VIII LECTURE NOTES

Ⅷ-1 Water-related disaster management for adaptation to climate change

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Abstract

Climate change is not a matter of future but of now. Human being is experiencing more frequent and more intensified hydro-meteorological extremes all over the world. The consequences are especially tragic in developing countries where infrastructure construction and management capacity development are behind. Disasters ruin development efforts.

There is no magic solution. But a mere continuation of the current exercise is not allowed and a major paradigm shift is necessary. Human has to reconstruct our way of living with nature. The combination between structural and non-structural means under the concept of integrated water resources management (IWRM) is necessary. Although there are various strong trials, it is not an easy matter at all. It is absolutely necessary to mainstream the water-related disaster management in decision making at all levels from the national government to localities.

Climate change is definitely the major agenda of the 21st century. There are some examples already emerging for adaptation to climate change especially against sea level rise. The paper reviews the recent reports by OECD, IPCC and River Bureau of Japan and shows some efforts that support the new way of living with floods that have been exercised by ICHARM such as global flood alert system, flood hazard mapping, capacity building etc. ICHARM calls for an alliance for localism to work together to solve real problems of the people.

1. Introduction

This year again, many flood disasters have taken place in the world. The heavy rain and floods that hit southeastern China, most notably the basin of Huai River, from June to August caused tremendous damage in various regions, including the loss of nearly 1,300 lives as reported. The continuous rain in the UK from June to July was unusually heavy for this country, recording a daily rainfall exceeding 100 mm at many locations and affecting more than one million people. The damage covered by insurance was reported 2 billion pounds (approximately 500 billion yen). The floods that struck Nepal, India, and Bangladesh from July to August reportedly caused 2,200 deaths and more than 30 million refugees in total. North Korea announced that the rain from August 7 to 15 left more than 600 persons dead or missing. Serious flood disasters also took place in Pakistan, Texas, and elsewhere, and several category 5 cyclones developed in various regions. On the other hand, many areas in Europe experienced high temperatures exceeding 45℃ this year, following the extraordinary heat wave in 2003. No less than 500 persons reportedly died from heatstroke in Hungary alone. Australia is experiencing an unprecedented spell of drought that has been continuing for 5 years since 2003. In particular, the year 2006 was declared as the year of drought that would occur once in a millennium. In Japan, a temperature of 40.9℃ was recorded in Tajimi and Kumagaya on August 16, breaking the past record of 40.8℃ in Yamagata 74 years ago. The situation is obviously abnormal. The effect of climate change has become a real and tangible problem.

From June 5 to 7, 2007, the Global Platform for Disaster Risk Reduction was held at Geneva International Conference Center organized by UN/ISDR. Nearly 1,000 participants, including representatives from various countries, international organizations, and NGOs, filled the conference venue on the opening day. During the opening session, John Holmes, UN Under-Secretary-General for Humanitarian Affairs, spoke as the Chairman of the Platform and explained the central theme of this conference, emphasizing that global warming is no longer a problem of the future but of the present. As he remarked, the climate change has already caused a dramatic increase in the occurrence of meteorological disasters, and the damage from such disasters is escalating all over the world. We have no time to waste. The need for the adaptation to climate change has become extremely urgent.

This conference was the first of the biennial events held as the follow-up to the Hyogo Framework for Action (HFA) in 2005. In response to the 4th IPCC report, published in February, many speakers argued that any efforts to reduce greenhouse gas emission would not be effective in arresting the expansion of climate change in the foreseeable future, and extreme meteorological events would continue to expand. Water-related disasters, which already represent 80% of all natural disasters at the present, would become even more serious. To cope with this situation, the conference repeatedly stressed that the adaptation to climate change must be positioned in the mainstream of national policies of all countries. While the conference called for a paradigm shift toward disaster risk reduction (DDR) under the slogan of "Mainstreaming DDR," the interest of many speakers were focused on the issues of meteorological disasters, in particular the adaptation to climate change.

In June, the leaders at the G8 summit in Heiligendamm agreed to seriously consider the proposal of EU, Canada, and Japan, including the halving of global emissions by 2050. This was an epoch-making decision, expected to have immeasurable impacts on society. Because global warming becomes a real problem when disasters resulting from it get out of control, it is sure that the political interest in the issue of CO_2 reduction will soon translate into the issue of the adaptation to climate change.

What each country needs to do? This will be the main issue in the Lake Toya G8 summit in 2009.

This article reviews the adaptation options implemented in various countries, discusses the necessary future directions of water-related disaster prevention, and considers what should be the basic stance of each coountry.

2. Water Disasters on the Increase

2.1 Water Disasters in Statistical Figures

CRED EM-DAT, operated by the Catholic University of Louvain, Belgium, is virtually the only international database on natural disasters available for statistical analyses. This database is the collection of information on natural disasters occurring in and after 1900 and fulfilling at least one of the following criteria: 10 or more people

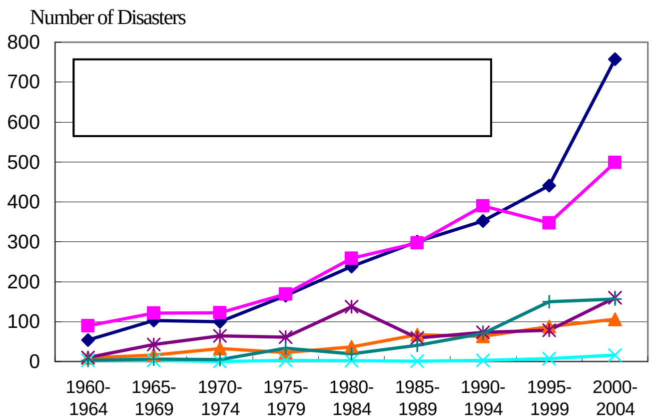

Fig. 1.1 Trend in the Occurrence of Water-related Disasters in the World (1960-2004)
Floods and storm disasters are increasing rapidly.

reported killed, 100 people reported affected, declaration of a state of emergency, or call for international assistance (http://www.em-dat.net/index.htm). However, the accuracy of this database is questionable, and some believe that NatCat, compiled by Munich Re, a reinsurance company underwriting disaster insurance, is more accurate. NatCat is, however, closed to the public and made available only in the form of reports. It is the data in EM-DAT that provides basic input for the making of most strategic plans all over the world.

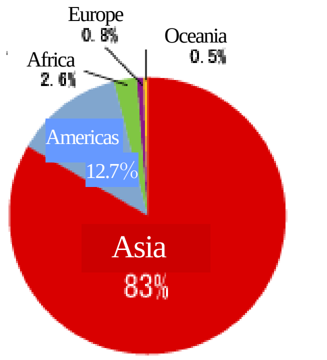

Fig. 1.2 Distribution of Deaths from Water-related Disasters by Continent (1980-2006)
The number in Asia is overwhelmingly large.

Fig. 1.1 shows the number of natural disasters in the period frc ... :M-DAT (Merabtene and Yoshitani, 2005). The rapid increase in the number of floods and storms is remarkable. While the recent expansion of mass media coverage may be contributing to the increased number of reported disasters, these figures certainly reflect the actual occurrence of hazardous events.

Landslide and storm surge disasters are few in terms of the number of incidences. Earthquakes and droughts are also few, though the amount of damage is large. Meteorological disasters (flood, storm, landslide, debris flow, drought, storm surge, and tsunami) represent 75% of the total amount of damage.

Fig. 1.2 shows the pie chart of the number of disaster deaths in the period from 1980 to 2006 by continent. Deaths in Asia represent 83% of the total. While the share of Asia in the number of disasters is about 40%, the concentration of fatalities in Asia is overwhelming. It is partly true that there are many deaths in Asia because 60% of the world's population lives there, but the high figure in Asia is out of proportion.

2.2 Climate Change is not the Principal Cause of Increase in Water Disasters

Disaster risk is often expressed by the following formula (Davis, 1978):

Disaster Risk (R) = Hazard (H) x Vulnerability (V)

This says that the risk of disasters occurs in the intersection of the external hazardous forces and the vulnerability to disasters, and the magnitude of risk is the product of hazard and vulnerability. In the case of natural disasters, hazard is the violent forces of nature and vulnerability is the characteristic of human society. In some analyses, the vulnerability of community is further broken down to the basic coping capacity of society, including economy, organizational structure, education as well as the efforts in developing disaster prevention infrastructure and emergency preparedness. Such approaches are expressed in the following forms:

Natural Disaster Risk (R) = Natural Hazard (H) x Societal Vulnerability (V) / Coping Capacity (C)

Natural Disaster Risk (R) = Natural Hazard (H) x Societal Vulnerability (V) x Exposure (E)

The former is the one advocated and practiced by the International Federation of Red Cross and Red Crescent Societies. Here, coping capacity means disaster prevention infrastructure and preparedness. The latter is proposed by Associated Program on Flood Management (APFM) of WMO. In contrary to the above, exposure refers to the people and assets that are left exposed in places lacking sufficient disaster prevention infrastructure and preparedness to cope with disasters. These are the people and assets that are not protected by strong buildings, embankments, or reservoirs. These modified expressions reflect the endeavor to clarify quantitative evaluation of the effectiveness of disaster prevention infrastructure. However, there are difficulties in the handling of dilemmas, such as that the presence of disaster prevention infrastructure may cause overconfidence and result in larger damage in the case of unexpectedly severe hazards.

As clearly shown in this analysis, the magnitude of natural disasters is determined by the product of the hazardous forces of nature and the vulnerability of society. Earthquakes and volcanic eruptions do not seem to be increasing in the long view, but the damage from such disasters is increasing. This trend reflects the increase in the vulnerability of society resulting from such factors as population growth, expansion of poverty, urbanization, and economic development. On the other hand, meteorological disasters are aggravating because of the intensification of meteorological phenomena in addition to the disaster vulnerability of society. Water-related disasters are getting severer as a result of the increase in the forces of nature and the increase in the vulnerability of society.

However, how large is the contribution of climate change in the increase in disasters shown in Fig. 1.1? It actually is fairly small. An overwhelmingly large part of this increase is caused by the increase in the disaster vulnerability of society. With urbanization, industrialization, and other changes, communities are experiencing a rise in population density, concentration of economic assets, a shift to more and more artificial lifestyle, development of economic activities, and land development in sloped areas and low-lying wetland. As a result, the probability of damage and the density of damage (damage potential) once extreme events hit the area, i.e., disaster vulnerability, are increasing year by year. The aging of inhabitants, the disruption of the inheritance of disaster experience resulting from mobilization of inhabitants, the weakening of community solidarity, etc. are also contributing to the increase. The intensification of meteorological phenomena resulting from climate change is a factor amplifying the severity of actual water-related disasters, but it is not the principal factor at the present.

In this respect, an interesting research was presented at IPCC WGII (2007). According to the case study in the US conducted by Choi and Fisher (2003), 82% of damage from disasters is explained by population density and the density of economic activities. The magnitude of hazard is responsible for only 7% of damage. This clearly indicates that the effect of disasters is determined primarily by the exposure of people and assets to natural phenomena. The best way to avoid disaster is to displace population and activities from disaster-prone areas.

2.3 Developing Countries and Developed Countries

Disasters hit weaker people harder. In addition to senior citizens, infants, sick persons, and physically handicapped persons, women are counted among vulnerable groups in many areas. In particular, women in some developing countries where gender discrimination remains often hesitate to evacuate because of the forced responsibility to keep their homes and the fear for the harsh living conditions in refuges, including the risk of being raped. Not a few women actually become victim to crimes in refuges. A further vulnerable group is the poor, and the people in many developing countries where the nations themselves are poor. People in poverty live in dangerous areas without disaster prevention measures. They have only limited access to disaster information such as forecasts, and lack sufficient resilience to disasters. Developing countries with many poor people cannot afford to develop the capacity to overcome vulnerability, such as the construction of disaster prevention infrastructure, development of preparedness, and disaster education.

The true causes of disasters in developing countries are poverty and poor governance. Because they are poor, they cannot invest in infrastructure, preparedness, or disaster education. Because the poor majority cannot afford to choose where they live in what types of residence, they live in disaster-prone areas unprotected and suffer great damage whenever hit by a disaster. They have fallen into a vicious cycle, where they cannot prevent disasters and a large part of their hard-earned economic growth is lost to disasters. Although development and growth can help people get rid of poverty, there is a factor impeding this. It is governance. People lack the self-governing ability, which is the ability to autonomously govern a state, city, or community and join forces toward the achievement of goals. While poverty is inseparable from this situation, social order has not been established sufficiently, due to local culture and customs, as well as the lack of education opportunities. As a result, reliability is not ensured when a precise and reliable system of responsibility is needed in various aspects from the accurate measurement and transmission of rainfall and river flow data to the direction and guiding of people in emergencies. Many organizations lack the basic mechanism for fair, impartial, and efficient development, as signified by the habits of bribery and kickbacks in the execution of budgets and selection of venders. Official development assistance (ODA) is also often spoiled by a culture of extortion, undermining the ability to achieve expected results.

On the other hand, problems in developed countries include the soaring of the amount of economic damage, the need for an enormous amount of fund for mitigation, and the difficulty in forming social agreement regarding the selection and execution of plans. It is extremely difficult to maintain or expand the investment in water management as has been conducted in the past. For this reason, it is clear that we need to make a shift toward water disaster management focusing on harmonious coexistence with nature, including the coexistence with floods, but we face a difficulty in finding an acceptable combination of land use and disaster prevention measures. The threat of large-scale meteorological disasters is expected to grow, and the need for measures against such disasters is well recognized, including those regarding the maintenance of economic activities and citizens' living and the relief for socially weak people. However, it is also extremely difficult to achieve an agreement regarding the choice of solutions. The central themes are the restoration of nature in dams and rivers and the restriction on land use. In considering this situation, we need to be aware that the populations in developed countries are not only aged but also have turned from stabilization to decrease. In a sense, this situation may be regarded as an ideal opportunity for the reconstruction of a coexisting relationship between humans and nature.

3. What Should Be the Adaptation Options

In this situation, we consider what should be the measures for adaptation to global warming. Adaptation options must be consistent with mitigation measures at the roots. In addition, this can be achieved only through the construction of a sustainable society based on scientific means and strategies. This basic principle is common to developed countries and developing countries. However, no adaptation options clearly following this principle have been implemented yet. Discussions are made almost exclusively in developed countries. As a starting point, we review in the following the specific adaptation options described in the reports of OECD and IPCC, as well as the strategy adopted by River Bureau of Japan.

3.1 Adaptation Options in Various Countries

OECD Report

The OECD report "Progress on Adaptation to Climate Change in Developed Countries" (Gagnon-Lebrun and Agrawala, 2006) presents the result of analysis on activities for adaptation to climate change in various countries based on the review of National Communications (Nos. 1-3), which member countries must submit regularly, and other material. The study was conducted by the Organization for Economic Cooperation and Development (OECD) in 2005-2006, covering 30 OECD member countries and 41 UNFCCC member countries, totaling to 43 countries (mostly consisting of developed countries and former USSR countries).

This report points out that the interest in the effect of global warming and measures for adaptation to it is limited as compared with the political discussion on greenhouse gas reduction. Only very few countries reported the implementation of specific adaptation options. The following lists some of concrete examples described in the report. Many of these are measures against sea-level rise.

- In New Jersey, where relative sea level is rising approximately one inch (2.5 cm) every six years, $15 million is now set aside each year for shore protection, and the state discourages construction that would later require sea walls.
- Maine, Rhode Island, South Carolina, and Massachusetts have implemented various forms of “rolling easement” policies to ensure that wetlands and beaches can migrate inland as sea level rises, and that coastal landowners and conservation agencies can purchase the required easements.
- A 2001 assessment concluded that the water supply of New York City is vulnerable to changes in climate parameters – such as temperature and precipitation, as well as sea-level rise and extreme events. On the basis of this assessment, the New York City Department of Environmental Protection initiated work to identify adaptation options, including the tightening of drought regulations, the construction of floodwalls around low-lying wastewater treatment plants, and the integration of the New York City system with other regional systems to alleviate the impacts of temporary disruption in some facilities as a result of inland flooding or of variations in water supply.
- A new sewage treatment plant was built in 1998 by the Massachusetts Water Resource Authority on Deer Island within Boston Harbor. Expecting future sea-level rise, this plant was sited at a level higher than the original plan by 1 m. While the short term costs of pumping untreated sewage up to the plant would have been lower had the plant been built at lower level, engineers attached more importance to the need for future construction of a protective wall and the cost of carrying water over the wall.

Fig. 2.1 Maeslantkering Storm Surge Barrier near Rotterdam, the Netherlands. Completed in June 1997

- The Thames Barrier was originally built over a 30-year period, following the 1953 storm surge in the North Sea, to protect London. While even the original design complied with high standards (generally one-in-a-1000-year flooding event), it did not explicitly take climate change into account at that time. The combination of rising sea level, due to climate change, and rapid housing development within the tidal flood plain is expected to increase the flood risk; it is estimated that by the year 2030 modifications to the barrier will be required. A Flood Risk Management Plan is therefore currently being developed to protect London and the Thames Estuary for the next 100 years. A multi-faceted study of adaptation options is currently underway and is assessing, among others, a) 337 kilometers of coastal defenses (including nine major flood control barriers); b) the evolution of the socioeconomic context throughout the Thames estuary; and c) the influence of political and other drivers on the choice of specific options.

- In the Netherlands, the Flooding Defense Act came into force in 1996. This act mentions, the safety standards for all water defenses varying from one in 10,000 to one in 1250 years (Note by author: The former applies to coasts, the latter to rivers). Every five years the Minister has to determine the decisive water levels matching to these frequencies. Since these decisive levels will determine the height of the embankments, the most recent knowledge on climate change can be incorporated every 5 years into the design of the flood defense.
- In 1995, the Technical Advisory Committee on Water Defense has recommended reserving space in the dune area to guarantee safety for the next 200 years, with a worst-case scenario of 85 cm sea-level rise and a 10% per century increase in storms.
- In the Netherlands, the design of (unavoidable) new engineering works with a long lifetime, like storm surge barriers and dams, will incorporate an expected sea-level rise of 50 cm. The first structure of this kind is the storm surge barrier near Rotterdam (Fig. 2.1), which opened in 1997.
- South Australian Government planning principles now require that coastal developments be safe for a 30-centimeter rise in sea level, or one meter in special circumstances. Developments must also be safe for, or capable of being protected against, 100 years of coastal erosion, with allowance made for the erosion resulting from a sea level rise of 30 centimeters.
- In New South Wales, the National Parks and Wildlife Service has developed a biodiversity strategy that recognizes the potential role of environmentally managed 'corridors' in enabling species migration in response to climate change.
- The Confederation Bridge in Canada (linking New Brunswick and Prince Edward Island) was completed in 1997. To accommodate for the potential sea-level rise over the 100-year lifespan, the vertical clearance planned to allow for the navigation of ocean-going vessels has been increased by one meter (Fig. 2.2).

Fig. 2.2 Confederation Bridge in Canada. Completed in May 1997. Length 12.9km, 60 m high navigation span (including 1 m allowance for sea-level rise).

Although few in number, these adaptation options testify that concrete actions to cope with sea-level rise has begun. If the problem of speed is set aside, sea-level rise is a simple issue and its impact and needed countermeasures are relatively obvious. Governments are tackling this problem based on the political judgment that they should begin with what they can. In contrast, the impact of global warming on floods and debris flow has not been clarified quantitatively. Many problems remain in the field of these disasters, and goals have not been achieved. Governments must first endeavor to solve the present problems. The impact of global warming is a burden imposed in addition to present problems.

Japan described no adaptation options in the National Communications to OECD. The only countries that did not mention adaptation options other than Japan were Slovenia, Estonia, Lithuania, and Mexico.

IPCC2007 WGII Report

Similar endeavors are also described in the report of IPCC 2007 WGII (Parry et al. eds., 2007), but there are few concrete descriptions. The following is the excerpt from Chapter 3 "Freshwater Resources and Their Management."

- The Metropolitan Water District of Southern California recently concluded a 35-year option contract (under which a buyer has a right to buy products on his/her will, and a seller has to sell products according to the buyer’s need) with Palo Verde Irrigation District. Under the arrangement, the district’s landowners have agreed not to irrigate up to 29% of the valley’s farm land at Metropolitan’s request, thereby creating a water supply of up to 137 Mm^3 for Metropolitan. In exchange, landowners receive a one-time payment per hectare allocated, and additional annual payments for each hectare not irrigated under the program in that year.
- Improved seasonal forecasting was shown to offset the effects of climate change on hydropower generation from Folsom Lake, California.
- In the UK, design flood magnitudes can be increased by 20% to reflect the possible effects of climate change.
- Measures to cope with the increase of the design discharge for the Rhine in the Netherlands from 15,000 to 16,000 m^3/s must be implemented by 2015, and it is planned to increase the design discharge to 18,000 m^3/s in the longer term, due to climate change.

Actions of the River Bureau of Japan

Although there have been no cases of adaptation options implemented in Japan, the River Bureau has established various committees under the River Section of Social Capital Development Council to study various measures for water-related disaster management. Following the storm and flood disasters in 2004 (10 typhoons hit Japan in this year), the General Policy Committee on Heavy Rain Disaster compiled "On the Promotion of Comprehensive Measures against Heavy Rain Disaster (Proposal)" (April 2005). After the record-breaking heavy rain in Miyazaki Prefecture and other areas due to Typhoon No. 14 in September 2005, the Study Committee on Large-scale Rain Disaster issued "Damage Minimization on Flood Disaster and Landslide Disaster" (December 2005). In response to the attack of hurricane Katrina on New Orleans in August 2005, the Zero-meter Zone Storm Surge Study Committee developed "Future Storm Surge Management in Zero-meter Zone" (January 2006).

While these committees addressed the problems with an eye to climate change, adaptation to climate change was not a direct focus in their activities. The Subcommittee on Flood Measures was therefore established to discuss "Flood Measures Adapting to Climate Change" (1st meeting on August 27, 2007). The basic understanding and the directions of adaptation options proposed by the subcommittee are, in terms of writer's interpretation, as summarized below.
(http://www.mlit.go.jp/river/shinngikai/flood_measure/index.html)

Basic Understanding:

1. Approximately one-half of the national population and three-fourths of total assets are concentrated in alluvial plains occupying 10% of national land area, and there are zero-meter zones along the 3 bays in crucial areas (Tokyo Bay, Ise Bay, and Osaka Bay). The current degree of achievement in river improvement is about 60% of the short-term goals (1/30 to 1/40 for large rivers and 1/5 to 1/10 for small and medium rivers). In this situation, sea-level rise and intensification of heavy rain and typhoon disasters are expected to occur due to climate change. Therefore, prompt planning of adaptation options is needed.
2. Adaptation and mitigation must be promoted side by side.
3. Even though there are ambiguities and uncertainties, the state government must fulfill its responsibility as the administrator of water management policies by indicating appropriate adaptation options before it is too late.
4. In this process, attention must be paid to the present state and future prospects of water management policies, including the consideration of the change in social conditions such as the decrease in population, less children and population aging, and the change in land use, as well as the state of investment capacity, facility improvement, and past water management plans.
5. Japan must make use of its successful experiences, programs, and technologies for the sake of international contribution.

Basic Directions of Adaptation Options:

Water management is a process of improvement works in long-term plans, and adaptation options responding to the change in hazard need to be incorporated in this process. The basic directions are the revision of facilities and social structure aiming at damage minimization on one hand and emergency disaster responses on the other.

Revision of Facilities and Social Structure

- Ensuring the reliability of facilities against the change of external factors (including inspections and other activities), full utilization and service-life elongation of existing facilities, and construction of new

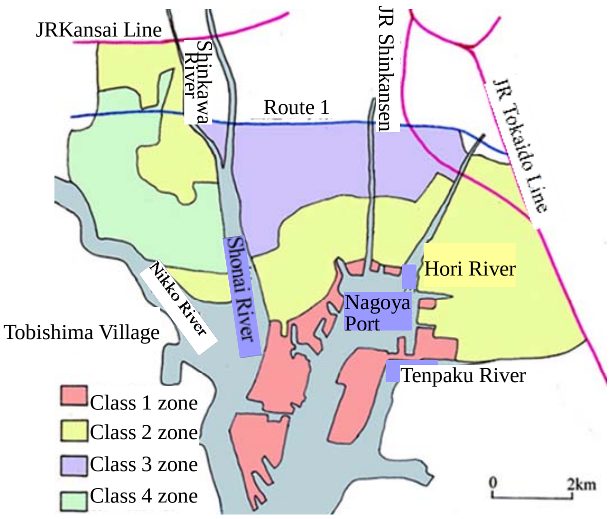

Fig. 2.3 Disaster Hazard Zones in Nagoya City (1961), designated following the Isewan typhoon in 1959.

facilities.

- In addition to the improvement of disaster prevention facilities and risk management measures, adaptation must include the revision of social structure such as alteration of land use and housing (e.g., the designation of class 1 to 4 disaster hazard zones in Nagoya City, 1961 (Fig. 2.3)).

Emergency Disaster Responses

- In addition to the state-operated wide-area disaster support system and disaster response network, collaboration with communities will be developed to achieve the capability and system to respond to large-scale disasters, including emergency responses and draining of floodwater in the event of embankment collapse and flooding.
- Assuming the increase in frequency and magnitude of hazard due to climate change, new scenarios will be developed and used in various non-structural measures combined with construction and improvement of structural facilities to support flood management, evacuation, rescue, restoration, and the construction of safe communities.

Methods to Implement Adaptation Options

- Investment will be concentrated on preventive measures in facilities and areas expected to be particularly vulnerable, as well as areas with high accumulation of population, assets, and central functions.
- As there are uncertainties in the prediction of climate change, it is necessary to use an adaptive approach in which scenarios will be modified according to future observation data and findings.
- Through collaboration of industry, academia, and government, new impact assessment methods and adaptation technologies will be developed. In addition, the experience, programs, and technologies of Japan will be made widely available for international contribution such as providing support to developing countries.
- Research and study will be promoted in collaboration with universities and research organizations, and the results will be reflected in water management plans.

These discussions are all reasonable as a starting point. It is highly valued that the government considers mitigation and adaptation as the two wheels of a cart and states "Even though there are ambiguities and uncertainties, the state government must fulfill its responsibility as the administrator of water management policies by indicating appropriate adaptation options before it is too late" in the Basic Understanding section. The recognition of the need for international contribution through disaster management technologies, as a part of Japanese foreign policy based on science and technology, should also be appreciated highly.

The Basic Directions section contains many proposals that are considered highly desirable, such as the full utilization and service-life elongation of existing facilities, the designation of disaster hazard zones, the emphasis on emergency responses and research, and prioritized investment in vulnerable areas. The River Bureau emphasizes the concept of adaptive measures and states "Water management is a process of improvement works in long-term plans, and adaptation options responding to the change in hazard need to be incorporated in this process" in the beginning. This seems to reflect the judgment of the administrative authorities that there should be no other practical ways. The key question is how far adaptation options can be promoted when the government plans to introduce them while continuing the present process of water management. This needs to be addressed in future discussions.

3.2 Water Disaster Prevention in Sustainable Development

The Best Mix of Mitigation and Adaptation

We have reviewed the present state through the OECD study, the IPCC report, and the proposals of the River Bureau. The actions of developed countries are clearly the extension to what they are doing at the present, mainly consisting of adjustment to the situation at hand. Measures such as raising storm surge barriers, increasing the height of bridges over estuaries, and "rolling easement" in wetlands all illustrate how humans are running about trying to escape from invading sea. It is natural that people take actions in such ways in the early stage of response, but we need something more to win.

On August 20 this year, the Cabinet Office organized the 1st Symposium on Climate Change "Optimization of Mitigation and Adaptation to Cope with Climate Change – Defining Comprehensive Measures against Global Warming." The theme of this symposium was the best mix of mitigation and adaptation. The purpose was to be able to overcome the changes in centuries to come by using the best mix of measures to mitigate global warming through greenhouse gas reduction and adaptation to climate change.

According to the report of IPCC 2007 WGI (IPCC, 2007), the A1FI scenario (very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies; a substantial reduction in regional differences in per capita income; fossil-intensive energy sources) would cause a temperature rise of 2.4-6.4 degrees (4 in average) by the end of the 21st century. The B1 scenario (the same global population as in A1; rapid change in economic structures toward a service and information economy, with reductions in material intensity and introduction of clean and resource-efficient technologies; global solutions to economic, social and environmental sustainability, including improved equity) would cause a temperature rise of 1.1-2.9 degrees (1.8 in average).

Mitigation measures to limit the temperature rise within 2 degrees must be rigorous. The strategy needed involves the introduction of energy-saving technologies and the realization of a sustainable recycling society through a shift away from mass production, mass consumption, and mass disposal throughout the world. Lifestyle change is an essential prerequisite for the shift from profuse use of materials and the realization of economic, social, and environmental sustainability. According to the presentation made by Mr. Shuzo Nishioka at the above-mentioned 1st Symposium on Climate Change, Japanese people need to reduce emissions by as much as 90% relative to the emissions in 1990, if a 50% global reduction were to be achieved by 2050 and all people in the world were to have equal share in emissions. This is a matter of ethics. Because the population and living standards in developing countries should continue to grow, developed countries need to attain reduction much larger than 50% to limit the temperature rise within 2 degrees. The Stern Review Report (2006), however, predicts that the costs of action – reducing greenhouse gas emissions to avoid the worst impacts of climate change – can be limited to around 1% of global GDP each year through the use of science and political leadership. Considering the stance of political leaders in the present world, including Al Gore Ex-Vice-President of the USA and Prime Minister Abe in Japan, the realization of this prediction seems to be possible, but it nevertheless requires a paradigm shift in society. If it is needed for mitigation, it also is needed for adaptation. This means the need for adaptation within the framework of sustainable development. We need to choose a way of living supporting harmonious coexistence with nature, rather than megastructures imposing much environmental burden.

Water-related Disaster Prevention in Harmonious Coexistence with Nature

Speaking of the choices in the way of living, we first need to base our discussion on the fact that water environment is established in the quasi-equilibrium of interactions among climate, land, and people. In such a system, a change in any of these elements must be responded with the change in all other elements toward a new state of equilibrium. It is a well-known fact that the failure of humans in accommodating to changes has resulted in the collapse of many civilizations in the history. The same applies to the present-day megalopolis civilization located in flood plains.

Flood plains have been developed for human activities because of various benefits they provide. We cannot and need not to give up the benefits. However, when a fundamental change takes place in natural conditions, we cannot forcefully hold back such change with physical structures and maintain our present way of living for a long time. We need to change our way of living and relocate activities so that we can attain a solution achieving the optimal use of land. We not only need to find a way to minimize damage under the existing conditions, but also move the place of living to the best locations under the new conditions. In short, we should avoid living in disaster-threatened areas as much as possible.

The population of Japan is expected to drop to 100 million by 2050 from the present 127.7 million. This means a decrease of approximately 30 million. Japanese regard this decrease as a great opportunity for choosing a new way of living and reconsidering harmonious coexistence with nature.

There are many measures to support water-related disaster prevention in harmonious coexistence with nature. Physical measures include dams, banks, soil-erosion control works, improvement of river channels, infiltration and storage facilities, drainage facilities, and water-resistant buildings. Non-physical measures include forecasting and warning, hazard maps, evacuation, land use regulation, flood prevention activities, and education and practice. All of these are indispensable measures and need to function in the best possible way. The problem is the specific contents and roles of these measures. It is important first to ensure the practice of basic watershed management, including the maintenance of the reservoir function of rice fields, preservation of the adjustment function of forests, basin-wide measures to stabilize sand and soil flow, and prevention of land subsidence through pumping restrictions.

In many developing countries and elsewhere in the world, the need to address emergencies at hand is impeding the development of responses based on long-term plans. In addition, problems are aggravating in many places due to the further concentration of population, land subsidence, illegal occupation of land, and other factors. In such areas, climate change may act as a force to compel people to move out of certain disaster-threatened areas.

4. International Contribution of Japan

Developing strong international relations in science and technology has long been a basic desire of Japan. In fact, Japan has been taking remarkable leadership in international contribution regarding environmental issues and disaster prevention. Notable examples in the environmental field are the Tokyo Declaration of "sustainable development" made by the World Committee on Environment and Development in 1987 and the adoption of the Kyoto Protocol in 1997. In the field of disaster prevention, the adoption of the Yokohama Strategy at the World Conference on Natural Disaster Reduction in 1994 and the adoption of the Hyogo

Framework for Action (HFA) at the UN World Conference on Disaster Reduction in 2005 are the most important developments. The HFA is now serving as the international guidelines for disaster management strategies. These will undoubtedly continue to play important roles in the adaptation to global warming.

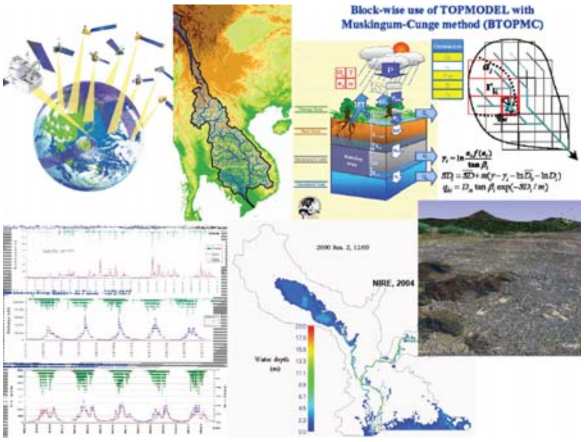

Fig. 3 Flood Forecasting and Warning System Proposed by ICHARM (Conceptual Illustration)

ICHARM, the Only Global Center for Water Disaster Management in the World

The International Center for Water Hazard and Risk Management (ICHARM) under the auspices of UNESCO is a category II center by UNESCO hosted by Public Works Research Institute, established in March 2006 under the agreement among UNESCO, the Japanese government, and Public Works Research Institute. ICHARM is the world's only research and educational organization specializing in water-related disaster reduction with a global view. Japan has a history of tackling severe water-related disasters and achieving remarkable development. The international contribution based on such experience and technical expertise is expected to be valuable.

In alliance with various organizations and initiatives sharing the similar aims and activities in the world, ICHARM aims to provide and assist implementation of best practicable strategies to deduce water-related disaster risk in the globe, nations, regions and localities. At the first stage, the focus is on flood-related disasters and accordingly, contribution to Asia and the Pacific is in the highest priority. The present activities at ICHARM are focused on prediction of the change in disaster risk due to global warming, flood forecasting and warning based on high technologies including satellites, advanced models and many IT tools, and the support to education, training, and local community activities. .

Because the adaptation to global warming must begin with the management of water-related disasters, the system for flood forecasting and warning is an indispensable adaptation technology. Similar to the Indian Ocean Tsunami forecasting and dissemination system, ICHARM is aspiring to be able to provide such warning also for floods. Fig. 3 shows the conceptual illustration of a system for flood warning.

In education and training, ICHARM is conducting long-established programs for training in dam and river management, as well as flood hazard mapping training. A comprehensive training program on tsunami disaster is also planned to begin next year under the ISDR framework. It is notable that a masters' course in water disasters opened in October jointly with the National Graduate Institute for Policy Studies (GRIPS) and JICA. The course started with 11 students in the first year. The target students are the practitioners in disaster management with engineering background. To foster the solution and practice oriented engineers who can work for the nation and with local communities is the objective of education. Education is truly the foundation for sustainable development of nations.

Practical support to local communities is the most difficult challenge. Planning of specific measures has begun with the participation of highly motivated people from Nepal and Malaysia.

To ensure the success of ICHARM, it is working with many partners in the world such as UNESCO, WMO, ISDR, UNU and other universities, research institutes, professional associations, ADB, JICA and other funding agencies and many related programs and initiatives such as WWAP, WWF, APWF, Sentinel Asia, GEOSS, International Flood Initiative (IFI), etc. For IFI, ICHARM is serving as a secretariat. Especially the national institute in charge of public works in each country is the most important partner. Needless to say, domestic supports by Ministry of Land, Infrastructure and Transport, Ministry of Foreign Affairs, Ministry of Education, Culture, Sports, Science and Technology, and other relevant government organizations are working together.

5. Conclusion

Large-scale meteorological disasters are occurring in the world at an unprecedented frequently in recent years, but the temperature rise in the past 100 years has been only 0.5 degrees. A further increase of at least 2 degrees in the coming 100 years is considered unavoidable, even if we make desperate efforts to take mitigation measures. Although we are only at the entrance of a new experience, it is easily imaginable that such an extent of temperature rise would cause tremendous intensification of heavy rain, typhoons, and droughts. Furthermore, global population is expected to grow until the middle of the 21st century, and urbanization and industrialization continue to accelerate. The adaptation to climate change is the problem of how we can manage the disaster risk resulting form this situation.

Our only resources are science and technology, and wisdom. However well we can sophisticate observation, forecasting, and warning, and however well we can manage large engineering structures, it is technically and economically impossible to solve everything by science and technology. There is no upper limit to the intensification of disasters. Then, we must use our wisdom. Using wisdom, we need to choose how we dwell and how we live. We need to reconstruct the way we live in harmonious coexistence with nature.

The same applies to the mitigation of climate change. We have no other choices than suppressing energy consumption, suppressing production, consumption, and disposal of goods, and suppressing environmental impacts to achieve the goal of a recycling society. Again, the only means for achieving this goal are science and wisdom. This wisdom pertains to how humans use nature and settle in a state of quasi-equilibrium in the harmonious coexistence with nature. It is not the matter of regarding economy and institutions as fetters, but of considering how we can use them to achieve a solution. In the end, it is the matter of the governance of the human species. The problem of governance is not the issue in developing countries alone.

Mitigation and adaptation measures to cope with climate change are the largest problem for human beings in the 21st century, and this problem is the axis of socioeconomic changes in the years to come. Like it or not, it will emerge in the mainstream of policy making. How science and technology, and politics and economy can address this problem in nation's development and work as a team in international collaboration will decisively determine the future of any country.

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Predicted Effect of Global Climate Change on Precipitation Characteristics in Japan and related Research Activities in NILIM

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Abstract: Since Japan's precipitation is heavily influenced by local topography, grid intervals of models, the fourth IPCC report refer to, are too large to realize the precipitation. In this situation, Japan Metrological Agency/Metrological Research Institute Japan has developed 20Km models of grid interval. This paper introduces the analyses of 20Km models' results from the view point of flood disaster. The analyses are required to discuss rainfall intensity of long return-periods, because of the lack of long term results of models in the same climate. Outline of the project study of NILIM concerning adaptation to flood change by warming, which includes rainfall analyses, is also introduced in this paper.

1. Introduction

After the publication of the fourth IPCC report, public concern with global warming problem has been aroused more, also in Japan. Until now, most of the concerns tend toward the mitigation issues, which impressed by Kyoto protocol (1997), Declaration of Heiligendamm Summit (2007), etc. and adaptation issues are not so much interested in. Analysis of National Communications' report, required by UNFCCC, categorized Japan as the country that has greater coverage of climate change concerning issues, but focuses almost entirely on assessment of impacts (OECD, 2006). The analysis indicated Japan's activities for adaptation were insufficient. As a matter of fact, Japan has not submitted any comment of adaptation issues to NCs in spite of the many reports of assessment activities.

The assessment of impacts is, however, very important for the examinations of adaptation measures. Appropriate adaptation plans cannot be formed without accurate and quantitative projections. With regard to flood disaster control, projection of rainfall variation, which is executed through numerical simulation using climate model, is the most fundamental information. Though plural model-results are employed in the fourth IPCC report for the climate projections and future temperature is quantitatively discussed, we cannot obtain quantitative conclusions for future precipitation from the report. Reason of this may be insufficient accuracy of the simulations about precipitation.

Since the climate models require enormous amount of calculations, computer capacity as well as complex and very unstable characteristics of precipitation phenomena can limit the accuracy of estimations. The shortest horizontal interval of grids used in the fourth IPCC models is grater than 100Km. This interval is not short enough especially for Japan's precipitation where the area of the country is not so large and precipitation is heavily influenced by the land configuration. In order to

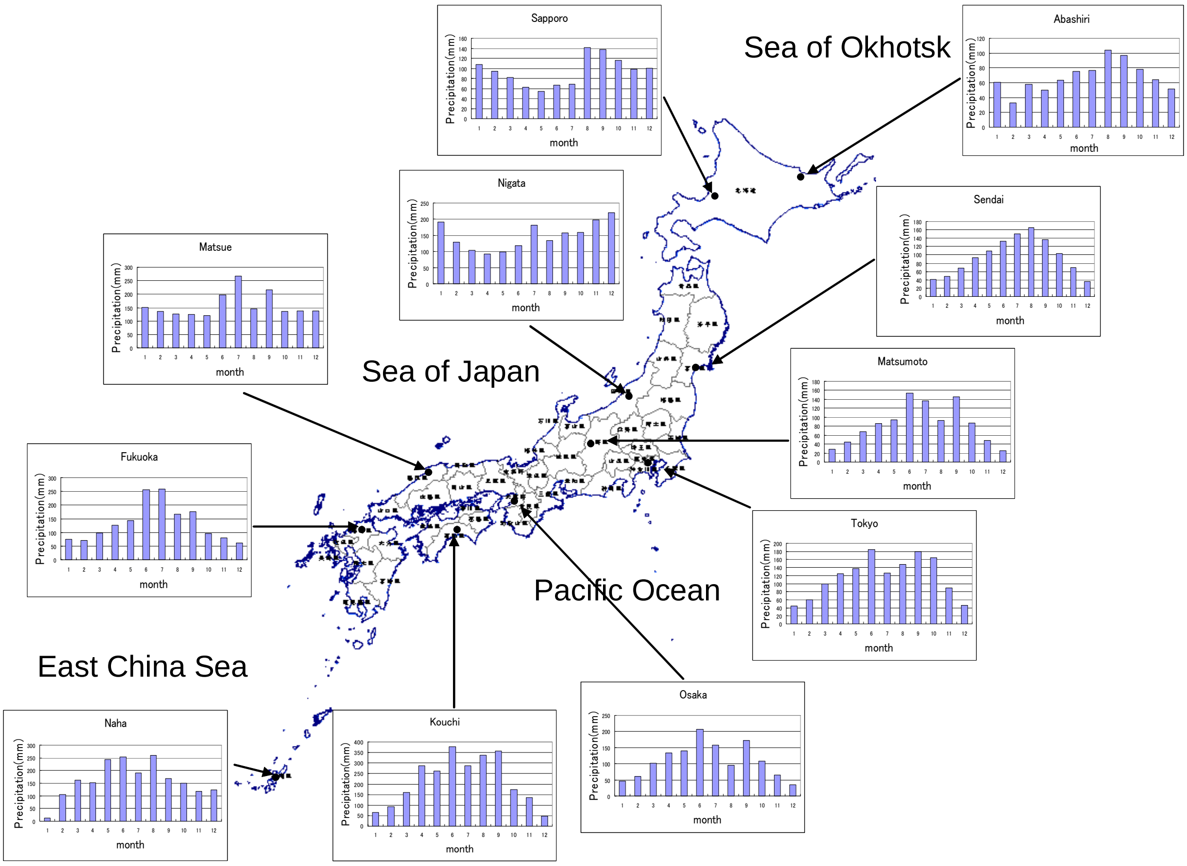


Figure-1 Monthly precipitations (average of 1961 to 1990) at representative points in Japan

obtain more accurate future precipitation projections of Japan's surrounding area, Japan Meteorological Agency/Meteorological Research Institute Japan have been trying to simulate using shouter interval grids.
This paper introduces calculation results of 20Km grid model, examined from the viewpoint of flood disaster control. They executed two 20Km grid model simulations; down-scaling regional model (RCM20) for A2 gas emission scenario and global model (GCM20) for A1B scenario. This paper mainly introduces the results of the global model. The global model results of other areas' could be expected to have the same accuracy as Japan's precipitation. The examination of the model results is a part of NIRIM's project study concerning adaptations to climate change effects. General of the project study is also introduced in this paper.

2. Japan's precipitation characteristics

Figure-1 shows the monthly precipitations (average of 1961 to 1990) of representative observatories in Japan. Though the area of Japan is not so large, Japan's land covers wide area in north to south direction. The topography including steep mountains is very complex. Also, Japan is located in the east coast of the Asian Continent where the climate is easily affected by the Continent and the Ocean. By above reasons, seasonal variation pattern of precipitation is considerably different by each region in Japan.

The rainy season in Japan is generally characterized by the phenomena of "baiu" front, "akisame" front and typhoon. "Baiu" front usually forms from June to July when the moist air over the Pacific Ocean meets the cooler continental air mass. When the warm air mass of Pacific Ocean weakens in autumn, the front comes back from north as “akisame” front (from September to October). Typhoons usually approach Japan from June to October. About three typhoons land annually on an average. Typhoon and “baiu/akisame” front sometimes act on each other and sometimes cause extreme rainfall.

Japan Sea side areas have somewhat large precipitation from November to February. The seasonal north-western wind caused by typical atmospheric pressure distribution in winter (west-high, east-low distribution) and mountains bring snowfall to those areas.

3. Outline of climate models

As mentioned before, the grid intervals of models, the fourth IPCC report refer to, are too large to the accurate projection of Japan’s precipitation. Japan Meteorological Agency (JMA) and Meteorological Research Institute Japan (MRI) presented two kinds of 20Km grid model (GCM20 and RCM20) for the precipitation change projection.

GCM20 and RCM20 is atmospheric model. Both models do not solve the interaction effects between atmosphere and sea. Sea surface is treated as the boundary conditions given by CGCM model’s results. CGCM model series are also developed by JMA and MRI and solve the interaction effects. IPCC reports refer to CGCM’s results. The horizontal grid interval of CGCM is about 280Km and the number of vertical layer is 30.

Table-1 shows the simulation conditions of GCM20 and RCM20. Because of the enormous amount of output data of GCM20, upper side data from surface were not stocked. We can use only surface data of GCM20.

Results of GCM20 will be mainly discussed in this paper. Though, the superiority of the models’ accuracy cannot be decided at this point, RCM20 generally shows somewhat larger results than GCM20’ results and observed precipitations.

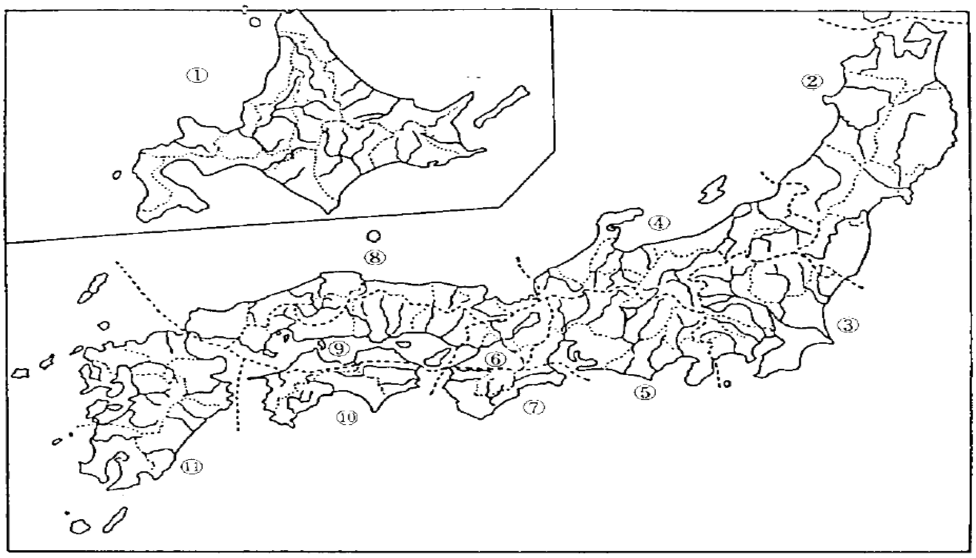
Table-1 Simulation conditions of GCM20 and RCM20

	Model	
	GCM20(General Circulation Model)	RCM20(Regional Climate Model)
Area	Global	Surrounding are of Japan
Horizontal resolution	Grid interval: about 20Km	Grid interval: about 20Km
	Number of grid: 1920x960	Number of grid: 129x129
Number of vertical layer	60 layers	36 layers
Condition of side boundary	—	Climate model of Asia area （Grid interval: about 60Km, 36 layers)
Gas emission scenario	A1B	A2
Interval of Calculation	Present: 1979－1998 Future: 2080－2099	Present: 1981－2000 Future: 2031－2050 and 2081－2100

4. Comparison between GCM20 with observed precipitation

Since the precipitation pattern considerably varies in each region, analyses introduced in this paper are executed in each region shown in **Figure-2**. The regional division of Figure-2 is decided by considering similarity of meteorology and run-off process, which used for one of the reference materials for design flood examination of dams.

Figure-3 shows the ratio of GCM20’s average daily precipitation to the observed one during 1979 to 1998 (20years) in each region. Average and standard deviation of the ratio in a region is shown in



NO	Region	NO	Region
①	Hokkaido	⑦	Kii-nambu
②	Tohoku	⑧	Sanin
③	Kanto	⑨	Setouchi
④	Hokuriku	⑩	Shikoku-nambu
⑤	Chubu	⑪	Kyushu・Okinawa
⑥	Kinki		

Figure-2 Regional division considering similarity of meteorology and run-off process

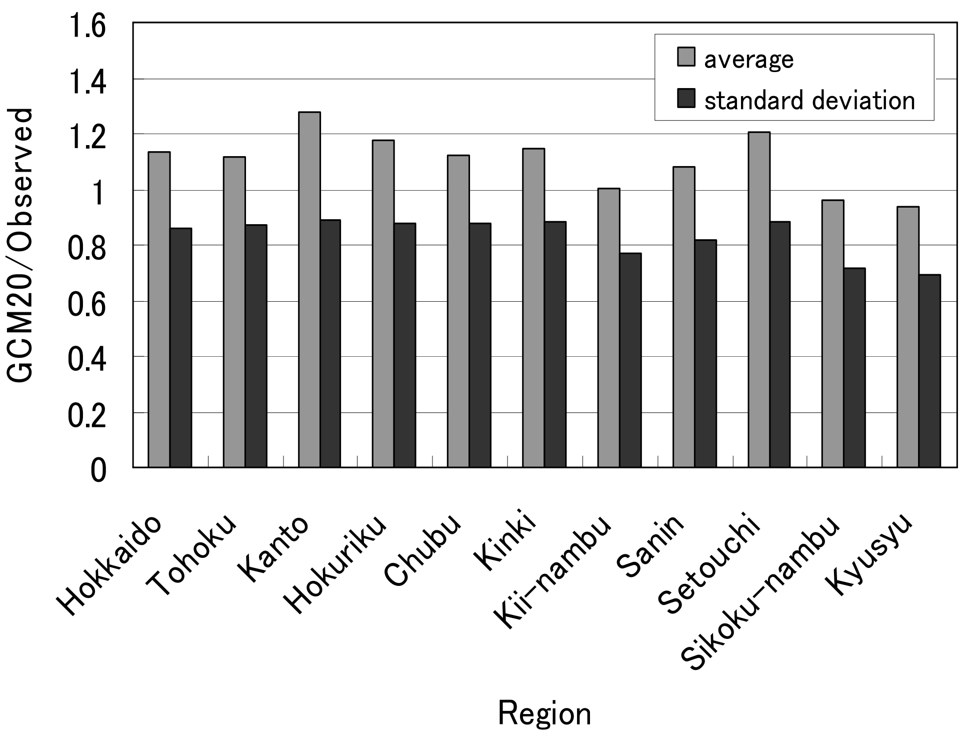


Figure-3 Ratio of GCM20' results to the observation regarding average daily precipitation

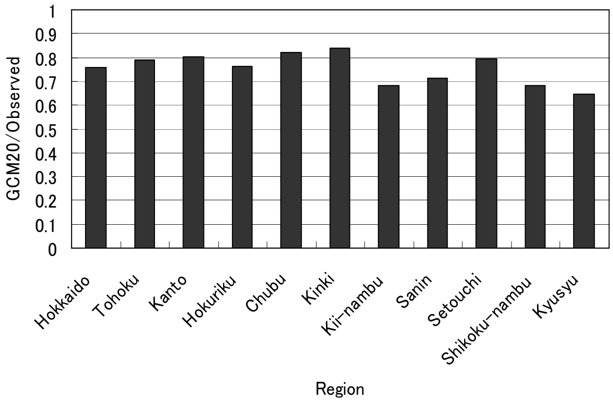


Figure-4 Ratio of GCM20's results to the observation concerning average annual maximum one-day rainfall

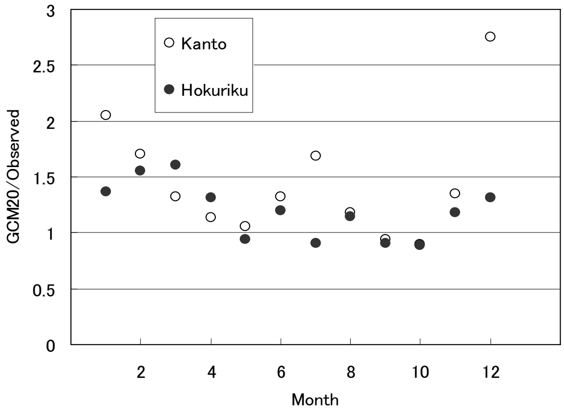


Figure-5 Examples of the ratio of average monthly precipitation of GCM20's results to the observation

the figure. AMeDAS (Automated Meteorological Data System) data of Japan Meteorological Agency are used for observed data, which has 1,300 observatories over Japan's land.

The average ratio is grater than 1 in eastern or Japan Sea side regions and less than 1 in west-southern regions. GCM20 has this regional tendency, but the average ratios are distributed near 1, from 0.94 to 1.28. So the regional average precipitation could be evaluated with comparative accuracy. On the other hand, all of the ratios of standard deviations are less than 1. They are from 0.69 to 0.89. This means variation of GCM20's precipitation is smaller than actual phenomena. **Figure-4** shows the ratio of GCM20's results to observed results concerning annual maximum one-day rainfall in each region. The ratio is the average ratio of 20 years in a region. While the values of ratios are nearly the same as the standard deviations of average daily precipitation, they are smaller in all of the regions. This may indicate that 20Km of grid interval is not small enough to realize extreme rainfalls of typhoons and fronts.

Figure-5 shows the examples of the ratios of average monthly precipitation of GCM20 to that of the observation. Kanto is a relatively large example of a ratio variation, and Hokuriku is a relatively small example. While the value is different especially in winter season, both show the concave variation pattern in the relation with month. This tendency is common to all regions, so GCM20 has the bias of larger winter precipitation

5. Precipitation variation at the end of 21st century

5.1 Averaged precipitation

The simulation results of GCM20 have the seasonal bias. Also they give smaller extreme rainfalls. They however, realize the fundamental seasonal precipitation characteristic of each region; give 64-84% of extreme rainfall intensity. Future change of precipitation could be discussed by the ratio of the precipitation in future duration (2080-2099) to present duration (1979-1998).

Figure-6 indicates the ratio of the future average daily precipitation to present in each region. The figure also indicates the ratio of deviation. The ratios of average are almost 1 (range is 0.94-1.09), so the average precipitation of future is nearly the same as present. While the ratios of standard deviation also indicate the value of nearly 1, all of them are grater than 1. Also they are grater than the ratios of average. These mean the larger variation of the future precipitation.

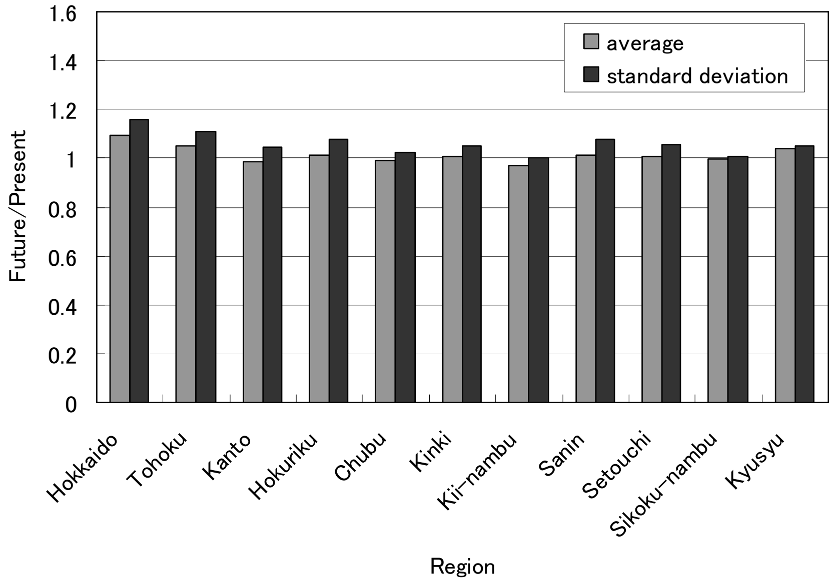


Figure-6 Ratio of future average daily precipitation to present （GCM20)

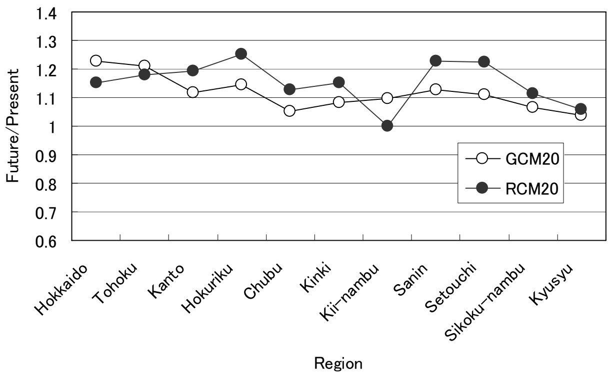


Figure-7 Future to present ratio regarding average annual maximum one-day rainfall

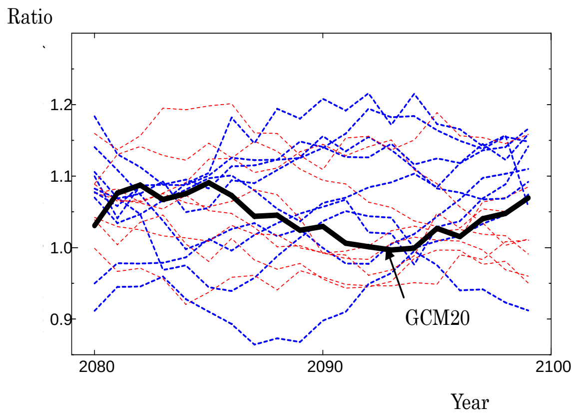


Figure-8 Change of average daily precipitation in surrounding area of Japan by GCM20 and IPCC models (average of 1979-1998 =1, A1B scenario)

Figure-7 shows the ratios of future average annual maximum one-day rainfall to present. RCM20's results are also plotted in the figure. The range of the ratios of GCM20 is from 1.04 to 1.23, and East or Japan Sea side regions' are larger than others. While the ratios of RCM20 are larger than GCM20 and the regional tendency of RCM20 is somewhat different from GCM20, both ratios indicate the almost same range and the same tendency of larger value in eastern or Japan Sea side regions. The range of the ratios of RCM20 is from 1.0 to 1.25.

Figure-8 shows the changes of average daily precipitations of IPCC's models compared with GCM20. The figure shows the ratios to the average of 1979-1998 precipitation of models. Since IPCC's models use long grid intervals, areas include surrounding seas as well as Japan's land. While 27 climate models are employed by IPCC, 14 models of them are plotted in the figure because the other results were not accessible at that time. From the figure, GCM20' results are within the variation of IPCC models' results.

5.2 Subject for rainfall intensity analysis of storm

5.2.1 Fundamental problems

For the examination of flood prevention plans, rainfall intensity of long return-period is important. But, there are problems to estimate this kind of extreme rainfall.

First problem is the effects of uncertainty and bias tendency of the simulation results. Considering this, ratio of future to present is selected as the parameter to evaluate the future precipitation change in 5.1; this parameter selection is from the idea of reducing the effects of uncertainty and bias tendency. But the effects can still remain, and the most serious problem is that there is no way to exam the effects.

Model results employed by IPCC are equally treated. There is no examination of accuracy superiority or result tendency of the models. The fourth IPCC report only shows the range and the average of future temperature and sea level, which calculated by whole model simulations. These are unusual situation in engineering scene, and may suggest analysis difficulties concerning climate phenomena. Although simulation measures have been remarkably developed recently, river engineers should know present level and characteristics of climate change simulation. Fortunately, GCM20 and RCM20 indicate similar results of future precipitation ratio to the present.

Another problem is a matter of hydrologic issues; this problem remains even a climate model has sufficient accuracy. Precipitation has large natural variation without climate change effects. The deviation of annual maximum rainfall, for example, must be much larger than the increased rainfall by climate change. Although average parameters of plural years and regional data may pick up the trend effects as shown in 5.1, rainfall intensity at a certain return-period cannot be discussed by average parameters alone. We should analyze the natural variation to discuss the probability of rainfall intensity, which requires long time rainfall data without climate change effects. On the contrary, as a matter of cause, the climate models aim at evaluating the future climate change by greenhouse gas emission, simulation results always reflect the conditions of greenhouse gas concentration at the point of time. Backgrounds of climate always change in the simulations. Add to this, the duration of GCM20/RCM20 future and present simulation is 20 years.

It must be very hard to pick up the natural rainfall variation at the point of time from the simulation results with continuous climate change conditions. Considering this, the assumption that the climate change effects are negligible in respective 20years of future and present is applied in this paper. From the view point of river engineer, long term calculation in fixed greenhouse gas concentration of each stage is desirable; computer environment, however, might limit the execution of this kind of calculation.

5.2.2 Scatter of annual maximum one-day rainfall

Rain fall intensity of long term return-period is usually examined by fitting distribution function to observed data plotted by an appropriate plotting method of probability. So the tendency of future to present ratios wiyh the rank of annual maximum rainfall should be discussed.

Figure-9 shows regional examples of ratio scatter at each rank (rank1 is the largest, rank20 is the smallest) of annual maximum one-day rainfall. Cover rate (%) means the rate of the number of points in the region, which ratios are less than the plotting ratio. In Hokuriku region, the figure shows the small change of 50% cover rate ratios, the concave and the convex shape of more than and less than

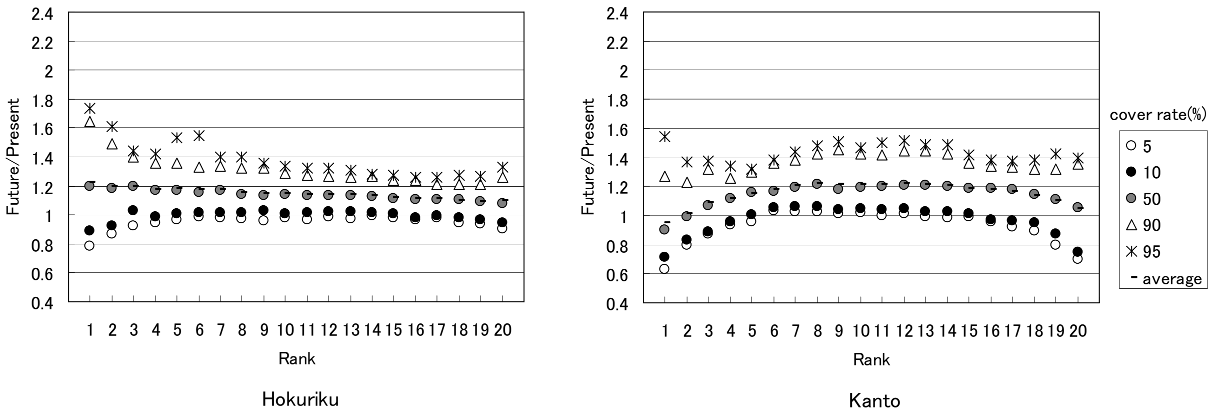


Figure-9 Examples of ratios of future annual maximum one-day rainfall to present in each rank (cover rate =the number of points less than the plotting ratio/the number of total points in a region (%))

50% cover rate ratios respectively. The concave and the convex shape mean larger scatter toward both edges of rank, especially rank1 side. Although Kanto region also has the similar characteristic with respect to the scatter tendency, 50% cover rate ratios change; not constant. They form the concave shape.

