Ministry of Land, Infrastructure,
Transport and Tourism

Provisional Translation

Climate Change Adaptation Strategies to Cope with Water-related Disasters due to Global Warming (Policy Report)

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Panel on Infrastructure Development

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Introduction

Climate changes that accompany anthropogenic global warming (hereinafter referred to as "climate change") are a serious issue as they are predicted to cause serious and large-scale adverse impacts, including those that may also shake the foundation of people's life, as well as those on ecosystems, water resources, foods, coastal and low-land areas, industries, and human health. In coastal and low-land areas, especially, both the frequencies and scales of floods, sediment disasters and flood, sediment-related, storm-surge and other disasters are predicted to increase due to sea level rise, frequent heavy precipitation events and intensified typhoons. Serious droughts are also likely to increase due to a greater degree of fluctuation in precipitation. (These disasters are called "water-related disasters".)

Amidst serious concerns over climate change, the Intergovernmental Panel on Climate Change (IPCC)[1] published its 4th report in 2007. The report suggests that it be as important to promote "adaptation" to the impacts of global warming as to promote "mitigation" since global warming "mitigation" centered around the reduction of greenhouse gases has limitations, and global warming impacts would continue over centuries even when "mitigation" is implemented.

That is, if nations took all the necessary measures to reduce greenhouse gas emissions as the Kyoto Protocol has been adopted, the greenhouse gas concentrations would still continue to increase, global warming would continue to worsen, and its impacts would emerge in various places across the world. This recognition has been seriously accepted by the international community. Some developed countries have already started taking some adaptation measures to climate change along with mitigation measures. They have systematically increase levee height while making efforts to reduce greenhouse gas emissions. On the other hand, in Japan, though one

1 Intergovernmental Panel on Climate Change (IPCC): An intergovernmental body consisting of international scientists to collect and analyze scientific studies on global warming.

of the most disaster-vulnerable among developed countries, impacts of climate change on water-related disasters are still under scientific study, and practical adaptation measures to climate change have not yet been sufficiently discussed.

Considering that the safety and security of people is a basic duty of a national government, it must quickly investigate and implement adaptation measures, including preventive structural measures, to cope with climate change based on long-term vision.

The subcommittee on climate change adaptation for flood control was originally established to analyze and assess climate change-induced changes in characteristics, such as frequency and scale, of flood, sediment-related, storm-surge and other disasters, and their impacts on society as well as to review adaptation strategies. While discussion progressed, however, subcommittee members emphasized the need of conducting investigations not only from a contracted viewpoint of conventional flood control but from various angles. Thus, the subcommittee decided to discuss and clarify the basic directions and contents of overall adaptation to water-related disasters from latitudinous perspectives.

The subcommittee met eight times from August 2007 to May 2008, discussed climate change adaptation strategies to cope with water-related disasters, and finally concluded this policy report

I. Common recognition

(Needs of taking urgent adaptation strategies)

Since 70% of the national land of Japan is mountainous, about a half of the population and three-fourths of the total property exist in alluvial plains, which account for only 10% of the area. Areas below sea level in the three major bays of Japan (Tokyo, Ise and Osaka Bays) occupy an area of 577 km^2, accommodating 4.04 million habitants. In Japan, which is located on the circum-Pacific orogenic zone, mountains are steep, rivers are short and fast, and many faults and landslide-prone areas exist across the country; thus, the country is topographically and geologically prone to disasters. The islands are also located on the eastern end of the Monsoon Asia, which is characterized by high precipitation, and suffer from extremely severe meteorological conditions – a mean annual precipitation of about 1,700 mm (twice the world average), frequent typhoon disturbances, and extreme rainfall events in which almost 200 mm-per-hour precipitation was once recorded. The land is thus vulnerable to flood, sediment-related, storm-surge and other disasters.

To control the disaster-prone conditions, Japan has been continuously implementing flood control projects, including the construction of continuous levees and flood-storage structures, such as dams. These efforts steadily improved the flood safety level. However, the construction of planned flood control structures has been slow and still remains at a low completion level, only reaching about 60% of the government's current goal, which is set to implement flood control measures against rainfall with a return period of 30-40 years for large rivers and 5-10 years for small and medium rivers.

Although the mean annual precipitation is twice the world average, the per capita precipitation is only one-third the world average, suggesting that Japan is not particularly abundant in water for regular use. The steep and short rivers of Japan quickly discharge collected water to the sea, and the difference between the maximum and minimum discharges is large, making stable water use difficult. In addition to these natural conditions, water supply and demand became increasingly imbalanced due to the population increase and rapid economic growth. Japan managed to cope with these problems by constructing facilities and structures for water resources development. On the other hand, urban water demand has leveled out due to recent changes in the industrial structure and the promotion of efficient water use; the demand has being balanced with the supply despite some local variations. However, there is a tendency that annual precipitation fluctuates more widely, and that extremely low precipitation years become more frequent, which may lead to higher drought risk and lower reliability of water supply.

The IPCC 4th Assessment Report touches upon situations for which past data and experience would not be practically useful since climate change would cause large-scale sea level rise, more intense storms and typhoons, and more serious droughts. Therefore, areas where disaster mitigation systems have been planned and executed based on past meteorological data and experience would possibly suffer even more devastating damage due to increases in scale and frequency of flood, sediment-related, storm-surge and other disasters, including serious droughts.

Moreover, river and coast environments are susceptible to changes in other environmental factors, such as temperature, water quality, flow regime, sediment discharge, environments of river basins and coastal areas. Anthropogenic changes are another factor which affects rivers and coasts. When river and coast environments are affected by those factors, their ecosystems as well as water and material cycles will naturally be affected, too.

To cope with those threats imposed by climate change, it is important to not only promote prevention and mitigation to reduce disaster risks attributed to flood, drought, sediment-related, storm surge disasters, but also to secure sound river/coast ecosystems and water/material cycles. To this end, observational systems should be enhanced, and social structure needs to be changed to be more disaster-resistant, in addition to conventional prevention and mitigation measures. Each citizen needs to be aware that water-related disasters are likely to be intensified and frequent due to climate change and that river and coast environments will be different. It is necessary to build “a strong society adapted to water-related disasters (water-disaster adaptation society)” in which sustainable socio-economic activity and livelihood are possible through an appropriate combination of adaptation and mitigation.

(Adaptation and mitigation – the two wheels)

To reduce projected adverse effects of climate change, mitigation and adaptation are both considered necessary. The former is to mitigate climate change and variability by reducing or absorbing greenhouse gases. The latter is to avoid or reduce possible damage by developing systems to cope with climate change.

Country-specific greenhouse gas reduction goals were set as a mitigation measure in December 1997, when the Kyoto Protocol[2] was adopted at the Third Conference of the Parties to the Framework Convention on Climate Change[3]. The protocol states that Japan will lower overall emissions of greenhouse gases by 6% compared to the reference year (1990) over the first commitment period of 2008-2012. To achieve this goal, the Cabinet approved the Kyoto Protocol Target Achievement Plan[4] in April 2005. Also, in May 2008, the “Environmental Energy Technology Innovation Plan” was released by the Council for Science and Technology Policy to halve global greenhouse gas emissions by 2050. The Ministry of Land,

[2] The Kyoto Protocol: Agreed on December 1997 at the third Conference of the Parties to the treaty based on the United Nations Framework Convention on Climate Change. It set legally binding numerical goals for developed countries to reduce greenhouse gas emissions, and introduced a mechanism for internationally collective efforts to achieve such goals.

[3] The Framework Convention on Climate Change: Officially called “the United Nations Framework Convention on Climate Change (UNFCCC or FCCC). It is a treaty which sets an international framework concerning global warming issues. The treaty is aimed at stabilizing greenhouse gas concentrations in the atmosphere.

[4] The Kyoto Protocol Target Achievement Plan: Drawn up by Japan to plan and implement necessary measures to reduce its greenhouse gas emissions by six percent.

Infrastructure, Transport and Tourism has set reduction goals for transportation, civilian, and other sectors to contribute to the reduction of greenhouse gases.

Meanwhile, the IPCC 4th Assessment Report clearly states the importance of both mitigation and adaptation: “There is high confidence that neither adaptation nor mitigation alone can avoid all climate change impacts. Adaptation and mitigation can complement each other and together can significantly reduce the risks of climate change.” Both the measures are indispensable to cope with the impacts of climate change.

(Promotion of mitigation of climate change impacts)

To mitigate climate change, it is necessary to curb the progress of global warming. In the fields of rivers, sabo and coasts, too, mitigation should be promoted as much as possible. To this end, not only energy should be saved in river works and management, but also a low-carbon society should be perused by introducing different measures, including carbon-dioxide reduction measures by absorbing carbon dioxide or preventing the Heat Island phenomena through the use of water, plants and space inherent to rivers and streams. Moreover, natural energy sources should be further utilized by, for example, enhancing small-scale hydraulic power generation.

(Adaptation to climate change: a duty of a national government)

Some advanced countries have already started adaptation planning, and some have even decided what strategies they should take. The European Union (EU), realizing that climate change will affect international security, has adopted the “EU directive on the management and assessment of flood risk” to formulate plans incorporating climate change impacts.

Considering that the land is generally vulnerable to water-related disasters and the implementation level of river, sabo and coastal structures is still relatively low, Japan should also start to plan appropriate adaptation measures with help from experts before it is too late, since it is a basic duty of a national government to seek for the safety and security of citizens, although there is still some uncertainty in the projections of sea level rise and the frequency of heavy rain events.

(Proposing effective adaptation strategies)

Effective adaptation strategies should be proposed after thorough discussion from the viewpoints of rationality, efficiency and effectiveness. Possible impacts of climate change need to be closely reviewed to minimize damage by avoiding extreme destruction. In addition, adaptation strategies should be planned to cover various subjects, such as the national land and society, in terms of flood control, water use and river environment, by revising issues and problems of existing structures for such use. However, it is always important to be aware of uncertainty in climate change projection and to make efforts to improve the projection accuracy.

(Introducing a flexible approach)

Adaptation measures should be planned using a “flexible” approach by which they will be revised based on future observational data and accumulated knowledge about the impacts of climate change on sea level, precipitation and river flow. Future climate change projection will be improved in accuracy, and it is necessary to devise appropriate adaptation plans best suited for the time based on the improved projection. Thorough consideration should also be paid to social conditions, such as population decrease, decline of birthrate and aging population, and land use change, and also to circumstances related to measures for flood control and water use, such as investment funds available, the completion level of planned structure development, and current/past flood control plans.

(Contributing to the international community)

Flood, sediment-related, storm-surge, drought and other disasters caused by climate change occur in global scale and are common issues facing members of the international community, although the degree of the impacts varies depending on region. Some of the Asia-Pacific countries especially share similar climatic and geological conditions to those in Japan in that they are located in the Monsoon Asia and have their production and living bases on alluvial plains. Also, in those countries, population is rapidly growing, and water-related problems are becoming more serious. It is important that Japan offers its experiences, strategies, and technologies to help those countries and contribute to the international community.

II. Intensification of external forces and impacts on national land and society

II-1. Descriptions of climate change in the IPCC 4th Assessment Report

The IPCC 4th Assessment Report[5] was published during the year 2007; the Working Group I Report in February, the Working Group II Report in April, the Working Group III Report in May. The report describes changes in air temperature, sea level, and other meteorological features as well as their impacts as follows:

(Observed changes in climate and their effects)

- Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level.

- The 100-year linear trend (1906-2005) was 0.74 [0.56 to 0.92][6] per 100 years.

- Rising sea level is consistent with warming. Global average sea level has risen over 1961 to 2003 at an average rate of 1.8 [1.3 to 2.3] mm per year and since 1993 at 3.1 [2.4 to 3.8] mm per year, with contributions from thermal expansion, melting glaciers and ice caps, and the polar ice sheets. Whether the faster rate for 1993 to 2003 reflects decadal variation or an increase in the longer-term trend is unclear.

- From 1900 to 2005, precipitation increased significantly in eastern parts of North and South America, northern Europe and northern a central Asia but declined in the Sahel, the Mediterranean, southern Africa and

5 The descriptions of climate change listed in this report are cited from the "Synthesis Report: Summary for Policymakers" of the IPCC 4th Assessment Report.

6 Numbers in square brackets indicate a 90% uncertainty interval around a best estimate, i.e. there is an estimated 5% likelihood that the value could be above the range given in square brackets and 5% likelihood that the value could be below that range. Uncertainty intervals are not necessarily symmetric around the corresponding best estimate.

parts of southern Asia. Globally, the area affected by drought has likely increased since the 1970s.

- It is likely that the frequency of heavy precipitation events has increased over most areas. It is likely that the incidence of extreme high sea level has increased at a broad range of sites worldwide since 1975.

- Changes in snow, ice and frozen ground have with high confidence increased the number and size of glacial lakes, increased ground instability in mountain and other permafrost regions and led to changes in some Arctic and Antarctic ecosystems.

- There is high confidence that some hydrological systems have been affected through increased runoff and earlier spring peak discharge in many glacier- and snow-fed rivers.

(Causes of the observed changes)

- Global greenhouse gas (GHG) emissions due to human activities have grown since pre-industrial times, with an increase of 70% between 1970 and 2004.

- Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic GHG concentrations.

- Advances since the Third IPCC Assessment Report show that discernible human influences extend beyond average temperature to other aspects of climate.

(Projections of future climate change and related impacts)

- Best estimates for global average surface air warming for the end of the 21st century (2090-2099) relative to 1980-1999 are 1.8°C under a scenario in which the global community balances environmental conservation and economic development and 4.0°C under a scenario with the highest GHG emissions.

- Ranges of sea level rise at the end of the 21st century (2090-2099) relative to 1980-1999 are 0.18 to 0.38m under a scenario with the lowest GHG emissions and 0.26 to 0.59m under a scenario with the highest GHG emissions.

- It is very likely that hot extremes, heat waves and heavy precipitation events will continue to become more frequent.

- It is likely that future tropical cyclones will become more intense. There is less confidence in projections of a global decrease in numbers of tropical cyclones.

- Extratropical storm tracks are projected to move poleward, with consequent changes in wind, precipitation and temperature patterns.

- Increases in the amount of precipitation are very likely in high latitudes, while decreases are likely in most subtropical land regions, continuing observed patterns in recent trends.

- By mid-century, annual river runoff and water availability are projected to increase at high latitudes and decrease at mid-latitudes and decrease over some dry regions at mid-latitudes and in the tropics. Semi-arid areas will suffer a decrease in water resources due to climate change.

- Altered frequencies and intensities of extreme weather, together with sea level rise, are expected to have mostly adverse effects on natural and human systems.

[Asia]

- By the 2050s, freshwater availability in Central, South, East and South-East Asia, particularly in large river basins, is projected to decrease.

- Coastal areas, especially heavily populated megadelta regions in South, East and South-East Asia, will be at greatest risk due to increased flooding from the sea and, in some megadeltas, flooding from the rivers.

- Climate change is projected to compound the pressures on natural resources and the environment associated with rapid urbanization, industrialization and economic development.

- Endemic morbidity and mortality due to diarrhoeal disease primarily associated with floods and droughts are expected to rise due to projected changes in the hydrological cycle.

[Small Islands]

- Sea level rise is expected to exacerbate inundation, flood, sediment-related, storm-surge and other disasters, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of island communities.

- Deterioration in coastal conditions, for example through erosion of beaches and coral bleaching, is expected to affect local resources.

- By mid-century, climate change is expected to reduce water resources in many small islands, e.g. in the Caribbean and Pacific, to the point where they become insufficient to meet demand during low-rainfall periods.

[Adaptation and Mitigation Options]

- A wide array of adaptation options is available, but more extensive adaptation than is currently occurring is required to reduce vulnerability to climate change.

- Additional adaptation measures will be required to reduce the adverse impacts of projected climate change and variability, regardless of the scale of mitigation undertaken over the next two to three decades.

- Some planned adaptation is already occurring on a limited basis. Adaptation will reduce vulnerability to climate change, especially when embedded within broader initiatives.

- Selected examples of planned adaptation in water and infrastructure/settlement (including coastal zones)

sector	Adaptation option/strategy	Underlying policy framework	Key constraints and opportunities to implementation (Normal font = constraints; *italics = opportunities*)
Water	Expanded rainwater harvesting; water storage and conservation techniques; water reuse; desalination; water-use and irrigation efficiency	National water policies and integrated water resources management; water-related hazards management	Financial, human resources and physical barriers; *integrated water resources management; synergies with other sectors*
Infrastructure /settlement (including coastal zones)	Relocation; seawalls and flood, sediment-related, storm-surge and other disasters barriers; dune reinforcement; land acquisition and creation of marshlands/wetlands as buffer against sea level rise and flooding; protection of existing natural barriers	Standards and regulations that integrate climate change considerations into design; land-use policies; building codes; insurance	Financial and technological barriers; availability of relocation space; *integrated policies and management; synergies with sustainable development goals*

(The long-term perspective)

- The five reasons for concern to consider the impacts of climate change
  a) An increasing risk to unique and vulnerable systems, such as polar and high mountain communities and ecosystems, is projected.
  b) The risks of extreme weather events, such as droughts, heat waves and floods, are projected to increase.

c) Regionally or socially vulnerable groups of people likely face greater impacts of and exhibit greater vulnerability to climate change.

d) Benefits from climate change are projected to peak at a lower magnitude. There will be higher damages for larger magnitudes of global temperature increase, and the costs of impacts of increased warming are projected to increase over time.

e) The risks of large-scale abrupt changes, such as sea level rise and accelerated ice-sheet melt, very likely increase.

- There is high confidence that neither adaptation nor mitigation alone can avoid all climate change impacts. Adaptation and mitigation can complement each other and together can significantly reduce the risks of climate change.

- Adaptation is necessary both in the short term and longer term to address impacts resulting from the warming that would occur even for the lowest stabilization scenarios assessed.

