beaches in Japan are vulnerable to erosion.




| | | | |
|---|---|---|---|
| Sea level rise (m) | 0.3 | 0.65 | 1 |
| Ave. beach retreat (m) | 30.55 | 65.4 | 101.04 |
| Eroded area rate | 56.6 | 81.7 | 90.3 |

Prepared by MLIT River Bureau based on “Impact assessment of sea-level rise on sandy beaches” by Nobuo Mimura, Shin Kiyohashishi, and Kaoruko Inoue

# Increasing drought risk

Policy Report pp.17-22
II-3. Increased External Forces

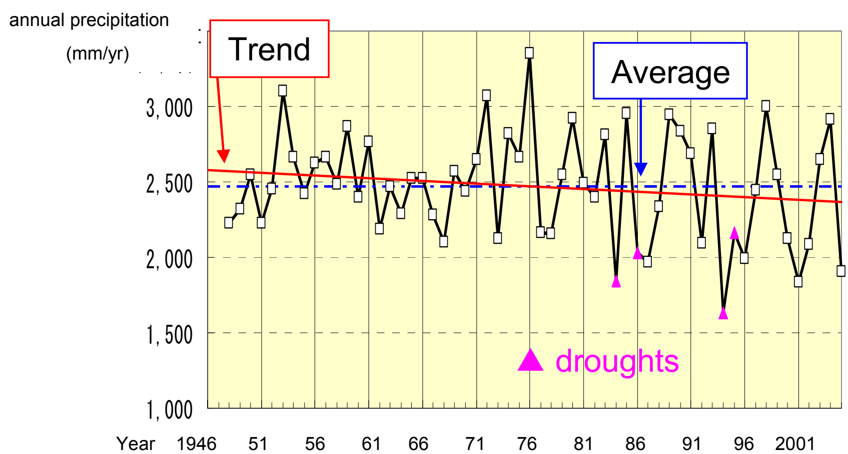
- Recent trend: Less precipitation with a wider variation of annual precipitation in comparison with the 1945-1974 period, during which many dams and other facilities were designed.
- As a result, stable water supply from the dams has been decreasing.

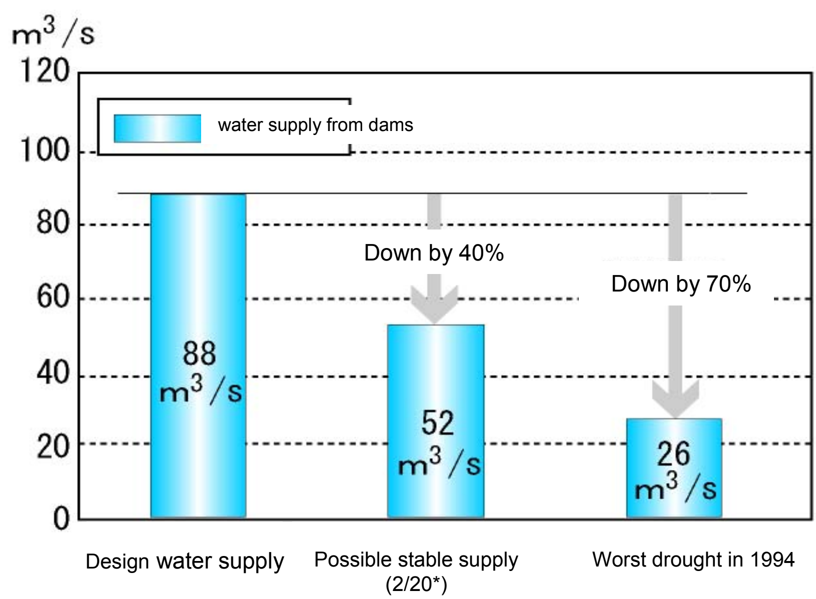
  Example in the Kiso river system

  Recent years (1979-1998): Water supply was about 40% less than the design water supply.

  Recent Worst drought (1994): Water supply was about 70% less than the design water supply.

**Trend of annual precipitation in Kiso river system**




2/20*: the probability referring to a drought that is presumed to be likely to occur twice every 20 years. (The calculated quantity was based on the assumption that such a drought would occur in FY1987 among 20 years from FY1979 to FY1998.) For water resource development involving the construction of dams, a plan is formulated in consideration of the occurrence of a drought that is presumed to be likely to occur once per decade to ensure stable water intake.

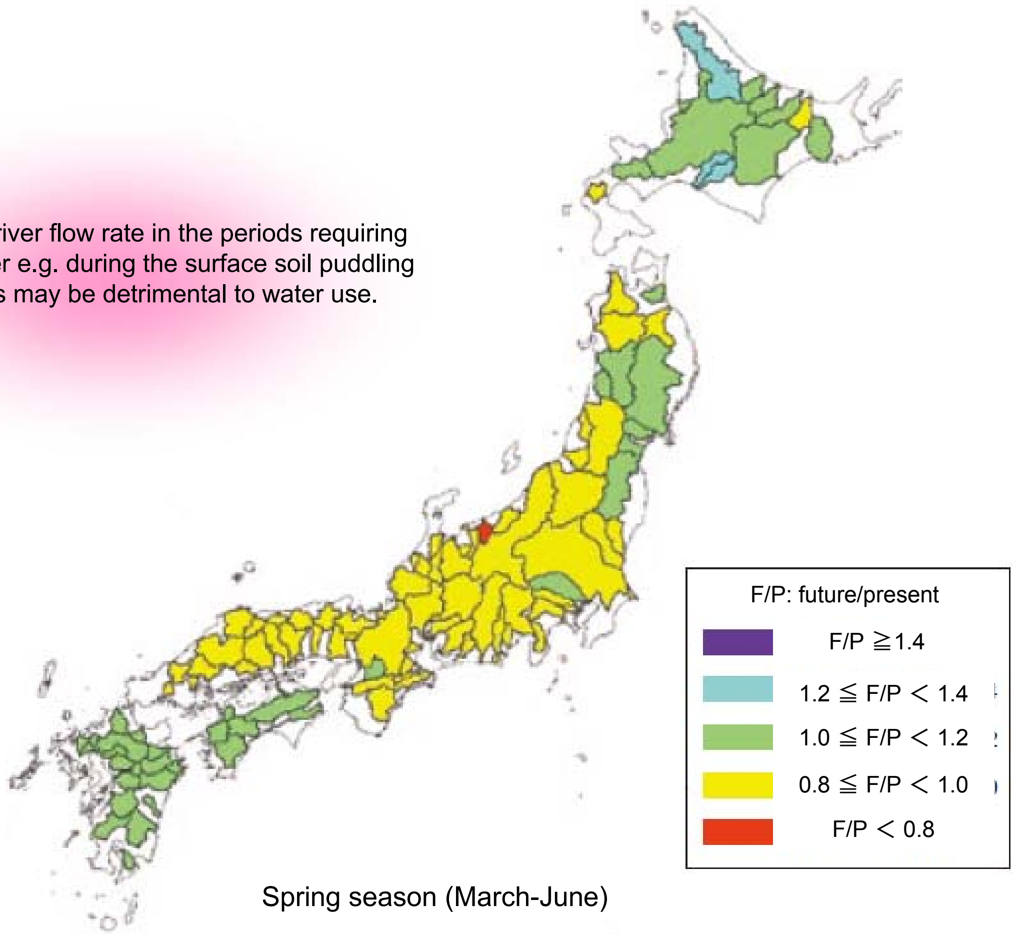
# Increasing drought risk



Water falling to the earth’s surface, or the sum of snowfall and rainfall in the March-June period, that impacts river flow rate will decrease in 100 years’ time in numerous areas.

Present conditions in Class A rivers (1979 to 1998) and water falling on the surface in the future (1080 t 2099)

Reduction of river flow rate in the periods requiring irrigation water e.g. during the surface soil puddling in paddy fields may be detrimental to water use.

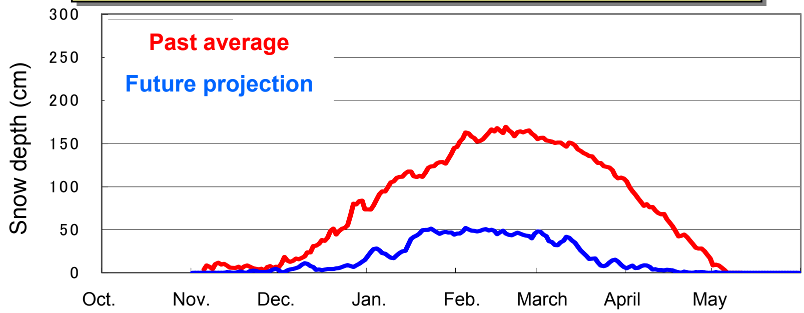



Spring season (March-June)

Source: Water Resources in Japan 2007, Land and Water Bureau, Ministry of Land, Infrastructure and Transport

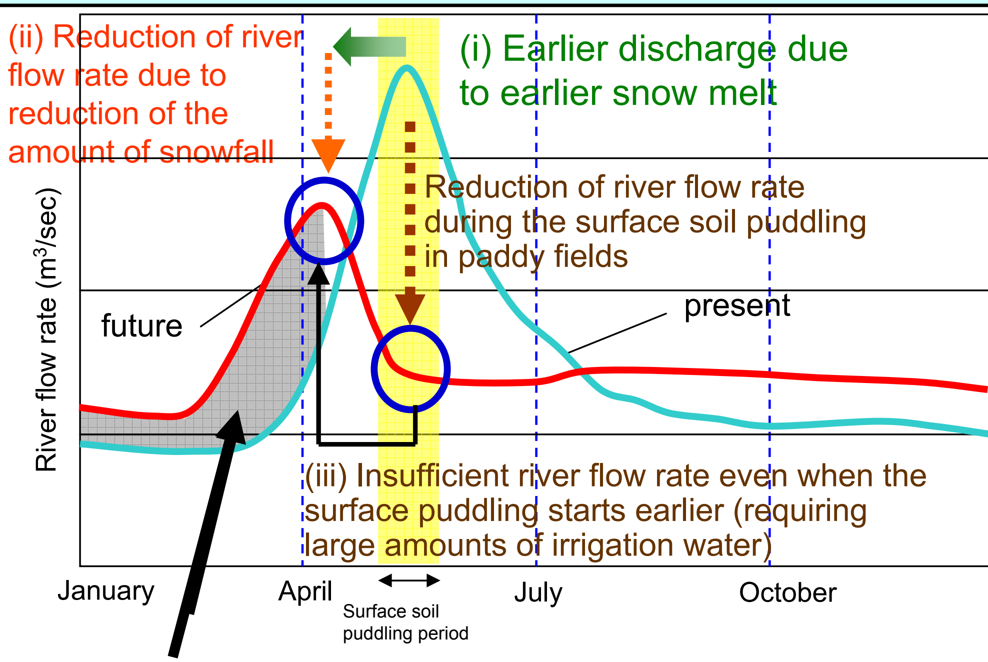
In the upper Tone River, snow cover is likely to be reduced considerably. That will accompany the reduction of river flow rate in the snow melt season or in early spring.

Change in snow cover in 100 years' time due to further global warming (Fujiwara)




*Prepared by Water Resources Department, Water and Land Bureau, Ministry of Land, Infrastructure and Transport based on Regional Climatic Model (RCM) 20, a global warming prediction model, developed by Japan Meteorological Agency.

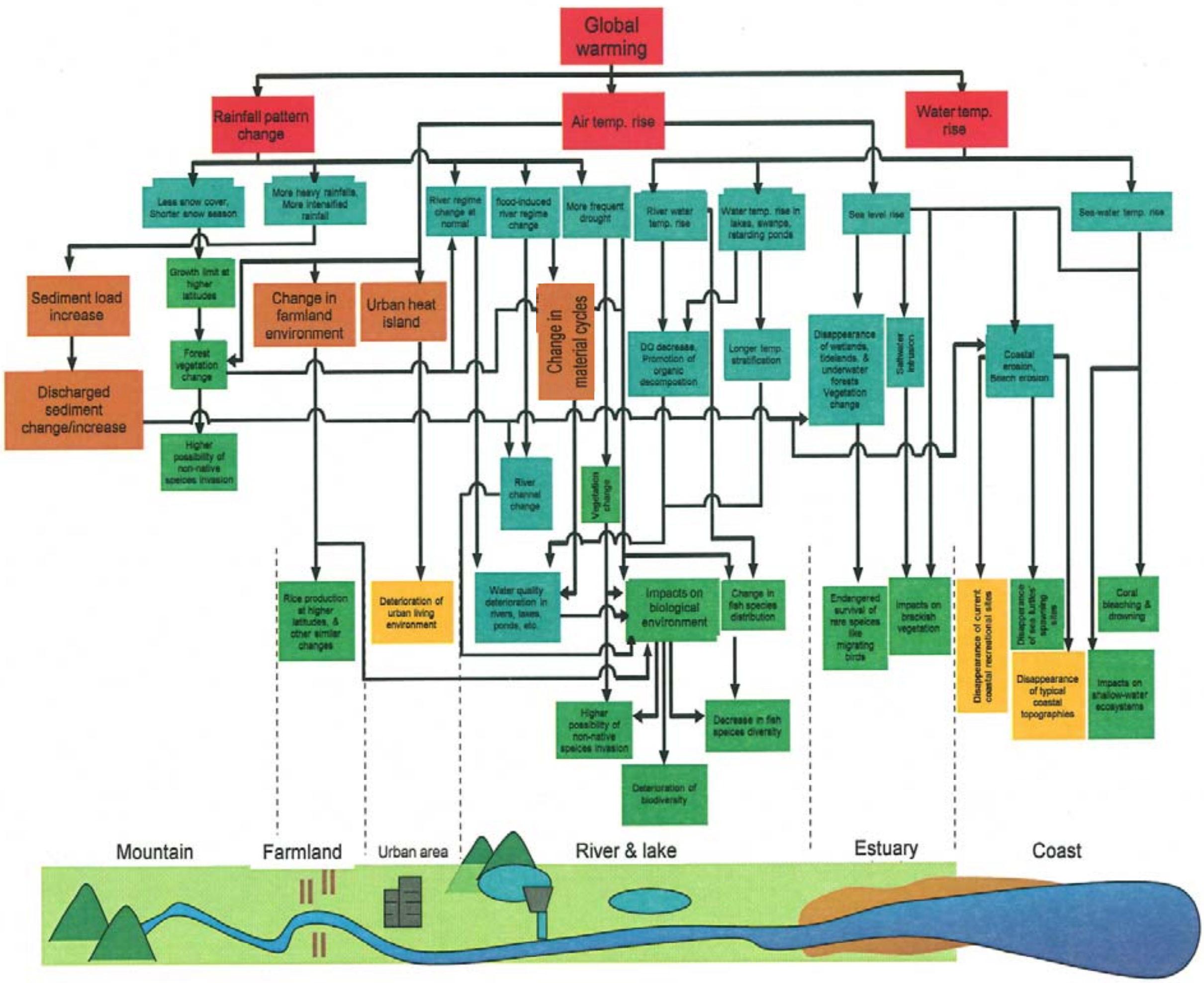
With global warming,
(i) earlier snow melt and (ii) reduction of snowfall induce changes in river flow rate, and (iii) earlier surface soil paddling in paddy fields is expected to cause the annual water demand pattern to change and to have serious impacts on water use




Release of reservoir water not contributing to effective water use
Where the reservoir is full, released water is not used effectively.

Source: Water Resources in Japan 2007, Land and Water Bureau, Ministry of Land, Infrastructure and Transport

# Conceptual figure of impacts on river/basin environment due to global warming



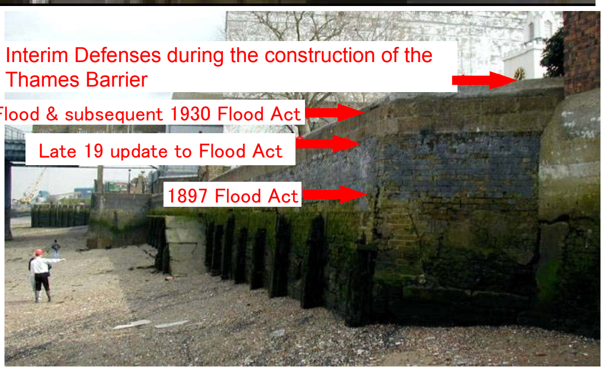

The figure was created by MLIT River Bureau based on:
-Global warming, National Institute for Environmental Studies, http://www.nies.go.jp/escience/ondanka/ondanka01/index.html.
-Global warming and Japan (Projection of impacts on nature and human beings), Compiled by Hideo Harasawa and Hidezo Nishioka, *Kokin-shoin*, 2003
-Global warming-based water environment management, Keisuke Hanaki, Journal of the Japan Society of water environment, Vol.29, No.2, pp57-61, 2006
-Reference No.2 provided in the fourth meeting of the Study Group for Holistic Water Resources Management based on Global Warming Risks
-Reference No.5 provided in the third meeting of the Subcommittee for Flood Control Measures to Cope with Global Warming
-*Newton*, August 2007, Newton Press
-Global Warming Impacts on Japan 1996, Committee for Global Warming Issues of the Environment Ministry of Japan, April 1997

# Overseas Trends in Adaptation Measures

**Policy Report pp.26-28**
**III-1. Overseas Adaptation Trend**

In several overseas countries, countermeasures against global warming have already been taken from the viewpoint of national land conservation.

## United Kingdom


Protection against storm surges along the Thames is provided in such a manner as to provide a degree of safety ensuring protection against storm surges of a scale that would occur once per millennium. However, it is estimated that the degree of safety will become in adequate for protecting against storm surges of scale that would occur once per century. Accordingly, a plan for coping with storm surges is currently being developed , which will be implemented by the end of October 2009.

Source:
●DAVID RAMSBOTTOM(HR Wallingford Ltd ), SARAH LAVERY (Environment Agency ). 2007.
● PAUL SAYERS(HR Wallingford), BEN GOULDBY(HR Wallingford), OWEN TARRENT (Environment Agency ). 2007
● Environment Agency. 2005.

## The Netherland


Conventional storm surge protection facilities have been designed and constructed in consideration of the disaster in 1953 as well as in expectation of the sea level rising (15cm over the period of 50 years, which represents the useful life of those facilities; this value is based on the assumption made around 1953 that sea level would rise by 30cm over 100 years).
Facilities that will be newly constructed and renovated in the future are supposed to be designed in expectation of the sea level rising 25 to 50 cm over the next 50 years. (For Maeslant Storm Surge Barrier, the sea level is expected to rise 50 cm.)

Source: Ministry of Transport, Public Works and Water Management

EU

## Directive on the assessment and management of floods

The EU directive states that a preliminary flood risk assessment including a study on the impacts of climate change on flood events should be conducted by 2011 based on existing knowledge, and that flood hazard maps and flood risk maps should be prepared by 2013, based on more than one probability scale. This directive also states that flood risk management plans should be prepared by 2015 based on these maps, with the impacts of climate change taken into account.

### (1) Preliminary Flood Risk Assessment

Member countries are obliged to conduct a preliminary flood risk assessment including the following items.

A) Maps to understand the geographic features and land utilization with basin divides and sub-basin divides. (Any coastal areas should be also incorporated into the map.)

B) Description of floods that caused significant impacts. If there is any possibility that similar events may occur, flooded areas, routes, and impacts of the floods should be assessed together.

### (2) Preparation of Flood Hazard Map and Flood Risk Map

**＜ Flood Hazard Map ＞**

Based on results of the preliminary flood risk assessment, flood hazard and risk maps should be drawn to the most appropriate scale to specify areas more likely to suffer significant damage due to floods. These maps should cover the following scenarios.

A) Low probability or extreme events
B) Intermediate probability (years when an event is expected to recur ≧100years), and
C) High probability

Flood hazard maps should indicate the following items:

A) Flooded areas, flood depth, or water level, and
B) flood velocity or flow velocity of related rivers, etc.

**＜Flood Risk Map＞**

Flood risk maps should cover the scenarios above and also indicate the following items:

A) Index indicating the number of residents living in areas likely to suffer damage due to floods,
B) types of economic activities in areas likely to suffer damage due to floods, and
C) facilities designated by other EU directives as those used to prevent environmental pollution and other environmentally hazardous facilities

### (3) Preparation of Flood Risk Management Plan

A flood risk management plan should be prepared based on the flood hazard maps and flood risk maps.