The scatter tendency in other regions is similar to both regions. Changes of 50% cover rate, however, show different patterns, gradual or rapid increase toward smaller number rank, rapid decrease toward smaller number rank and wave etc. In order to discuss the long term return-period rainfall, fundamental characteristics of these results should be appropriately understood.

Figure-10 is obtained by Monte Carlo simulation in the condition of the same future and present distribution function (the ratio of the same nonexceedance probability is 1). Gumbel distribution is used for the simulation, which is one of the most general distribution functions for the analyses of extreme rainfall, and characterized by the parameter of σ/μ (σ: standard deviation, μ: mean). From the GCM20's simulation results in each region, the range of σ/μ is 0.35-0.5 and the figure shows the result of σ/μ=0.4.

The number of year of Monte Calro trial is 20, GCM20's simulation duration, and the number of points in a region is sufficiently large number of 5000. So the scatter in the figure is caused only by the short duration of 20 years. We can comprehend the general effects on ratio scatter of short 20 years simulation by the figure. **Figure-10** indicates the scatters in **Figure-9** can be generated only by the effect of short term simulation.

Because of the function characteristic near zero nonexceedance probability, the scatter of rank20 side in **Figure-10** is larger than that in **Figure-9**. Since the value of the Gumbel function probability reaches to $-\infty$ near zero nonexceedance probability, minimum value of 0.001 is set in the simulation. Actual minimum rainfall seems to be grater than this.

Figure-11 indicates the influence of σ/μ on ratio scatter. 5% and 95% cover rate ratios in rank1 and 10 are plotted. The ratio scatter increases as σ/μ increases, and the change of ratio scatter is relative large within σ/μ interval of GCM20 simulation results in each region.

Here, return to **Figure-10**, 50% cover rate ratios show the constant value of 1, a true value. Therefore, it may be possible to detect the tendency of the relationship between the rainfall intensity and the occurrence probability from 50% cover rate ratios analyses. But the relationship between the

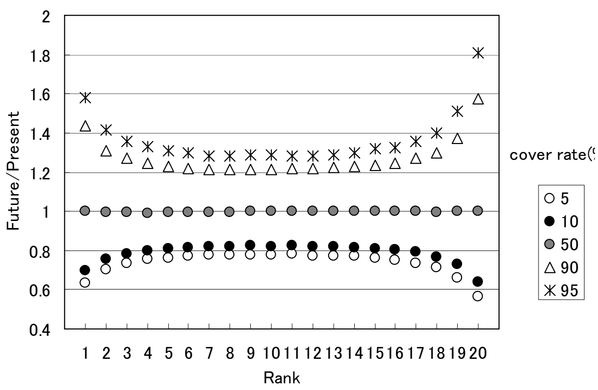


Figure-10 Scatter of ratios in the same Gumbel distribution of future and present (σ /μ=0.4, 20 years, 5000 points)

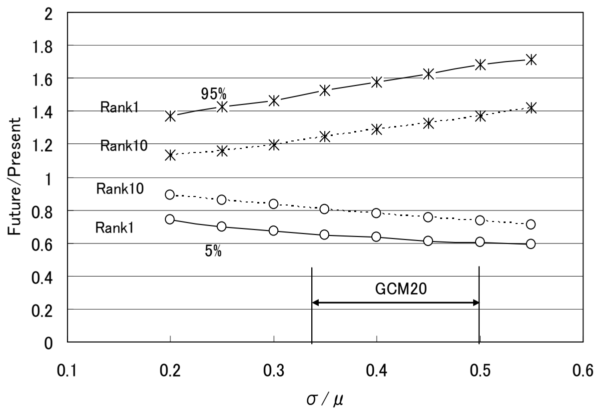


Figure-11 Influence of σ / μ on ratio scattering in the same Gumbel distribution of future and present (20 years, 5000 points)

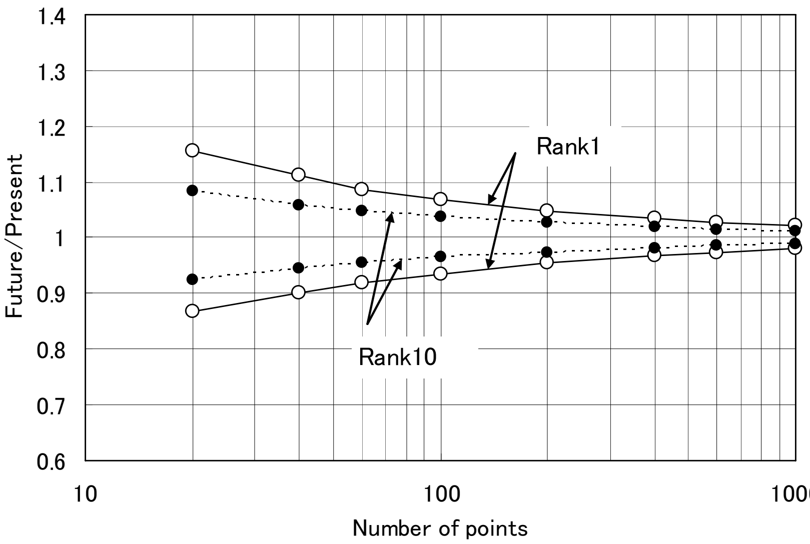


Figure-12 Relationship between 95% confidence interval of 50% coverage and the number of points in the same Gumbel distribution (σ/μ=0.4, 5000 Monte Carlo trials)

future to present ratio and the rank, obtained from GCM20's results, irregularly changes with regions, as exampled in **Figure-9**. One of the reason of this, small number of points in a region can be supposed.

Figure-12 shows the influence of the number of points on 50% cover rate variation in the condition of σ/μ =0.4. The 95% confidence interval of rank1 and rank10, obtained by 5000 times Monte Calro simulation trial, is plotted. The range of the number of points of GCM20 in each region is about 30-250, and the variation of 50% cover rate is considerable large in this range. The dimension of variation is smaller than some GCM20's results to some extent. However, the variation is influenced by several factors such as σ/μ, distribution function and the ratio of future to present mean rainfall. Here, therefore, the conclusion is limited to indicate that 50% cover rate can be varied by the small number of points in a region.

5.3 Trial for rainfall intensity projections at the end of 21st century

The examination of 5.2 shows the considerable large scatter characteristic of 20 years and 20Km grid interval simulation results. In order to reduce the scatter dimension, if it can be, the number of data of year or point required to be increased. One of the methods for this, using obtained GCM20's results, is to count a year and a point as the same element of occurrence probability. This can be done if following assumptions are adequate.

① data in a region are independent of each other.

② data in a region possess similar characteristics of dimension and distribution.

The cumulative distribution function of probability can be obtained for each region by above assumptions. All of future and present annual maximum one-day rainfall data in a region are ranked by their dimensions respectively, and plotted on a nonexceedance probability-data dimension graph.

Plotting results indicate that the relationship between future and present distribution function in each region reflects the variation characteristic of 50% cover rate introduced in 5.2.2. The results seem to indicate the short of the number of data in each region; distribution functions may still considerably include the scatter effect.

Average distribution function of all regions is obtained for the interaction of the scatter effect of each region. In order to obtain the average function, annual maximum one-day rainfall data are divided by mean value of each region. **Figure-13** shows the future and the present average distribution function. Both functions completely overlap each other. This means the future to present ratio dose not vary with nonexceedance probability, i.e. return-period, and decided by the ratio of mean value. Gumbel distribution is also shown in the figure. Although Gumbel distribution is very similar to the average distribution functions, there are tendencies of larger variation rate in small probability area and smaller variation rate in large probability area.

In order to ascertain above, i.e. to ascertain the independent relation between future to present ratio

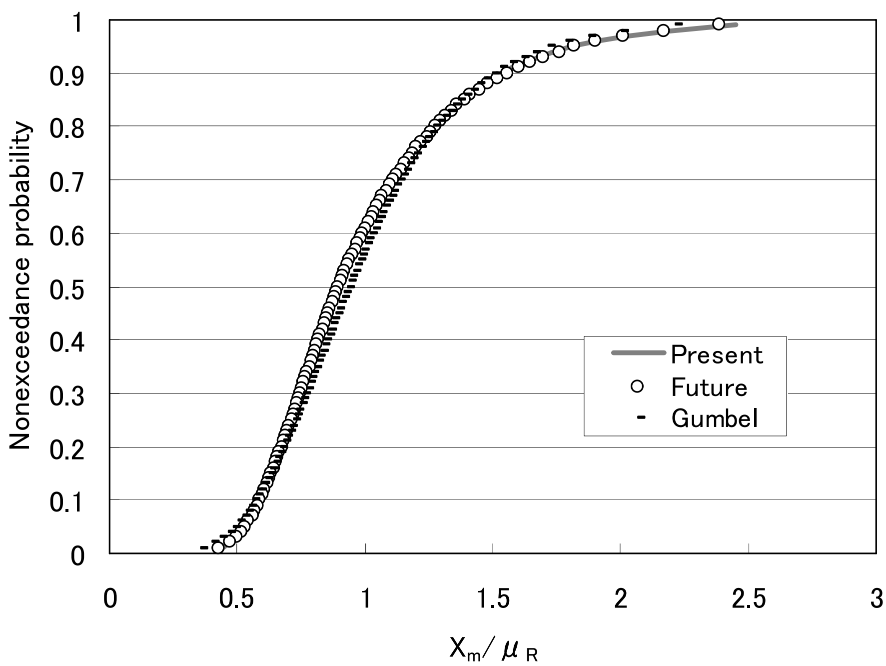


Figure-13 Averaged probability distribution (X_m: annual maximum one-day rainfall, μ_R: mean of each region; GCM20)

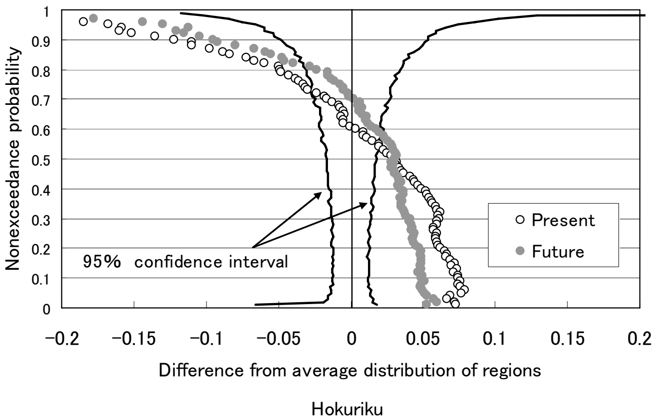
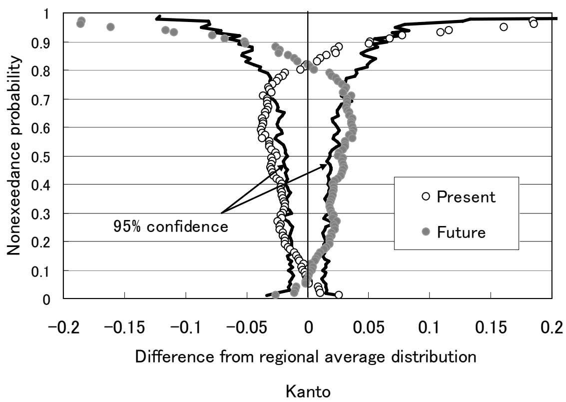


Figure-14 Example of the relationship between 95% confidence area and simulation results based on average distribution of regions (5000 Monte Carlo trials, GCM20)



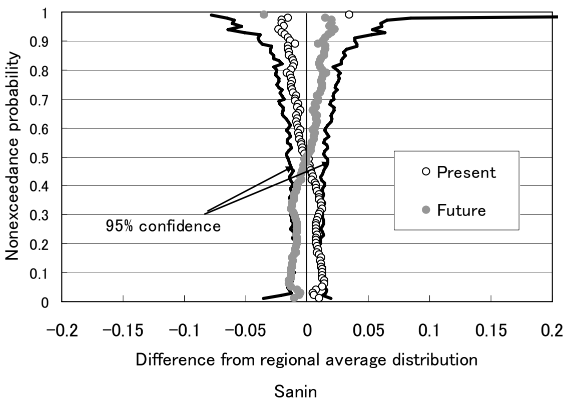


Figure-15 Examples of the relationship between 95% confidence area and simulation results based on regional average distribution (5000 Monte Carlo trials, GCM20)

and nonexceedance provability, Monte Calro simulations are executed with the assumption of the same future and present distribution function (basic distribution function, hereinafter). The number of data in the simulation is 20×(number of points in a region), and trialed 5000 times to obtain 95% confidence interval. The future to present function of each region, obtained by GCM20's simulation results, is compared with the 95% confidence interval to check the accuracy of the assumption.

Figure-14 shows the example of the results, using the average function of future and present function in **Figure-13** as the basic distribution function. The differences from the basic distribution function are shown in the figure, and large part of the GCM20's results is out of 95% confidence area. Also, a certain tendency of the GCM20 results can be recognized.

Above result suggests that the basic distribution function is different from each other region, and then the average of future and present distribution function of each region is used for basic distribution function. Examples of this simulation results are shown in **Figure-15**. Almost all GCM20's results located inside of 95% confidence area in Sanin region. On the contrary, large part is out of 95% confidence area in Kanto region. However, differences between the results and 95% c onfidence boundaries are much smaller than the former case exampled in **Figure-14**.

In **Figure-16**, nonexceedance probability is divided into within and out of 95% confidence interval.

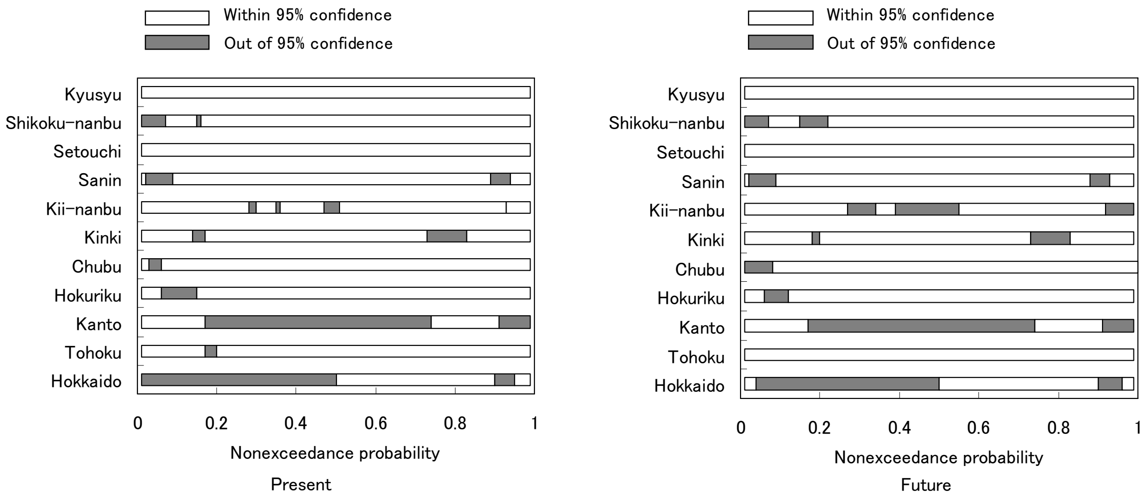


Figure-16 Within and out of 95% confidence interval divisions of noneexceedance probability based on regional average distribution (5000 Monte Carlo trials, GCM20)

White bars indicate the within part, while gray bars indicate the out of part. The figure shows that all or almost GCM20's results located within 95% confidence interval in almost region except Kanto and Hokkaido region. Correctly to say, data locations within 95% confidence interval dose not directly mean the same distribution function of future and present. However, the same distribution function can be mentioned for GCM20's results because the difference between the future and the present distribution function can be introduced by the same function in almost regions, also the average future and present function of all regions overlap each other. Therefore, the ratio of future to present one-day rainfall intensity is shown in **Figure-7**, 1.04-1.23 by GCM20, 1.06-1.25 by using larger value of GCM20 and RCM20.

Regional division of Kanto and Hokkaido should be improved. Southern part of Kanto is largest plane in Japan and may have different rainfall intensity from northern mountainous area. Rainfall in Hokkaido may be influenced by Okhotsk Sea, Japan Sea and the Pacific Ocean. These are subjects that should be examined in the near future.

6. NIRIM's studies concerning adaptation against stronger rainfall intensity

6.1 Outline of the project study

NIRIM executes many study subjects concerning technology for river management. As a matter of course, all of them relate to the adaptation against flood disaster to a certain extent, this paper introduces the project study titled 'Study on the river and coast management concerning adaptation against climate change'. The examination introduced in chapter 5 is a part of this project study.

Figure-17 shows the outline of the project study. Though the study includes issues related with drought and flood tide, flood disaster will be mainly introduced in this paper; issues of drought and flood tide are omitted in the figure.

Main goals in each stage of the project study are as follows.

①to project river discharge change caused by rainfall intensity change.

②to improve estimation methods of flood damage for reflecting influences of increased frequency and dimension of over planning discharge rate.

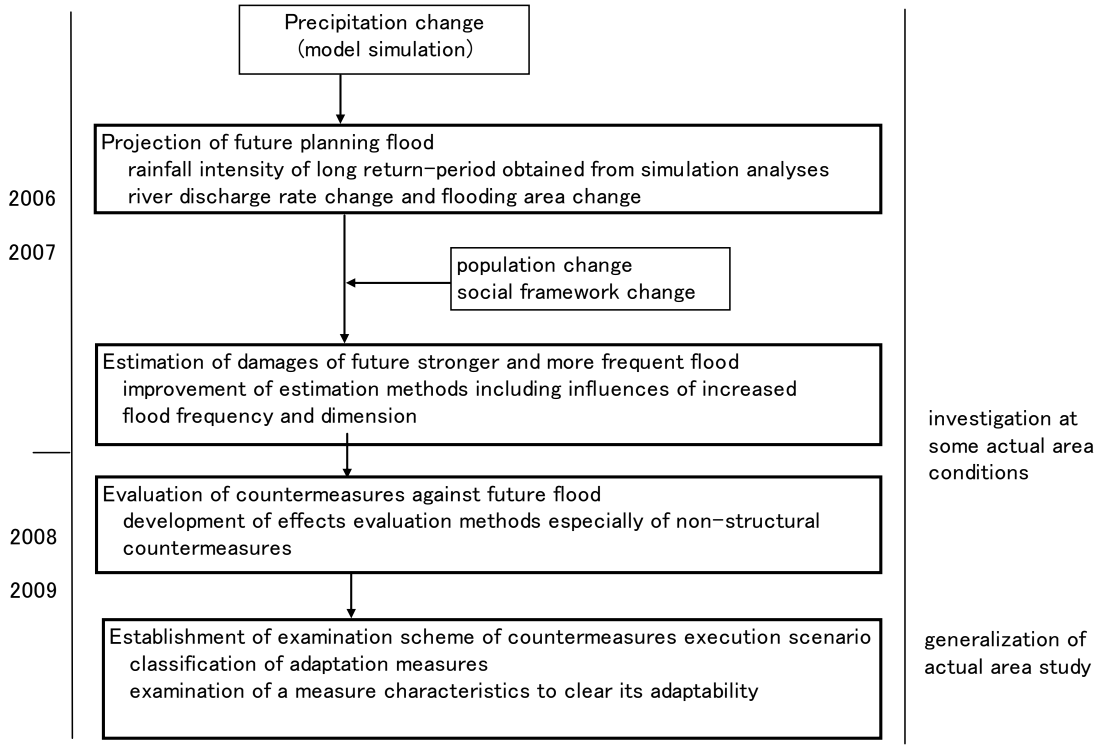


Figure-17 Study flow of 'Study on the river and coast management concerning adaptation against climate change' (part of adaptation to flood change)

③to develop effects evaluation methods of non-structural countermeasures that reduce flood damage.

④to classify adaptation measures including both of structural and non-structural measures and present examination scheme of execution scenario.

With respect to river discharge rate, trial calculations for several river show that future to present ratio is larger than that of the rainfall intensity because of the initial losses in ran-off process, etc. Future rainfall intensity may increase 10% to 30% or more by GCM20's results. And the return period of 100 years reduces to 20-40 years by 20% rainfall intensity increase for example. Also, the completion of embankment requires many year construction activities even for present planning level. So, off course the importance of the stable embankment construction is unchanged, non-structural countermeasures should be much noted and appropriately evaluated.

The changes of rainfall intensity and river discharge rate have been being examined in the project study and results that have obtained are already mentioned. The other items are introduced hereinafter. Since almost examinations concerning the items start in this or next fiscal year, general perspective of the study will be introduced in this paper.

6.2 Flood damage estimation and effects evaluation of countermeasures

Cost and benefit is usually estimated in the examination of flood prevention structural projects. **Table-2** shows the general items for damage estimation used for benefit estimation in Japan.

The loss of flood damages is calculated based on actual results obtained by field investigations and so on. And the actual damages are usually assumed as independent phenomena until now; i.e.

independent of former damages, also independent of other area’s damages. The larger frequency and scale of flood requires the appropriate estimation of former damage or other area’s effects.

As for former damages effects, continuous characteristic of damage effects has been investigated by post field survey of experienced serious disasters in Japan, including earthquake, flood and so on, recently. With regard to the effects of other area’s damages, recent activities of companies and other organizations become closely and complexly related with each other over wide regions. In this year, many factories of plural famous car production companies were forced to stop their production line for some days. This occurred by the earthquake damage of the factory of parts production company in Kashiwazaki city. Indirect effects, include other damage in **Table-2**, should be considered in the estimation of disaster damage loss.

Also, social effects of flood damage such as regional community cutting should be considered. New conceptions and methods are required to evaluate social effects, knowledge and technique of wide field specialists should be instilled into this project study. Closer connection with university or other organizations are also very important for the evaluation of economical effects. However, arrangements for this connection have not been established yet. They are just under examination.

With regard to non-structural measures such as warning and evacuation activities, land use regulation and multiuse space setting for water storage, the relationship between a countermeasure and a kind of damage loss reduced by the measure should be cleared in the first, then the extent of the reduction and effects should be evaluated.

Table-2 General items of damage estimation for B/C examination

Estimation methods		
Indicated		Not indicated (trial allowed by each project)
Direct damage	Indirect damage	Other damage
・house, building ・household articles ・house repayment and stock assets of business ・house repayment and stock assets of firming and fishery ・firm products ・public works etc.	・business suspension ・domestic emergency measure ・business emergency measure	・obstruction of ordinary activities at home ・emergency measures by national or local government ・influences of traffic stoppage ・influences of lifeline cutting ・influences of business suspension to surrounding areas' ・human life etc. ・underground market ・risk premium ・highly developed effects of land

6.3 Fundamental course for adaptation study

The propriety of adaptation measures are examined from various view points such as the efficiency (relationship between load weights of a measure execution and effects of reducing damage loss by the measure), the extent of the difficulty of realization and the required duration for realization.

Figure-18 shows one of the images of countermeasure executions considering the required duration for completion. The longitudinal axis of the figure is an additional load by climate change, and is assumed to rise upwards with time. Adaptational countermeasures are categorized in on-site countermeasures, water-shed countermeasures and regulation/support countermeasures, and considered longer duration will be required by the latter category.

The study concerning above will be executed for some actual areas chosen by vulnerability, regional typical or special conditions of the matter of rainfall, run-off and river condition, development situation of water-shed, economic and social condition, topology and so on. Results of actual areas will be generalized through analyses with multiple views. The study will be pursued in cooperation with government office and organizations mentioned in 6.2.

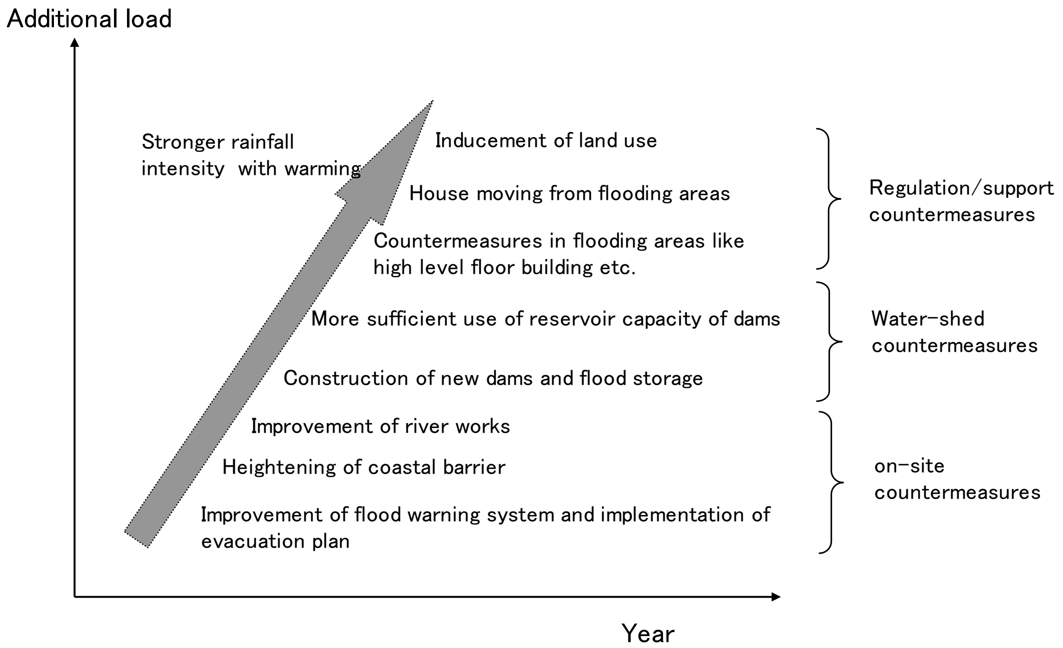


Figure-18 Image of countermeasure execution considering the required duration

7. Conclusions

Future rainfall intensity varied by grovel warming in Japan is discussed from a view point of flood disaster. Also, the general of the project study of adaptation in NILIM is introduced. Main conclusions are as follows.

1) Though the simulation results of GCM20 have the seasonal bias and smaller extreme rainfalls, future change of rainfall can be discussed by the ratio of future to present rainfalls.
2) Since the background condition is always changed in climate model simulation, and the calculation term is short in GCM20/RCM20, analyses for long return-period rainfall intensity have a fundamental problem of the lack of long data in the same climate condition.
3) Appropriate regional division can be expected to make up the lack of long data assuming independence and similar characteristics of data in a region. From GCM20 results, the ratio of future to present non-dimensional rainfall (divided by mean) in each region, dose not vary with return-period and represented by the ratio of mean value. The range of the future to present ratio of annual maximum one-day rainfall is 1.04-1.23 by GCM20, 1.06-1.25 by RCM20 in JAPAN.
4) NILIM has the project study program concerning adaptation to warming. Subjects of the study will include developing evaluation methods of effects of structural and non-structural countermeasures, and indicating examination scheme of execution scenario of them.

The Investigation on the Drought Risk Assessment in Japan Due to Global Warming

November 29, 2007

National Institute for Land and Infrastructure Management

Nario YASUDA, Head, Water Management and Dam Division, River Department

Tomokazu TADA, Senior Researcher, Water Management and Dam Division, River Department

Study on the Soundness Index of a Basin Water Cycle System

Table 1. Example Composition of Soundness Index of a Basin Water Cycle System

	Driving force	Pressure	State	Impact	Response
Water Use	Population in watershed Climate change	Precipitation Water usage Water intake from rivers and other sources Water conveyance out of watershed	Frequency of droughts Duration of droughts Flow conditions (river flow rate, interruption of stream flow) Water resource reserves	Shortage of water for urban use Wildlife habitats	Storage of water with dam and other facilities
Flood Control	Land use in watershed Climate change	Precipitation Flood flow rate Frequency of floods	Inundation and flooding	Amount of damage from water disasters	Various water control measures Flood control with dams and other facilities
Water Quality	Population in watershed Economic and productive activities Climate change	Generation of pollution load Inflow of pollution load	River water quality Water quality in lakes and dam reservoirs	Quality of drinking water Recreation Odor Wildlife habitats Crop growth and quality	Development of sewerage system Use of septic tanks and other facilities Measures against eutrophication

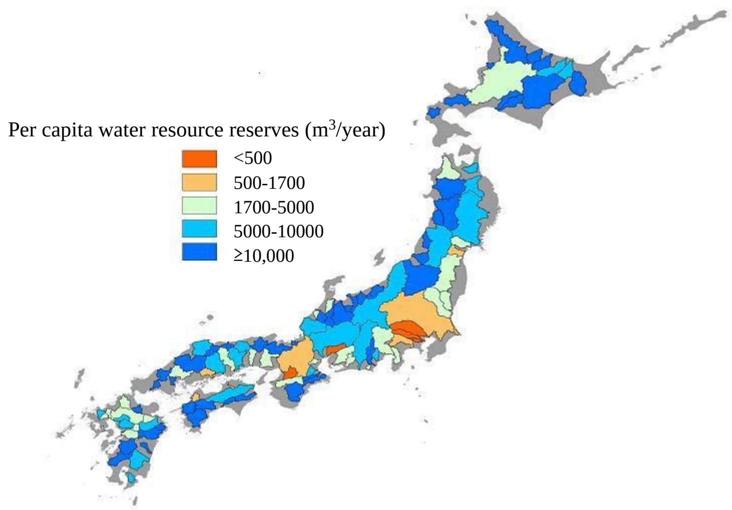


Fig. 2. Per Capita Water Resource Reserves

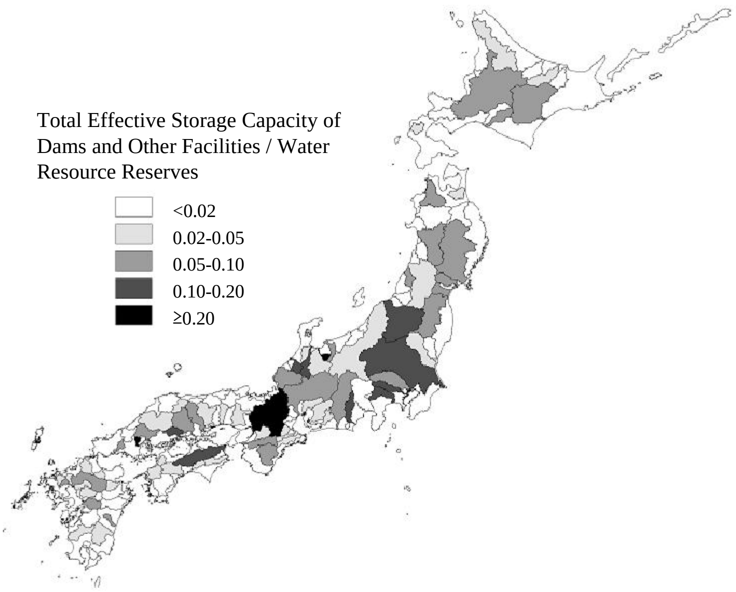


Fig. 3. Ratio of Total Effective Storage Capacity of Dams and Other Facilities to Water Resource Reserves in Each River System

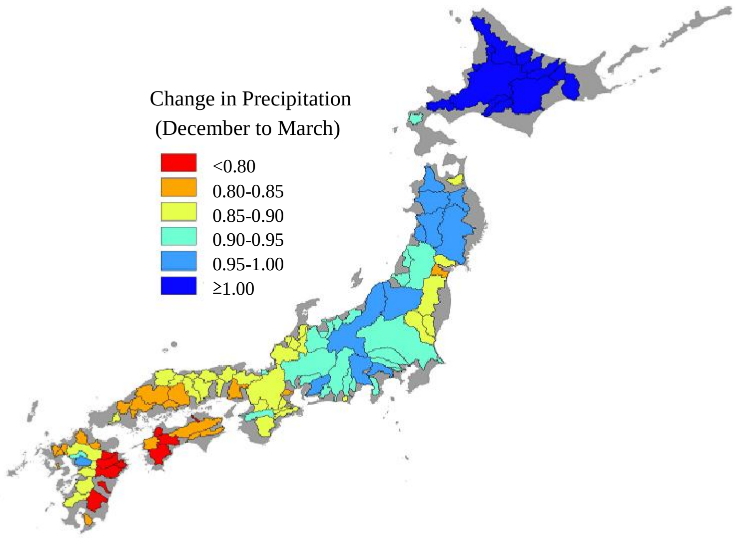


Fig. 4. Change in Precipitation Due to Global Warming in Each Drainage System (December to March)

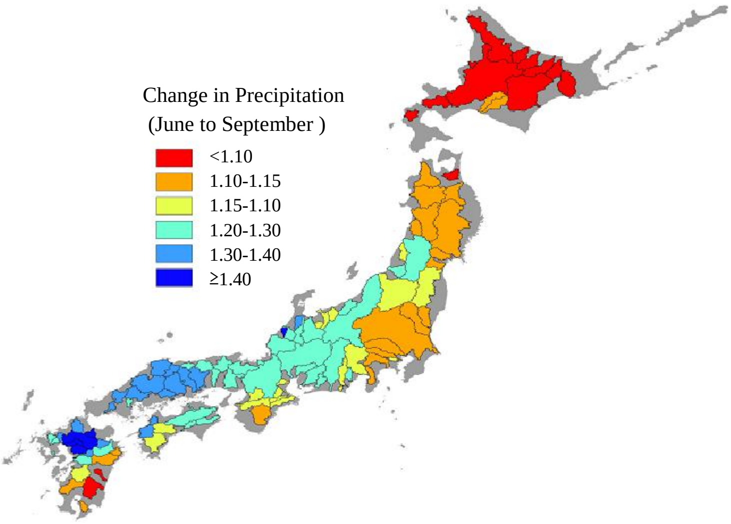


Fig. 5. Change in Precipitation Due to Global Warming in Each Drainage System (June to September)

Study on the Effect of Climate Change on Water Resources in Tone River Watershed

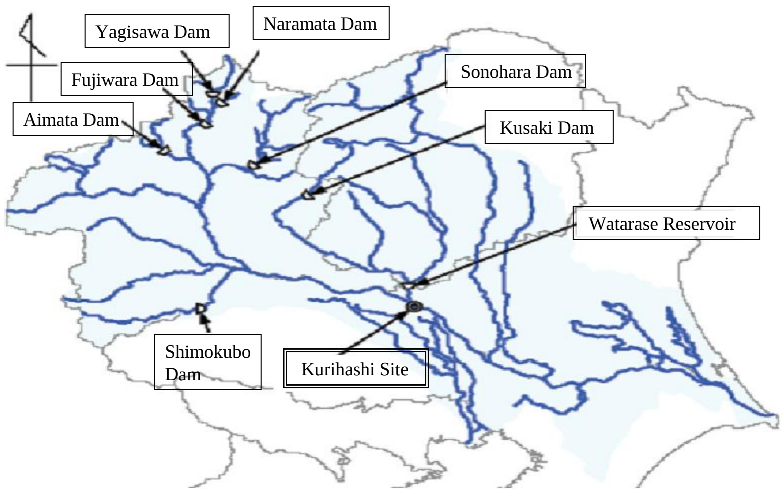


Fig. 6. The Site and Dams in Tone River Basin Examined in This Study

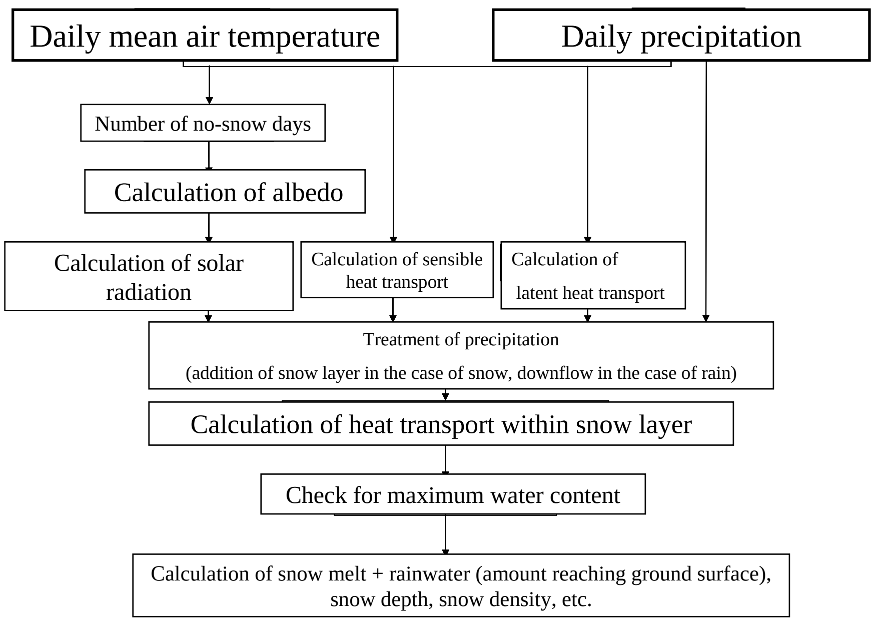


Fig. 7. Flow Chart of Calculation of Show Accumulation and Snow Melt

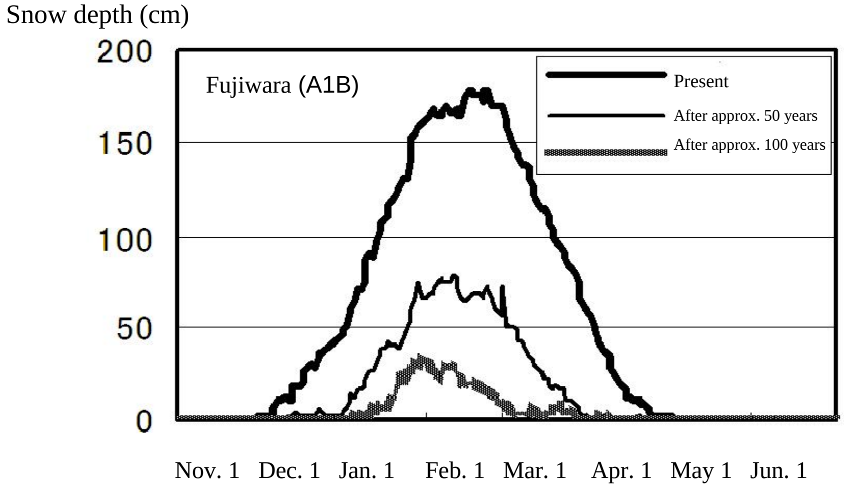


Fig. 8. Future Changes in Snow Depth (Fujiwara A1B)

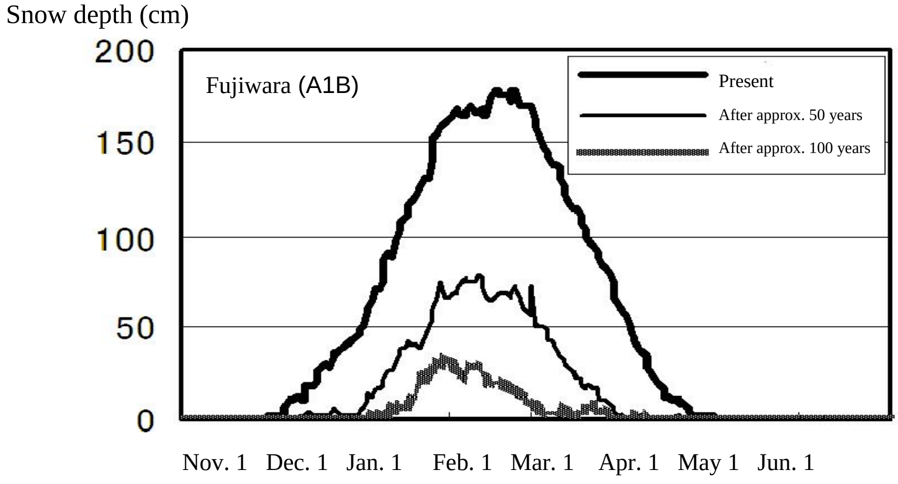


Fig. 9. Future Changes in Snow Depth (Fujiwara B1)

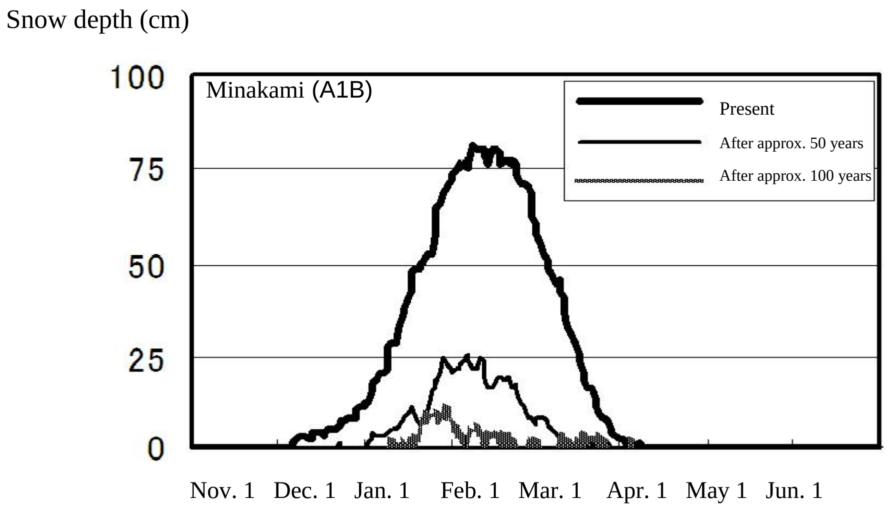


Fig. 10. Future Changes in Snow Depth (Minakami A1B)

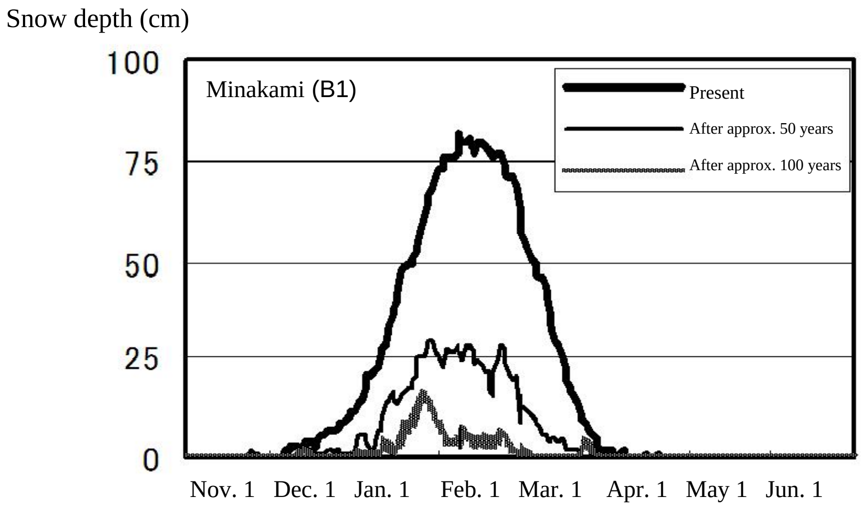


Fig. 11. Future Changes in Snow Depth (Minakami B1)

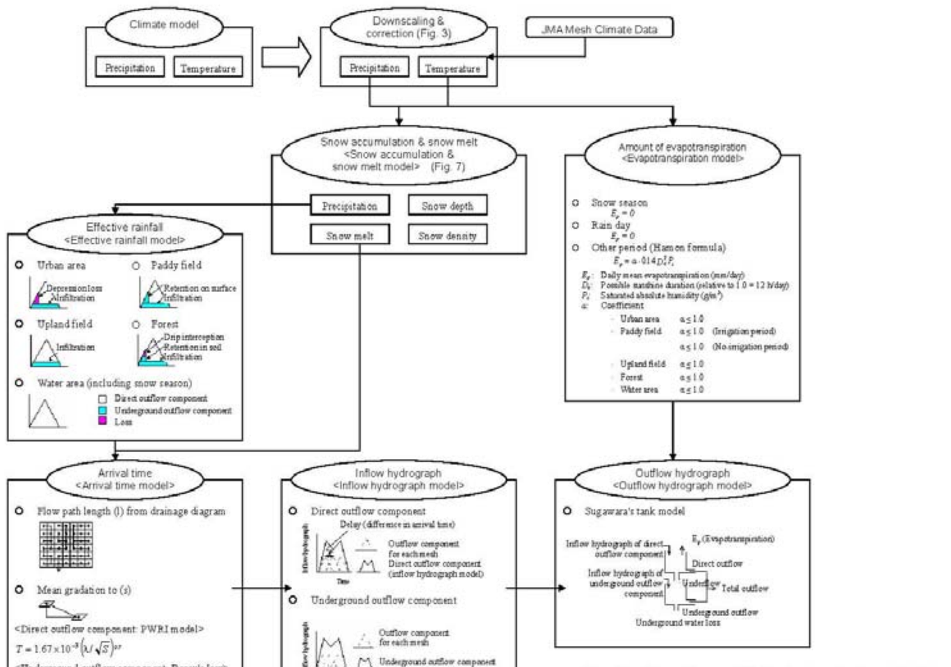


Fig. 12. Flow Chart of Calculation of River Outflow

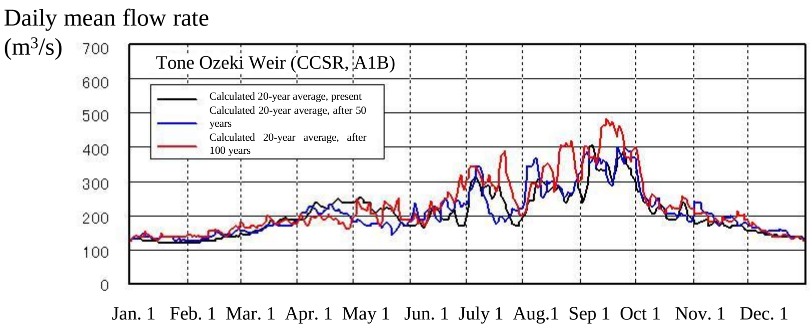


Fig. 13. Calculated 20-year Average Flow Rate at the Present and after 50 and 100 Years (Tone Ozeki Weir) A1B

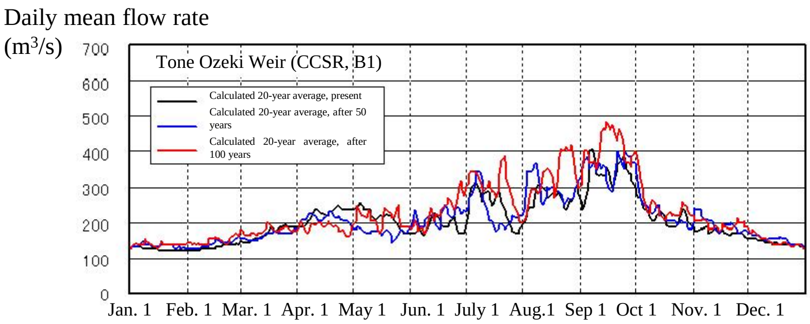


Fig. 14. Calculated 20-year Average Flow Rate at the Present and after 50 and 100 Years (Tone Ozeki Weir) B1

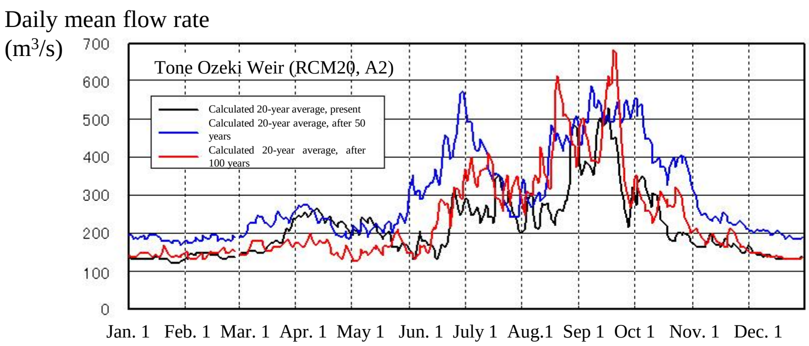


Fig. 15. Calculated 20-year Average Flow Rate at the Present and after 50 and 100 Years (Tone Ozeki Weir) A2

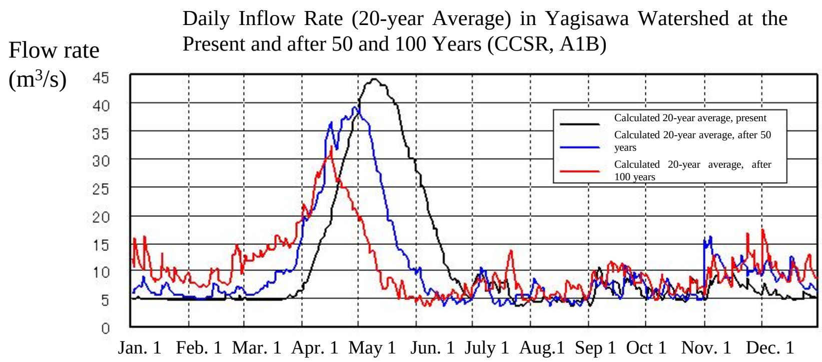


Fig. 16. Calculated 20-year Average Flow Rate at the Present and after 50 and 100 Years (Yagisawa) A1B

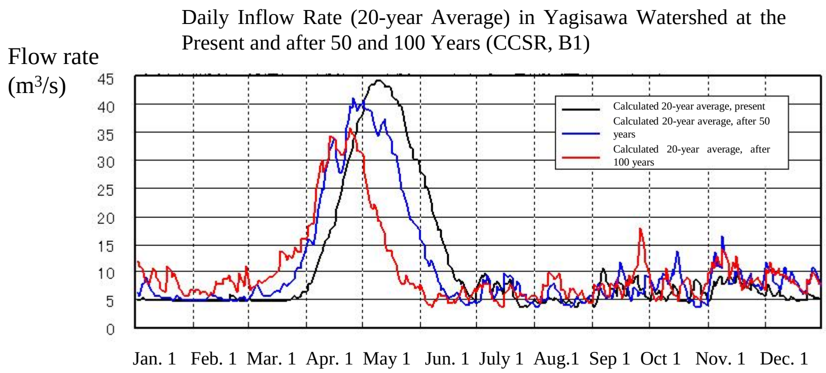


Fig. 17. Calculated 20-year Average Flow Rate at the Present and after 50 and 100 Years (Yagisawa) B1

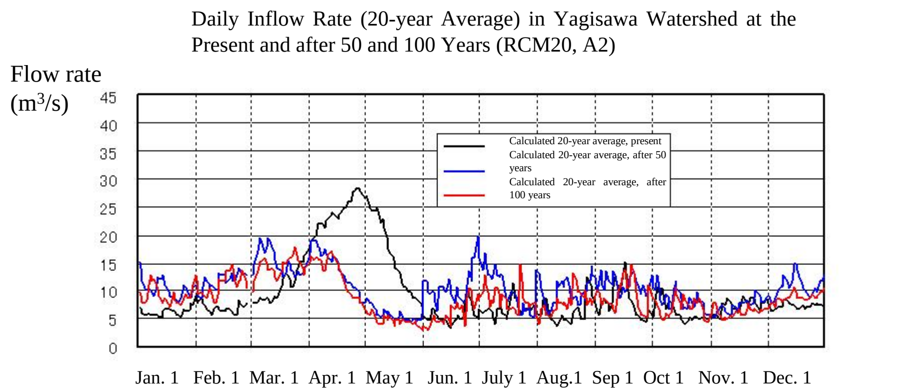


Fig. 18. Calculated 20-year Average Flow Rate at the Present and after 50 and 100 Years (Yagisawa) A2

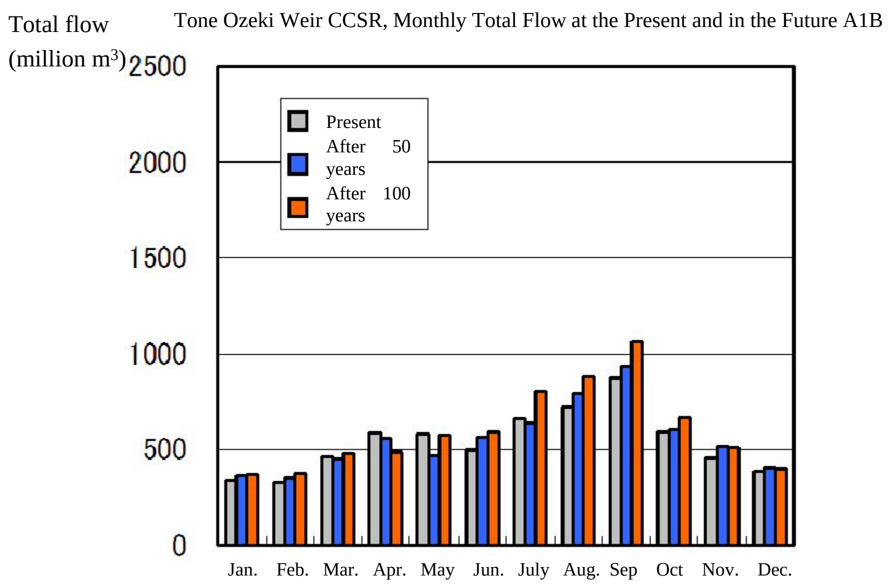


Fig. 19. Calculated 20-year Average Monthly Total Flow at the Present and after 50 and 100 Years (Tone Ozeki Weir) A1B

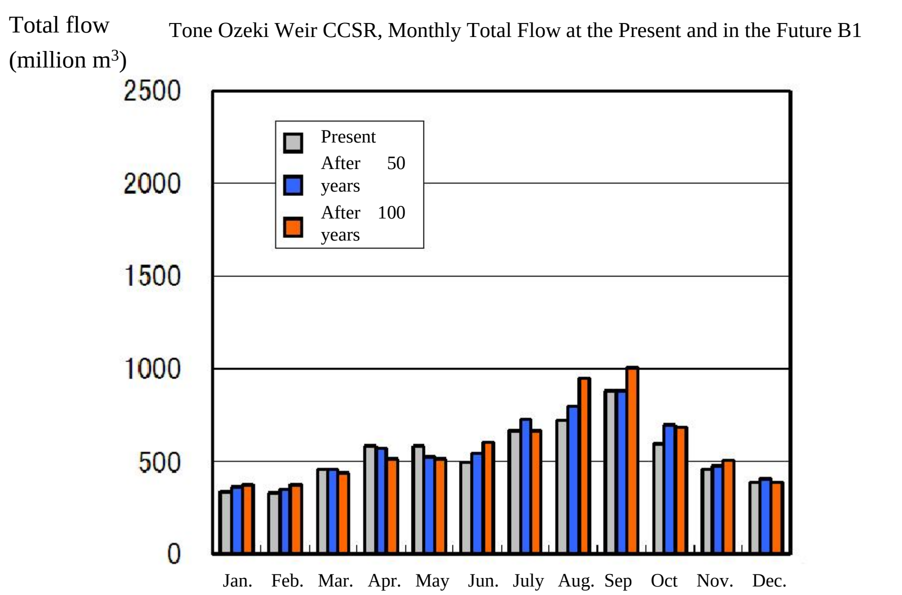


Fig. 20. Calculated 20-year Average Monthly Total Flow at the Present and after 50 and 100 Years (Tone Ozeki Weir) B1

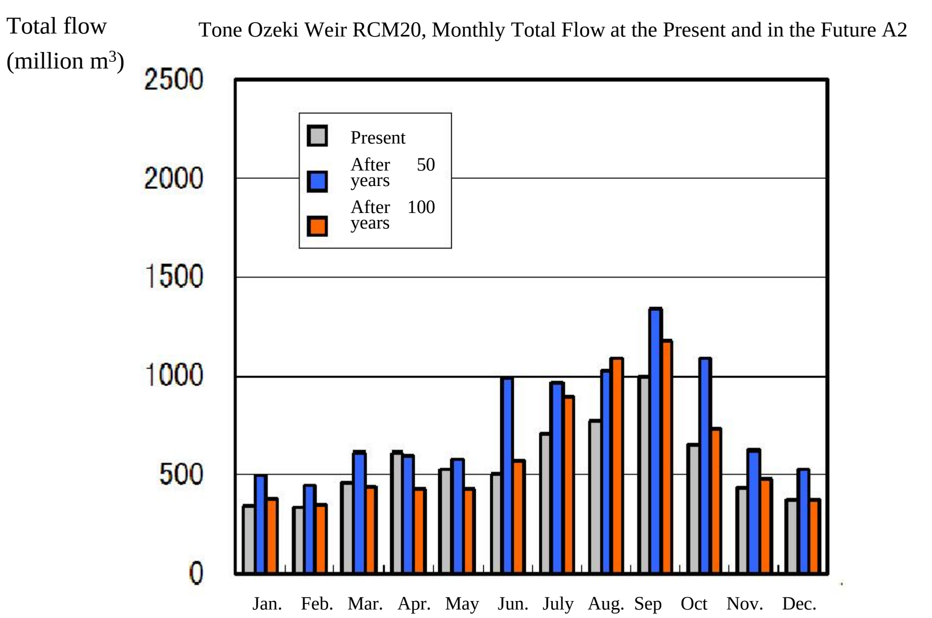


Fig. 21. Calculated 20-year Average Monthly Total Flow at the Present and after 50 and 100 Years (Tone Ozeki Weir) A2

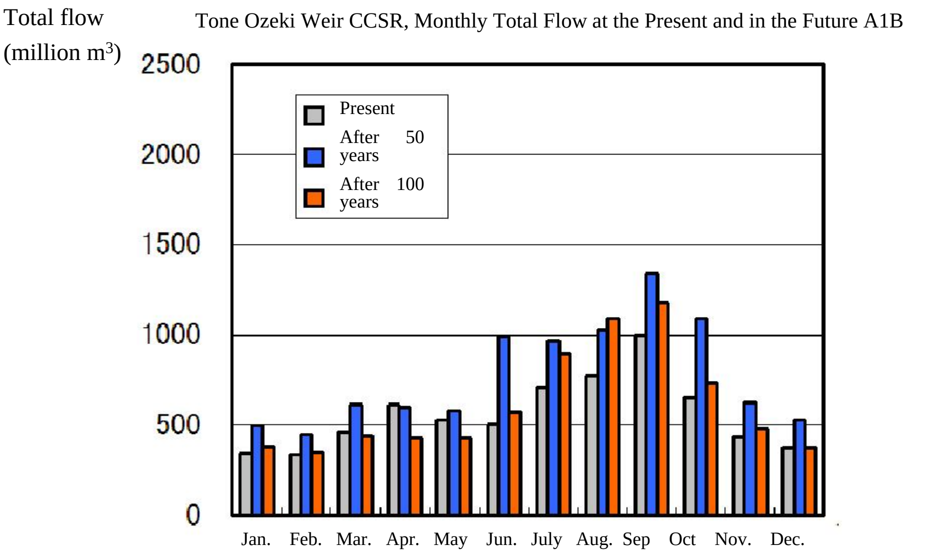


Fig. 22. Calculated 20-year Average Monthly Total Flow at the Present and after 50 and 100 Years (Yagisawa) A1B

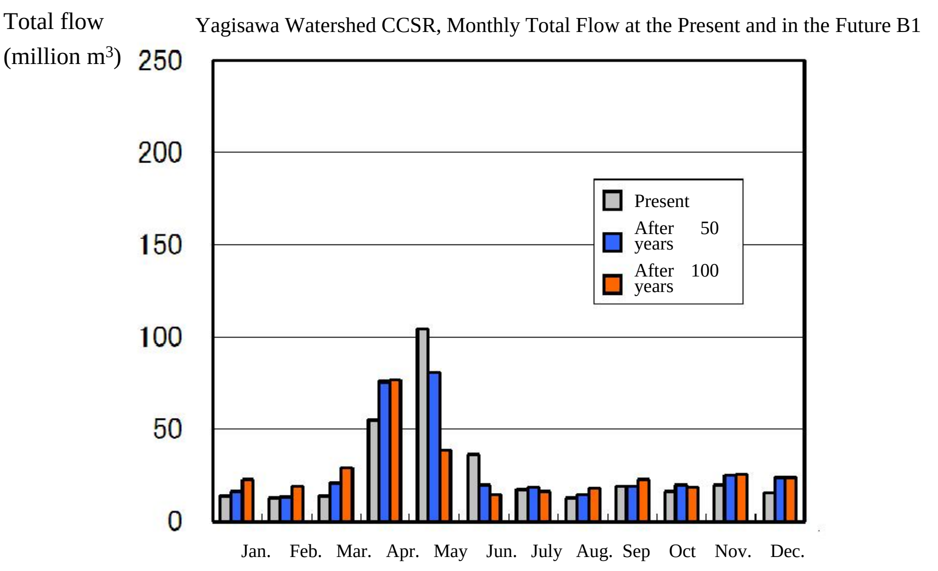


Fig. 23. Calculated 20-year Average Monthly Total Flow at the Present and after 50 and 100 Years (Yagisawa) B1

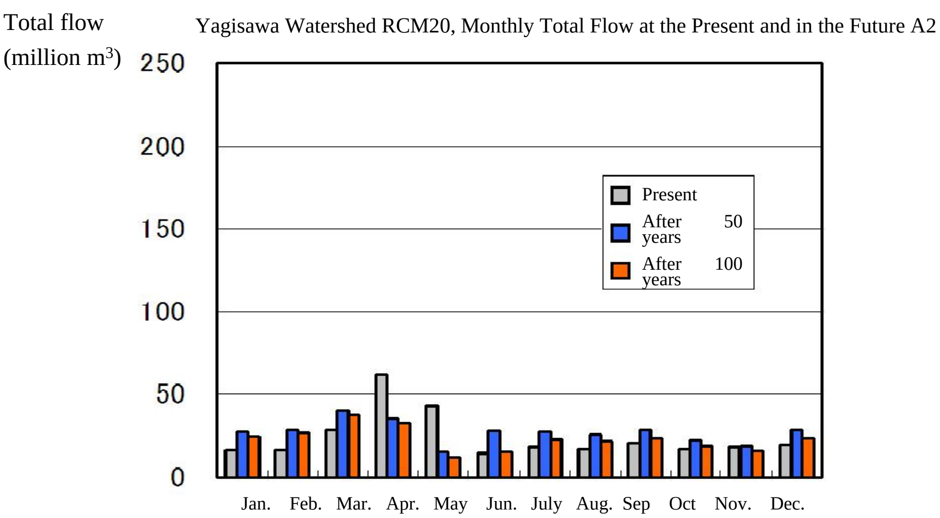


Fig. 24. Calculated 20-year Average Monthly Total Flow at the Present and after 50 and 100 Years (Yagisawa) A2

Table 2. Storage Capacity for Water Utilization Assigned to Dam Groups in the Upper Courses of Tone River

	Non-flood Season (Oct. 1 to Jun. 30 next year) (million m^3)	Flood Season (Jul. 1 to Sep. 30) (million m^3)
Watarase Dam Group	76.90	42.70
Shimokubo Dam	120.00	85.00
Okutone Dam Group	302.93	253.99

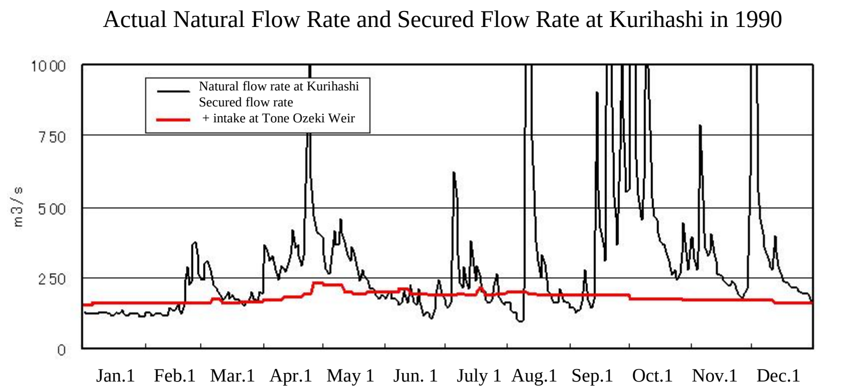


Fig. 25. Actual Natural Flow Rate and Secured Flow Rate
at Kurihashi (Example Data for 1990)