- Sea level rise under warming is inevitable. Thermal expansion would continue for many centuries after GHG concentrations have stabilized, for any of the stabilization levels assessed, causing an eventual sea level rise much larger than projected for the 21st century. The eventual contributions from Greenland ice sheet loss could be several meters, and larger than from thermal expansion, should warming in excess of 1.9 to 4.6°C above pre-industrial be sustained over many centuries. The long time scale of thermal expansion and ice sheet response to warming imply that mitigation strategies that seek to stabilize GHG concentrations at or above present levels do not stabilize sea level for many centuries.

II-2. Descriptions of climate change in Japan in different assessment reports

The following descriptions are cited from several reports on changes in climate and sea level published by the Japan Meteorological Agency. The descriptions include some simulation results which are useful to understand a trend of future climatic changes over Japan. However, it is important to keep in mind that those data contains some degree of uncertainty.

(Observed meteorological trends)

[Temperature]

- The mean annual temperature in Japan has increased at a rate of 1.07°C per 100 years since 1898, when observational data was first available. (#2)

[Precipitation]

- Rainfall fluctuations between years have become greater although no long-term trend has been observed in annual precipitation. (#2)

- Extremely low monthly precipitation has significantly increased annually. There is no significant long-term trend in extremely high precipitation. (#2)

- There was a significant increasing trend during a 106 year period from 1901 to 2006 in number of days with a daily precipitation of 100mm or more or of 200mm or more. The number of days with 100mm or more in the last 30 years is about 1.2 times as high as those in the first 30 years of the 20th century, while days with 200mm or more is about 1.4 times as high. (#2)

- There has been an increasing trend in short-time heavy rainfall (50mm or more per hour or 80mm or more per hour) in the last 30 years. (#2)

[Typhoon]

- There was no clear trend during the period of 1951 to 2006 in number of typhoons generated, approaching and landing on Japan. (#2)

[Winter climate]

- Decadal trends in annual average deepest snow cover were calculated for the northern, eastern and western coastal zones on the Japan Sea side based on the 1962-2004 time-series changes in annual average deepest snow cover of those coastal zones. The calculation results were -4.7%, -12.9% and -18.3% for the northern, eastern and western coastal zones, respectively, and show a significant decreasing trend for the eastern and western coastal zones. (#1)

[Sea level]

- Mean deviations of annual average tide levels at five tide stations were calculated relative to the average tide level during the period of 1906 to 2004, and then the average mean deviations were calculated to use them as indices to find out the average sea level changes around Japan. The results show no statistically significant increasing trend in sea level around Japan in the last 100 years. Since the mid-1980s, however, the sea level around Japan has continued to rise and has reached the highest level in the last 100 years, which is as high as the 1950 level. (#1)

- It has been pointed out that there is the possibility that the recent sea level rise is due to different factors (e.g. thermal expansion due to ocean warming) than those for the 1960-1990 sea level changes. (#1)

(Projections of climate and sea level)

Simulations were conducted to project future climatic changes over Japan due to global warming, and used RCM20[7] or CRCM[8] models under the A2[9], A1B[10] and B1[11] scenarios. The simulation results

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7 RCM20 (Regional Climate Model 20): A regional climate model to simulate climatic conditions in Japan and its surrounding areas. Horizontal resolution: 20km x 20km.

8 CRCM (Coupled atmosphere-ocean Regional Climate Model): A coupled atmosphere-ocean regional climate model developed by combining RCM20, an atmosphere model for the Japan region, and NPOGCM*, a high-resolution North Pacific Ocean model.

*NPOGCM (North Pacific Ocean General Circulation Model): An ocean model for the North Pacific region. Resolution: Longitude = 1/4°, Latitude = 1/6°

9 A2 scenario: This scenario assumes a heterogeneous world, in which economy and politics are primarily regionally oriented, trades and movement of people and technologies are limited, economic development is slow, interests in the environment are also low.

10 A1B scenario: This scenario assumes a world of very rapid economic growth, in which global economy further develops, major revolution will occur in education, technology and some other areas, and a balance across energy sources is emphasized.

11 B1 scenario: This scenario assumes a convergent world in which a global population peaks in mid-century. Also, economic structures change rapidly to become service- and information-oriented.

The reports of the Japan Meteorological Agency cited in this section:

(#1) *Ijo-kisyo Report 2005* (2005 Report on Extreme Meteorological Events)

(#2) *Kiko-hendo-kanshi Report 2006* (2006 Report on Climate Change Monitoring) projected the following climatic changes over Japan in 100 years (2081-2100) relative to the climate conditions of the present time (1981-2000):

[Temperature]　A2 scenario – RCM20
- Temperature in general is projected to be higher all over Japan throughout the year. In particular, the temperature is projected to rise at a higher rate from winter to spring in northern Japan. (#3)

- Mean annual temperature is projected to rise approximately 2 to 3°C (4°C in part of Hokkaido, the northernmost prefecture of Japan). (#3)

[Precipitation]　A2 scenario – RCM20
- Precipitation is projected to decrease from winter to spring in many parts of Japan, while increasing during the period between the summer and fall rainy seasons. (#3)

- Annual precipitation is projected to increase in most parts of Japan. In particular, western Japan is projected to experience a higher rate of increase, e.g. as high as 20% in some areas. (#3)

- Summer precipitation is projected to increase especially in western Japan, while it is projected to fluctuate to a greater extent in eastern Japan in forthcoming years. (#3)

- Heavy rainfall events are projected to become more frequent in most parts of Japan. The number of days with a daily precipitation of 50mm or more is projected to increase by three days or more per year, particularly in some coastal zones on the Japan Sea side in western Japan. (#3)

[Winter climate]　A1B and B1 scenario – CRCM
- The average temperature under winter climate (December to March) in the end of the 21st century is likely to increase to a greater degree in higher altitudes. The projected increases based on the A1B scenario are more than 3°C in Hokkaido, 2 to 3°C from the Tohoku region to the western Japan, and 1.5°C in the Okinawa and Amami islands. Those based on the B1 scenario are 1.5 to 2°C in Hokkaido and 1 to 1.5°C in other parts of Japan. (#4)

(#3) *Chikyu-ondanka-yosoku-joho vol.6* (Global Warming Forecast Information, vol.6)
(#4) *Chikyu-ondanka-yosoku-joho vol.7* (Global Warming Forecast Information, vol.7)

- In Hokkaido, *Mafuyubi*, or a day on which the daily high temperature remains below 0°C, is projected to be half as frequent as today (A1B scenario). Also, in the Tohoku region, *Fuyubi*, or a day on which the daily low temperature drops below 0°C, is projected to be half as frequent as today (A1B scenario). In other regions, such as Hokuriku, Kanto, Tokai and the western Japan, the number of *Fuyubi* is likely to be half of the current level (B1 scenario) or decrease close to zero (A1B scenario). (#4)

- The precipitation under winter climate in the end of the 21st century is projected to show an increasing trend across Japan except the islands of Okinawa and Amami. A 10 to 30% increase is projected based on A1B scenario in Hokkaido and the Tohoku region along the Sea of Japan. (#4)

- The snowfall in the end of the 21st century is projected to decrease across Japan except in Hokkaido, regardless of type of emission scenario. High-altitude areas in Hokkaido are likely to have more snowfall, regardless of type of emission scenario. (#4)

- Heavy snowfall is projected to be more frequent in high-altitude areas in Hokkaido. Other parts of Japan are likely to experience less heavy snowfall events. (#4)

[Precipitation]　A2 scenario – RCM20

- Sea surface temperature is projected to rise around Japan. A long-term trend by the end of the 21st century shows a 2.0 to 3.1°C increase in the next 100 years based on the A1B scenario and 0.6 to 2.1°C based on the B1 scenario. Long-term sea temperature rise by the end of the 21st century is projected to a greater degree in the Sea of Japan than in the seawaters south of Japan. (#4)

- Sea level is projected to rise around Japan. A long-term trend by the end of the 21st century shows a 9 to 19cm increase in the next 100 years based on the A1B scenario and 5 to 14cm based on the B1 scenario (Note that the projections ignored the land-ice melting in Greenland and the Antarctica.). (#4)

II-3. Intensifying external forces

"External forces" refer to meteorological quantities (e.g. precipitation) which are subject to the impacts of climate change. They also refer to hydrological quantities, such as discharge and water levels, which are caused by meteorological quantities and determine the scales of flood, drought, sediment-related, storm-surge and other disasters. A planning of adaptation to climate change requires a proper assessment of changes in such external forces. Simulations on future climatic changes over Japan have been conducted based on different regional climatic models. The simulation results have been published and are very useful to assess quantitative changes in external forces, although careful attention should be paid to uncertainty contained in projections. Generally, regional-scale projection results tend to reflect a higher degree of uncertainty than those of global scale. In addition, only a few regional-scale climate projections have been conducted to date, and efforts should be made to improve projection accuracy.

1. Change in precipitation

The IPCC 4th Assessment Report was prepared based on global-scale projections. To precisely understand the impacts in Japan and use the knowledge for policy making, investigations are needed using downscaling[12] models, which can precisely simulate phenomena around Japan.

Future changes in external forces were projected using intermediate-level scenarios although results contain some degree of uncertainty due to the capacities of computers and little-understood meteorological factors.

The projection results showed that the rate of change would be 1.0 to 1.5 in RCM20 studies under the A2-type scenario[13] when annual

[12] Downscaling: Translating predictions of coarse resolutions into detailed resolutions that can reproduce regional climate characteristics
[13] Rate of change calculated using RCM20: (mean of 2081 to 2100) / (mean of 1981 to 2000)

maximum daily precipitations were compared between the present time and 100 years later. A calculation using GCM20[14] (Scenario A1B) showed different rates of change[15]; about 1.1 to 1.2 in general, 1.3 in some regions, such as Tohoku and Hokkaido, and 1.5 at the highest.

Using the calculated results in RCM20 (A2-type scenario) studies, the rates of change in 100-year return-period maximum daily precipitation in 50 and 100 years were calculated. The rate of change in 50 years[16] was about 1.1 to 1.2, and that in 100 years[17] was about 1.2 to 1.4.

Those results show that the reasonable estimation of precipitation in 100 years is about 1.1 to 1.3 times of the current value and 1.5 times at the highest.

Table 1 tabulates 11 regions of Japan and medians of increase rates of annual maximum daily precipitation in 100 years based on the GCM20 model by region.

The values were based on the projection available today, and further efforts should be made to improve projection reliability.

[14] GCM20 (General Circulation Model 20): A climate model for calculating the entire globe. Horizontal resolution: 20 km x 20 km

[15] Rates of change calculated using GCM20: (mean of 2080 to 2099) / (mean of 1979 to 1999)

[16] Rate of change in 50 years: (calculated values for 2031 to 2050) / (values calculated for 1981 to 2000)

[17] Rate of change in 100 years: (calculated values for 20831 to 2100) / (values calculated for 1981 to 2000)

Table 1 Regional increase rates of annual maximum daily precipitation in 100 years

Region	Increase rate	Region	Increase rate
Hokkaido	1.24	Southern Kii	1.13
Tohoku	1.22	Sanin	1.11
Kanto	1.11	Setouchi	1.10
Hokuriku	1.14	Southern Shikoku	1.11
Chubu	1.06	Kyusyu	1.07
Kinki	1.07		

2. Increased floods

The impacts of the precipitation changes in 100 years on flood scales in different rivers were reviewed. The degree of reduction of the flood safety levels[18] in 82 class A rivers was provisionally estimated based on the regional changes in annual maximum daily rainfall in 100 years projected using the GCM20 model. Changes in the flood safety levels in 100 years are expressed in exceedance probability[19] under current climate (Table 2) according to the regions and flood safety levels of the present plans. The estimations show that a probability of once in 200 years may be reduced to once in 90 to 145 years, once in 150 years to once in 22 to 100 years, and once in 100 years to once in 25 to 90 years, indicating that the occurrence of extreme events is likely to increase. In particular, Hokkaido and Tohoku shows higher rainfall increase rates, suggesting that extreme events occur more frequently and thus, their flood safety levels lower to a greater degree. A similar case can be applied to small and middle-sized rivers, meaning lower flood safety levels.

18 Flood safety level: Degree of safety of a river in flood control plan

19 Annual probability of exceedance: An annual probability of exceedance is a rate showing that a certain event occurs once in every so many years. For example, when the annual probability of exceedance for a certain scale of precipitation is one tenth, it means that such rainfall will occur at a rate of once in every ten years.

Those projections show that future precipitation increase will sharply lower the flood safety levels of the present plans, and clearly suggest the risks of inundation and flooding will increase.

Table 2 Impact of precipitation increase in 100 years on flood safety levels

Region	Future flood safety level (annual probability of exceedance) assessed under present climate					
	For 1/200 probability floods	No. of rivers	For 1/150 probability floods	No. of rivers	For 1/100 probability floods	No. of rivers
Hokkaido	-	-	1/40 – 1/70	2	1/25 – 1/50	8
Tohoku	-	-	1/22 – 1/55	5	1/27 – 1/40	5
Kanto	1/90 – 1/120	3	1/60 – 1/75	2	1/50	1
Hokuriku	-	-	1/50 –1/90	5	1/40 – 1/46	4
Chubu	1/90 – 1/145	2	1/80 – 1/99	4	1/60 – 1/70	3
Kinki	1/120	1	-	-	-	-
Kii-nanbu	-	-	1/57	1	1/30	1
Sanin	-	-	1/83	1	1/39 – 1/63	5
Setouchi	1/100	1	1/82 – 1/86	3	1/44 – 1/65	3
Shikoku-nanbu	-	-	1/56	1	1/41 – 1/51	3
Kyusyu	-	-	1/90 – 1/100	4	1/60 – 1/90	14
National variation	1/90 – 1/145	7	1/22 – 1/100	28	1/25 – 1/90	47

3. Intensified debris flows

Climate change will alter the temporal and spatial distribution of precipitation and possibly cause increases in short-period and total precipitation, which may trigger sediment-related disasters, such as debris flows and landslides. It is also possible that climate change would accelerate weathering of the ground surface and affect the vegetation on slopes, which are causative factors of sediment-related disasters, although impacts are yet little understood.

Possible impacts of climate change on sediment-related disasters include increases in frequency and scale and change in timing of occurrence. More frequent sediment-related disasters may result in the expansion of landslide occurrence areas, i.e. landslide occurrences outside sediment-related disaster risk zones, and increase in simultaneous sediment-related disasters at multiple locations. Particularly, unexpectedly heavy rainfall on areas that have little experienced such rainfall may cause severe sediment-related disasters. The time from the start of rainfall until landslide occurrences may become shorter, suggesting that there may be less time for safe evacuation. The scale of landslides is also likely to increase. Increased frequencies of deep-seated landslides may increase the amount of landslide mass and the debris coverage.

Increase in sediment discharge may cause floods containing a huge amount of sediment in the middle and lower reaches of rivers. In addition, a large amount of sediment deposit in river channels may increase the risk of flooding and adversely affect river environment. Moreover, if sediment is rapidly deposited in dam reservoirs, it will hamper the planned function of dams.

4. Intensified storm surges and coastal erosion

In the ocean, the heat only slowly propagates down to depths, causing seawater to expand for centuries. Thus, sea level rise would continue even if greenhouse gas concentrations were to be stabilized.

Since sea level rise is strongly affected by natural factors, such as multi-decadal changes in atmospheric flow and changes of the Japan Current, it is technically difficult to precisely project the degree of rise in each region, but it is technically possible to reflect the impacts of the phenomenon in structure design, because it is relatively stable over a long period of time.

As the intensity of typhoons increases, sea level is likely to rise due to their low atmospheric pressures, and the winds will cause strong drifts and high waves. Thus, intensified typhoons, besides sea level rise, are likely to increase damage caused by storm surges.

Coastal topography is primarily formed by the balance of coast- and sea-ward sediment deposits. The balance change by sea level rise will cause further beach retreat than the increase in sea level rise. Moreover, more frequent storm surges caused by intensified typhoons are projected to accelerate coastal erosion.

5. Increased risks of droughts

Japan has faced some low precipitation years since 1965. Precipitations in 1973, 1978, 1984, 1994, 1996, and 2005 observed far less than mean annual precipitation, resulting in droughts. The difference between extremely low precipitation and extremely high precipitation has expanded in recent years. Future climate change is possible to cause large-scale droughts equivalent to or even severer than the 1994 drought. Trends of decreased snow cover and earlier snowmelt are also likely to be enhanced.

In Japan, urban water use amounts to approximately 28.3 billion cubic meters per year as of March 2007. At present, the water supply largely depends on water resources development structures/facilities, such as dams – specifically speaking, around 63% (about 17.8 billion m^3/year) of the current urban consumption. The actual water supply capacities of the dams in Japan have, however, become lower than the design supply capacities due to recent decrease in rainfall, which indicates a higher possibility of failing to secure stable water supply for urban and other uses. Also, in areas where people depend on snowmelt water for agriculture and other purposes, it is possible that people may suffer from serious impacts on water use during and after spring because of decreased snow cover and earlier snowmelt.

Extremely low precipitation will decrease river discharge and dam storage volume, which pose a problem for securing necessary river discharge downstream. In addition to that, if snow falls less and melts earlier than the present due to global warming, the timing of snowmelt will become earlier along with less river discharge, and thus dam storage volume will be low even in the soil-paddling season for rice fields. It will be difficult to secure necessary river discharge for agriculture and also other uses.

In general, water demand greatly changes as social conditions do. Drought risk should be assessed based on both climate change and changes in social conditions. It is difficult to have a clear projection for long-term water demand.

6. Changes in river environment

Climate change (e.g. temperature increase), will give impacts on ecosystems and environment over wide-spreading areas beyond river basins. This section, however, will describe projected changes in river environment at the river-basin level.

Temperature increase, precipitation change, environmental change in basin areas, including forests and rice and other fields, will all affect river regime and discharges of sediment, nutrients and other materials.