# Overseas Trends in Adaptation Measures

Policy Report pp.26-28
III-1. Overseas Adaptation Trend

The OECD report assesses that Japan has made progress in evaluating the impacts of climate change, but lags behind other countries in taking adaptation measures. In other countries, various measures for global warming have been implemented in order to protect their national lands

| | Examples of Measures Adopted by Other Countries | | | |
|---|---|---|---|---|
| U.S.A. | In New Jersey, one million dollars is allocated annually for revetment works. The state will not permit construction requiring revetment works in the future. | Four states adopted the "periodic easement" policy so that wetlands and beaches can be moved inland when sea level rises in the future. | New York City is considering the construction of flood control walls, etc. around sewage disposal plants located in lowlands as necessary infrastructure to address the impacts of climate change. | The water treatment plant located on Dear Island was sited at a higher location than originally planned, considering the necessity of constructing protection walls due to the impacts of sea level rise. |
| U.K. | On the Thames in the U.K., it is considered necessary to improve tidal barriers by 2030 in order to maintain the current flood control level for addressing the possible impacts of sea level rise due to climate change and the rapid estate land development in areas likely to suffer damage due to a storm surge. Therefore, Thames Estuary 2100 (TE2100) is being prepared as a flood risk management plan to protect London and the mouth of the Thames for the next 100 years. | | | |
| Netherlands | The tidal barriers and dams are designed assuming that the sea level will rise by 50 cm. The tidal barrier near Rotterdam was constructed in 1997 as the first construction built taking into account the impacts of sea level rise. | The technical Advisory Committee recommends ensuring safety for the next 200 years under the worst-case scenario of sea level rising by 85cm and the number of rainstorms increasing by 10% in the next 100 years. | The Flooding Defense Act, which establishes safety standards regarding all types of revetment structures, must be revised every 5 years by the minister. The latest data regarding climate change are incorporated into the design of revetment structures every 5 years. | |
| Australia | Regarding coastal development, the state government of New South Wales in Australia requests ensuring safety that can withstand coastal erosion that is expected to occur in the next 100 years, assuming that the sea level will rise by 30cm. | | | |

Source: OECD: PROGRESS ON ADAPTATION TO CLIMATE CHANGE IN DEVELOPED COUNTRIES AN ANALYSIS OF BROAD TRENDS

## Country Level Activities on Climate Change in Relation to Water Resource Issues

From Annex 1 "Country level activities on climate change in relation to water resource issues "of "Climate change and water adaptation issues (EEA Technical report)(2007.2) "

| Country | Major Activities |
|---|---|
| Belgium | ・When embankments need to be built, a 60-cm rise in sea level is taken into account.<br>・With the current climate, the risk level is estimated at one flood every 350 ears, but the risk is expected to rise to up to one in 25 years by 2100 due to climate change and related sea level rise. |
| Czech Republic | ・The BILAN (CR), CLIRUN (Poland), and SAC-SMA (USA) models were used to study climate change impacts in the river basins of the Labe (Elbe), Zelivka, and Upa Rivers.<br>・In 2001-2002 a team of hydrological specialists examined the application of newly developed methods of assessing the impacts of climate change on water resources. |
| Finland | ・An adaptation strategy was published in January 2005 (Ministry of Agriculture and Forestry, 2005) based on a set of scenarios for future climatic and economic conditions. (As an adaptation measure for 2005-2015, a list of areas likely to suffer flood damage and a comprehensive management plan were prepared and approved.)<br>・Ongoing research include the development of methods to analyze the risk of hazardous events, regional climate model simulations, and application of regional climate model simulation results in community planning. |
| France | ・In 2006, France enacted a major legislative framework (the Water Act 2006) with the aim of ensuring that climate change is taken into account so far as water management is concerned.<br>・Hazard maps covering the entire country were prepared and are available on a Web site.<br>・A study on adaptation was launched. Four pilots are to be implemented on river basins (Meuse, Loire, Gironde, and Rhone). |
| Germany | ・Flood control is being implemented taking into account possible increases in the frequency and probable increases in discharge volumes.<br>・Baden and Bavaria introduced a 'climate change factor' to be taken into account in any new plans for flood control measures. (In the Neckar basin area, small and medium flood discharges are expected to increase by around 40 to 50%, and once-in-100-year floods are expected to increase by 15%.) |
| Iceland | ・Expected sea level rise has already been taken into account in the design of new harbors in Iceland. |
| Spain | ・**Spain has already published a national adaptation strategy.** |
| Sweden | ・According to the Rossby Centre scenarios, future climate change and changes in average discharge have been revealed, which differ depending on selected scenarios, regions, and seasons, However no comprehensive survey of how future climate change may affect extreme water flows has het to be conducted.In terms of adaptation, there is no national strategy yet in Sweden, but a government inquiry on climate change and vulnerability was initiated in the summer of 2005 and is scheduled to be completed in October 2007. The inquiry report will cover a variety of fields such as infrastructures (roads, Railways, and communication), agriculture, human health, and biodiversity. |

# Status of Adaptation Measures in Asian Countries

| | |
|---|---|
| **Bangladesh** | Proposals on tree planting in coastal areas on a community basis, the construction of flood shelters, disaster information support centers in major flood plains, and statements on organizations leading such projects and necessary budgets（NAPA2005） |
| **Bhutan** | Proposals on landslide management in pilot areas, flood protection measures, installation of early-warning systems in the Pho-Chu basin （NAPA2006） |
| **Cambodia** | Construction and recovery of flood control embankments in residential and agricultural areas, recovery of coastal protection facilities（NAPA2006） |
| **China** | Requests for technical assistance for insufficient flood control technologies and prediction and warning technologies (First National Report,2004) |
| **India** | Statements on the necessity of accurately predicting the impacts of climate change for adaptation measures (First National Report, 2004) |
| **Thailand** | Statements on the necessity of accurately predicting the impacts of climate change for adaptation measures (First National Report, 2000) |
| **Indonesia** | No specific statement on adaptation measures (First National Report, 1999) |
| **Philippines** | No specific statement on adaptation measures (First National Report, 2000) |
| **Vietnam** | Consideration of the construction of flood control reservoirs (15 to 20 billion $m^3$) to adapt to possible increase in peak flood discharge (First National Report, 2003) |
| **Korea** | Korea acknowledges that each division must take measure for adaptation to climate change; the water division aims to establish an effective early-warning system.(Second National Report, 2003) |

Asian countries (except Japan) are referred to as Non-Annex I countries* under the United Nations Framework Convention on Climate Change. Most of these countries do not take adaptation measures as a national project due to a lack of necessary technologies and funds. Least-developing countries (Bangladesh, Bhutan, and Cambodia) have been participating in the National Adaptation Program of Action (NAPA), which is aided by the Global Environment facility (GEF) with financial assistance from the UNEP and World Bank.

*Developing countries having no numerical targets for reducing $CO_2$ emissions

Prepared based on NAPAs and country reports of each country in the UNFCCC portal site:

http://unfccc.int/adaptation/napas/items/2679.php
http://unfccc.int/national_reports/non-annex_i_natcom/items/2979.php

# Overseas Trends in Adaptation Measures

**Policy Report pp.26-28**
**III-1. Overseas Adaptation Trend**

- Developed countries are aware of global warming impacts on water resources and implementing impact assessment.
- Some developed countries are taking adaptation strategies at national, regional and basin levels.
- Few Asian countries incorporate adaptation in their national policies due to technical and financial constraints.

| Country | Emerging drought events | Future drought projection | Adaptation strategies (water resources) |
|---|---|---|---|
| U.S.A.[1)] | ✓ 20% of the nation constantly experience drought.<br>✓ 80% experience a mild to extreme drought when it wide spreads. | ✓ Increase in evapotraspiration and drought risk due to global warming.<br>✓ Wetter winter and a longer dry summer in the west coast.<br>✓ 25% less snowfall in Sierras Mountain Range by 2050 | ✓ Impact assessment and adaptation option reviews by California Climate Change Center<br>✓ Enhancement of water-saving practice and water management/supply systems, including surface/underground water storage and water supply facilities |
| Canada [2)] | ✓ Drought (2001-2002) caused $ 5 to 6 billion loss for crop damage and insurance payment. | ✓ More winter discharge, less summer discharge, lower water temperature | ✓ Implementation of a comprehensive regional water policy to deal with climate change issues in British Columbia. |
| Australia [3)] | ✓ An extreme drought caused a decrease in 2002-2003 wheat production by more than a half to 10,100,000 tons. | ✓ 15% less rainfall since the mid 1970s in southwestern West Australia<br>✓ Even less rainfall in the area due to future temperature rise | ✓ Adaptation strategies have been developed to deal with global warming impacts on southwestern West Australia. |
| EU [4)] | ✓ EU countries experienced several severe droughts in the past 30 years.<br>✓ 10-40% more precipitation per year in the past 100 years in northern Europe; 20% less in southern and eastern Europe. | ✓ 1-2% increase in annual precipitation per decade; less summer precipitation<br>✓ Less annual and summer precipitation in southern Europe, possibly resulting in more frequent extreme droughts | ✓ The EU Commission published in 2007 a “Green Paper” and “Climate change and water adaptation issues” to emphasize the importance of adaptation. |


**Reference:**

**Data on the adaptation trends of developed and Asian countries was cited from the latest National Communications submitted to UNFCCC.**

**1)U.S. Environmental Protection Agency. 2006. Fourth National Communication of the United States of America Under the United Nations Framework Convention on Climate Change.**

**The California Strategic Growth Plan –Flood Control and Water Supply (Governor’s Budget 2008-2009)**

**2) Environment Canada. 2006. CANADA’S FOURTH NATIONAL REPORT ON CLIMATE CHANGE Actions to Meet Commitments Under the United Nations Framework Convention on Climate Change.**

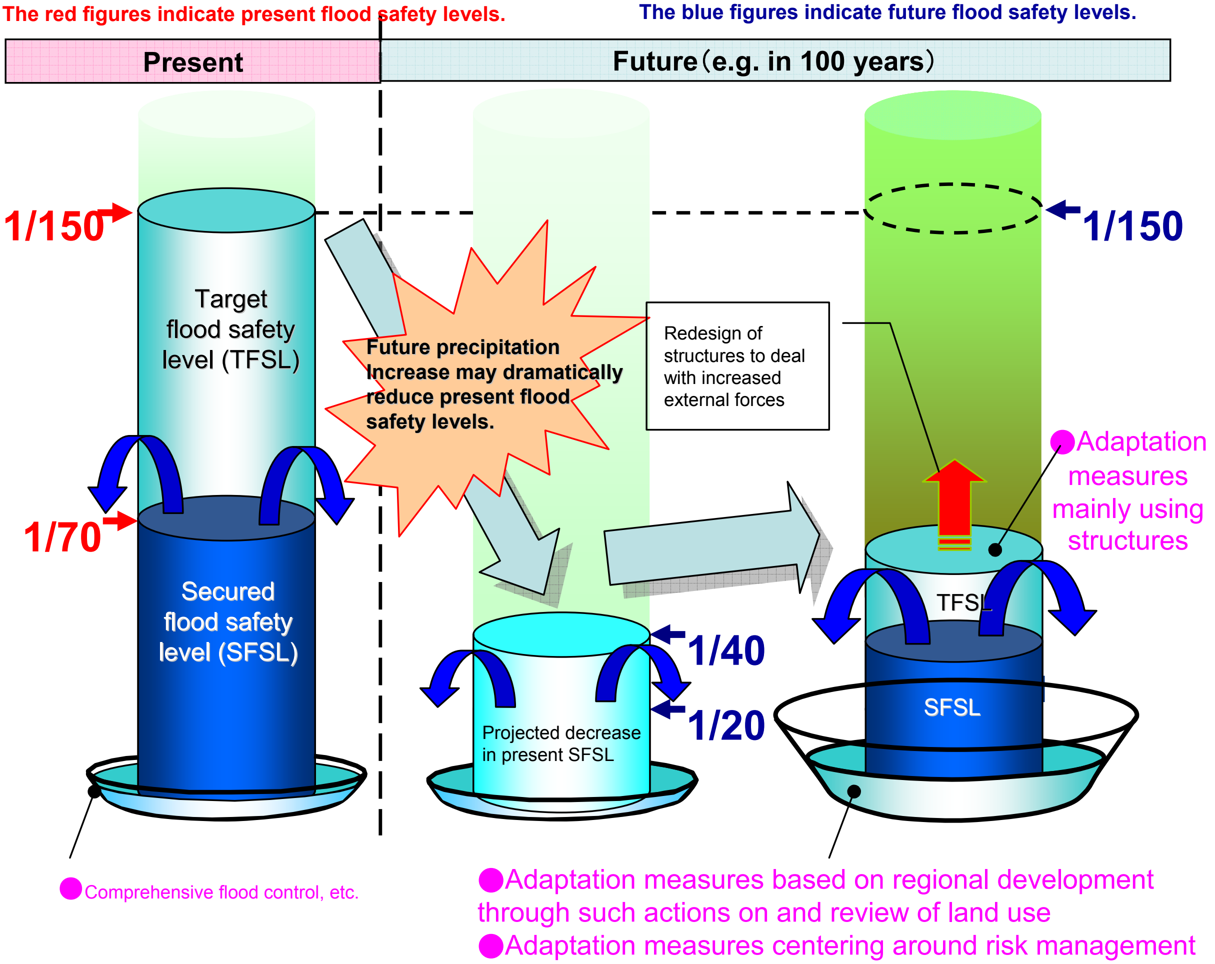
**3) Australian Greenhouse Office within the Department of the Environment and Heritage. 2005. Australia’s Fourth National Communication on Climate Change A Report under the United Nations Framework Convention on Climate change**

**4)Climate change and water adaptation issues; EEA Technical Report, 2007**

# Adaptation to increased external forces
# Multilayered flood control policies

Policy Report pp.26-45
III-1. Basic Directions of Adaptation

Multilayered flood control policies should be promoted by developing;
- "Flood control policies at the river level"
  centered around river improvement and flood control structures to meet target discharge levels for previously planned projects
- "Flood control policies at the basin level"
  to deal with increased external forces




**Flexible measures should be taken at the basin levels to deal with all possible floods of different scales.**

# Adaptation to increased external forces
# Staged measures for storm surges

**Policy Report pp.26-45**
**III-1. Basic Directions of Adaptation**

To cope with sea level rise and intensified typhoons, concrete storm surge barriers should be rebuilt higher to enhance their protection capacities against intensified external forces, especially at a time of renewal, so that inundation occurs less frequently.

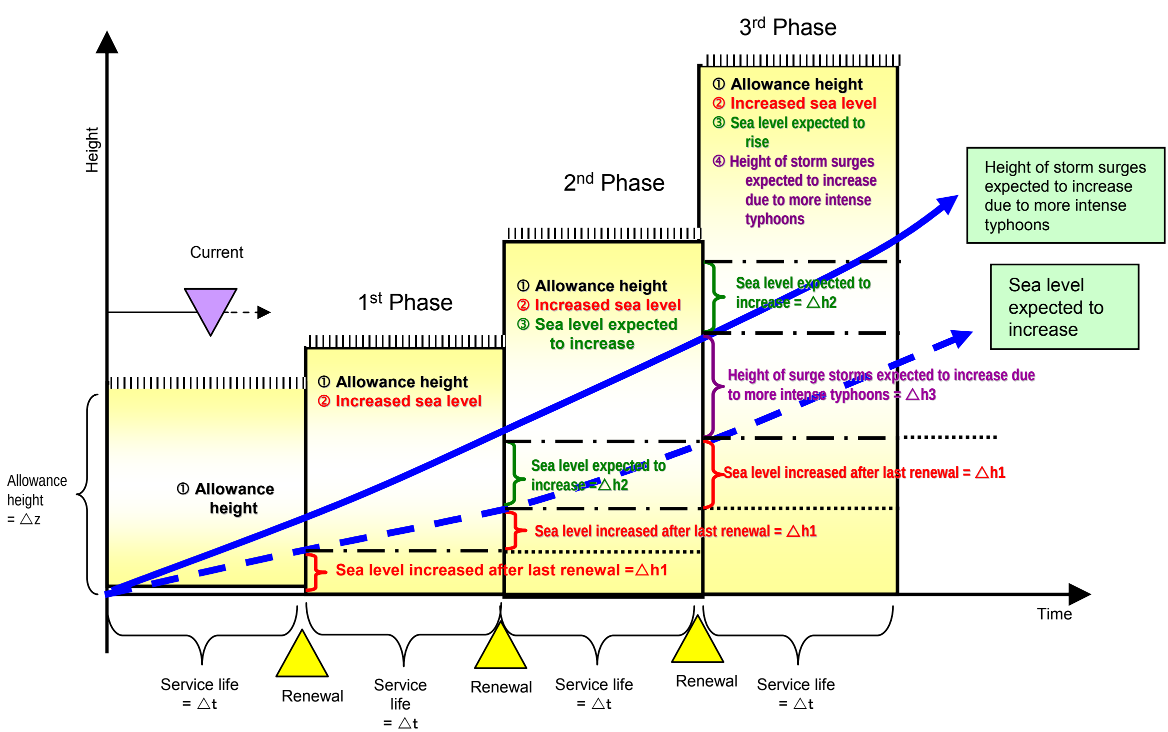
In practice, barrier heights should be raised in stages in step with the progress of research on sea level rise and intensified typhoons:

Phase 1: The increased sea level is taken into account.

Phase 2: In addition to increased sea level, sea level rises expected in the future are taken into account based on the trend in sea level rise and prediction calculation. The service life of facilities in also taken into account.

Phase 3: In addition, the height of storm surges expected to increase due to more intense typhoons is taken into account.

Storm surge barriers should be designed so that they are hard to breach even if external forces are more powerful than expected due to sea level rise.



# Adaptation to increased external forces
# Coping with drought risk

**Policy Report pp.26-45**
**III-1. Basic Directions of Adaptation**

## Social needs

**Effective use of water resources**

**Safe, good-tasting drinking water**

## Changes in natural/social conditions

**Increasing risk at an earthquake/accident**

**Newly-recognized risks due to global warming**

## Holistic water resources management

-- to enjoy rich water resources that are kept safe and reliable --

## Fundamentals to promote holistic water resources management

### For effective use of water resources

Quantity

- Management from the demand & supply sides
- Demand side: Promotion of a water-saving society
- Supply side: Maximization of the existing water resources
- Integrated management of surface/ground water

### Integrated management in quantity & quality

Quality

- Integrated management of water resources in quantity & quality with more focus on quality that greatly affects human life and health, taste of water, human-water relationship, and survival of living creatures.

### Risk management

Risk management

- Minimization of the impacts on citizens in case of earthquake or accident in terms of national security.