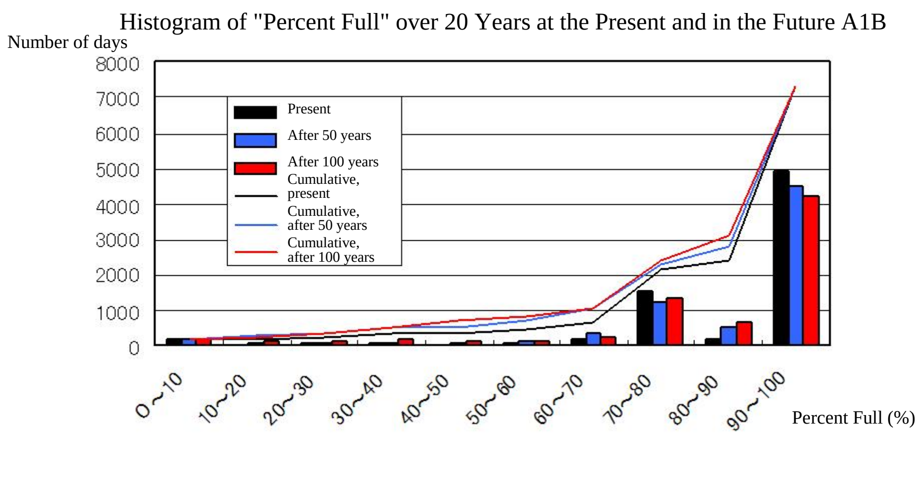


Fig. 26. Histogram of Overall “Percent Full” of 8 Dams
at the Present and after 50 and 100 Years, A1B

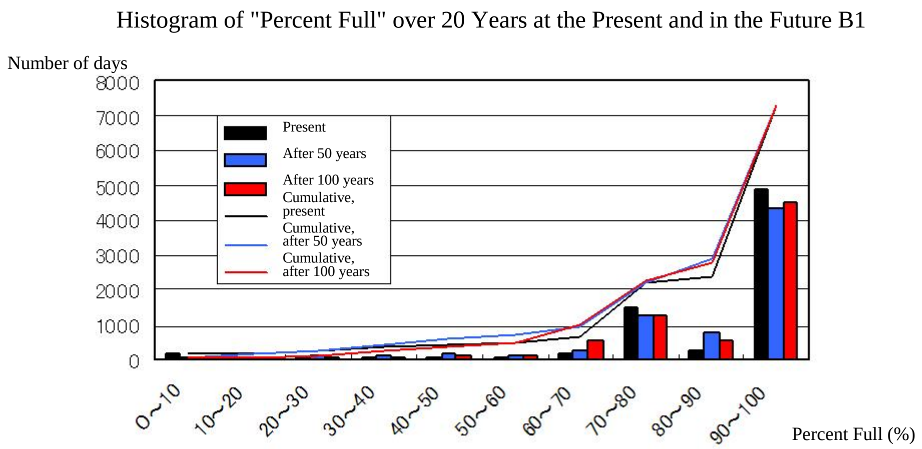


Fig. 27. Histogram of Overall “Percent Full” of 8 Dams
at the Present and after 50 and 100 Years, B1

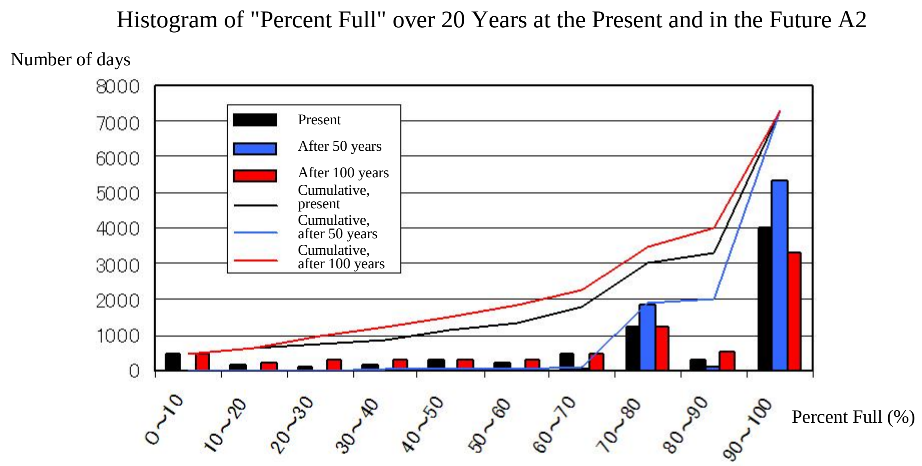


Fig. 26. Histogram of Overall “Percent Full” of 8 Dams
at the Present and after 50 and 100 Years, A2

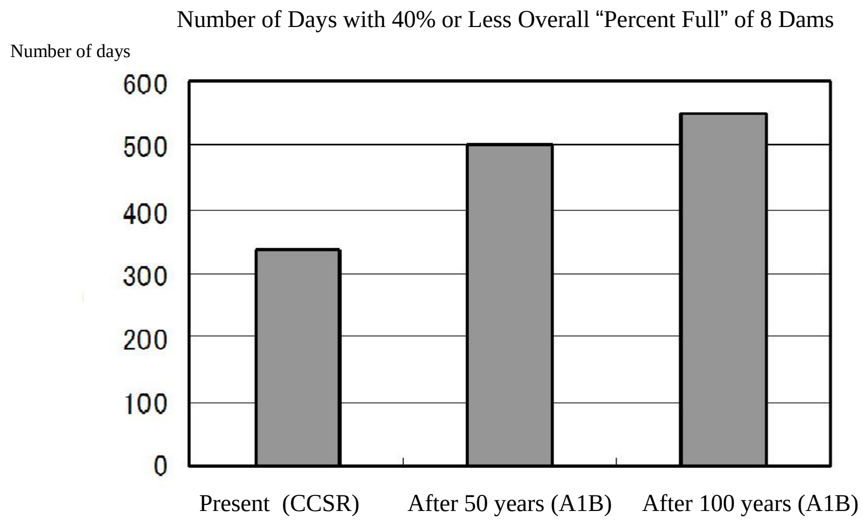


Fig. 29. Number of Days with 40% or Less Overall “Percent Full”
of 8 Dams at the Present and after 50 and 100 Years, A1B

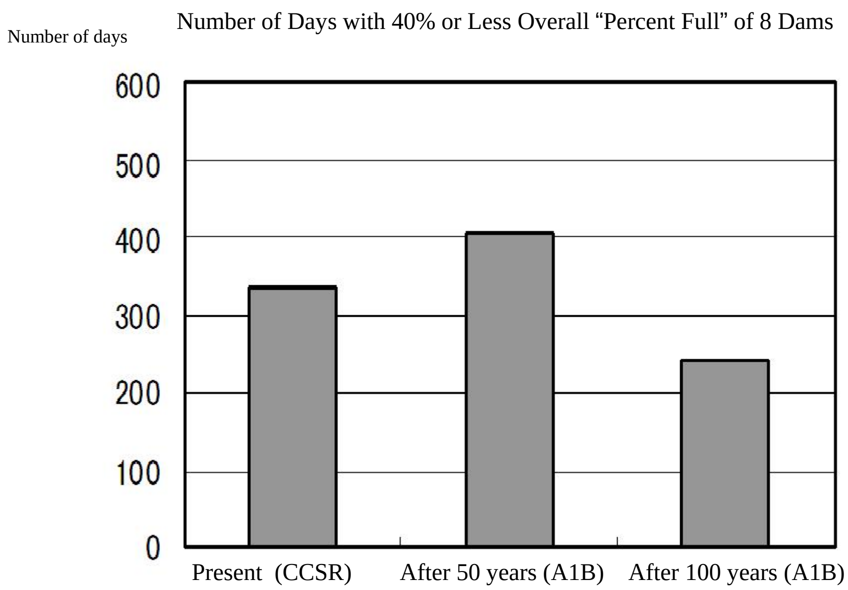


Fig. 30. Number of Days with 40% or Less Overall “Percent Full”
of 8 Dams at the Present and after 50 and 100 Years, B1

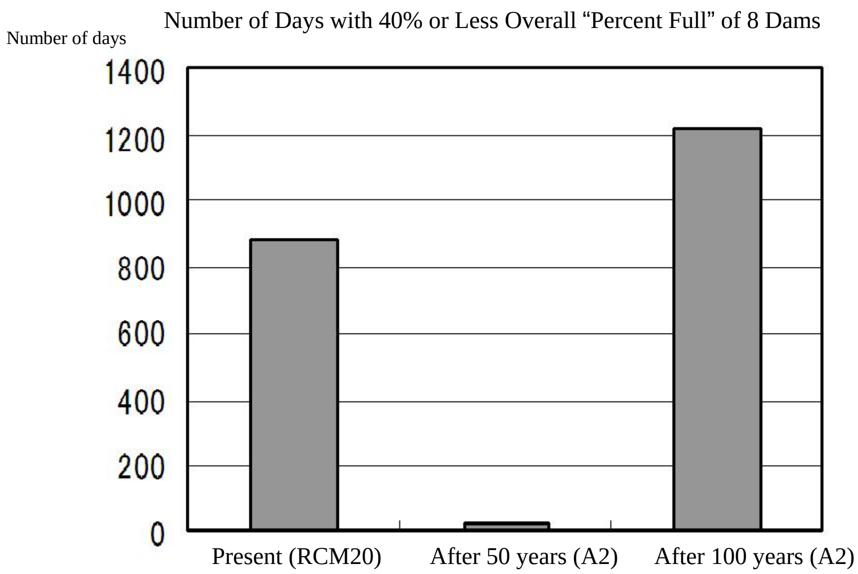


Fig. 31. Number of Days with 40% or Less Overall “Percent Full” of 8 Dams at the Present and after 50 and 100 Years, A2

Actions for the Future

Research on River and Coast Management in Response to Climate Change

2006 - 2009

[Outline of Study]

・To realize a safer society through prevention and mitigation of water disasters, the study focuses on the prediction of the time- and region-specific impacts of climate change on river and coast management, and considers measures for each stage of impacts.

・For the impacts that are already felt at the present (abnormal heavy rain, abnormal small rainfall, etc.), the study considers readily applicable practical measures making the best use of precipitation prediction information from Japan Meteorological Agency.

・For the impacts expected in the future (temperature rise, change in precipitation, sea-level rise, etc.), the study considers a wide range of measures based on the results of calculation for climate predictions, anticipating future social changes and assuming damage from flooding and droughts.

[Content of Study]

I. Next-generation Water Management Using Precipitation Prediction Information

(1) Study on flood prediction using precipitation prediction information

(2) Study on damage mitigation against predicted flooding

(3) Study on flexible dam operation using precipitation prediction information

II. Impacts of Global Warming on Rivers and Coasts and Response Measures

(1) Study on river management responding to global warming

(2) Study on the effect of sea-level rise and increase in heavy rain on the safety of flood-prone areas and response measures

(3) Study on the impacts on water management and response measures

(4) Study on coast protection measures anticipating future changes

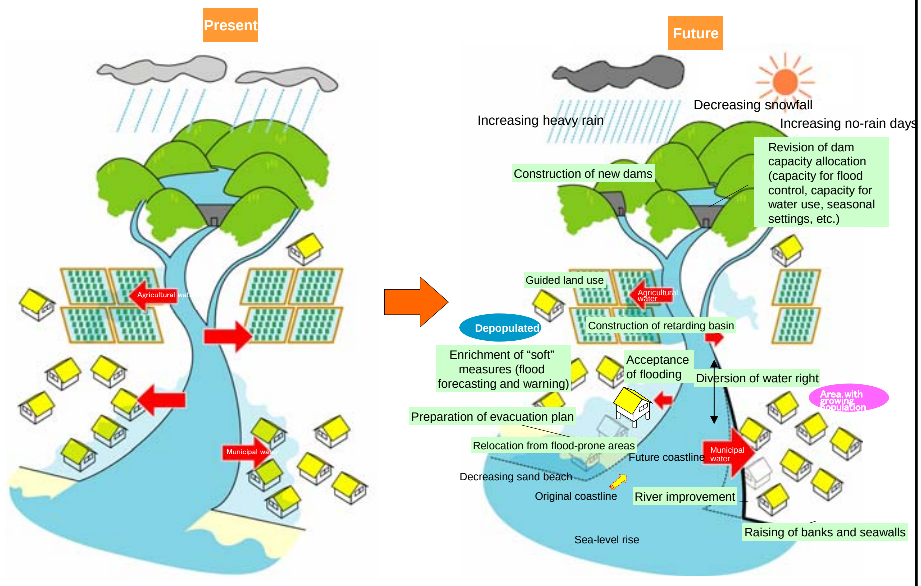


Fig. 32. Impacts of Global Warming on Rivers and Coasts and Examples of Response Measures

Developing Land Protection Measures Adapting to the Impacts of Climate Change Due to Global Warming

Identification of high disaster risk areas based on hazard assessment

Specific hazard assumptions about rainfall, high waves, etc. in river basins and coastal areas

Identification of areas with high disaster risk

Study on the socioeconomic impact evaluation of climate change

・Increases in frequency and extent of droughts, floods, high waves, etc.
・Expansion of damage to wide area and long period due to complex and continuous events

Socioeconomic impact evaluation method

Execution of socioeconomic impact evaluation

Study on the adaptation strategies for rivers and coasts responding to climate change

Adaptation measures for droughts, floods, high waves, and other individual events (including "hard" and "soft" measures

Estimation of effect and cost of adaptation measures

Planning of integral adaptation measures

Proposal of short- and long-term adaptation measures responding to climate change

Fig. 32. Flow of Study

Study on Advanced Water Management Using Water Circulation Simulator（2008-2010）

Purpose

・Future global climate change is expected to cause further increase in damage from droughts.
・This study evaluates drought control measures that are implemented in various forms, and proposes and refines optimal drought control menus.

Content of Study

・To propose and evaluate optimal drought control menus responding to local conditions (water use management, sea water desalination, underground dams, reuse of highly treated sewage, dam-to-dam transfer, etc.)
・To design programs for implementation of drought control menus.
・To examine the effectiveness in controlling droughts due to future climate change

Goals

- Proposal of optimal drought control menus responding to the conditions of individual watersheds (water use management to prevent droughts, sea water desalination, underground dams, use of bottom water, use of gray water, recovery and use of industrial water, reuse of treated sewage, rainwater storage in cities, marine transport of water, dam-to-dam transfer, etc.)
- Evaluation of drought control menus
- Identification of institutional frameworks that need to be modified for implementation of optimal drought control measures
- Evaluation and proposal of low flow observation sites needed for advanced water resource
- Evaluation and proposal of drought control measures to meet future change in water supply and demand

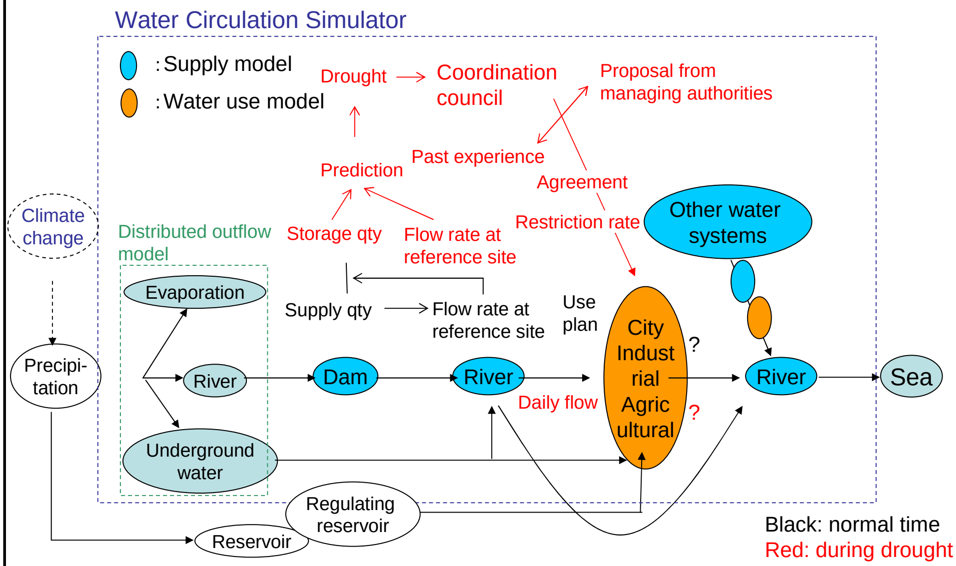


Fig. 33. Concept of Water Circulation Simulator

Policy Making and Implementation Processes for Securing Water Resources in the Tokyo Metropolitan Area to Cope with the Rapid Population Growth

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Abstract

In the Tokyo metropolitan area have shown rapid population growth and urbanization especially during the period of high economic growth, and diverse water policies on flood control, water utilization, and environmental protection have been taken. These are easy-to-understand examples demonstrating the relationship between an external force of population growth and responses to the force. In this study, the structures of response systems, which were assumed to exist between the external force of population growth and responses, were investigated to extract useful knowledge from the experiences in Japan and to process the information for facilitating the water policies to be drawn up for watersheds in Monsoon Asia.

Key Words : *water policy, water resources development, Tokyo metropolitan area, rapid population growth, water shortage, integrated water resources management, environmental impact*

1. Introduction

It is predicted that Monsoon Asia will face serious water issues, such as frequent floods, shortages of water supply, and deterioration of water quality, as a result of rapid population growth in the cities. In Japan, population had converged to Tokyo and neighboring metropolitan areas causing rapid urbanization to occur, especially during the period of high economic growth beginning in the late 1950s, and the implementation of various water policies on flood control, water utilization, and environmental protection have been effective to a certain degree. This process may be useful for solving the above-mentioned water issues in other areas of Monsoon Asia. However, even if the problems are similarly attributable to rapid population growth, policies effective in one region may not be effective in another area or at different times; therefore, the universality, commonality, and individuality of case experiences should be analyzed to establish a structured “knowledge”.

Recognizing these aspects, this study conducts the following analyses. Firstly, the policies in Japan were analyzed by interpreting the afore-mentioned Japanese experiences as being the response to an “external force” of rapid population growth. This external force and the increase in the demand for city water were reviewed, and the relative magnitude of the external force was evaluated against the available water resources. Secondly, the time sequence of water shortages caused by the external force was reviewed. Furthermore, the time series variation of the population’s awareness on water shortage problems, which relates to the driving force of policy promotion, was quantified by searching for newspaper articles. The transition of and the mutual relationship between the various water policies were summarized by time series since 1930s, and the correlation with the most important output - the additional water intake from the Tone River - was determined. Finally, the responses to land subsidence and water pollution, as well as the flow rate of the

Tone River, were examined as the possible factors promoting or inhibiting the policy implementation. By taking a panoramic view of the results of these analyses, the influence of the external force, the structure of response system in the application of water policy application, the effects and the governing parameters were studied.

There are many studies (individual references are made in the text) that summarize and analyze the progress of policies related to water resource development or management of water environment, and the general direction of the future water policies have also been discussed. However, studies that analyze the implementation process of various policies with a panoramic view are rare. By focusing on a predominant external force, such as the population growth in the Tokyo metropolitan area, and the characteristic responses of human/ecological system, being the securing of water resource, it is expected to enhance the understanding of the systems concerned in the water policy formulation.

2. Rapid Population Growth as an

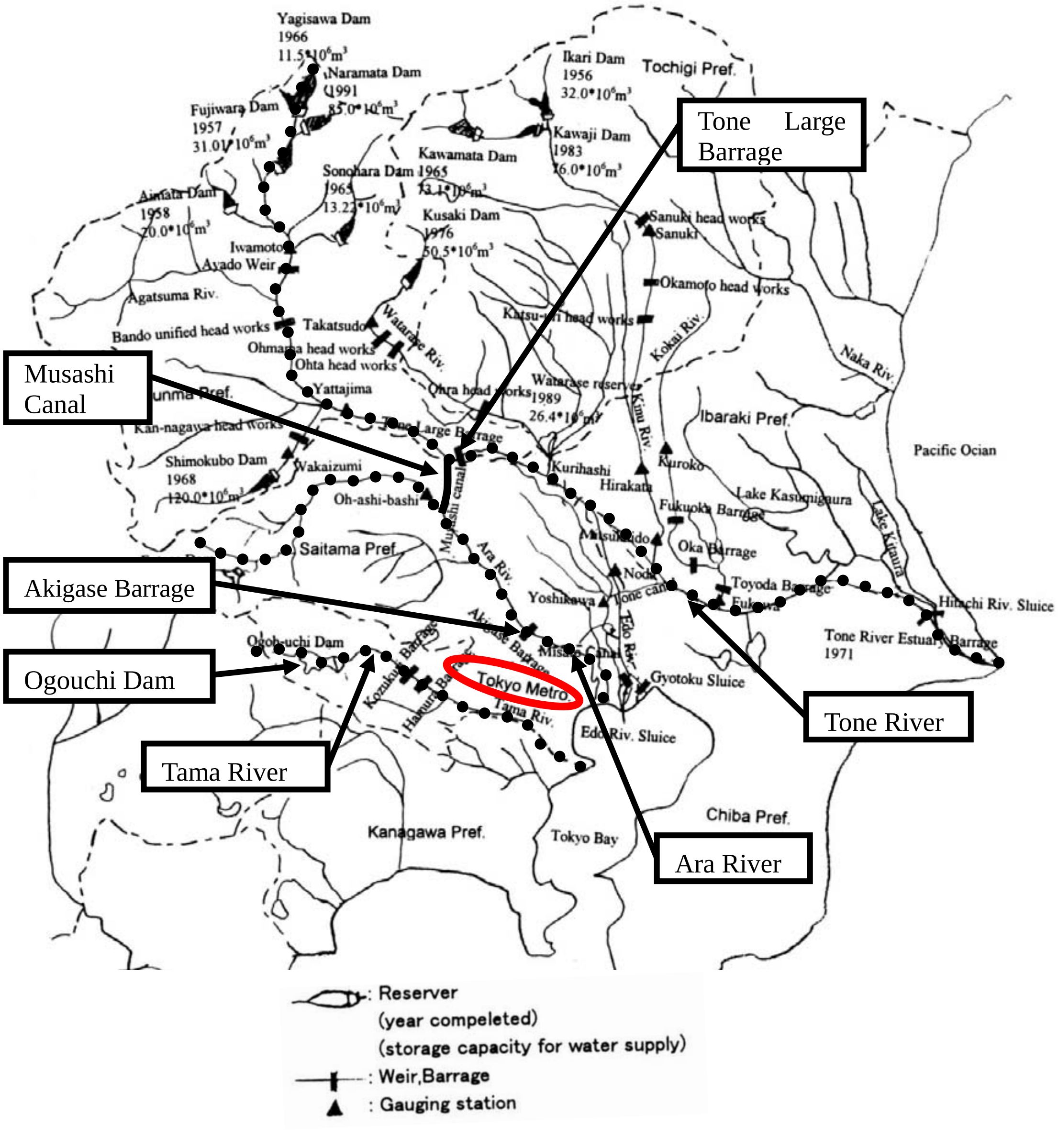


Figure 1 Rivers and basins in the Tokyo Metropolitan area and facilities for water resources development (River Bureau, Ministry of Construction (Supervised) (1997). Drought Conciliation and Water Rights, Infrastructure Development Institute – Japan, pp.II-3.)

External Force

(1) Increased demand for public-supply water use

Figure 2 shows the demographic changes in the Tokyo metropolitan area: Tokyo and the five prefectures, excluding Kanagawa prefecture that is less dependent on the Tone River (throughout the study, the analyses are done on Tokyo and the five prefectures, unless otherwise stated). The population had increased from approximately 15 million in the pre-war period to 22 million in 1965, and had reached 31 million by 1990.

The relationship between the population growth and the increased demand for city water is shown in **Figures 3** and **4**. Based on the two graphs, it can be calculated that, when the volume of water required per person is assumed to be approximately 400 liters, 1 billion m^3 per year of additional water withdrawal was required to respond to the population growth of 7 million from pre-war period to 1965, and additional 2.3 billion m^3 per year for the population growth of 16 million by 1990. In **Figure 4**, there is an increase of approximately 2 billion m^3 for the annual water supply between 1967 and 1990, which exceeds the estimation described above (2.3 - 1.0 = 1.3 billion m^3). This is probably attributable to increased water consumption per person, and the transition from groundwater use to public-supply water use. As indicated in **Figure 5**, during the period 1965 to 1990, the increase in population served by the public-supply water in Tokyo and the five prefectures was 14 million, 5 million people more than the population increase in the same period.

Therefore, it can be said that in addition to population growth being the major factor, the transition towards the use of public-supply water, and the increased water consumption per person have resulted in at least 3 billion m^3 per year of additional demand for city water.

(2) Increased industrial water use due to the convergence and expansion of industrial activities in the Metropolitan area

Synchronization of rapid population growth and the convergence/ expansion of industrial activities also resulted in a sharp increase in the demand for industrial water, although the rising demand did not directly lead to an increased supply. As seen in **Figure 6**, this can be explained by the drastic improvement in the recycling & reuse rate of industrial water from the mid 1960s to 1970s. The volume of industrial water supply was

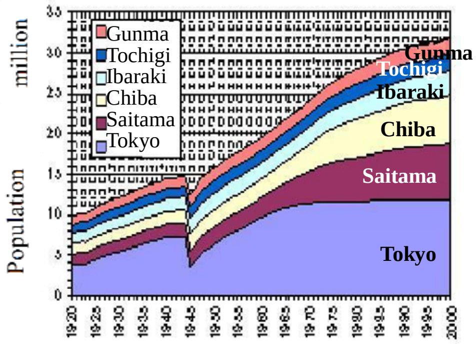


Figure 2 Demographic changes in the Tokyo metropolitan area (Tokyo and 5 prefectures).

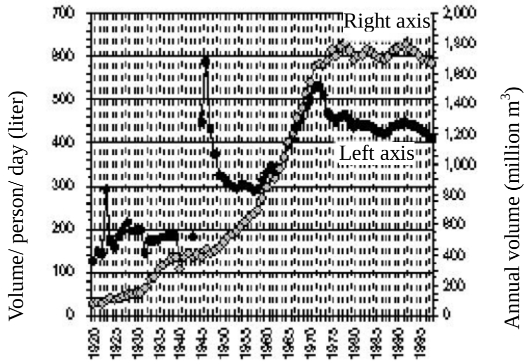


Figure 3 Transition of daily water-distribution volume per person and the annual water-distribution volume for public-supply use by year, in Tokyo.

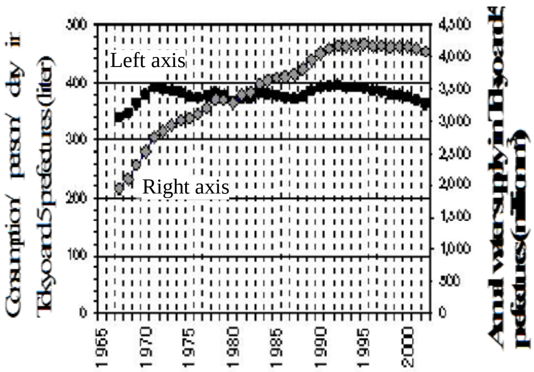


Figure 4 Transition of daily consumption per person and the annual water consumption of public-supply water by year, in Tokyo and 5 prefectures.

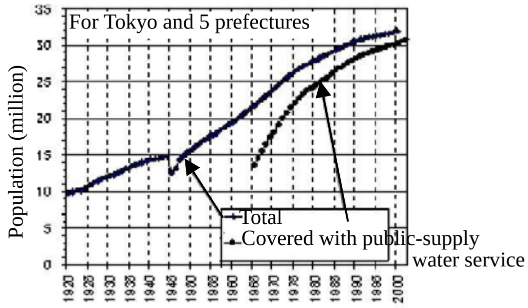


Figure 5 Transition of the population in Tokyo and 5 prefectures and the population covered with public-supply water service by year.

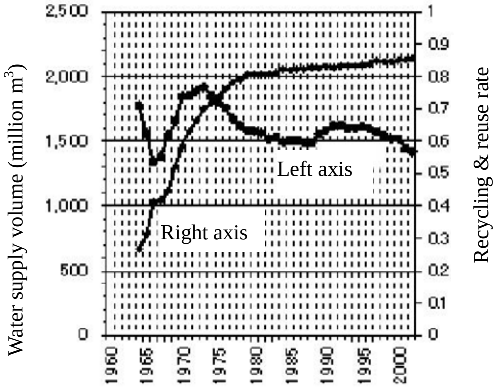


Figure 6 Transition of industrial water supply and recycling & reuse rate by year, in Tokyo and 5 prefectures.

approximately 1.5 billion m^3 in the early 1960s, almost equal to the previously mentioned demand for public-supply water use, but has not greatly changed until today. It can be assumed that the pressure to increase the supply of industrial water was at its peak between the 1950s and the early 1960s.

Assuming that the recycling & reuse rate had remained at about the same level as in the mid 1960s, i.e. 25%, and if 85% was taken as the actual rate, the calculation would give the increased quantity beyond the latter half of 1960s to be approximately 6 billion m^3 per year. If the volume increase before that period was also included, it would amount up to 7 billion m^3. Hence, together with the volume of public-supply water, the total increase that resulted from the population growth and the convergence/ expansion of industrial activities is estimated to be in the order of 9 to 10 billion m^3 per year.

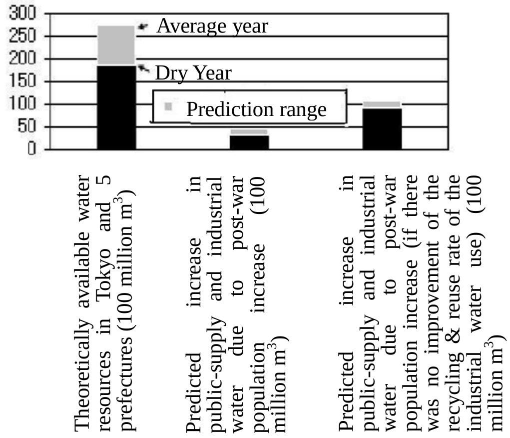


Figure 7 The impact of the increasing demand for public-supply and industrial water use accompanying the post-war population growth in comparison with theoretically available water resources.

(3) The impact of increased demand for public-supply and industrial water on the river basins of the Tokyo metropolitan area

The left bar chart of **Figure 7** shows the theoretically available water resource in Tokyo and the five prefectures. The other two bar charts on its right include, as a comparison, the prediction of increased demand for public-supply and industrial water use due to population growth (based on (1) and (2) described above). If there is no improvement of recycling & reuse rate, about half of the available water resources would be required to cover the additional volume of public-supply and industrial water required, and considering the proportion of water resources that can be used as public-supply and industrial water, it is evident that the increased demand would have acted as a serious external force on the river basins in question. Therefore, it can be said that the improvement of industrial water recycling & reuse rate had played an important role in adapting to the external force.

3. Water shortage problems induced by an external force of rapid population growth

(1) Overview of water shortages

What had mainly occurred as the direct result of rapid population growth acting as an external force, were shortages of public-supply water. The water shortages that had occurred intermittently between 1961 and 1964 in Tokyo, especially the so-called "Olympic water shortage" of the summer of 1964, had made a serious impact by causing water rationing and also suspension of water supply lasting for hours. The overview of these incidents can be summarized as follows. It should be noted, that the public-supply water of Tokyo at that time was withdrawn from Tama River system, and the water shortages concerned the Tama River system (see **Figure 1**).

a) Restriction of water supply in 1961 to 1962

In 1961, the precipitation in the Kanto region was substantially lower than the average in the past 22 years, with Tokyo marking a precipitation of 37mm in September, a mere 1/6 of the average year. Meanwhile, the water in the Ogouchi Dam (see **Figure 1**) had continued to decrease from its full capacity since June 1959, and the water level had decreased to approximately a 1/3 of the full capacity in early October. From 20th October, level 1 restriction of water supply was imposed on 545 thousand households in the 17 districts served by the dam, with a cut-back target of 20% (restriction hours lasted from 22:00 to 5:00).

The situation had still not improved by 1962, and the water restriction was scaled-up to level 2 on 16th April (cut-back target of 30%). The influence of water restriction expanded to a larger scale, which led to the establishment of "Provisional Task Force for the Water Shortage in Tokyo" on 1st May 1962. On 7th May, water restriction level 3 (cut-back target of 35%) was implemented, which included day-time rationing. Substantial alleviation of the restriction (back to level 1) was only realized in September, when the reservoir storage was recovered after considerable amount of precipitation.

b) Restriction of water supply in 1964

In autumn 1962, the water level of the Ogouchi Dam continued to decrease because of insufficient precipitation. Water restriction level 2 (cut-back target of 25%) was imposed again on 21st November, which continued almost throughout 1963. The strengthening and alleviation of water restriction continued to be repeated until July 1964. Finally in June 1964, with urgent withdrawals of 400 thousand m^3/day from the Naka and the Edo Rivers, the water restriction was alleviated back to level 1 (cut-back target of 15%) for the first time in 18 months.

However, the precipitation in May, June and July of 1964 was 261mm, approximately 50% of an average year, and water restriction was scaled-up to level 2 on 9th July. On 17th July, "Provisional Task Force for the Water Shortage in Tokyo" was re-established in order to respond to the emergency situation. Water restriction was strengthen to level 3 on 21st July (cut-back target of 35%, restriction hours from 23:00 to 5:00, and from 11:00 to 16:00), and to level 4 on 6th August (cut-back target of 45%, restriction hours from 22:00 to 5:00, and from 10:00 to 17:00). On 15th August, level 4 restriction was strengthened further (cut-back target of 50%, severe restriction including suspension of water supply during day-time). The restriction was imposed on 600 thousand households served by the reservoir, and the water shortage had a serious influence on the life of the citizens.

On 20th August, the water level of the Ogouchi Dam marked a record low of 1.6% of the full capacity. In addition, the river flow in the downstream of the Tama River also decreased considerably, and restriction of water supply was extremely strengthened in the areas served by the downstream water purification plants such as Tamagawa, Kinuta-kami, Kinuta-shimo, and Komae, and in the areas served by Nagasawa water purification plant that has the water diverted from Kanagawa as its source (376 thousand households in Shinjuku, Ohta, Shinagawa, Meguro, Setagaya, Suginami, and Nakano districts). Under the restriction, the water supply to the areas was limited to only 5 to 10 hours per day. The restriction started on 4th August and continued until the situation of the Tama River was improved by the torrential rain on 20th August.

c) From 1965 onwards

In the Tokyo metropolitan area, water shortages have continued to occur relatively frequently even after 1964. However, restrictions have mainly been on withdrawals and the socio-economic impact has been minimal in comparison to the water shortages described in the previous sections (a) and (b). “Withdrawal restriction” is a restriction imposed on water supply corporations for their water withdrawals. For example in the capital city of Tokyo, water withdrawal restriction can be overcome without restricting the water supply (water consumption), if the level of withdrawal restriction was not severe, by managing the water utilization or by requesting the citizen’s cooperation in water-saving. On the other hand, if restriction is imposed on the water supply, various steps will be taken that will directly affect the end-users, such as the lowering of pressure of water supplied from purification plants, and adjustments on the valves of water pipes.

Despite rapid population growth and frequent water shortages that continued beyond mid-1960s, they never lead to a large-scale restriction on water supply as in the first half of 1960s, owing, to a large extent, to the implementation of policies for securing water resources, described later in section 4. The first half of 1960s can be described as a period where the combined influence of climatic variation and population growth had become apparent, and overcoming such difficulties was a crucial stage in the implementation of water policies for coping with the rapid population growth.

(2) Changing awareness of the population

How these water shortage problems are viewed by the local/ national population, is one of the important factors to consider in policy formulation. The transition in the number of related newspaper headlines was studied as one of the means to quantify such awareness. The Asahi Shimbun Post-War Headlines Database 1945 – 1999 was used as a database for this analysis. Local edition articles of Tokyo are also included. The calculation method is summarized below.

The analysis was carried out for the period between 1945 and 1999. The total number of article headlines, excluding those classified as international articles, such as diplomatic issues, foreign affairs, and global topics, was taken as the total number of domestic article headlines. With this total as the denominator, the proportion of headlines that include a certain key word was calculated, as an indicator to measure the level of interest in that particular topic. During the applicable period, the annual total number of domestic article headlines had increased from 14 thousand to 74 thousand. The selected key words were “water shortage or drought or water famine”, “water supply and restriction”, and “water supply suspension”. All headlines that were extracted using a key word search function were checked, and those that were clearly irrelevant to the purpose of the study were omitted (e.g. water stoppage due to accidents or power cut of the purification plant etc.). Articles which were area-specific and unrelated to the Tokyo metropolitan area (e.g. Fukuoka water stoppage, water shortage in Hachijo-island, water shortages abroad etc.) were also excluded.

The results obtained are summarized in **Figure 8**, together with the information of the major water shortage years. The graphs show an increase in the number of headlines from the late 1950s, with a large peak in the earlier half of 1960s. As previously described, this was the time when serious problem of public-supply water shortage came to surface in Tokyo, ahead of other regions in the country, and the sharp rise in the number of articles reflects the sensitivity of the society on this topic. Although the number of headlines decreases after that, it can be observed that large number of headlines appear in the years matching the occurrence of water shortage, and this pattern continues until today. However, while the number of headlines including the word “water supply suspension” almost equaled the number of articles related to water shortage in general (water shortage or drought or water famine) in the earlier stage, a greater decrease of the former in comparison to the latter can be observed in the later stage. This trend may signify that there were fewer or more localized situations where direct damages were caused by water shortages.

Therefore, it can be said that the recognition of public-supply water shortage among local/ national population had become wide-spread in the latter half of 1950s and had peaked in early 1960s, and that this corresponds well

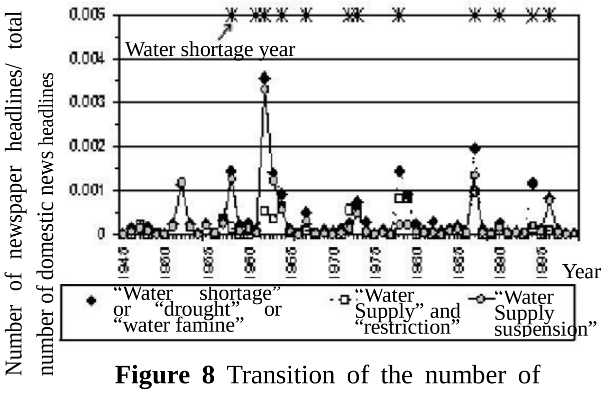


Figure 8 Transition of the number of newspaper articles on water shortage (Asahi Shimbun Post-War Headline Database 1945-1999).

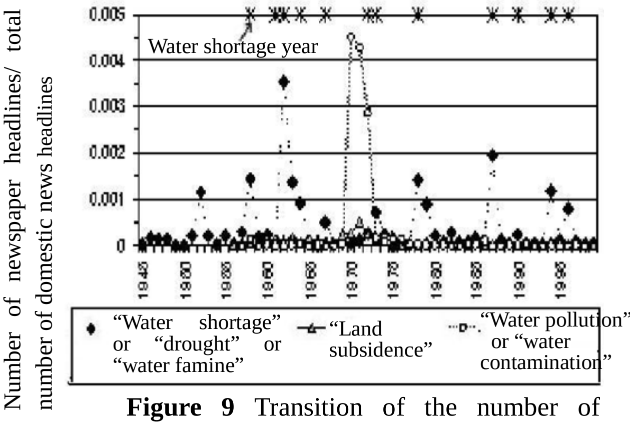


Figure 9 Transition of the number of newspaper articles on land subsidence and water pollution (Asahi Shimbun Post-War Headline Database 1945-1999).

with the years of serious damages caused by water shortages.

Figure 9 shows the transition in the number of headlines related to land subsidence and water pollution, calculated in the same method as above, as well as the number of headlines related to water shortage in general. Regarding the water pollution, the graph shows a major peak in the early 1970s, indicating a strong awareness of the issue among the population. Meanwhile, the peaks of the headlines concerning land subsidence is lower in comparison to the peaks of water shortage or water pollution; however, there are recurring peaks over the whole period starting from the late 1950s, with a slightly higher peak also in the early 1970s. It can be assumed that the phenomenon does not have a fluctuating nature that would result in sharp peaks, but the awareness of the problem had been fostered and maintained over the years. The relationship between these two phenomena and the policies for securing water resources will be discussed in section 5.

4. Effective policies for water shortage management and the outputs

(1) Overview of the policies

The policies that have been effective in the management of water shortages are listed and reviewed below. Please refer to **Figure 10**, which summarizes the whole picture.

a) Policies following "the basin-scale river water control concept", the germ of comprehensive river development

The concept of utilizing dams for flood control, hydraulic power generation, agricultural and public-supply water supply had emerged in around 1930s. The plan to construct the Ikari dam, the first multipurpose dam in Japan, had been formulated in 1925, and the construction of the dam started in 1950. In 1937, a survey of the most upstream Tone river basin for a river water control project had started, and the plans to construct the Yagisawa dam and other multipurpose dams with the purpose of securing public water supply and hydraulic power generation for Tokyo were formulated by 1939.

b) Post-war reconstruction and flood control policies immediately after the end of World War Ⅱ

Around 1950s, flood control in response to frequent occurrence of devastating disasters, increase of food production and securing energy for post-war reconstruction were some of the top priority agenda of the country. Multipurpose dams that can be used to secure agricultural water and generate hydraulic power in addition to its main purpose of flood control, attracted a lot of attention, leading to the following section (c).

c) Tone River Specified Area Comprehensive Development Plan as part of the National Land Development Plan

In 1949, the Flood Control Investigation Committee decided upon the river improvement plan of the ten major river systems, including large-scale flood flow regulation by the multipurpose retarding basin. For the Tone River system, the basic principle was to control the floods with the upstream dams (Numata, Fujiwara, Sonohara, Aimata, Sakahara, and Yatsuba). In 1950, the formulation of a Comprehensive Development Plan for Specified Areas was decided under the Comprehensive National Land Development Act, and Tone River was designated as a specified area in 1951. In response, the 10-year Tone River Specified Area Comprehensive Development Plan was endorsed by the Cabinet in 1957. Hence, land conservation based on flood control plan consistent for the whole river system, which promotes water utilization for agricultural development, secures electrical power generation, and strengthens industrial development, became the policy direction. Furthermore, the "Comprehensive River Development" that uses multipurpose dams as concrete tools, came to occupy an important position in the National Land Development Plan.

d) Comprehensive River Development of the Tone River

As the result of the above-mentioned process, the constructions of several dams including Ikari, Fijiwara, Aimata, Sonohara, Yagisawa, Shimokubo, Kusaki, and Kawaji were sequentially completed and placed in service. The time-scale from the survey to the completion of each dam is indicated in **Figure 10**. "FNAWIP" in the diagram refers to the different purposes of dams (F: Flood control / disaster prevention of agricultural land, N: water for unspecified use / river maintenance flow, A: Irrigation water, W: Public-supply water, I: Industrial water, P: Hydraulic power generation).

e) Specified Multipurpose Dam Law (1957)

The law was enacted to ensure the unification of planning, construction, management of dams, to establish the rights to use a dam, and to ensure the smooth and effective use of dams.

f) Laws concerning water resources development (Water Resources Development Promotion Law, 1961 /

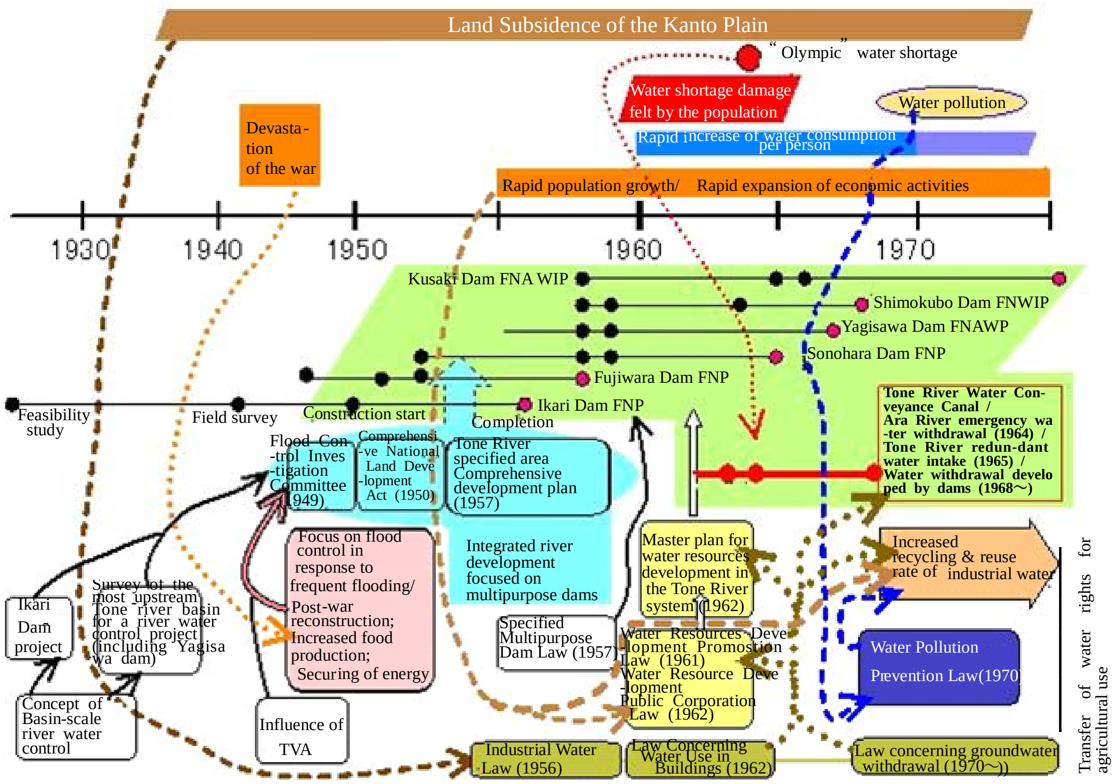


Figure 10 Time sequence of events and implemented policies relevant to water resources management to cope with the rapid population growth (the arrows show relationships or presumable influence).

Water Resources Development Public Corporation Law, 1962)

With the systems that existed previously, there were problems such as difficulty to utilize lake waters, unclear role of channels, lack of means to use investment and loan funds, difficulties for broad-based or advance development, and formulation of plans by each individual corporation. Moreover, while rapid population growth and industrial development had lead to a sharp increase in the demand for water in the Tokyo metropolitan area, the transition of groundwater use to surface water became an important issue because of land subsidence. The issue of securing public-supply water was particularly pressing for the Tokyo area, where there was narrow possibility for new water resource development in the Tama River system.

Under such circumstances, these legal systems were established based on the principle that the water resource development would play an important part in the country's economic plan, thus requiring a broad-based and a systematic approach. As a response, the Tone River and the Yodo River were designated as the river systems for water resource development in 1962, and a Water Bureau was created within the Economic Planning Agency.

g) Tone River Water Conveyance Canal Project

Even before the war, the municipal government of Tokyo has had the idea of withdrawing the high quality water in the upstream of the Tone River for the purpose of public water supply. A plan based on the idea (conveying the water from Yagisawa and Shimokubo dams to Higashi-murayama purification plant, via a tunnel in the western region of Saitama prefecture) was taken up by the Ministry of Construction as a Water Resources Development Public Corporation project (hereinafter referred to as the Public Corporation). The Ministry of Agriculture and Fisheries was against the withdrawal of water from a position that is further upstream than the withdrawal position for agricultural use. Therefore, the Ministry of Agriculture and Fisheries proposed a plan with a combined canal for agricultural and public-supply purposes. Both the Ministry of Health and Welfare and the Ministry of International Trade and Industry also proposed other Public Corporation projects respectively.

Despite the strong request from the municipal government of Tokyo, the implementation method of new water withdrawal was still not established in 1962, when the Master Plan for Water Resources Development in the Tone River System was formulated. Therefore the Public Corporation urgently designed a plan with the combined canal, and the construction was initiated in 1963. The goals of the Projects were i) to convey the public-supply water developed from the dams in the upper stream of Tone River to Tokyo and Saitama prefecture, through Musashi Canal and Ara River, ii) to provide stable supply of irrigation water to 29,000ha of rice fields in the Tone River middle reach, iii) to urgently but provisionally provide the Tone River's surplus water for the purpose of Sumida River purification.

The whole Tone River Water Conveyance Canal Project (Akigase Barrage, Asaka Canal, Tone Large Barrage, and Musashi Canal) was completed in March 1968. In order to respond to the occasional water shortages in Tokyo during the construction period between 1963 and 1968, provisional functioning was effectuated as emergency measures. First, in August 1964, together with the Olympic water shortage, the crisis had forced a rush construction work to realize partial water flow (Ara River emergency water withdrawal). Furthermore, after the completion of the Musashi Canal in March 1965, the surplus water of Tone River has been able to flow. Thus, such emergency measures in addition to the whole Project, have been important in responding to the crisis situations.

h) Others

The continuous efforts made by all the concerned parties in the transfer of water rights from agricultural use to public-supply water, has played a role to a certain degree. Moreover, institutional improvements were made on the various measures for minimizing the impacts of dam and reservoir construction on communities around the site.

(2) Output of policy implementation: Changes in withdrawals

The easiest way to quantitatively determine the overall achievements of various policies would be to examine the changes in the volume of withdrawals and their breakdown. Given that the industrial water supply had not increased greatly beyond late 1960s due to the improvement in recycling & reuse rate, as described in section 2(2), this study focused on the public-supply water, because it can be assumed the use of the public-supply water would be the direct reflection of the measures against rapid population growth. The withdrawals and their breakdown were calculated by employing the following method.

First, based on the statistical data on water supply, the total public-supply water withdrawals for Tokyo and the five prefectures were examined by year. Next, also based on the statistical data on water supply, the ratio of the volume of water rights from the Tone River as well as from the Tone River dams, were calculated against the total volume of water rights. Since the total volume of withdrawals includes the water that is not within the scope of water rights, the calculation was done by using only those to which water rights are applicable (surface water, lake water and river-bed water) and multiplied by the above-mentioned ratios of water rights to determine the breakdown of withdrawals from the Tone River system including the dams (for every 5-year period). In reality, the water rights are not necessarily equal to actual withdrawals; therefore, the calculation will have inherent margin of error. However, it was considered to be an effective means of assessing the situation with a broad perspective.

The results of the above, together with the data on demographic changes, are indicated in **Figure 11**. From the graphs, it can be observed that the majority of the 2.5 billion m^3 additional withdrawals during the period of 1965 to 1990, was covered by the withdrawals from the Tone River system (approximately 2.3 billion m^3). If the required volume per person was 400 liters, this would correspond to a water supply for 16 million people, which greatly exceeds the population increase of 9 million from 1965. As mentioned in the section 2(1), this is probably attributable to the increased water consumption per person and the transition from groundwater use to public water service. Furthermore, it is possible that industrial water is partially included.

Also from **Figure 11**, it can be observed that the ratio of withdrawals premised on the dams of the Tone River system (described as "withdrawals from the dams on the Tone River system" on the graph) is large against the additional withdrawals from the Tone

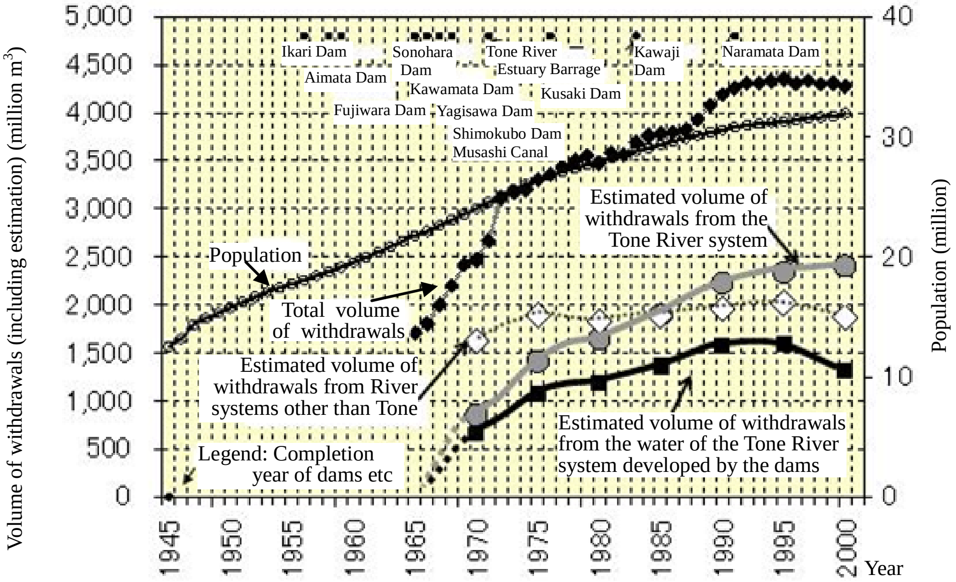


Figure 11 Transition of population and the volumes of public-supply water withdrawals by year, in the Tokyo metropolitan area (Tokyo and 5 prefectures).

River system. This signifies an important role played by the increased volume of water rights, in line with the new water resource development by dam construction.

For example, when the Tone River Water Conveyance Canal Project was completed in 1968, the rights for public-supply water use from the Tone Large Barrage were for the newly constructed Yagisawa Dam and Shimokubo Dam. Although there have been occasions where time-lags have emerged between new water resources development and the increase in public-supply water demand, the framework of linking new water resources development with the increase of withdrawals has been maintained.

5. Analysis of other factors related to the implementation of policies

(1) Related incidences and policies that influenced the policies for securing water resources

Here, land subsidence and water pollution that are thought to have exerted significant influence on the policy making processes, will be examined. Reference should be made to **Figure 10**.

Land subsidence occurs mainly as a result of excessive withdrawal of groundwater, for the purpose of industrial use. In Koto district of Tokyo, it is known to have started back in the mid 1920s. Public awareness on land subsidence, as explained in the section 3(2) and with **Figure 9**, is evident from the number of newspaper articles appearing continuously from the late 1950s and peaking in the early 1970s. Countermeasures have started in the late 1950s, and the Industrial Water Law was enacted in 1956, followed by the so-called law concerning water use in buildings which was enacted in 1962. In 1970, regulatory measures were applied on groundwater based on Chiba Prefecture's environmental pollution prevention ordinance, followed by Saitama, Tokyo, Ibaraki, and 49 other municipalities.

The implementation of these measures coincides with the period where water shortage due to rapid population growth surfaced and drastic measures were in demand. Therefore, it is possible to assume that increasing the groundwater use would not have been a practical option to respond to the population growth and rising demand for industrial water. There is also a possibility that this functioned as a "secondary external force" that raised the industrial water recycling & reuse rate.

On the other hand, it is evident from **Figure 9** that water pollution became a major interest of the population around about 1970, and the Water Pollution Prevention Law was enacted in 1970, in addition to the existing Water Quality Preservation Law and the Industrial Waste Water Regulation Law. The population's strong request for water quality preservation became one of the important factors that encouraged the rationalization of industrial water usage, in other words the improvement in the recycling & reuse rate. According to Aya and Matsumoto, the campaign for the rationalization of industrial water, run by the Industrial Water Association, had been highly effective in strengthening the increase of production without depending on new water resources and by reducing the speed of land subsidence. They continue to suggest that the decrease in supplementary water signifies effluent reduction, allowing small quantity of highly concentrated effluent to be purified and discharged. They point out that the rationalization of industrial water had made water quality preservation possible with a surprisingly small amount of investment, and that the campaign had in fact stressed that the rationalization of industrial water would be the most economical means to clear the regulations of Water Quality Preservation Law.

Therefore, it can be said that the awareness for land subsidence and water pollution together with the implementation of policies for coping with them had functioned as important promoting factors in solving the problems related to the securing of water resources, by creating a structure where an increased demand for industrial water is overcome by an improved recycling & reuse rate.

(2) Analysis on the environmental impact induced by the implementation of policies

As another factor, incidences related to possible environmental impacts induced by the policies for securing water resources will be examined.

Figure 12 shows the transition by year, of the 185-day low flow in the Tone River at points upstream and downstream of the Tone Large Barrage (diversion weir to the Musashi Canal) (the data are from the annual Flow Rate Chronology). These points are Yattajima, Futto, Tone Large Barrage, Kawamata, the confluence of the Watarase River, and Kurihashi, from upstream downwards. It can be seen from the graph, that the low flow at Kawamata which was approximately equal to that at Futto in 1968, drops from then onwards in the order of $50m^3/s$. This also corresponds to the actual withdrawal volume from the Tone Large Barrage (1.87 billion m^3 in 2001, the breakdown being 730 million m^3 for agricultural water, 1.09 billion m^3 for public-supply water, and 50 million m^3 for river water purification. The annual total flow of the Tone River in the reach is 6.29 billion m^3). In other words, the Tone Large Barrage had caused reduction of discharge in the channel downstream of the barrage. The influence of this reduction becomes apparent at times of the year when the flow is low, and after 1968, the 355-day low flow at Kawamata is halved. It is also clear from the above-mentioned breakdown, that the decrease is not only attributable to public-supply water use but also to agricultural water use.

Next, assessment of the influence of additional water intake on water quality was conducted by applying the watershed-scale hydrological and material cycle simulation model that incorporates all the major river systems flowing into the Tokyo Bay. The discharge and the water quality at some of the major points on the Tone River and the Ara River for years 2001, 1976 and 1970 have been reconstructed almost to the level of actual measurements, by using this model. With 1976 taken as the target year, under the social conditions such as population and land use, the meteorological conditions such as rainfall, and the actual loading, the discharges was calculated with the actual withdrawal volume to the Tone River Conveyance Canal as case 1, and with no withdrawal from the Tone Large Barrage as case 2. For the case 2, the water intake from Akigase Barrage on the Ara River is also

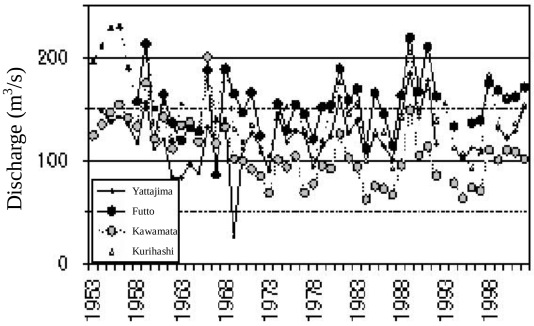
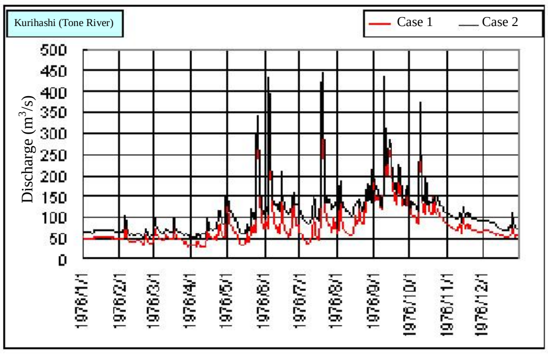


Figure 12 185-day low flows in the Tone River upstream and at points downstream of the Tone Large Barrage

considered to be zero, as no water is channeled from the Tone River to the Ara River (see **Figure 1**).

The results of the analyses are shown in **Figures 13** to **16**, from which the following observations on the impact of water conveyance (the result of case 1 in comparison to case 2) can be made. Naturally, the discharges at Kurihashi (Tone River) downstream of the Tone Large Barrage decreased, but the discharges at Sasamebashi (Ara River) downstream of the Akigase Barrage did not change greatly since the conveyed water is withdrawn at this point. The water quality indicated by BOD, hardly changed at Kurihashi, but decreased slightly in Sasamebashi depending on the season. This can be explained by the fact that while there is no major source of burden that would affect the concentration in the downstream of the Tone Large Barrage, the inflow of water in the Ara River may have a slight dilution effect depending on the season.

Therefore, it is assumed that the withdrawal from the Tone Large Barrage did not have a major effect on BOD, for both the Tone River and the Ara River. Regarding the flow required to be left in the river even during drought period for maintaining river environment and ecology, it is stated as “the maintenance flow” in the draft proposal for the Technical Guideline for River Works, issued in 1977, and it is highly probable that such concept existed in the 1960s. However, apart from the specific areas or cases where the problems induced by discharge reduction are clear, such as salt water intrusion in estuaries, it was probably not necessary at the time to specify the maintenance flow throughout a whole river reach. In fact, even



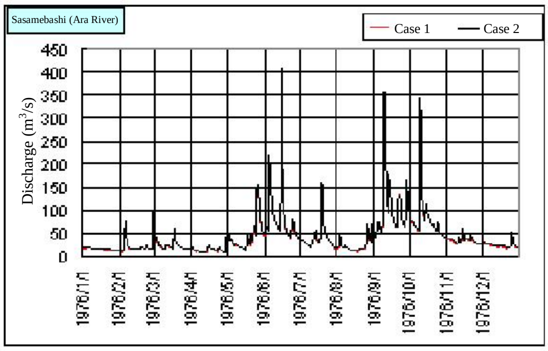
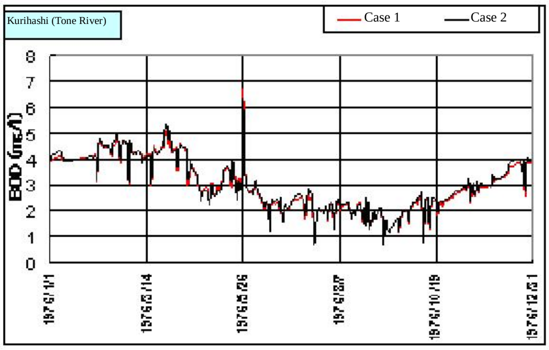


Figure13 Comparison of discharge at Kurihashi (Tone River)

Figure 14 Comparison of discharge at Sasamebashi (Ara River)



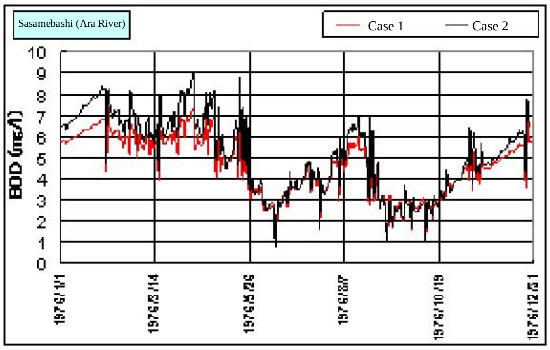


Figure 15 Comparison of water quality at Kurihashi (Tone River)

Figure 16 Comparison of water quality at Sasamebashi (Ara River)

for the Tone River Water Conveyance Canal Project, the maintenance flow is not specified in the lower reach immediately after the Tone Large Barrage.

Thus, if we look at the environmental impact based on the evaluation standards of those days, it is unlikely that the environmental concerns could have been the inhibiting factor for the implementation of the water intake from the Tone River to the Tone River Conveyance Canal.

6. Discussion

The policies to cope with the rapid population increase in the Tokyo metropolitan area will be easily understood if they are divided into four categories: (i) new public-supply water development relying on the Tone River system, (ii) improvement in the industrial water recycling & reuse rate, (iii) transfer of water usage (from agricultural water use to public-supply water use), and (iv) economizing of domestic water use. It can be said that the two formers largely and practically contributed to solving problems. Regarding (i), as it can be reconfirmed in **Figure 10**, the Tone Water Conveyance Canal has allowed the initiation of a large-scale water intake from the Tone River dams in 1968. This is only 4 years after the Tokyo Olympic water shortage in 1964, and based on the usual time-scale of infrastructure development, this time-lag can be considered to be short.

