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A Study on the development of Robust Water Resources Policy in Japan

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EXECUTIVE SUMMARY

It is imperative that a good understanding is developed of how climate change affects the events that are reflected in hydrological extremes such as droughts and floods and how practitioners in water resources management deal with them. Since there is still major uncertainty as to how the impact of climate change affect actual water resources management, it is important to build robustness into management schemes and communities. This paper provides an analysis of current water resources management and presents some pilot cases for water resources management and community activities that ensure robustness at various levels.

Climate change is likely to result in increases in the frequency or intensity of extreme weather events such as droughts, tropical cyclones and storms. In Japan the effects of global warming include not only temperature and sea level rise but also precipitation changes in the form of a more frequent occurrence of abnormally high or low rainfall when compared with the trend of observation data and predictions of climate models. Long-term precipitation trends, provided by a total of 51 Japan Meteorological Agency (JMA) meteorological stations, show that annual maximum daily precipitation has gradually increased, with increasingly greater amplitude, at many locations from the observations of the first half of the 1900s. Average precipitations, calculated from Gumbel distributions, also show an increasing trend at 28 locations in the Aomori area and the areas to the north of Aomori, the area from Kanto to Niigata, the area from Kansai to Nagoya, and the middle and western parts of Kyushu. The rates of increase in the middle and western parts of Kyushu are particularly high. In terms of drought risk, annual precipitation trends, together with the 1/10 annual precipitation trends for many of the Class A rivers in Japan, show annual precipitation trends that are negative at 44 out of the 51 locations. The regional climate change model with a 20 km grid and daily prediction developed by the JMA Meteorological Research Institute (RCM20) calculated results for a total of 60 years (1981–2000, 2031–2050, 2081–2100) with adequate verification for monthly precipitation, annual maximum precipitation and the extreme value distribution. 100-year probability daily precipitation values for 50 years later show national average increases of 10 to 20%. Some areas, particularly northern Hokkaido, Kanto, Hokuriku and the Nansei Islands, show increases of more than 20%. After 100 years, the 50 year trend becomes even more pronounced, and increases of 40% or more occur in many areas including Hokkaido, northern Tohoku, Hokuriku and Kanto. Even when annual precipitation is not directly related to drought risk, seasonal precipitation may have a substantial influence in agricultural water use, especially for rice paddy fields. It is predicted that the decrease in winter and spring precipitation results in decreases in snowmelt floods in March to May in snowy regions, which are vital for agricultural production. It should be noted that there are major uncertainties in future climate projections, as well as in future socio-economic trends. These result from incomplete knowledge concerning the complex systems involved, insufficient observations of

trends and a lack of information on socio-economic development and human behavior. Climate adaptation strategies must therefore focus on exploring how well strategies perform on the basis of a wide range of assumptions and uncertainties.

Vulnerability analysis and integrated water resource planning are two pathways for integrating climate information into water resources planning and management. Vulnerability analysis includes both top-down and bottom-up perspectives. The former uses projections of global or spatially downscaled models to drive resource models and project resource impacts. The latter utilizes water supply planning tools to identify what changes in climate would be most threatening to their long-range plans or operations. One of the top-down approaches for water resources planning can be seen in the World Water Assessment Programme (WWAP) organized under UN Water. The first output of this program was issued in 2001 and included a pilot case study of the Greater Tokyo region comprised of five river basins (Tonegawa, Arakawa, Tamagawa, Tsurumigawa and Sagamigawa) covering about 22,600 km^2 with a total population of 27 million and total assets of about \$2.9 trillion. The Greater Tokyo case study focused on risk management, wise governance, water resources sharing, and protection of ecosystems and relevant knowledge. Among five points of the regional concern, this case study sought to propose indicators for two aspects; flood risk and water quality on proposed six criteria: relevance, clarity, cost, continuity, comprehensibility and social benefit. For another top-down approach, other water cycle and basin indicators were also developed for 109 major rivers in Japan using a comprehensive approach, as a combination of P (human pressure on the basin), S (state of the basin) and R (human response factor for improvement of the basin). Though there is still more room for improvement in indicators on the knowledge and data availability, these limitations do not mean that indicator development is useless and the work on them should continue.

A bottom-up approach to water resources planning focuses on exploring how well policy alternatives perform across a wide range of assumptions and uncertainties. Public policy frameworks are important in this process and so before the efficiency was assessed, traditional water rights system in Japan was reviewed so as to provide a clear social and historical background in terms of an overall value perspective. The hallmark of custom-based water rights system in Japan is that it tries to regulate disparate instances of water use. However, at present, a situation has already been reached in which the drought level of flow for many of Japan’s rivers is equal to, or even less than, the flow required to maintain normal river functions and meet vested water rights. The acquisition of new water rights is therefore dependent on the construction of water resource facilities such as dams to increase the drought level of flow of rivers. Water rights in Japan cannot fully adapt to various changes in demands and uses of water. The system needs more efficiency and accountability. While it cannot be ignored that the water rights system is one policy which can provide protection against poverty in local agriculture, the price of water can be a key determinant of both the economic efficiency and the environmental effectiveness of water services through demand management. An analysis of water demand and the price of recent domestic water use obtained from available information concerning domestic water supply shows that elasticity has become smaller year by year, so there are limits on managing water only through water pricing. One feasible solution following the bottom-up approach requires building a consensus among the different interest groups and stakeholders. The National Environmental Policy Act of 1969 (NEPA) in the USA made participatory decision making a procedural requirement. For example, the legal implications of the case, Marsh vs Oregon Natural Resources Council, led to the conclusion that NEPA's procedural requirements can deter arbitrary and capricious decision making even though such legal cases always took a lot of time and financial resources once they became conflicts. As an alternative to legal procedure, in order to save time and other resources, public involvement in the decision-making process can be required in bottom-up approaches for consensus building. Shared Vision Planning (hereafter SVP), developed mainly by the Institute for Water Resources, U.S. Army Corps of Engineers is a process that attempts, through stakeholder participation in model building and analyses, to create a common understanding of how the watershed or river basin of interest works or functions, and what the impacts will be particular to land and water management policies or practices. A Comprehensive Study of the Koishibaragawa and Satagawa tributaries of the Chikugogawa River suggests that a model can be generally evaluated as an effective tool because of its relevance, validity, transparency, flexibility and acceptability in spite of much uncertainty in the relationships between surface and ground water. A separate model, called the Ground Water Analysis Program and comprised of sub-models (both surface and subsurface) can precisely evaluate the interaction between river and subsurface, and can also assess the cultivation water required for paddy fields.