### Adaptation to global warming risks

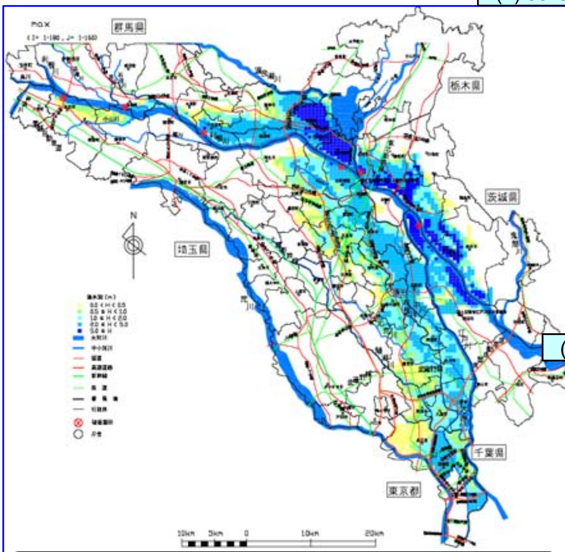
Quantity

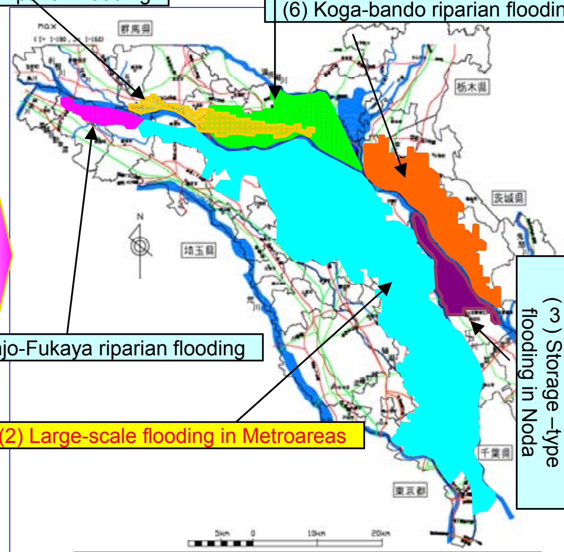
- Early, gradual adaptation to newly-recognized risks as fundamental risks

# Disaster risk assessment
## Evaluating adaptation measures & deciding policies

**Policy Report pp.26-45**
**III-1. Basic Directions of Adaptation**

Inundation analysis of Tonegawa River

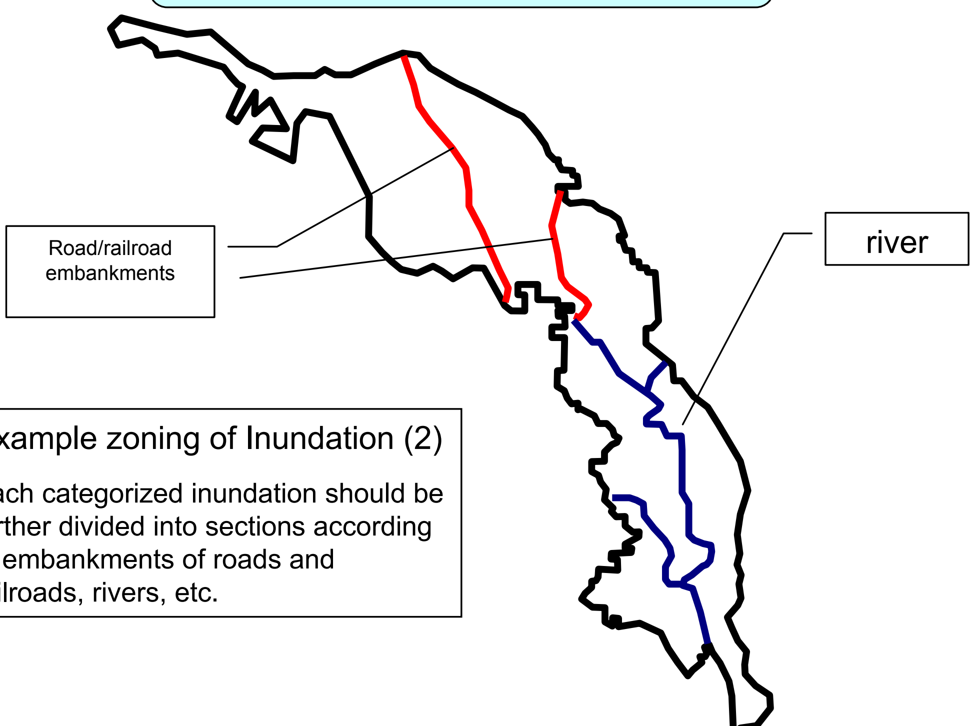



Conduct a basin inundation analysis

Categorize inundations in the basin by type
( (1)-(6)= inundation )

Zone each categorized inundation by adaptation measures




Example zoning of Inundation (2)

Each categorized inundation should be further divided into sections according to embankments of roads and railroads, rivers, etc.

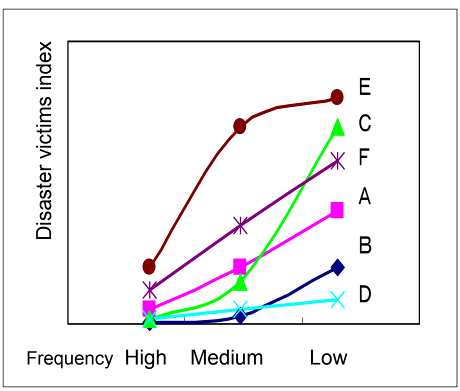
# Disaster risk assessment
# Concept of risk and risk mapping

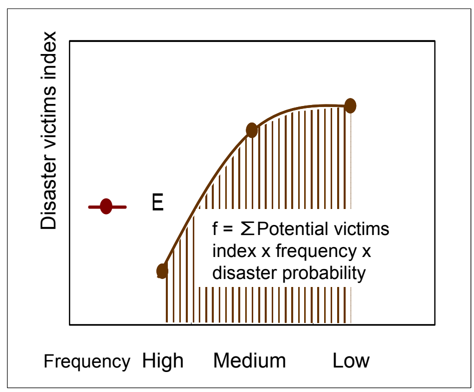
Policy Report pp.26-45
III-1. Basic Directions of Adaptation

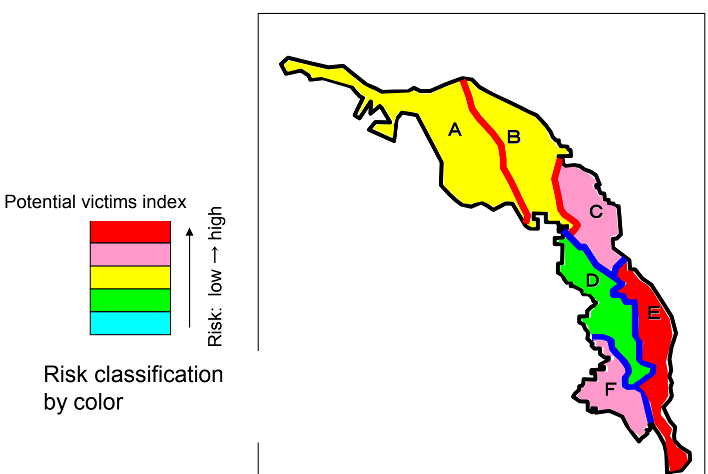
The "external force index" is likely to rise due to global warming. To mitigate "disaster risk", the "disaster preparedness index" needs to be improved through the construction of structural measures, revision of land use, enhancement of risk management. Enhanced disaster preparedness should bring down the "damage/impact index," which should further contribute to disaster risk mitigation.

$$\text{Disaster risk} = \frac{\text{External force index} \times \text{Damage/impact index}}{\text{Disaster preparedness index}} \times \text{Damage probability}$$

-External force index:
  Natural external forces and local characteristics
  (scale of external forces and meteorological, hydrological, topographical, geological, and other conditions)
-Damage/impact index:
  Social vulnerability to disasters
  (inundated population/houses, impacts on roads, railroads, lifeline facilities, etc.)
-Disaster preparedness index:
  Disaster risk management at national, municipal, and community levels (adaptation)
  (completion level of flood control structures/facilities and hazard maps, public disaster awareness level, etc.)



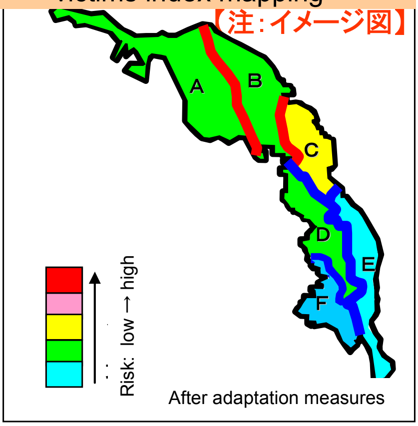

An inundated area is further divided into sections according to road/railroad embankments, rivers, etc.

# Disaster risk assessment
## Evaluating adaptation measures & deciding policies

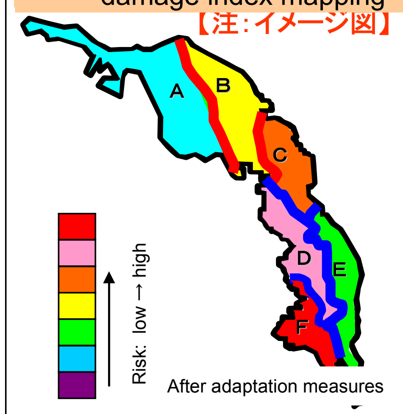
**Policy Report pp.26-45**
**III-1. Basic Directions of Adaptation**

Policies should be determined after comprehensively reviewing relationships between evaluation items, trade-offs, and costs in terms of goals.

Conceptual figure of potential victims index mapping




Conceptual figure of economic damage index mapping




The target function should be maximized under the constraints of evaluation items, adaptation measures, etc.

Damage and impacts should be reviewed based on several indices.

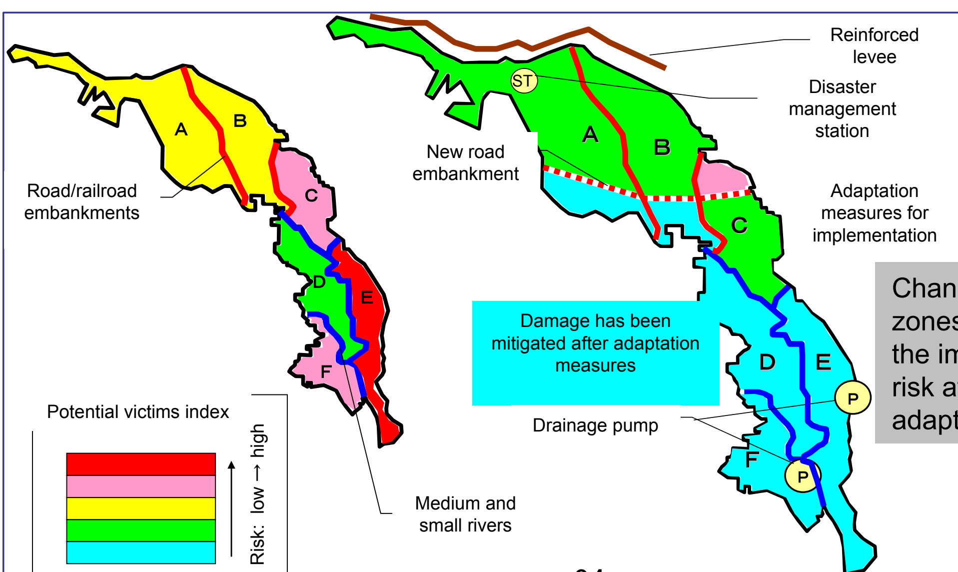
$$\Delta f = f_1 - f_2$$

$$\sum_{i}^{n} \alpha_i \cdot \Delta f_i \Big/ \sum_{i}^{n} C_i$$

f1: current damage/impact index
f2: post-adaptation damage/impact index
Δf: mitigated damage/impact index by adaptation measures
αi: weighting factor for each damage/impact index for evaluation
n: No. of the evaluation items
C: cost

Sample damage/impact indices

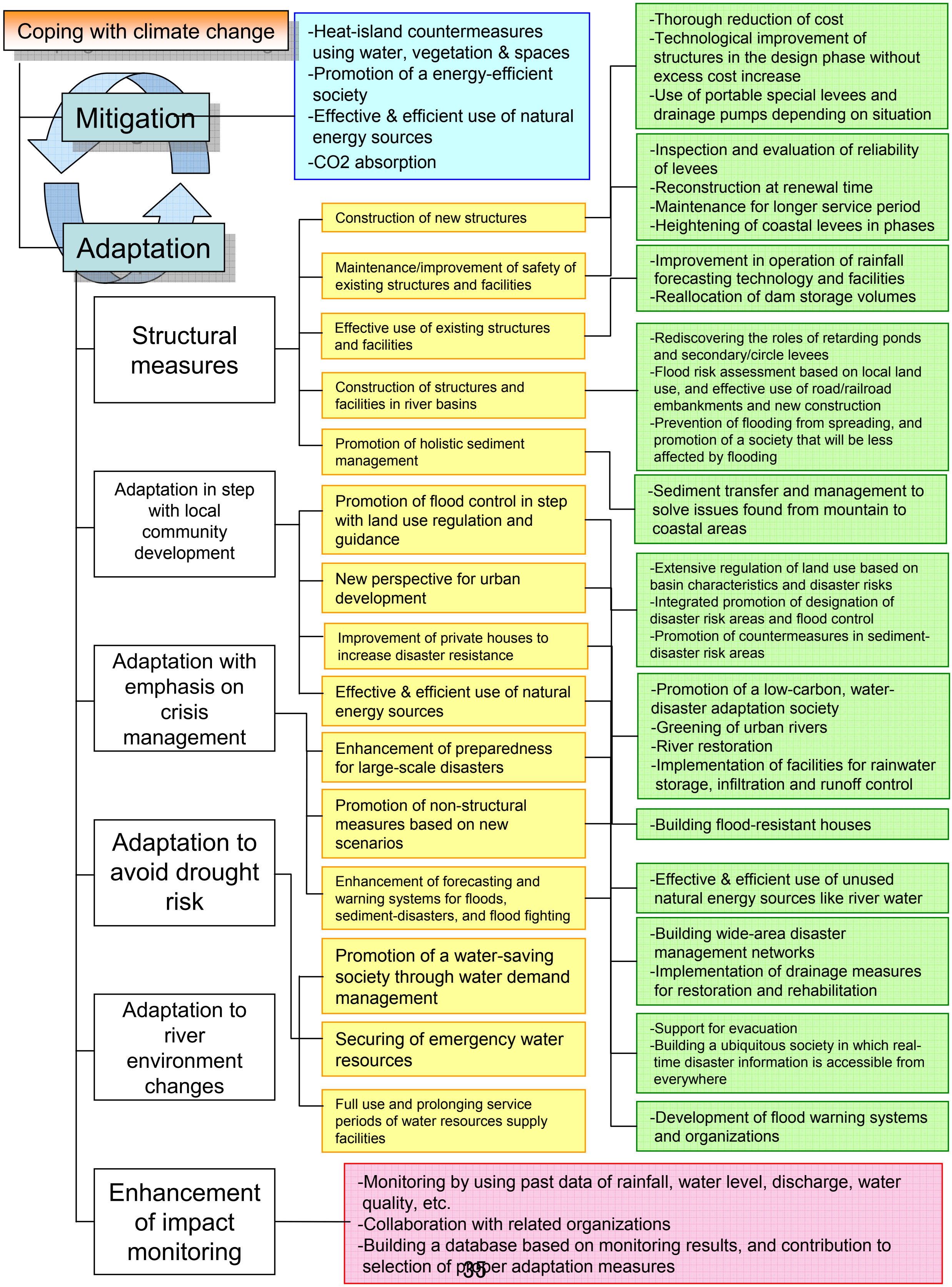
Damage/impact indices: f
- -potential victims index
- -economic damage index
- -public-service damage index
- -Inundated houses index
- -Environmental damage index




Changes in color of zones A to F indicate the improvement of risk after implementing adaptation measures.

# Outline of mitigation & adaptation to climate change

**Policy Report pp.26-45**
**III-1. Basic Directions of Adaptation**

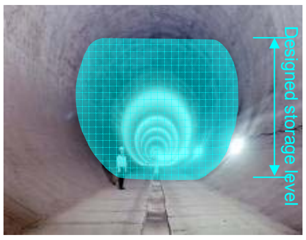


## Constructing new structures: levees, flood regulation structures

**Policy Report pp.33-54**
**III-2. Basic Directions of Adaptation**

Constructing new structures: levee improvement, river-channel widening, flood regulation dams

**Floodwater regulation structure (Dam)**



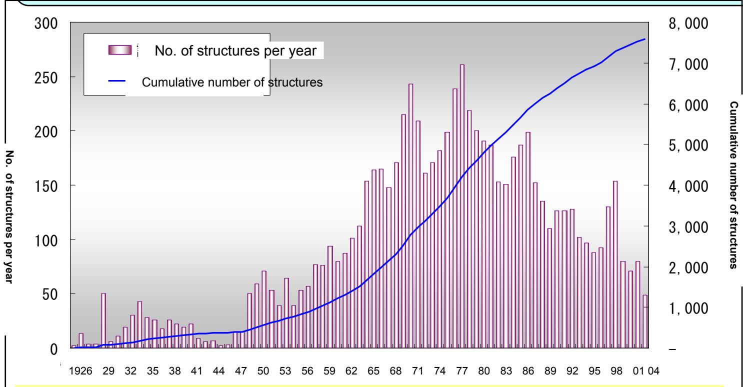

**Floodwater regulation structure (Underground regulation pond)**

**High-standard Levee**

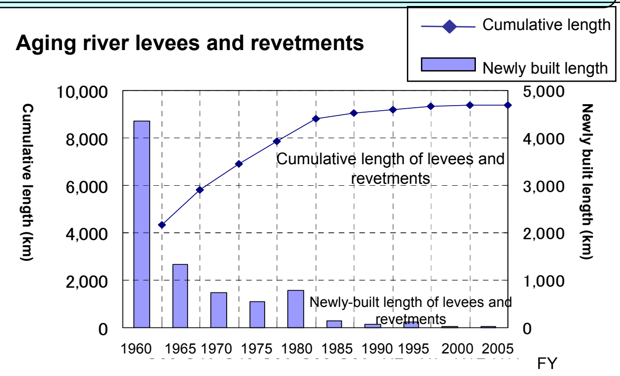
## Maintaining and improving the reliability of existing structures: response to aging revetments

**Policy Report pp.33-54**
**III-2. Basic Directions of Adaptation**

To avoid financial concentration on renewing structures, they should be inspected and assessed in terms of reliability, and maintained and managed systematically by taking preventive measures to prolong their service lives.




Maintenance/renewal cost is expected to increase for existing structures extensively built during the economic growth in the 1960s (1926-2004)




About 60% of today's shore protection and revetment work was build before 1960

**Before**

**Deteriorated concrete of aging shore protection work**

**After**

**Rehabilitation work by widening of the protection**

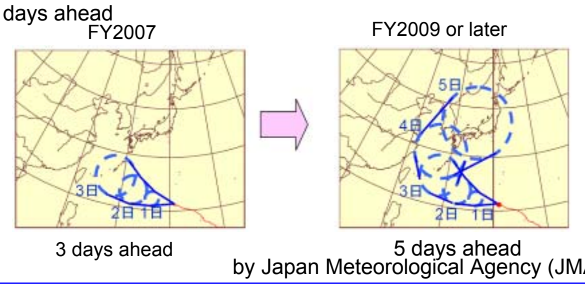
## Utilization of existing structures: rainfall/discharge forecasting technology and the improvement of structure operation

Policy Report pp.33-54
III-2. Basic Directions of Adaptation

Flood control should be enhanced through more effective dam operation by improving rainfall/discharge forecasting accuracy.

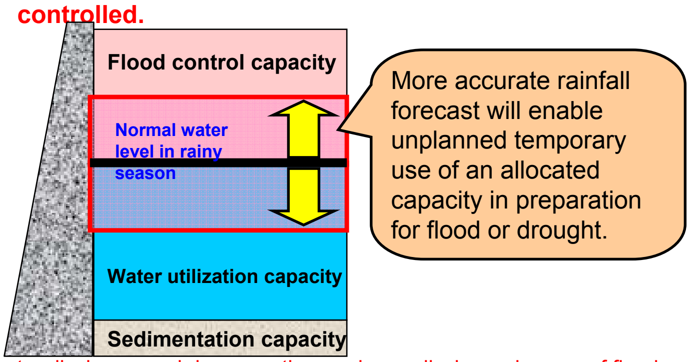
**◎Case of JMA's effort for rainfall forecasting technology development**

Building new system from FY2009 for typhoon forecasting 5 days ahead

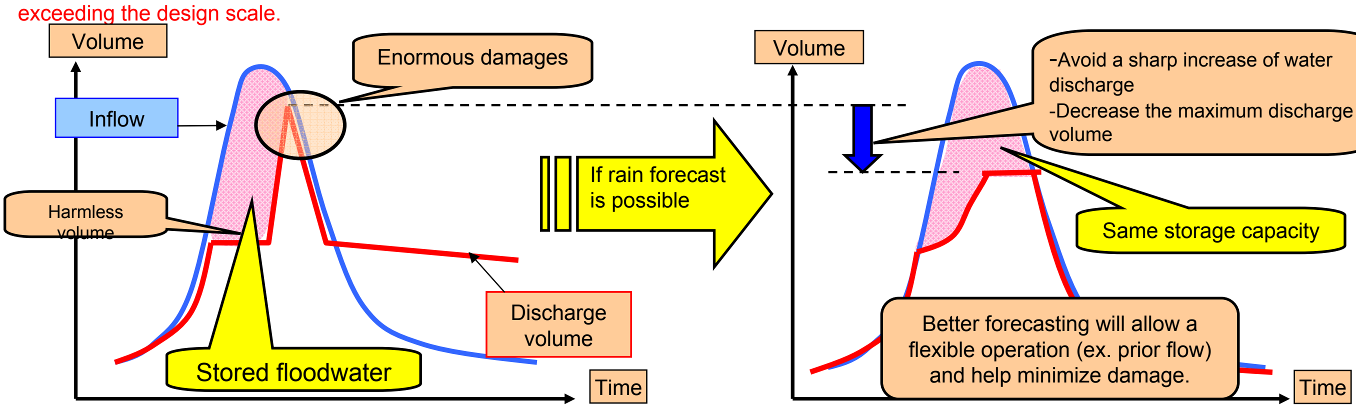



by Japan Meteorological Agency (JMA)

**◎A dam's water level should be more flexibly controlled.**



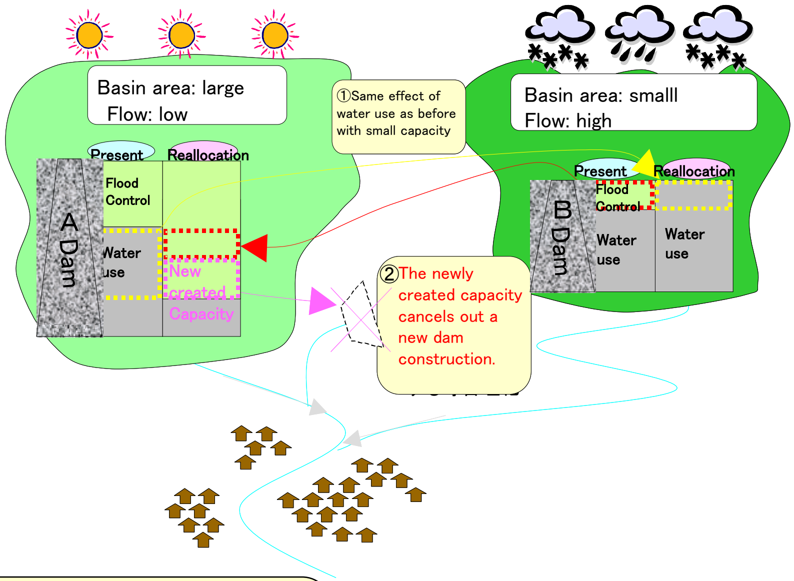

◎Improved forecasting technology can help avoid a sharp increase of water discharge and decrease the maximum discharge in case of flood exceeding the design scale.