When reviewing the reasons why it was possible to successfully respond to the convergence of population and economic activities that became increasingly evident in the late 1950s, the following points may be considered. The direct and the most important contributing factor is the fact that the various emergency measures employed to overcome the early-60s critical situation were eventually and smoothly followed by the full-scale control measures such as (i) and (ii) mentioned above. As for (i), the Tone Water Conveyance Canal would not have functioned on its own but was made possible by “the Master Plan of Water Resources Development in Tone River System”, a framework that had been formulated just beforehand (1962), which allowed the fundamental conditions for the Tone River water intake to be developed. In addition, based on the National Development Plan which had been formulated ten years in advance with post-war reconstruction and flood control as the core purposes, the comprehensive river development plan had already begun in practical terms. As the construction of multipurpose dams was the main focus of the river development plan, rapid response to the external force was made possible. Meanwhile, in terms of significant improvement in the industrial water recycling & reuse rate mentioned in (ii), external forces such as the regulation on groundwater withdrawals for the alleviation of land subsidence, or the effluent regulation for water pollution prevention, induced recycling & reuse rate improvements rather than relying on the increase in water supply.

Figure 17 attempts to summarize the structure of policies taken to meet the rapid population growth in the Tokyo metropolitan area. Here, the developmental stages from the exertion of external force to the output (achievements) of policy application are classified into issues recognition, forces encouraging investigations and execution of the policies (and the strength of responses of each player), the tools for policy implementation, and external factors related to policy implementation (sub-divided into interaction with policies with other purposes, consensus among interested parties, environmental impacts, and geographical conditions). The powers each of these categories may exert on various policies have been qualitatively indicated on the table: promoting power (arrows to the right), impeding power (arrows to the left) and neutral power (straight vertical line). Furthermore, if application in another region is being considered today, the level of contemporariness and universality should be re-considered for the policies and factors which have been shaded.

Figure 17 shows that emphasis had been placed on infrastructure construction and

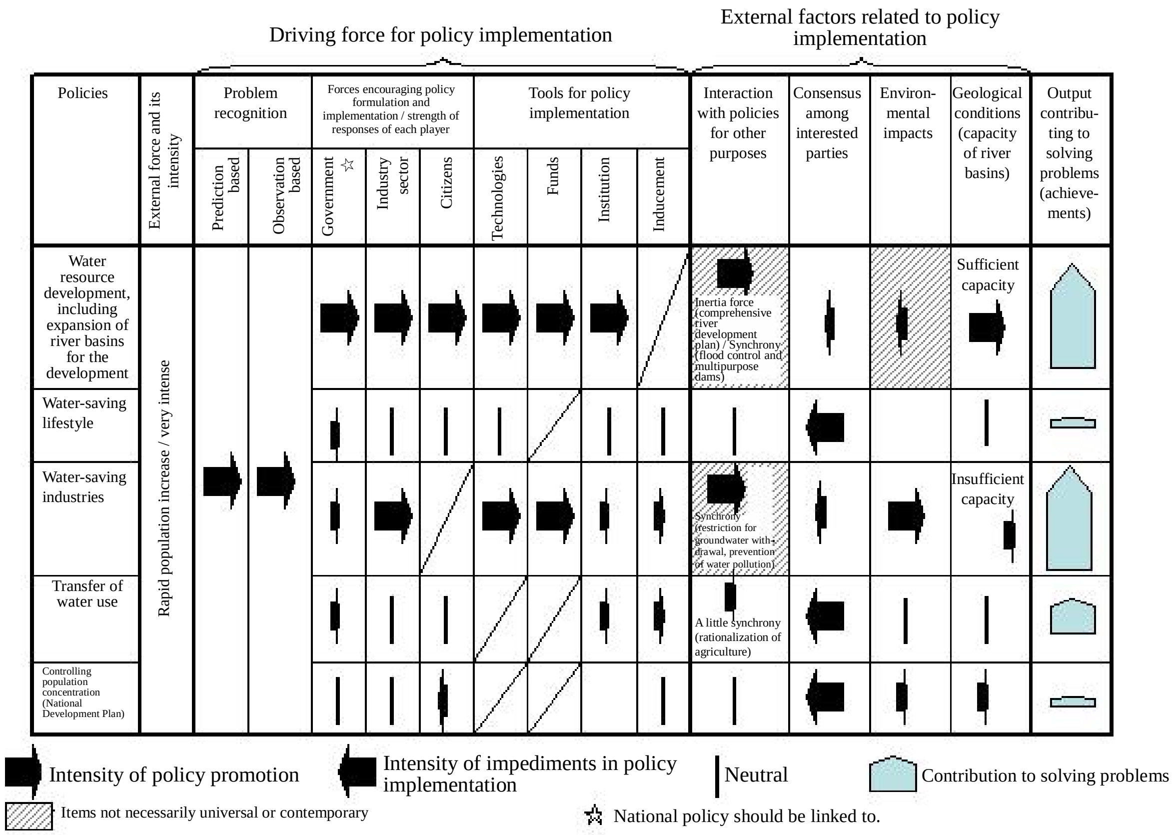


Figure 17 Structure of the formulation and implementation of policies taken to meet the rapid population growth in the Tokyo metropolitan area

firm-based policies. The synchrony among flood control measures, restrictions on groundwater collection, and measures against water pollution, which existed then, would have played an important role in the policy promotion in those days. Furthermore, the Comprehensive River Development Plan of the Tone River basin with a core focus on the construction of multipurpose dams mainly for flood control, had been developed over a long period of time, and such prior policies (inertia force) had greatly contributed in the resolution of the problems. Therefore, the favorable interactions with policies for other purposes being in a "win-win" situation, and to what extent they can be applied or expanded, would also be a valid point of discussion when considering the application of the experiences summarized in **Figure 10** in another region today. For example, a combined application of the effluent regulation for water quality preservation and the policies related to the improvement of industrial water recycling & reuse rate may be a useful proposal for a comprehensive water policy of today.

The other shaded area is related to environmental impact, which is more emphasized today than at that time. Depending on the relationship between the capacity of the target river basins and the pressure of population increase, there may be cases where the management of environmental impacts of the policies becomes an important issue. For the policies implemented in the past, one may simulate the possible development of events by assuming that the level of knowledge and the demand for the environmental protection in those days had been as high as they are today. This process would help to determine whether the policies would be applicable today, and to consider substantial methods to expand them. Environmental considerations on the maintenance flow, flow regime, frequency of disturbances of a river could be some of the examples.

7. Concluding Remarks

In Japan, various policies related to the securing of water resources have been formulated in the past, in response to the rapid population growth in the Tokyo metropolitan area experienced mainly during the period of high economic growth. Various aspects of the external force (rapid population growth), events induced, problem recognition, policy implementation and its outputs, and other related factors have been examined, and by analyzing them from a panoramic perspective, an overview of the interactions between various events and policies could be summarized as seen in **Figure 10**. Furthermore, a conceptual framework of the developmental process, from the exertion of external force to the outputs of policy implementation, has been presented in **Figure 17**. They will be of assistance in analyzing the universality and the individuality in the formulation process of each water policy, and may be used to objectively consider how an experience in a particular point in time and in particular region can be applied to a different case in another region and in different pointing time.

The evaluation of flood risk and prevention of flood disaster

National Institute for Land and Infrastructure Management

Research, Evaluation, and Publication of River Improvement Status Focusing on Small and Medium Size Rivers

(Regarding the Use of Laser Profiler Measurement)

Purpose and Outline

○Recent rash of water-related disasters across Japan

Severe damage along small and medium size rivers that are susceptible to the impact of localized heavy rain.

Levee Breach in 2004

July, heavy rain in Niigata and Fukushima	Niigata	Igarashi R., Kariyata R.
July, heavy rain in Fukui	Fukui	Asuwa R.
Sep., typhoon No. 23	Hyogo	Maruyama R., Izushi R.

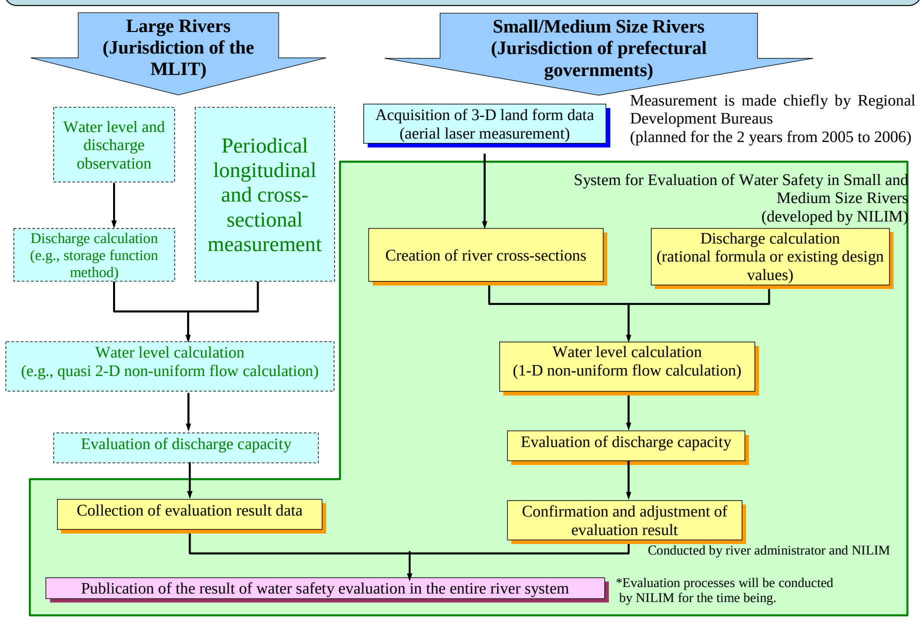
①Promotion of efficient and effective flood control
②Practical crisis management in the event of disaster
③Enhancement of inhabitants' awareness of risk

⇨ Based on discharge capacity and other data, the status of river improvement must be grasped, evaluated, and publicized.

However,
the data on discharge capacity and other basic important parameters are often missing due to the lack of longitudinal and cross-sectional measurement of river channels, as well as monitoring of water levels and discharges, in many stretches of small and medium size rivers.

Water safety evaluation covering small and medium size rivers in the watersheds of class A rivers across Japan will be conducted using simple methods and unified standards instead of traditional data collection and analytic procedures.

Flow Chart of Survey, Evaluation, and Publication of the State of River Improvement in Class A River Systems



Scope of Evaluation and Coverage of Aerial Laser Measurement

1. Scope of Evaluation

River section under the jurisdiction of MLIT and prefectural governments requiring improvement within class A river systems

River section under the jurisdiction of MLIT in class A river systems: approx. 10,500 km
River section under the jurisdiction of prefectural governments in class A river systems: approx. 32,000 km
(Total length of river section under the jurisdiction of prefectural governments is approx. 77,000 km)

2. Coverage of Aerial Laser Measurement

River channels and flood regions related to river section under the jurisdiction of MLIT and prefectural governments state-managed segments and prefecture-managed segments requiring improvement within class A river systems

(Approx. 120,000 km² including mountainous areas covered by the measurement using fixed-wing airplanes)

- ●Data acquisition is conducted by Regional Development Bureaus
- ●Data acquisition schedule: Measurement of all areas is planned to be completed in 2006.
- ●Types of data sets to be obtained:

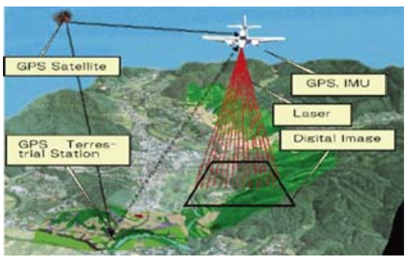
①Original data (river channels and flood plains) Accuracy: horizontal ±30 cm, vertical ±15 cm

②Ground data (river channels: approx. 20-m zone inward from the toe of slope behind embankment)
* Ground data are generated by filtering original data to remove unnecessary features.

③Aerial photos (orthophoto images) (river channels and flood plains)

Outline of Aerial Laser Measurement

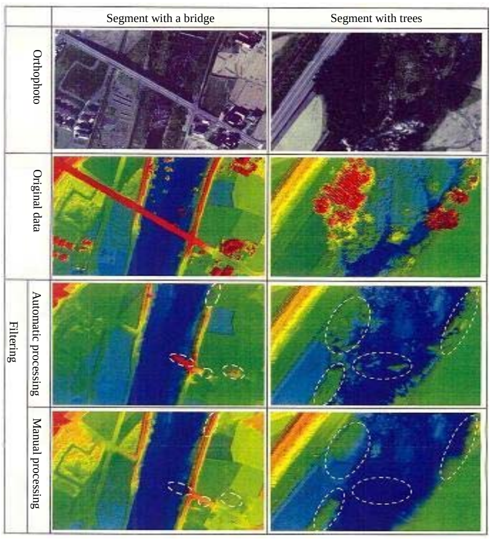
Outline of Aerial Laser Measurement



Major Filtering Items

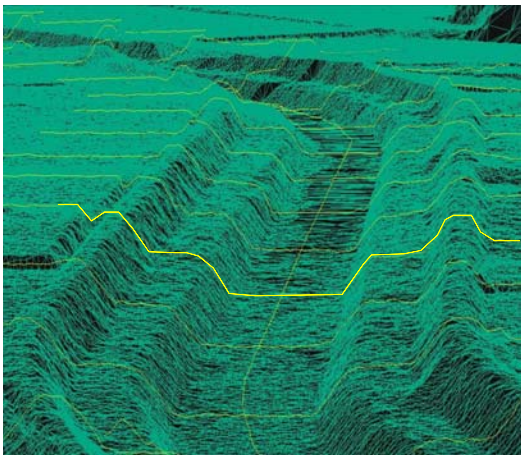
Transportation facilities	Road facilities, etc.	Road bridge (length 5 m or longer)
		Overhead pass, pedestrian overpass
	Railway facilities	Railway bridge (length 5 m or longer)
		Overhead pass (including overhead monorail lines), link-line bridges
Foliage		Trees, bamboo forests

Filtering of the Data from Aerial Laser Measurement



Grasping the Present State of River Channel

○A triangulated irregular network (TIN) model is generated from the acquired ground data, and used as the basis for generation of river channel cross-sections at regular intervals.
(Automatic generation using the software developed at NILIM)



Errors in River Channel Cross-sections

- ・Accuracy of aerial laser measurement (horizontal ±30 cm, vertical ±15 cm)
- ・Errors from the spatial resolution of laser data
- ・Errors from the filtering of features
- ・Errors from the inability to measure underwater features

○Using mostly winter measurements that are not so badly affected by foliage growth

○Carrying out accuracy checks, correction and interpolation with the use of river channel measurement cross-sections when they are available

Discharge Flow Calculation

Considering the present state of data collection and analysis in small and medium size rivers and aiming at quickly and simply establishing a minimal ability for consistent calculation of the discharge capacity of small and medium rivers nationwide, we uniformly apply the inexpensive, efficient, and simple method using rational runoff formula instead of traditional procedures.

$$Q_P = \frac{1}{3.6} frA$$

Qp: flow at the peak of flooding (m^3/s), f: runoff coefficient, r: precipitation intensity within the time of flood concentration (mm/hr), A: area of flow region (km^2)

・Flow coefficient (f):

- ・Weighted average of the flow coefficient for each land use region (related to the area of each region)
- ・0.7 for mountainous areas, 0.8 for flat areas

・Precipitation intensity within the time of flood concentration (r):

・This uses the AMeDAS Probable Precipitation Calculation Program developed by the Public Works Research Institute.

This program creates the precipitation intensity equation (Fair formula) based on precipitation recorded between 1971 and 2000 in 748 of the approximately 1,300 Japan Meteorological Agency's AMeDAS measurement locations positioned throughout the entire country. (http://www.pwri.go.jp/jpn/tech_inf/amedas/top.htm)

$$r_t^T = \frac{bT^m}{(t+a)^n}$$

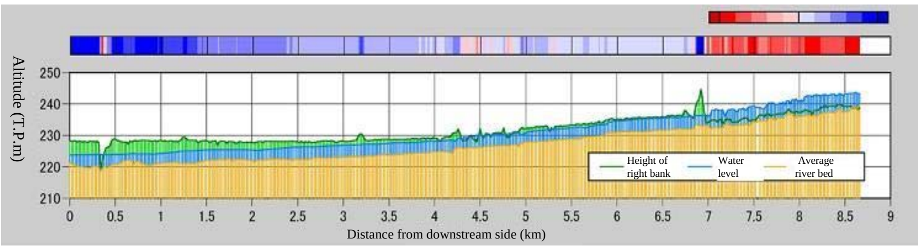
r_t^T : Probable amount of rainfall (mm/hr)
T : Return period (year)
a,b,m,n : Parameters of Fair formula
t : The time a flood is likely to occur (either Kraven formula, Kadoya formula, or Doken formula)

Water Level Calculation

○ Considering the present state of data collection and analysis in small and medium size rivers and aiming at quickly and simply establishing a minimal ability for consistent calculation of the discharge capacity of small and medium rivers nationwide, we uniformly apply the inexpensive, efficient, and simple method using 1-dimensional non-uniform flow calculation instead of traditional procedures.

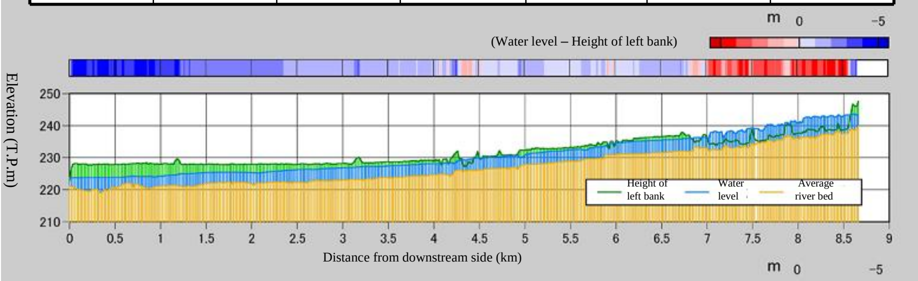
* Roughness Coefficient

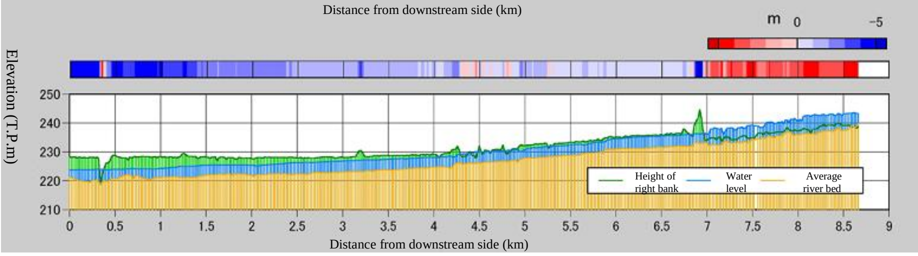
・The value of n=0.033 is used based on the analysis of trends in the roughness coefficient in 58 small and medium size rivers, where the roughness coefficient has been studied in detail from actual measurement and other sources.



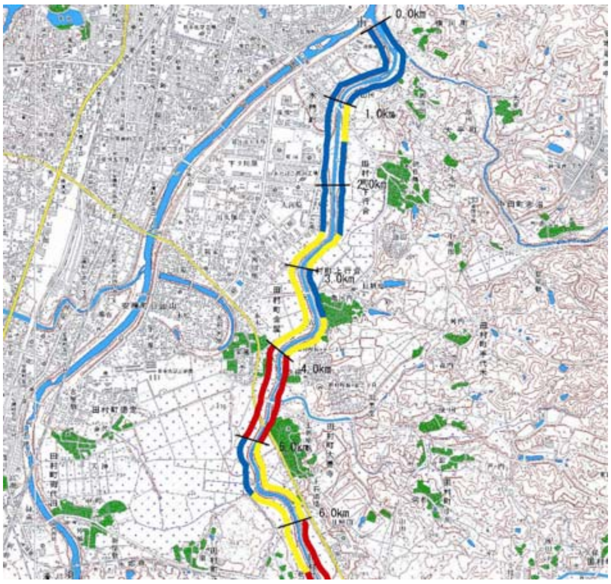
Output of Evaluation Results (1) Discharge Capacity Evaluation Chart Showing Water Level and Bank Profile

River Name	Calculated Length	Probability Scale	Probable Precipitation	Probable Flow	% of Satisfactory Parts on Left Bank	% of Satisfactory Parts on Right Bank
A River	8.6 km	1/10	47 mm/60 min	400 m³/s	78%	85%





Output of Evaluation Results (2) Water Safety Evaluation on Plan Map



The degree of water safety is evaluated as the minimal discharge capacity in each segment (500-m pitch).

Legend	
(blue line)	Segment that can withstand floods expected to occur once in 30 years. (Segment with a discharge capacity of 600 m^3/s or more) (Segment with a risk of flooding caused by a rainfall of 50 mm/h or more)
(yellow line)	Segment that can withstand floods expected to occur once in 10-30 years (Segment with a discharge capacity of 480m^3/s - 600m^3/s or more) (Segment with a risk of flooding caused by a rainfall of 30 mm/h or more)
(red line)	Segment that cannot withstand floods expected to occur once in 10 years (Segment with a discharge capacity of 480m^3/s or less) (Segment that cannot withstand a rainfall of 30 mm/h)

The largest past flooding in this river
(year __, month __)
Approx. 1/20, 550 m^3/s, 40 mm/h

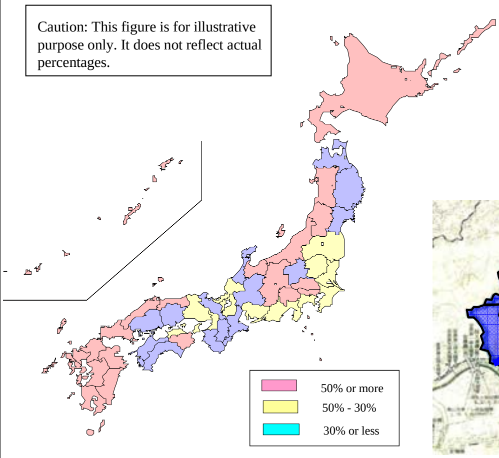
• Thresholds and segmentation (500-m pitch in this figure) require further refinement considering other cases.

Output of Evaluation Results (3)
Average % of Safe River in Each Prefecture and Each Municipality

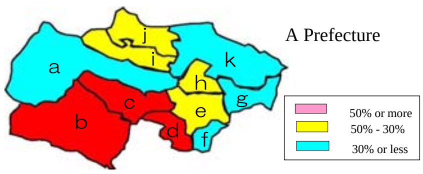
Average % in Each Prefecture
The percentage of river stretches that cannot withstand floods expected to occur once in 30 years.

Average % in Each Municipality
The percentage of river stretches that cannot withstand floods expected to occur once in 30 years

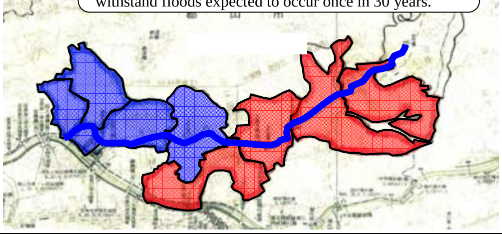
Caution: This figure is for illustrative purpose only. It does not reflect actual percentages.



A Prefecture



Average % in Each District
The percentage of river stretches that cannot withstand floods expected to occur once in 30 years.

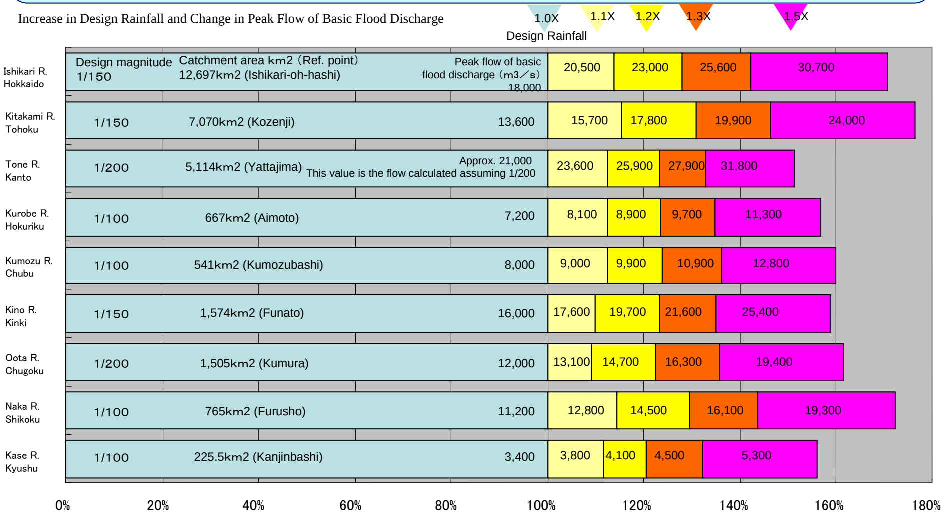


These figures are for illustrative purpose only. We need further discussion as to how evaluation results should be publicized.

Adaptation Measures to Flood Disaster

Impact of Climate Change on Peak Flow of Basic Flood Discharge

The rainfall in various prediction studies is generally in the range from 1.0 to 1.2 times; 1.3 times in some regions and 1.5 times at the maximum.
Therefore, we selected 9 class A rivers where design rainfall is set on a daily basis and estimated the peak flow of basic flood discharge assuming the design rainfall of **(1) 1.1, (2) 1.2, (3) 1.3, and (4) 1.5 times**.



*Estimation using the flow model in the Fundamental Policy assuming the design rainfall increased by factors from 1.1 to 1.5

Lowering of Water Safety Due to Future Increase in Rainfall

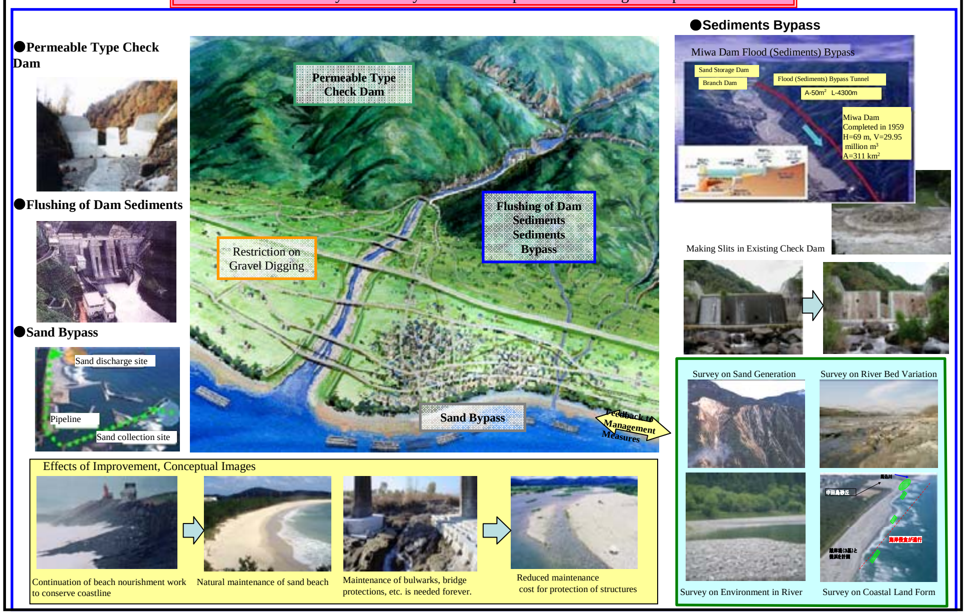
River Name	Expanded Design Rainfall (Upper: Rainfall, Lower: Probability (Years) *1)	(Unit)	1.1X	1.2X	1.3X	1.5X	Lowering of Water Safety Due to Future Increase in Rainfall (Probability (Years)*2) Design Scale	1.1X	1.2X	1.3X	1.5X
Ishikari R.（Hokkaido）	260	mm/3d	286	312	338	390	150	100	80	60	35
	150		350	500	700	1,300					
Kitakami R.（Tohoku）	200	mm/2d	220	240	260	300	150	70	40	23	10
	150		350	720	1,400	2,900					
Tone R.（Kanto）	319	mm/3d	351	383	415	479	200	100	55	35	15
	200		430	910	2,000	8,900					
Kurobe R.（Hokuriku）	455	mm/2d	501	546	592	683	100	50	30	20	10
	100		200	400	700	2,500					
Kumozu R.（Chubu）	358	mm/d	394	430	465	537	100	50	30	20	10
	100		200	400	800	3,300					
Kino R.（Kinki）	440	mm/2d	484	528	572	660	150	70	40	25	12
	150		570	1,200	2,300	8,700					
Ota R.（Chugoku）	396	mm/2d	436	475	515	594	200	100	55	35	15
	200		450	990	2,200	11,000					
Naka R.（Shikoku）	640	mm/2d	704	768	832	960	100	45	22	12	6
	100		270	740	2,000	16,000					
Kawse R.（Kyushu）	615	mm/2d	677	738	800	923	100	60	35	23	12
	100		170	340	560	1,800					

*1 Determined by extrapolation from present probability distribution
*2 Values read from probability paper

Prepared by River Bureau

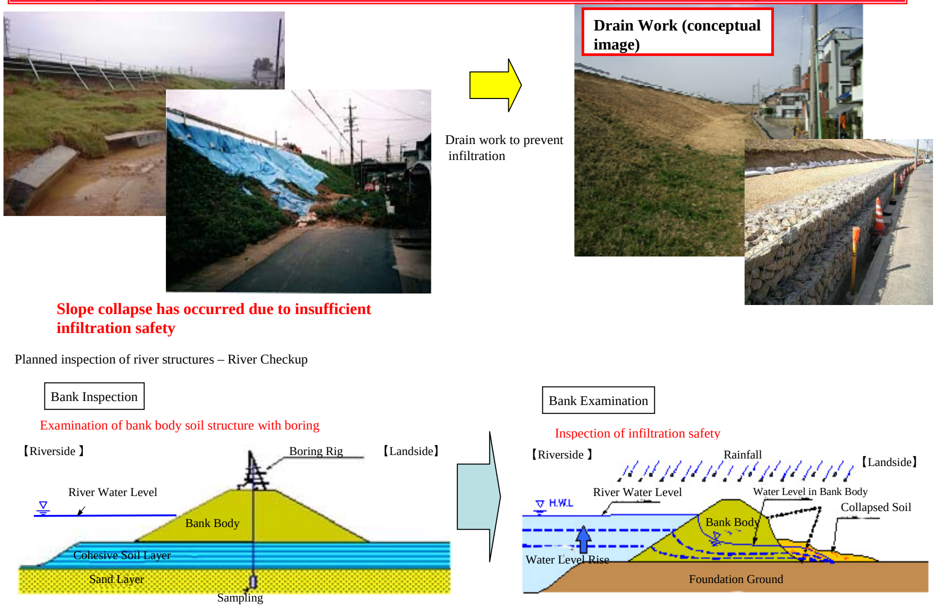
Strengthening of River Bed Stabilization and Other Measures

Measures against river bed variation, soil erosion, dam sedimentation, and coastal erosion are conducted systematically based on comprehensive management plans.



Qualitative Improvement of Facilities (Improvement of Infiltration Resistance)

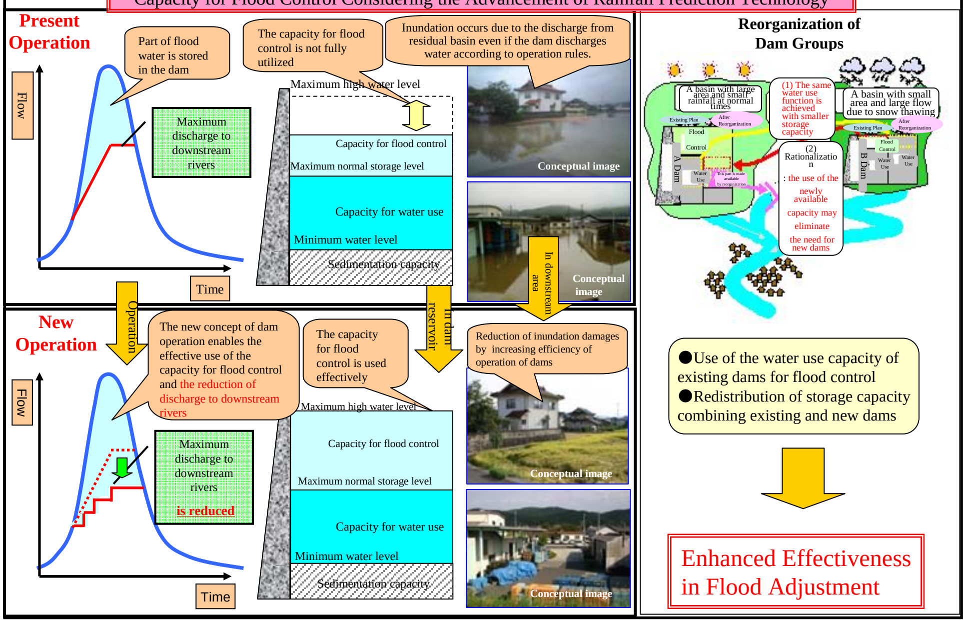
Inspection and evaluation of infiltration resistance of banksand promotion of improvement



Efficient Use and Operation of Flood Adjustment Facilities

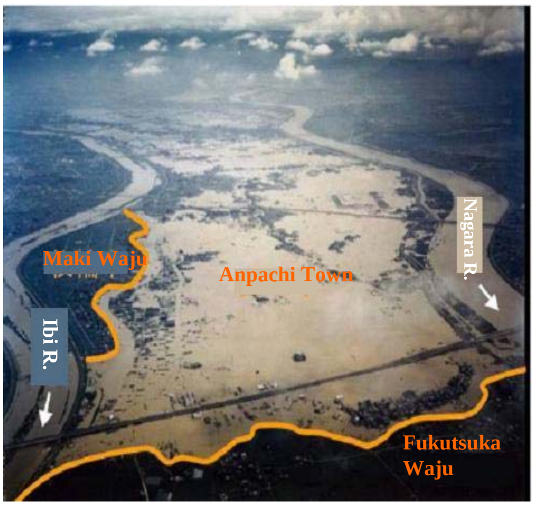
(Advanced Operation, Further Strengthening of Integrated Operation, etc.)

Revision of Operation Procedures for Flood Adjustment Facilities and Redistribution of Storage Capacity for Flood Control Considering the Advancement of Rainfall Prediction Technology



Measures in Flood Areas (Flood Flow Control Using Ring Levees)

Implementation of Flood Flow Control to Prevent the Expansion of Disaster Area Using Ring Levees and other Means

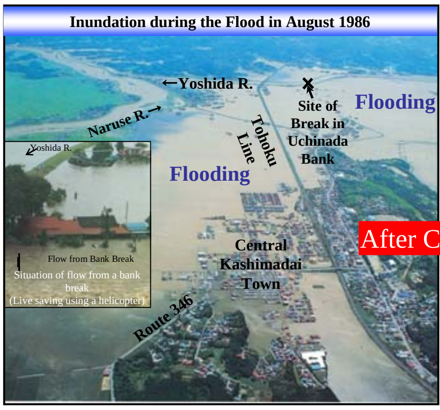


- During the flood in September 1976, a bank break occurred on right bank in the middle stretch of Nagara River.
- The flood was stopped by the ring levee, and the expansion of flood flow was prevented. This contributed to the minimization of damage.

Condition of the Ring Levee (Fukutsuka Waju)

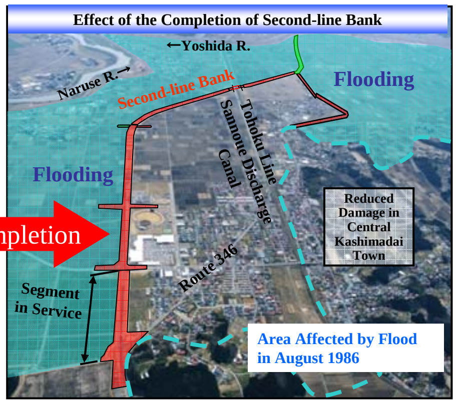
Measures in Flood Areas (Flood Flow Control Using Second-line Banks)

Implementation of Flood Flow Control to Prevent the Expansion of Disaster Area Using Second-line Banks and other Means



The bank breaks in 4 locations submerged 3,060 ha of land and 1,510 houses (above the floor). Inundation continued for 12 days in some low-lying areas.

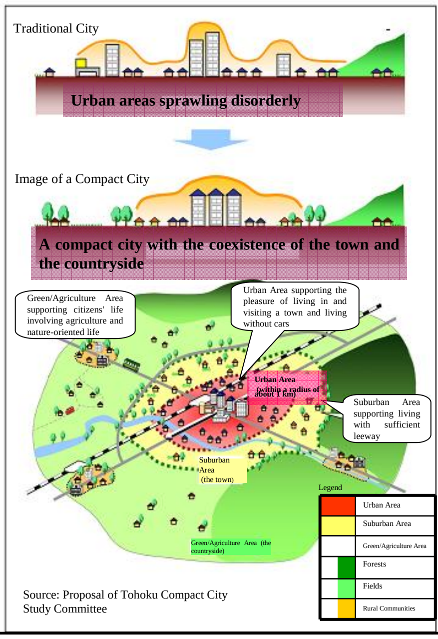
After Completion



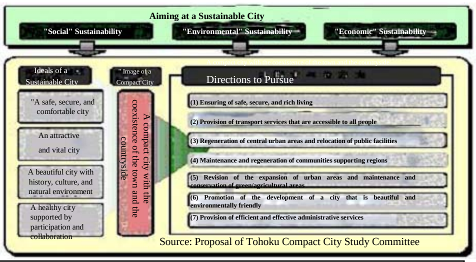
The construction of second-line bank in this district is promoted combined with a road project (bypass construction).

Measures in Flood Areas (Water Management Combined with Urban Development, a Compact City)

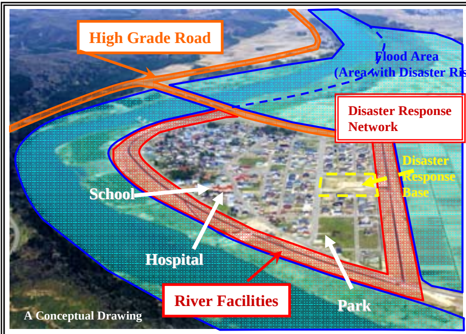
■ Concept of a Compact City Assuming "a Small/Medium City in Tohoku"



Source: Proposal of Tohoku Compact City Study Committee



Source: Proposal of Tohoku Compact City Study Committee



By surrounding the town with a ring levee, disaster response functions were improved while preserving existing local communities.

Measures in Flood Areas (Changing Land Use and Dwelling)

Changing Land Use and Dwelling in Flood-prone Areas and Areas with the Risk of Landslide Disasters

Promotion of Building Structures That Can Cope with Flooding

Yokohama Rapport

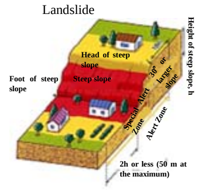
▲Because the site is located in the multi-purpose retarding basin of Tsurumi River, a piloti structure was employed so that the facility can be used at the time of a flood.

▲Using the past experience in living near Tsurumi River, the owner chose a piloti structure to avoid damage from floods.

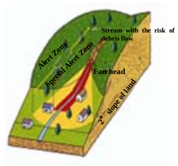
Designation of Landslide Disaster Alert Zones (Enactment of the Landslide Disaster Prevention Law in 2000)

Dangerous sites are indicated by zoning
→ Establishment of alert and evacuation systems, restriction on land use, restriction on building structures, recommendation for relocation of existing houses

Landslide



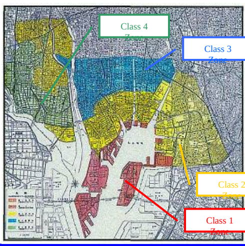
Debris Flow



Disaster Risk Zones under the Building Standards Act

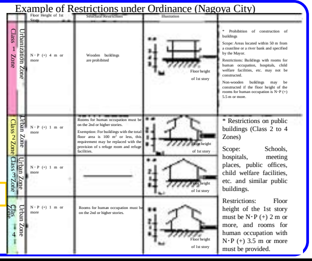
Excerpt from the Building Standards Act (Disaster Risk Zone)

Article 39. Local governments may designate in ordinances the areas with significant risk of damage from tsunami, storm surge, flooding, etc. as disaster risk zones.
2. The prohibition of construction of buildings for residential use and other restrictions regarding construction of buildings within a disaster risk zone shall be defined in the ordinances mentioned in the previous item.



Map of Disaster Management Zones in Seaside Area of Nagoya City

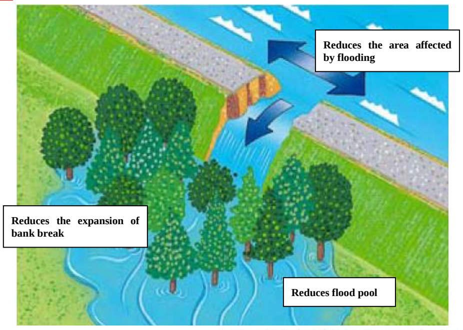
Example of Restrictions under Ordinance (Nagoya City)



Measures in Flood Areas
(Flood Flow Control Using Flood Prevention Forests and Green Belts)

Implementation of Flood Flow Control Using Flood Prevention Forests, Green Belts, etc.

Flood Prevention Forest




Condition of the site of a bank break


Prevention of soil flow into the area behind the bank

Example of an existing green belt along Ara River in Abukuma River System.

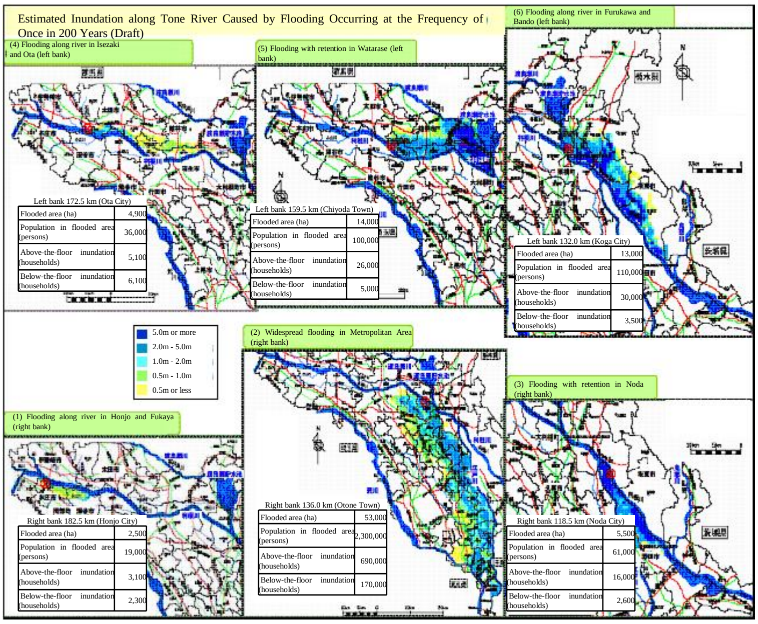
Uses of Green Belts

Green belts serve multiple purposes not only for flood flow control but also for providing good environment in urban areas, use as parks, and prevention of fire expansion.

Measures in Flood Areas (Classification by the Type of Flooding)

Classification by the Type of Flooding

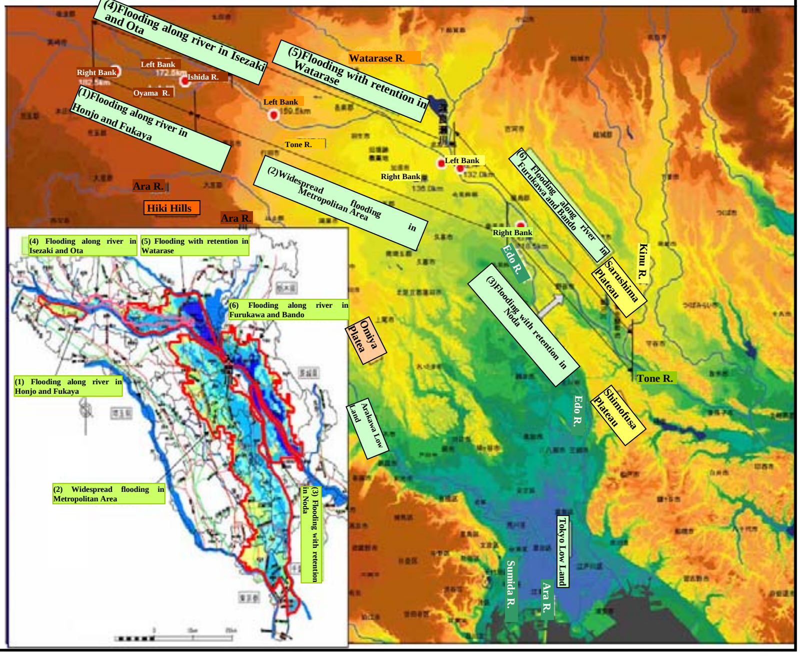
Category Disaster scenarios are prepared for each classification



Source: Material for the 5th Special Study Meeting on Large-scale Water Disaster Management, the Cabinet Office

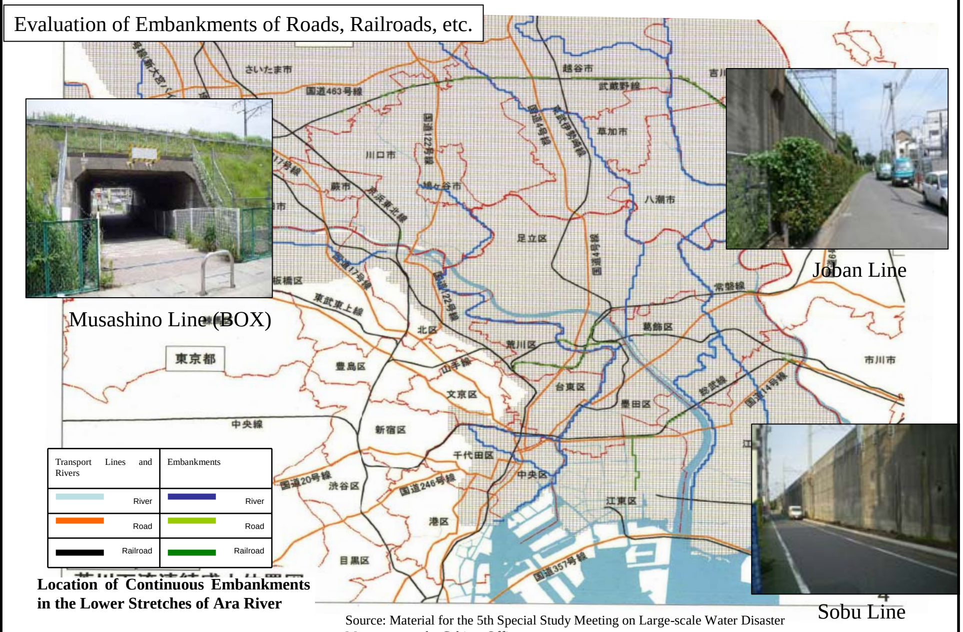
Measures in Flood Areas (Classification by the Type of Flooding)

Based on detailed analysis of topography, regional classification categories are assigned according to the type of flooding.



Measures in Flood Areas (Evaluation of Flood Controlling Structures)

Evaluation of Embankments of Roads, Railroads, etc.

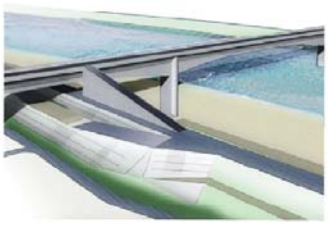


Location of Continuous Embankments in the Lower Stretches of Ara River

Source: Material for the 5th Special Study Meeting on Large-scale Water Disaster Management, the Cabinet Office

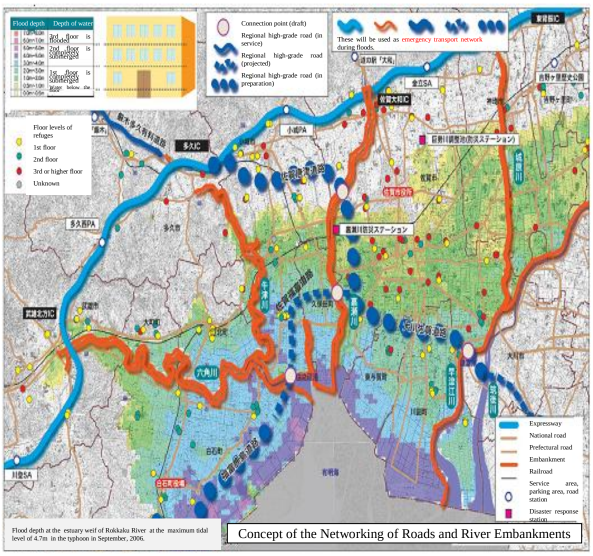
Wide-area Disaster Response and Crisis Management (Construction of Wide-area Disaster Response Network)

Construction of Wide-area Disaster Response Network
through the Utilization of Banks, Emergency Roads in Riverbeds, Elevated Roads, etc.
in Combination with Wide-area Disaster Response Bases



Conceptual drawing of the connection between a road and a river embankment

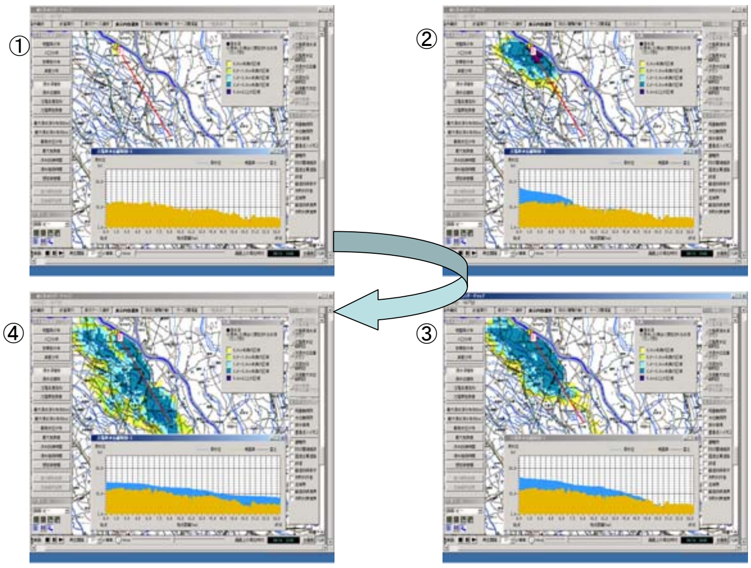
Flooding of R34 in the July 1990 flood



Concept of the Networking of Roads and River Embankments

Hazard Maps and Other Software Measures (Moving Hazard Maps)

Monitoring of flood flow and moving hazard maps showing over-time development of flood flow:
These are used for guiding people in evacuation and providing suppor to disaster response activities.



Disaster Management Information (Interactive River Information Platform)

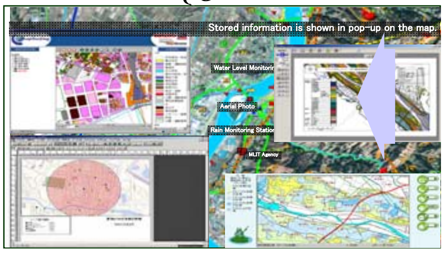
Interactive River Information Platform

Use of real time data, various stock data, the Internet, etc.
Construction of an information platform enabling GIS-based compilation and analysis of information from local inhabitants and other sources

River Manager

・Provision of disaster management information
・Provision of hydrological information on rivers
・Provision of environmental information on rivers
・Publication of flood hazard maps
etc.

Information Provision/Collection through a Geographical Information Platform

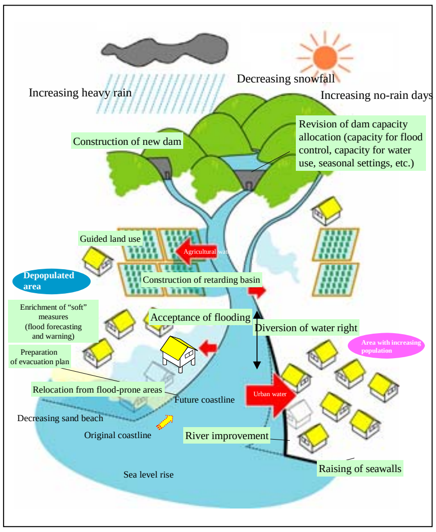


Inhabitants

・Information from disaster management NPOs
・Information from environmental NPOs
・Information from administrative agencies
・Information from local inhabitants
etc.

Labor saving and centralization in river management **at normal times**
Advanced crisis management **in emergencies**

Study of National Land Conservation Adaptation Measures to the Impact of Climate Change Due to Global Warming



Changes in hazard such as sea level rise, droughts, floods, and storm surges associated with climate change

Study on the impact of climate change

Study on direct impacts
・More frequent and severer droughts, floods, storm surges, etc.
・Lowered reliability of river and coastal facilities
・Increased coastal erosion due to sea level rise

Study on indirect impacts
・Impact on land use and social structure
・Impact on flood control scenarios and facility operation rules

Case study high-risk areas based on hazard assumptions

○Identification of high-risk areas based on hazard assumptions
Based on specific assumptions of rainfall, storm surge, and other hazard, model areas are identified considering the future changes in population and industry structures in the areas.

○Study on the evaluation of social and economic impacts of climate change
Development of the methods for evaluating direct and indirect economic impacts of disasters, including general damage to assets and the damage from interruption of distribution of goods due to transport disruption, as well as social impacts resulting from the breaking of local communities and prolonged living in refuges

Study on strategies responding to climate change in rivers and coasts

○Study on concrete adaptation measures combining structural and non-structural measures

○Economic evaluation of various adaptation measures and proposal of appropriate short- and long-term adaptation strategies

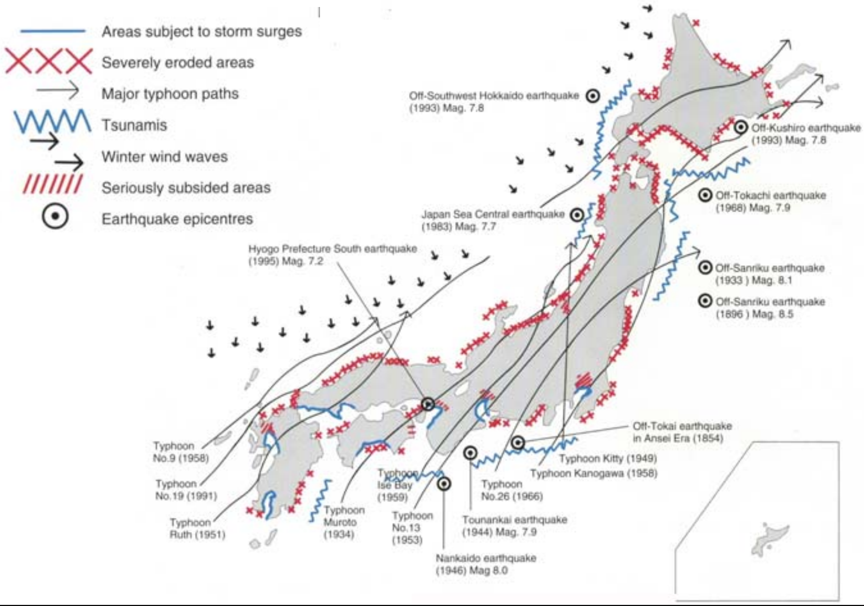
Utilization of Results

Proposal of adaptation measures for short- and long-term social and economical impacts responding to climate change ➡ **○Building a resilient country that can cope with future disasters**

Storm Surge Forecast System for Floodfighting Warnings

Masaya Fukuhama
Coast Division, River Department
National Institute for Land and Infrastructure Management

Coastal Disasters in Japan



Storm Surge Disasters in Japan

Date	Major damaged area	Human casualties			Damage to houses		
		Dead	Injured	Missing	Completely destroyed	Partially destroyed	Washed away
1 Oct. 1917	Tokyo Bay	1,127	2,022	197	34,459	21,274	2,442
13 Sep. 1927	Ariake Sea	373	181	66	1,420		791
21 Sep. 1934	Osaka Bay	2,702	14,994	334	38,771	49,275	4,277
27 Aug. 1942	Suo Sea	891	1,438	267	33,283	66,486	2,605
17 Sep. 1945	Southern Kyushu	2,076	2,329	1,046	58,432	55,006	2,546
3 Sep. 1950	Osaka Bay	393	26,062	141	17,062	101,792	2,069
14 Oct. 1951	Southern Kyushu	572	2,644	371	21,527	47,948	1,178
25 Sep. 1953	Ise Bay	393	2,559	85	5,985	17,467	2,615
7 Sep. 1959	Ise Bay	4,697	38,921	401	38,921	113,052	4,703
16 Sep. 1961	Osaka Bay	185	3,897	15	13,292	40,954	536
21 Aug. 1970	Tosa Bay	12	352	1	811	3,628	40
30 Aug. 1985	Ariake Sea	3	16	0	0	589	0
24 Sep. 1999	Yatsushiro Sea	12	10	0	52	99	0



Storm Surge Flood in 2004

Takamatsu City

(facing the Seto Inland Sea)

3 people died, 15561 houses flooded

(photo: Shikoku Regional Development Bureau)

Measures against Storm Surge

'Hard' Measures

'Soft' Measures

Coastal dike

Hazard map

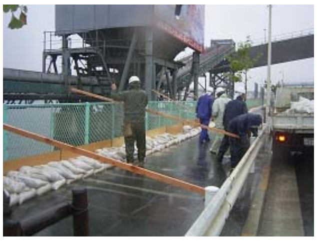
Warning system

Evacuation drill etc.

Floodfighting on Coasts

Patrolling

Sandbagging



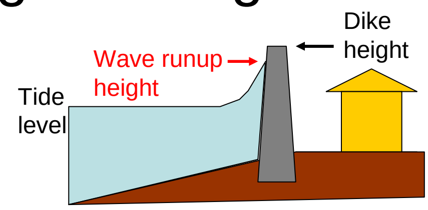
Closing water gates

(Tokyo Port Disaster Prevention office)

Draining

Wave Runup Forecast for Floodfighting Warning

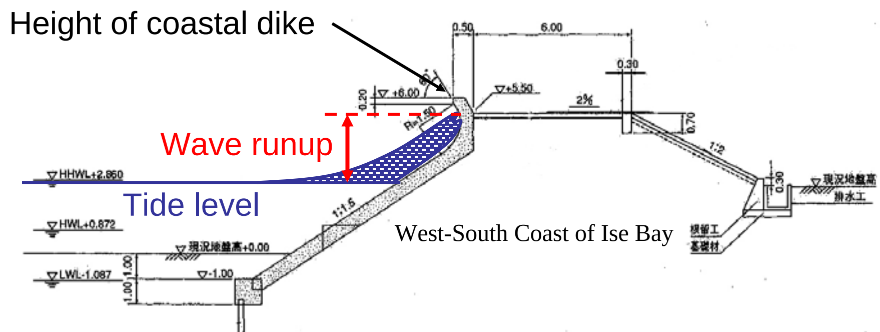
Wave runup on each coast will be forecasted before a typhoon approach, and transmitted to prefectures for issuing flood-fighting warnings on the coast.



JMA		MLIT		Prefectures		Floodfighting administrators (mayors etc.)
Prediction of typhoons, storm surges, and waves	→	Prediction of wave runup heights	→	Issue of floodfighting warnings	→	Floodfighting activities
	Tide level, wave		Wave runup height		Floodfighting warning	

(123 coasts is designated for floodfighting warnings.)

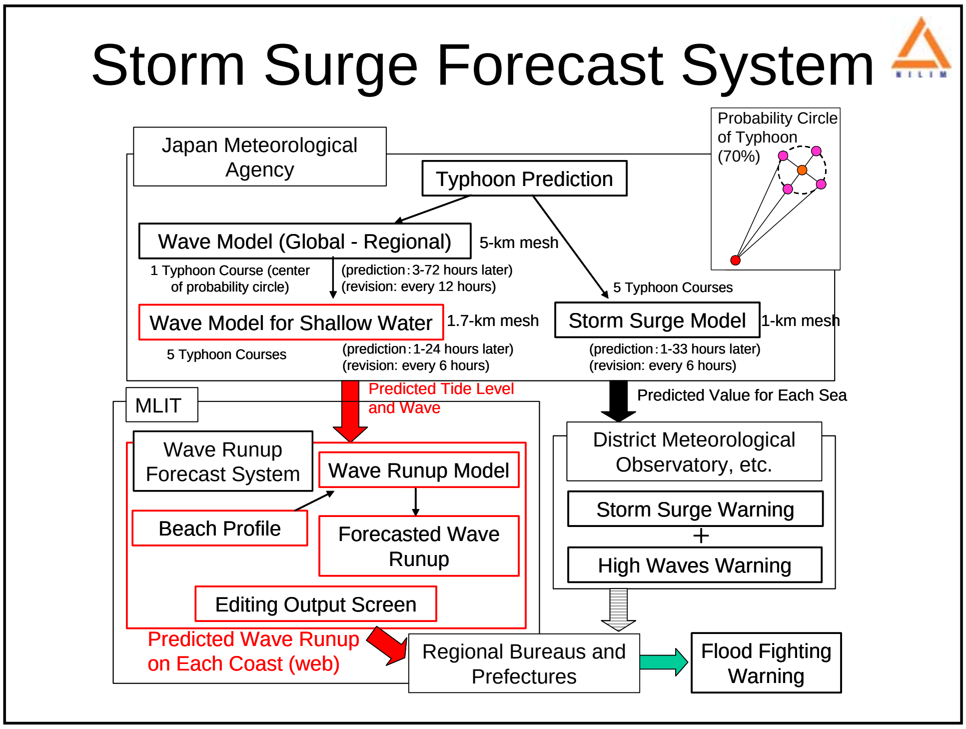
Design of Coastal Dike Height

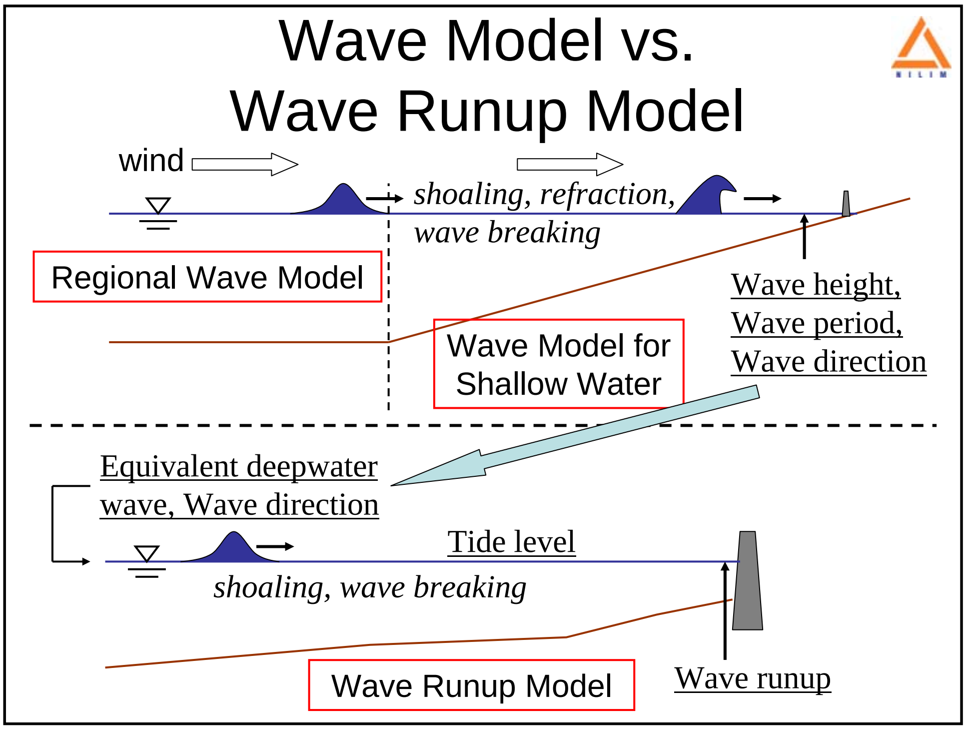


Height of coastal dike is set considering wave runup. Therefore, storm surge forecasts do not indicate whether major wave overtopping will occur or not.