The greater variation of precipitation will cause the greater variation of river discharge, resulting in extreme floods and droughts. Discharge patterns will also change due to changes in snowfall and the timing of snowmelt. The discharges of sediment and materials will also increase because of extreme floods and more frequent large-scale floods, and affect water quality (turbidity) and river-bottom environment. Different discharge patterns will give impacts on the lifecycles of fish species, and the patterns could decline the number of species inadaptable to change. Changes in river-bottom environment caused by increased turbidity and silt/clay sedimentation will affect fish, benthic animals, attached algae and other species. Changes in flow regime and the discharge of sediment and other materials will affect vegetation in river channels and species distributions depending upon degree of disturbance. For instance, the distribution pattern of plant species will become different to the degree of disturbance. The changes brought upon different species will further spread over the entire ecosystems as they affect each other. There is also a possibility that foreign or new species will be carried to and grow robustly in new places as river environment with continuity changes.

There is also a concern over the deterioration of water quality caused by lowered dissolved oxygen concentration, resulting from water temperature increase and the degradation reaction by microorganisms which consume dissolved oxygen. Lakes, mashes and reservoirs will suffer worse deterioration of water quality than rivers. In water environment of these kinds, increases in air and water temperature will affect their thermal stratifications and the activity level of phytoplankton. In addition, changes in water quality will also affect living species.

Additionally, at this moment, it is difficult to project the impacts of climate change on ecosystems and water/material cycles due to insufficient knowledge and data.

II-4. Impacts on national land and society

Flood, drought, sediment-related, storm-surge and other disasters due to climate change may have huge impacts on the national land and society, but the impacts may vary depending on topography, river morphology, and social and living conditions in basins. Thus, adaptation strategies should be developed for each basin by dividing a basin into upper, middle and lower basin areas and coastal zones. Appropriate strategies differ depending on zone, as described in the following examples.

1. Upper basin areas

In upper basin areas, mountainous regions typically suffer from forest degradation due to the lack of proper forest management which is caused by progressive depopulation and aging of communities. Therefore, sediment-related and windfall-tree disasters are likely to increase due to increased precipitation amount, higher short-time rainfall intensity, and more intensified typhoons. Sediment-related disasters, especially, may cause greater immediate damage due to increases in frequency and scale and changes in time of disaster occurrence.

More frequent and severer damage by sediment-related disasters will fatally affect mountainous communities, which already suffer depopulation and aging. Consequently, further emigration of younger community members will progress, and those communities will become extremely aged and ultimately disintegrated.

Also, increase in sediment run-off is projected to cause sediment deposition in flood control reservoirs in the lower reaches, hindering their capacities for flood control and water use. In addition, large quantities of sediment will also accumulate in river channels, blocking flood-water flow and thus deteriorating their flood safety levels. Increased sediment run-off will also prolong the period of turbid water.

2. Middle basin areas

In middle basin areas between mountainous regions and alluvial fans, flooding and inundation are projected to be more frequent due to levee breaches caused by heavier precipitation, higher short-time rainfall intensity, flooding from the upper reaches, and greater sediment run-off. In some middle basin areas, floods have been controlled by constructing levees, and land use in the flood plains has been changed from agricultural to residential use. Because of this land use change, open levees (called "*kasumi-tei*" in Japanese) have been closed, although originally designed to serve as retarding basins and also to help floodwaters flow back into the main streams. In flooding by levee breaches in alluvial fans, floodwaters will spread over large areas, causing widespread damage. Floodwaters that flow down steep rivers will contain large quantities of sediment, and wash away houses and buildings by their huge energy like debris flows, and cause destructive damage. Frequent, large-scale floods and increased sediment run-off may destabilize river beds, causing the destruction of structures, such as bridges, and levee breaches, which may lead to more floodings.

Inundation caused by levee breaches will spread over the lower reaches after inflicting different types of damage on locally important cities, industrial parks, rice paddies, and agricultural fields producing local specialties. When the revitalization of local economies is one of today's important tasks in Japan, floods reduce the competitiveness and vitality of local communities and seriously affect local economies.

In the meantime, extremely low snowfall and the earlier timing of snowmelt due to air temperature rise will decrease river discharge and greatly affect agricultural water use, for example, in the soil-paddling season for rice fields. There will be a concern over water use in the middle basin areas from early spring on, because water use in these areas is dependent on snowmelt.

3. Lower basin areas and coastal zones

In lower basin areas and coastal zones, where low lands and areas below sea level spread, intensified precipitation, higher short-time rainfall intensity, rising sea level, intensified typhoons, and flooding waters from the middle reaches are likely to cause more frequent inundation and flooding events due to levee breaches. Advanced urbanization in low lands and below-sea-level areas has caused larger discharge, making proper draining difficult. Thus, inundation by river and landside waters due to flood, sediment-related, storm-surge and other disasters are likely to prolong over a long period of time.

Particularly in below-sea-level areas along the three major bays in Japan (Tokyo, Ise and Osaka Bays), the area and population below the mean sea level would increase by about 50% if the mean sea level were to rise by 59 cm, which is the extremist projection value in the IPCC 4th Assessment Report. Greater damage by storm surges is projected in this case.

In many cases, lower basin areas and coastal zones are over populated and have accumulation of property. Particularly because the three megacities serve as the centers of social and economic activities, flood, sediment-related, storm-surge and other disasters will affect not only the lives and property of people but also cause governmental functions to be paralyzed and international competitiveness to drop.

Also, coastal erosion is already advancing in some coastal zones due to decrease in sediment supply. Further sea level rise and intensified typhoons may accelerate coastal erosion and cause sand beaches to disappear. A sea level rise of 30 cm is projected to cause about 60% of all sand beaches in Japan to disappear.

Impacts of sea level rise and intensified typhoons may constitute huge hindrances to national land protection.

Droughts due to climate change can also pose a serious problem for urban water use, if they occur in the downstream and coastal areas where population is concentrated. They will impair a great deal of urban functions and industrial production. On the other hand, water intake from river and underground waters are also threatened by wide-spreading salt-water intrusion to rivers and underground water salination due to sea level rise.

III. Basic directions of adaptation strategies

III-1. Trends of adaptation strategies in foreign countries

1. Adaptation strategies for floods and storm surges

In October 2007, the European Union (EU) announced the Directive on the Assessment and Management of Flood Risks. The directive requires the member nations to assess flood risks based on available knowledge including the impacts of climate change on flood occurrence. It also requires them to prepare flood hazard maps and flood risk maps based on multiple annual probabilities of exceedance. The directive also calls for consideration of impacts of climate change when preparing and revising flood risk management plans.

In England, the flood safety level against storm surges are projected to drop from once every 1,000 years to once every 100 years by sea level rise due to recent climate change and rapid housing land development. Thus, the Thames Estuary 2100 (TE 2100), which is a flood risk management plan in England, is being planned as well as improvement of Thames tide embankment.

In the Netherlands' flood risk management plan called "Room of the River," a total of approximately 7,000 ha are to be secured for retarding areas to cope with increase in discharge of the Rhine. The Maeslant Barrier along the Lek River is designed to cope with sea level rise in 50 years. Other storm surge barriers are also designed to cope with sea level rise during their service periods.

In May 2006, the Organization for Economic Cooperation and Development (OECD) summarized the progress regarding adaptation strategies for climate change in developed countries. Adaptation strategies are also being promoted and reviewed in European nations, such as Germany and France, the US, and Australia.

On the other hand, Asian nations other than Japan are Non-Annex I

Parties under the Framework Convention on Climate Change[20], and only few have developed adaptation strategies in their national projects mainly due to insufficient adaptation technologies and funds. Of the few, Korea has developed national strategies for water security and systems for assessing impacts on water resources. For the least developing nations such as Bangladesh, Bhutan, and Cambodia, the National Adaptation Programme of Action (NAPA) is being implemented with the financial assistance of the Global Environmental Facility (GEF) and the cooperation of the United Nations Environment Program (UNEP) and the World Bank.

2. Adaptation strategies for droughts

The Organisation for Economic Co-operation and Development (OECD) published a progress report on adaptation strategies for climate change in developed countries in May 2006, and reported that many of them understood the impacts of climate change on water resources, were conducting climate-change impact assessments, and started planning adaptation strategies in water resources.

California State of the United States of America is discussing the expansion of water management and water transfer systems, including water-saving enhancement, ground- and underground-water storage, water transfer facilities. The state is also working on adaptation strategies with the energy policy sector to reduce emission gases through effective water use by applying the trade-off between water and energy.

Canada is also planning or has already taken necessary adaptation strategies to droughts: water saving by users, prioritization of plans

[20] Non-Annex I Parties under the Framework Convention on Climate Change: A group of 148 developing countries for which no numerical goals to reduce greenhouse gas emissions are set by the Kyoto Protocol under the UN Framework Convention on Climate Change (UNFCCC). Annex I Parties are a group of countries listed in the UNFCCC Annex I and have quantitative obligations as described in the annex of the Kyoto Protocol. Annex I Parties include developed countries and transition economies, such as former Soviet Union and Eastern European countries.

and preparation for droughts, state monitoring over the quantity and quality of water and climate conditions, establishment of procedures for fair water distribution which are also friendly to river ecosystems, modification of crop species with temperature resistance, development of irrigation systems.

In Australia, the south-western section of Western Australia State formulated the “Water Resources Development Plan 2005-2050” in 2005, which is a security strategy based on diversity. The plan was designed to adapt the section to future water demand increase and climate change through a broad range of adaptation measures, such as sea water desalination, reuse of recycled wastewater, water resources management, water trade, alternative water resources independent from rainfall, and revision of original implementation years.

In European countries, the following adaptation measures are being reviewed or have been already implemented: technological measures for water supply increase, promotion of effective water use (e.g. reuse of wastewater), reform of economic measures (water price setting), insurance systems, water use limitation, national land development plans to improve water balance, forecasting/monitoring/information dissemination.

III-2. Basic directions of adaptation strategies

1. Basic policy of adaptation strategies

It has been commonly recognized not only in the IPCC Fourth Assessment Report but also in the international community that adaptation is as important as mitigation to cope with global warming. In Japan, however, this internationally recognized concept has not been paid due attention to, and discussion over global warming tends to be more about mitigation over adaptation. It is important to increase public awareness toward adaptation, because Japan is particularly vulnerable to water-related disasters among the developed countries.

When coping with climate change, it is important to have a perspective that society and culture which have been nurtured to date should be handed down to younger generations, as well as a safety perspective of protecting human lives. Adaptation to climate change should be promoted while working on other social issues, such as the falling birthrate and aging population and the lifestyle enhancing mass production, consumption and disposal. A sustainable "water-disaster adaptation society" should be built through an appropriate combination of adaptation and mitigation, while revising the present social structure and aiming to build a society coexisting with nature and realizing high energy efficiency in addition to safety and security.

2. Defining clear goals -- Aiming for "Zero victims" --

Since it is difficult to totally protect everything from flood, sediment-related, storm-surge and other disasters of different scales, which are likely to be intensified by climate change, adaptation strategies for climate change need to be developed aiming for "zero victims." In areas, such as the Tokyo metropolitan area, where key functions are concentrated, it is also important to minimize damage by prioritizing the protection of state functions from paralysis.

Multiple disasters, in which an earthquake triggers a landslide, for example, should be taken into account since Japan is prone to earthquakes and volcanic activities.

3. Coping with intensified external forces (Multilayered flood control policies)

Considering future precipitation increase, design flood peak discharges need to be further raised if present flood safety levels are to be maintained. However, it is sometimes extremely difficult to construct structures, including river-improvement and flood-control structures, which can accommodate such increased discharges, because of social and other constraints. Also, construction of structures usually takes a considerably long period of time before completion.

Keeping present design discharges would result in severe drops in flood safety level in the future, and the risks of floodings and inundations may increase.

To solve these issues, the increment in external forces caused by climate change should be included and coped with in flood control policies.

Therefore, future flood control policies should be multilayered. In addition to traditional “flood control policies to secure safety at the river level” through river improvement and the construction of flood control structures to meet target discharge levels for past and current river projects, “flood control policies to secure safety at the basin level” through preparation for possible increase in excess floods should also be implemented. Multilayered flood control policies will be effective to flexibly cope with possible floods of different scales in each basin. Basin-based flood control measures should be proactively promoted, while comprehensive flood control measures which have been implemented should be further enhanced.

(Enhancing measures against intensified sediment-related disasters)

Because of social constraints and a large amount of time required for completion, it is not practical to take every possible preventive measure to cope with more frequent and intensified sediment-related disasters, such as debris flows. It is important to design appropriate response measures depending on risk level. When implementing preventive structures, the priority should be set upon places with the high risk of sediment-related disasters, where such structures can protect human lives. Financial concerns are also important; construction cost should be reduced as much as possible so that structures can be built in as many places as possible. Non-structural measures are also important to cope with the increased risk of sediment-related disasters. It is necessary to promote land use regulation, such as designation of sediment-related disaster danger zones. Warning and evacuation systems should also be strengthened to accurately monitor and collect information about the precursors and initial status of disasters. Information technology should be utilized to share information between disaster management organizations and residents.

Comprehensive sediment control measures from mountain to coastal areas should be enhanced to cope with increased sediment runoff while balancing flood control, water use and environment in basins. In particular, there is a growing concern that increased sediment deposit in river channels will accelerate sediment deposit in reservoirs. It is necessary to take effective measures, including sediment runoff control and flood control in upstream areas as well as sand removal at dams which also gives due consideration to water use and river environment. River-bottom heights should be properly maintained while keeping their dynamic equilibrium by taking necessary countermeasures for sediment deposit in river channels and river bottoms locally lowered resulting from flow changes caused by such deposit.

(Staged measures against storm surges and enhancement of response measures for coastal erosion)

To cope with sea level rise and intensified typhoons, storm surge barriers should be implemented in an appropriate way. Concrete barriers should be rebuilt higher to enhance their protection capacities against intensified external forces, especially at a time of renewal so that the frequency of inundation can be reduced.

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

- First stage: Barriers should be raised for the height equivalent to the current sea level rise.
- Second stage: Barriers should be raised for the height equivalent to the past sea level rise as well as predicted or extrapolation future rise during the service life of the barriers.
- Third stage: Heights of storm surges caused by intensified typhoons should be considered together with the rises determined in the second stage.

The second- and third-stage measures should be taken earlier depending on importance of hinterlands. 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.

Comprehensive sediment control should also be promoted to cope with coastal erosion in progress. Sediment should be properly supplied to coasts. The continuity of sediment transportation in coastal areas should be secured by, for example, installing sand by-pass systems. Longshore sediment transport should be controlled by building coast conservation structures.

(Coping with drought risk)

To secure the sufficient amount of safe water over a long period of time, comprehensive water resources management has been promoted. It has three pillars of the effective use of water resources, the integrated management of water quality and quantity, and crisis management to be able to cope with present issues of effective use of water resources and earthquake risk management. Increasing drought risk due to climate change should also be addressed as one of the priority issues under the framework of comprehensive water resources management.

(Coping with environmental changes in rivers and coasts)

At present, it is still difficult to predict the impacts of climate change on ecosystems and water/material cycles. It is thus important to keep close attention to how climate change affects flow regime, sediment/material runoff, environments of river basins and coastal areas, and in turn how these changes affect the living environments of various creatures. The impact of temperature rise on water quality is another important factor which requires close monitoring. For these reasons, continued efforts should be made to understand changes in river/coast environments as well as climatic changes.

4. Disaster risk assessment

To discuss adaptation strategies, the impacts imposed on society and economy by water-related disasters due to climate change should be presented to the general public and related organizations in an easy-to-understand form. It is increasingly important to inform people of the vulnerabilities of land structure and social systems through risk assessment. The selection of appropriate adaptation strategies will be possible only after people sufficiently understand those vulnerabilities.

There are different ways of water-related disaster risk assessment. For flood disasters, for example, risk can be assessed for each flood type categorized by different flood scales in a river basin. Also, different risk assessment can be conducted by multiplying the magnitude and probability of disaster damage on human and economy assessed based on communities' capacity, including the implementation level of protection structures and evacuation activities. When conducting risk assessment, it should be noted that levee breaches along large rivers could totally destroy socio-economic activity and livelihood and make restoration virtually impossible. Assessment results should be presented visually, for example, by plotting them on risk maps. Risk assessment is important not only to visually show current vulnerabilities but also to show differences to be made after the introduction of adaptation measures, which help people understand how effective they can be in terms of risk management.

Risk assessment can also apply to droughts. Based on future changes in river regime, projections should be made on to what degree the discharge of a river becomes lower than the required normal discharge, to what extent and how long water intake and supply should be restricted, which river section should be subject to water recession. drought risk can be assessed for each river system using such information.

5. Proposal of specific adaptation strategies

Possible impacts of climate change on each basin need to be notified to the public and related organizations when considering specific adaptation strategies for climate change. It is important for the national government to take the initiative in developing coping strategies at the basin level, including role-sharing among related organizations.

Basin-based adaptation strategies may require the restructuring of the relationship between rivers and basin communities. Thus, the development of such strategies requires close cooperation between related agencies and communities in upper and middle river basins to gain a common ground. It is important to use every possible opportunity to inform the public about the relationship among communities, nature and safety in basins and disaster risks and cost in addition to the impacts of climate change. Adequate information sharing will contribute to the formation of consensus among parties involved.

It is also important to prepare transbasin response to a water-related disaster, because there is a possibility that a disaster may occur in multiple basins at a time.

In terms of floods, it should be first clarified to what extent structures can protect a basin from flooding. Then, different types of alternatives should be reviewed: how to reduce runoff from the basin, how to mitigate damage from flooding and inundation, and how to restore damaged facilities/structures and rehabilitate damaged areas. Efforts should be made to achieve goals, such as “zero victims,” coping with possible floods of different scales.

Adaptation strategies are proposed and elaborated under four different themes. “Adaptation strategies using structures” describes how to mitigate damage from flood, sediment-related, storm-surge, and other disasters using structural protection. “Adaptation strategies in relation to community development” introduces a perspective of community development. “Adaptation strategies based on crisis management” discusses how to minimize damage in case of flooding, inundation and sediment-related disasters. There is also a section about “adaptation strategies to avoid drought risk.” In addition, “adaptation strategies for river environment changes” centers on the understanding of the impacts of climate change on river environment as follows.