## Utilization of exciting structures: Re-organization of dams by re-allocating flood-control and water-use capacities

Policy Report pp.33-54
III-2. Basic Directions of Adaptation

Dams' flood-control and water-use capacities should be re-allocated based on their current operation and the rainfall/discharge characteristics of their basins.




**Re-allocation of dam capacity**
●Re-allocation of water use capacity to flood control capacity.
●Capacity allocation among existing and newly-planed dams

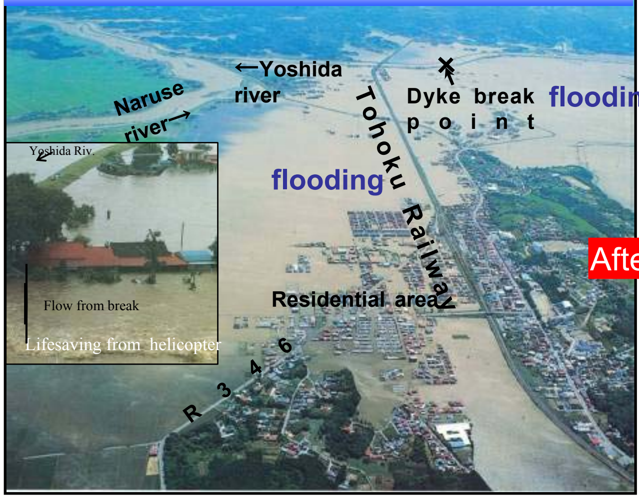
Re-allocation will improve flood control, and thus enhance flood safety level.

## Structure construction in river basins: floodwater control with secondary levees

**Policy Report pp.33-54**
**III-2. Basic Directions of Adaptation**

### Floodwater control with secondary levees to prevent expansion of a damaged area

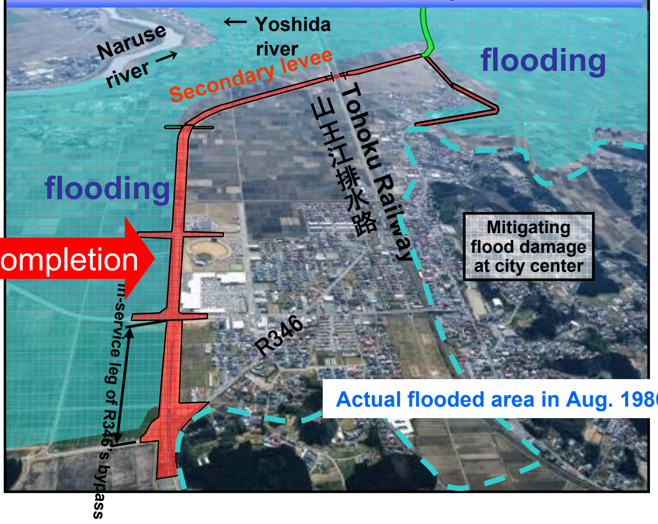
**Inundation due to the Aug. 1986 flood**




Due to 4 break points, 3,060ha was flooded, 1,510 houses were flooded above the floor level, and some parts of the area stayed under water up to 12 days.

**After completion**

**Expected effect of secondary levee**



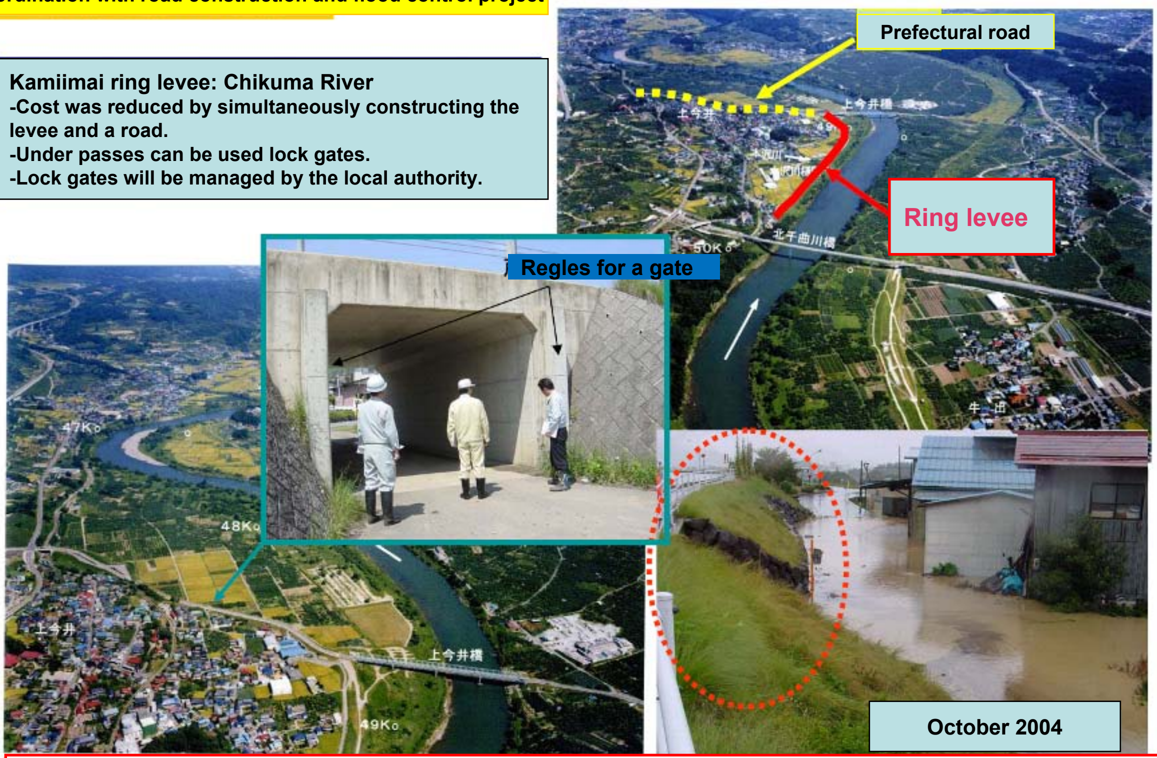

This secondary levee is under construction in coordination with road construction.

## Structure construction: Ring levees along with road construction

**Policy Report pp.33-54**
**III-2. Basic Directions of Adaptation**

**Coordination with road construction and flood control project**

**Kamiimai ring levee: Chikuma River**
- Cost was reduced by simultaneously constructing the levee and a road.
- Under passes can be used lock gates.
- Lock gates will be managed by the local authority.

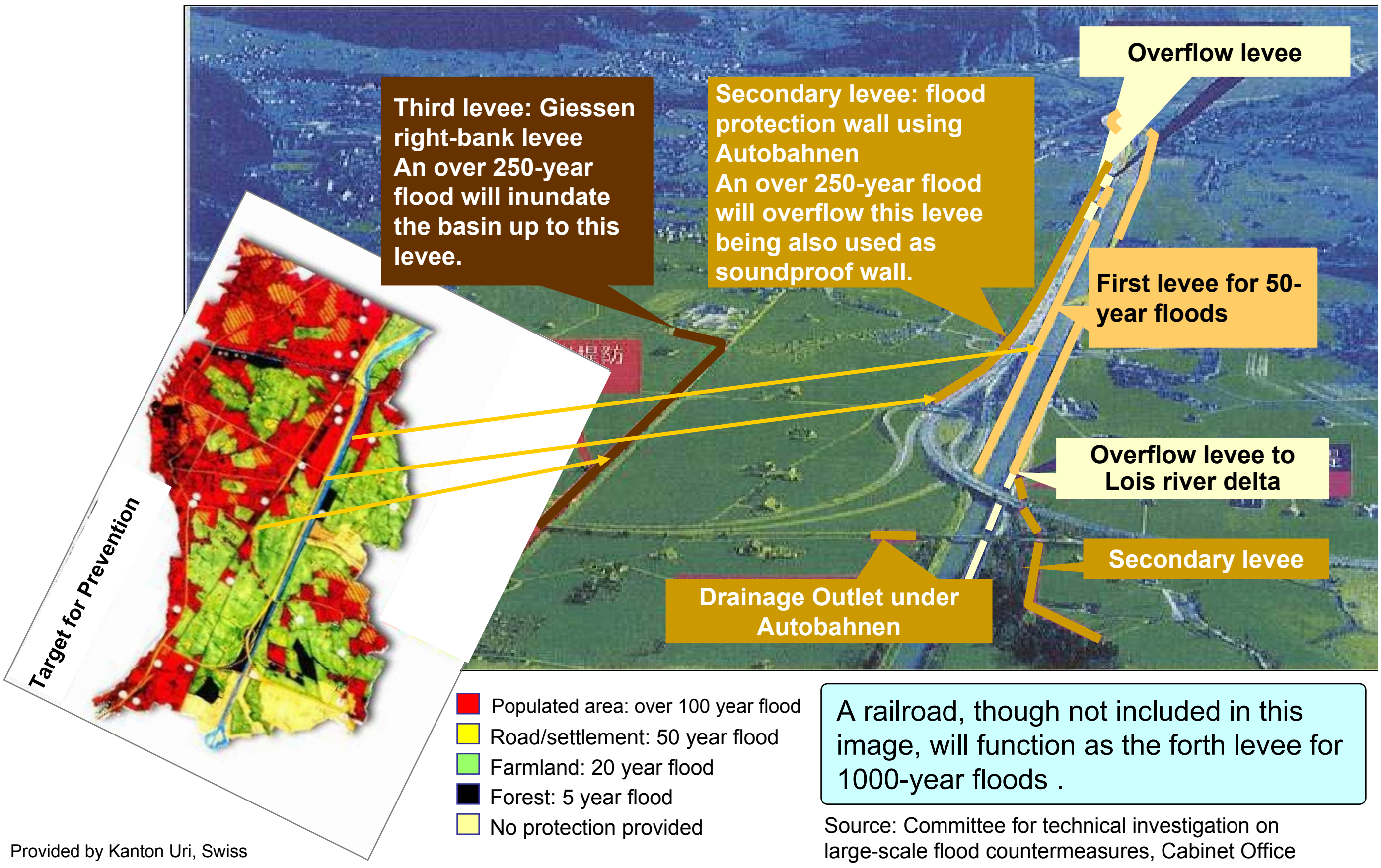



**Flood control should be enhanced as early as possible in coordination with other local construction projects.**

Provided by Hokuriku Regional Development Bureau, MLIT

## Structure construction: setting flood safety levels based on land use and multiple-layered flood control structures (Swiss)

Policy Report pp.33-54
III-2. Basic Directions of Adaptation




- Populated area: over 100 year flood
- Road/settlement: 50 year flood
- Farmland: 20 year flood
- Forest: 5 year flood
- No protection provided

Provided by Kanton Uri, Swiss

A railroad, though not included in this image, will function as the forth levee for 1000-year floods .

Source: Committee for technical investigation on large-scale flood countermeasures, Cabinet Office

## Structure construction: Facilities for rainwater storage, infiltration and run-off regulation

Policy Report pp.33-54
III-2. Basic Directions of Adaptation

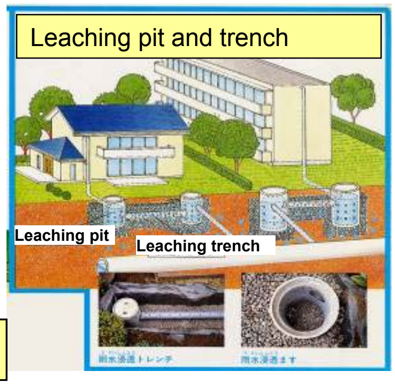
Rainwater storage and infiltration facility

Normal Situation

Flood Situation

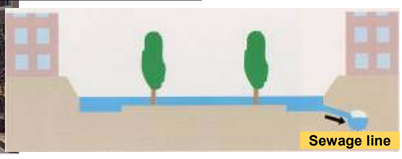
Rainwater storage at school ground

Leaching pit and trench




Permeable pavement

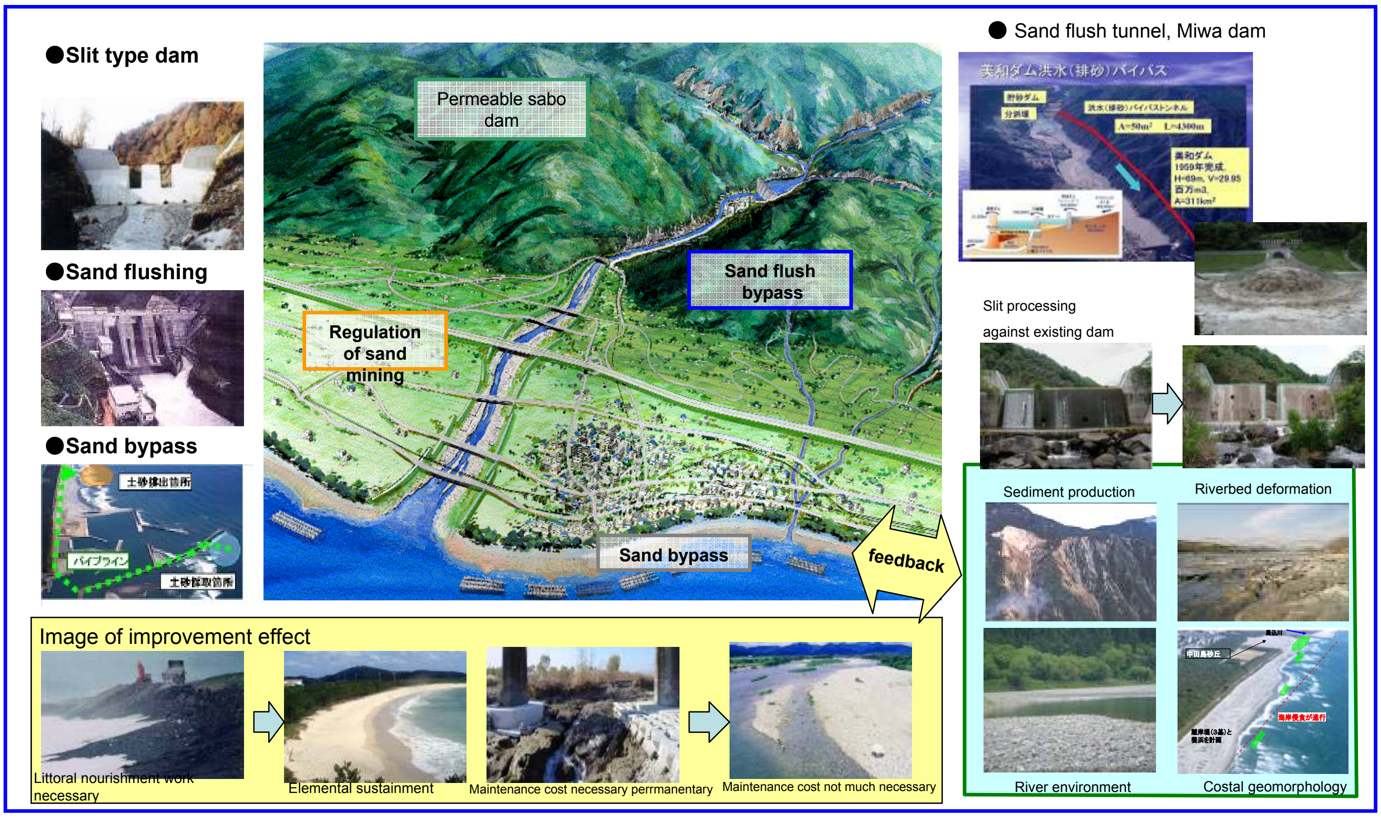
Rainwater storage at residential area



## Promotion of comprehensive sediment management

Policy Report pp.33-54
III-2. Basic Directions of Adaptation

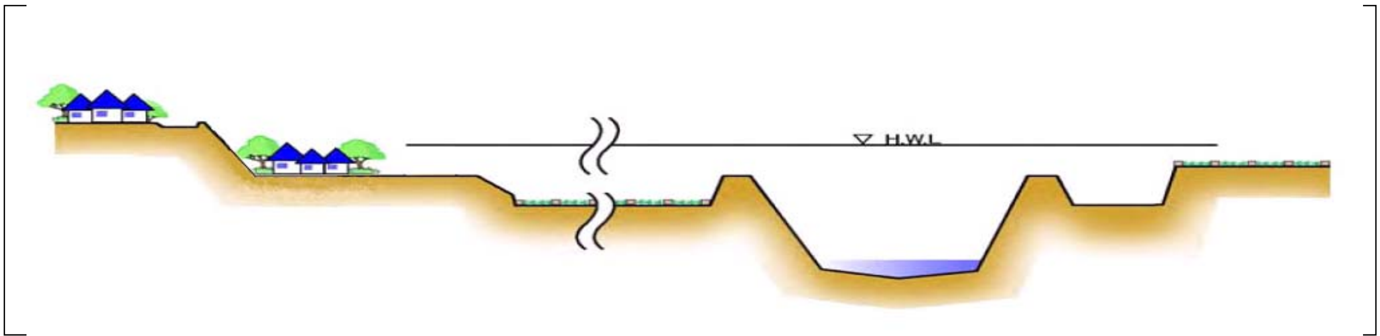
Comprehensive sediment management should be promoted to take measures for sabo, dam sedimentation, river-bed deformation, and costal erosion.




## Promotion of flood control in step with land use regulation and guidance

Policy Report pp.33-54
III-2. Basic Directions of Adaptation

Land use and regional development should be promoted on the assumption that a flood will occur to cope with floods exceeding the design levels of structures.

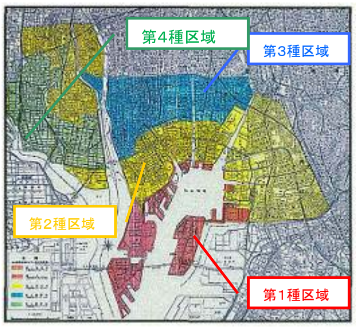



### Land use regulation: designation of disaster hazard areas

**Building standard law (concerning DHA)**

Article 39 A local government can, in an ordinance, designate an area prone to tsunami, storm surge, and flood as disaster hazard area.

2 Necessary conditions, such as prohibition of building houses or other restrictions in DHA should be specified under the previous item.