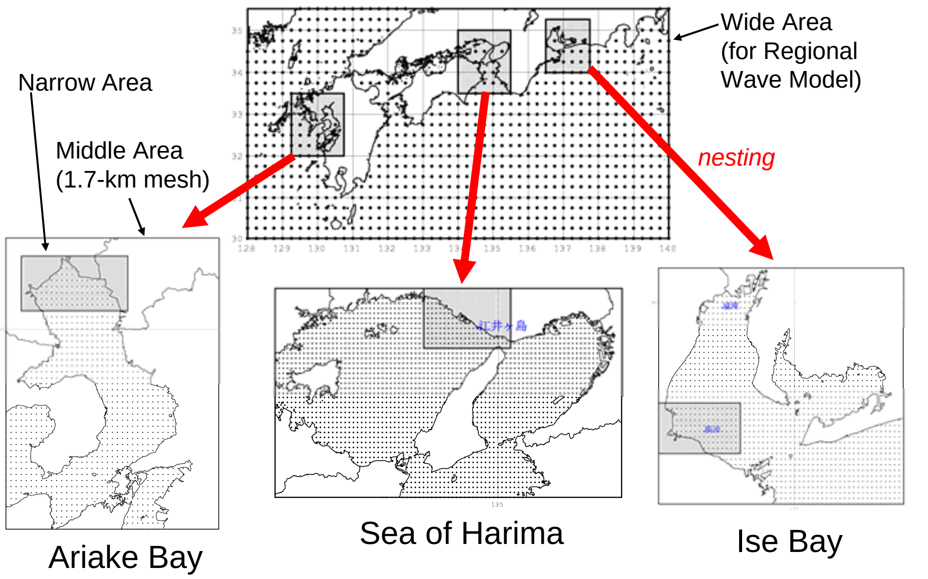
↓

Wave runup as well as tide level should be forecasted.


Storm Surge Forecast System
Japan Meteorological Agency
Typhoon Prediction
Probability Circle of Typhoon (70%)
Wave Model (Global - Regional)
5-km mesh
1 Typhoon Course (center of probability circle)
(prediction：3-72 hours later) (revision: every 12 hours)
5 Typhoon Courses
Wave Model for Shallow Water
1.7-km mesh
Storm Surge Model
1-km mesh
5 Typhoon Courses
(prediction：1-24 hours later) (revision: every 6 hours)
(prediction：1-33 hours later) (revision: every 6 hours)
MLIT
Predicted Tide Level and Wave
Predicted Value for Each Sea
Wave Runup Forecast System
Wave Runup Model
Beach Profile
Forecasted Wave Runup
Editing Output Screen
District Meteorological Observatory, etc.
Storm Surge Warning
＋
High Waves Warning
Predicted Wave Runup on Each Coast (web)
Regional Bureaus and Prefectures
Flood Fighting Warning


Wave Model vs. Wave Runup Model
wind
shoaling, refraction, wave breaking
Regional Wave Model
Wave height, Wave period, Wave direction
Wave Model for Shallow Water
Equivalent deepwater wave, Wave direction
Tide level
shoaling, wave breaking
Wave Runup Model
Wave runup

Seas for Model Examination



Review of Wave Forecasting Model

Wave hindcasting was conducted for major typhoons in 1997-2004.

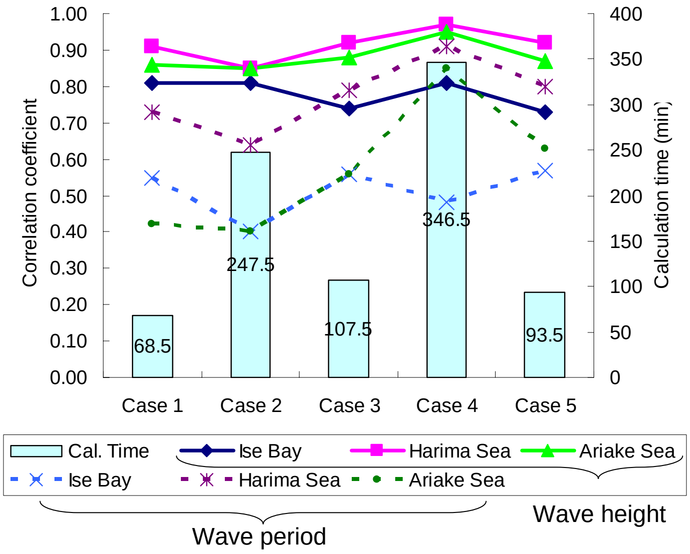
Case	Middle Area (bay scale)	Narrow Area (coast scale)
1	WAM	WAM
2	WAM	SWAN
3	WAM	Wave transformation model
4	SWAN	SWAN
5	-	Wave transformation model

Review points:

- Preciseness of hindcasting

- Necessary time of hindcasting

Results of Model Comparison



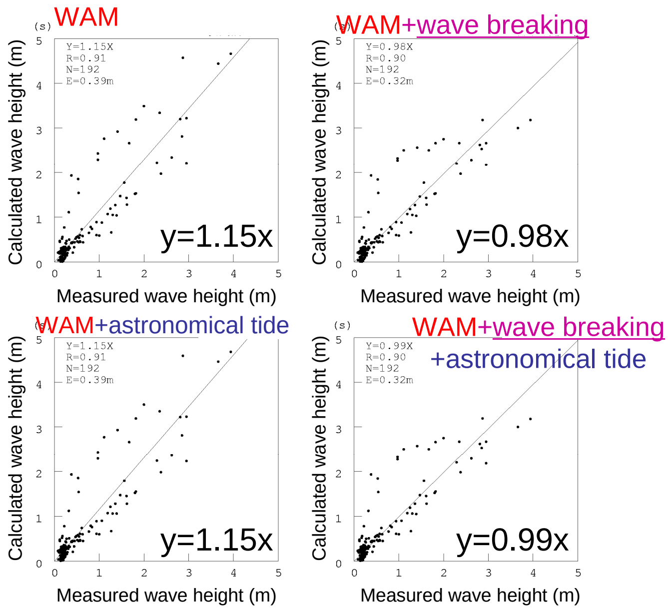
Improvement of Wave Forecast Model

- WAM does not consider the effects of wave breaking.
- Astronomical tide are so large in inner seas that time variation of water depth may influence waves.

- Combining WAM with the bore model used for SWAN, and considering water depth change by using the ocean tide model (NAO.99b)

- Review of the improved model by hindcasting waves for recent major typhoons.

Results of Wave Simulation



Conclusion

An improved WAM that considers wave breaking and tides can forecast waves in inner seas with good precision in real time. Information for proper floodfighting warning can be supplied by combining this system with the forecast system for wave runup at each coast.

The system will start soon!

- This system will be operated in Tokyo Bay, Ise Bay, Osaka Bay and Harima Sea, and the Ariake Sea.
- Test operation for one typhoon course started in September 2007.
- After solving operating problems, we will begin full-scale operation for five typhoon courses in August 2008.

Support for Evacuation Ahead of Sediment Disasters

– Using Rainfall Indices to Predict the Danger of Sediment Disasters –

Erosion and Sediment Control Division, Research Center for Disaster Risk Management

1. Introduction

Mountainous and hilly regions that cover approximately 70% of the land of Japan provide us with a rich natural environment, but many sediment disasters occur in these regions every year. Because sediment disasters not only occur without warning but also have extremely large destructive force, they cause severe destruction when they occur.

It is difficult to say that measures to prevent them have been adequately taken. At locations with topography that clearly indicates a high risk of debris flows for example, a total of 183,863 torrents have been designated as debris flow danger torrents (announced in 2002).

Sediment check dams or other protective structures have been constructed to provide a certain degree of safety in only about 20% of the total of 89,518 torrents with five or more homes and where the occurrence of a debris flow would cause severe damage. But it will be difficult to construct such structures rapidly considering Japan’s present financial circumstances. And even in cases where they have been constructed, because they are designed hypothesizing a specified scale of rainfall, they are not completely safe when a natural phenomenon that exceeds the hypothetical scale has actually occurred.

It is important for people to evacuate before a sediment disaster occurs in order to protect themselves. And in order for residents to evacuate at the correct time, the time and place of danger, the method of informing people of the danger, the evacuation method, and evacuation site must be decided in advance. In order to predict the time and place of danger, the Erosion and Sediment Control Division is conducting research on the prediction of the danger of occurrence of debris flows.

2. Concept of CL

When the object of a prediction is inundation of land by river water, directly observing levee height and water level provides information needed to judge the time and place of occurrence, but in the case of a sediment disaster, it is difficult to directly observe a slope because (1) the object of the observation is underground and (2) the range that should be observed spreads over a wide area. Therefore, rainfall that is one factor influencing sediment disasters is monitored to indirectly predict the degree of danger.

Specifically, rainfalls that caused sediment disasters (occurrence rainfalls) and rainfalls that did not cause sediment disasters (non-occurrence rainfalls) are indicated together on a map and the range where many occurrence rainfalls are distributed is classified as the danger range and the range where non-occurrence rainfalls are distributed is classified as the safe range. The occurrence of a sediment disaster is predicted depending on whether or not a line that links rainfall that is now falling in a time series (snake curve) crosses the boundary line between two ranges: a line is called the sediment disaster occurrence danger critical line (Critical Line: below “CL”) (Fig. 1). This critical line is prepared for each specified district (often a range that includes one or a number of municipalities) based on the topography, geology, rainfall properties, etc. In a range where long-term rainfall is less frequent than short-term rainfall, the range that is theoretically unobtainable (Unreal Area) is shown in black on the figure.

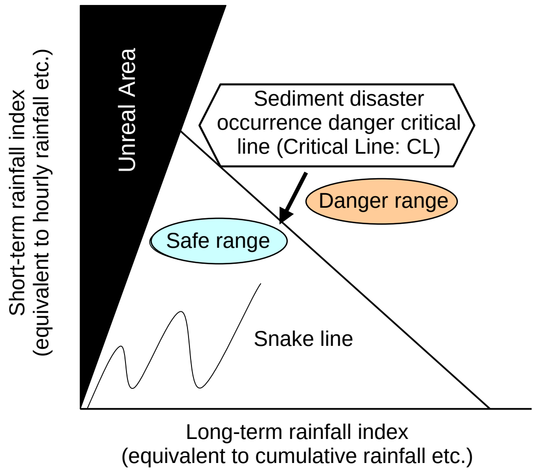


Figure 1. Method of Using CL to Predict Occurrence

3. The conventional method and its shortcomings

Starting from the position that long-term rainfall such as intensive rainfall of the June – July seasonal rain front (cumulative rainfall for example) and short-term rainfall such as squalls (hourly rainfall for example) should be treated as the forms of rainfall that causes sediment disasters, these two indices are used to determine the boundary line (see Figure 1). To improve the precision of the boundary line when using this method, it is necessary to collect more rainfall data. But although approximately 1,000 sediment disasters occur annually throughout Japan, by region, adequate quantities of rainfall data have not necessarily been obtained. But, even a small number of rainfall data do not accurately clarify the occurrence time because the occurrence location and rainfall occurrence locations are separate, and in many regions, it is impossible to ensure the reliability of the timing that is essential to predict the danger of occurrence.

The boundary is uniformly drawn as a straight line regardless of the regional characteristics of rainfall, it is difficult to decide on the way to draw it (Fig. 2), and one standard must cover a wide area of at least a city, town, or village. As a result, the frequency of the announcement of false warnings increases.

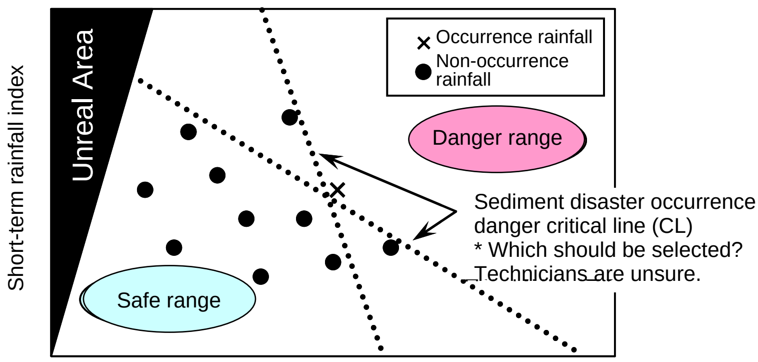


Figure 2. Example of Uncertainty when Setting by the Conventional Method

4. The newly developed method

In order to resolve problems with the conventional method, it is necessary that (1) a boundary line can be drawn, even for a region with small number of occurrence rainfall data, (2) the method of determining the boundary line is rational and reproducible (the result is the same, no matter who does it). In regards to (2) in particular, a method should be established allowing a non-linear boundary line to be drawn; not only a straight line, according to the distribution of rainfall data under constant rules. And to set them in ranges smaller than city, town, or village units (or each hamlet or each danger location), it will inevitably be necessary to set far more lines than in the past, requiring that the work be done more efficiently.

As a measure to resolve these problems, a method of determining the boundary line using an RBF Network (Radial Basis Function Network) that is a kind of neural network has been developed.

An RBFN is a hierarchical structure that models a brain and nervous system, and its calculation process is done by three layers: input layer (*n* elements), middle layer (*m* elements), and output layers (1 element) (Fig. 3).

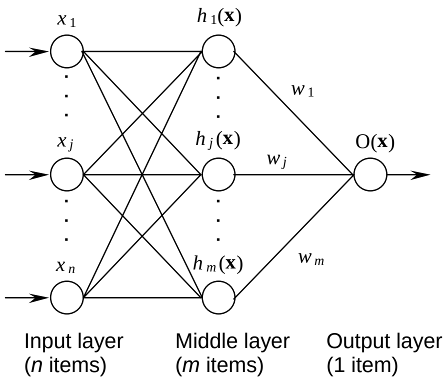


Figure 3. RBFN Concept

In simple terms, as rainfalls that have actually been observed (input layer) are listed and the positional relationship of the rainfall data (distance, quantity) are compared (medium layer), they are calculated as a scale of occurrence probability (output layer). Normally when a person draws a line to enclose an entire range that is an aggregate of points, the person draws a boundary that seems appropriate while observing the way the points are distributed (Fig. 4(a)). When doing this, the person makes a mental judgment that widely separated individual points “should be eliminated because they rarely occur.” It is now possible to draw lines using the results of calculations in order to invest this work with objectivity and reproducibility (Fig. 4(b)).

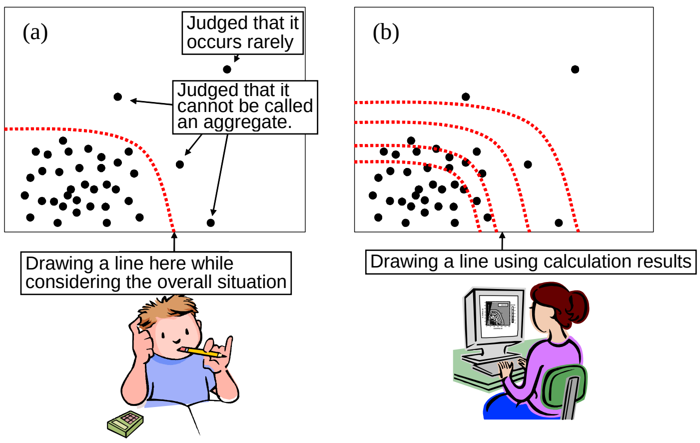


Figure 4. Image of Task of Preparing the Range of the Aggregate of Points

The position and shape of boundary lines that technologists subjectively set based on their experience can now be set objectively and efficiently under fixed rules by using this method.

And the replacement of the conventional method that is “seeking the boundary of the safe range and the danger range” with the method, “seeking the outer edge of the safe range”, permits the determination regardless of whether a sediment disaster occurs or not, because the rainfall data that is used is limited to non-occurrence rainfall.

5. Setting CL using RBFN

This method starts with setting a curve that represents values that express the degree of the probability of rainfall occurring at an optional point on a plane map with the long-term rainfall index and the short-term rainfall index as the *x* axis and the *y* axis respectively by teaching the input value of non-occurrence rainfall as 1 (Fig. 5).

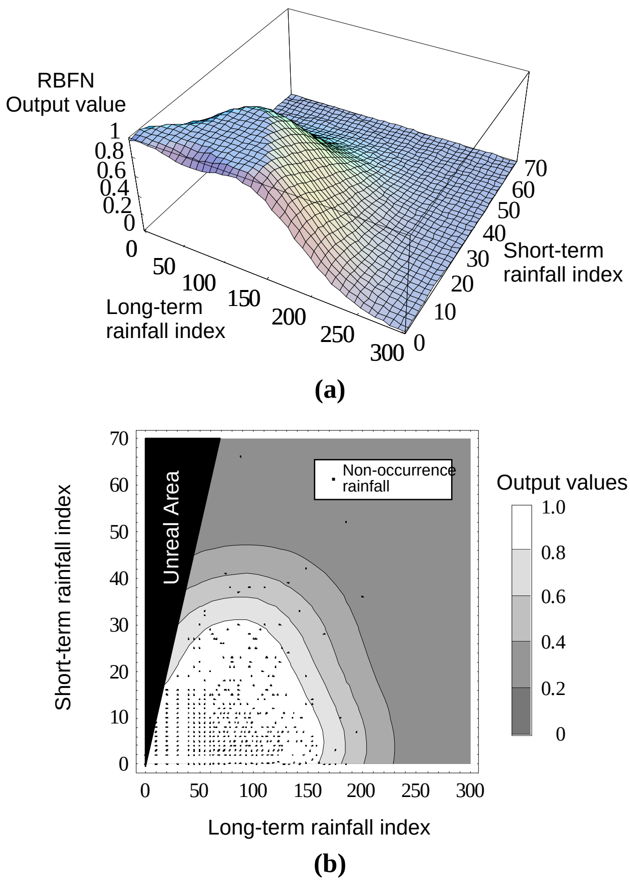


Figure 5. Example of Setting Curves

The long-term rainfall index and the short-term rainfall index used were the soil rainfall index and the Radar Amedasu Analysis rainfall that are each provided by the Meteorological Agency assuming that they are combinations of the soil rainfall index [Note 1] and the sixty minute cumulative rainfall considering ease of operation while maintaining a specified precision. Figure 5(a) shows that in parts with high output values, the probability of non-occurrence rainfall is high, in other words, it is a region where many rainfalls that

[Note 1]
It is assumed that if the index is obtained based on the total of the storage height of a line of three tank models and is a high value, the danger of a sediment disaster is high. Many have heard TV weather announcers give warnings such as, “the danger of sediment disasters is higher than it has been for the past several years,” but those were judgments based on this index.

cause almost no sediment disasters are observed, so it is called a safe range. And parts where the output value is low are, inversely, the range where the probability of a sediment disaster occurring is high. Figure 5(b) shows the same figure in two dimensions, and the white range near the origin point is the range where there is a high probability of non-occurrence rainfall. In this figure, a total of 4 boundary lines are shown at output value 0.2 intervals, but it is necessary to focus on one of the lines in order to set a standard for predicting the danger of a sediment disaster. In this case, if the boundary is on the inside, the capture precision is high, but inversely, the standard is achieved more frequently. It is necessary to consider balancing, “can it be appropriately captured?” with “will the standard be achieved too often?” in order to use it to smoothly issue evacuation advisories etc., and as a rule, 1 line is selected from among a total of 9 candidate lines drawn at intervals of 0.1.

The curve that was set is corrected so that it will not contradict actual phenomena (Fig. 6). In the ranges enclosed by the dotted lines in the figure, the inclination of the tangent is positive, but this occurs because when setting such a boundary line, regardless of the same short-term rainfall index, the longer long-term rainfall index is the safe range (inside the boundary line) and the shorter long-term rainfall index is the danger range.

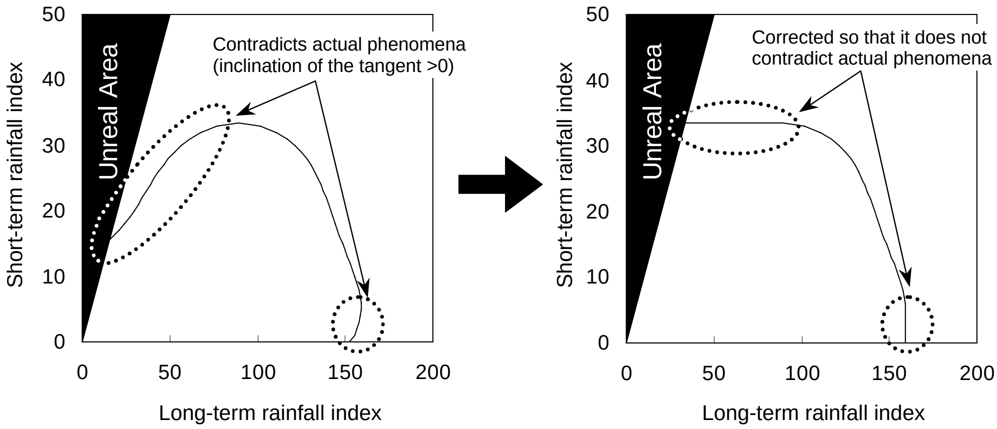


Figure 6. Correction of Contradiction with Actual Phenomena

6. Even if the rainfall properties change…..

Using this method, the more rainfall data available, the more closely the curve that is formed reflects actual rainfall properties. After CL has been set, it is important to add new rainfall data and to continue to verify whether or not the disasters that occurred were appropriately captured. This is assumed to be a method that allows this revision work to be done easily. By continuing revisions it is possible to revise the boundary line to support appropriate advance evacuations even when, presumably as a result of climate change, short-term rainfall or long-term rainfall never previously experienced occurs.

7. Conclusion

A new initiative to announce warning information concerning sediment disasters began in Kagoshima Prefecture in September 2005. The Kagoshima Regional Meteorological Observatory and the Sabo Division of Kagoshima Prefecture jointly predict the occurrence of sediment disasters, then announce the results to the public and to the municipalities through the mass media etc. The announcements include information that is expected to help people begin evacuating before a sediment disaster occurs.

This initiative in Kagoshima Prefecture was the first of its kind to begin operating in Japan, but when, shortly after its introduction, Typhoon No. 14 approached and reached the land, a number of problems with the warning information that was announced at that time were discovered. The minimum range where warnings were issued were municipalities, but because people could not distinguish the specific locations of greater danger, the announcements were not sufficient for them to evacuate appropriately in advance. Figure 7 shows a method that will provide residents with warning information so that it is easily understood. At this time, information is presented only for each municipality, but it is now necessary to devise methods of dividing these into smaller areas and using radar rainfall so that the state of rainfall can be understood over a wide area and to devise ways to permit both the area to be evacuated and the degree of urgency (classified as preparation for evacuation, evacuation advisory, evacuation order) of its evacuation to be understood at a glance.

This sediment disaster claimed many victims, but we must learn from this disaster and reflect this important lesson in future information provision, and we wish to provide technological support to achieve this goal.

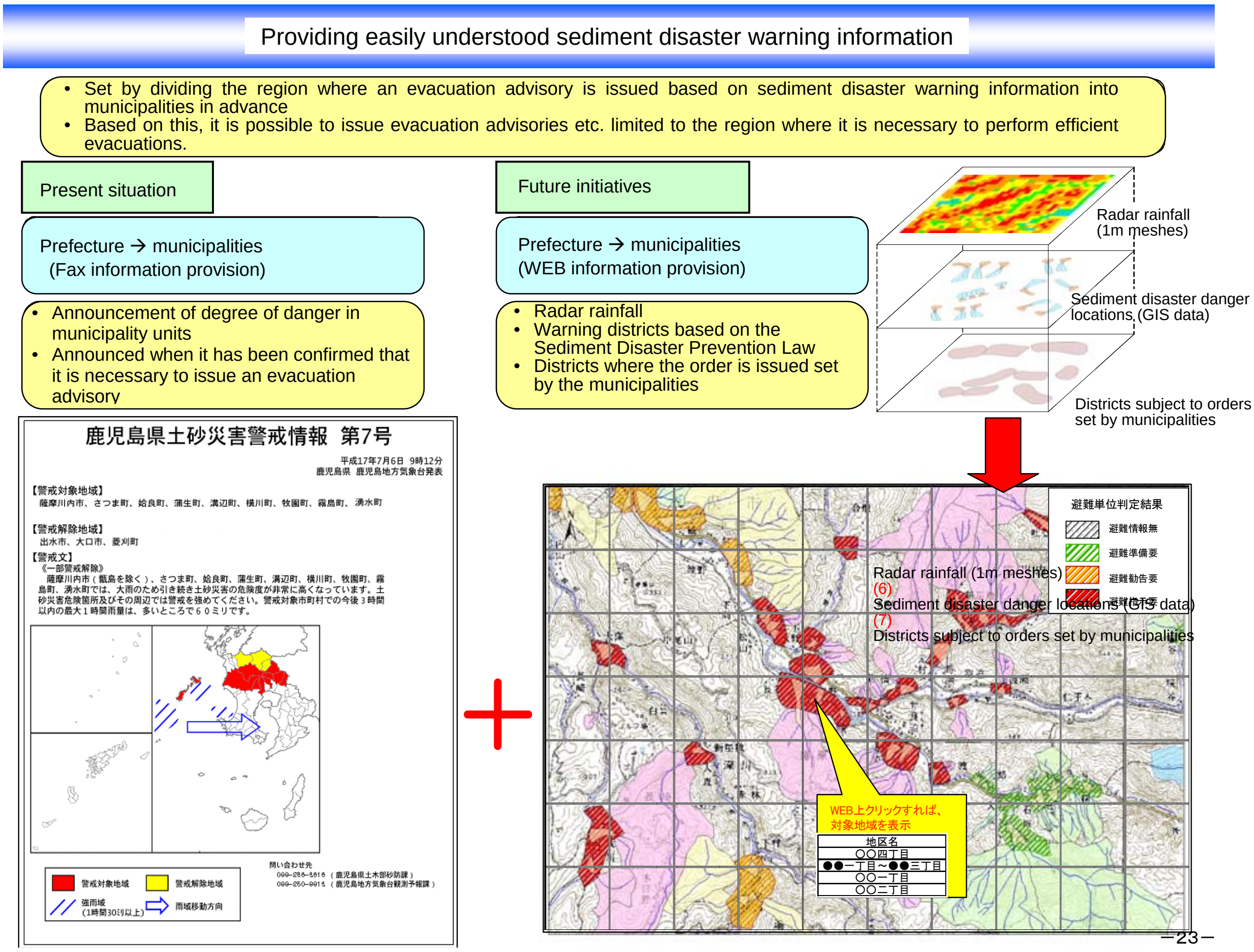


Figure 7. Easily Understood Warning Information Approach
(Partial Revision of a Document from the Large Scale Rainfall Disaster Study Committee, Sediment Disaster Subcommittee (Third)

Planning adaptation programs for future climate change

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Public Works Research Institute

1. Background

In response to more reliable scientific prediction on impacts of unavoidable climate change on extreme events and policy shift to adaptation, River Bureau of MLIT has started flood control policy making to adapt to the future climate change from August 2007. This note summarizes facts and issues raised at on-going discussion in the process of policy-making efforts.

2. Possible climate change impact observed and responses

Besides series of the OECD (For example, Progress on adaptation to climate change in developed countries, May 2006) and fourth IPCC reports, ICHARM has found the following historical hydrologic change observations that show trends of frequent or bigger extreme flood events. These observations are used in various reports or brochures to demonstrate climate change.

However, the trends do not necessarily attribute to climate change but other factors such as land subsidence and urbanism. Statistical significance may be tested either in some reports. Moreover, it is noted that frequent and bigger flood prediction is based on numerical simulation result of climate science research activities. The resulted trends are widely used to attract public attention as well as remarkable impact of climate change.

2.1. Japan

Refer to the other reports of this conference.

2.2. Republic of Korea

Typhoon Rusa of 2002 and typhoon Maemi of 2003 caused biggest damage to the nation as shown in Figures 1 and 2. Typhoon Rusa brought record-breaking daily precipitation of 870mm that exceeds the PMP (probable maximum precipitation). There is observation of the frequent record-breaking precipitation as a climate change issue.

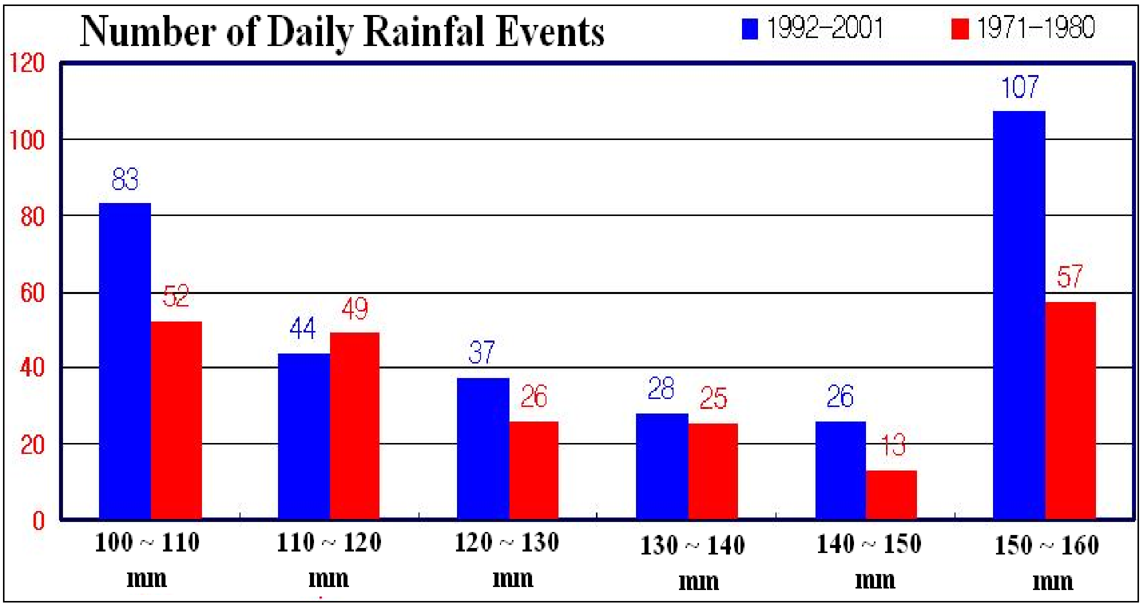


Figure 1. Increased rainfall intensity in S. Korea (*Source: Dr. Kim Sung, 2004*)

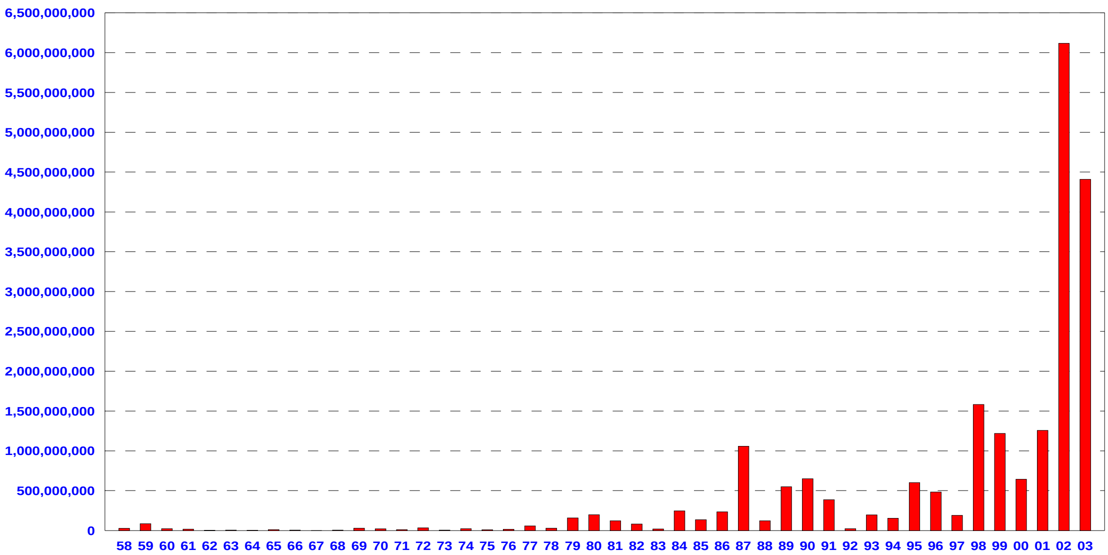


Figure 2. Total Damages in S. Korea by Natural Disaster in thousand Won during 1958-2003 period (*Source: Dr.Kim Sung, 2004*)

2.3. California , USA

California Water Plan Updated in 2005 has acknowledged rising in sea level and reducing snowmelt in the past century as shown in Figures 3 and 4.

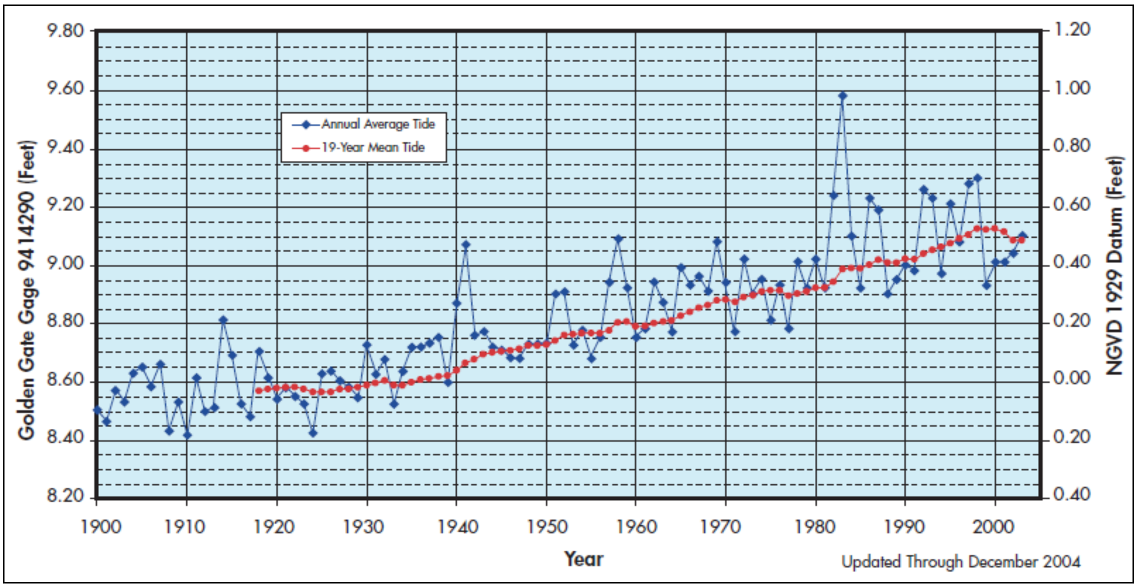


Figure 3. Sea level rise at Golden Gate Gorge, California, USA
(*Source: California Water Plan Update 2005 Volume 1*)

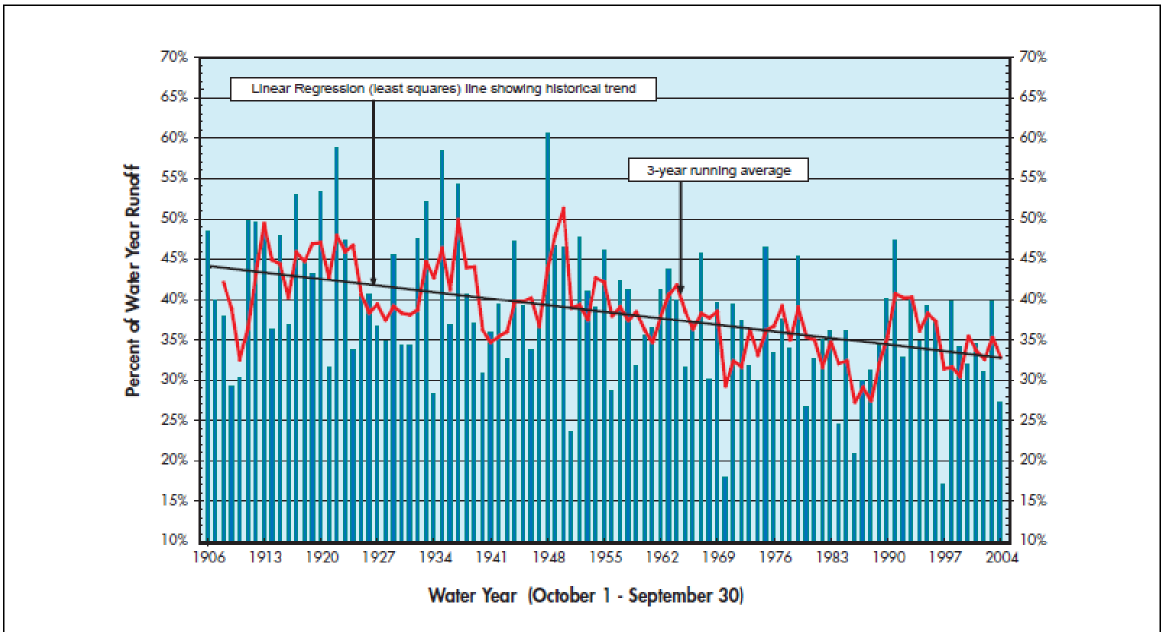


Figure 4. Reduced snowmelt runoff at Sacramento River, California, USA
(*Source: California Water Plan Update 2005 Volume 1*)

2.4. England and Wales

"Climate Change" section of Environmental Agency homepage has published a trend of drier summers and more wet winters (Indicator: Rainfall of summer and winter). It is shown in figure 5 and it can be considered as an example of climate change impact on increasing extreme hydrological events. Figure 6 is an example of bigger flood trend quoted in Environmental Agency's brochure under the title of "The climate is changing; time to get ready (2005)"

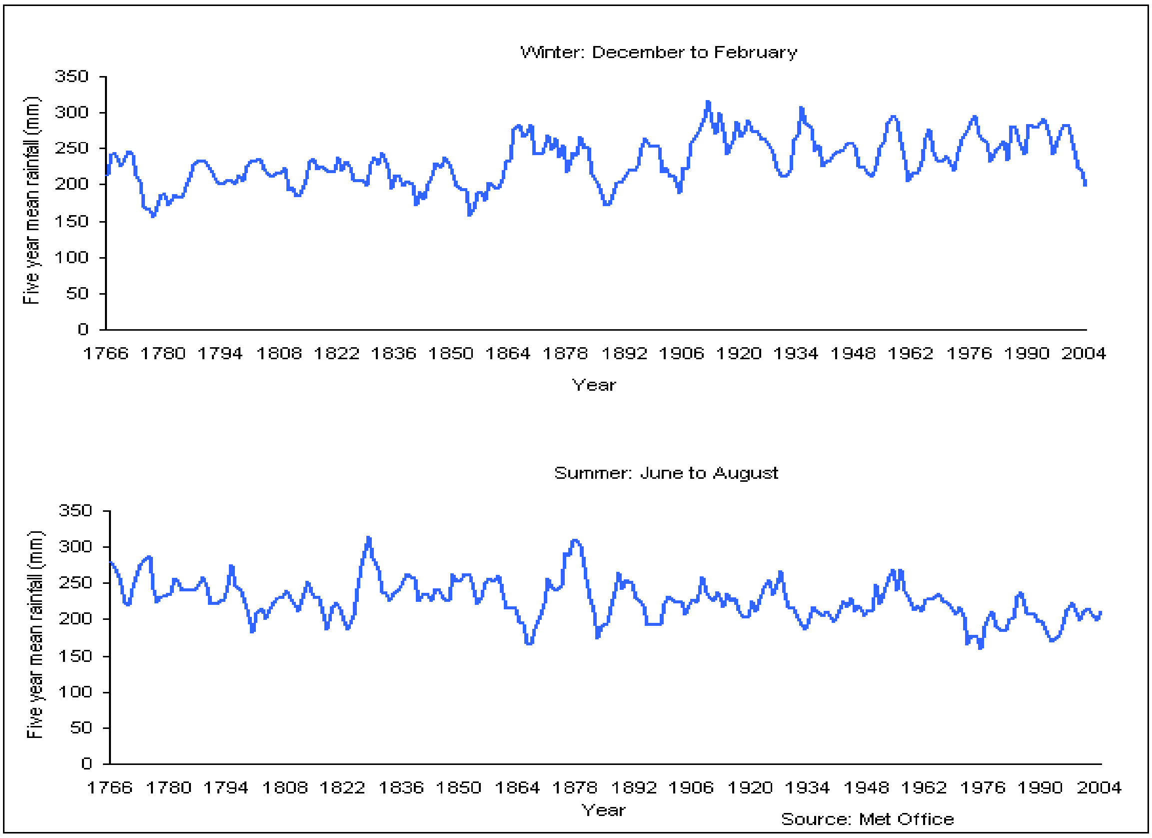


Figure 5. Rainfall in winter (up) and summer (down) in England and Wales
(*Source: http://www.environment-agency.gov.uk*)

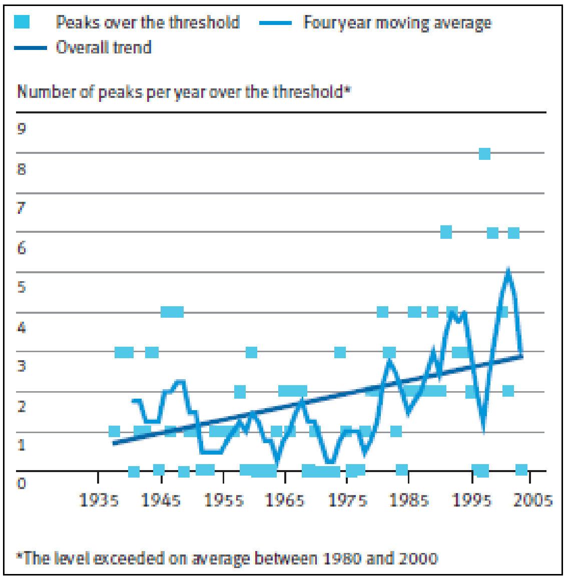


Figure 6. Number of peaks over the threshold in the River Wye, Wales
(*Source: the climate is changing, Environmental Agency, 2005*)

2.5. The Netherlands

Prof. Hugo Coops from RIZA of the Netherlands in his lecture on River Rhine Flood Control Plan at PWRI in June 2005 reported sea level rise at the rate of 20cm per 100 years in the past (Figure 7)

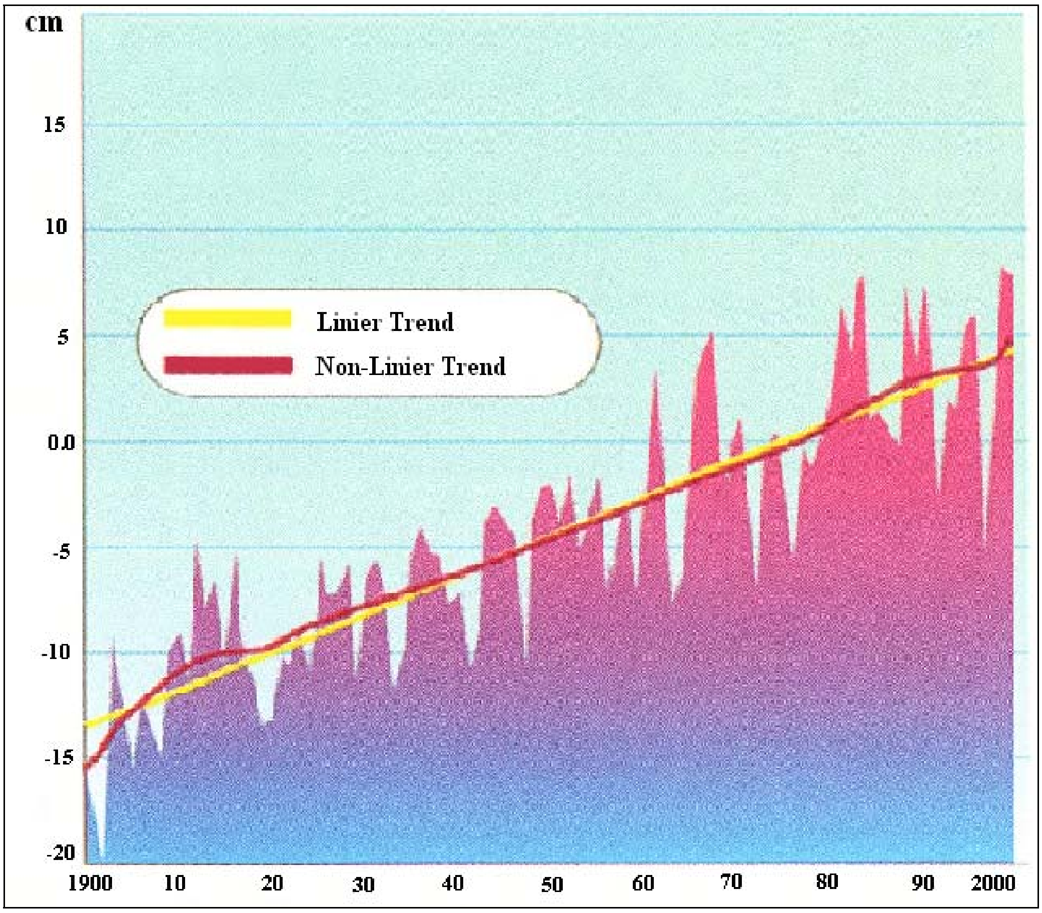


Figure 7. Sea level rise in the Netherland in the past 100 years

2.6. Thailand

Major large-scale reservoirs in Thailand were hardly become full due to large capacity compare with inflows to reservoirs. Then, primarily operation for irrigation did not conflict with flood control since there was always enough space to control floods. However, for the first time in Thai history, all reservoirs became full in the middle of flood season of 2006 as shown in Figure 8.

Despite so far, there is no article or any other reports written in English on this issue, It is heard in a scientific workshop from Thai hydrologists that they need to consider seriously need of adaptation measures for the possible climate change. Some of them claimed to promote a dam construction plan while environmental movement is suspending.

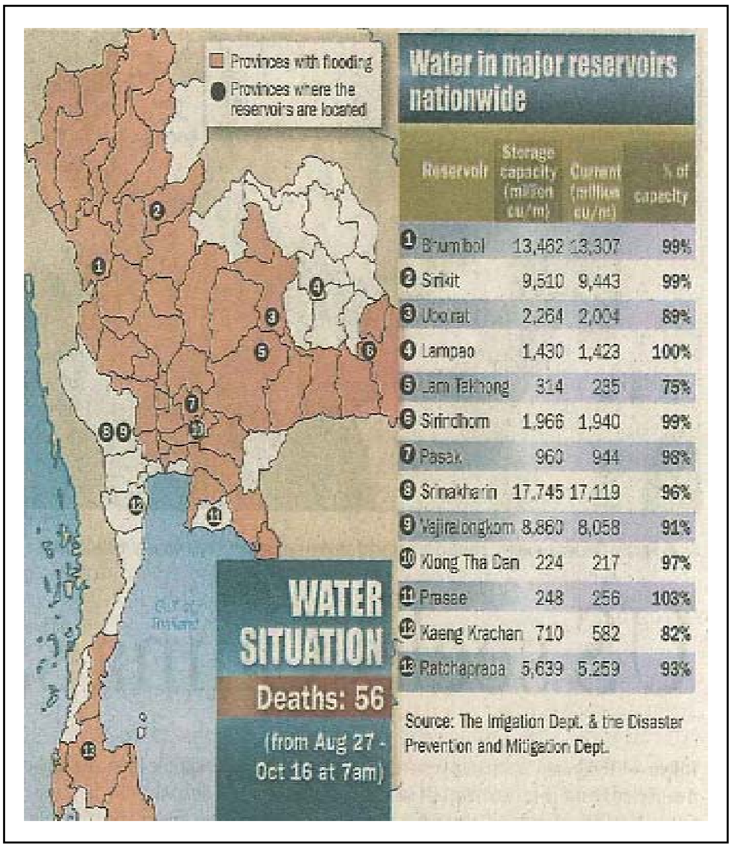


Figure 8. Water storage in major reservoirs in Thailand, October 16, 2006
(*Source: Expert urges formal compensation plan, Bangkok Post, October 17, 2006*)

3. Climate change adaptation plans and implementation

National Adaptation Programs for Action (NAPAs) under the United Nation Framework Convention on Climate Change provide a process for Least Developed Countries (LDCs) to identify priority activities that respond to their urgent and immediate needs with regard to adaptation to climate change (excerpt from http://unfccc.int/adaptation/napas/items/2679.php). In Asia, Bangladesh, Bhutan and Cambodia already have country-wide NAPAs.

Besides NAPAs, series of OECE and IPCC reports, there is some more climate change adaptation plans or climate change related actions as follows. Some of them are governmental or official and some other are only initiative or research activity.

3.1. Japan

River Bureau in Ministry of Land Infrastructure and Transport has formed a sub-committee on climate change adaptation for flood control under Panel on Infrastructure Development’s River Sectional Committee from summer 2007. Members are consisting of 13 academic experts in the field of hydrology, water resources, atmospheric science, planning, media, disaster management, coast engineering, and environment. Major opinions raised in the meetings up to now (Late October 2007) are:

- Before start of any new policy making, we should recognize that the current safety level of flood control is far behind the planned one. This is because of geomorphologic and climate factors in Japan as well as some other Asian countries:
  (1) Geomorphologic factor: many people are living in flood plain
  (2) Climate factor: extreme rainfall events are very high
  The above factors causing huge investment required for flood control plans. Therefore, flood control plans in Japan are behind of the similar plans in the US or Europe due to huge investment required (see Figure 9).
- A 20% increase in designed rainfall (multiply it by 1.2) is changing 100-year return period of exceeding level of designed peak discharge to once in every 30 or 40 years. It is not feasible to stick on 100-year return period since there is little hope to receive extra funds in order to develop necessary infrastructures for adaptation. Therefore, the adaptation directions should be sharp and narrow-focused such as basin management rather than river system management and priority protection rather than equitable protection. It will also helps for the purpose of attracting public and media's attention.

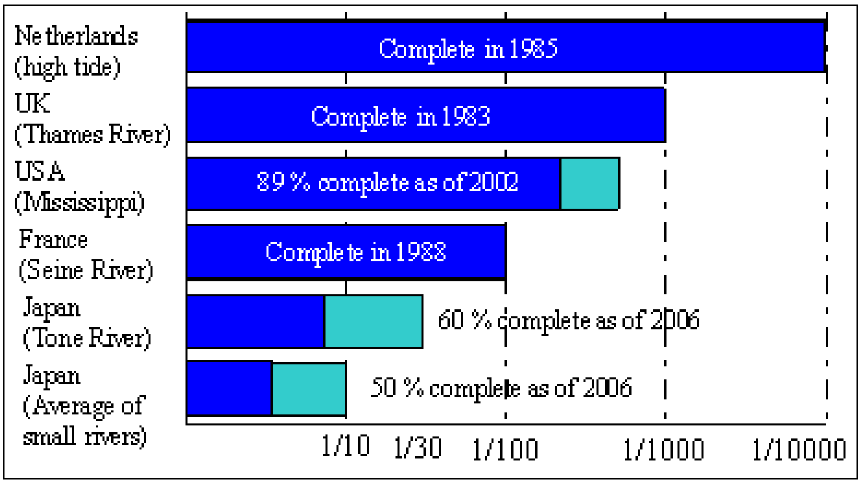


Figure 9. Safety level of Flood Control Plan and Progress
(after Climate Change Adaptation Subcommittee)

3.2. Republic of Korea

Korean Ministry of Construction and Transportation (MOCT) is convinced by frequent observation of the record-breaking precipitation to do a necessary revision on dam safety guideline. According to an emergency action plan, studied by Korean Water Resources Corporation, there are several dams that need the following enhancement and adaptation alternatives:

Spillway improvement; gate installation; increasing level of dam crest; restricted water level lowering; change in reservoir operation rule, etc.

The MOCT's press release in August 2007 has stated that 23 dams are identified for kind of enhancement project in order to secure safety in the context of **Global Warming, El Niño and La Niña**. The improvement projects of two dam have already completed and 13 out of 23 dams are under improvement works. The spillway improvement and gate installation of Yeong-cheon will be completed by October 2007.

3.3. The Netherlands

The Dutch Cabinet has launched a package of measures called the Spatial Planning Key Decision "Room for the River". The main objectives are flood protection of the Rhine River delta without any rise in river flow level (no levee heightening) and promoting overall environmental quality by 2015 with a budget of 2.2 billion Euros. Adaptation to climate change is also included to this plan.

The designed discharge of Rhine River flood control plan for 1/1250 probability was set to 15,000 m3/s at Lobith, where the river cross the border of the Netherlands. The designed discharge is increased to 16,000 m^3/s after a reanalysis considering new flood events. The river should have safe capacity of carrying out discharge flow of 16,000 m^3/s by the year 2015 using several measures. The measures are including lowering of river foreland, removal of obstacles, lowering of groins, dike setback and de-polder, deepening base flow course and flood by-pass. The river should have safe capacity of carrying out discharge flow of 18,000 m^3/s by the end of 21st century. It is not clear from literatures whether the accommodating 18,000 m^3/s is feasible by these alternatives or not.

References of above information are:

Dutch Ministry of Transport, Public Works and Water Management (V&W), Spatial Planning Key Decision 'Room for the River' Investing in the safety and vitality of the Dutch river basin region, September 2006;

Wim Silva, Frans Klijn, and Jos Sijkman: Room for the Rhine Branches in the Netherlands, October 2001; and

Lecture by Hugo Coops at PWRI in June 2005

3.4. UK

UK Environmental Agency proposed a new Planning Policy Statement called PPS25 for the Thames Region. This policy aims to make sure that flood risk is taken into account at all stages in the planning process and include stopping inappropriate development in areas at risk of flooding and to direct development away from areas at highest risk in a long run. (Managing flood risk, Thames Region Catchment Flood, Management Plan, summary document Consultation, January 2007)

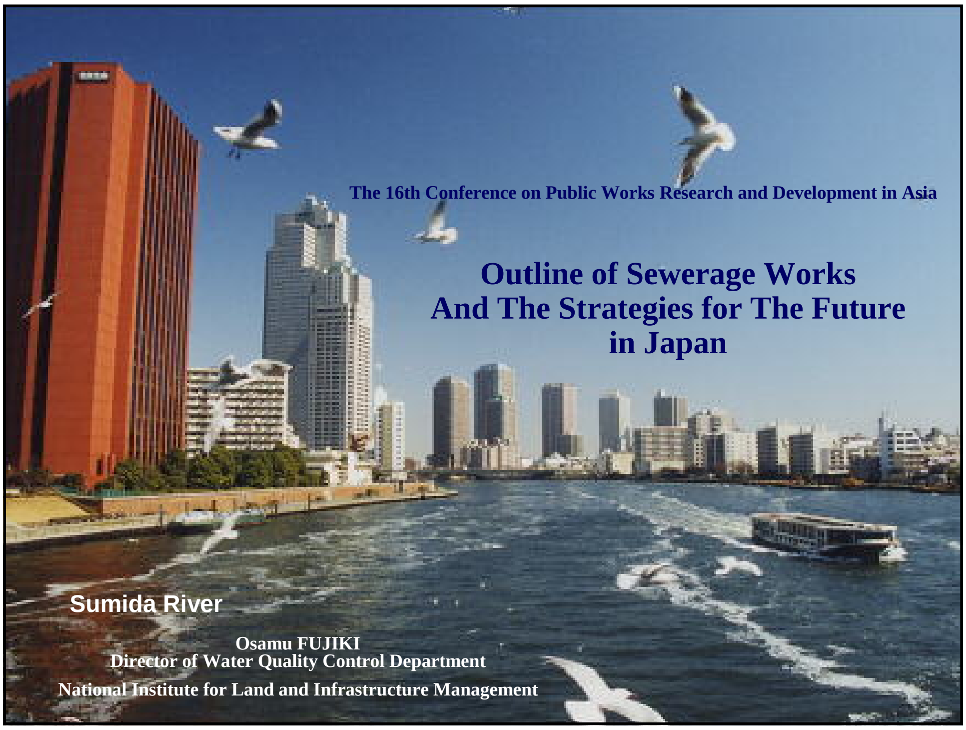
3.5. Iran

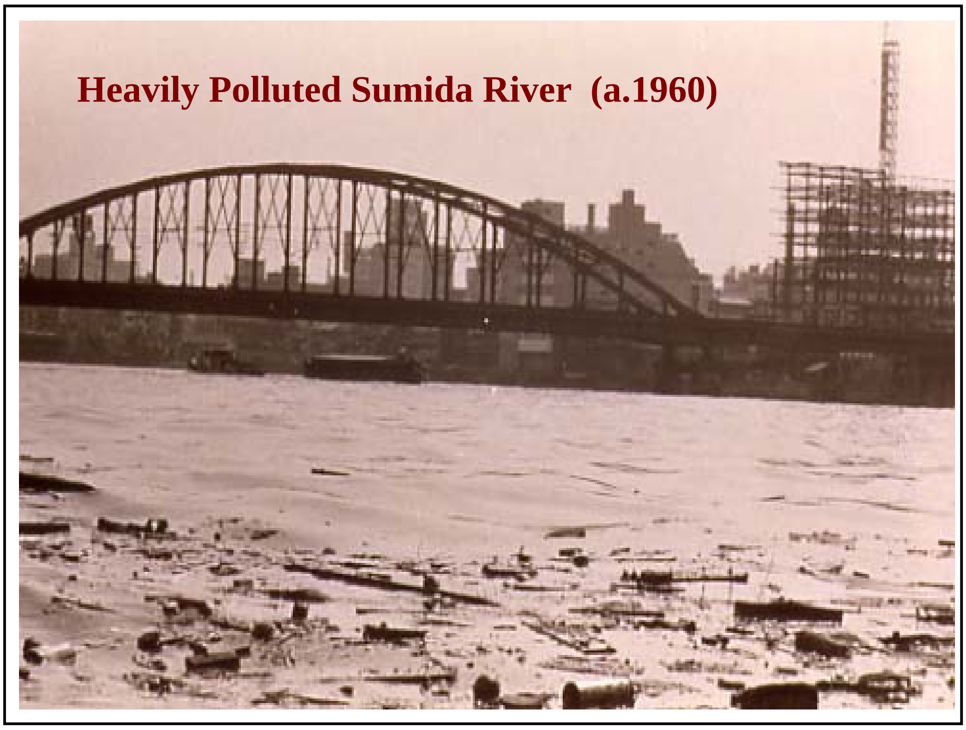
Trans-basin water transfer is considered as a counter measure for climate change adaptation in water sector. Result of a study in Zayandeh Rud basin in the Central part of Iran has shown that climate change will confront the basin with more sever water scarcity that makes proper water management at basin level more crucial. Transfer of water from the neighboring basins to the Zayandeh Rud was considered an essential adaptation measure. Two tunnels are presently under construction and will be operational before 2010. This water diversion can supply deficit in water resources of basin in order to adopt with water scarcity due to climate change. Moreover, another tunnel for water transfer is under study and it is considered as a supplementary plan for more severe climate change impact scenario in future.

4. Recommended Actions to the Asian Research Institutes

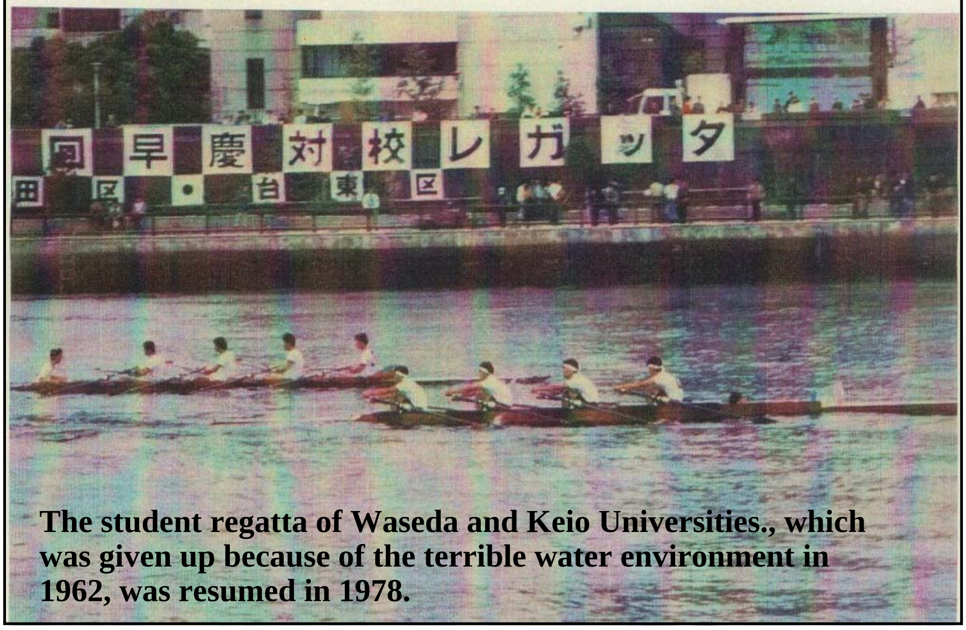
The following are some action proposal for the Asian Research Institutes.

- Highlight climate change impact phenomena of Asian region and its different compare with other regions of the world. It is important to show, in both international and national level, reason of slow start of adaptation programs for flood control in Asian countries due to different social and natural condition. This can be resulted by inter-comparison of the following factors in Asia and other region: current safety level and target level, attainability of the goal in terms of financing and consensus building of public and politicians, severity of extreme events, vulnerability and future change due to population growth, past investment and necessary cost and special social concerns.
- Study on methods and actions to speed up and promote climate change impact adaptation measure in Asian countries. This can be done by pay more attention to more realistic Benefit/Cots (B/C) analysis of climate change adaptation measures as well as compatibility of the suggested methods to the socio-economic condition.
- Sharing information and experiences among Asian Research Institutes and build up a platform for information sharing.
- Joint-research activities on climate change adaption measures with focus on regional climate change impacts and trans-boundary river basins.


The 16th Conference on Public Works Research and Development in Asia
Outline of Sewerage Works
And The Strategies for The Future
in Japan
Sumida River
Osamu FUJIKI
Director of Water Quality Control Department
National Institute for Land and Infrastructure Management


Heavily Polluted Sumida River (a.1960)

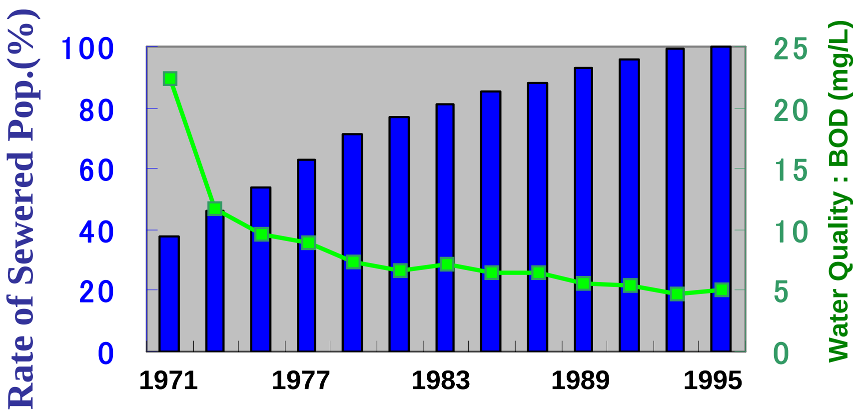
Regatta of University Students in Sumida River



The student regatta of Waseda and Keio Universities., which was given up because of the terrible water environment in 1962, was resumed in 1978.