(1) Adaptation strategies using structures

Structures prevent external forces from causing human and property damage, when such forces are within their design capacities, allowing people to engage in regular social and economic activities. Therefore, in terms of protecting the lives and property of the citizens, it is important to keep improving structural capacities as much as possible and to put certain emphasis on the prevention and minimization of damage through structures.

However, the implementation level of flood protection structures is still low. It is not practical at this moment to set higher design levels for structures to cope with intensified external forces, when considering it will be quite a long time to complete structures according to the design levels already planned. For the time being, structural development should be steadily continued to achieve the current design levels while adding necessary structures based on carefully reviewed social conditions.

1) Constructing new structures

When constructing new protection structures, major efforts should be made to reduce construction cost and take full advantage of design ingenuity and technology to enhance structural strength without excessively increasing the cost. Conventionally, structures are designed based on design floods as external forces. However, new structures should be checked for their safety levels even when water levels reach up to their bankful levels.

When social and financial constraints prevent structures from installation, or when flexibility is more important to cope with disasters over other factors, transportable levees and drainage pumps are probably better options to mitigate damage.

2) Maintaining and improving the reliability of existing structures

Flood control structures, such as levees, have a long history as protection structures. However, the priority has been placed on the stretch, not exactly the quality, of the structures built. It is urgent to maintain and improve the reliability of existing structures to cope with more frequent floods due to climate change.

Levees, in particular, should be promptly inspected and assessed nationwide in terms of reliability. If found insufficient in that respect, they should be thoroughly enhanced. Technological research and development should be promoted to develop methods for strengthening levees.

Also, storm-surge barriers built at the wake of the Ise-wan Typhoon and flood control structures built to protect rapidly urbanized areas in river basin become old and needs to be renewed. To avoid concentrating financial resources on the renewal of these structures as well, they should be inspected and assessed in terms of reliability so that a systematic management will be possible in which preventive and conservative measures can be taken to prolong structural lives. Specifically, storm surge barriers should be rebuilt to cope with changes in external forces due to climate change at the timing of renewal. It is also effective to build enhanced structures as part of restoration when they are damaged in a disaster.

3) Full utilization of existing structures

Taking full advantage of existing structures is a very effective way of quickly achieving the desired effect in flood control with little financial resources. Existing social infrastructures should be utilized. Existing facilities and structures should be improved, recycled, and put into multi-purpose use by the current and innovative technologies. The re-organization of multiple facilities and structures is also effective.

-Rainfall and discharge forecasting technology and the improvement of structure operation

To cope with change in rainfall patterns, structure operation, such as dam operation, should be improved in reliability through the enhancement of observational systems and rainfall and discharge forecasting technology. To use flood control and conservation capacities more efficiently and effectively, further improvement, rehabilitation and more sophisticated operation are necessary.

-Re-organization of dam storage volumes

To improve the efficiency of flood control and water supply by existing dams, their capacities can be re-allocated, considering rainfall and discharge characteristics in river basins and current dam operation rules. For more effective use, coordination with hydro-power dams should also be considered.

4) Structure construction in river basins

It is important to build communities with low risk of serious damage, including human lives, even if inundated. Such communities can be developed by zoning a flood plain into several blocks and taking measures to prevent flooding from spreading. The traditional roles of secondary levees, ring levees, retarding ponds and other measures in basins should be understood, and they should be used along with current land use to prevent flooding from spreading. Flood risk assessment should also be conducted based on local land use. Earth fills from road and railroad construction should be used as well as additional structural development.

In some local communities, those structures may be removed for convenient reasons. It is important to manage them in an integrated manner along with river and coastal structures.

Although it is difficult to improve urban rivers in many urban areas, it is important to take measures for discharge control, such as regulating ponds and rainfall detention/infiltration facilities. The effective use of limited spaces should also be promoted, such as underground rainfall detention facilities.

5) Promotion of comprehensive sediment management

Increase in sediment runoff due to climate change will affect not only flood control and water use but also the entire sediment transport system including river and coast environment. Costal erosion will progress further due to sea level rise and intensified typhoons. It is necessary to monitor and analyze sediment dynamics and understand how it will affect flood control, water use, and river and coast environment.

There are different issues related to sediment transport along rivers from mountain to coastal areas. To cope with them, it is necessary to conduct appropriate sediment transport and management, to control coastal drifting sand, and conserve and reproduce coastal areas. Both structural and non-structural measures, such as coordinated structure construction and operation, maintenance, and sand extraction regulation, are necessary to achieve these goals.

(2) Adaptation strategies in step with local community development

In Japan, land use and ways of living have altered along with changes in social conditions, such as the low birthrate and the decreasing and aging population. Taking adaptation measures in step with these social changes is effective and highly practical. It is difficult to protect communities from major external forces which are likely to become stronger due to climate change. Different countermeasures are needed to diversify the power of external forces so that it is more likely that communities can protect themselves effectively in social, economical, and environmental senses. Comprehensive flood control measures, which have been applied to limited river basins, should be expanded. Community building projects, including the reduction of carbon dioxide which is a cause for intensified external forces, should also be promoted according to social structure changes. It is important to build “a water-disaster adaptation society" with primary focus on energy efficiency, urban environment, and the reduction of flood disaster risk in addition to economic efficiency and convenience.

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

Prevention measures are effective if put into practice with land use regulation and guidance in areas suffering frequent inundation or showing high inundation risk or in areas with the high risk of sediment-related disasters, such as landslides and debris flows.

Some overseas countries not only promote structure construction but also pose severe land-use restrictions on some specific high risk areas by placing land use regulation on some lands, depending on basin characteristics and disaster risks. This example shows that countermeasures should be taken not only to contain disasters in certain areas but also to allow room for them.

-Promotion of flood control with designation of disaster risk zones

Disaster-prone areas can be designated as disaster risk zones based on a legal code regarding such designation. No more houses can be built in the designated areas. Houses can be protected from flooding more effectively when protected by ring levees, heightening of housing land, inundation protection facilities, retarding and inland-water drainage.

Moreover, areas with higher disaster risks can be led to less susceptive land use by disaster risk disclosure and insurance incentives.

-Implementation of countermeasures for Sediment-related disaster risk zones

Countermeasures for sediment-related disaster risk zones should be further implemented. In such zones, the further construction of new houses should be restricted, and the relocation of old houses should be promoted. To cope with intensified sediment-disasters due to climate change, the previously designated risk zones should be reviewed if necessary.

When an area for urbanization is set in an urban development plan, sediment-related disaster risk zones should be excluded from the area.

2) A new concept for urban development

Rivers have their own limits in their discharge capacity. It is important to enhance basins' storage, infiltration and runoff control capacities in the process of urban development.

Also, to realize a low carbon society, the reduction of environmental load should be promoted by decreasing the emission of carbon dioxide, in addition to strengthen the safety level through the implementation of flood control measures.

To this end, river improvement should be conducted from many perspectives. It is important to preserve and use river waterfront and green spaces as well as to reduce flood risk and conserve riparian landscapes and amenity. Moreover, it should contribute to mitigating the heat-island effect and reducing carbon dioxide.

-Urban development for a low-carbon, water-disaster adaptation society

Urban development for a low-carbon, water-disaster adaptation society should be promoted. Urban areas can be designed to be compact for better energy efficiency and easier implementation of flood control measures. Housing complexes where houses and large regulating ponds co-exist should be encouraged to be built; houses in such complexes should have high CO_2 reduction effect, for example, using solar energy.

-Greening of urban rivers

The greening of urban rivers, including the development of river-side forests, can contribute to flood control and flood fighting and should be promoted. In addition to that, waterfront and green spaces should be increased in urban areas to form a green network along with other green spaces, such as parks and walking paths, and eventually create paths for breeze to blow through.

-Restoration of rivers

Rivers which were concrete-covered or became closed conduits during urban development should be restored to form waterfront and green spaces in urban areas and eventually to create urban areas with such spaces and breeze paths.

-Implementation of facilities for rainwater storage, infiltration and runoff control

The implementation of facilities for rainwater storage, infiltration and runoff control should be promoted as one of the basin-based water retention measures through regulations, such as city codes, and subsidies. It is especially important to take such a step for small and middle-sized rivers to mitigate rapid rainwater runoff. The installation of these facilities should be well coordinated with that of sewage systems in urban development.

3) Enhancement of the disaster resistance of private houses

In areas with the risks of inundation or sediment-related disasters, to mitigate disaster damage and to enable quick restoration and rehabilitation, the disaster resistance of private houses should be enhanced applying building structures designed particularly to increase their resistance to floods or sediment-related disasters. It is also important to take other self-protection measures based on possible disaster damage. The locations of plug-ins and electric appliances, such as computers, should be carefully designed. Structures should also be designed from a viewpoint of security and safety, for example, for those who need assistance in case of emergency. Waterstops and sandbags will be helpful in case of flood fighting.

-Building flood-resistant houses

To keep houses in good condition for a long period of time, it is important to build them applying structures resistant to inundation and sediment-related disasters in areas with inundation risk. The piloti structure and the reinforced concrete structure are appropriate to increase flood resistance. The reinforced concrete structure is also effective to strengthen house walls.

On the other hand, consulting flood risk maps and building houses outside flood risk areas is also effective to use them in good condition for a long time.

4) Use of natural energy sources

To mitigate the impacts of global warming and the heat-island effect, efficient energy use should be promoted. For example, heat pump systems using unused natural energy sources like river water.

(3) Adaptation strategies with emphasis on crisis management

Intensive facility construction and improvement alone will not ensure the complete protection from flood, sediment-related, storm-surge and other disasters, disaster damage can affect socio-economic activity and livelihood. Also, it is important to prepare for sudden, large-scale disasters at normal times to quickly respond to them and mitigate disaster damage. Thus, mitigation and restoration/rehabilitation measures for large-scale disasters with emphasis on crisis management need to be implemented along with preventive structure/facility construction.

1) Promotion of preparation for responding to large-scale disasters

Preparedness for large-scale disasters should be substantially promoted to avoid devastating damage, complete restoration and rehabilitation quickly, and continue socio-economic activity and livelihood. The national government should enhance wide-area disaster relief systems and organize trans-regional disaster mitigation networks so as to better manage disaster risks and respond to actual disasters. Also, the national government and local bodies should cooperate and implement coping measures for different disaster cases: urgent measures in case of levee break and inundation, measures for floodwater and its drainage in flood-prone areas, and quick, appropriate response measures during large-scale sediment-related disasters.

-Building wide-area disaster management networks

When roads and streets are inundated, it will make it difficult to lead safe evacuation, quickly restore and rehabilitate affected sites, provide fuel supply for drainage pump stations, and block emergency relief operation. It will keep it almost impossible to transport relief supplies for a long time even during post-disaster rehabilitation. Therefore, wide-area disaster management networks are necessary to secure every access possible from disaster management stations and emergency supplies storage facilities to affected areas. For instance, such access networks can be built by connecting levees and emergency river-side roads which are hard to inundate with elevated roads.

-Implementation of drainage measures for restoration and rehabilitation

When a large-scale flood occurs, inundation may affect a widespread area and continue for a long period of time depending on the topography of the floodplain and with levees and earthfills blocking floodwaters from flowing back to the original river or other channels. In such a case, local communities will be left under an extremely stressful condition; thus, it is important to minimize damage as much as possible. To quickly restore affected facilities and structures and rehabilitate affected areas, preparation should be made for quick floodwater drainage using drainage pumps and through the proper operation of water gates. In addition, emergency slucing outlets should be installed.

2) Promoting non-structural measures based on new scenarios

Non-structural measures, such as information communication, flood fighting, evacuation, rescue efforts, restoration and rehabilitation, should also be promoted along with structural measures, because structural measures work reliably and effectively but at the same time have limited protection capabilities. To increase the safety level and appropriately manage non-structural measures, they should be thoroughly reviewed based on not only conventional scenarios but also new scenarios which consider changes in frequency and timing of external forces.

Residents should be well informed of disaster mitigation and able to share necessary information with public offices through two-way communication, because self-help and mutual support are essential to mitigate flood damage in local communities whose populations are decreasing due to the low birthrate and the aging population. Also, efforts should be made to improve local disaster preparedness for flood, sediment-related, storm-surge disasters to mitigate disaster impacts through communal cooperation.

-Support for evacuation

Appropriate sites for evacuation are hard to find in low-lying areas, such as zero-meter zones, or areas lying below or as low as the sea level. It is similarly difficult to secure such sites in densely populated areas. In these areas, it is effective to designate multi-story buildings as evacuation sites. Adequate support should be given to help local communities easily take such a step by providing necessary information, such as hazard maps and disaster risk.

Also, to facilitate quick evacuation, it is important to realize a ubiquitous society, where strangers and residents who are likely to be affected at the initial stage of a disaster can easily obtain information on evacuation routes, river water levels, flooding, and sediment-related disasters in real time.

3) Enhancement of forecasting and warning systems for floods, sediment-disasters and flood fighting

To conduct such activities as flood fighting, evacuation and emergency restoration in disaster management, it is very important to provide residents and relevant organizations with forecasts and warnings based on the prediction of the precursors, timings and scales of floods, debris flows and storm surges.

Therefore, it is necessary to enhance forecasting and warning technologies and systems through the improvement of observational systems and runoff forecasting technologies.

Sediment-related disaster warnings should be more detailed than those presently disseminated so that people will know how soon a debris flow will occur, for example. At the same time, disaster warning systems should be further improved to increase information reliability.

-Development of flood warning systems and organizations

To conduct evacuation and emergency response effectively at the right timing in case of disasters, there are several important issues which need to be addressed in terms of the enhancement of forecasting and warning technology. Disaster forecasting systems which can cope with new phenomena due to climate change should be put into use and improved in accuracy. Lead time should be secured to respond to disasters appropriately. Information communication should be carried out faster in different channels. To this end, it is necessary to establish specialized organizations and systems aiming to strengthen observations of meteorological, hydrological and terrestrial phenomena and promote the sharing of these data with other related organizations. It is also important for such organizations to perform reliable, efficient operations and to develop specialists.

(4) Adaptation strategies to avoid drought risk

Adaptation strategies to avoid drought risk caused by climate change should be considered to be an emerging priority issue in comprehensive water resources management. Water resources should be systematically managed and carefully coordinated within each river system.

When reviewing adaptation strategies to avoid drought risk, it is important, first of all, to understand that water use requires energy consumption and is always accompanied with CO2 emission increase. It should also be kept in mind that it is difficult to have a long-term outlook on climate change. For these reasons, the key is to establish a water-saving society, which focuses on water demand control from normal times and contributes to the reduction of energy consumption and CO2 emission. Adaptation strategies should be based on the establishment of such a society. Adaptation strategies should be formulated and implemented to secure water in emergency so that the impacts of serious droughts due to climate change on citizens can be minimized. Another way is the thorough use of water supply facilities and the prolonging of their service lives from normal times. This is extremely effective in terms of cost and also time because virtually no time is necessary to achieve target effects. If existing facilities, though fully utilized, cannot meet the local needs, more facilities should be constructed. Furthermore, future water use should be reviewed based on possible social structural changes.

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

For the effective use of limited water resources, a water-saving society, in which water demand is carefully controlled on a regular basis. Publicity for a water-saving society should be promoted to raise public awareness towards water saving. It will also be effective to implement regulations which mandate some kind of water saving or give incentives to the general public and private corporations which develop water-saving equipment. In addition, the reuse rate of industrial water should be further increased, and rainwater use should be promoted. The use of recycled waste water should also be further increased by taking advantage of advanced water processing technologies, such as membrane water treatment.

2) Securing of emergency water resources

Emergency water supply systems should be established, because a serious drought could cause unexpected effects on socio-economic activity. Emergency systems include transportation systems by which bags of water can be carried to areas critically affected by water shortage. The installation of connecting pipes between local water supply systems can be effective to share water with each other when a drought hits certain areas. Other water supply and storage measures should be promoted, including transportable seawater desalination facilities. The coordination between water users within a river system should also be enhanced to share limited water supply among them in case of drought.

3) Making full use and prolonging service lives of water resources supply facilities and structures

Water supply facilities and structures should be made full use of by effectively using, reorganizing, differently operating existing facilities and structures as well as prolonging their service lives. Dams should be heightened, and sediment deposit should be removed. Multiple-dams operation in a river system can be grouped and re-coordinated, and water capacities can be reallocated. Dam operation should also be improved. In addition to the full use of existing facilities and structures, the implementation of new facilities and structures should be promoted if necessary.

(5) Adaptation strategies to river environment changes

At present, it is difficult to monitor and project the climate-induced changes of river environment, because so many factors are involved, and also there is little knowledge and data about the effects of climate change on river environment. It is important to collect knowledge and data through enhanced observation. Based on that, efforts should be made to analyze some kind of relationship between river environment changes and climate change and to review and apply appropriate management to river environment.

(6) Enhancement of observational systems for the impacts of climate change

As with adaptation efforts and changes in social conditions which contain some degree of uncertainty, there exists a wide range of variation among projected changes in external forces. For that reason, it is important to conduct research and observation on a regular basis to understand the impacts of climate change.

Relevant organizations should cooperate with each other to observe changes in external forces, based on data collected in river systems and coastal areas, such as rainfall, water level, discharge, tide level, wave height, water quality, sediment runoff, river channel shape, living creature, and disaster damage. Under clearly defined indices, external forces change should be properly studied and observed. Current study or observation methods will be reviewed and improved, and new technologies should be implemented if necessary.

Observational results should be stored in a database, summarized regularly, and used to review adaptation strategies. They should also be provided to the general public in an easy-to-understand manner. Organizations should cooperate with each other and share data on climate change.