Hazard map in costal area, Nagoya city

| | First floor level | Structural rule | 図解 | |
|---|---|---|---|---|
| 第1種区域 市街化区域 | N・P(+)4m以上 | Timber construction prohibited | First floor level | House, hospital and social welfare facilities prohibited Except am-timber construction and floor level is above 5.5 m from N.P |
| 第2種区域 市街化区域 | N・P(+)1m以上 | Living room should be more than second floor | First floor level | Public building prohibited |
| 第3種区域 市街化区域 | N・P(+)1m以上 | ―― | First floor level | |
| 第4種区域 市街化調整区域 | N・P(+)1m以上 | Living room should be more than second floor | First floor level | |

Example of limitation by ordinance for building code, Nagoya city

## Promotion of flood control in step with land use regulation and guidance: flood control projects coupled with land use regulation

**Policy Report pp.33-54**
**III-2. Basic Directions of Adaptation**

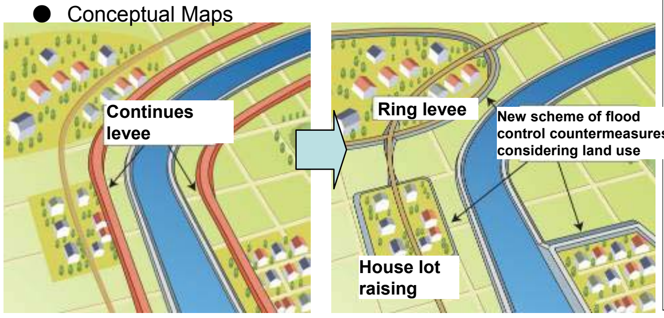
More local governments have established ordinances including the designation of disaster hazard areas (DHA) because the DHA designation became a requirement for discontinuous levee construction.

**Requirements for implementation of efficient and effective countermeasures for inundation of houses in an area where it is difficult to implement flood control measures.**

○Countermeasures should be to protect houses from above-floor inundation, including construction of ring levees and reservoirs and heightening of residential land. Other principle requirements are as follows;

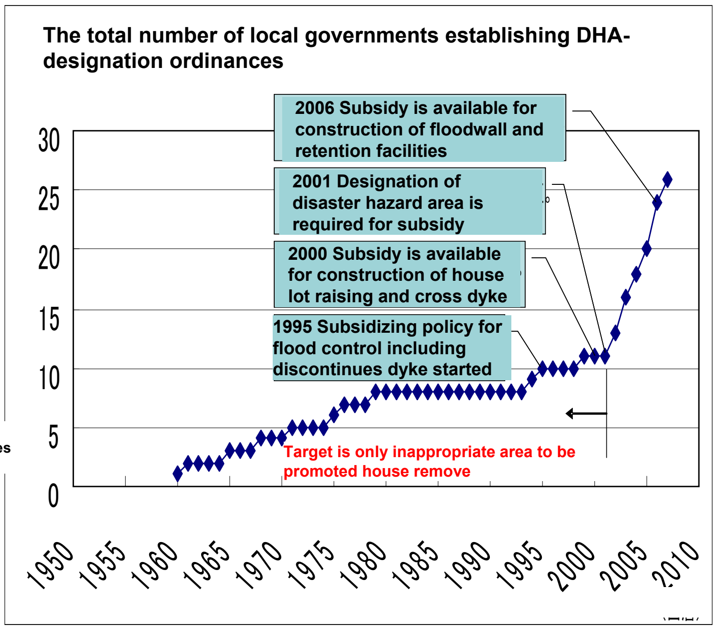
1. The area has recently suffered substantial flood damage.
2. The selected countermeasures are included in a river improvement plan and meet local needs.
3. The total project cost will not exceed that of conventional continuous levees.
4. Appropriate measures, such as the DHA designation, must be taken for areas to be flooded.

● Conceptual Maps




Substantial cost and time are necessary to complete

Mitigation measures can be implemented faster by selecting ring levees or house lot raising

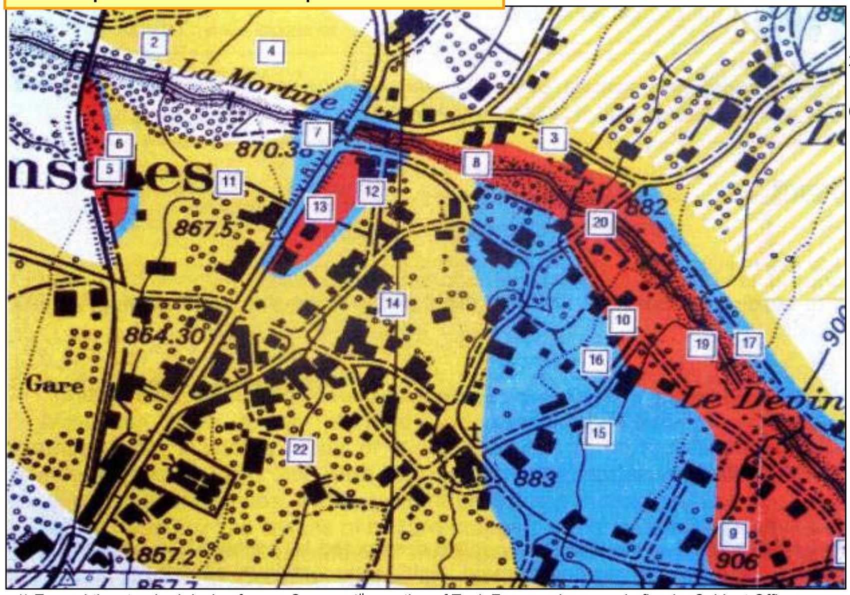



## Promotion of flood control measures in step with land use regulation: Land use regulation utilizing disaster hazard areas (Swiss)

**Policy Report pp.33-54**
**III-2. Basic Directions of Adaptation**

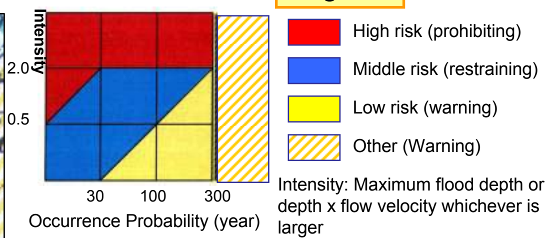
- Three different colors are used to categorize risk levels in the sample Swiss hazard map, and an area which can be affected by an enormous disaster[1)] is also indicated.
- Risk levels, thus 3 colors, are categorized based on disaster intensity (maximum flood depth, or depth x flow velocity) and occurrence probability as indicators.
- Information provided by hazard maps is included in land use plans of local governments as recommended by FED.
- The Swiss system is adopted in Sachsen Province in Germany, Nicaragua, Ecuador, and Czechoslovakia.

Example of hazard map in Swiss



1) Exceed the standard design forces, Source: 4th meeting of Task Force on large-scale floods, Cabinet Office

Legend




Intensity: Maximum flood depth or depth x flow velocity whichever is larger

| | |
|---|---|
| High risk (prohibiting) | New houses are prohibited. Existing buildings are allowed to be used. (lives are at risk even in buildings.) |
| Middle risk (restraining) | New houses are allowed but must have sufficient strength against disaster impacts. More detailed restrictions are defined by each local government standard. |
| Low risk (warning) | Hospitals or schools must have sufficient strength against disaster impacts. |
| Other | No land use regulation. Water works, schools and hospitals should implement response measures in risk management plans and for securing safety in case of disaster. |

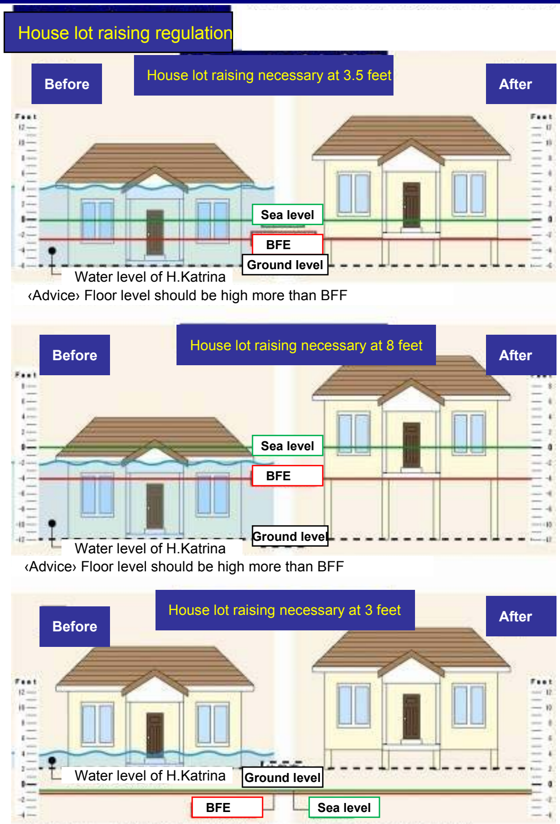
National Platform Naturgefahren ,Hazard Maps Instruments The Swiss System And its Application Aboard

## Promotion of flood control in step with land use regulation and guidance: Damage mitigation using insurance

**Policy Report pp.33-54**
**III-2. Basic Directions of Adaptation**

- Building code in US
  In flood hazard areas[a] defined by FEMA, DFE[b] is set higher than BFE[c], which is equal to flood water level. Floor levels should be higher than DFE[1)p.300, 2)p.37].
  - DFE is set by region cosidering the national flood insurance program[3)].
  - In New Orleans, DFE is set at either BFE or 3 feet high over the ground level, whichever is higher. And out of flood disaster areas, floor levels should be 3 feet higher than the house lot[4)p.9].
  - FEMA grants subsidy up to 30,000 USD to an insurer in a flood-prone area, if the cost for house lot raising is 50% higher than the assessed value of a house.

Raising rule in New Orleans city[6)]→




‹Advice› Already high more than BFF but should be reconstructed on 3 feet high pier.
Source: Committee for technical investigation on large-scale flood countermeasures, Cabinet Office

a) : Areas which may be inundated by a 100-year flood
b) : BFE: Base Flood Elevation
c) : DFE: Design Flood Elevation


1) International Building Codes 2006, International Code Council
2) Flood Resistant Design and Construction, ASCE Standard
3) Christopher P. Jones, PE (2006), Flood Resistance of the Building Envelope (http://www.wbdg.org/design/env_flood.php)
4) Lambert Advisory. Bermello, Ajamil & Partners Inc. Hewitt- Washington (2006): Reconstruction Implications (http://www.nocitycouncil.com/advisoryBaseFloodElevation.pdf)
5) FEMA(2006): Increased Cost of Compliance Coverage (http://www.fema.gov/business/nfip/icc.shtm)
6) New OrleansNet LLC: Raising Rules (http://www.nola.com/katrina/pdf/raising_rules.pdf)


## Promotion of flood control in step with land use regulation and guidance: Countermeasures for sediment-related disaster risk zones

**Policy Report pp.33-54**
**III-2. Basic Directions of Adaptation**

Sediment-related disaster risk zones should be revised based on increased sediment-related disaster risks.

**■Outline of the law related to promotion of measures for sediment-related disaster prevention established in 2000**

**Target: slope failure , debris flow, landslide**

**Basic guidelines drawn by MLIT include:**

**-Basic matters**
**-Guidelines for carrying out of basic investigation**
**-Guidelines for designating sediment-related disaster risk zones**
**-Guidelines for building relocation, etc. in disaster high-risk zones**

**Prefectures conduct basic investigations.**

**1. Prefectures will carry out investigations required for the risk-zone designation.**
**2. MLIT may help prefectures with part of investigation cost.**

**Prefectural governors designate sediment-related disaster risk zones.**

- Implementation of warning/evacuation systems
- Public information about warning/evacuation systems

→ **Local disaster prevention plan (Disaster counter-measure basic act)**

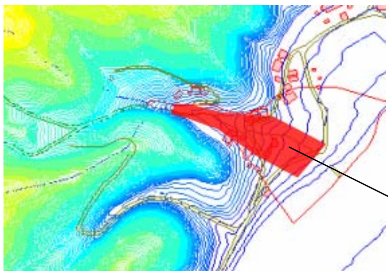
**Prefectural governors designate sediment-related disaster high-risk zones**

- **Development restriction for specific purposes, including sale of house lot and construction of social welfare facilities.**
- **Building regulation**
- **Recommendation on relocation**
- **Providing financial help for relocation**

→ **Regulation of houses' structural resistance (Building standard law)**

→ **Support for relocation (Housing loan corporation)**

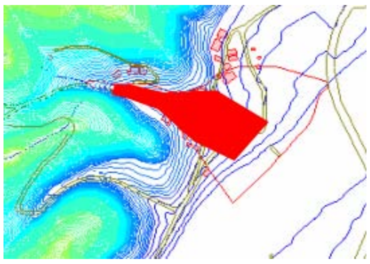
- If maximum 24-hour rainfall increases, a disaster high-risk zone will expand.



Example
River basin area: 0.3km$^2$
24-hour rainfall: 330mm/24hrs

High-risk area

If rainfall increases by 50%



The high-risk area will expand

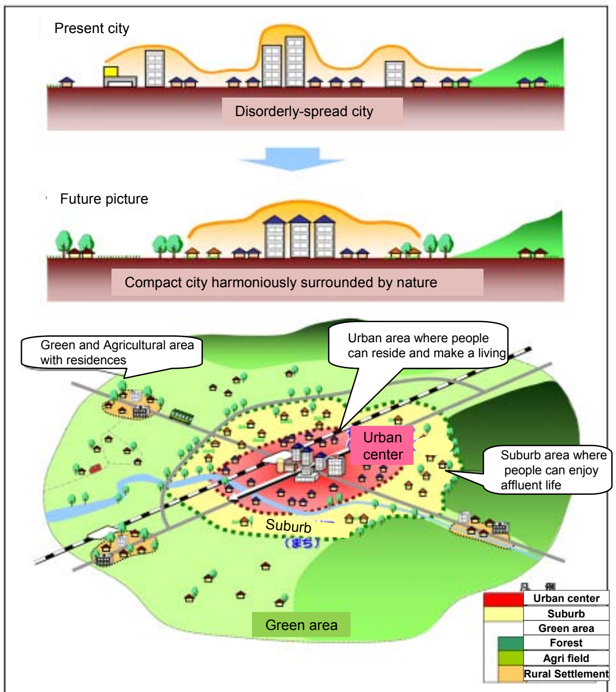
**Revision of designated area**

## A new concept for urban development :
## Compact community easier to implement flood control measures

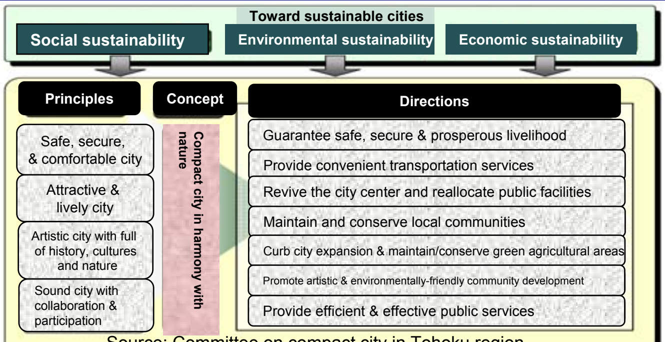
**Policy Report pp.33-54**
**III-2. Basic Directions of Adaptation**

**Compactly-built residences provide better energy efficiency and easier environment for flood control projects**

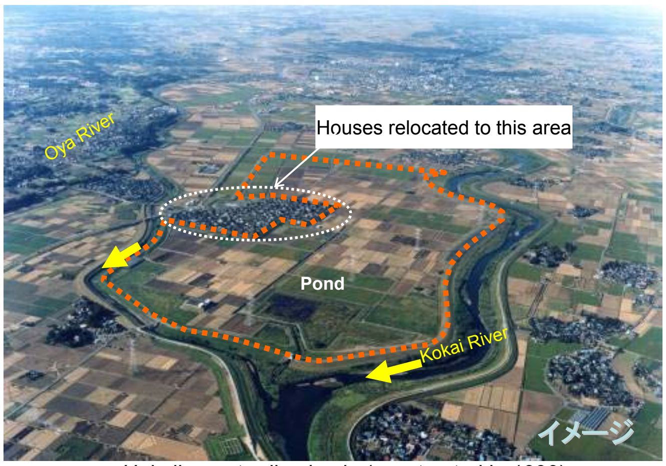
■ **Conceptual figure of compact city for present small and medium cities in Tohoku region**




Source: Committee on compact city in Tohoku region




Source: Committee on compact city in Tohoku region




Hakojima retarding basin (constructed in 1990)

## A new concept for urban development:
## urban development for a low-carbon, water-disaster adaptation society

**Policy Report pp.33-54**
**III-2. Basic Directions of Adaptation**

**Urban development should be promoted to build a low-carbon society which is also less vulnerable to floods.**

### Integrated project (Lake Town Development Project)

Construction of a regulating pond in a flood control project

( More safe river basin against floods )

＋

Urban development by a land readjustment project

( Creation of pleasant, green-rich water-front designed with care for safety, convenience and amenity )

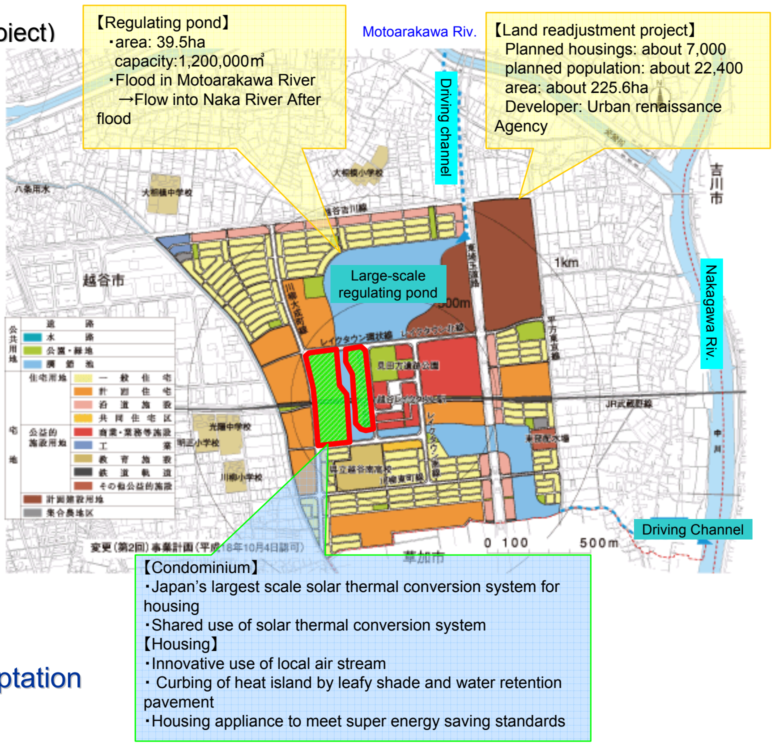
Plus adaptation

Project to reduce $CO_2$ emission by 20% from the town (First adaptation of Environmental Ministry's Model Project)

**Housing developers built 550 condominiums and132 housings**

Urban renovation with both mitigation and adaptation

Source: Urban Renaissance Agency website : modified by River Bureau



## A new concept for urban development: Securing wind corridors by green network in urban areas

**Policy Report pp.33-54 III-2. Basic Directions of Adaptation**

- Tokyo Metropolitan Government released a picture of Tokyo in 10 years in December 2006
- The first pillar is restoration of Tokyo full of water and green corridors
- In addition to urban disaster prevention and amenity/pleasant functions, multi-functions of the pillar are expected including heat island mitigation.

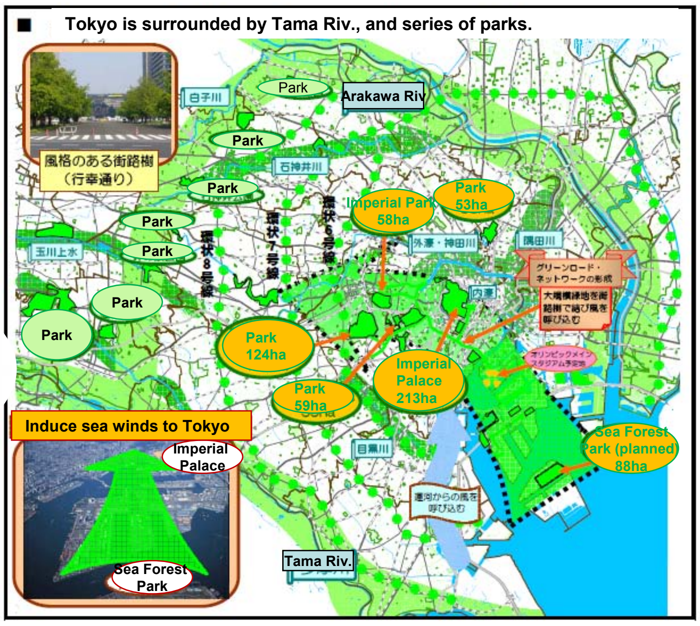
Create "wind corridors" by connecting green areas above a certain size

Numerical goals of "Tokyo in 10 years" project and road map

Waterfront greenery rate (on a river stretch basis)
Over 90% by 2016 (52% in 2005)

Greenery waterfront corridor

Ivied embankment




Source: TMG website "Tokyo in 10 years, changing Tokyo", edited by River Bureau

## A new concept for urban development: Formation of waterfront and green space by urban river restoration of underdrains

**Policy Report pp.33-54 III-2. Basic Directions of Adaptation**

Cheong Gye Cheon River restoration project removed 5.8km-long covering structure (6-lane surface road and 4-lane elevated freeway) above the Cheong Gye Cheon River that flows in the center of Seoul from west to east and restored the urban river.