Impact of Sewerage

The Relationship Between Water Quality And the Rate of Population Served with Sewerage

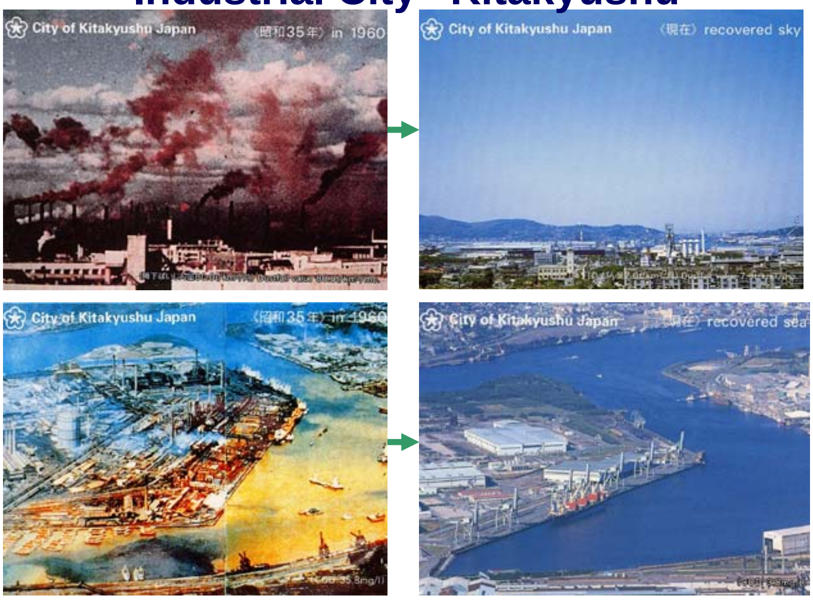


Sumida Firework

The Sumida Firework Festival was also resumed after the river water restoration in 1978.

Another Example

Industrial City “Kitakyushu”



Overview of Sewage Works in Japan

Overview of Japan

- Japan is an archipelago stretching over a great distance from north to south with a vast range of climatic zones
- About 80% of the territory is either mountain or forested land

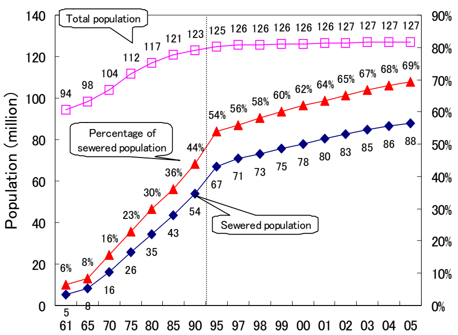
Comparison between India and Japan

	India	Japan
Population (million)	1,080	128 (12%)
Area (billion m2)	3,287	377 (11%)

Progress in Public Sanitary Sewerage System

- Sewage work in Japan was developed rapidly since 1960's
- Regional divide is one of the distinguishing characteristics of sewage works in Japan
- Narrowing the gap of regional divide remains a major challenge

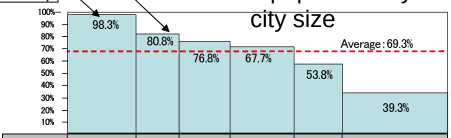
Percentage of sewered population



Tokyo (100%)
Kyoto (99%)
Osaka (100%)

Kitakyushu (100%)

Percentage of sewered population by city size



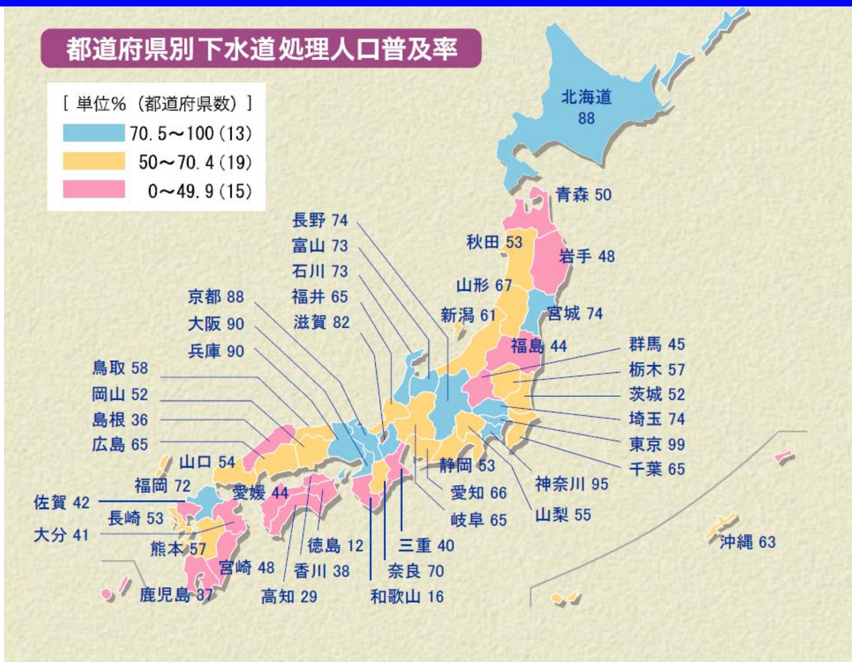
Population (thousand)	Over 1,000	500~1,000	300~500	100~300	50~100	Less than 50
Total number of cities	11	15	46	189	282	1,279
Total population (million)	26.19	10.76	17.79	30.45	19.62	22.25
Sewered population (million)	25.76	8.69	13.66	20.62	10.56	8.74

Increasing constantly (1.5 points par a year) since 1960's

24 million people are not sewered

Sewered ratio is only 39% among the cities with population less than 50 thousand

Rate of Sewered Population in Each Prefecture



Institutional System of Sewage Works in Japan

Coverage Rate of Appropriate Sewage System 82.4%

As of the end of FY 2006

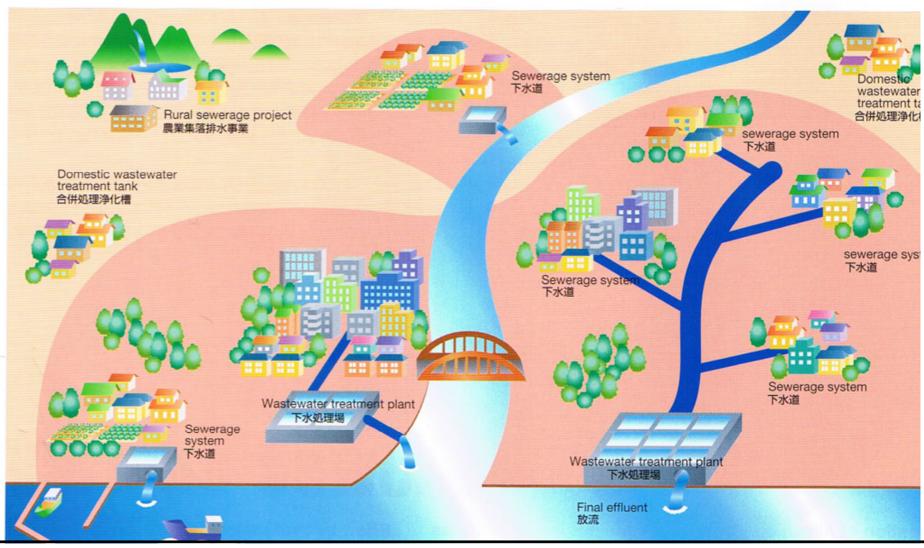
	Sewerage system	Rural sewerage system	Domestic wastewater treatment tank	Flush toilet wastewater treatment	Toilet with storage tank
Share	70.5%	2.8%	9.0%	17.6%	
Construction and Maintenance	Local-Governmental		Private or Local-Governmental	Private	
Law	Sewerage Law	Domestic Wastewater Treatment Tank Law			Waste Disposal and Public Cleansing Law
Ministry Responsible for Jurisdiction	Ministry of Land, Infrastructure and Transport	Ministry of Agriculture, Forestry and Fisheries	Ministry of the Environment		
National Treasury Subsidy	With			Without	

Right System in the Right Place (1)

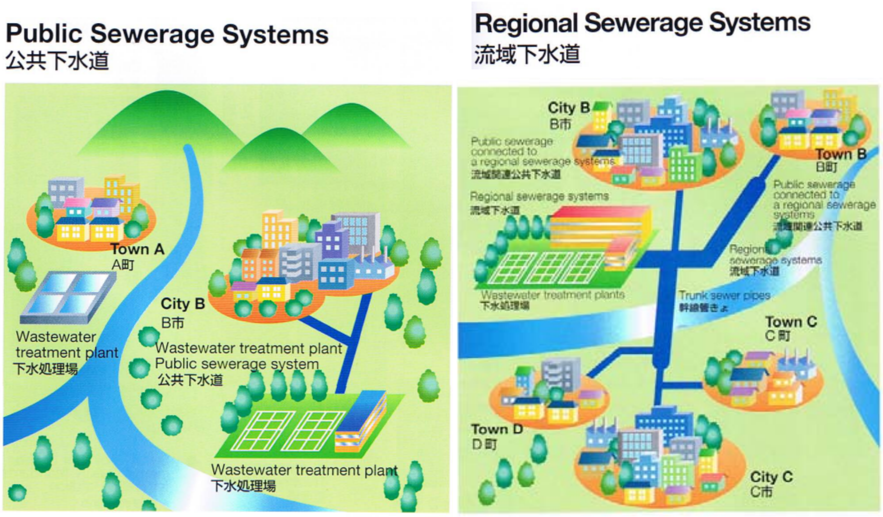
Different Measures between Urban and Country Areas

Effective Sewerage System Construction and Imprementation Meaures

効率的な下水道整備と事業実施方法

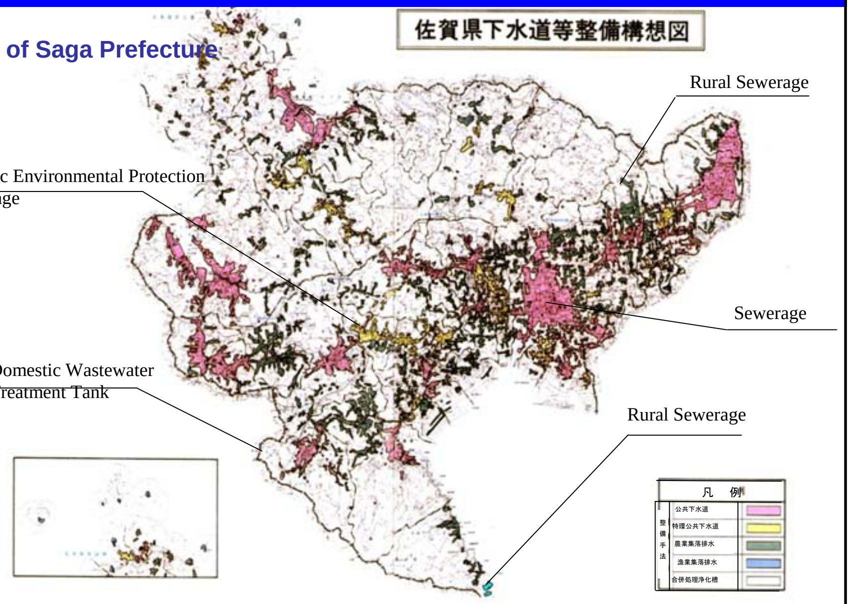


Right System in the Right Place (2)
The Role of Prefecture Government

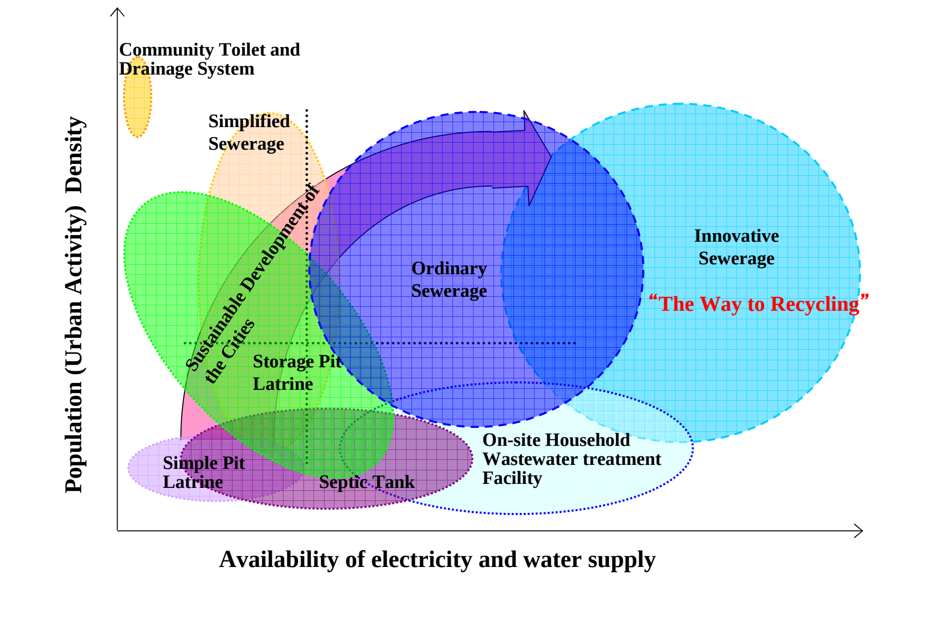


Right System in the Right Place (3)
Prefecture-wide Sewerage Map

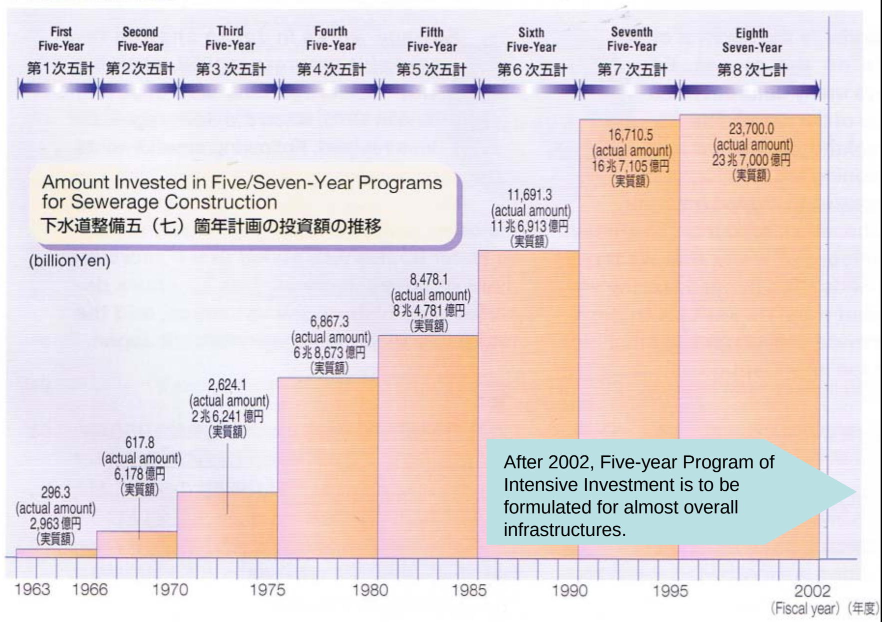
Example of Saga Prefecture



Right System in the Right Place and in the Right Time
Evolution of Sewage System



Progress of Investment in Sewerage Construction
(Five-year Program of Sewerage Construction)



Resources for Public Sewerage Construction

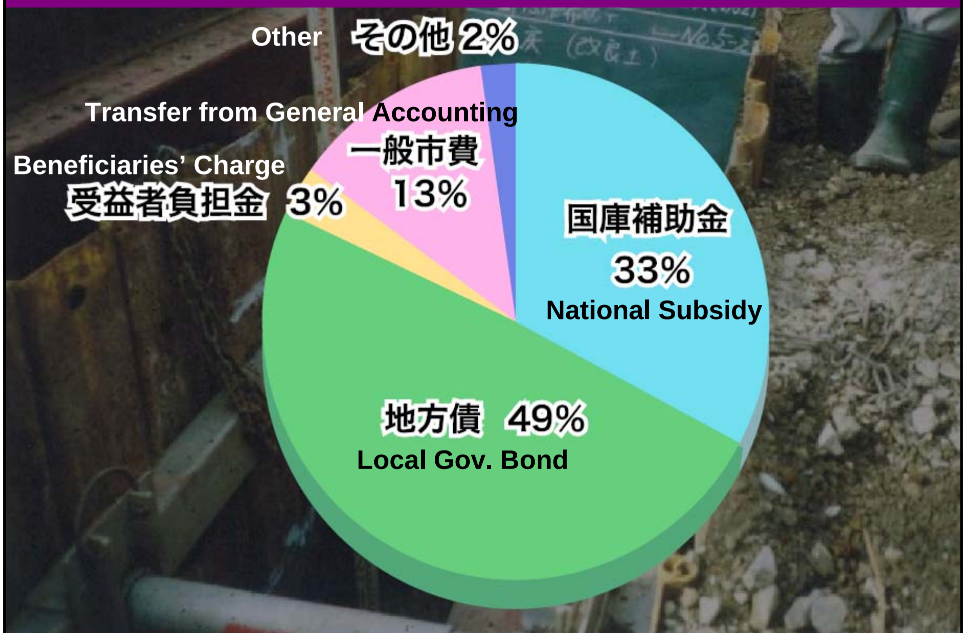
Public sewerage system

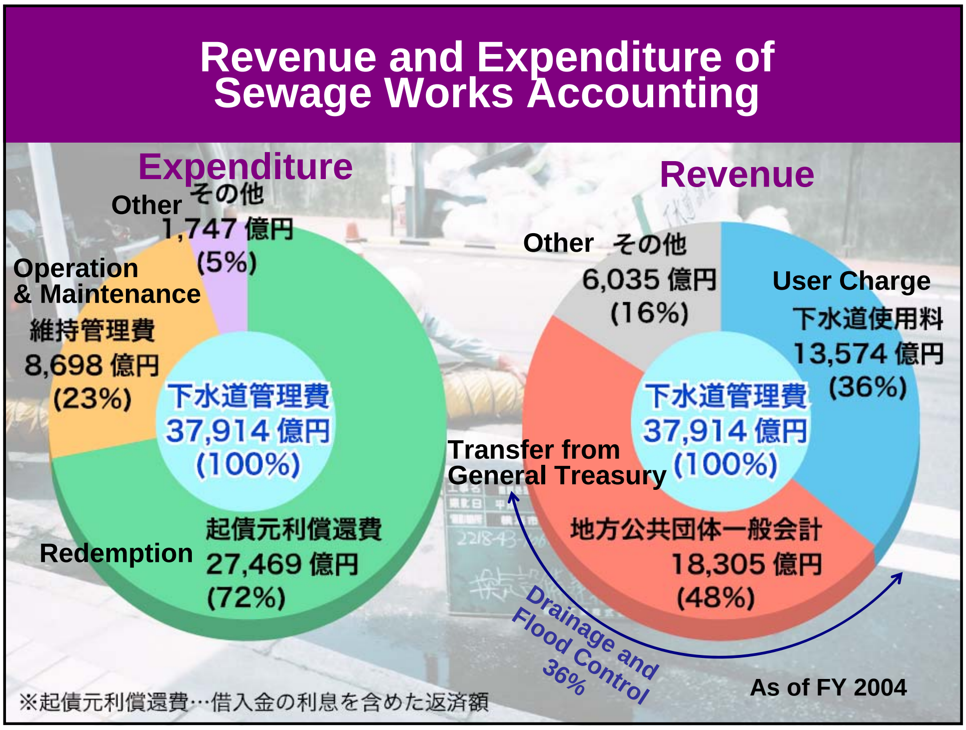
- National Subsidy (national treasury subsidy)
- Local spending
  - Local government bonds
  - Beneficiary’s charge etc.

Storm-water channel

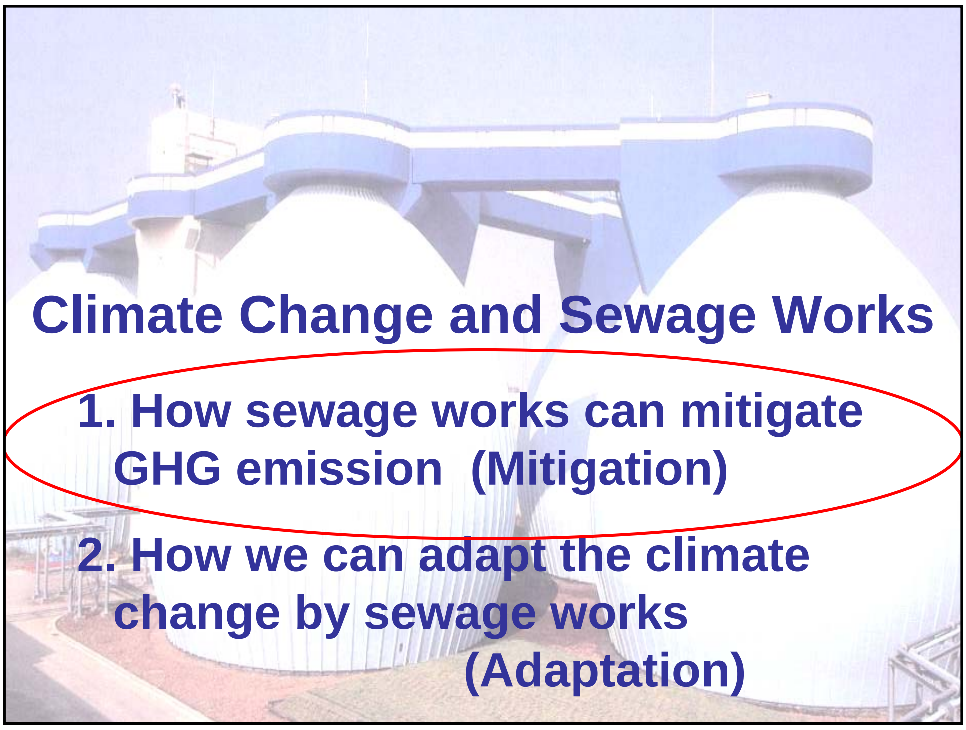
- National spending (national treasury subsidy)
- Local spending
  - General local government expenditure
  - Local government bonds etc.

Resources for Developing Public Sewerage





Revenue and Expenditure of Sewage Works Accounting
Expenditure
Other その他
1,747 億円
(5%)
Operation & Maintenance
維持管理費
8,698 億円
(23%)
下水道管理費
37,914 億円
(100%)
Redemption
起債元利償還費
27,469 億円
(72%)
Revenue
Other その他
6,035 億円
(16%)
User Charge
下水道使用料
13,574 億円
(36%)
下水道管理費
37,914 億円
(100%)
Transfer from General Treasury
地方公共団体一般会計
18,305 億円
(48%)
Drainage and Flood Control 36%
As of FY 2004
※起債元利償還費…借入金の利息を含めた返済額



Climate Change and Sewage Works
1. How sewage works can mitigate GHG emission (Mitigation)
2. How we can adapt the climate change by sewage works (Adaptation)

How Sewage Works can mitigate GHG emission

1. Mitigation of N_2O emission from incinerator

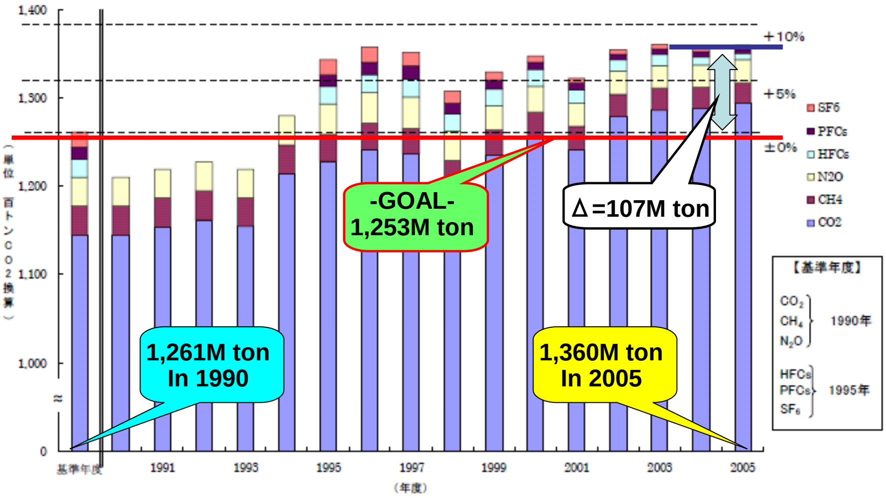
2. Mitigation of CO_2 emission by energy saving

3. Producing carbon-neutral fuel from sludge
   Biogases
   Sludge charcoal through dryer or carbonization

4. Alternative energy
   Utilization of sewage energy by heat pump
   Wind power, Solar energy, Effluent waterpower, etc.

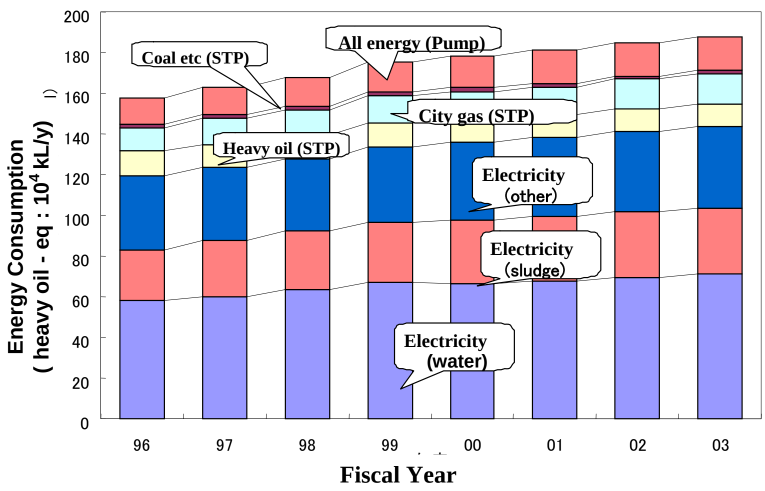
5. Battery energy storage system

GHG emission in FY 2005 amounts to 1,360 million t-CO_2, which exceeds that of 1990 by 7.8%.

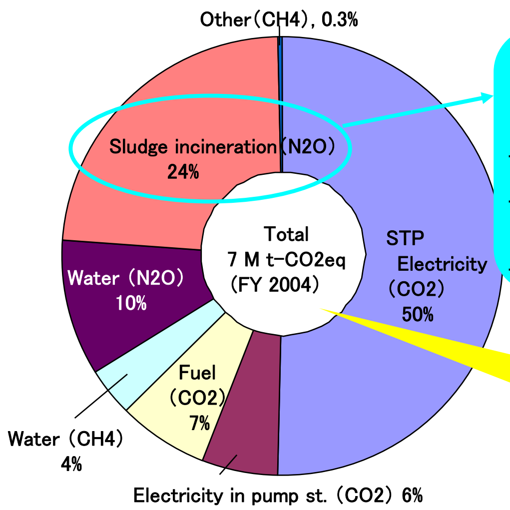


Change in GHG Emission in Japan

Change in Energy Consumed by Sewerage Facilities



GHG Emission from Sewerage Facilities



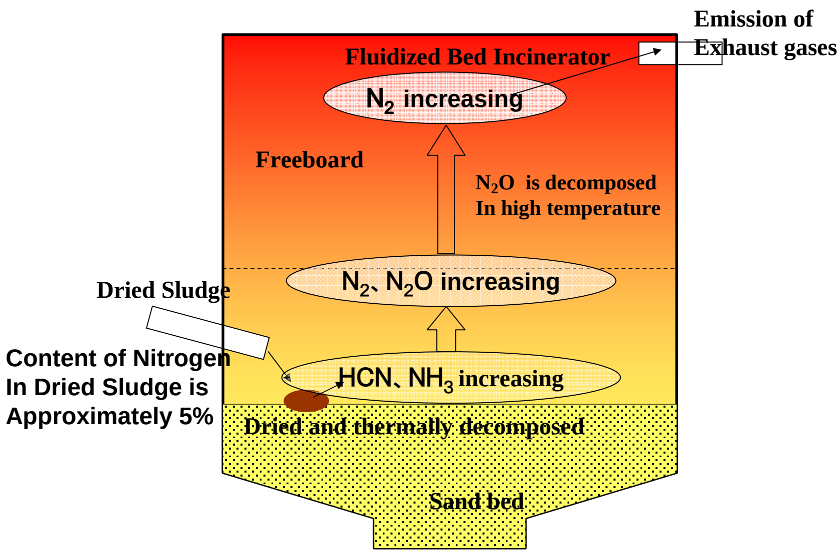
Sewage sludge is rich in nitrogen and easy to evolve N_2O when incinerated.

Emission Rate(g-N_2O/t)	
Sewage Sludge	294 ～ 1,508
Garbage	21 ～ 180

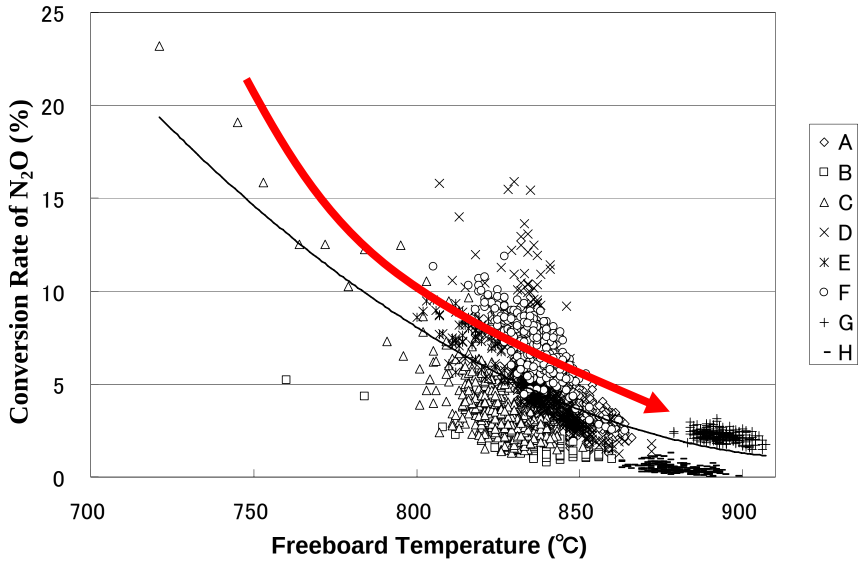
0.5% of total emission

6.5% of the gap between goal and the present

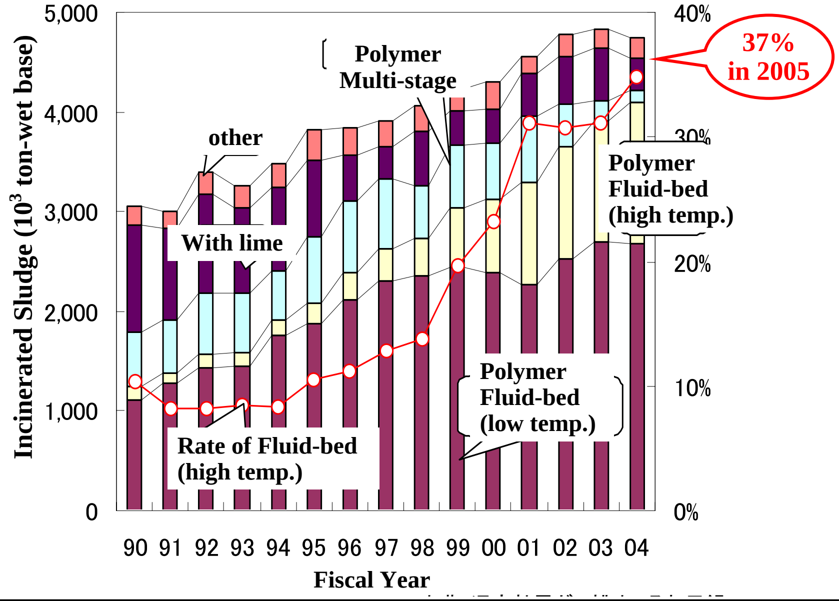
N_2O Composed in Sludge Incinerator



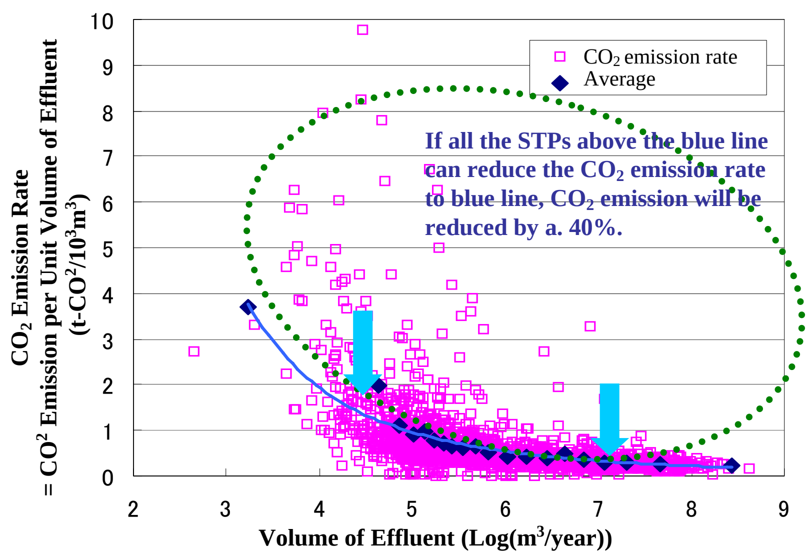
Relation between N_2O Conversion Rate and the Freeboard Temperature in Sludge Incinerator



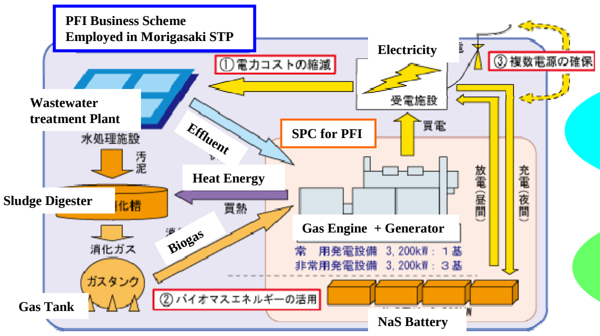
Change in Incinerated Sludge Volume and Conversion to High-temperature Incinerator



Best practice can reduce GHG emission by a.40%



Save Fossil Fuel, and Save Money
Challenge of Morigasaki STP in Tokyo



Saving energy equivalent to a. 23,000 drums of heavy oil every year

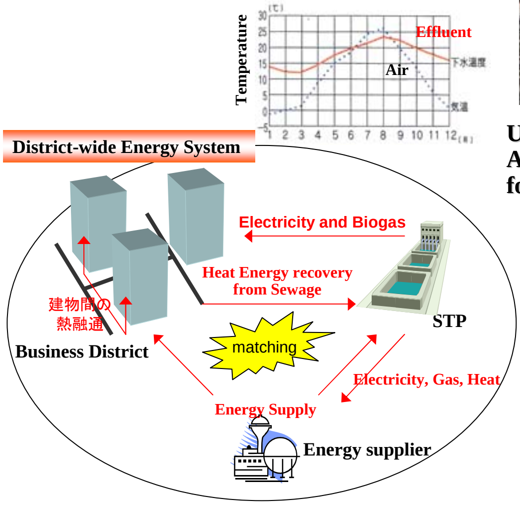
Reducing the emission of GHG by a. 4,800 tons of CO_2-eq every year

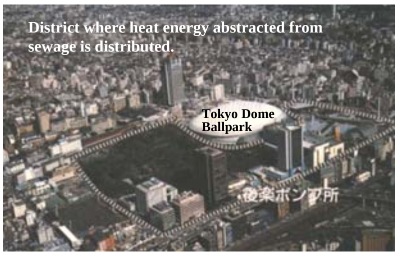
Abating the O/M cost by 13 billion yen for 20 years

NaS Battery

Gas Engine + Generator

Let STP be involved into the District-wide Energy System





Utilization of the Heat Energy Abstracted from Sewage by Heat Pump for the District-wide Air Conditioning (Tokyo)

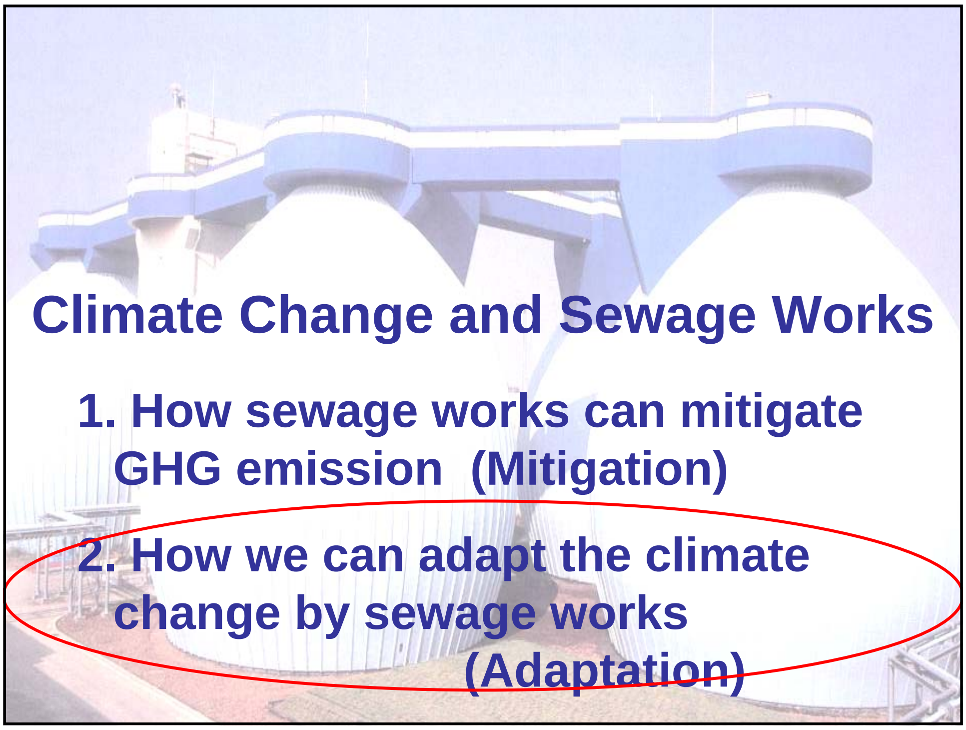
Utilization of Biogas for Vehicles Kobe City

APEC Action Agenda

SYDNEY APEC LEADERS' DECLARATION
ON CLIMATE CHANGE,ENERGY SECURITY AND CLEAN DEVELOPMENT
Sydney, Australia, 9 September 2007

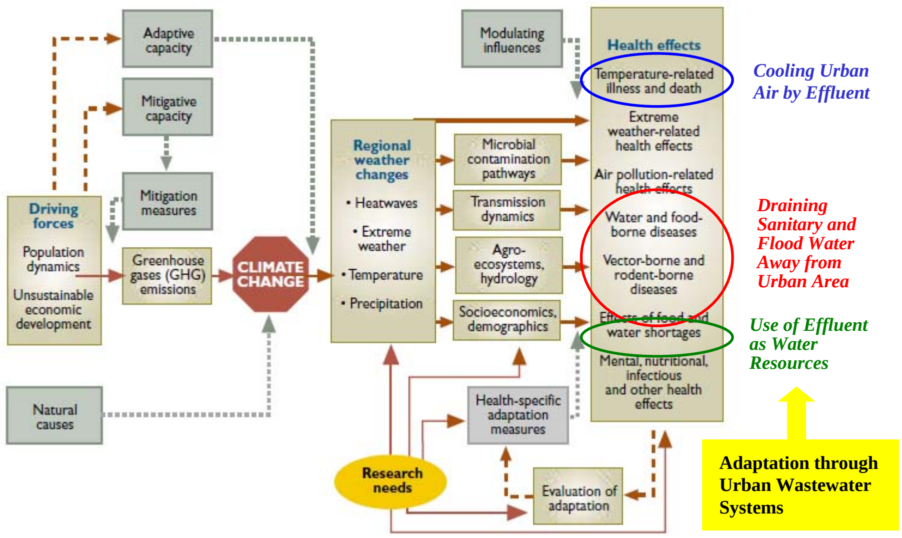
We have decided to:

highlight the importance of <u>improving energy efficiency</u> by working towards achieving an APEC-wide regional aspirational goal of a <u>reduction in energy intensity of at least 25 per cent by 2030</u> (with 2005 as the base year);



Climate change and health: pathway from driving forces, through exposures to potential health impacts. Arrows under research needs represent input required by the health sector

(Modified from "Climate change and human health : risks and responses", WHO 2003)

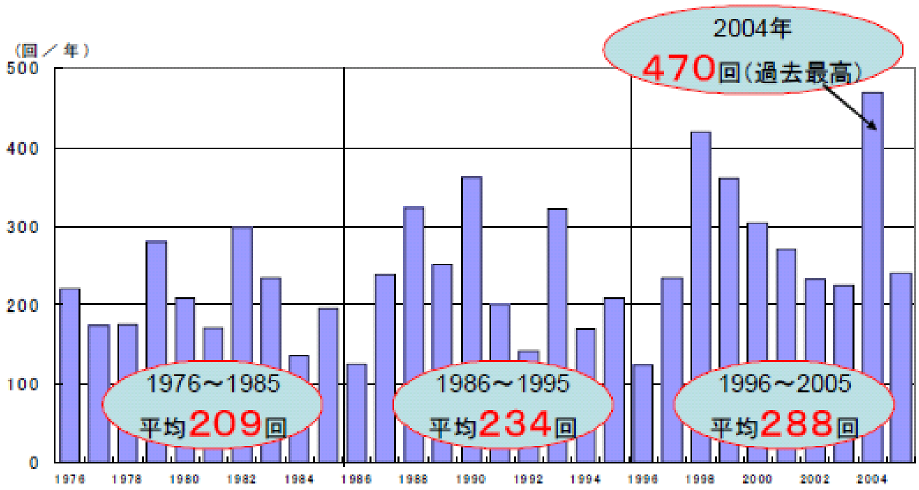


Inundation Caused by Intensive Rainfalls

Hibiya, Tokyo (2000)

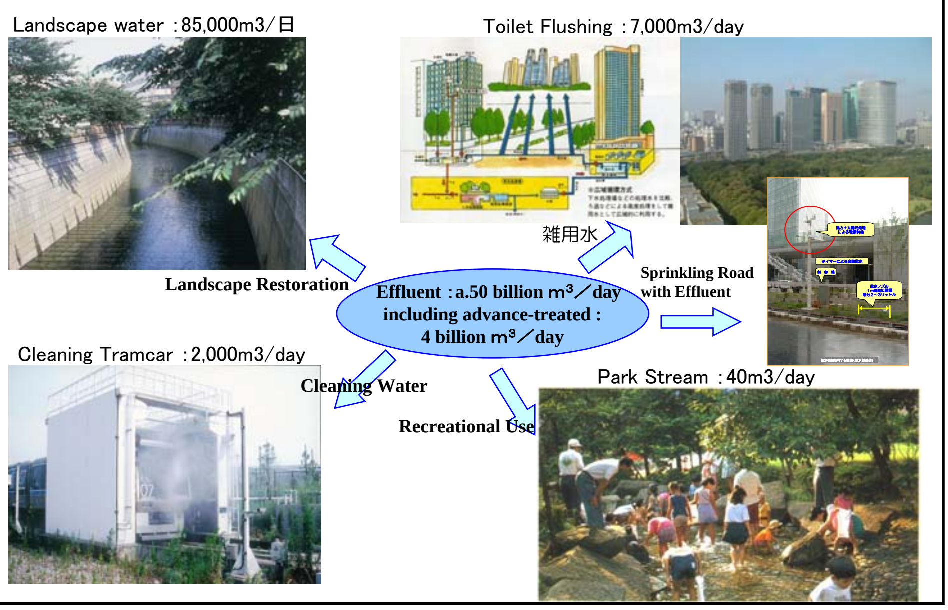
Fukuoka, (1999)

Frequency of Extreme Event of Rainfall (more than 50mm/hour)

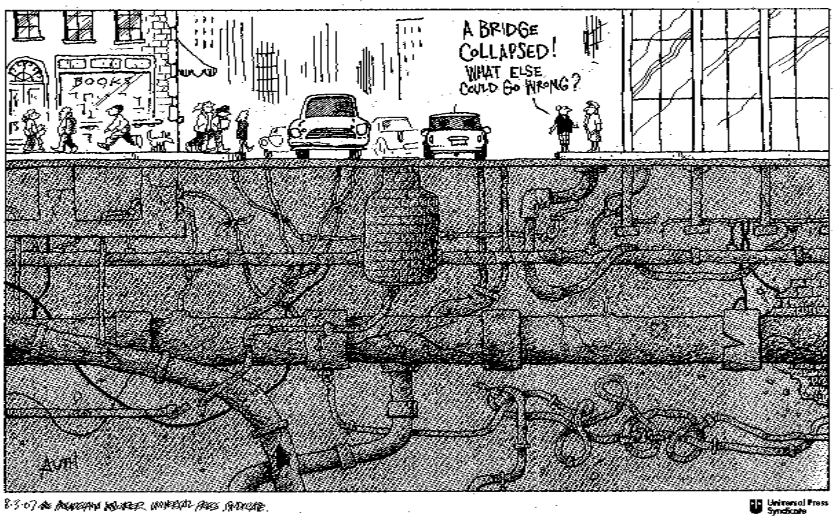


Utilization of Effluent

Example of Tokyo Metropolitan Government



How Should We Manage the Aging Facilities ?

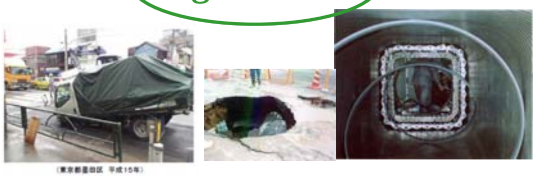


New Concept of Sewage Works
“The Way to Recycling”

The way to New Water

The way to Resources

Regeneration




Thank you

The 16th Conference on Public Works Research and Development in Asia

Urban Stormwater Management

Takashi SAKAKIBARA

Jun ENDO

Norihide TAMOTO

Wastewater System Division,

Water Quality Control Department,

National Institute for Land and Infrastructure Management (NILIM),

Ministry of Land, Infrastructure and Transport(MLIT)

Urban Stormwater Management-Topics

1.Backgournd

2.Current Status

3.Plan

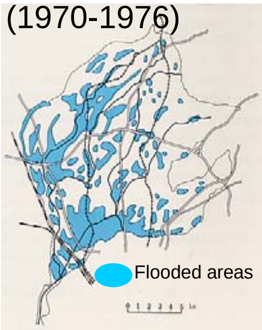
4.Countermeasures

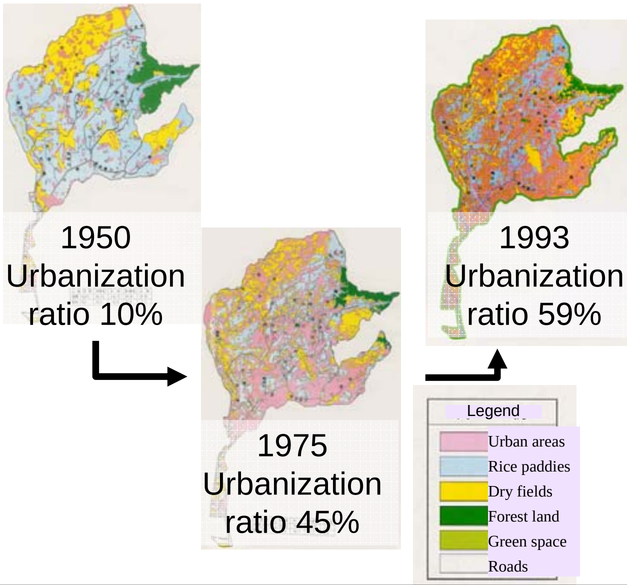
5.Combined Sewer Overflow Problem &Control

6.Toward the Global Warming Problem &Control

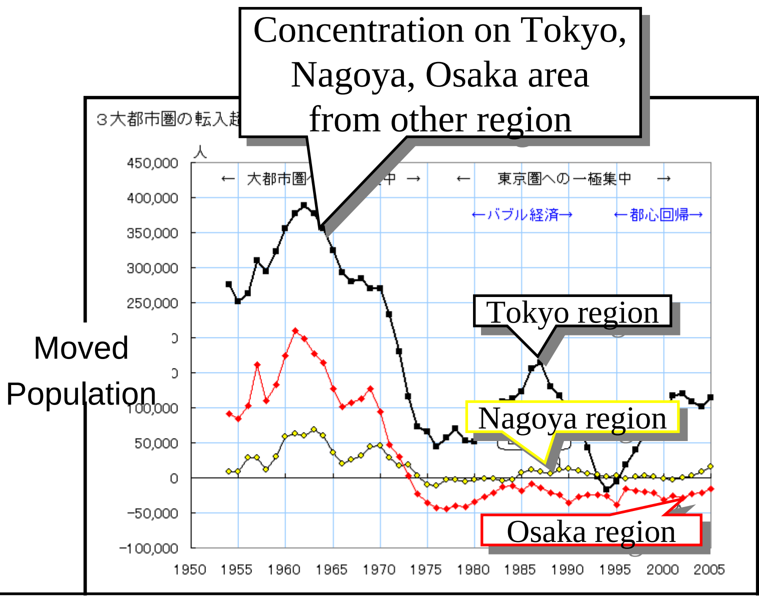
1. Background

Shinkawa (Aichi Prefecture)
Flood history (1970-1976)

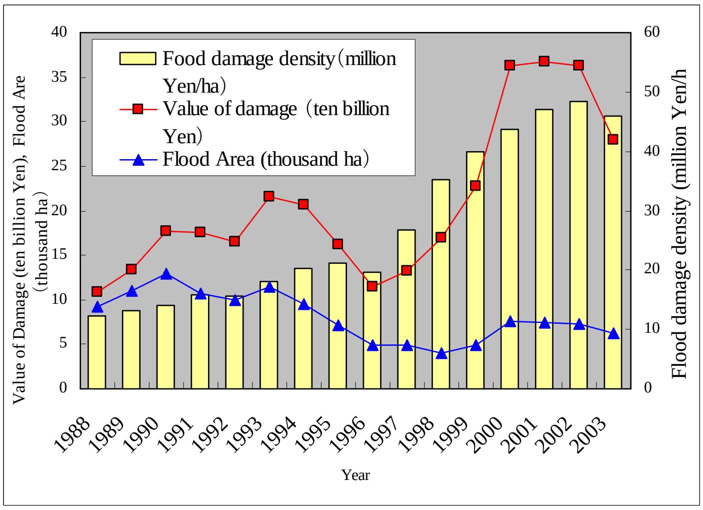




Population Migration



Urbanization & Flood Damage



Note: The data are the average figures for a five-year period.

Source: Flood Damage Statistics compiled by the Ministry of Land, Infrastructure and Transport, Japan

2. Inner Water Damage in Japan

Kochi city (1998)

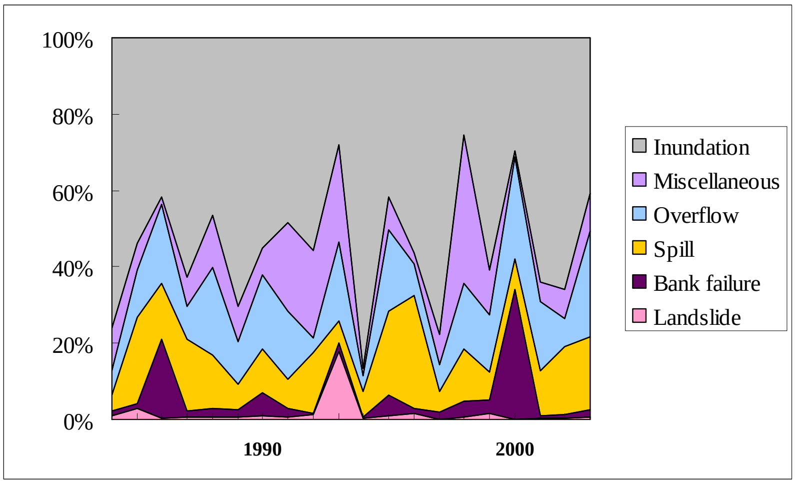
Fukuoka city (1999)

Nagoya city (2000)

cf. Flooding in Kand River,Tokyo

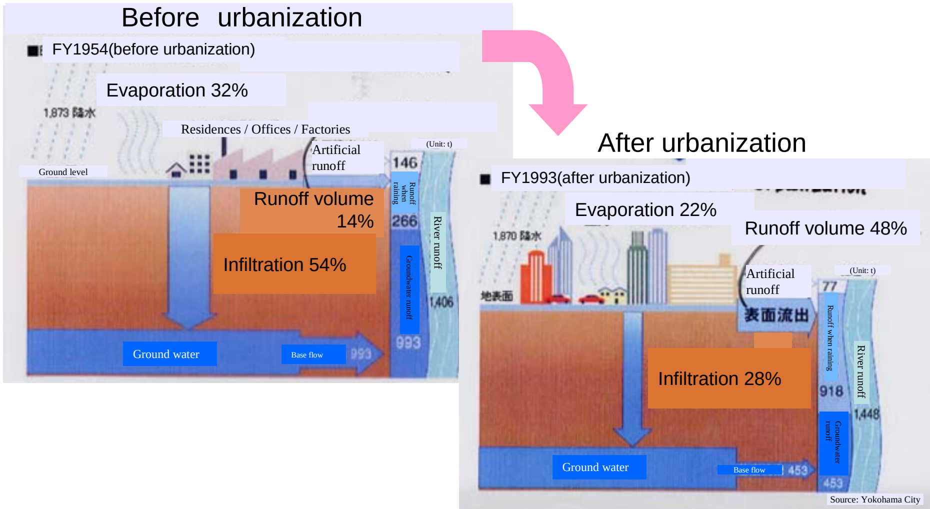
Breakdown of Inner Water Damage Amounts

(About region of Tokyo, Nagoya and Osaka)



Rate of flood damage by cause

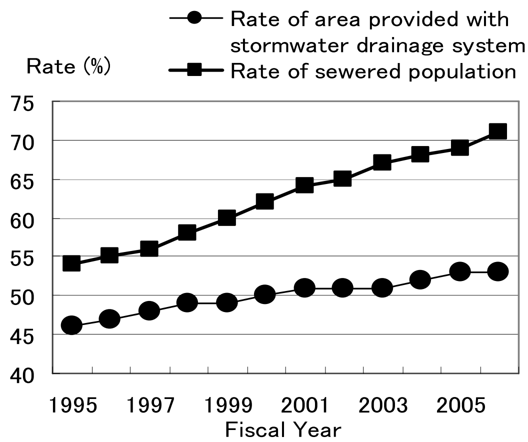
Increase of Outflow by Urbanization



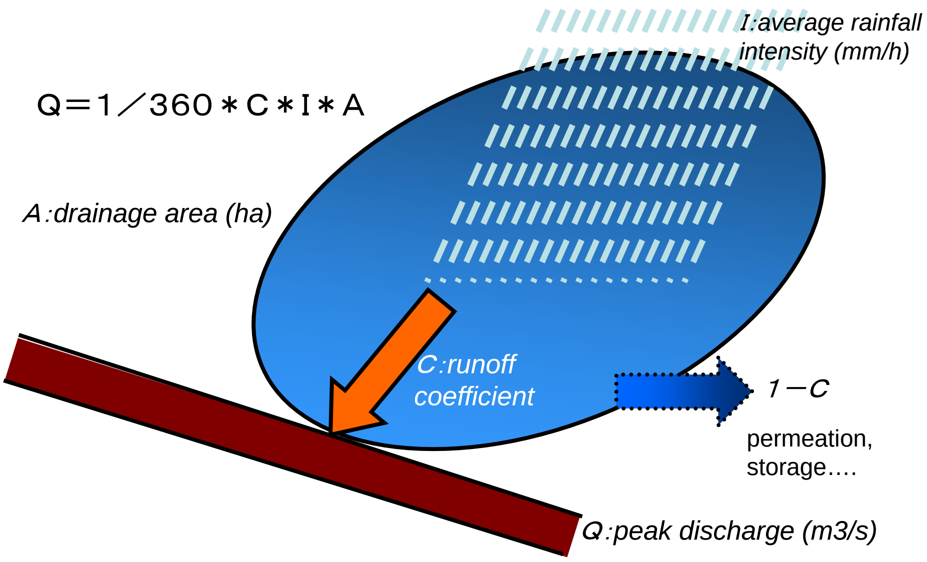
3. Plan for Urban Inner Water Drainage

Sewerage for Storm Water Falls Behind in Japan

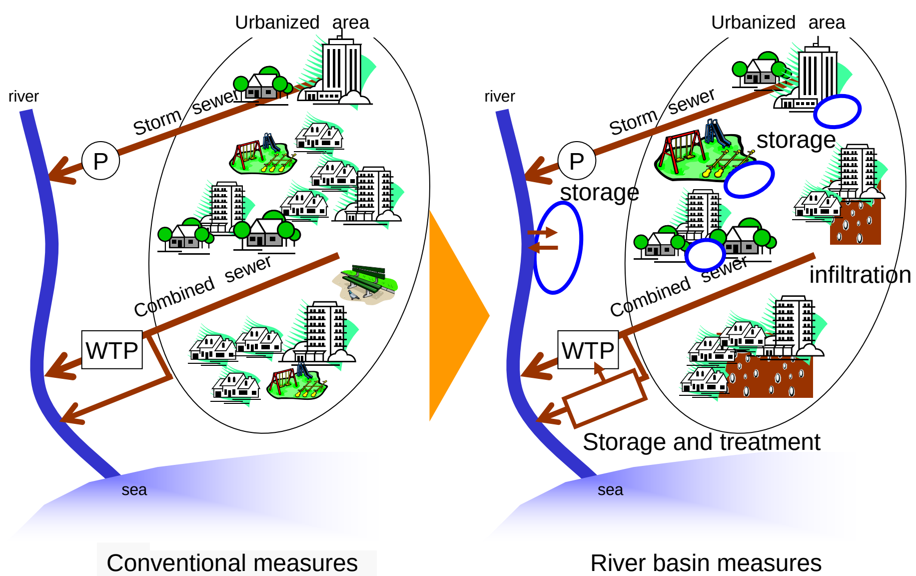
Situation of sewerage in Japan



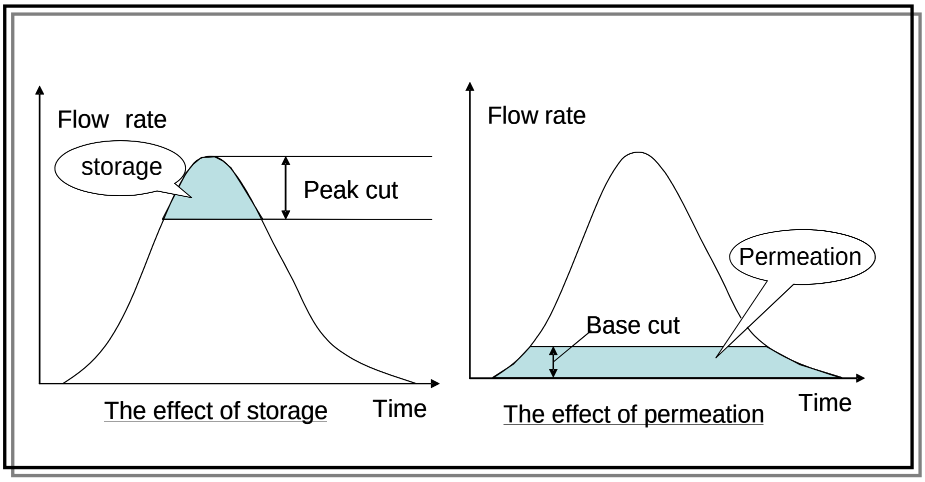
Calculation method for stormwater volume



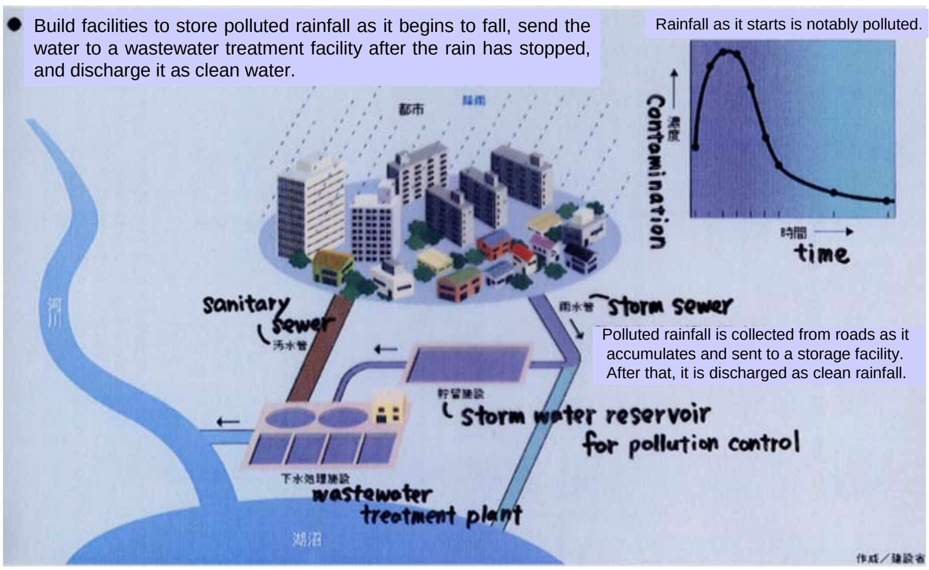
Considering Storage and Permeation Facilities' Effect