6. Issues for implementing adaptation measures

There will be a number of issues to be addressed to implement adaptation strategies for climate change which contains uncertainty. Some of them lack sufficient knowledge and data, some concern mostly research and observation, and some involve different organizations. However, issues directly related to adaptation should be the responsibility of the Ministry of Land, Infrastructure, Transport and Tourism. Besides efforts by the national government and partnership among related ministries and agencies, a cooperation system among industry, academia and government should be formed to create a framework for collecting wisdom. The following are main issues for the implementation of adaptation strategies:

- Understanding of changes in external forces due to climate change (projection, research and observation, analysis, etc.)
- Announcement of the methods and results of disaster risk assessment
- Policy and methods for securing safety in river basins
- Methods for the projection and assessment of the impacts on river ecosystems and water/material cycles

IV. Implementation of adaptation measures

1. Basic implementation strategies

Since flood control should be executed along with long-range plans, changes in external forces should be appropriately estimated, and adaptation measures to climate change should be incorporated in currently on-going flood control policies.

On such an assumption, adaptation measures should be implemented based on the following basic strategies.

(1) Governmental efforts

Considering the importance of adaptation, the entire government should promote the implementation of adaptation measures. The government should promote the discussion of adaptation at opportunities in which relevant organizations meet, such as the Central Disaster Management Council.

(2) Promotion of cooperative work with the public

Cooperative work with the general public is indispensable to plan and implement adaptation measures. Efforts should be made at every possible opportunity to provide easy-to-understand information and gain better, wider public understanding of the impacts of climate change on flood, sediment-related, storm-surge and other disasters, as well as the national land and society.

In recent years, an increasing number of people have less experience in disasters and less knowledge about sabo and coasts. Because of that, river administrators should cooperate with other organizations to provide opportunities for people to systematically learn basic knowledge about disaster mitigation and river environment, including elementary knowledge about disasters and appropriate behaviors in case of disaster.

(3) Priority investment in preventive measures

While funds are limited, investment priority should be placed on preventive measures for certain structures that are predicted to become degraded and to protect areas where population, property and central functions are concentrated.

(4) Clear prioritization

To strengthen adaptation measures to climate change within limited funds, priority measures and components should be carefully selected in addition to comprehensive sets of measures.

(5) Preparation of road maps

Clear road maps for different time frames should be drawn up from short- and middle-range viewpoints of five and ten years and also from a long-range viewpoint for national land planning. Disaster risk assessment should be conducted for plans with different time frames to make clear road maps. When making clear road maps, it is important to design plans reflecting projection uncertainty affected by the impacts of climate change and changes in social conditions which may well be different from time to time. Such plans will allow people to select different measures from many different options.

(6) Adoption of a flexible approach

Adaptation measures should be designed and implemented in a flexible manner in which prediction scenarios for the measures will be continuously revised in accord with accumulation of observational data and knowledge because climate change prediction always contains some uncertainties.

Based on the results of projection and observation as well as the impacts on society, adaptation measures should be reviewed in terms of content, combination of measures, and priorities to prevent from regress. Projection for this kind of review should be conducted along with long-term projection.

(7) Cooperation with related organizations

In basins for which adaptation measures are comprehensively planned, river administrators alone cannot carry out necessary tasks in many cases. Thus, it is indispensable to gain cooperation from residents and related organizations and conduct the tasks in collaboration with them. Cooperation with the sections of urban and housing development and agriculture is necessary to implement adaptation strategies in community development. Support from the sections of road, sewage, fire management, police, and Self-Defense Forces is essential for adaptation strategies with primary focus on crisis management. Adaptation strategies for droughts require help from the water user groups. To this end, disaster risk assessment and road maps should be used to coordinate all parties involved and to execute comprehensive adaptation strategies, and eventually to implement integrated management involving water-related organizations.

(8) Developing new technologies and contributing to the international community

New technologies for climate-change impact assessment and adaptation should be developed and put into full use under collaboration among industry, academia and government. Japan should demonstrate strong leadership in this field and try to contribute to the international community by actively transferring its experiences, policies and technologies through the promotion of science technology diplomacy.

(9) Promotion of research and application of their results to plan flood control, water use, and environmental conservation

Research on the risks and impacts on river/coast environments of flood, drought, sediment-related, storm-surge and other disasters that may accompany climate change should be promoted jointly with universities and research institutes, and the results should be reflected when planning flood control, water use, and environmental conservation.

2. Procedure for the implementation of adaptation measures

The issues for implementing adaptation measures (III-2.6) should be studied during the first short-range period, which is about five years until the IPCC Fifth Assessment Report is published as a summary of a next set of new knowledge. The present designs for structural measures should be reviewed to cope with the increasing scales of external forces. Road maps for structure implementation should be drawn up, and existing measures which are considered to be important adaptation measures should be immediately implemented with special emphasis.

The adaptation measures in the first period should be reviewed and prioritized based on the review results for the implementation during the subsequent period (second period). Adaptation strategies which are newly recognized as effective and efficient should be intensively implemented. Based on that, the road maps need to be revised. To build “a water-disaster adaptation society,” flood control policies and adaptation strategies selected for implementation should be reflected in the Basic River Improvement Master Plans and River Improvement Strategic Plans as well as in national land planning, which illustrates future visions for national land development and community development.

After the second period onwards, it is important that adaptation measures should be designed based on changes in social conditions, a wide range of accumulated knowledge, and changes in condition settings based on sufficient observational data and actual disaster records. These measures should be implemented step by step. The target level of structural implementation should be reviewed and redefined if necessary.

3. Promotion of international contribution

To contribute to the international community, in which water-related disasters due to climate change is a common issue although different regions suffer damage to different degrees, Japan should address to world leaders the importance of adaptation strategies as most important national policies as well as the need of international cooperation. It is also important to assist other countries in the design and implementation of adaptation strategies as well as in the prediction of climate changes in the Asia-Pacific region using global models as well as resultant impacts on society and national lands.

Also, Japan should provide its experience and expertise to help UN organizations conduct projects in water management and disaster response in developing countries.

Conclusions

The IPCC 4th Assessment Report was published, showing more realistic impacts of global warming. Also in Japan, adaptation measures to climate change caused by global warming have been reviewed in various fields. The subcommittee is set to consider the impacts on the national land and society of intensified flood, sediment-related, storm-surge, drought and other disasters, and also to discuss from different perspectives the basic directions and practical adaptation measures for avoiding destructive damage and building “a strong society adapted to water-related disasters (water-disaster adaptation society).”

The subcommittee has reviewed the impacts of climate change on increases in external forces as well as on the national land and society, although at the moment there is some degree of uncertainty in the global warming scenarios, future social conditions and simulations of climate change. The subcommittee has defined the adaptation goals clearly, and reviewed present policies for flood control and water use. Based on that, it has shown the basic directions of adaptation strategies which should be added to the conventional policies. Climate change is threatening to pose serious impacts on the land of Japan, which is still vulnerable in terms of flood control, water use and river and costal environment, but the challenge must be faced by constructing reliable structures which will secure safety for the next generation and also by taking adaptation measures which in step with community development along with the reformation of social structure and changes in social conditions.

However, adaptation measures that involve changes in social structure cannot be fully executed by river administration alone. They need to be promoted by the entire government and related ministries with the understanding and cooperation of citizens and related organizations. Thus, a mechanism is necessary for all parties involved to work together on adaptation to water-related disasters. The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) should make efforts to make various kinds of information fully available to the general pubic in an easy-to-understand manner to build a common recognition about water-related disasters among basin residents, relevant organizations, local municipalities, and private corporations. By doing so, the ministry can help form a consensus on adaptation measures among all parties involved. Efforts should also be made to reduce projection uncertainty regarding climate change to set well-informed goals.

In the wake of this report, opinions and ideas should be fully exchanged with the Central Disaster Prevention Council and subcommittees of the Panel on Infrastructure Development and the National Land Development Council, so that it will be possible to discuss what adaptation strategies are more practical and how they can and should be implemented. The subcommittee recommends that based on this report, MLIT formulate a practical action plan immediately and start working on the implementation of the plan.

In December 2007, the first Asia-Pacific Water Summit was held in Kyushu, Japan. The participating countries and groups agreed that water issues were the highest priority issues to be solved and that urgent, effective action needs to be taken to mitigate damage by water-related disasters, such as floods and droughts. They also shared the common recognition on the importance of adaptation. The subcommittee hopes that the G8 Summit in Toyako, Hokkaido in July 2008, will also recognize the importance of adaptation to water-related disasters and start promoting the realization of a secure and safe global community. To this end, the subcommittee also hopes that Japan will proactively send pertinent messages this report provides at the coming summit meeting.

Subcommittee on Climate Change Adaptation for Flood Control, River Sector Committee, Panel on Infrastructure Development

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Note: The names are listed in an alphabetical order without honorifics.

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Committee members

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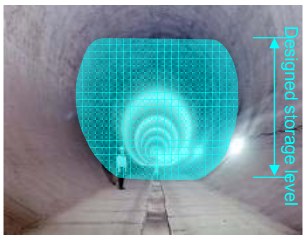
Note: The names are listed in an alphabetical order without honorifics.

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)



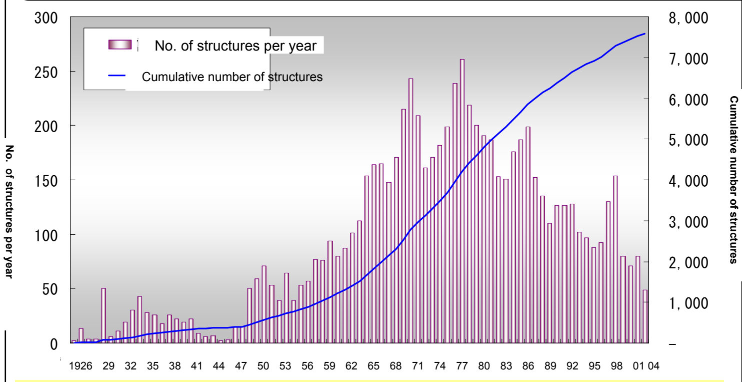
Floodwater regulation structure (Underground regulation pond)

High-standard Levee

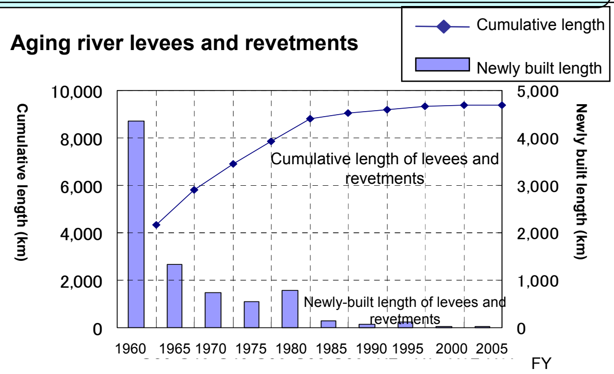
Maintaining and improving the reliability of existing structures: response to aging revetments

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

Deteriorated concrete of aging shore protection work

Rehabilitation work by widening of the protection

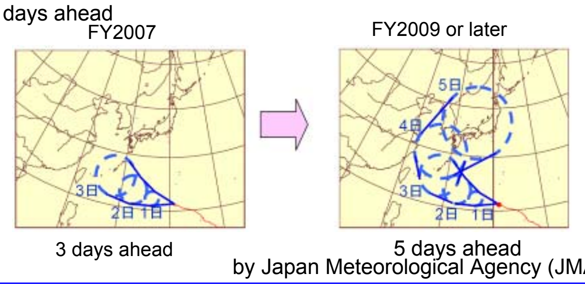
Utilization of existing structures: rainfall/discharge forecasting technology and the improvement of structure operation

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.

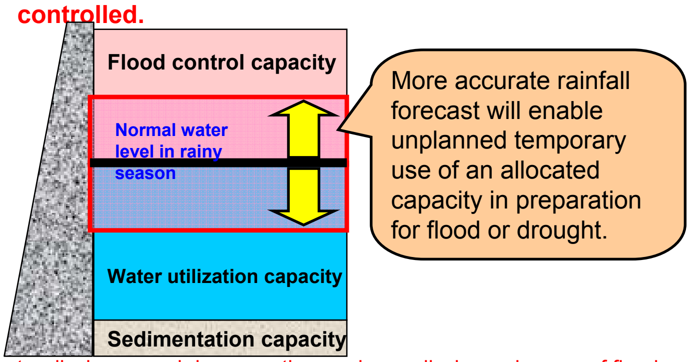
◎Case of JMA's effort for rainfall forecasting technology development

Building new system from FY2009 for typhoon forecasting 5 days ahead

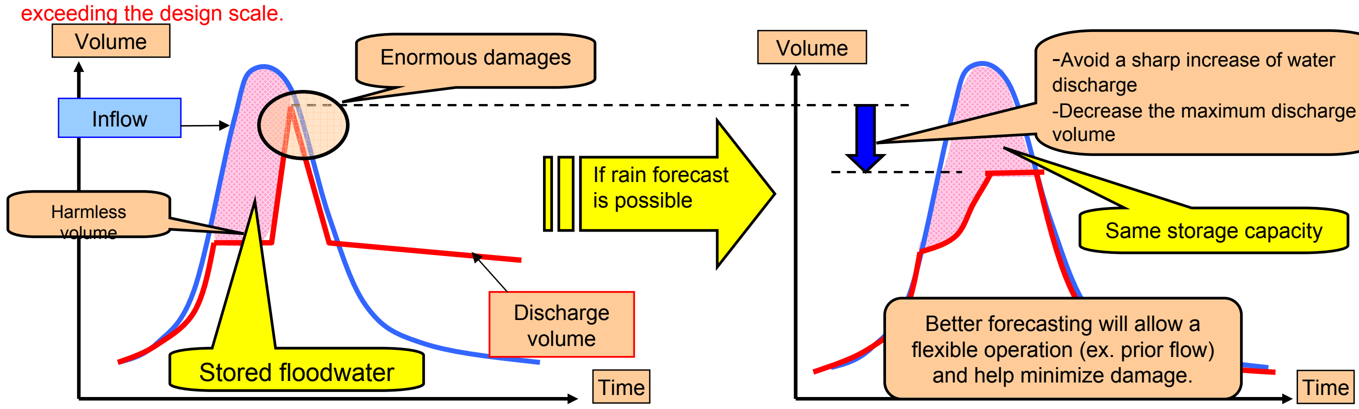


by Japan Meteorological Agency (JMA)

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



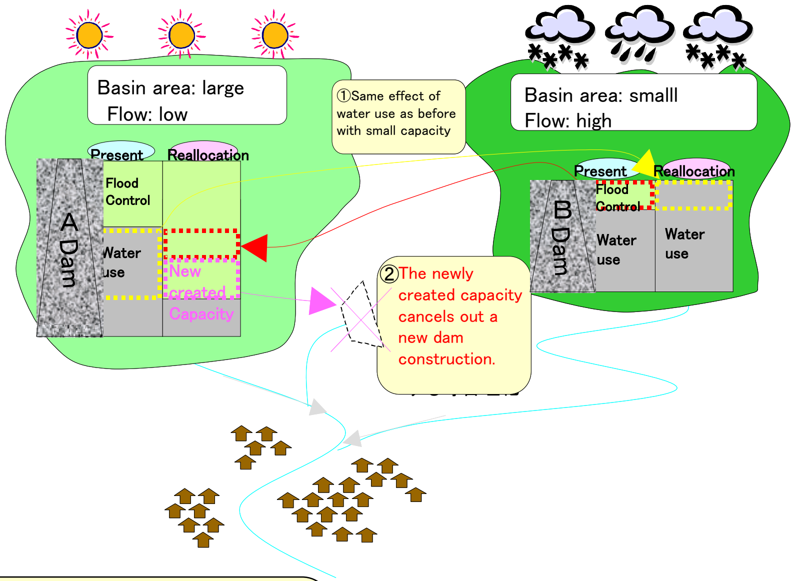
◎Improved forecasting technology can help avoid a sharp increase of water discharge and decrease the maximum discharge in case of flood exceeding the design scale.



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

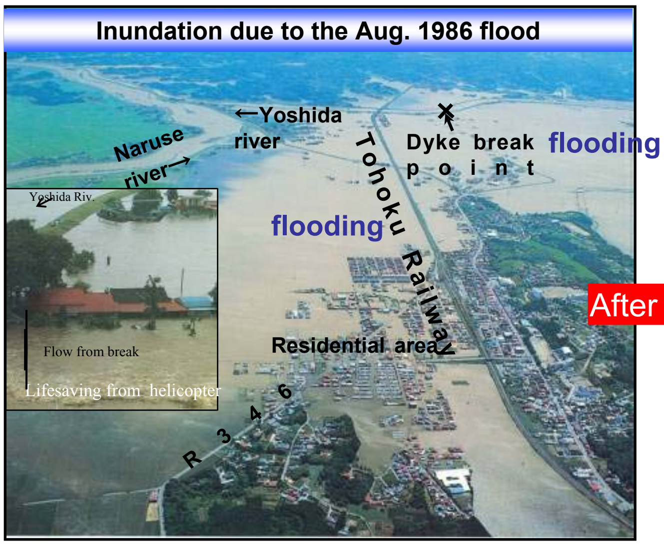
Dams' flood-control and water-use capacities should be re-allocated based on their current operation and the rainfall/discharge characteristics of their basins.