### ＜Outline of project＞

○Period : July 2003- September 2005

○Work : Removal of elevated freeway and restoration of Cheong Gye Cheon River

○Length : 5.84km

○Cost : Approximately 390 billion won


### ＜Benefits＞

(1) Increase in visitors
(2) Decrease in air temperature
(3) More lively shopping district
(4) Restoration of diverse living creatures

**The Cheong Gye Cheon River Basin acts as if a natural air conditioner. Summer air temperature on the basin is an average of 3-4℃ lower than surrounding areas.**

・Air temperature near the stream decreased up to 23% before the project. It is 1.7- 3.3 degrees lower than in Jongno 5 ga.
・Average wind speeds increased up to 6.9% at Cheon Gye 4ga, and up to 7.8% at Cheon Gye 8ga.

Source: City of Soul

## A new concept for urban development: Regulatory storage, infiltration and runoff control of rainwater

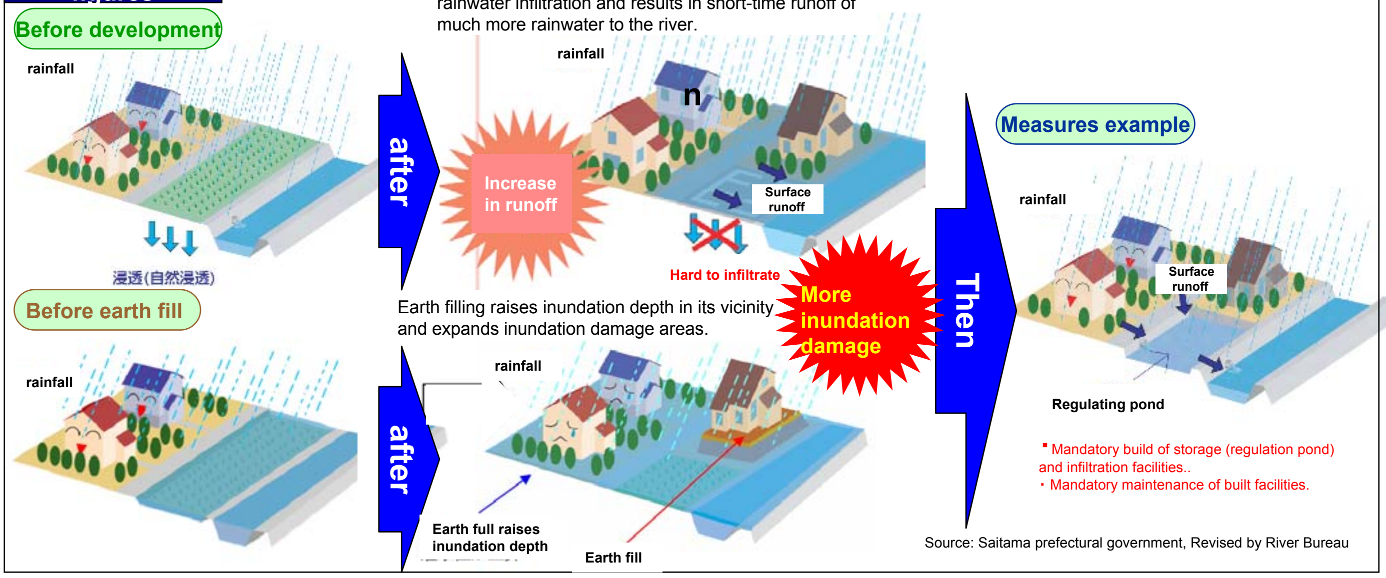
**Policy Report pp.33-54**
**III-2. Basic Directions of Adaptation**

Decrease of inundation damage by developers' mandatory installment of runoff control facilities

Example of Saitama **Ordinance on installment of rainwater runoff control facilities** October 2006

| Outline of ordinance | ・Developers of 1ha area or more and earth filling in designated areas must build a runoff control facility<br>・After the completion of the facility, developers are responsible to maintain the facility's functions, → The ordinance carries penalty. |
|---|---|

**Conceptual figures**




Source: Saitama prefectural government, Revised by River Bureau

## A concept for urban development: Subsidiary and regulation on storage infiltration and runoff control of rainwater

**Policy Report pp.33-54**
**III-2. Basic Directions of Adaptation**

- Rainwater storage and infiltration facility control runoff.
- Combination of incentive and control measures promote installment of facilities

Example of city of Ichikawa, Chiba **Ordinance on citizen's rainwater**

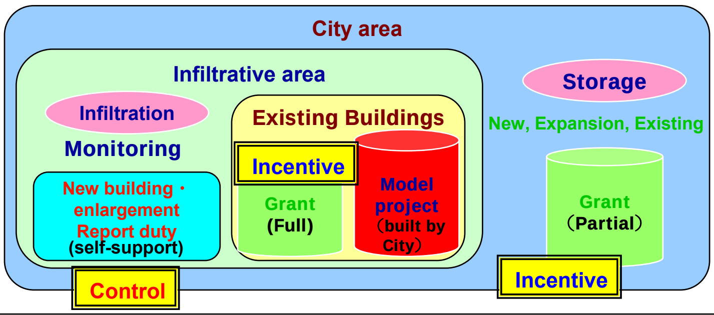
○Ordinance on rainwater infiltration into ground and its effective use in the city of Ichikawa (July, 2005)

**Outline of ordinance**

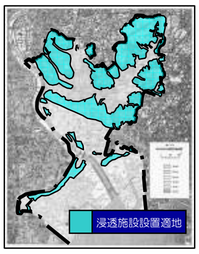
- Mandatory installment of infiltration facility for new or enlarged buildings in city's designated areas.
- Grant for infiltration facility installment for existing buildings in city's designated areas.
- Grant for small storage facilities for new, enlarging, existing buildings in the whole city area.

○About regulation:
【infiltration】・・・designated areas, new/enlargement
One infiltration facility with 350$\phi$ ×600 dimensions per 38m$^2$ areas of new or enlarging building.
○About grant
【Storage】・・・Whole city of Chiba
For gutter type, 1/2 of cost ( up to 25,000JPY)
For septic tank type, 2/3 of cost ( up to 80,000JPY)
【Infiltration 】・・・designated areas, existing buildings
Full of grant according to city's cost estimation

**Outline**




**Designated area**




High infiltration areas were designated after soil survey

**Main facilities**


Storage tanks (connected with gutter)

Storage tank (converted from septic tank)

Source: city of Ichikawa, revised by River Bureau

## Enhancement of the disaster resistance of private houses: raised structures

Policy Report pp.33-54
III-2. Basic Directions of Adaptation

### Introduction of buildings less susceptive to flooding

Yokohama Rapport

▲This is built in the Tsurumi River Retarding Basin.

▲the owner of this building selected a raised structure considering the past frequent flood damage in this area.

## Enhancement of the disaster resistance of private houses: Incentive for promotion of raised houses

Policy Report pp.33-54
III-2. Basic Directions of Adaptation

### Providing incentives for raised houses for less flood damage

Example of city of Nakano, Tokyo

**Grant program for raising houses**

December 2005

**Background**

Intensive rainfall in September 2005

Over 100mm/h rain
Flooded Myoshoji and Zenpukuji Rivers
Inundated areas: 119ha
Depth below floor: 1,171
Depth above floor: 2,175
(Summary of cities of Shinjuku, Nakano, and Suginami)

Flooding (provided by city of Nakano)

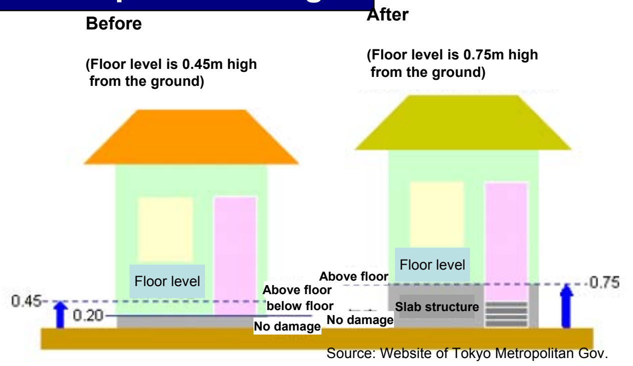
Started a grant program to partially support cost of house-raising works.

(December 2005)

### Outline of program

○Name: Grant program for raise works
○Eligibility: Housing owners in designated areas
○Grant conditions
(1) Raised floor is 75cm high or more from the ground and can prevent above-floor inundation.
(2) Structures below floor are water-proof and will not block water flow.
○Amount of grant
A half of estimated cost of raising work (up to 2 million JPY)

### Conceptual drawings




Source: Website of Tokyo Metropolitan Gov.

## Enhancement of the disaster resistance of private houses: Incentive for promotion of waterstops

**Policy Report pp.33-54**
**III-2. Basic Directions of Adaptation**

### Providing incentives for waterstops for less flood damage

Example of city of Abiko, Chiba

**Grant program for inundation protection work** **(from April 2004)**

**Outline of program**

City provides grant to lower economic load on inundation protection work to reduce flood damage after affected houses, stores, business buildings, parking lots and other structures.

Name: Grant program for inundation protection work

Eligible: Individuals listed on city's flood victims book, or owners or users of buildings damaged by a past flooding in designated areas shown in flood hazard map.

Eligible work:

(1) Works to set a waterstop to prevent floodwater intrusion at the housing entrance or inside the site

(2) Works to build a block wall and its subordinate works to prevent floodwater intrusion.

Amount of grant: A half of the total cost for eligible works (up to 300,000JPY)

**Example of work**

Setting of waterstop



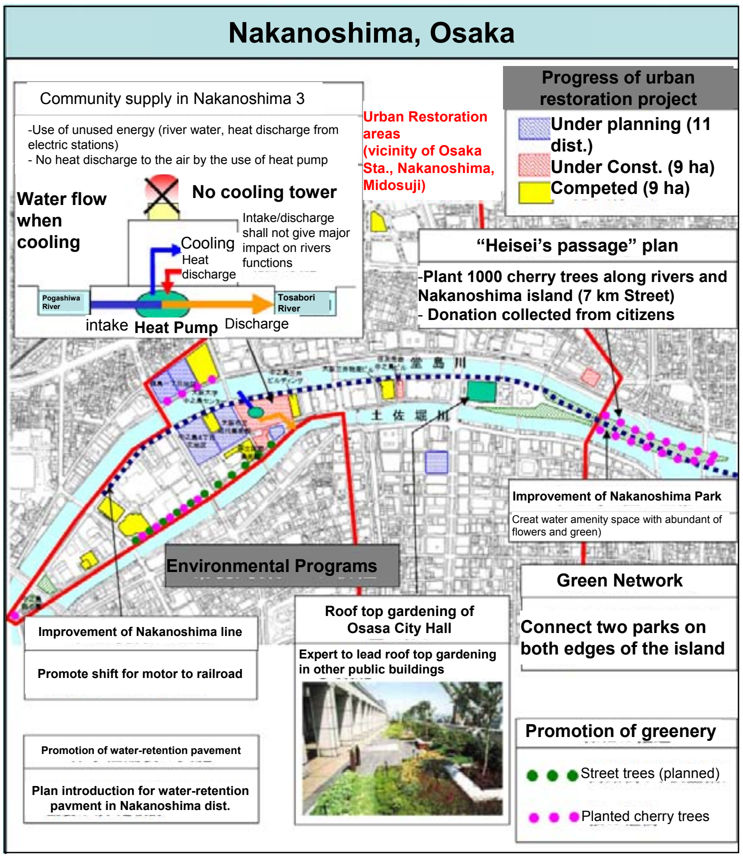
Raise of parking ground




Photos: City of Abiko

## Use of natural energy sources: introduction of heat pumps

**Policy Report pp.33-54**
**III-2. Basic Directions of Adaptation**




- Community cooling and heating by using unused energy source (river water), improvement of parks and greenery areas in conjunction with railroad work
- Intensive implementation of global-warming/heat-island measures taking advantage of a water town, Osaka

**Toward realization of low $CO_2$ type Urban Design**

① Effect of $CO_2$ emission reduction in Nakanoshima 3

*(Past record, estimate)*

Approximately 8.0 kg-$CO_2$/$m^2$/year reduction

(Per gross floor area)
(Independent heat source, Air heat source methods)

② Expansion to whole Nakanoshima district

Gross floor area in whole district: about 2 mil.$m^2$

(15 buildings including planned)

Assuming a half uses high-end systems

Approximately 8000 ton-$CO_2$/$m^2$/year reduction

Reduction goal of Osaka in 2010: 315000 ton CO2 per year (about 2.5% of the goal)

Economic value: 24mil JPY per year (CO2 emission trade, assuming the cost of 300JPY per ton

Impact on river water temperature is simulated to raise by 2~3 $^oC$ during summer high tide hours. However, it will go back to original temperature in a half day

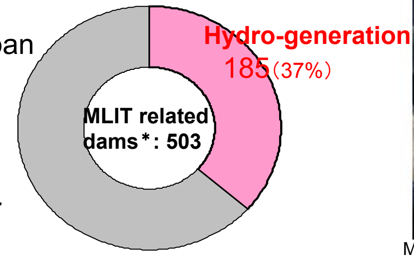
Source: developer's website

## Use of natural energy sources: application of hydro-energy

Policy Report pp.33-54
III-2. Basic Directions of Adaptation

### Hydraulic power generation at multi purpose dams

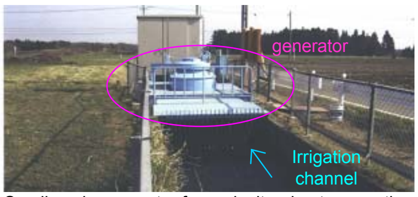
Currently, 185 multi-purpose dams in Japan generate about 640 mil KW energy at maximum.




（*Ones operated by MLIT, Japan Water Agency, and prefectural governments）

Miyagase dam, MLIT (Aikawa generator #1, Kamagawa)

### Backup of small-scale hydro-generation (New energy development)




Small-scale generator for agricultural gate operation

A lot of small-scale hydro-generator plans are proposed from the private sector against the background of raised awareness for environment and establishment of subsidiary systems.
When permission of water right is necessary, river administrators simplify the application procedure in order to promote global warming mitigation as a non-structural measure.

### Effective use of hydraulic energy at any drops, and maximum use of existing facilities

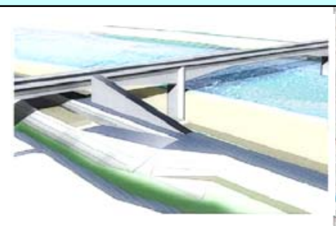
The administrative environment should be improved to promote effective use of potential hydraulic energy at river facilities.
Examples:

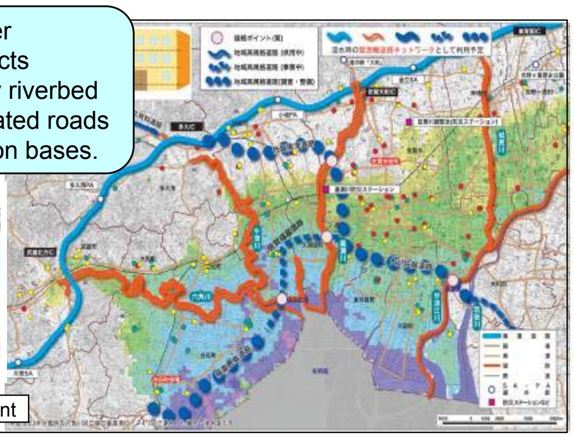
○Invitation of power generators to non-generating dams (planned)
○Augmentation of generation by changing water release rules (planned)
○Active disclosure of related data to power generators, provision of test fields.


## Promotion of preparation for responding to large-scale disasters: Wide-area disaster prevention network that ensure access from disaster prevention basses to damaged locations

Policy Report pp.33-54
III-2. Basic Directions of Adaptation

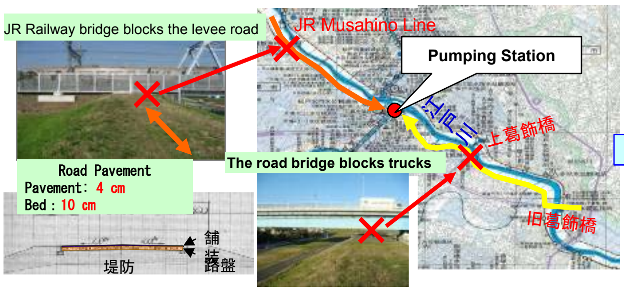
Building of a wide-area disaster prevention network that connects embankment, roads on the dry riverbed for emergency traffic and elevated roads to wide-area disaster prevention bases.





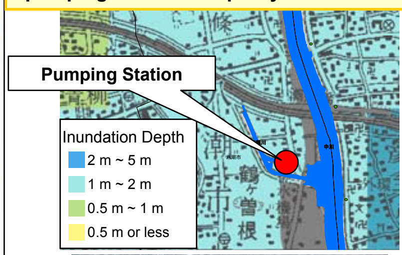
Network of roads and river embankment

Tank trucks cannot reach pumping station when a levee road is blocked by a bridge or road pavement can not tolerate heavy trucks.




**Source**: *8th meeting of Taskforce on large-scale floods, Cabinet Office*

Fuel can not be charged when surrounding traffic inundated even if pumping station is kept dry.





Inundation of National Highway R34 in July 1990
Levees and high-standard roads and free from inundation

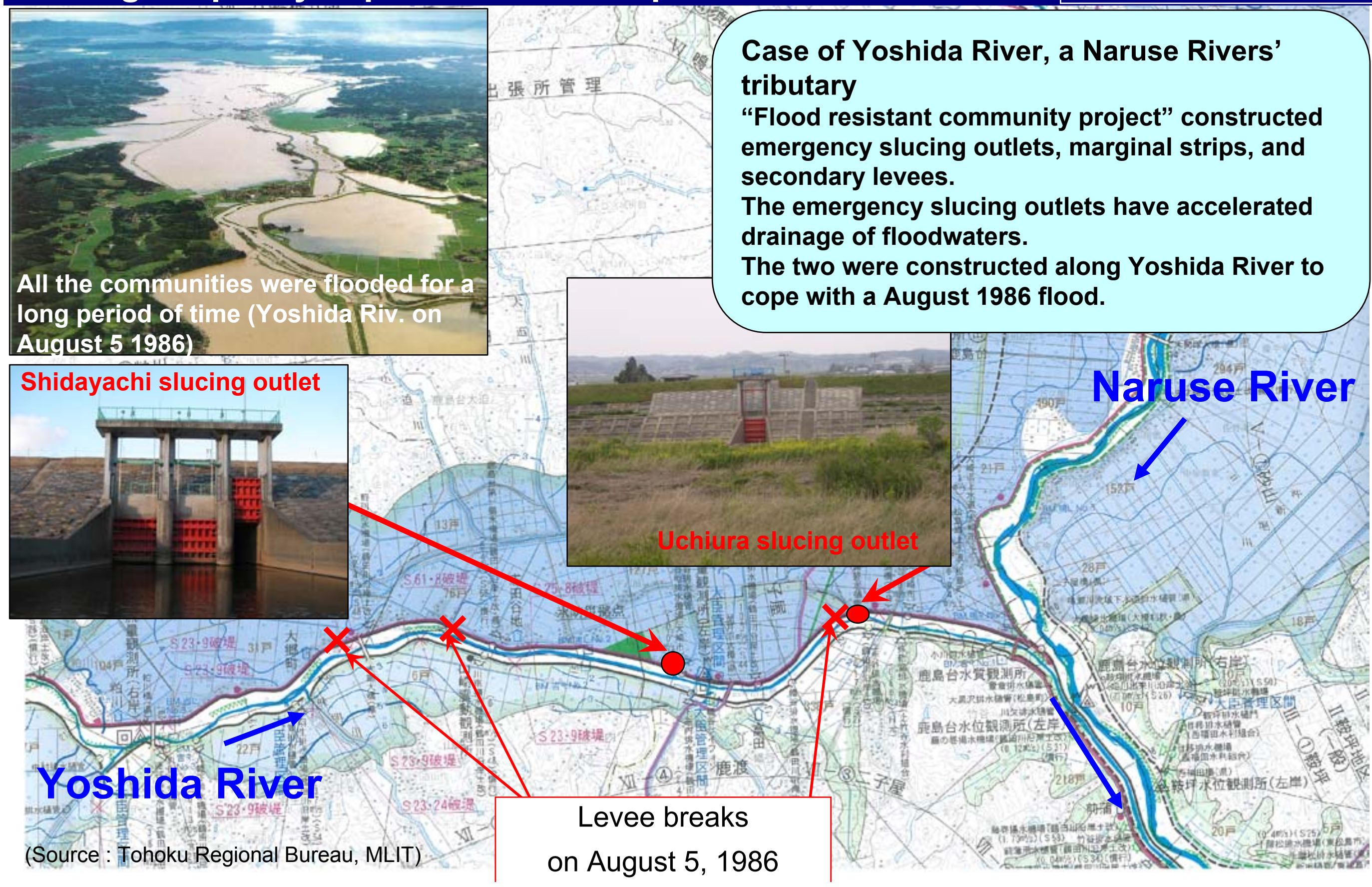
**Source**: *8th meeting of Taskforce on large-scale floods, Cabinet Office*

## Promotion of preparation for responding to large- scale disasters: **Drainage capacity expansion in flood-prone areas**

**Policy Report pp.33-54**
**III-2. Basic Directions of Adaptation**

**Case of Yoshida River, a Naruse Rivers' tributary**

**"Flood resistant community project" constructed emergency slucing outlets, marginal strips, and secondary levees.**
**The emergency slucing outlets have accelerated drainage of floodwaters.**
**The two were constructed along Yoshida River to cope with a August 1986 flood.**




(Source : Tohoku Regional Bureau, MLIT)

## Promoting non-structural measures based on new scenarios: Securing evacuation routes and shelters by pedestrian deck and tall building

**Policy Report pp.33-54**
**III-2. Basic Directions of Adaptation**

Pedestrian decks and robust buildings should be assigned as shelters in case of flooding and tsunami after big earthquakes.