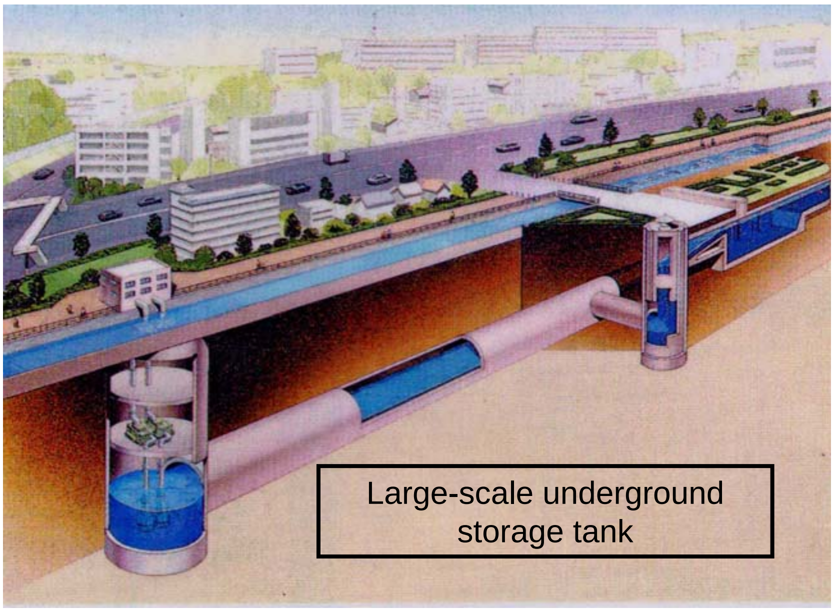
Peak Cut & Base Cut



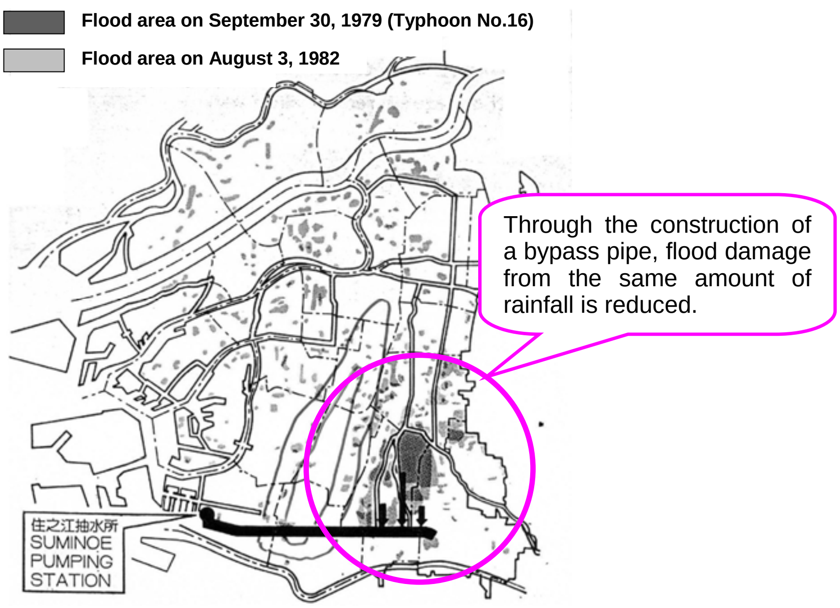
To Reserve First Runoff of Rain Water



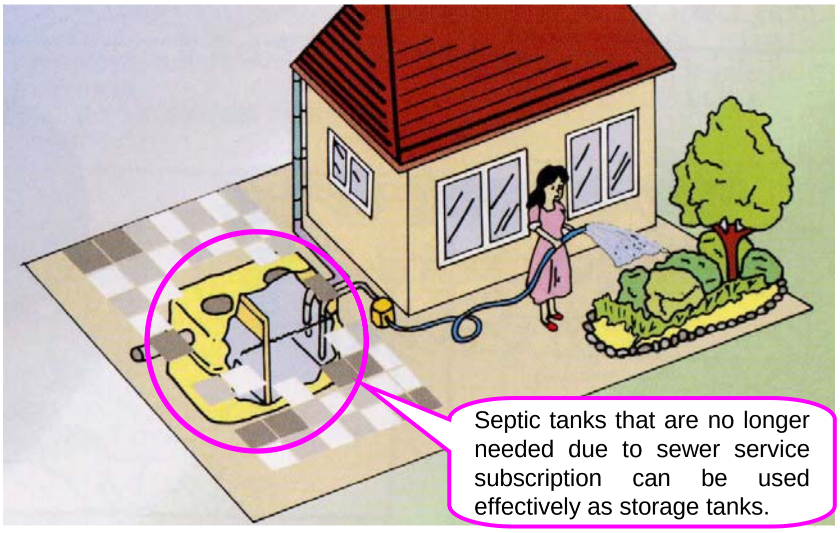
4. Examples of Sewerage in Japan



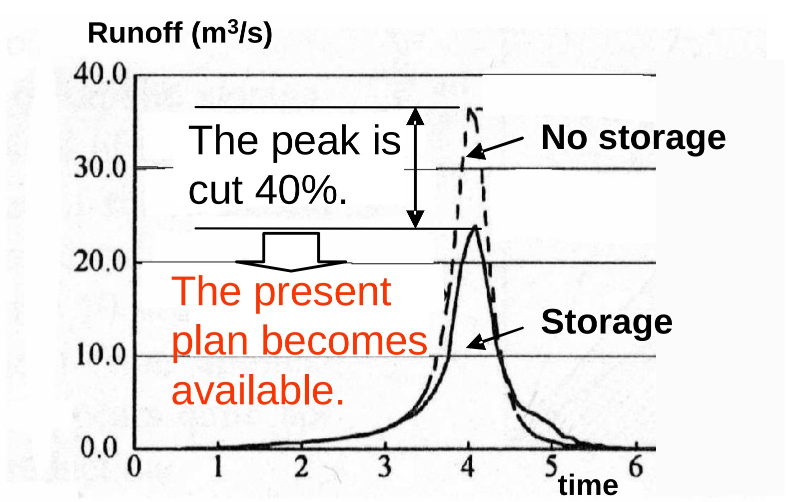
Bypass Pipe in Osaka



Residential Storage

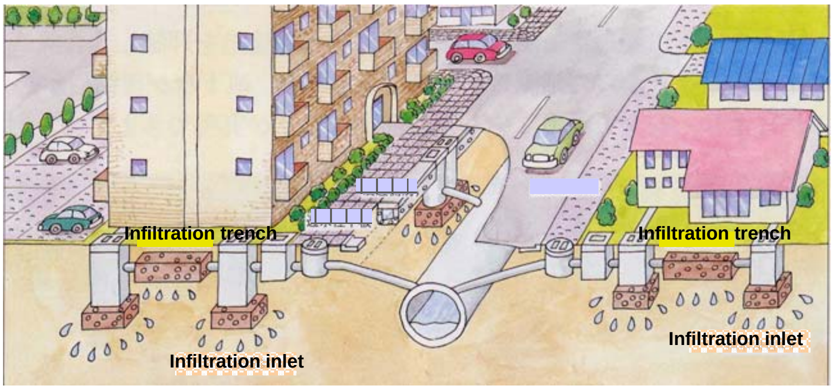


Simulation of the Effect of Storage Facilities

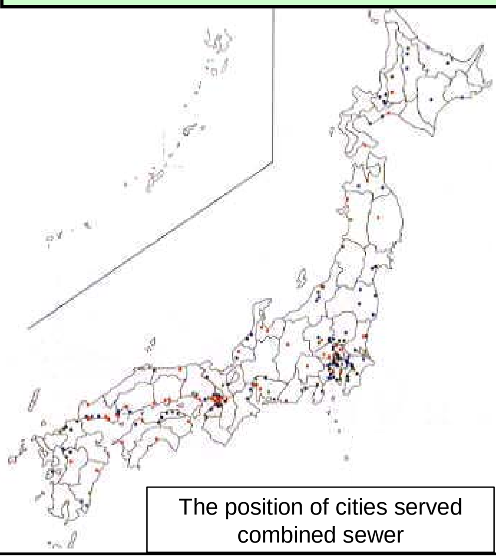


Simulation of storage effect

Infiltration Trench

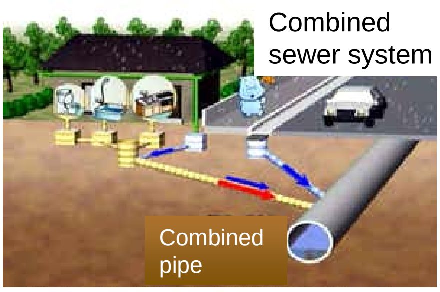


5. Challenges of Sewerage in Japan -Combined Sewer Overflow Problem & Control

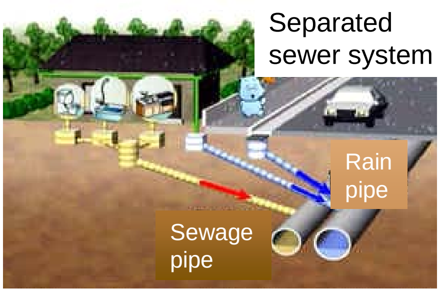


The position of cities served combined sewer

"Combined" and "Separate" Sewer Systems

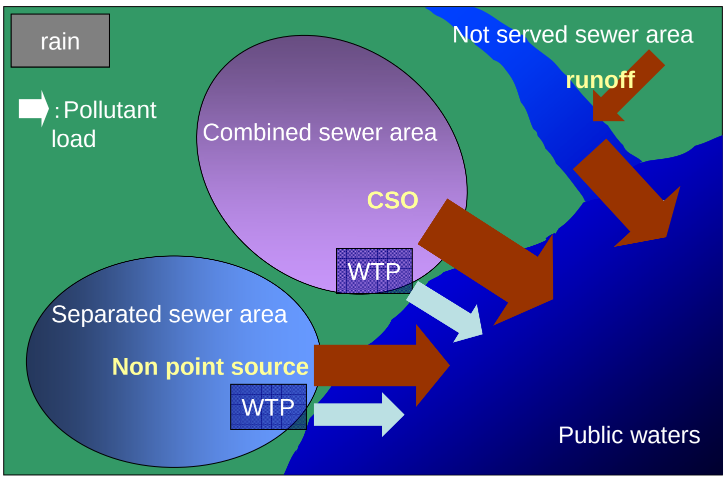


Not expensive but problem of CSO



No problem of CSO but expensive

Problem of Combined Sewer System

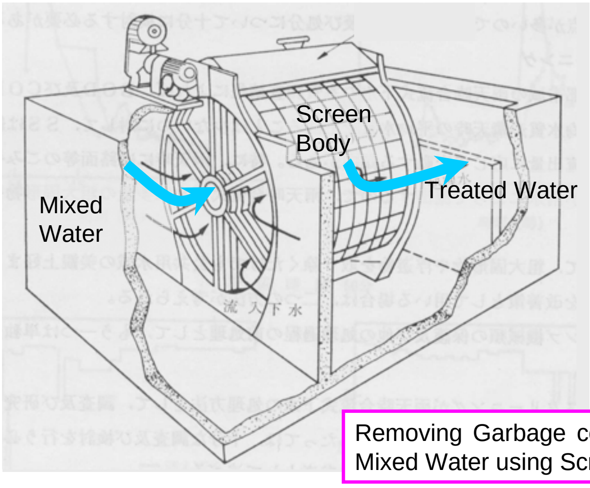


Combined Sewer Improvement

･Reduce pollution load

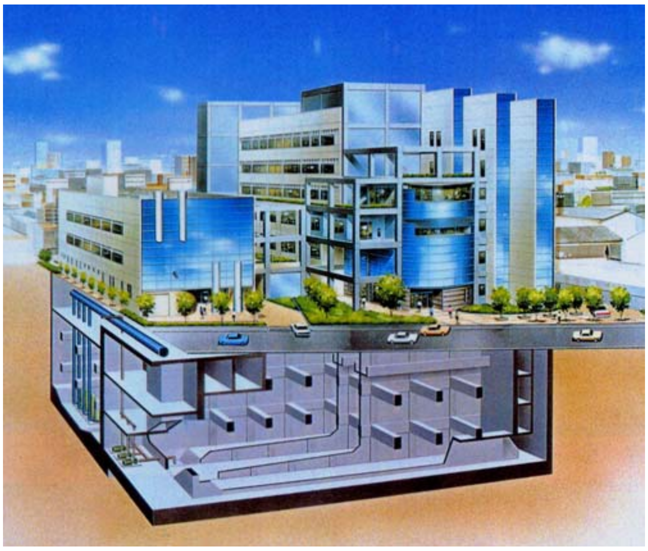
･Reduce overflow times

･Remove garbage from mixed water



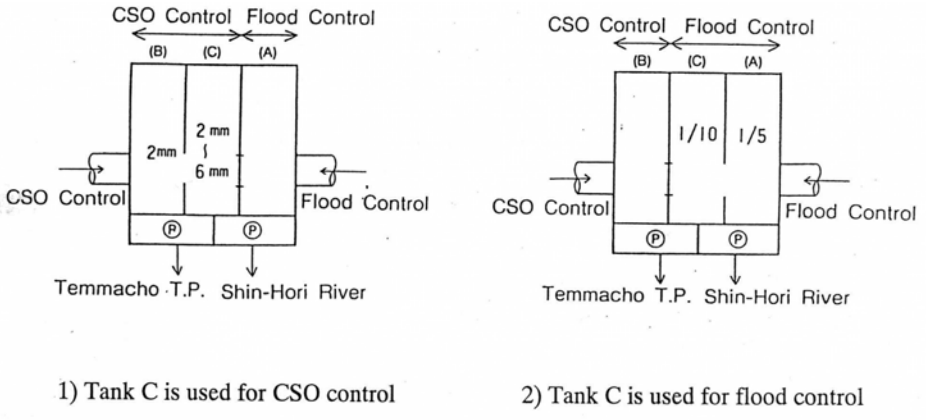
Removing Garbage contained in Mixed Water using Screens

Storage Tank under Building in Nagoya

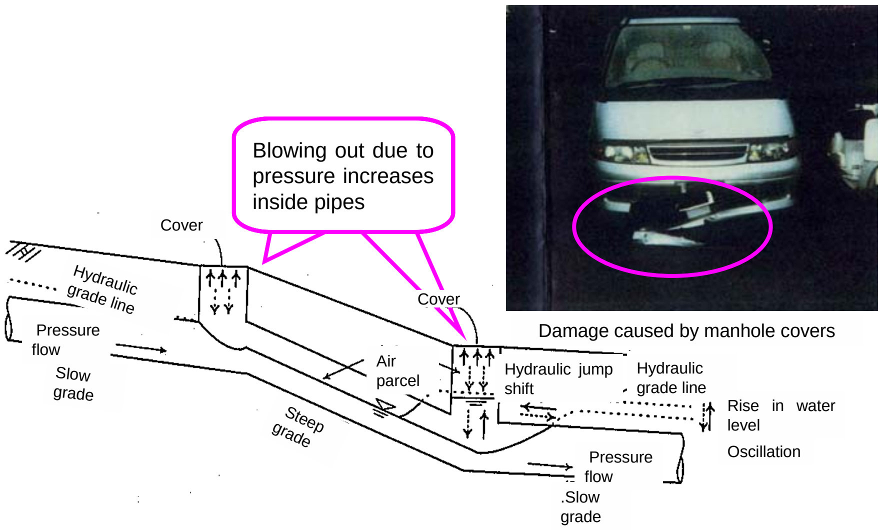


Fukue rain water storage facility

One Facility has Two Functions

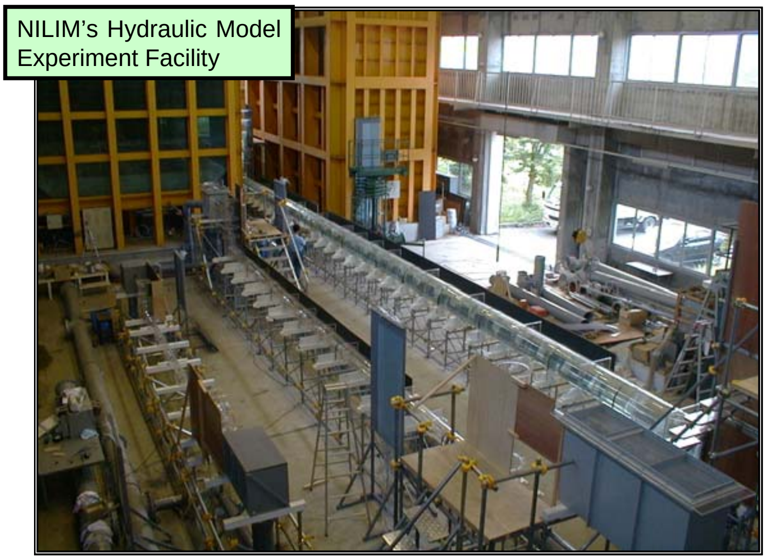


Manhole Cover Blown Up by Heavy Rain



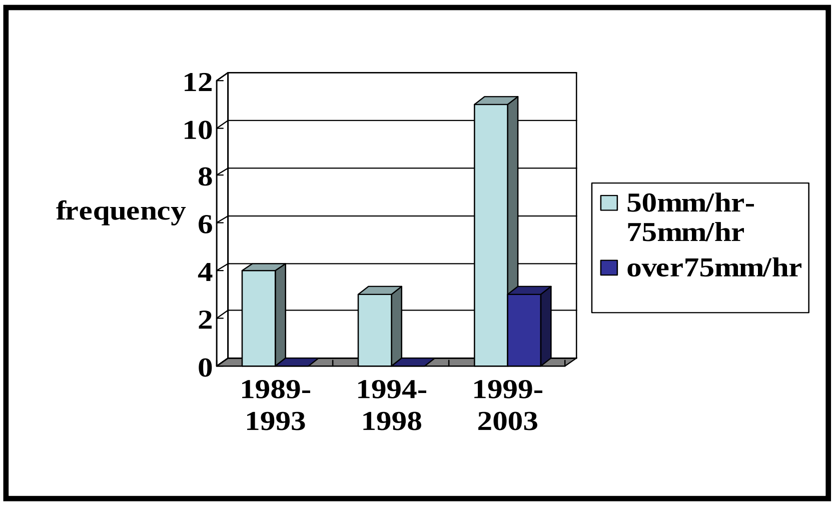
Damage caused by manhole covers

NILIM Experiment Facility

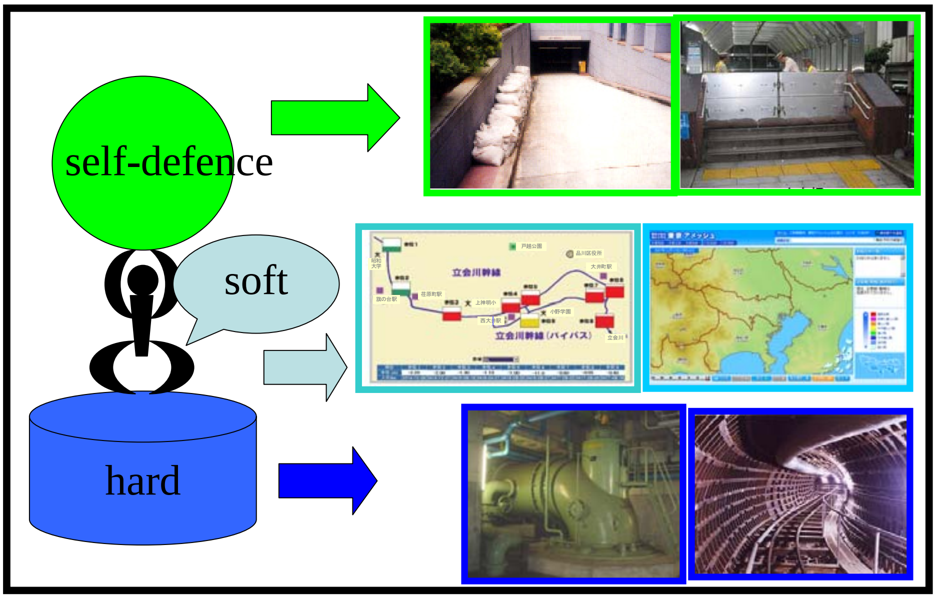


Frequency of heavy rainfall intensity -from Amedas* data in Tokyo

*Automated Meteorological Data Acquisition System



Strategy for Urban Stormwater Management



3. Utilization of Reclaimed Wastewater

A. TAJIMA*, M. YOSHIZAWA**, K. SAKURAI, H. YAMAGATA, A. MIYAMOTO, and M. MINAMIYAMA

Wastewater and Sludge Management Division,
Water Quality Control Department,
National Institute for Land and Infrastructure Management (NILIM),
Ministry of Land, Infrastructure and Transport (MLIT)

(Recent Position: * Sewerage and Wastewater Management Department, MLIT, ** Shiga Prefectural Government)

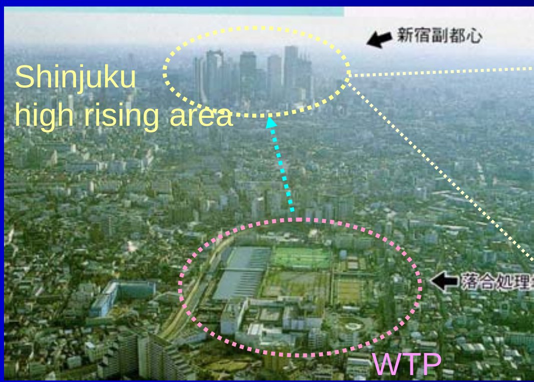
Water Reuse

- Treated Wastewater Utilization in Japan

- Guidelines for the Utilization of Reclaimed Water

2

Reuse of treated wastewater to flush toilet



Shinjuku area in Tokyo since 1984

3

Landscape use

Kobe city

Yokohama city

4

Landscape / recreational use

Kobe city

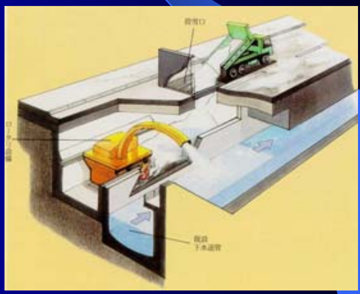
5

Recreational use

Tokyo

6

Reuse for melting snow through snow damping ditches or tanks or road spray

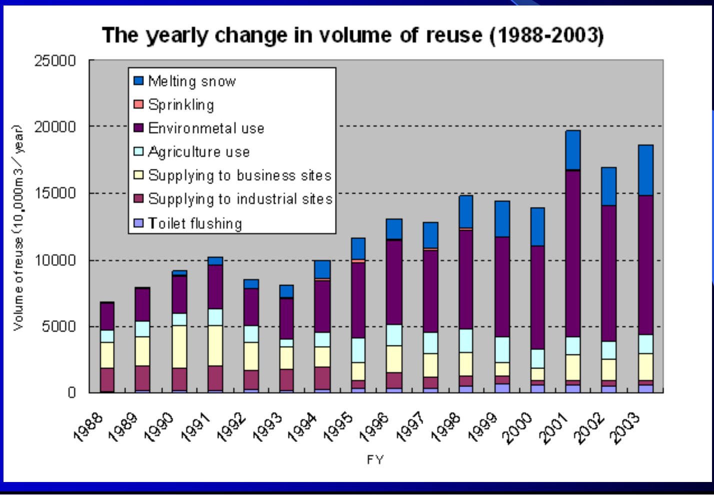


In Sapporo city since 1990

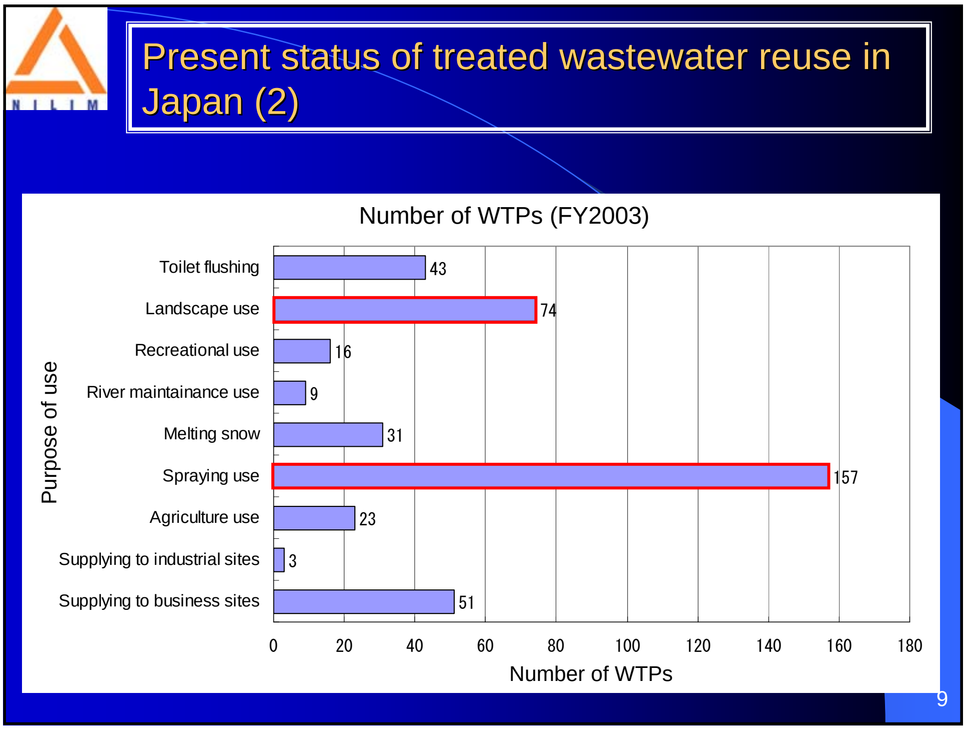
7

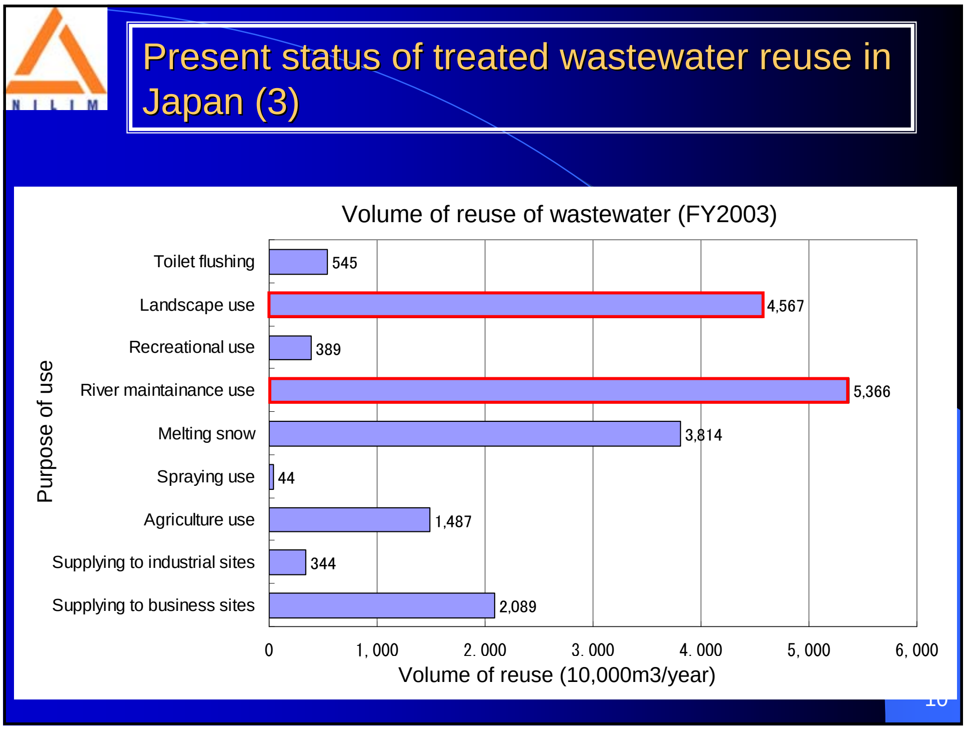
Present status of treated wastewater reuse in Japan (1)

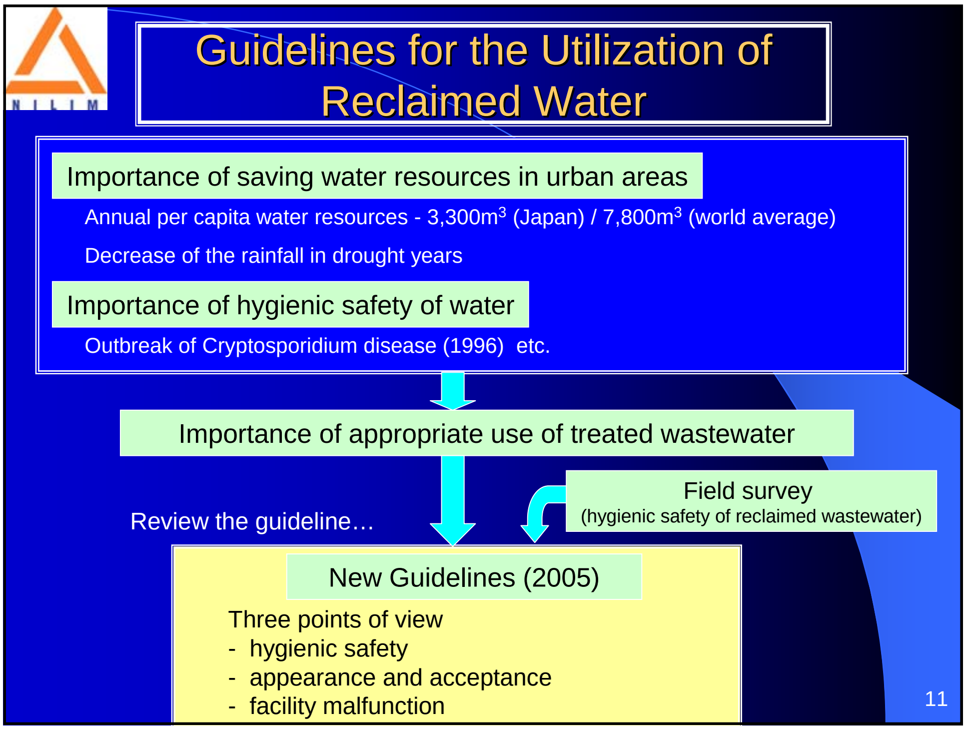
186 million m^3 (FY2003) = 1.4% of the total treated wastewater
246 WTPs (FY2003) = 13% of the total WTPs

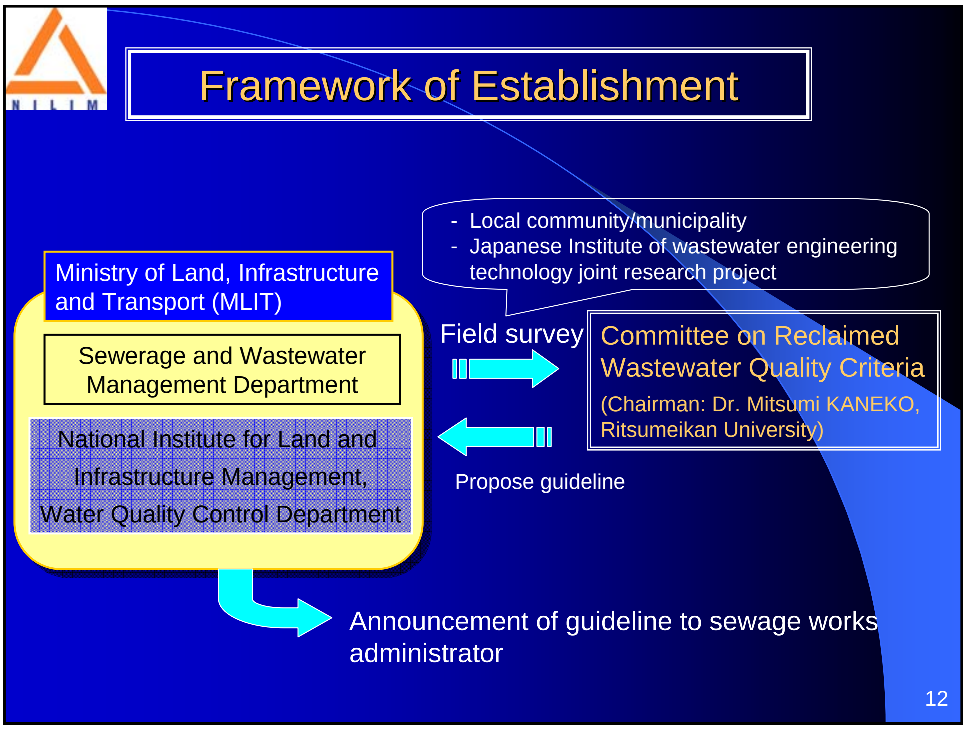


8


Present status of treated wastewater reuse in Japan (2)
Number of WTPs (FY2003)
Purpose of use
Toilet flushing 43
Landscape use 74
Recreational use 16
River maintainance use 9
Melting snow 31
Spraying use 157
Agriculture use 23
Supplying to industrial sites 3
Supplying to business sites 51
0 20 40 60 80 100 120 140 160 180
Number of WTPs
9


Present status of treated wastewater reuse in Japan (3)
Volume of reuse of wastewater (FY2003)
Purpose of use
Toilet flushing 545
Landscape use 4,567
Recreational use 389
River maintainance use 5,366
Melting snow 3,814
Spraying use 44
Agriculture use 1,487
Supplying to industrial sites 344
Supplying to business sites 2,089
0 1, 000 2. 000 3. 000 4. 000 5, 000 6, 000
Volume of reuse (10,000m3/year)


Guidelines for the Utilization of Reclaimed Water
Importance of saving water resources in urban areas
Annual per capita water resources - 3,300m3 (Japan) / 7,800m3 (world average)
Decrease of the rainfall in drought years
Importance of hygienic safety of water
Outbreak of Cryptosporidium disease (1996) etc.
Importance of appropriate use of treated wastewater
Review the guideline…
Field survey
(hygienic safety of reclaimed wastewater)
New Guidelines (2005)
Three points of view
- hygienic safety
- appearance and acceptance
- facility malfunction
11


Framework of Establishment
- Local community/municipality
- Japanese Institute of wastewater engineering technology joint research project
Ministry of Land, Infrastructure and Transport (MLIT)
Sewerage and Wastewater Management Department
National Institute for Land and Infrastructure Management, Water Quality Control Department
Field survey
Committee on Reclaimed Wastewater Quality Criteria
(Chairman: Dr. Mitsumi KANEKO, Ritsumeikan University)
Propose guideline
Announcement of guideline to sewage works administrator
12

Scope of application (1)

- Applications pertain to a large number of unspecified persons
- Reclaimed wastewater that was distributed directly from WTPs

Toilet flushing

Sprinkling

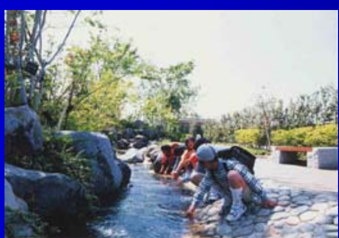
(trees, plants, lawns, road flushing)

13

Scope of application (2)

Landscape use

(Environmental use (untouchable))



Recreational use

(Environmental use)

* Including large-scale waterfalls or fountains that may produce aerosol

14

Previous guidelines/standards for treated wastewater use (Reference)

	Japan Sewage Works Association (proposed in 1981)			Working group composed of Ministry of Construction and some big cities (proposed in 1990)	
	Toilet flushing	Sprinkling	Landscape use	Landscape use**	Recreational use***
Coliform group	≤10 (CFU/mL)	N.D.	N.D.	≤1000 (CFU/100mL)	≤50 (CFU/100mL)
Residual Chlorine (mg/L) *	Trace amount	≥ 0.4	-	-	-
Appearance	Not unpleasant	Not unpleasant	Not unpleasant	-	-
Color (color unit)	-	-	-	≤ 40	≤ 10
Turbidity (mg-kaolin equivalent/L)	-	-	≤ 10	≤ 10	≤ 5
Odor	Not unpleasant	Not unpleasant	Not unpleasant	Not unpleasant	Not unpleasant
pH	5.8 – 8.6	5.8 – 8.6	5.8 – 8.6	5.8 – 8.6	5.8 – 8.6
BOD (mg/L)	-	-	≤ 10	≤ 10	≤ 3

Note: * combined residual chlorine, **restricted human contact, ***limited human contact

15

New criteria for the reuse of treated wastewater

	Toilet flushing	Sprinkling	Landscape use	Recreational use
E.coli	N.D./100mL	N.D./100mL	≤1000 CFU /100mL as Coliform groups 1)	N.D./100mL
Appearance	Not unpleasant			
Turbidity	≤ 2 (target value) 2)			≤ 2 2)
Color			≤ 40 units	≤ 10 units
Odor	Not unpleasant			
pH	5.8 - 8.6			
Residual chlorine (target value)	≥ free: 0.1mg/L or combined: 0.4mg/L	≥ free: 0.1mg/L or combined: 0.4mg/L 3)		≥ free: 0.1mg/L or combined: 0.4mg/L 3)
Treatment	Sand filtration or equivalent			Chemical precipitation + sand filtration or equivalent
Notes	1) Provisional value 2) Unit: mg-kaolin equivalent/L 3) Not applicable for cases in which long-term effects of disinfection is unnecessary			

16

Grounds for the new criteria (1)

E-coli / coliform groups)

Coliform groups not suitable as the index for contamination by excrement

E-coli N.D. / 100mL in drinking water by establishing a quick and easy culture method

No detection / 100mL, new criteria

However,

For landscape use, tentatively same as previous (Coliform groups 1000CFU /100mL) because handling not permitted and effluent criteria set as coliform group

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Grounds for the new criteria (2)

Residual chlorine

Control of regrowth of pathogenic bacteria in distribution

Field survey…

(Drinking water criteria)
Free: ≥ 0.1mg/L
Combined: ≥ 0.4mg/L

Possible to control regrowth

new criteria
Free: ≥ 0.1mg/L
Combined: ≥ 0.4mg/L

However,

Not applicable for landscape use (handling not permitted, ecosystem preservation)

Not applicable for cases in which long-term effects of disinfection is unnecessary (sprinkling, recreational use)

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Grounds for the new criteria (3)

Treatments / Turbidity

Against facility malfunction

- No blockage, **sand filtration** should be added
- **Turbidity of 2 or less as target value** to ensure effective treatment

Against protozoa (recreational use)

- **Chemical precipitation and sand filtration** should be added
- **Turbidity of 2 or less as value to be observed at all times** to ensure effective treatment

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Grounds for the new criteria (4)

pH

Corrosion control / same as previous (**pH: 5.8 - 8.6)**

Appearance / Color / Odor

Appeal and acceptance / same as previous
(Appearance, Odor: Not unpleasant
Color: ≤ 40 units (Landscape use),
≤ 10 units (Recreational use))

However,

It is preferable to give criteria considering the wishes of regional users

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Consideration for treated wastewater reuse

Hygienic safety

1. Loss of residual chlorine in the distribution system
2. Cross-connection
3. Accidental intake
4. Deterioration of the quality of reclaimed wastewater

Appeal and acceptance

1. Red water, colorless, cloud
2. Growth of algae (Landscape use, Recreational use)
3. Outbreak of Chirnomid (imago/larva) (toilet flushing)

facility malfunction

1. Corrosion and blockage of pipes and other equipment

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Prevention of cross connection

Place signs on or color-code pipes and other equipment

Example of distinction by color-coding the pipes
(Yellow is reclaimed wastewater, blue is drinking water)

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Prevention of accidental intake (1)

1) Posting of notices to users that reclaimed wastewater is used

Example of posting of notices that reclaimed wastewater is used and not for drink

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Prevention of accidental intake (2)

2) Prevention of accidental intake of aerosol (watering use)

Example of watering use that is hard to produce aerosol

24

Amendment of sewerage law (1)

Objective

- Sound urban development
- Enhancement of public sanitation
- Water quality control of public water bodies

public sanitation

prevention of inundation

spread of flush toilet

water quality control in public water body

utilization of sewerage resources

creation of preferable water circulation and water environment

Growing interest in favorable water environment

Changes in roles of sewerage

Amendment of sewerage law (2)

Structural standards

Shielding, fences etc. must be installed to prevent entry to the facilities

- Culvert
- **Recreational use facilities** NEW

  Quality standards for final effluent

  E.coli **N.D./100mL**

  Turbidity of less than 2mg-kaolin equivalent/L
- …

Future task

1. Study on the criteria for viruses
2. Study on the ingestion scenario
3. Improvement of analysis methods of pathogens
4. Development of cheap and advanced wastewater treatment
5. Study on the possibility of application to new purpose of use

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Extension of reclaimed water utilization is needed in Japan

Annual water reserves per capita is less than half of the world average

Rainfall in draught years show a decreasing tendency

Reclaimed water is...
- available even in summer
- stable in quality

Sprinkling on roads for heat island mitigation is a new way of using.

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Facility for road sprinkling

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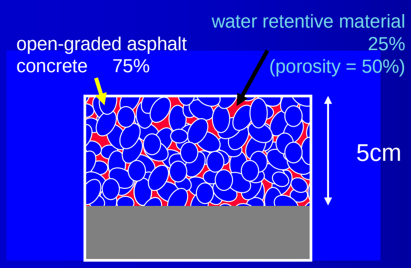
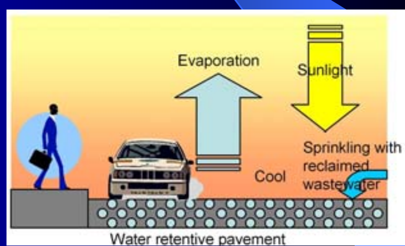
water retentive pavement mitigates the heat island



water retentive pavement

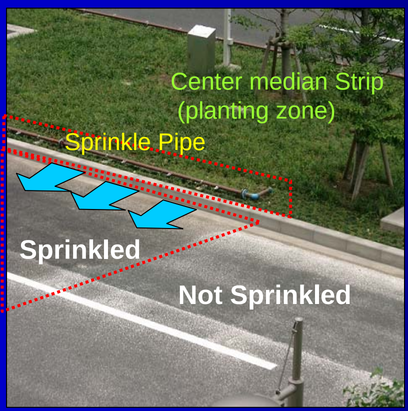
Water stored in the pavement evaporates slowly and lowers the temperature by vaporization

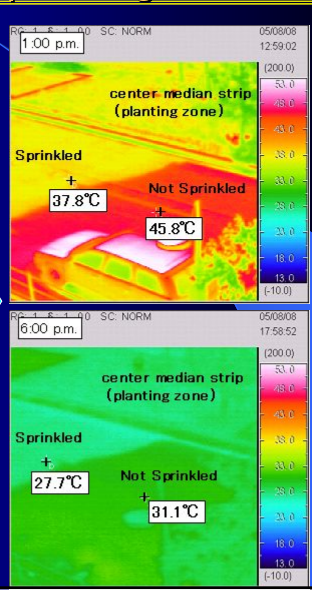


340,902m^2 is paved with this method (FY1994 to 2005)

30

Road surface temperature was decreased as same as that on planting zones





The road surface temperature distribution measured by thermography

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Acknowledgement

The new criteria and considerations were proposed by the Committee on Reclaimed Wastewater Quality Criteria. We express our deep appreciation to the members of the committee who extensive effort into developing and proposing the guidelines.

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16th International Symposium on National Land Development and Civil Engineering in Asia: Integrated Water Resource Management Adapting to the Global Climate Change

Utilization of Reclaimed Wastewater

Thank you very much for your attention !

Beneficial Use of Biomass at Wastewater Treatment Plants

Masaaki OZAKI
Recycling Research Team

PWRI

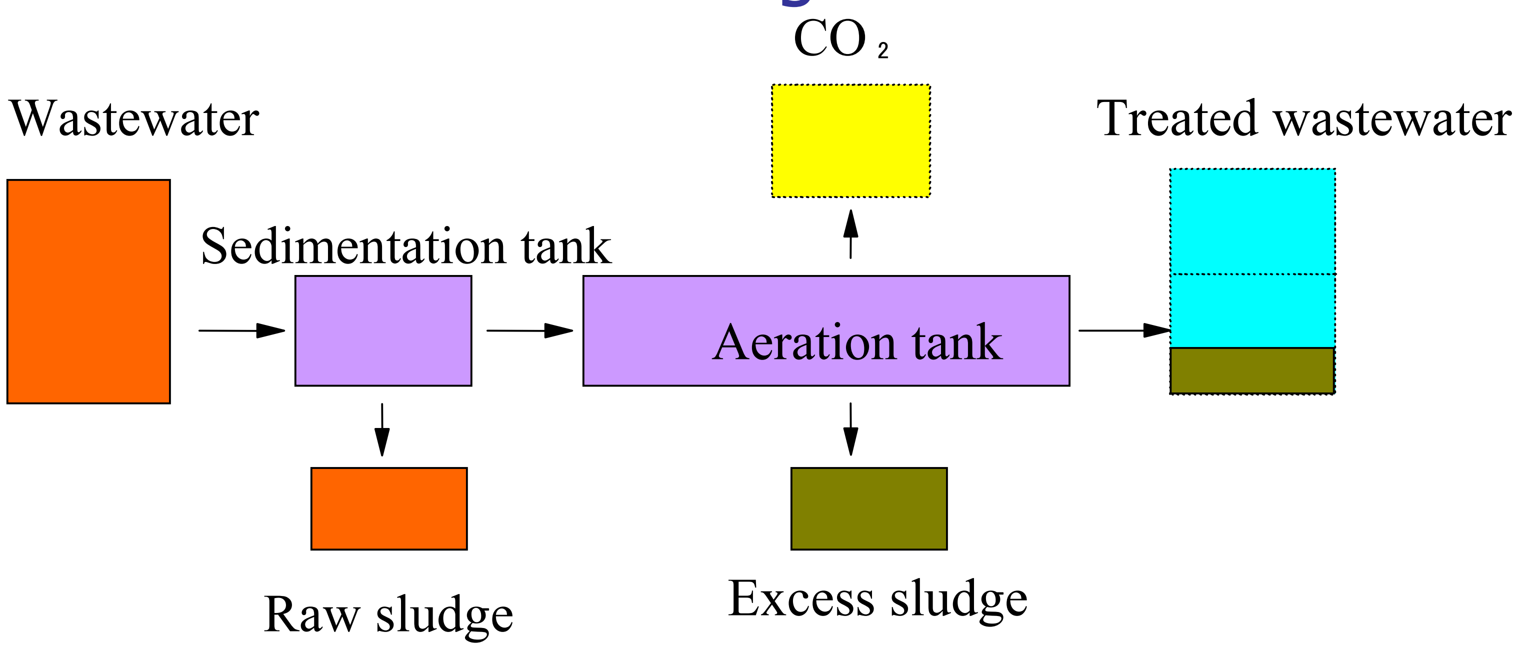
Contents

1. Bio-solids treatment
2. Beneficial use of bio-solids
3. Increase of bio-gas production
4. And the bio-gas utilization
5. Others

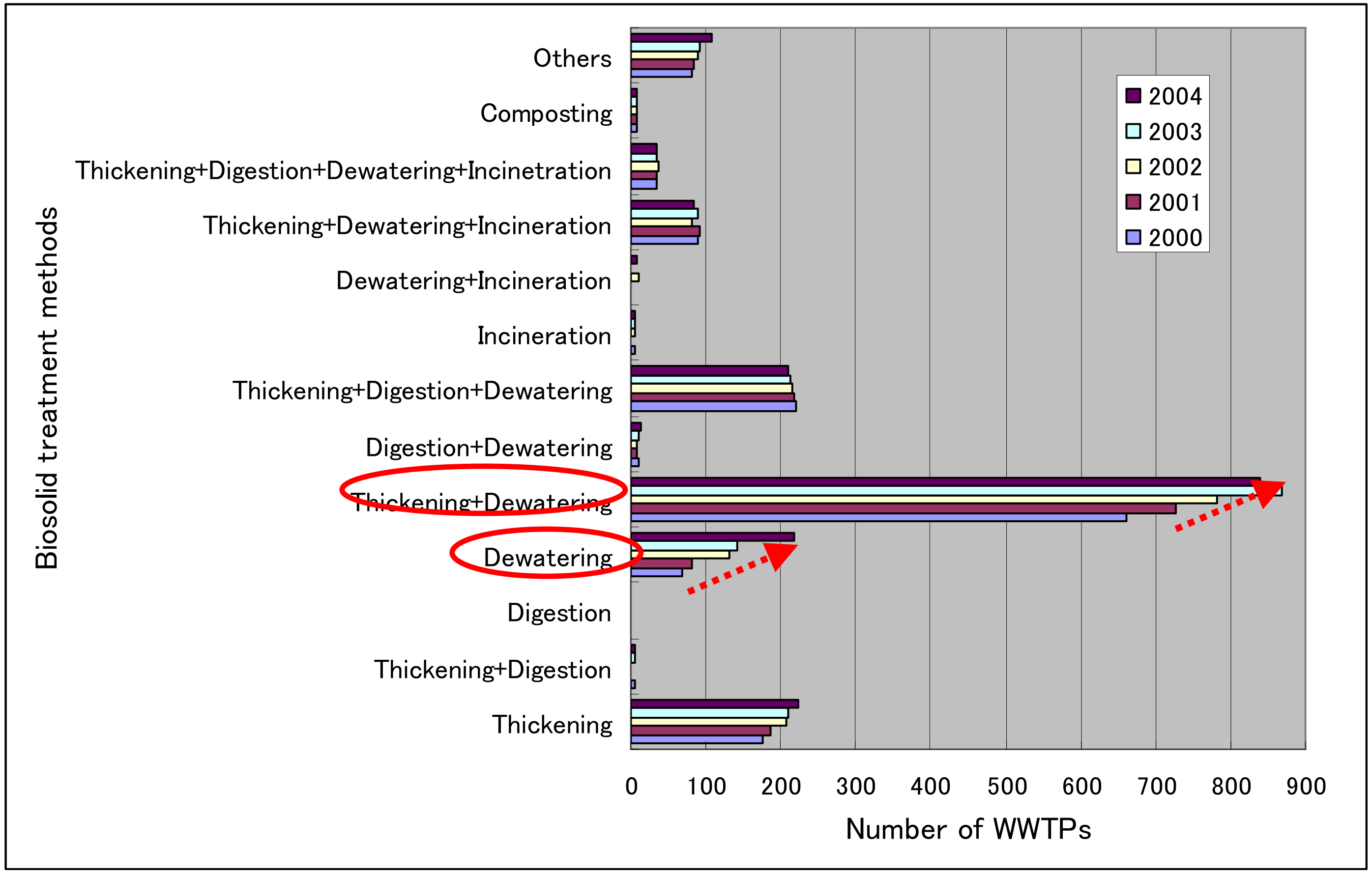
1.Bio-solids treatment

Production of Bio-solids

Balance of organic material



Bio-solids treatment in Japan (1)

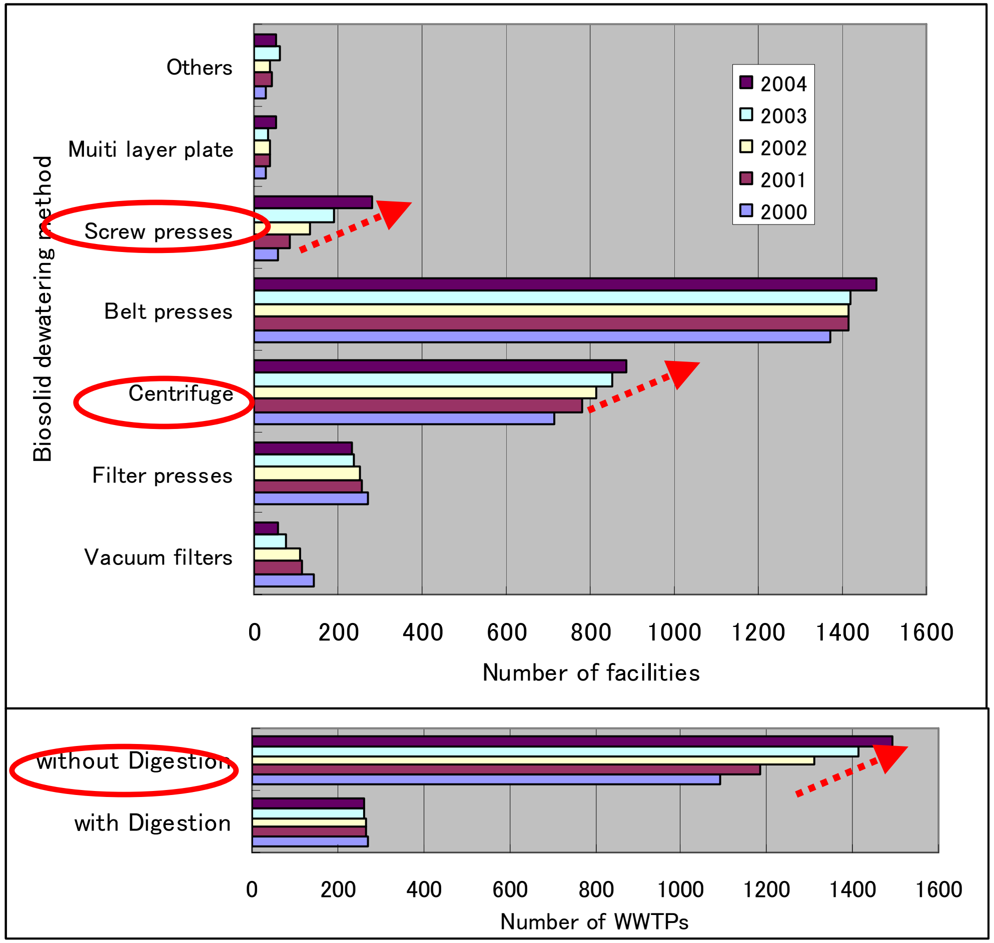


Statistics of sewage works by JWSA

Bio-solids treatment in Japan (2)

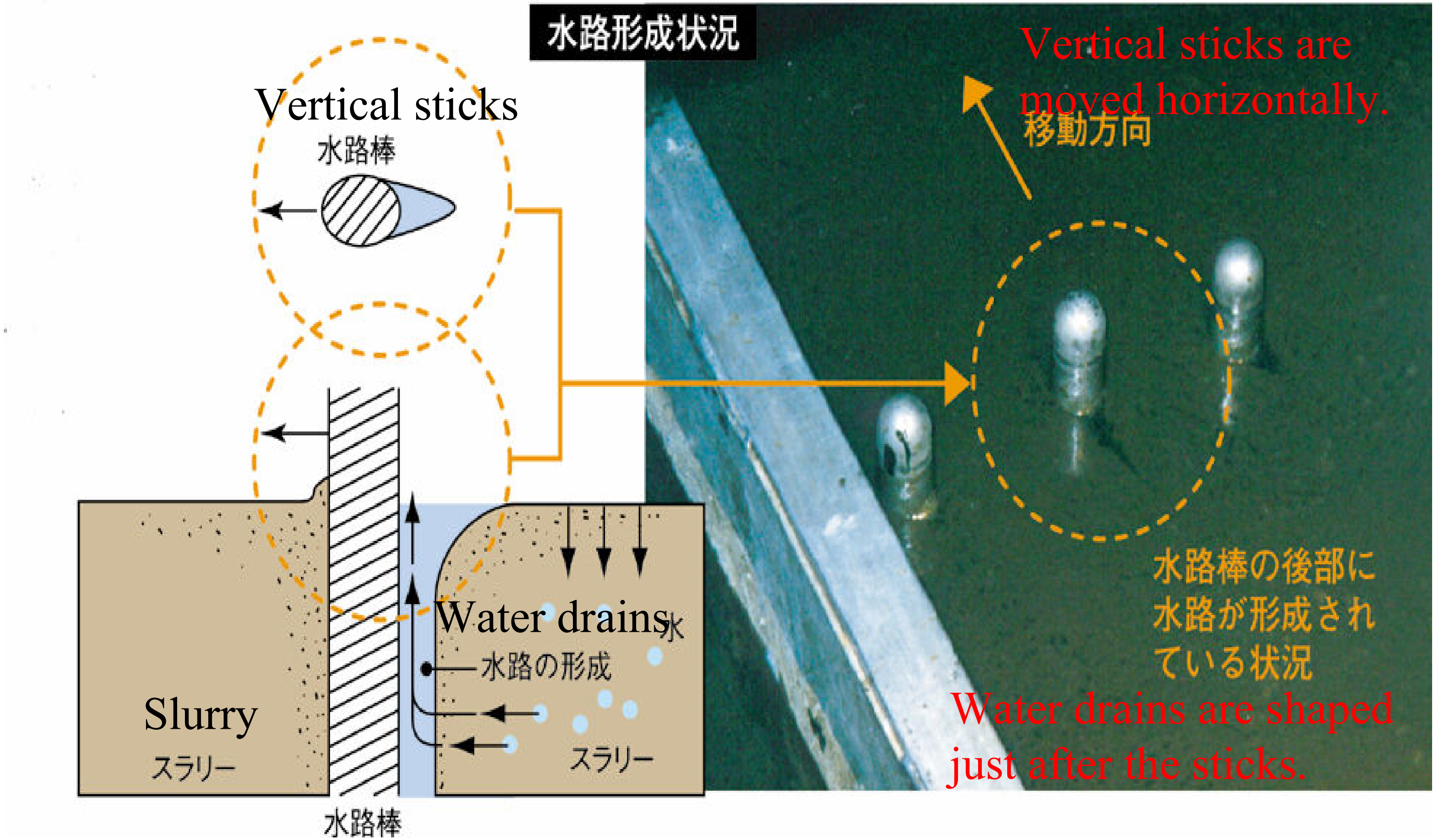
Dewatering

Digestion

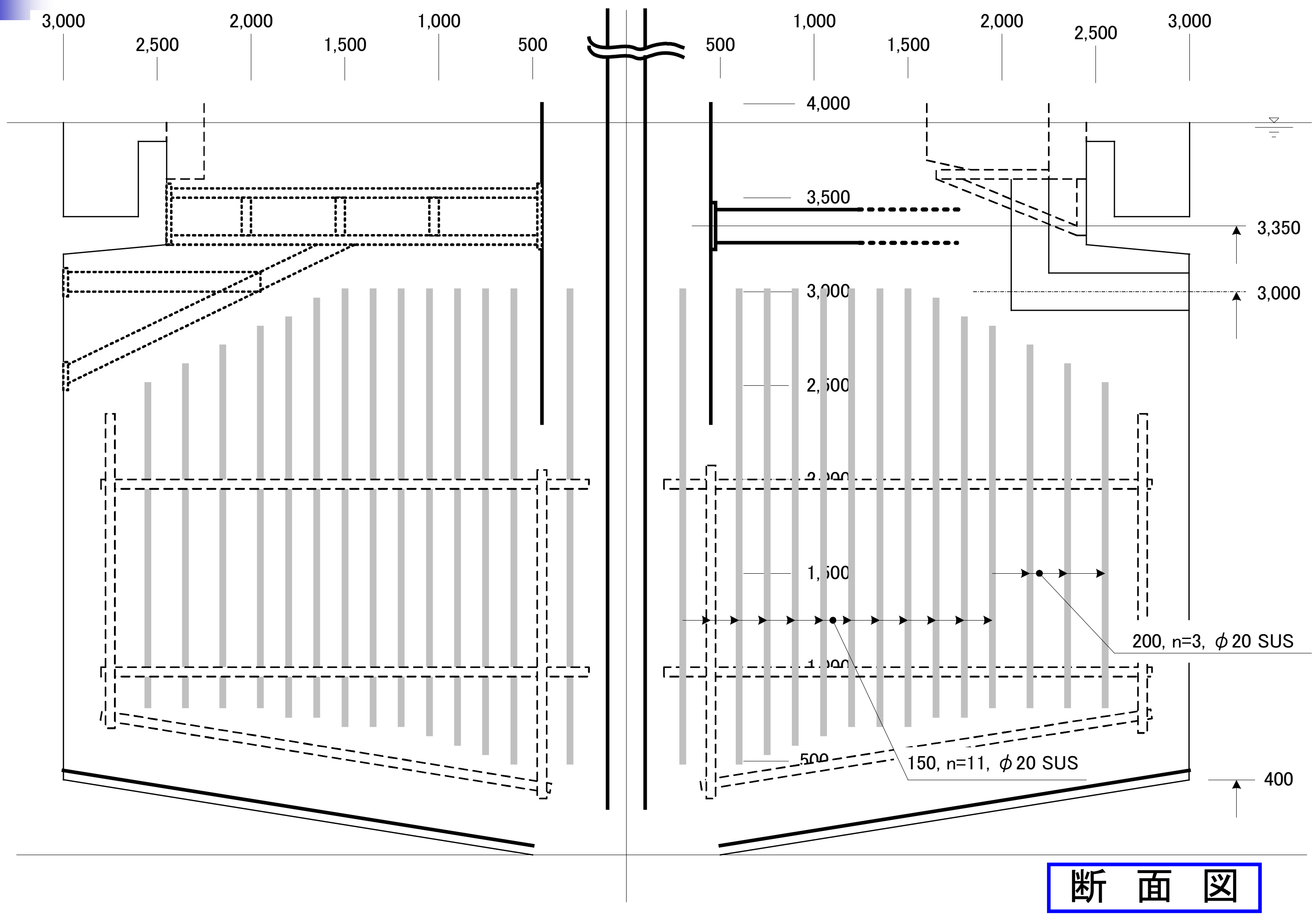


Statistics of sewage works by JWSA

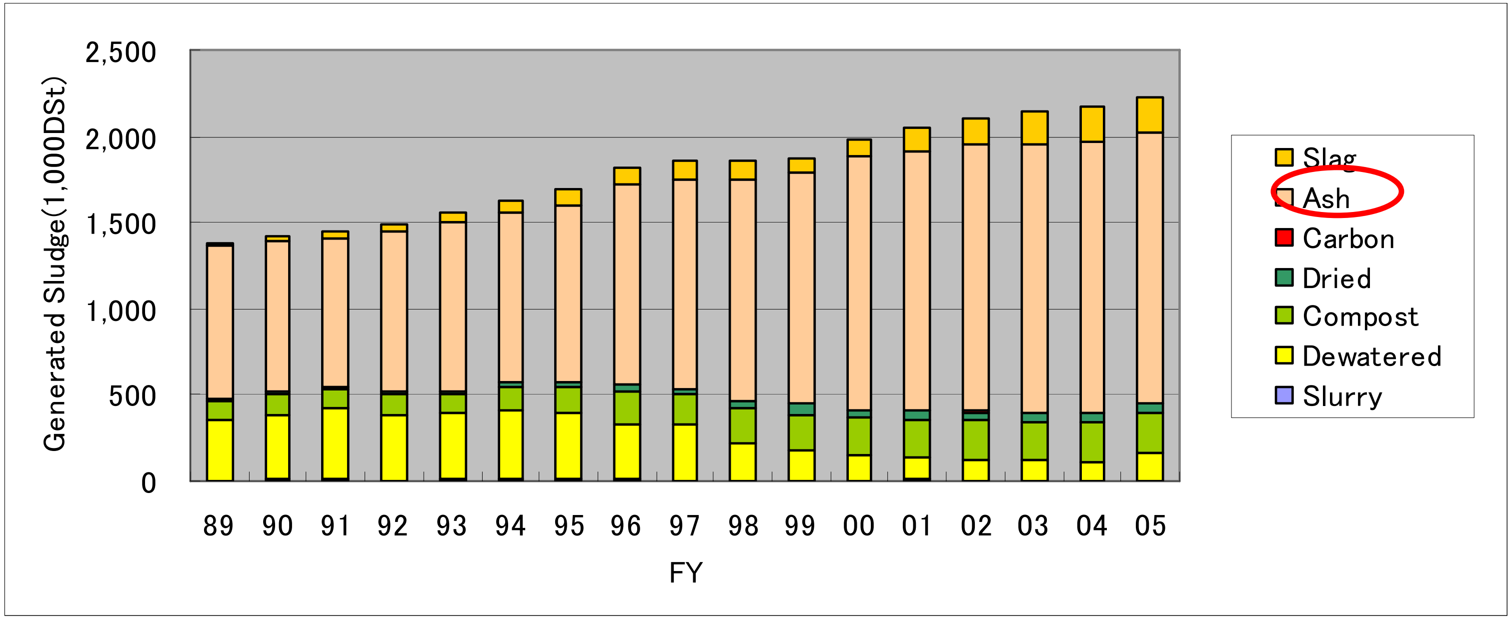
Gravity thickening technology (1)



Gravity thickening technology (2)

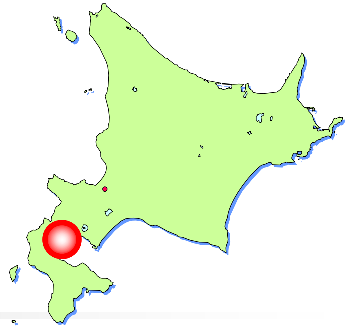


Transition of generated bio-solid

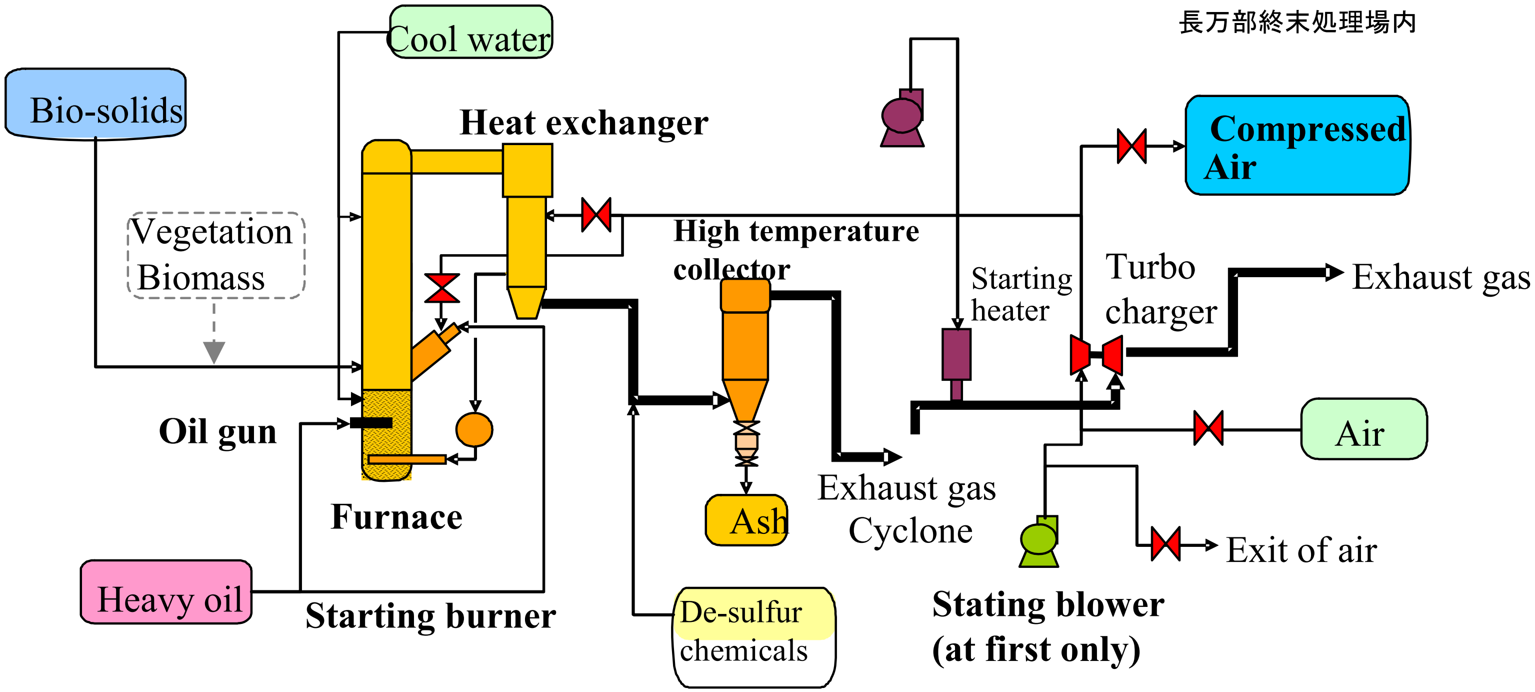


Approximately 70% of bio-solids was incinerated in Japan.