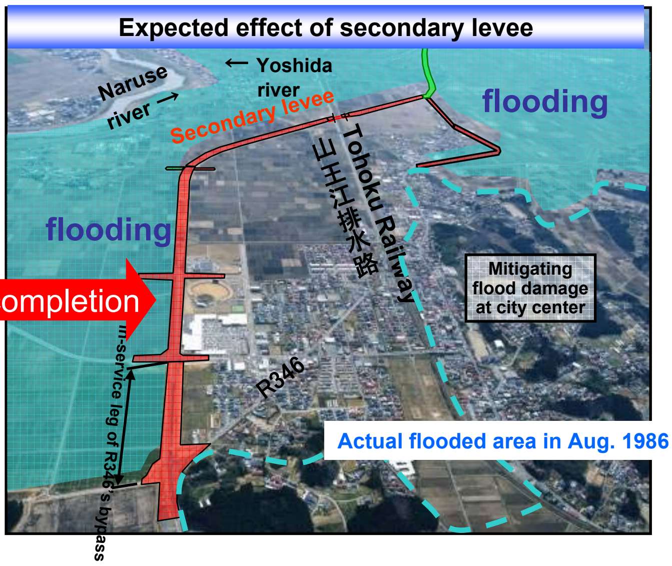
Re-allocation of dam capacity
●Re-allocation of water use capacity to flood control capacity.
●Capacity allocation among existing and newly-planed dams

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

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



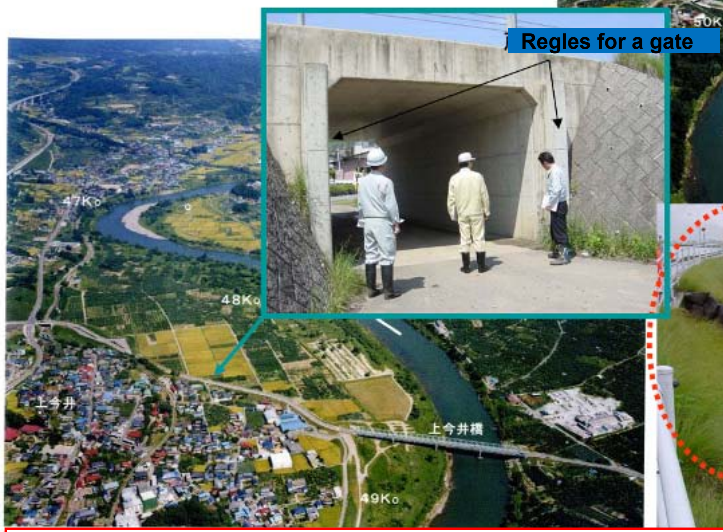
Due to 4 break points, 3,060ha was flooded, 1,510 houses were flooded above the floor level, and some parts of the area stayed under water up to 12 days.



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

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)

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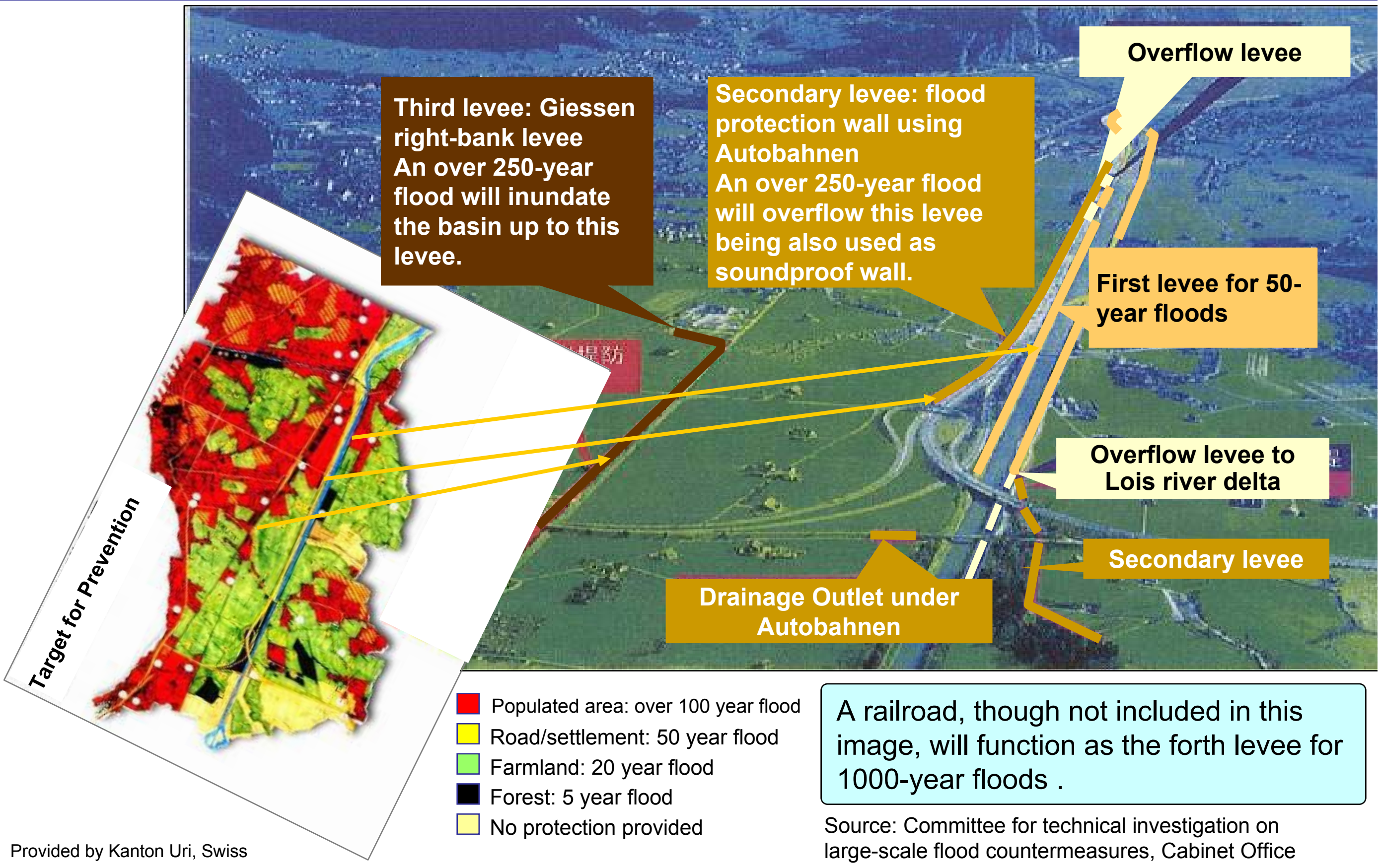
III-2. Basic Directions of Adaptation



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

Provided by Kanton Uri, Swiss

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

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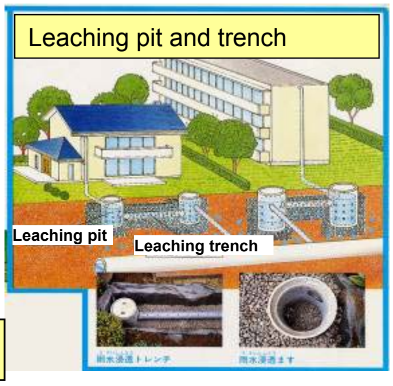
III-2. Basic Directions of Adaptation

Rainwater storage and infiltration facility

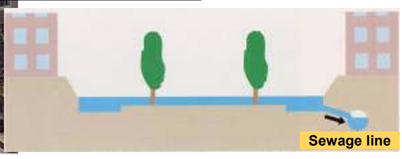
Rainwater storage at school ground

Leaching pit and trench



Permeable pavement

Rainwater storage at residential area



Promotion of comprehensive sediment management

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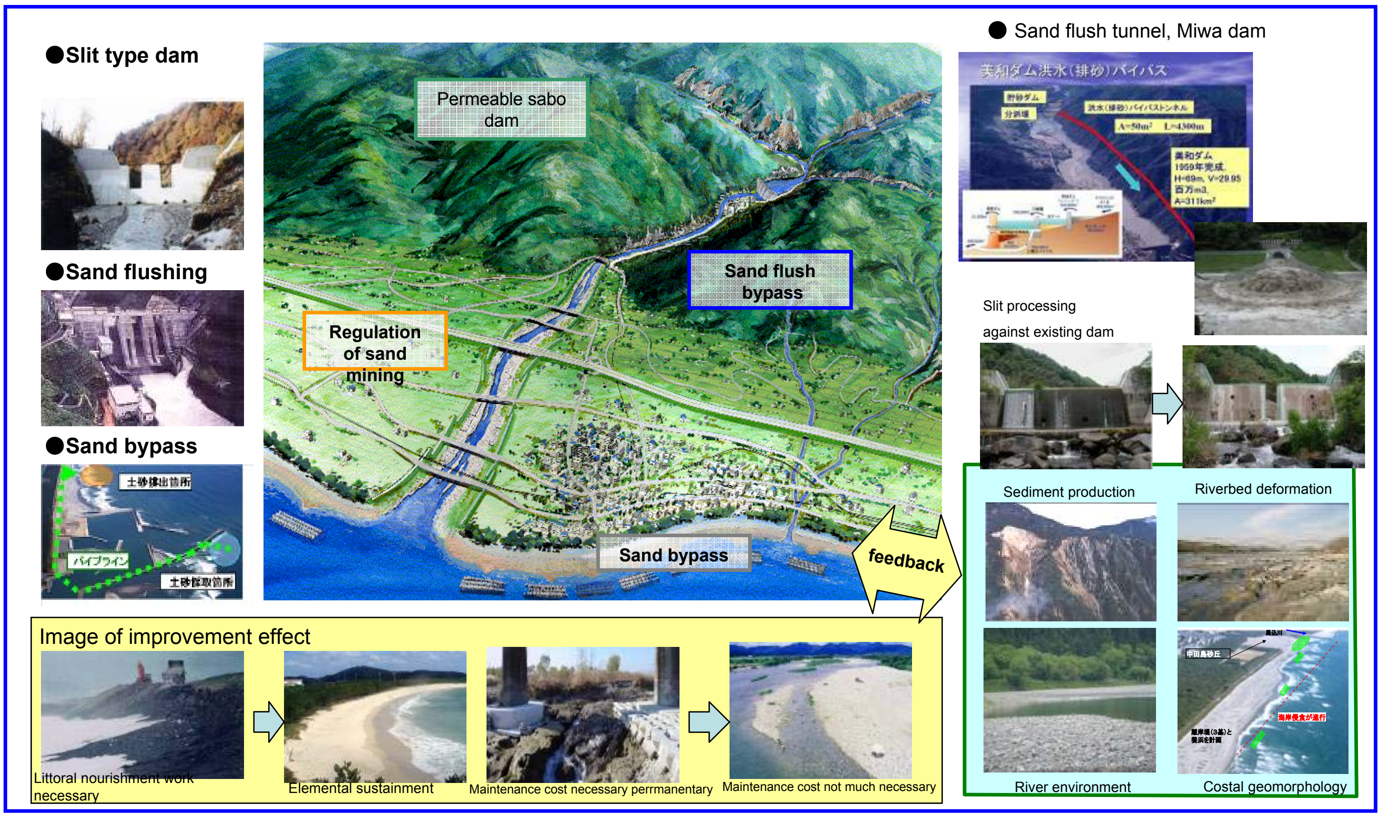
III-2. Basic Directions of Adaptation

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

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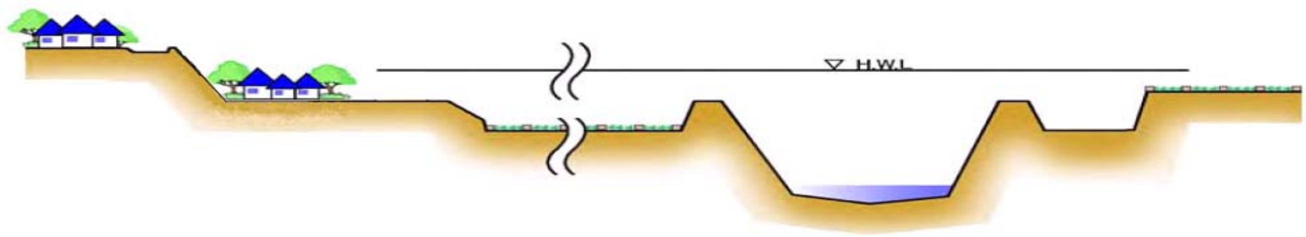
III-2. Basic Directions of Adaptation

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.

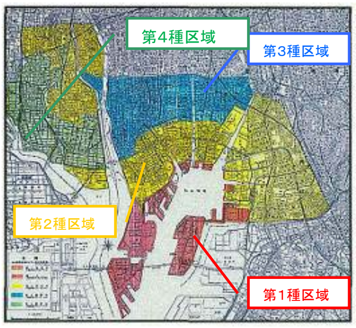


Land use regulation: designation of disaster hazard areas

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

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III-2. Basic Directions of Adaptation

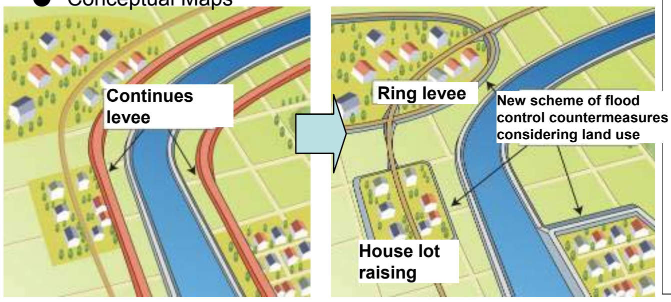
More local governments have established ordinances including the designation of disaster hazard areas (DHA) because the DHA designation became a requirement for discontinuous levee construction.

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.

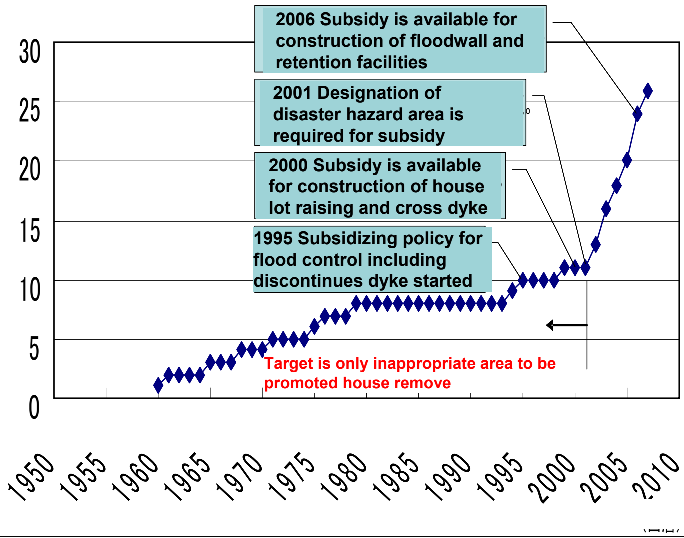
● Conceptual Maps



Substantial cost and time are necessary to complete

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

The total number of local governments establishing DHA-designation ordinances



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

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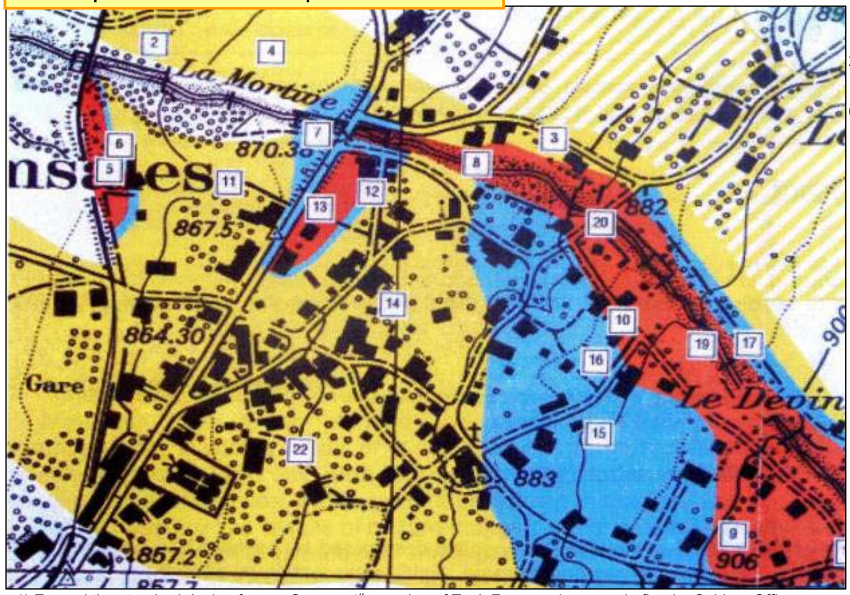
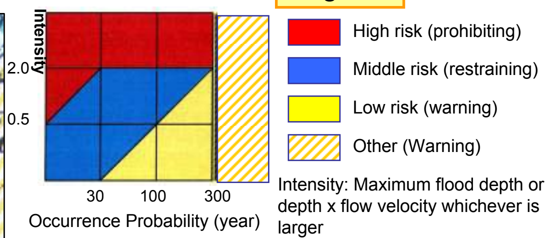
- Three different colors are used to categorize risk levels in the sample Swiss hazard map, and an area which can be affected by an enormous disaster[1)] is also indicated.
- Risk levels, thus 3 colors, are categorized based on disaster intensity (maximum flood depth, or depth x flow velocity) and occurrence 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

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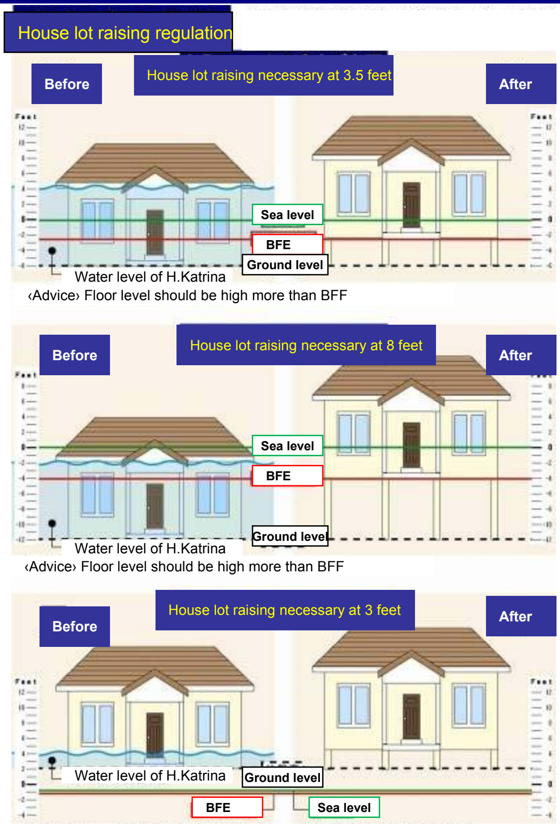
III-2. Basic Directions of Adaptation

- 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

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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)**

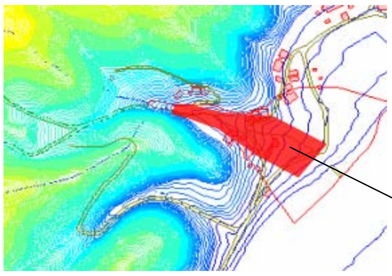
Prefectural governors designate sediment-related disaster high-risk zones

- **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)**

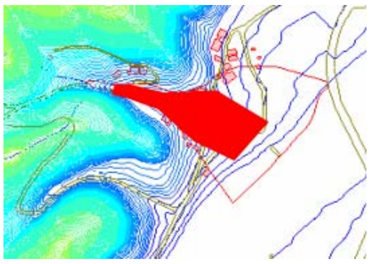
- If maximum 24-hour rainfall increases, a disaster high-risk zone will expand.