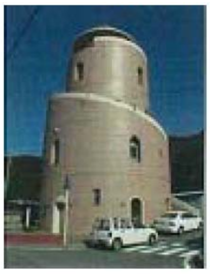
Pedestrian deck

**Kokufu fisherman's village center emergency shelter (Shima, Mie)**

**City hall of Kushimoto, Wakayama**

**Katahama community disaster prevention center (Sagara, Shizuoka)**

**Nishiki Tower(Oki, Mie)**



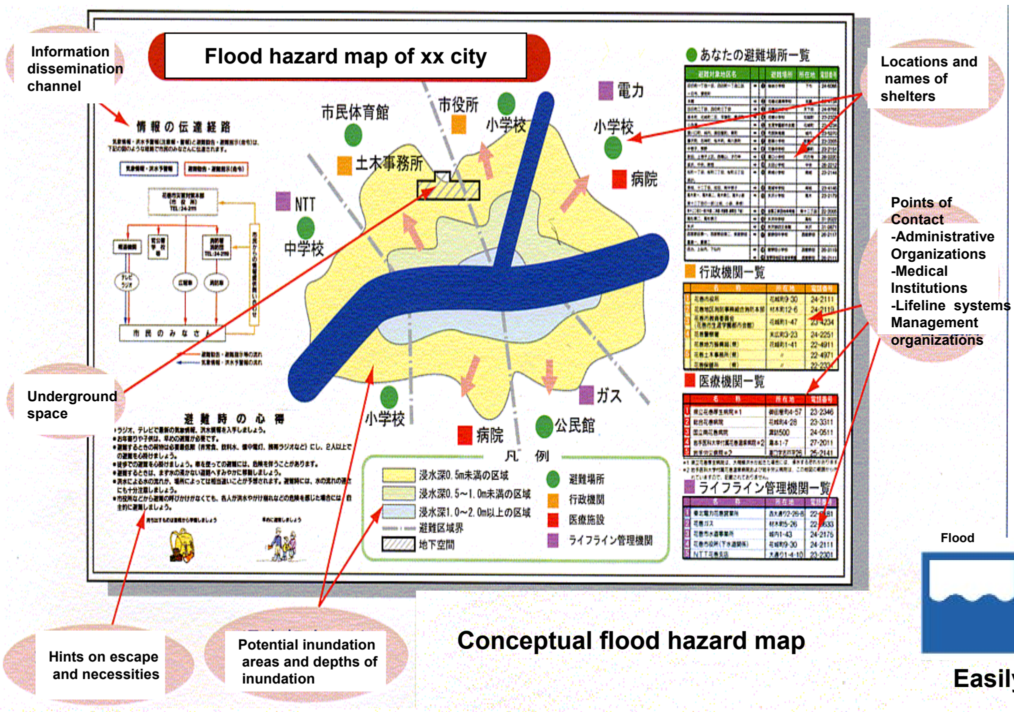
Tsunami shelters

(Source: Large-scale rainfall disaster study committee)

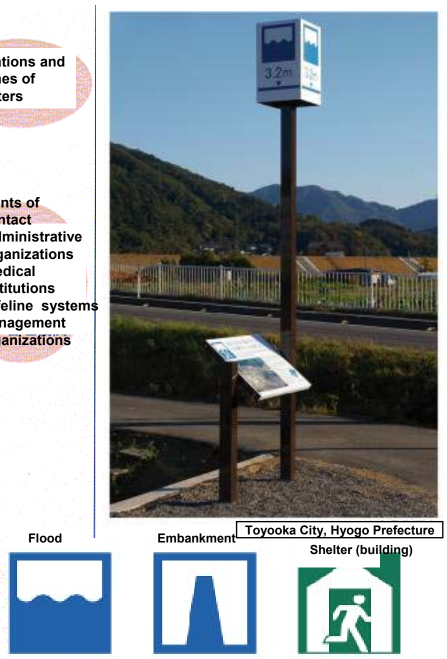
## Promoting non-structural measures based on new scenarios: Sharing preliminary information concerning the degree of flood risks

Policy Report pp.33-54
III-2. Basic Directions of Adaptation

Water levels in build-up areas in the past floods are indicated on the hazard map.




Conceptual flood hazard map

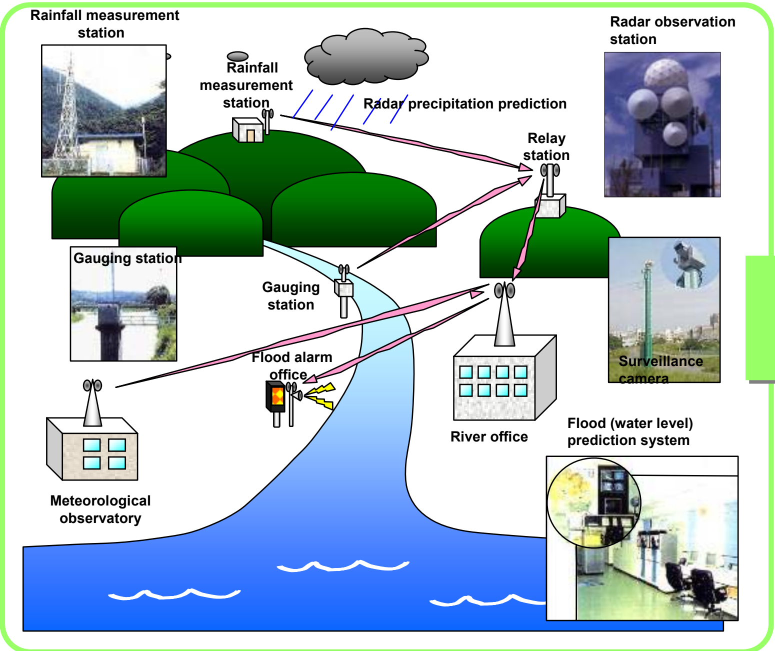



Easily recognizable signs

## Promoting non-structural measures based on new scenarios: Sharing real-time information

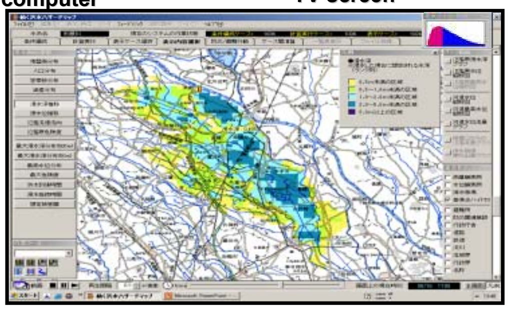
Policy Report pp.33-54
III-2. Basic Directions of Adaptation

- Real-time provision of rainfall and water levels via cellular phones, the Internet or local disaster prevention radio systems
- Flood forecasting through real-time simulation




Information provision via cellular phone or personal computer

Delivery of an image to a TV screen

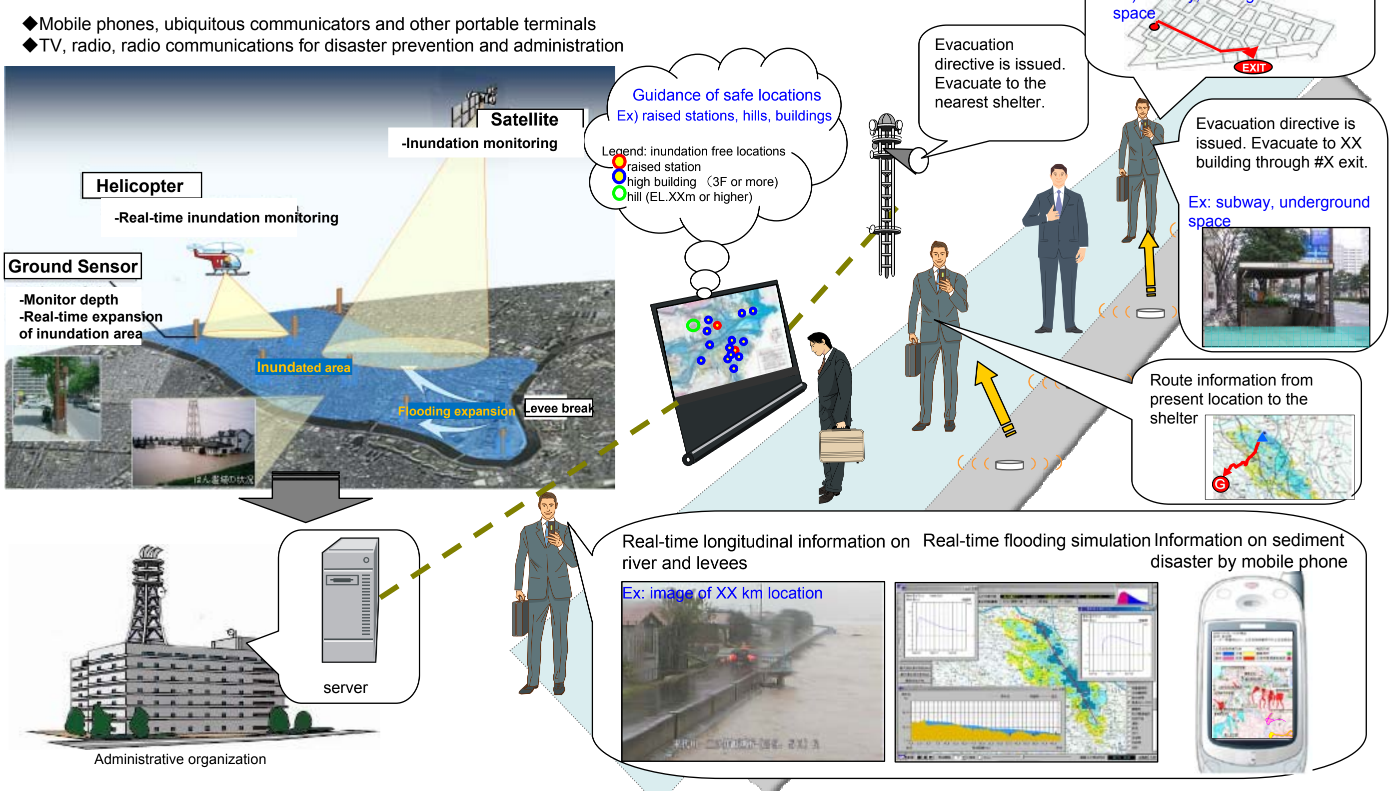


Floodwater prediction through real-time simulation

## Promoting non-structural measures based on new scenarios: Evacuation guidance by ubiquitous network

**Policy Report pp.33-54**
**III-2. Basic Directions of Adaptation**

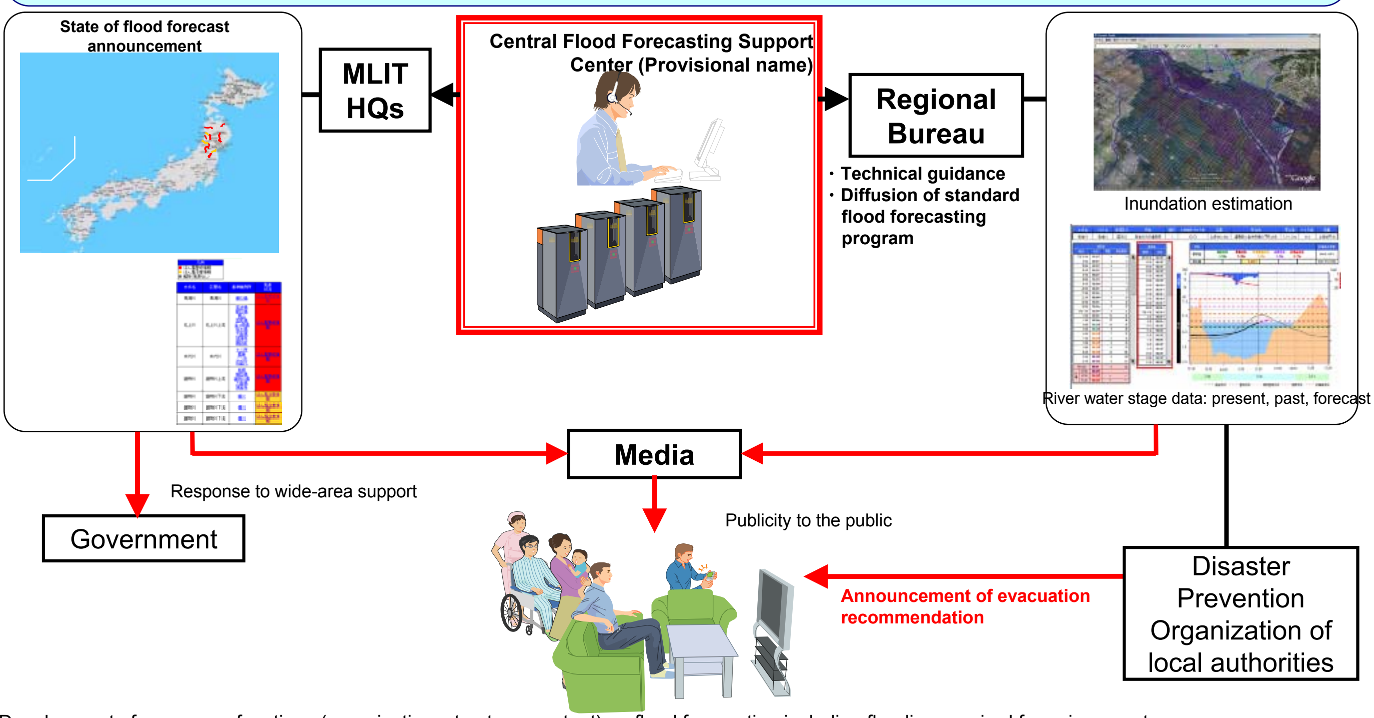
- A ubiquitous network enables to obtain information in no service areas of cellular phones and GPS.
- A ubiquitous network enables strangers to obtain evacuation routes.




## Promoting non-structural measures based on new scenarios: Standard system of flood forecasting central center

**Policy Report pp.33-54**
**III-2. Basic Directions of Adaptation**

1. During a non-flood period, a flood forecasting central center provides technical support and assistance and accumulates knowhow of more accurate forecasting
2. A flood forecasting central center promptly responds to wide-area support, summarizing information from each local flood forecasting organization.
3. A flood forecasting central center provides long-term forecasting and calls for river administrators' attention.




Development of necessary functions (organization, structure, content) on flood forecasting including flooding required for unique center

## Establishment of a water-saving society with primary focus on water demand management

**Policy Report pp.33-54**
**III-2. Basic Directions of Adaptation**

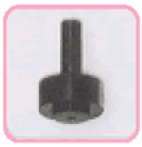
- Build awareness of water saving (persistent public relations)
- Regulations and incentive programs for individuals or companies to promote development of water saving appliances
- Further increase in recycled rate of industrial use of water
- Promotion of wastewater reuse and water harvesting

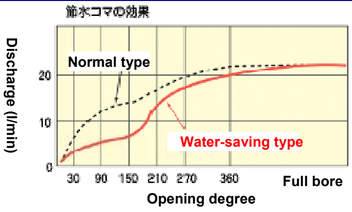
### Efforts of water-saving awareness raising in the city of Matsuyama (from webpage of Matsuyama city)

●Grant up to 1,000 – 20,000JPY to purchase of water-saving appliances below in order to raise water-saving awareness

●Ordinance to enforce use of water-saving appliances (toilet, bath, kitchen) and rainwater tank (water harvesting) for newly-built or enlarged large-scale buildings (gross floor area 1,000m$^2$ or more) as part of water-saving urban design.

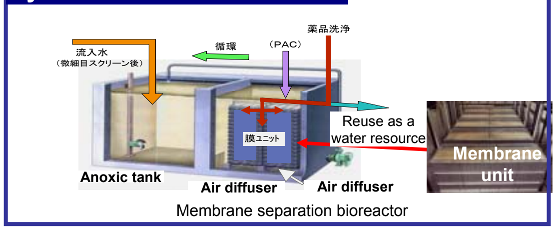

### Water-saving by faucet valve (from webpage of Waterworks Department Tokyo Metropolitan Gov.


▲water-saving faucet valve




This valve can reduce 6littor/min water if set to a faucet in a kitchen or wash-basin Waterworks Department of Tokyo Metropolitan Gov. distribute the valve for free of charge.