Energy saving fluidized-bed incineration system (1)



設置場所：北海道山越郡長万部町字旭浜４番地の８
長万部終末処理場内



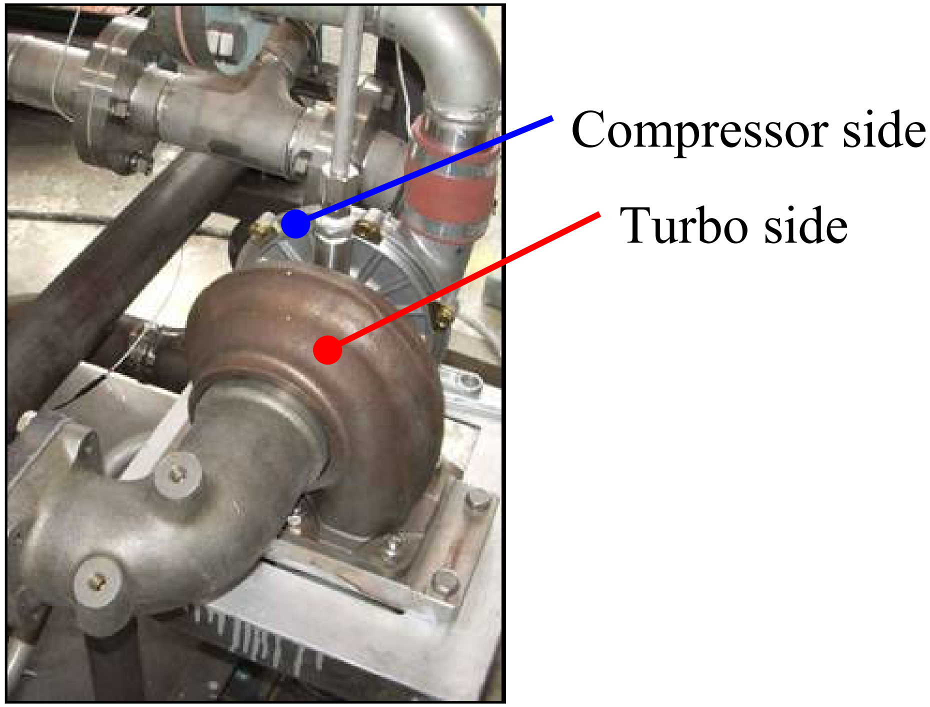
Pilot plant at Oshamanbe WWTP in Hokkaido

Energy saving fluidized-bed incineration system (2)

<Incineration furnace>

4.3t-dewatered sludge/day

ϕ1,200(ϕ700)×H9,200



<Turbo charger>

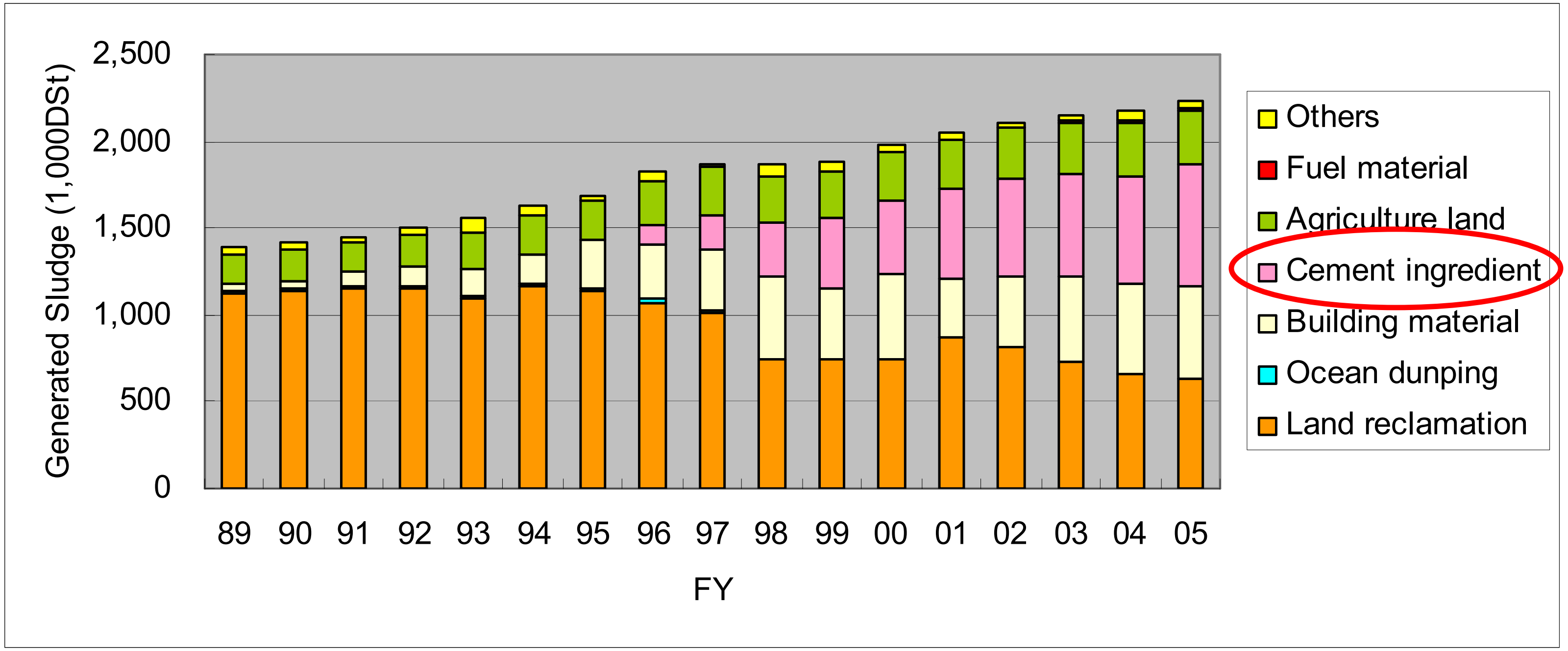
ϕ300mm×400mm

2. Beneficial use of bio-solids

Category for utilization

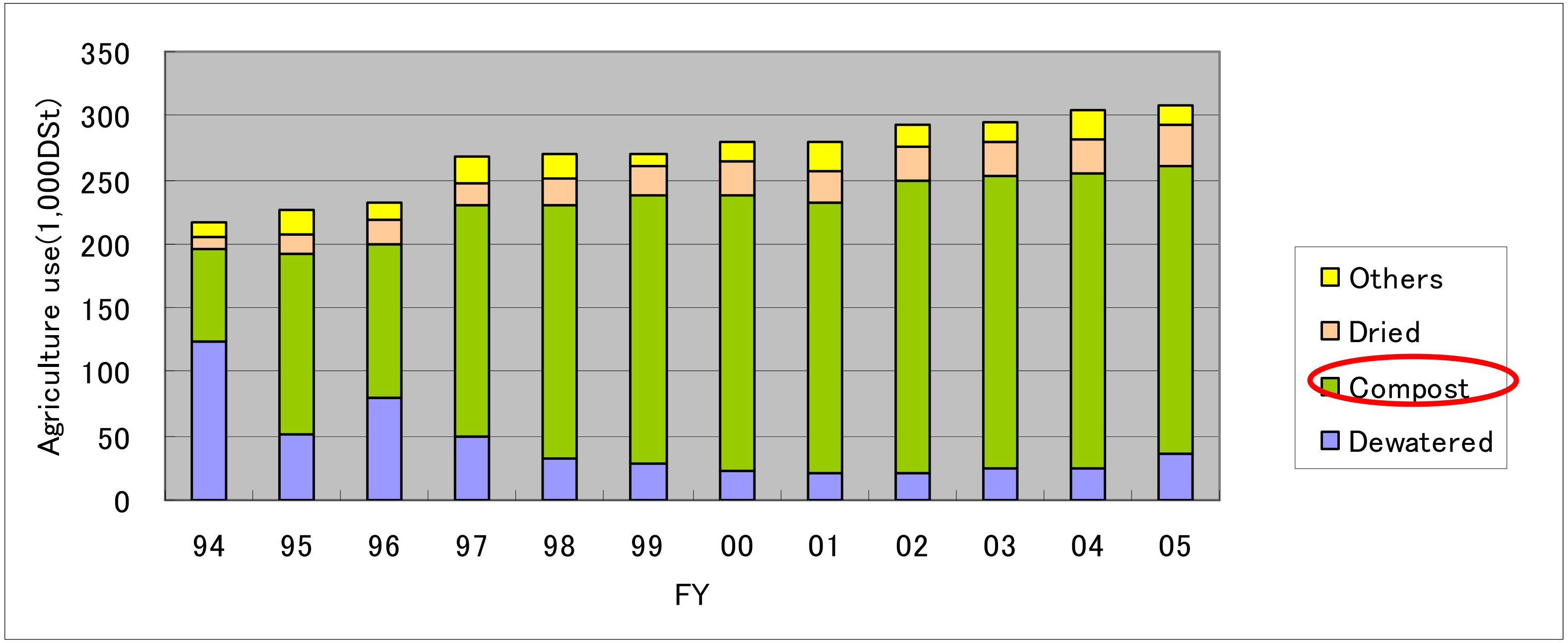
- Agriculture land
- Construction material
  - Incinerated ash
  - Melt-solidified slag
- Energy utilization
  - Bio-gas
  - Solid fuel for Coal Power Plant

Transition of utilized bio-solid



Approximately 70% of bio-solids was utilized in Japan.

Agriculture Utilization

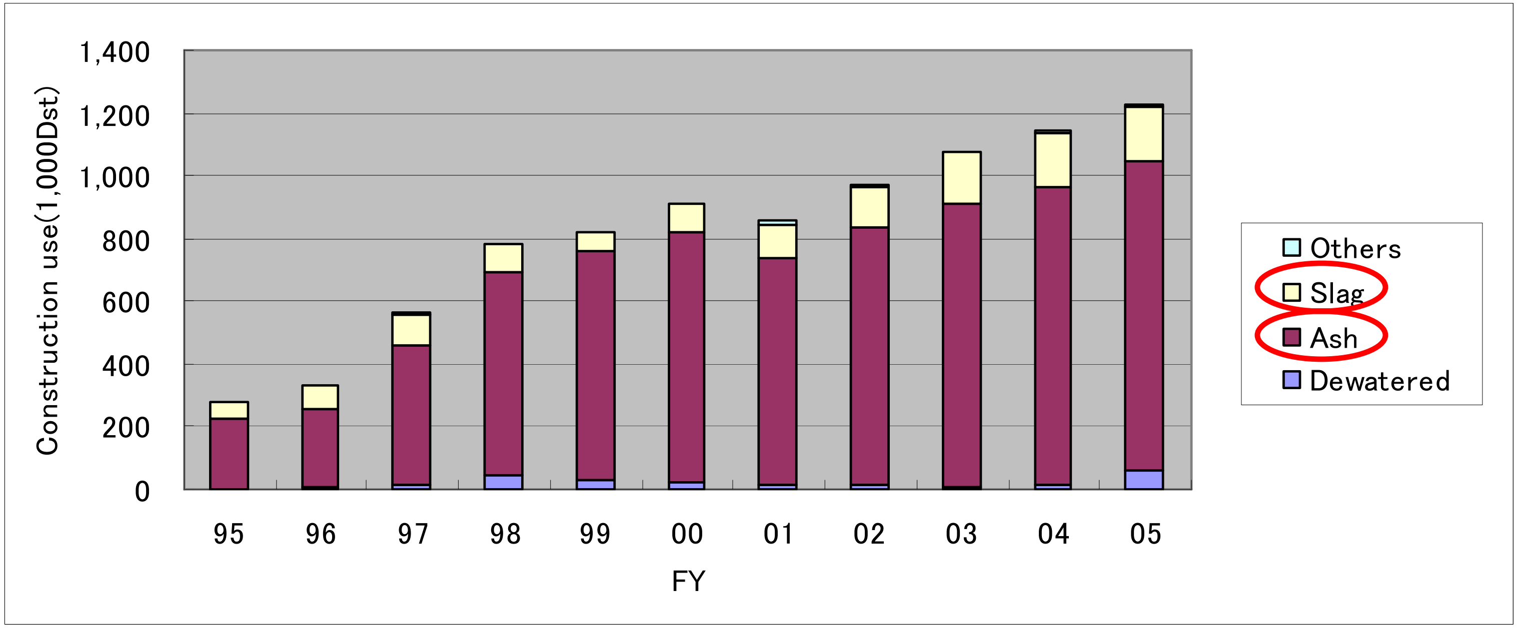


Fusion compost with cow feces

Bio-solids: Nitrogen and Phosphorus rich
Potassium shortage

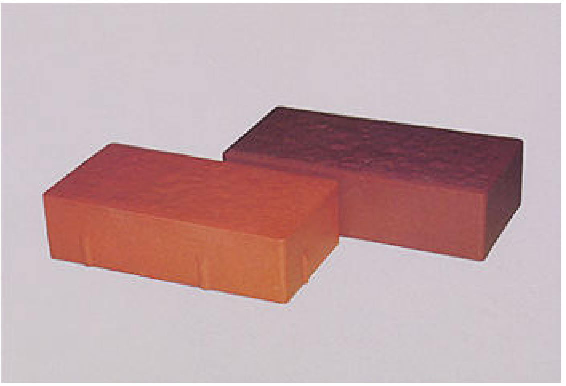
Cow feces: C/N balance and Potassium rich

Construction materials



Construction materials made of ash

Ash products from WWTPs



"Haikara" brick made of ash at Gifu city

Bricks made of 100% ash.

Control office at Kinu-ura Tobu WWTP in Aich pre.

Building materials such as wall and roof with tiles made of ash.

Slag products at Hyogo pref.

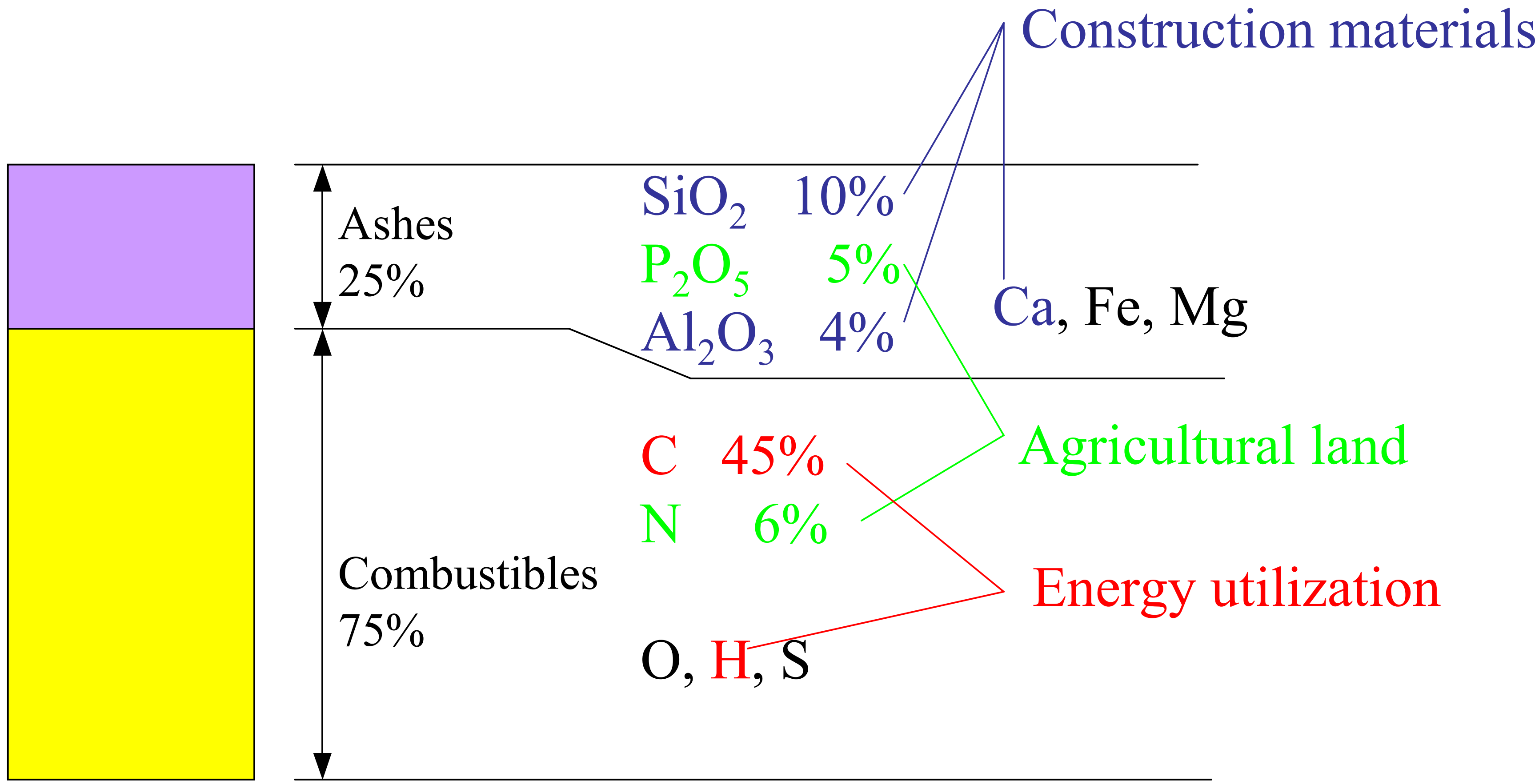
Slag products from WTP

Asphalt paving

Concrete factory products

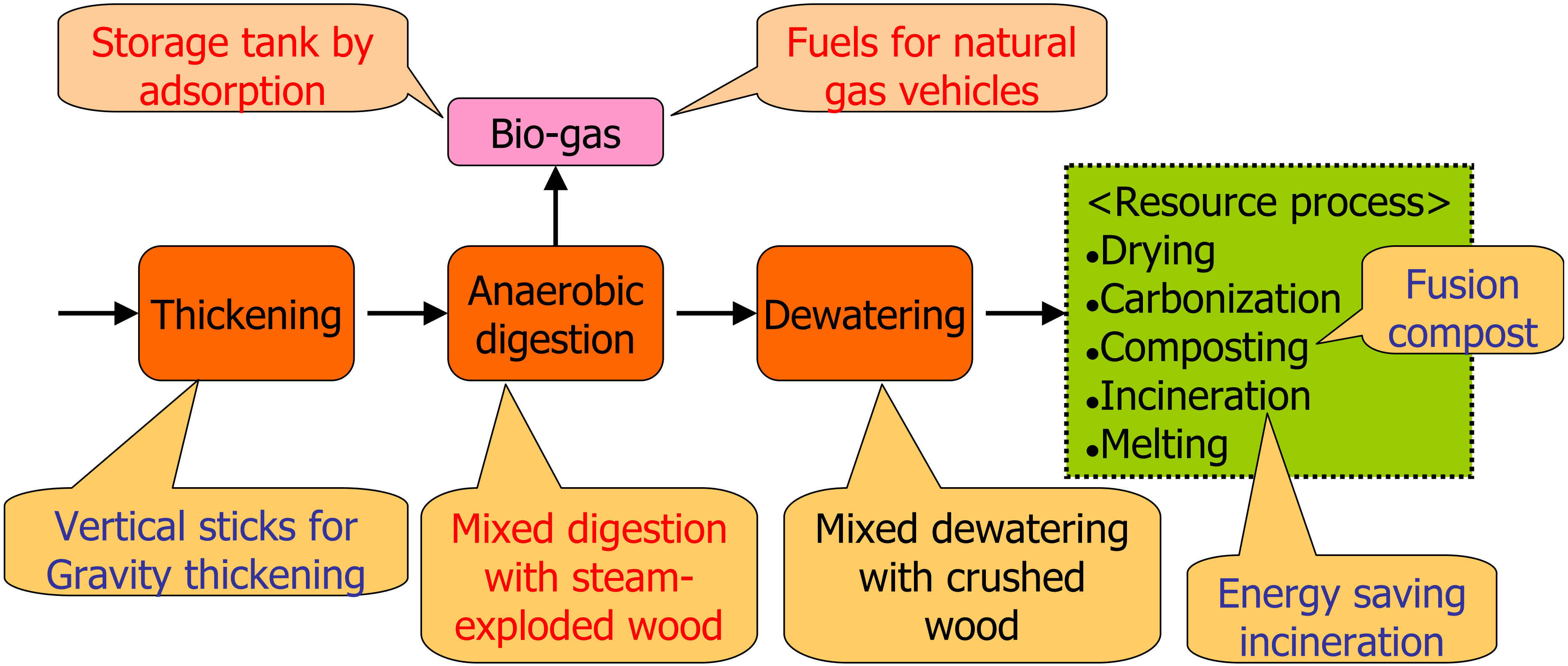
[Asphalt paving]
2004~
Road construction works
[Concrete factory products]
2007~
Road construction materials

Components of bio-solids

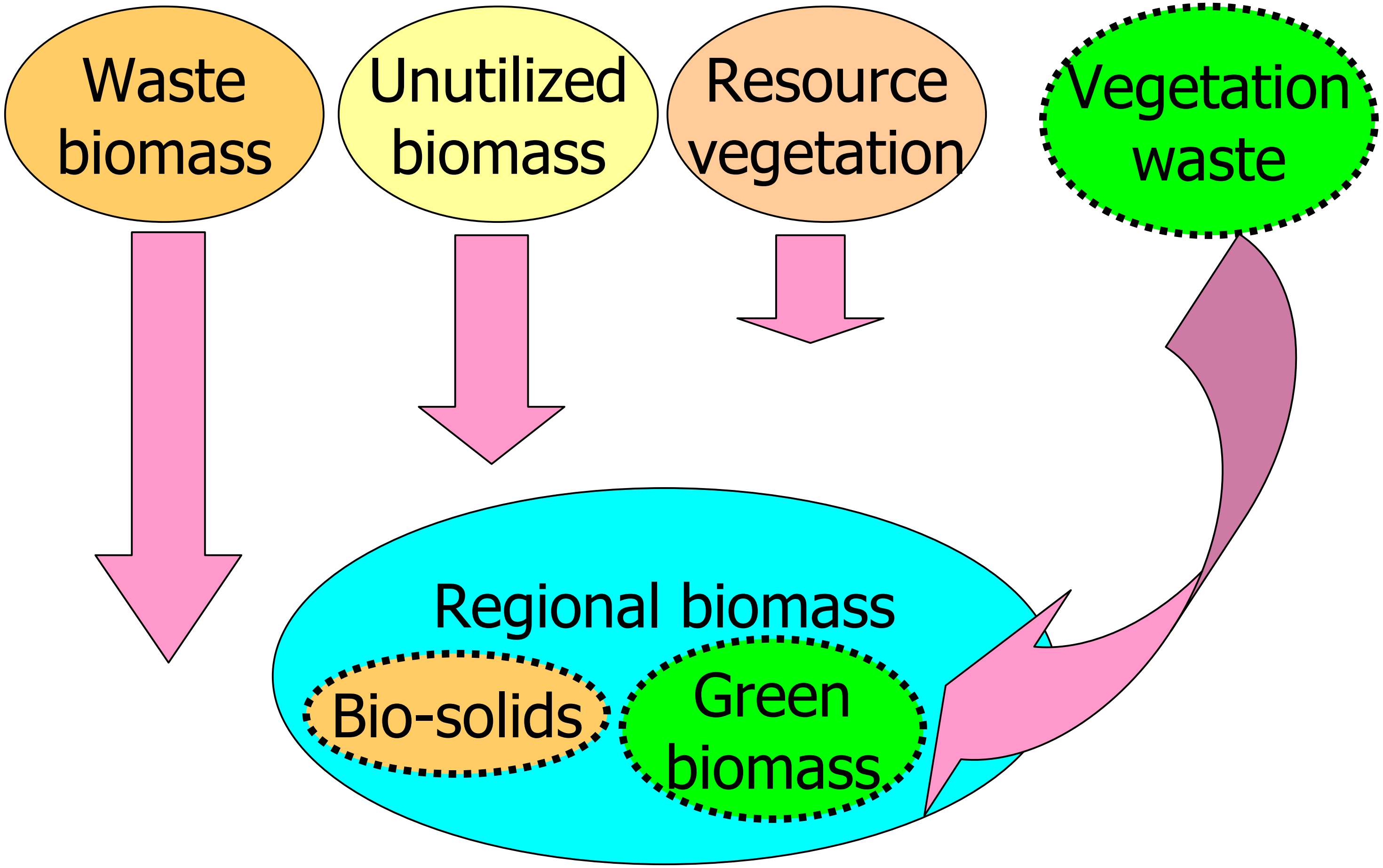


3. Increase of bio-gas production
Bio-solids treatment process

Essential technologies for energy utilization



Regional biomass



Green biomass from public works

Once cut per year

Storage on riverbed
for utilization
as litter at orchard

Kagetsu river, Chikugo-gawa river office

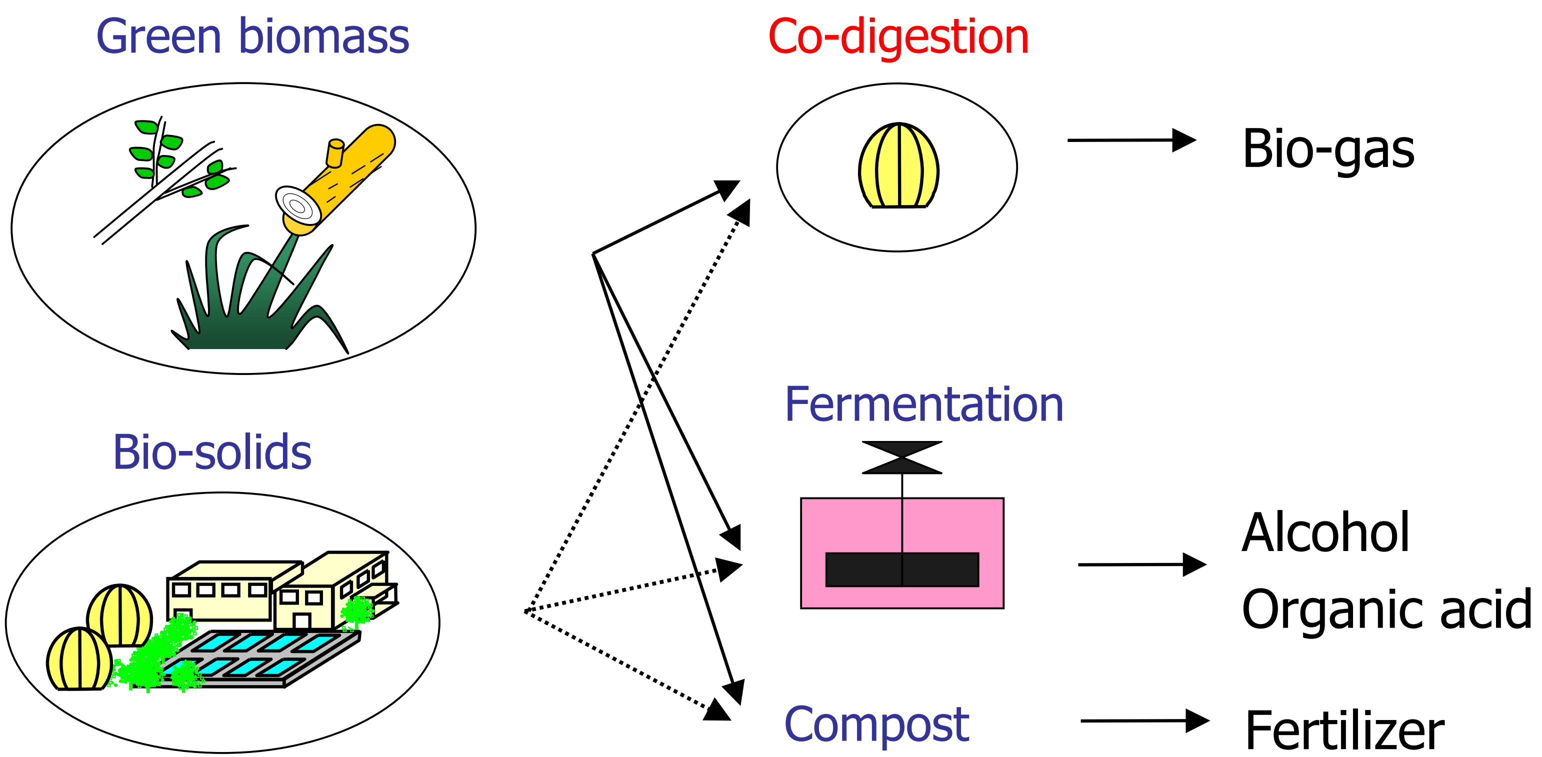
Once cut Twice cut

MWS*:
Municipal Solid Waste

Transport to MWS* combustion

Rout 3, Kita-kyushu road office

Recycling technology for organic waste



Recycling and utilizing biomass from public works

Data base for biomass

Driftwood into dam reservoirs

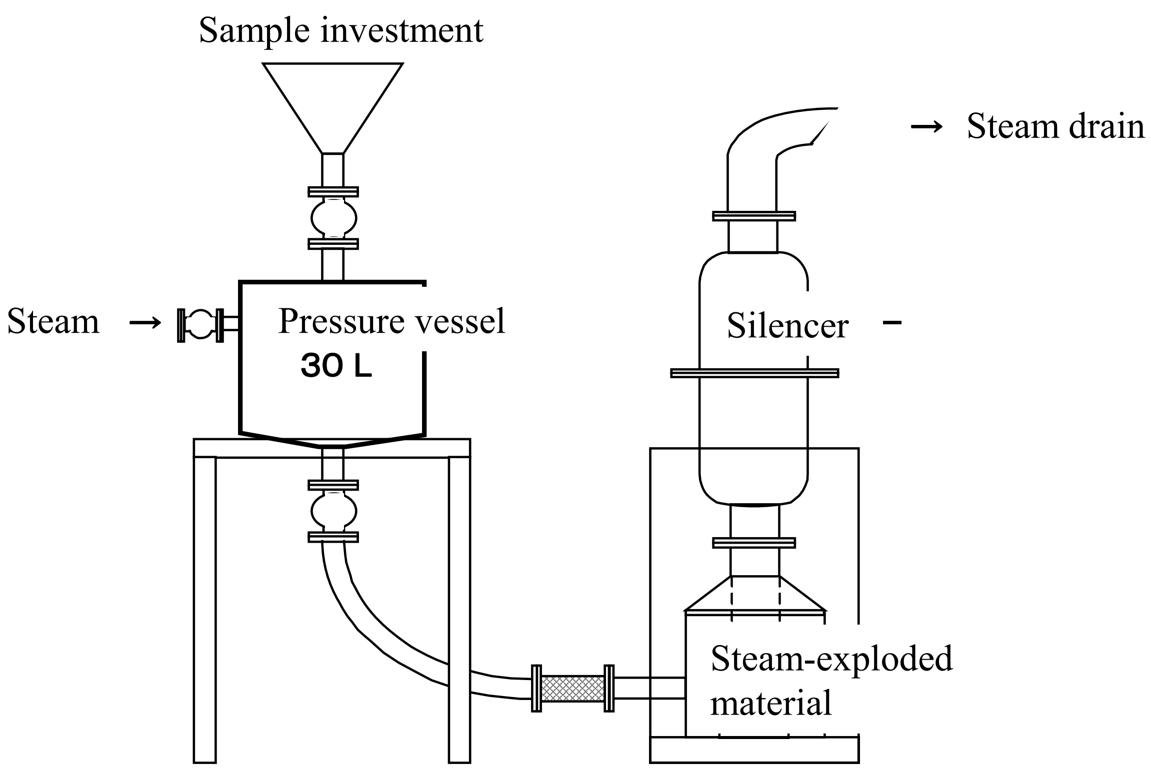
Technologies for recycling

Alternative material of peat moss
(Thick layer basic materials spaying)

Develop the system which provides and manages the data base of biomass from each public work.

Pilot works for practical use about the developing and existing useful technologies

Steam-explosion device

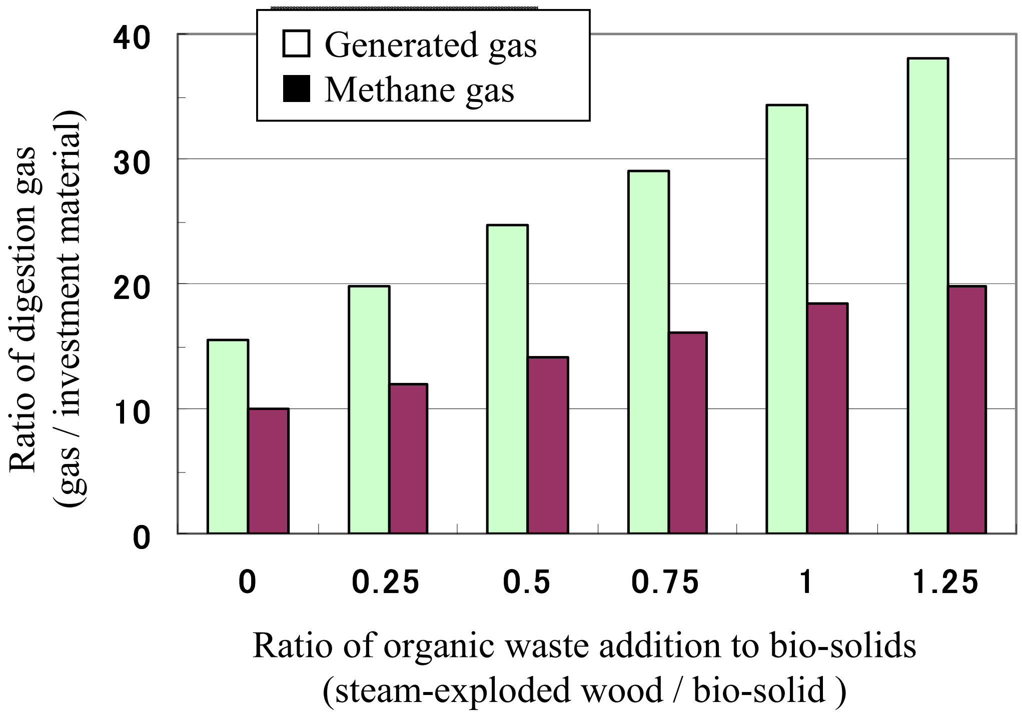


Sequential methane fermentation experiment

Steam-exploded broadleaf tree chips prepared under pressure of 2MPa for 15 minuets.

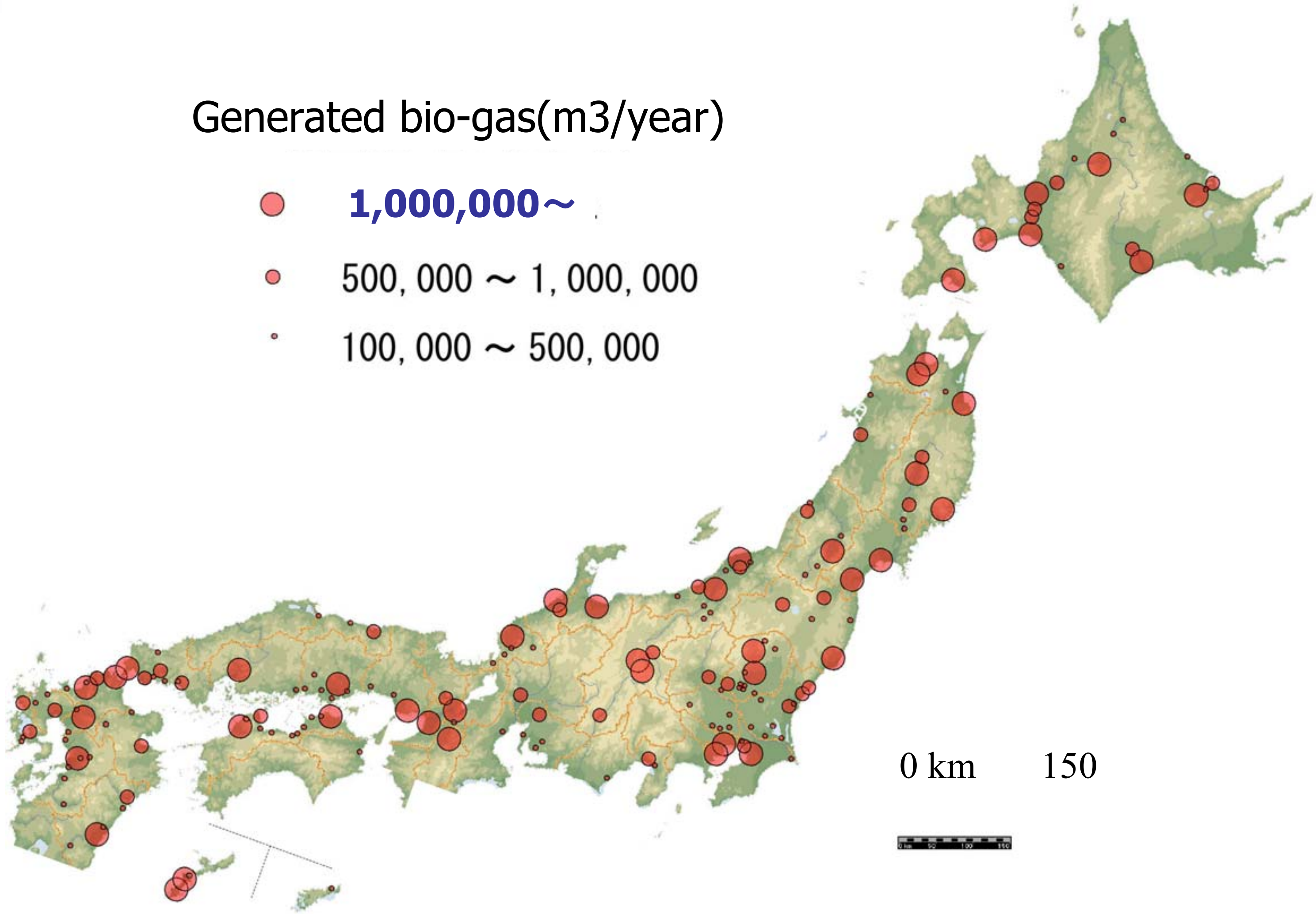
Inserting and removing samples once per day at 35 degrees for 50 days, while varying the ratio of the added plant waste to the bio-solids.

Recovery of methane gas from steam-exploded wood

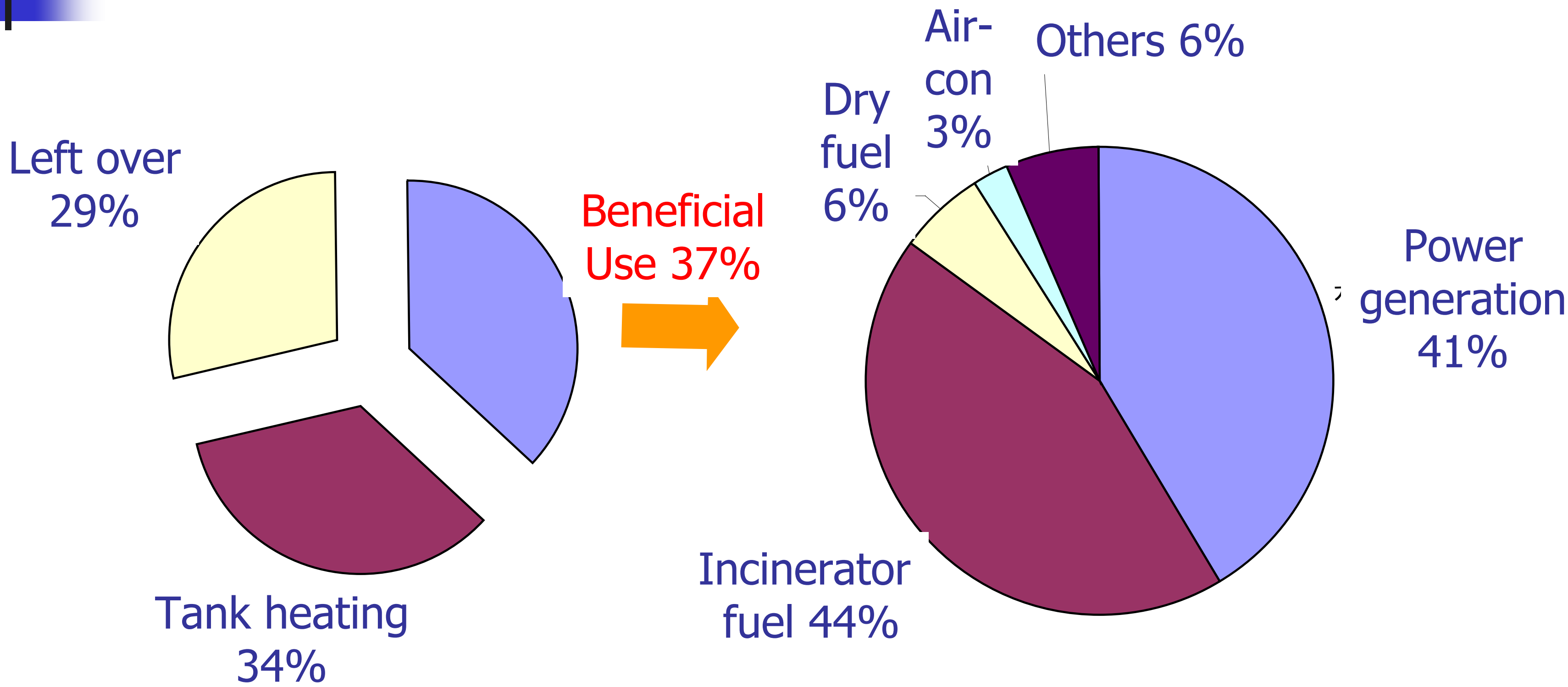


Methane gas production increased in proportion to the ratio of added steam-exploded wood to the bio-solids.

4. And the bio-gas utilization
Distribution of digestion facilities



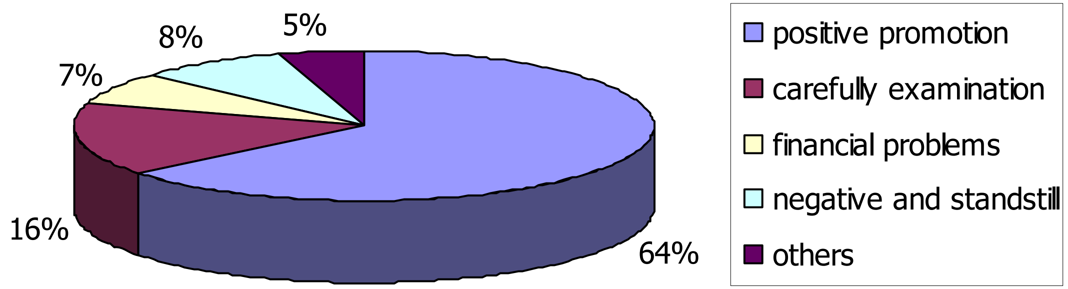
Utilization of biogas (1)



Bio-gas was generated 280 million m^3 per year in Japan.
And approximately 30% is left over and burned off

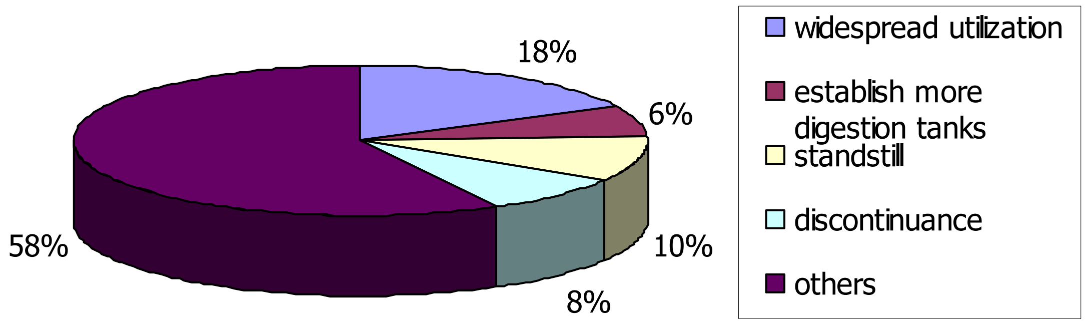
Utilization of biogas (2)

Questionnaire about digestion (FY2006)



Opinion for bio-gas utilization

Opinion about "positive promotion " is about 64%.

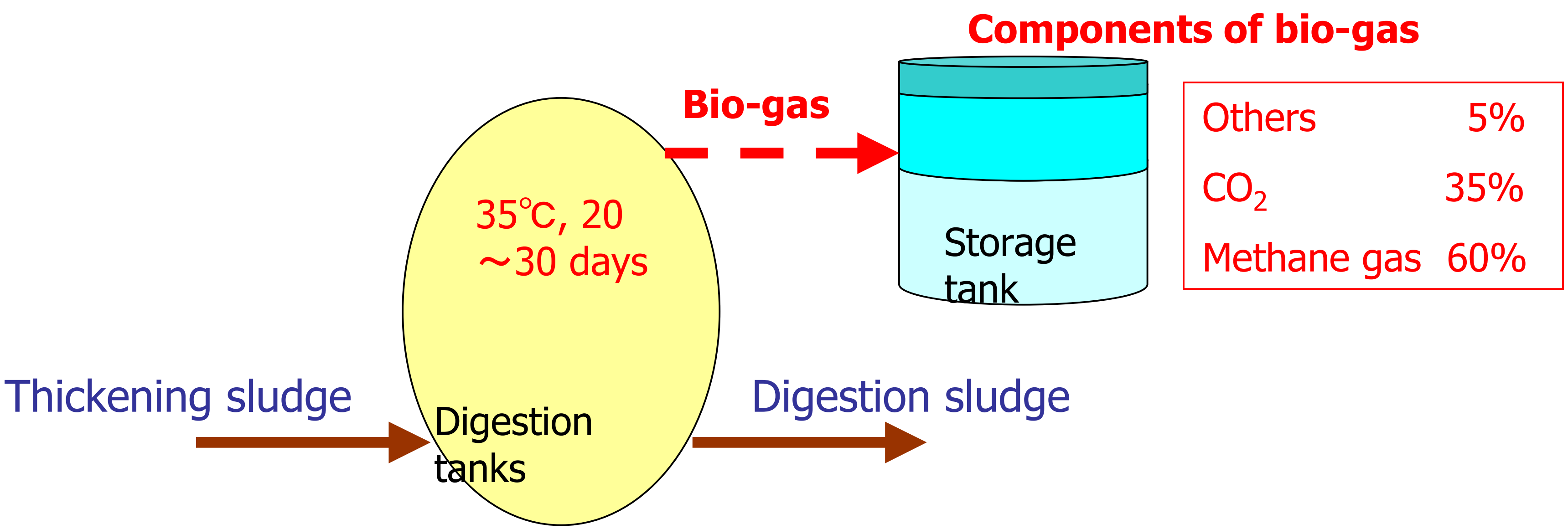


Action for bio-gas utilization

But it seems expectations, because 58% of cities does not have an actual action program for bio-gas utilization.

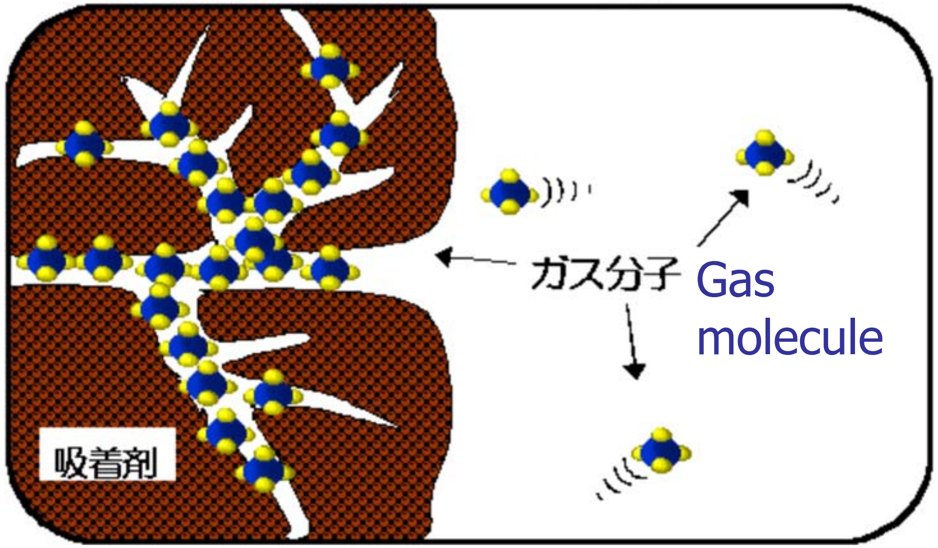
Components of bio-gas

- Reduce organic materials into low-molecule and liquefy or gasify them, by anaerobic micro-organism
- Decrease organic materials by 40-60%



Biogas adsorption system

Adsorption zone Compression zone

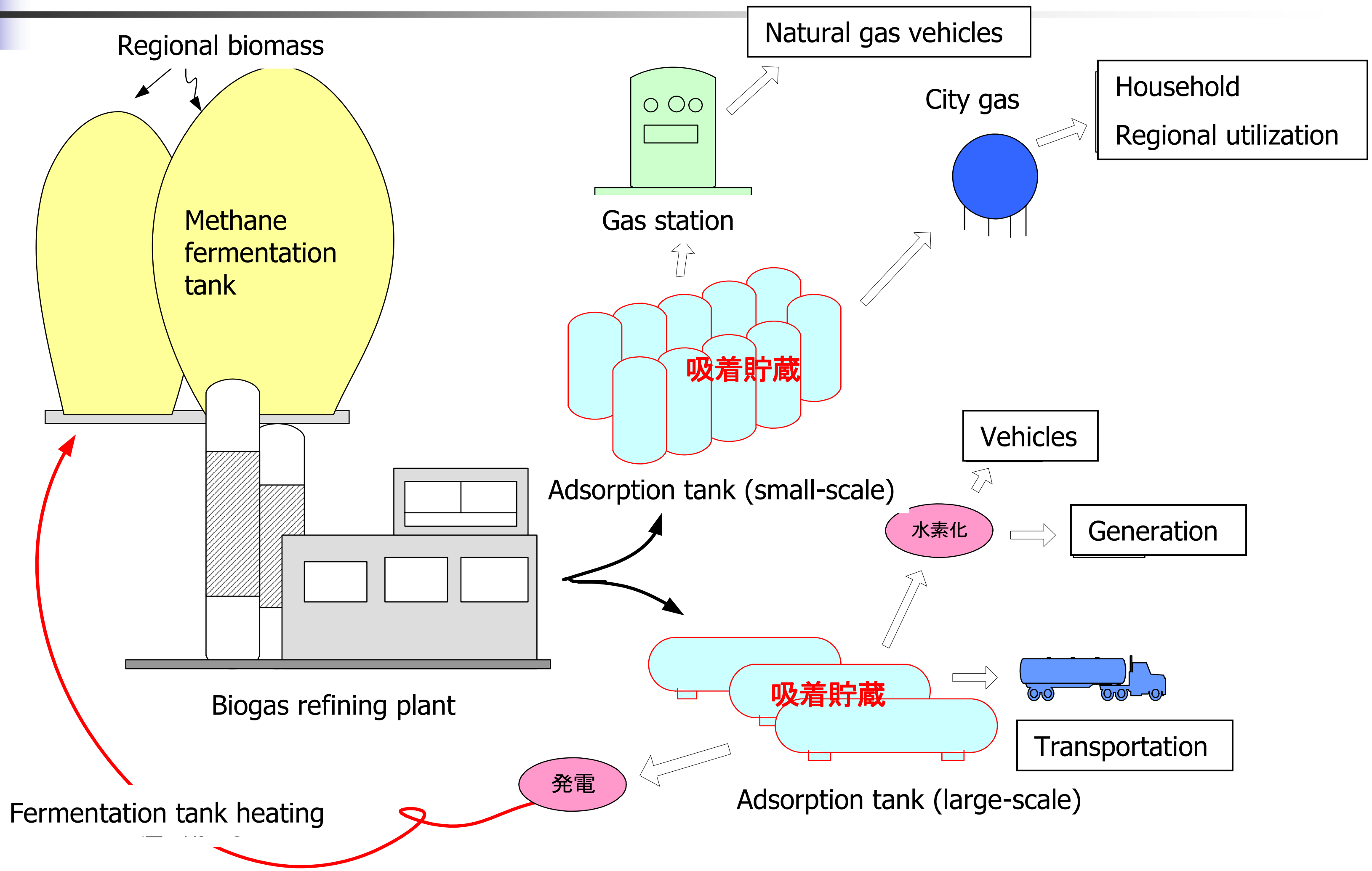


Adsorption media

Gas storage tank by adsorption (e.g. Tsuruoka city)

Left small tank: adsorption type
Right big tank: usual type

Biogas utilization project

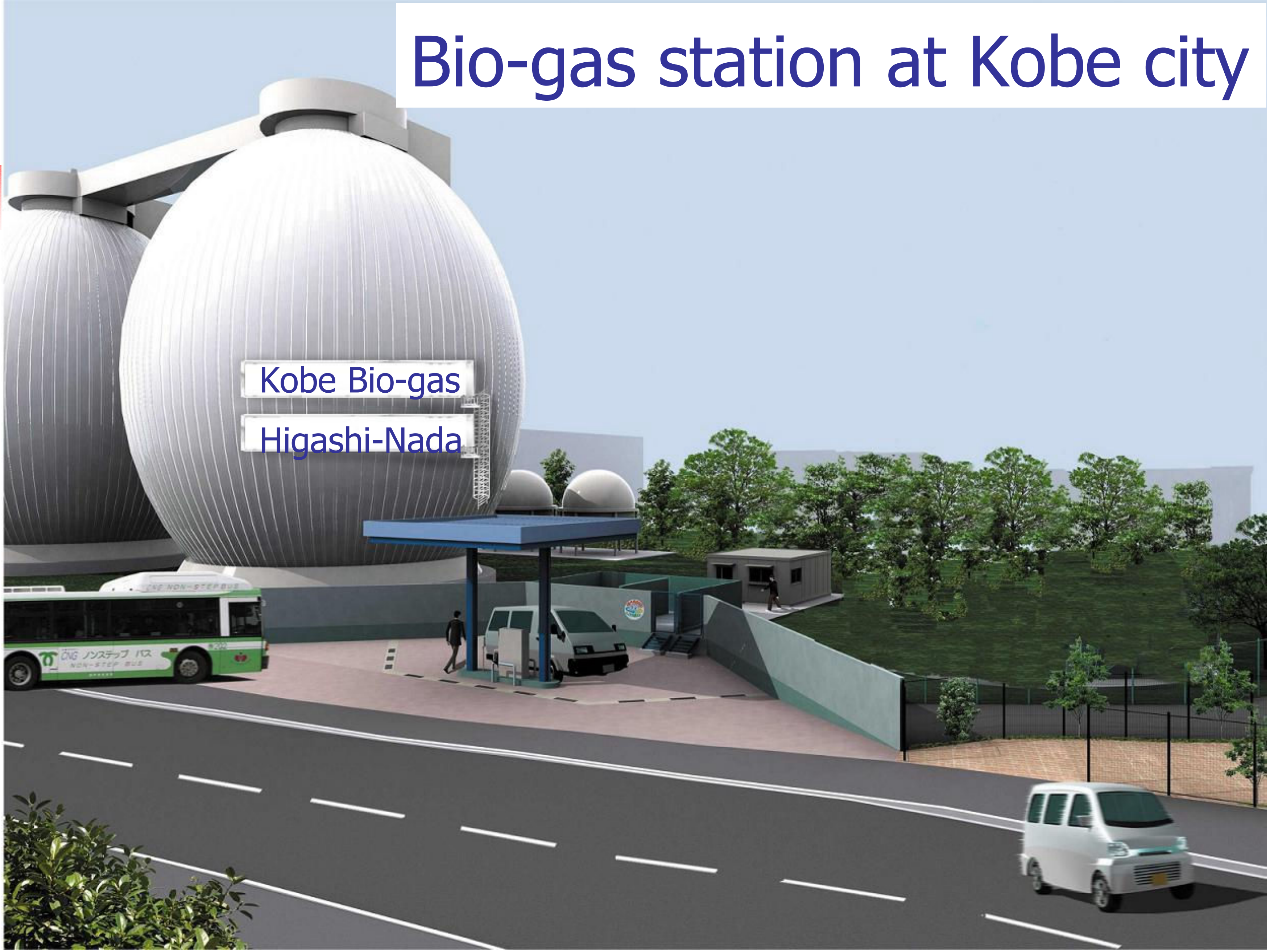


Kobe biogas

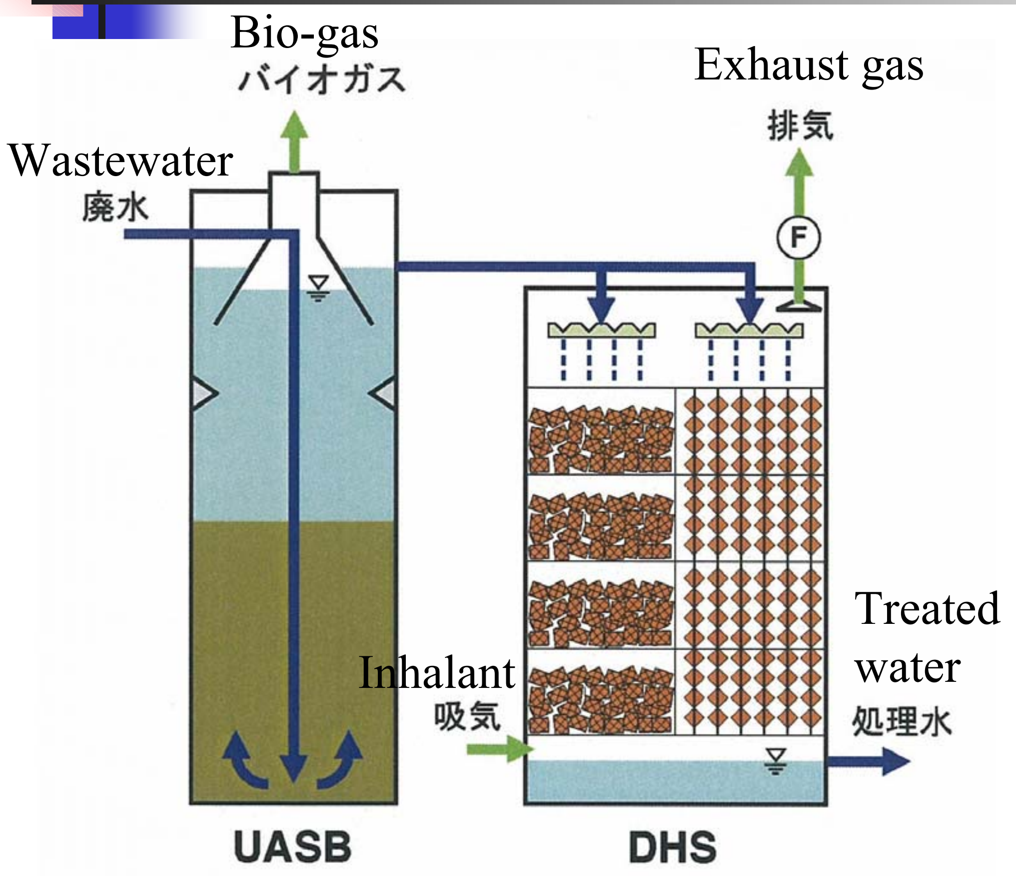
- Kobe biogas
  - Refined biogas = 98% methane gas
  - Kobe city bus opened the business from 2nd October, 2006
- Full-scale plant
  - Spring 2008 open
  - 2,000m^3/day
  - 40 buses (50km/day)

(PWRI, Kobe City, KOBELCO ECO-SOLUTIONS CO.)

Bio-gas station at Kobe city



5. Others
Energy saving water treatment (1)



Flow sheet of the system

UASB: Upflow Anaerobic Sludge Blanket

Applicable to the wastewater which has low content of organic materials. Energy saving, no heating and reduce the generated sludge.

DHS: Downflow Hanging Sponge

Treatment by the micro-organism fixed in sponge. No need aeration system and save much energy.

Energy saving water treatment (2)

Target for technology development

- Energy saving: 70% of Active Sludge Treatment (AST)
- Decrease CO_2 emission: 70% of AST
- Decrease the amount of generated sludge: 70% of AST
- Quality of treated water (BOD, SS, Total coliform): equal to AST

Pilot plant at Kokubu-Hayato WWTP in Kirishima City, Kagoshima pre.

Summary

- Bio-solids treatment
  - Mechanical dewatering, without digestion
- Beneficial use of bio-solids
  - Cement ingredient
  - Construction materials (ash and slag)
- Increase of bio-gas production
  - Co-digestion with green biomass
  - Biogas vehicles system

Thank you very much
for your kind attention.