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

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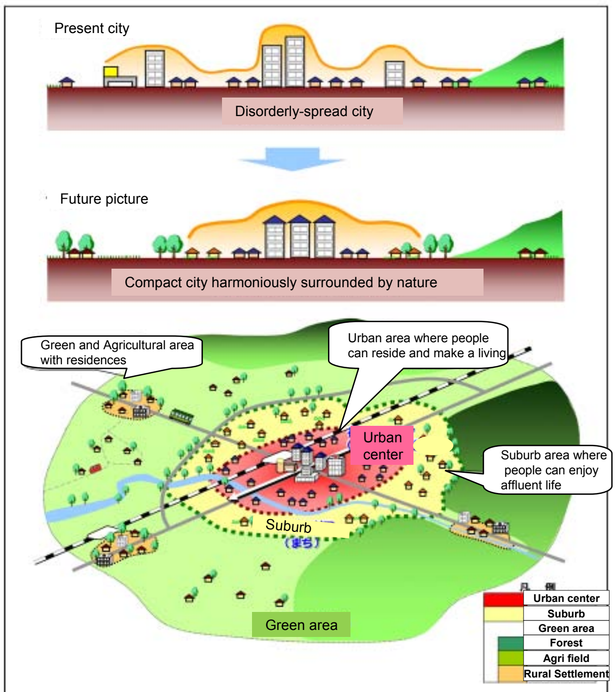
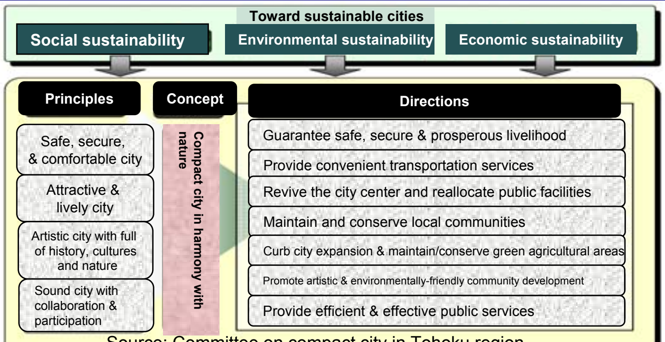
III-2. Basic Directions of Adaptation

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

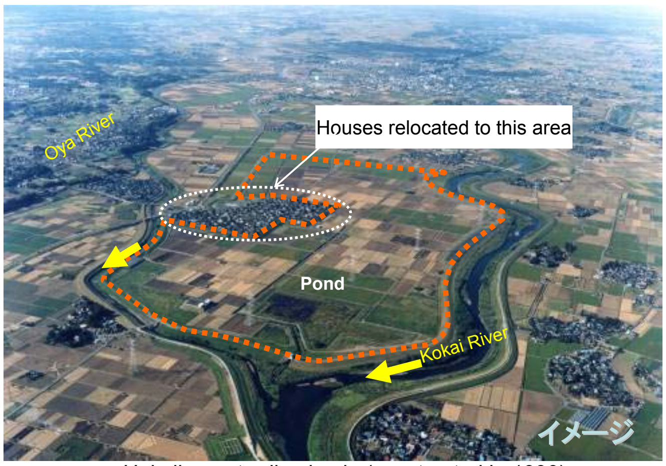
■ Conceptual figure of compact city for present small and medium cities in Tohoku region



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

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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)

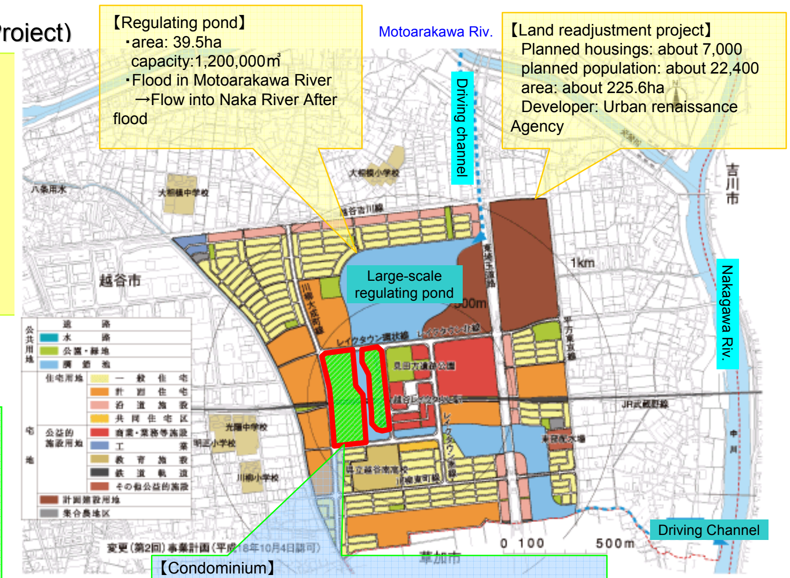
Plus adaptation

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



【Condominium】
・Japan's largest scale solar thermal conversion system for housing
・Shared use of solar thermal conversion system
【Housing】
・Innovative use of local air stream
・ Curbing of heat island by leafy shade and water retention pavement
・Housing appliance to meet super energy saving standards

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

- 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.

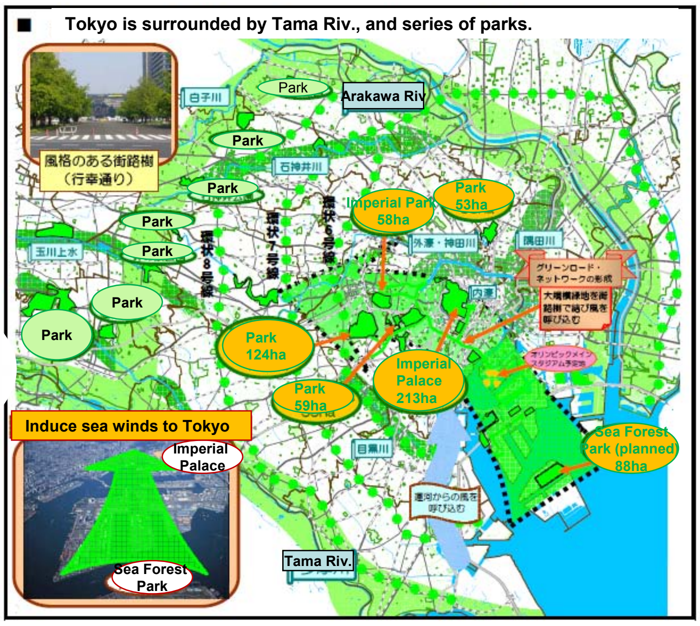
Create “wind corridors” by connecting green areas above a certain size

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

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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% a Cheon Gye 8ga.

Source: City of Soul

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

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III-2. Basic Directions of Adaptation

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

Example of Saitama

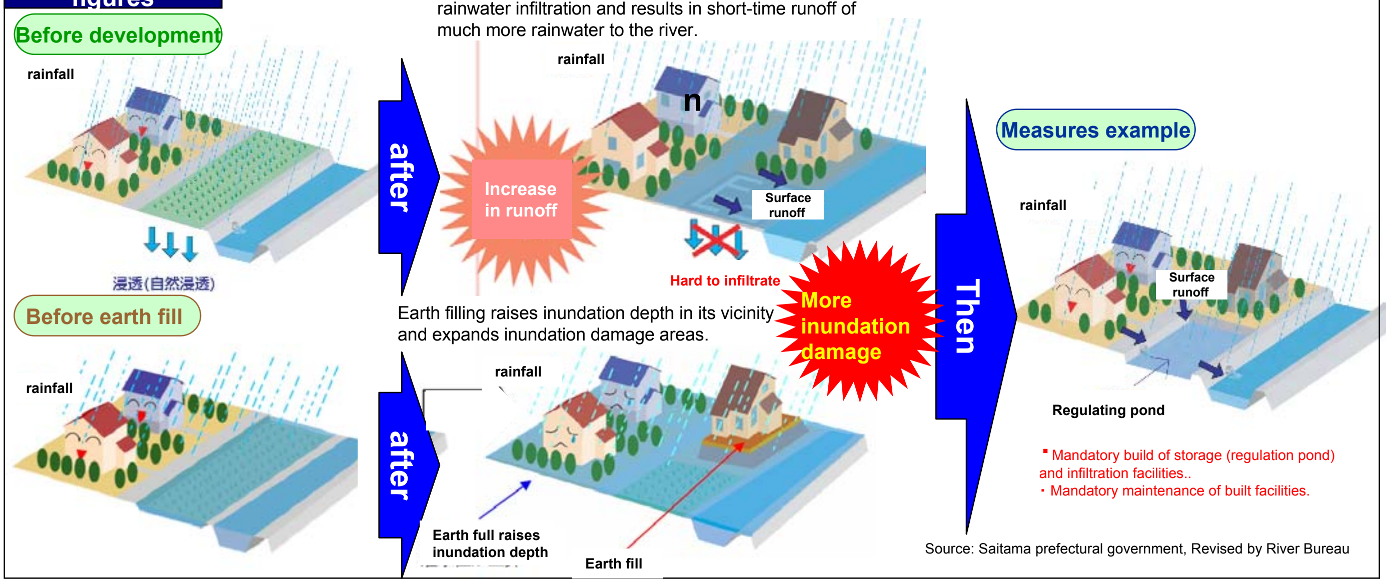
Ordinance on installment of rainwater runoff control facilities

October 2006

Outline of ordinance

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

Conceptual figures



- Mandatory build of storage (regulation pond) and infiltration facilities..
- Mandatory maintenance of built facilities.

Source: Saitama prefectural government, Revised by River Bureau

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

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- 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)

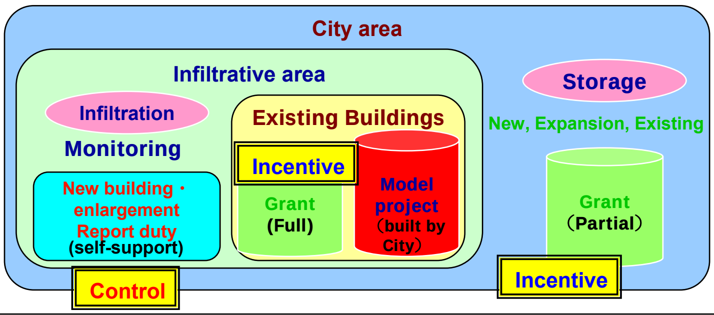
Outline of ordinance

- 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.

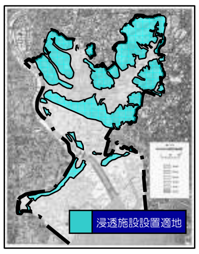
○About regulation:
【infiltration】･･･designated areas, new/enlargement
One infiltration facility with 350φ ×600 dimensions per 38m[2] areas of new or enlarging building.

○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

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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

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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)

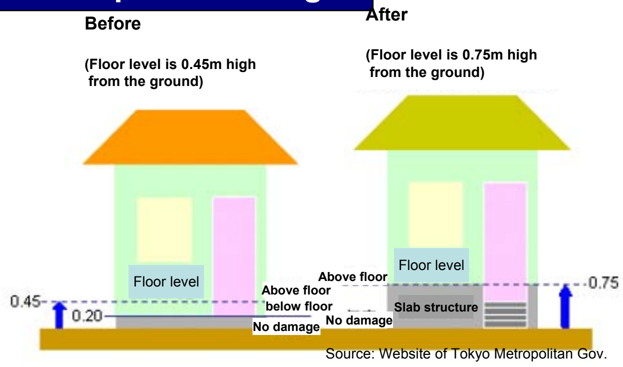
Started a grant program to partially support cost of house-raising works.

(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

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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

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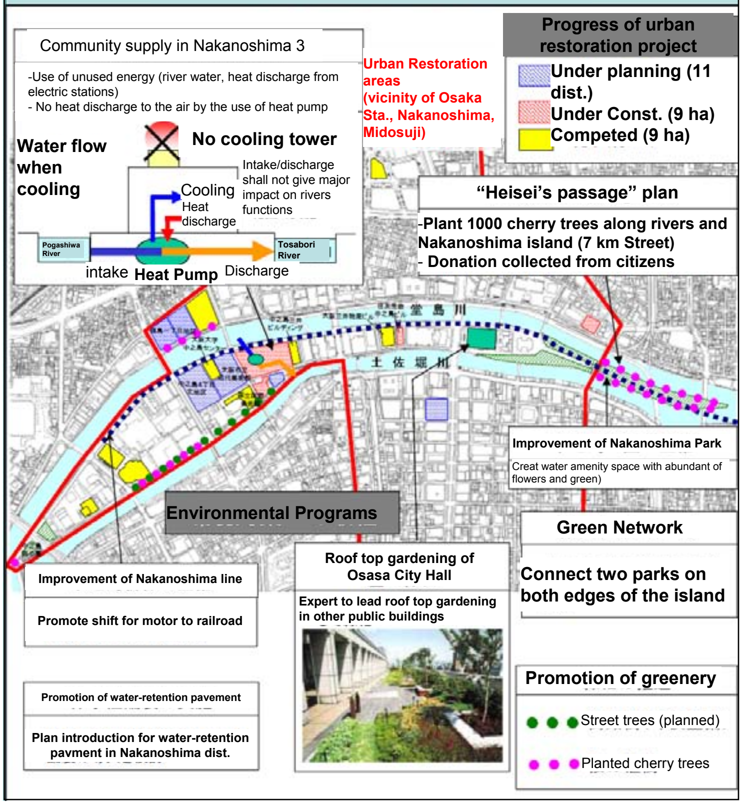
III-2. Basic Directions of Adaptation

Nakanoshima, Osaka



- 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

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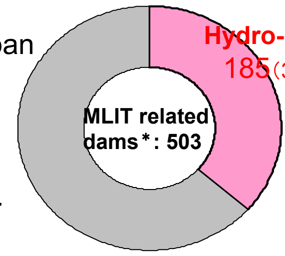
Hydraulic power generation at multi purpose dams

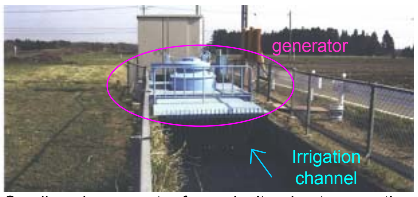
Currently, 185 multi-purpose dams in Japan generate about 640 mil KW energy at maximum.



（*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

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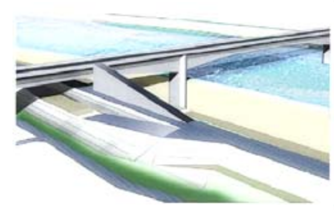
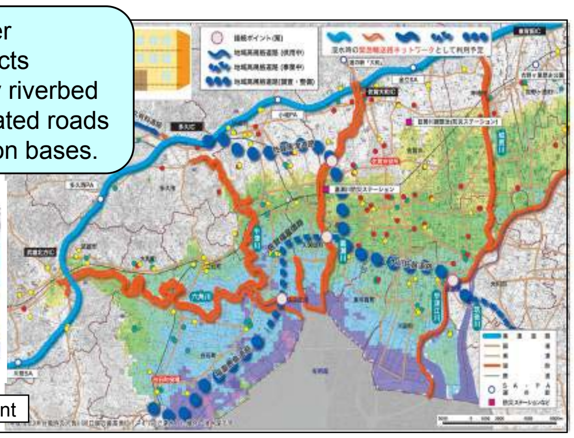
III-2. Basic Directions of Adaptation

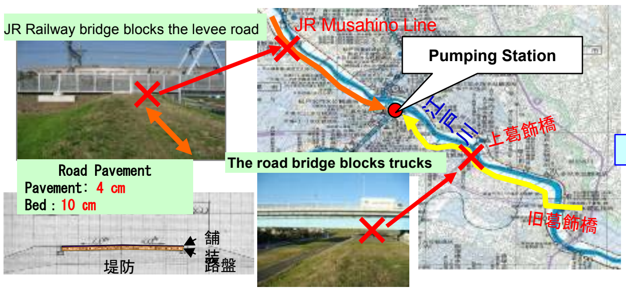
Building of a wide-area disaster prevention network that connects embankment, roads on the dry riverbed for emergency traffic and elevated roads to wide-area disaster prevention bases.