### System of wastewater reuse




World's advanced built in membrane separation bioreactor

## Securing of emergency water resources

**Policy Report pp.33-54**
**III-2. Basic Directions of Adaptation**

- Water transportation: Arrangement of water bags for fast transportation of water at a large scale
- Transportable desalination units: water supply from transportable desalination unit
- Versatile types of water storage in factories and houses
- Water right transfers between water users in the river system ( drought coordination work)

### Water bag


Photo: MTI

Test water transportation by water bag implemented by Ministry of Economy, Trade and Industry and Japan Water Agency for the purpose of emergency transport of massive water to water shortage areas and supply

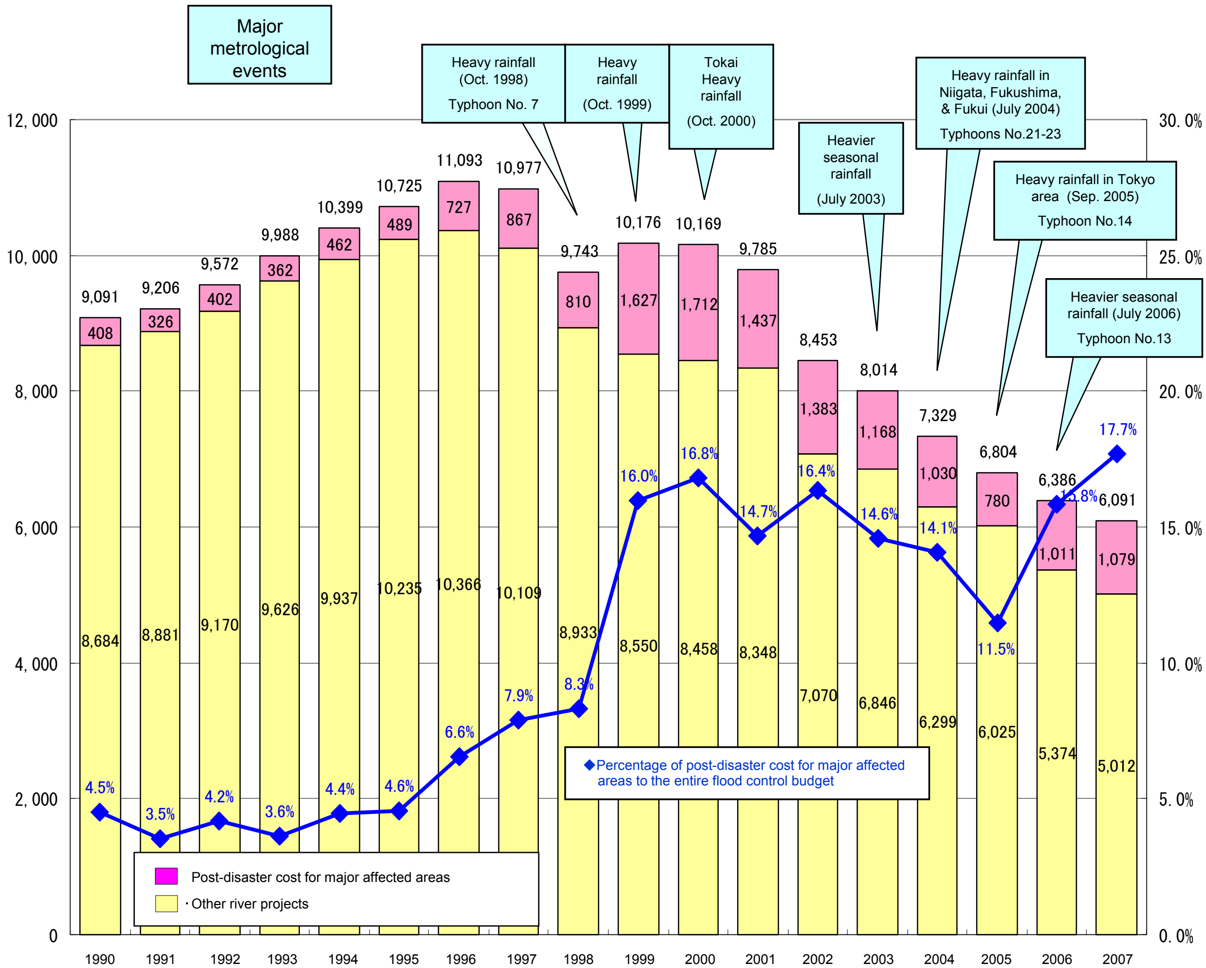
### Transportable desalination unit


Photo: Japan Water Agency

Desalination system was remodeled to be transportable to supply water to areas in short of water as an alternate source

Source: Report on alternate industrial water source, March 2007, MITI

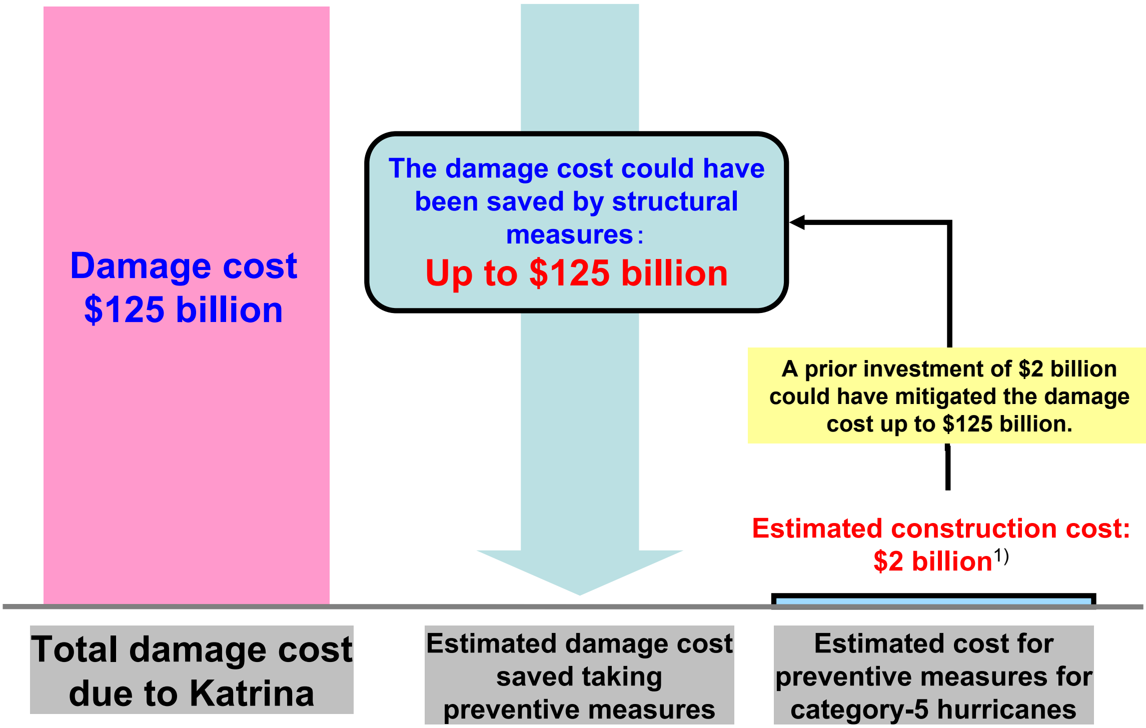
Post-disaster financial support for affected areas increases due to frequent floods in recent years while the total flood control budget continues declining.



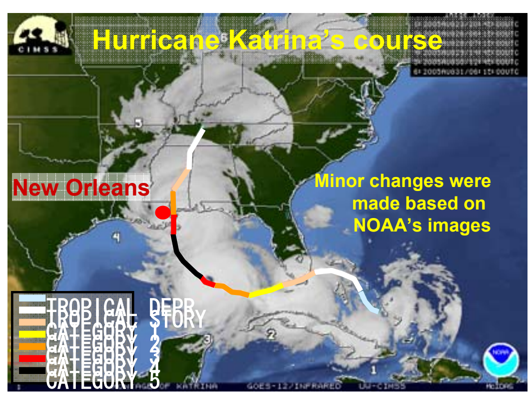

River project budget (excluding maintenance & repair costs)

# Strategic investment in preventive measures

## Hurricane Katrina (Aug. 2005)




- It had been claimed that structural measures for category-5 hurricanes (equivalent to Katrina) should be implemented (referring to the **cost effectiveness of prior investment**)[1)]
- USACE was aware that the construction projects in the affected areas (for category-3 hurricanes; scheduled to be completed by 2015) was **behind schedule due to inadequate funding**.[2)]

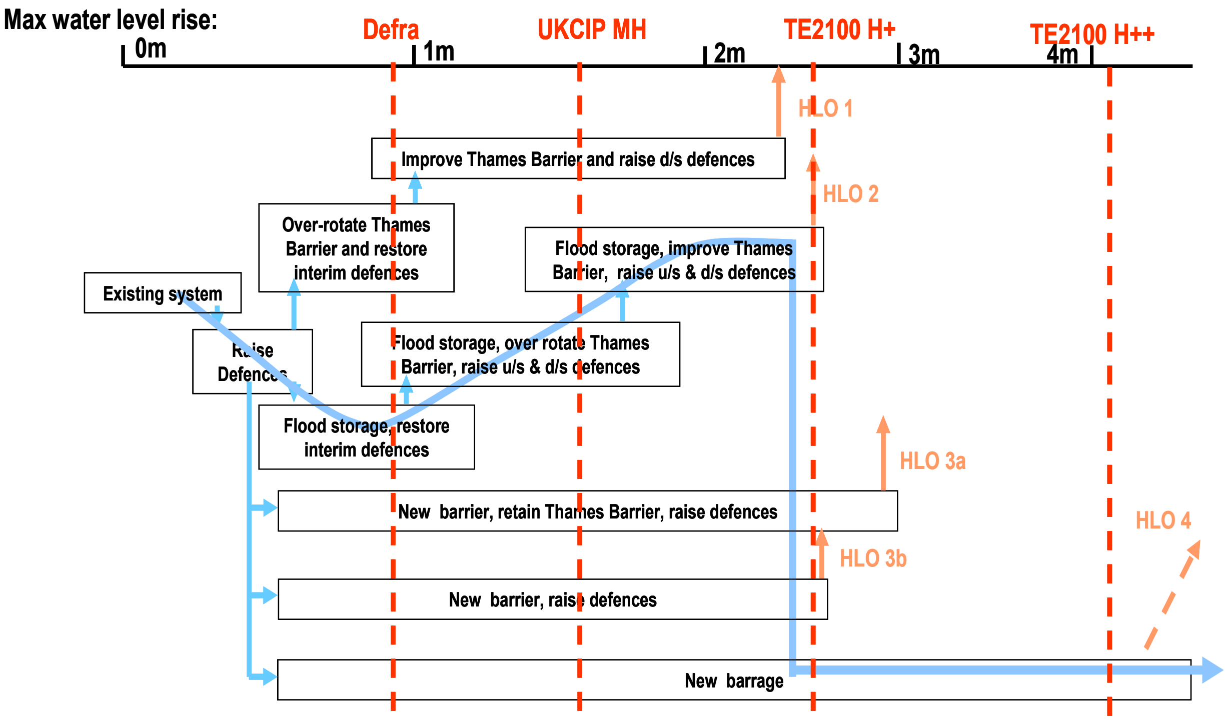




Source: 1) "River Side" Sep.-Oct. 2004, US Army Coups of Engineers
2) Website of the New Orleans Office of the US Army Coups of Engineers

# Preparation of a road map Thames Estuary 2100 (TE21000)

Policy Report pp.46-49
III-1. Implementation of Adaptation

TE2100 prepares 4 adaptation measures: 1) conventional engineering approach, 2) water storage in floodplains, 3) new barriers, and 4) new dykes. TE2100 does not take measures based on a specific scenario, but flexibly promote adaptation in phases while analyzing the defense level that can be reached by improving the existing structures.



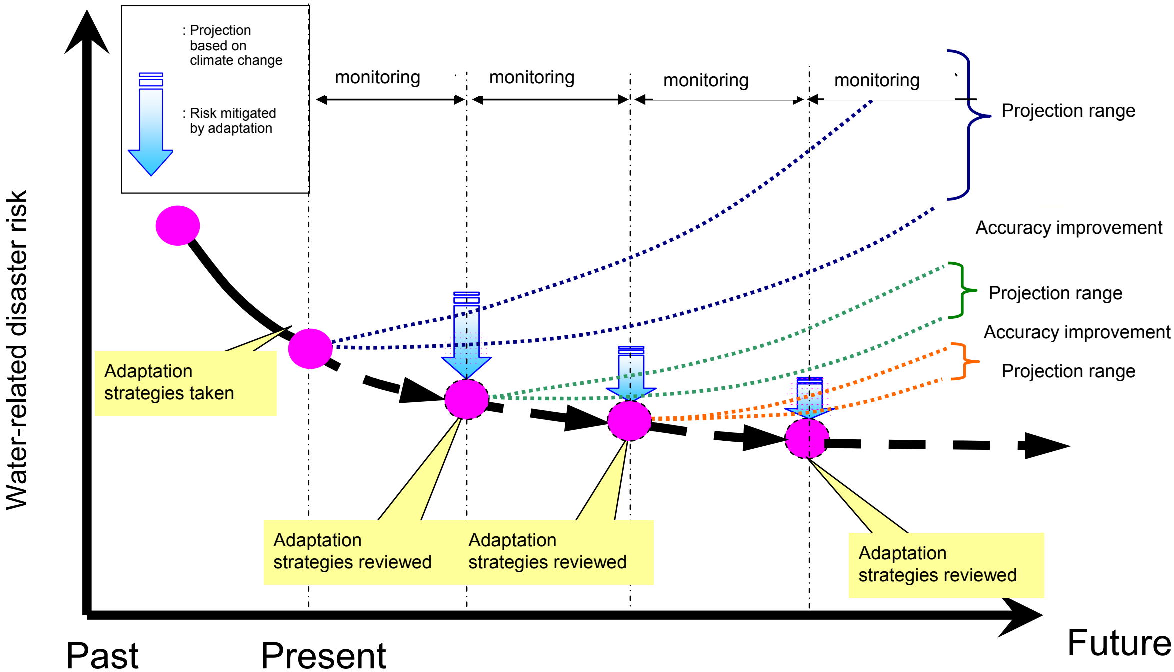

The final plan may be a combination of approaches

Source: Provided by Tim Redder, head of the Regional Climate Change Programme, Department for Environment, Food and Rural Affairs

# Flexible approach

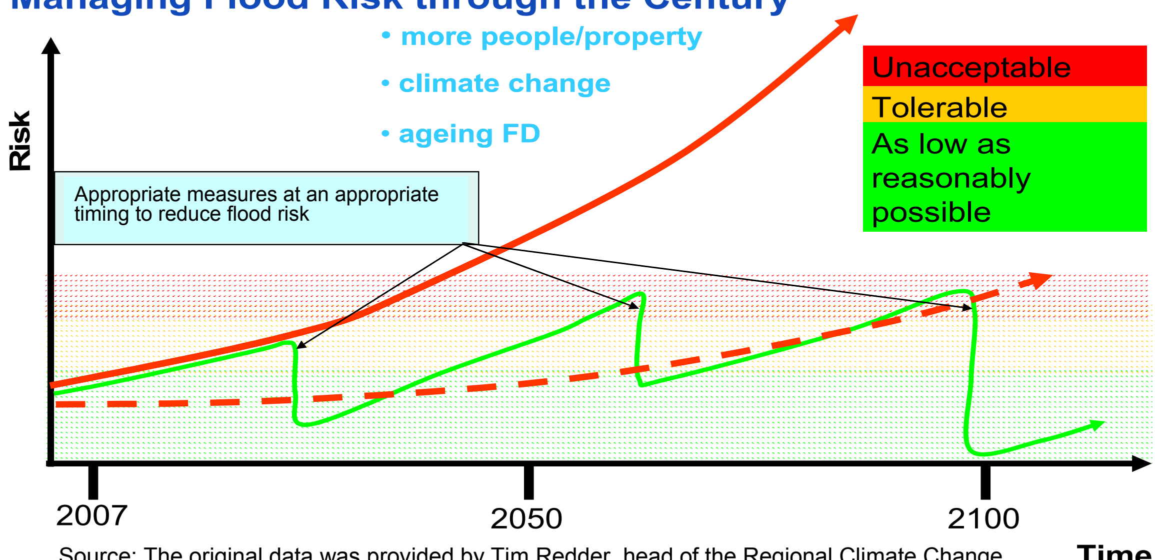
Policy Report pp.46-49
III-1. Implementation of Adaptation

Adaptation strategies will be periodically reviewed based on the constant monitoring of climate and social changes and the analysis of flood and other water-related disaster risks. (EU reviews its strategies every six years.)




TE2100's strategies are based on the policy that flood risk should be kept in a tolerable range by taking appropriate measures at an appropriate timing.

## Managing Flood Risk through the Century




Source: The original data was provided by Tim Redder, head of the Regional Climate Change Programme, Department for Environment, Food and Rural Affairs.

# Outline of discussions at the First Asia-Pacific Water Summit

**The Summit was held under the theme of Water Security: Leadership and Commitment.**
**Ten sessions were held under three main themes: Water infrastructure and human resources development, water-related disaster management and water for development and ecosystems.**

**"Message from Beppu", a summary of two-day discussions, was issued.**

- ✓Top priority will be given to water and sanitation in economic , development and political activities in each country in the Asia-Pacific region and assistance will be enhanced.
- ✓Effective actions will be taken promptly to prevent or reduce floods, droughts and other water-related disasters and to save or assist victims on a timely basis.
- ✓Assistance will be provided urgently to island countries, which are vulnerable to the impacts of climate change, to help them protect human lives and property.
- ✓Some countries have already been witnessing the impacts of climate changes such as the melting of snow caps and glaciers in the Himalayas, and sea level rise. The Message suggests that the U Conference on Climatic Change meeting in Bali put the relationship between water and climate change on the agenda.

- ➢ **Leaders in the Asia-Pacific region had full-scale discussions about the adaptation measures for reducing the risk of climate change.**
- ➢ **Leaders in the Asia-Pacific region faced with challenges in relation to water got together and re-confirmed their understanding that solving water-related problems is the top priority.**

## Address by His Imperial highness the Crown Prince of Japan (excerpts)

-Water poses serious problems in relation to climate change. There is the fear that global warming is likely to have various adverse impacts on people's activities such as sea level rise, frequent abnormal weather conditions, more severe disasters and large-scale water shortages. There have recently been more heavy rains throughout the world and wider areas have been subjected to the impacts of droughts. I feel great sorrow for the heavy damage caused by water-related disasters that have been occurring frequently in the Asia-Pacific region.

- Water-related issues are intertwined. Water supply, sanitation and flood control are not independent of one another. To deal with the issues, it is important to understand the diverse characteristics of water from the widest viewpoint possible and to take step-by-step approach suitable to the regional conditions based on a comprehensive perspective and through the innovative and cooperative efforts of those concerned.

## Address by Prime Minister Yasuo Fukuda of Japan (excerpts)

-The Asia-Pacific Region, although enjoying prosperity, is faced with various water-related issues. We are in a serious situation as the majority of world's water-related issues are concentrated in the region.

-Water-related disasters attributable to climate change have been increasing and are expected to have great impacts. We need to take measures urgently to control water-related disasters.

-Global climate change substantially impacts human kind through water.

-Building an international framework is an immediate task. I will raise environmental and climate change issues as the main topic on the agenda at next yea's G8 Hokkaido Toyako Summit.

-The vigorous discussions at the Asia-Pacific Water Summit will provide great momentum and wisdom to the G8 Summit.

Source: Website of Prime Minister's Office

# Reference


1. Water Resources in Japan 2007 – for secure and safe use of water – (Water Resources Department of the Land and Water Bureau, Ministry of Land, Infrastructure, Transport and Tourism)
2. Summary for Policymakers of the Synthesis Report of the IPCC Fourth Assessment Report
3. Summary for Policymakers of the Working Group I Report of the IPCC Fourth Assessment Report
4. Synthesis Report of the IPCC Fourth Assessment Report
5. Working Group I Report of the IPCC Fourth Assessment Report
6. Report on the “Development of Super High Resolution Global and Regional Climate Models” under the research project of “Sustainable Coexistence of Human Nature and the Earth,” (Central Research Institute of Electric Power Industry)
7. Global Warming Projections, Vol.6 (Japan Metrological Agency)
8. Presentation at a water resources symposium entitled the “World Water Day – climate change-induced water issues” (Masahide Kimoto)
9. Extreme Climate Report 2005 (Japan Metrological Agency)
10. Global Warming Projections Vol.7 (Japan Metrological Agency)
11. “Changes in Rainfall Characteristics due to Global Warming and Flood/Drought Risk Assessment” (Kazunori Wada, Katsuhiko Murase and Yosuke Tomizawa; Journal of the Japan Society of Civil Engineers No. 796)
12. “Impact assessment of sea-level rise on sandy beaches” (Nobuo Mimura, Shin Kiyohashishi, and Koruko Inoue; Journal of Coastal Engineering Vol.40)
13. Global warming, National Institute for Environmental Studies, http://www.nies.go.jp/escience/ondanka/ondanka01/index.html.
14. Global warming and Japan – Projection of impacts on nature and human beings – (Compiled by Hideo Harasawa and Hidezo Nishioka, Kokin-shoin, 2003)
15. Global warming-based water environment management (Keisuke Hanaki, Journal of the Japan Society of water environment, Vol.29, No.2, pp57-61, 2006)
16. Study Group for Holistic Water Resources Management based on Global Warming Risks (Water Resources Department of the Land and Water Bureau, Ministry of Land, Infrastructure, Transport and Tourism)
17. Newton, August 2007, Newton Press
18. Global Warming Impacts on Japan 1996 (Committee for Global Warming Issues of the Environment Ministry of Japan)
19. Directive of the European Parliament and of the Council on the assessment and management of flood risks (European Parliament and the Council)
20. Progress on adaptation to climate change in developed countries an analysis of broad trends (OECD)
21. Climate change and water adaptation issues (EEA Technical report、2007.2)
22. National Adaptation Programmes of Action (UNFCCC)
23. Initial national communication and date of submission (UNFCCC)
24. Fourth National Communication of the United States of America Under the United Nations Framework Convention on Climate Change (U.S. Environmental Protection Agency, 2006)
25. The California Strategic Growth Plan –Flood Control and Water Supply (Governor’s Budget 2008-2009)
26. CANADA’S FOURTH NATIONAL REPORT ON CLIMATE CHANGE (Environment Canada, 2006)
27. Actions to Meet Commitments Under the United Nations Framework Convention on Climate Change (NUFCCC)
28. Australia’s Fourth National Communication on Climate Change A Report under the United Nations Framework Convention on Climate change (Australian Greenhouse Office within the Department of the Environment and Heritage. 2005)
29. Experts Panel on Major Water-related Disasters of the Central Disaster Prevention Council (Cabinet Office)
30. Proposal by the Committee on Tohoku Compact Cities (Tohoku Regional Development Bureau)
31. Data provided by Tim Redder, head of the Regional Climate Change Programme, Department for Environment, Food and Rural Affairs