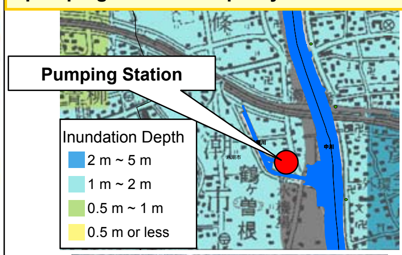
Network of roads and river embankment

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**

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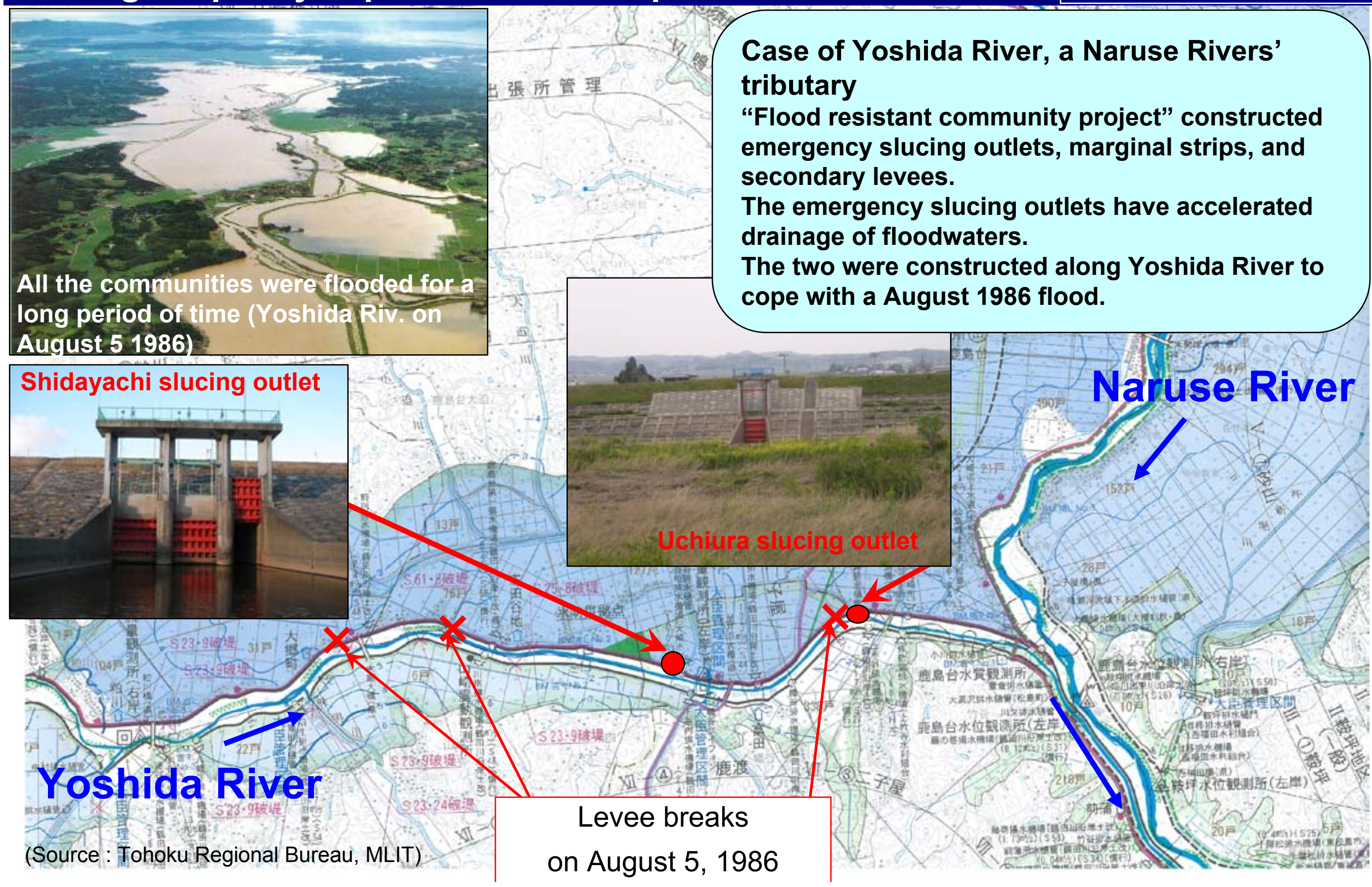
Case of Yoshida River, a Naruse Rivers' tributary

"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

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

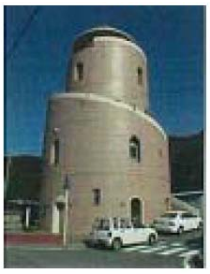
Pedestrian deck

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

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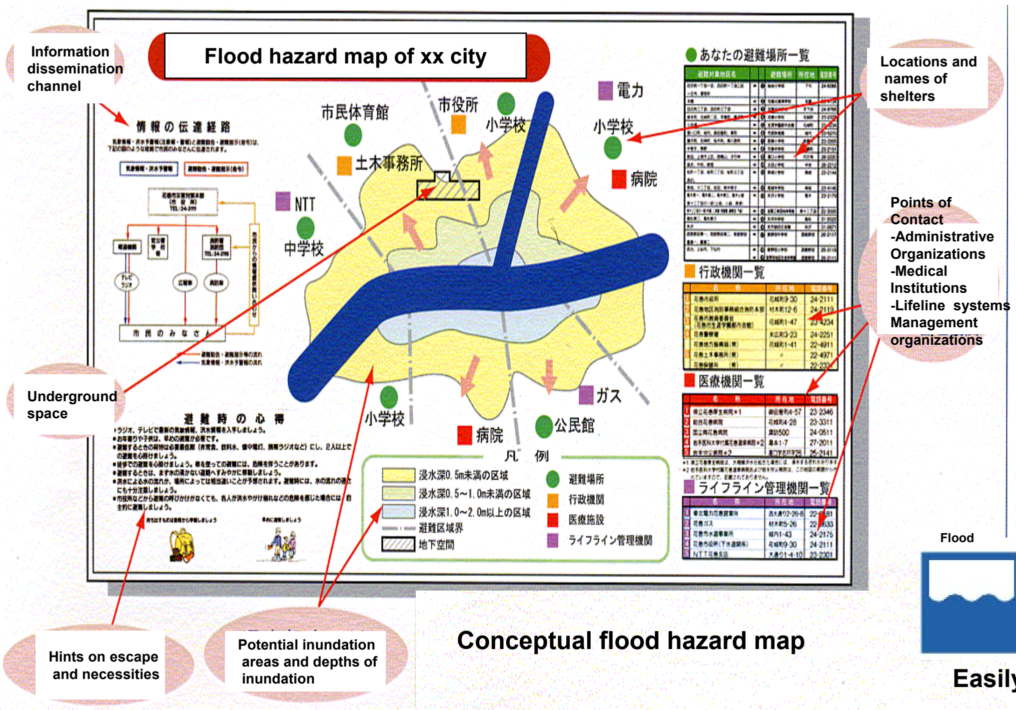
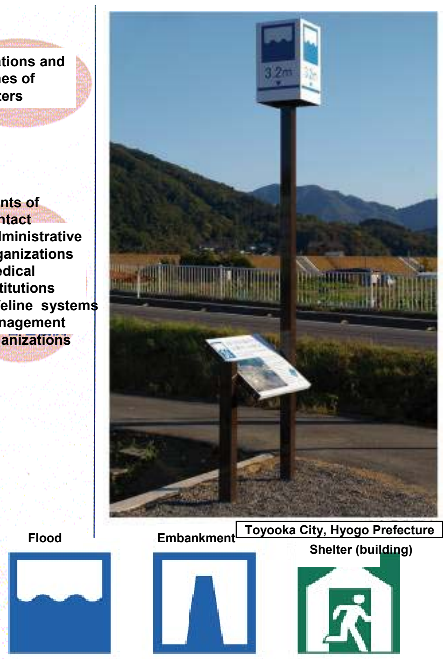
Water levels in build-up areas in the past floods are indicated on the hazard map.



Conceptual flood hazard map



Easily recognizable signs

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

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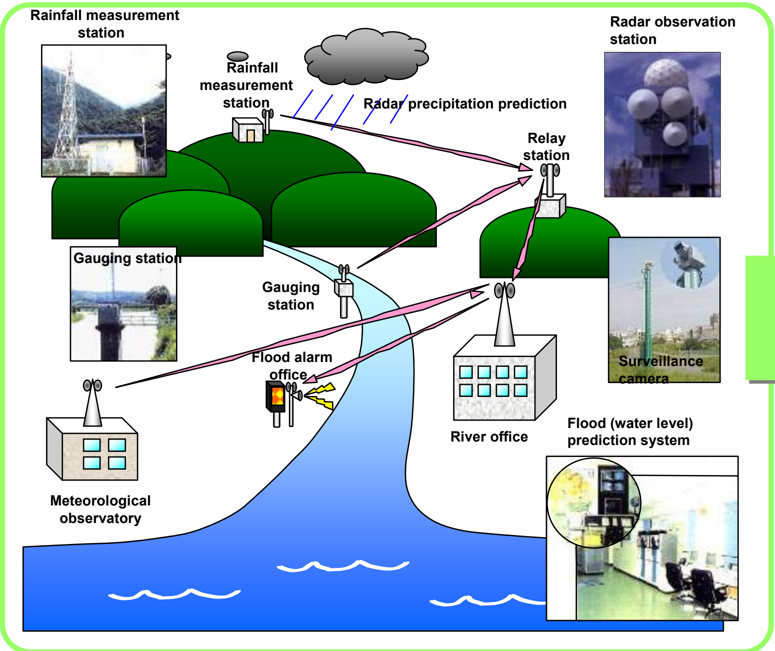
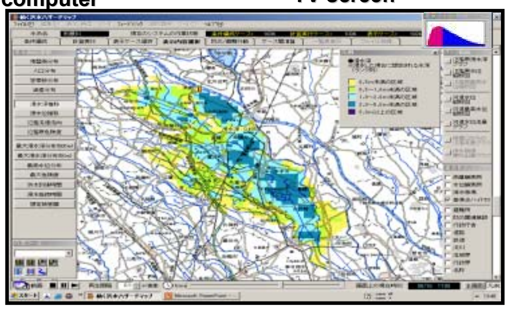
・Real-time provision of rainfall and water levels via cellular phones, the Internet or local disaster prevention radio systems
・Flood forecasting through real-time simulation



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

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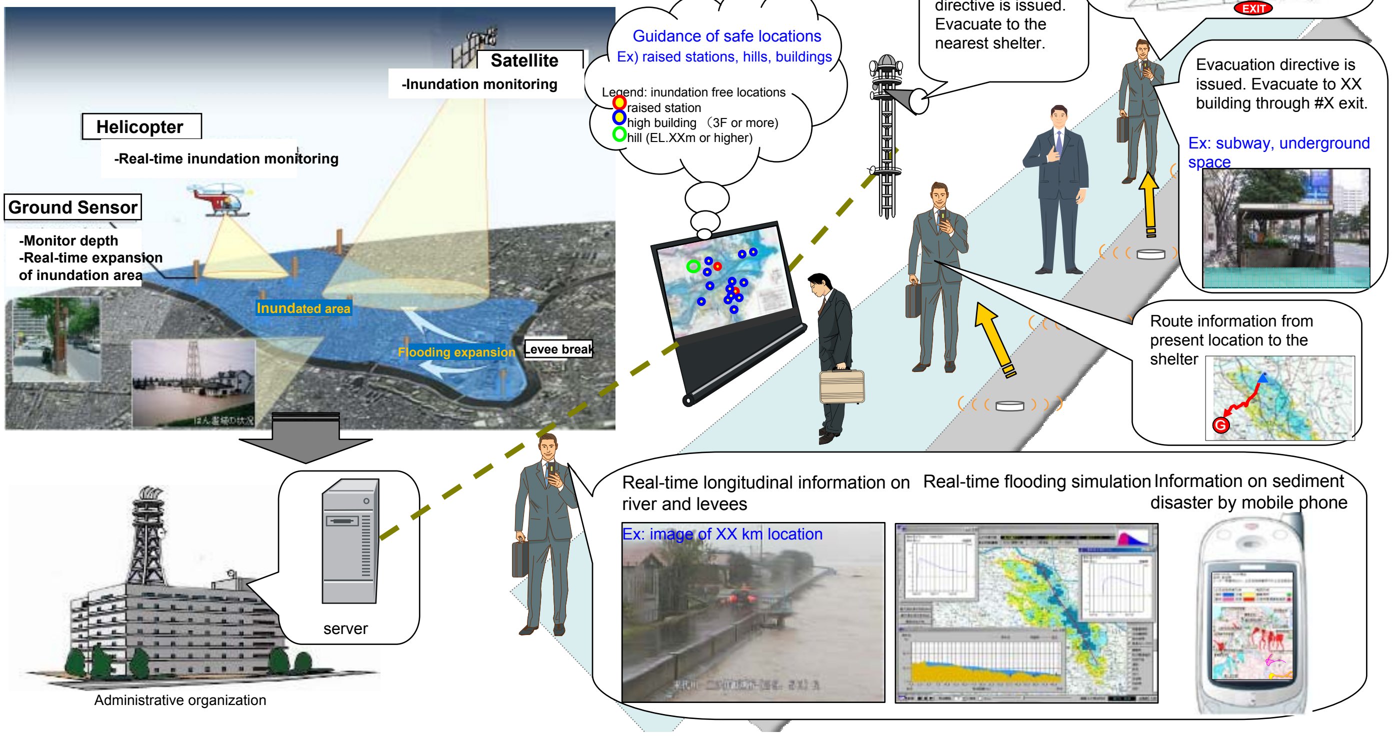
- A ubiquitous network enables to obtain information in no service areas of cellular phones and GPS.
- A ubiquitous network enables strangers to obtain evacuation routes.

◆Mobile phones, ubiquitous communicators and other portable terminals
◆TV, radio, radio communications for disaster prevention and administration



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

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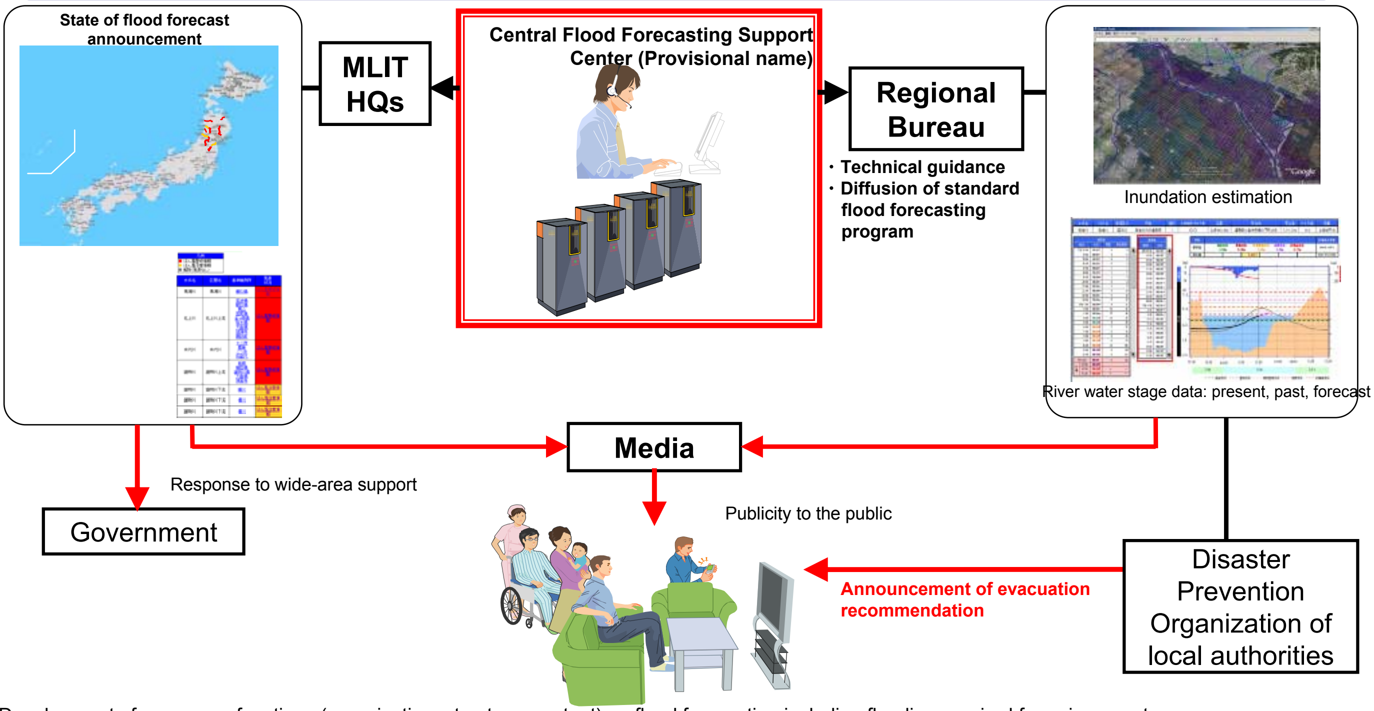
1. During a non-flood period, a flood forecasting central center provides technical support and assistance and accumulates knowhow of more accurate forecasting
2. A flood forecasting central center promptly responds to wide-area support, summarizing information from each local flood forecasting organization.
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

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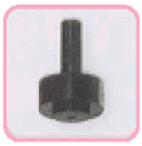
- Build awareness of water saving (persistent public relations)
- Regulations and incentive programs for individuals or companies to promote development of water saving appliances
- Further increase in recycled rate of industrial use of water
- Promotion of wastewater reuse and water harvesting

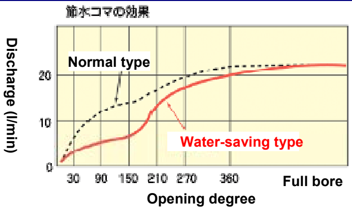
Efforts of water-saving awareness raising in the city of Matsuyama (from webpage of Matsuyama city)

●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.

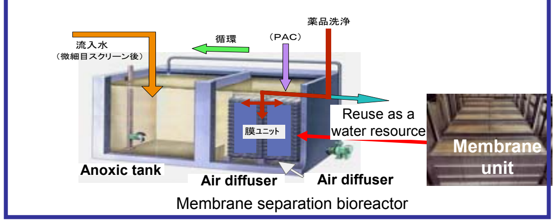
Water-saving by faucet valve (from webpage of Waterworks Department Tokyo Metropolitan Gov.


▲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

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- 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