In those countries, such as Japan, where agriculture continues to be an important source of livelihood, floodplains provide excellent opportunities for habitat, agriculture and commerce. The robustness for water resources planning then recognizes the Integrated Flood Management (IFM) approach since this approach aims to maximize the net benefits from floodplains at the same time as reducing the risk of loss of life and damage because of flooding. Living harmoniously with floods is an important strategic option which provides a suitable framework for risk management towards its robustness. To follow an integrated approach to flood management, it is beneficial to define and understand the construct of flood risks that consists of the magnitude of flood hazard, the exposure of the elements to flooding and the vulnerability of the elements at risk. The costs of accepting flood risk have to be distributed not only among those occupying the floodplains and drawing direct benefits but also among those who derive indirect benefits. For equity and fairness these costs have to be appropriately shared in a transparent manner among several stakeholders: the federal, state and local governments and the flood effected individuals, both in physical and financial manners. There is a need to expand the application of flood insurance from property to agriculture where theoretically the primary interest is in reducing vulnerability and poverty. Insurance policies must address the needs of low income groups. As regards robustness in water resources planning, there is an actual case that is quoted by MLIT Takeo River

Office, Japan. The robust measures to reduce vulnerabilities and to enhance social resilience can be ensured by properly assessing vulnerability and identifying the underlying factors contributing to its increase. Conditions determining vulnerabilities can be improved by coherent approach to economic development and other types of public development policies with the progressive enhancement of local capacities including human, financial, technical and knowledge resources. MLIT Takeo River Office developed a new contingency plan in 2004, supporting the idea that local residents can develop their community based on a risk management viewpoint, called “development of a disaster-prevention community” in daily life, by improving community disaster prevention capacity, revitalizing the local community, and strengthening the relationship of trust between the community and local governments. The mapping exercise is greatly facilitated by referring to the outcome as “My Hazard Map”. This map combines the usual features of security and safety, welfare, education, environment, etc. with the unusual such as flooding and other disasters. It combines the viewpoints of each community’s initiatives. A voluntary disaster prevention organization is established to implement emergency and evacuation drills and collaborate with the related organizations such as national government, prefecture and municipal authorities and thus maximize the robustness of the communities in an integrated manner.

BIOGRAPHICAL SKETCH

Masahiko Murase was born in Kyoto, Japan in 1967. He graduated from Kyoto University, receiving a master's degree of Civil Engineering in 1992. Following graduation, he joined the Ministry of Construction (the present Ministry of Land, Infrastructure, Transport and Tourism, MLIT). Since then, he worked as an engineer at the River Bureau of MLIT, some branch offices and the National Institute for Land and Infrastructure Management (NILIM). During his time with NILIM, he studied at the Cornell Institute for Public Affairs in the USA from 1999 to 2001 on the basis of a fellowship from the Japan International Cooperation Agency and was awarded the degree of Master of Public Administration. After meeting curriculum requirements at Cornell, he worked at the Institute for Water Resources of the U.S. Army Corps of Engineers from January to June of 2001 as a visiting researcher while completing his thesis requirements. From 2007 to 2010, he was dispatched to World Meteorological Organization (WMO) in Geneva, Switzerland as a professional officer. Since July 2010, he has been working as a director, Takeo River Office of MLIT. He is married and lives with a wife and two children (son and daughter).

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I am grateful to Professor Kaoru Takara, who provided continuous guidance, unfailing encouragement and strong support. Professor Tetsuya Sumi, Professor Tomoharu Hori, Professor Keiichi Toda and Professor Takashi Hosoda at Kyoto University gave me considerable advice through the entire process. Professor Emeritus Hiroji Nakagawa and Professor Iehisa Nezu have supported my study since my undergraduate study at Kyoto University.

Dr. Eugene Z. Stakhiv at IWR provided me with valuable information and assistance during my research in the USA, mostly in 2001. Mr. Avinash Chand Tyagi, Director of the Climate and Water Department, WMO, supported my research during my stay in WMO. Many other colleagues at WMO provided collegial support and strongly encouraged me to complete my mission there. In addition, Dr. Arthur Askew, Past-President of the International Association of Hydrological Sciences (IAHS) and the former Director of the Hydrology and Water Resources Department, WMO, kindly offered editorial suggestions.

My studies would have been impossible without the generous support of MLIT which provided me with many opportunities for my research through the various posts that have held.

It should be noted that the extreme earthquake that occurred in the eastern part of Japan on 11 March 2011 just as I was finalizing this research. This continues to have major repercussions throughout the country and has had a huge impact not only on my current job but also on my way of thinking about natural disasters. My deepest sympathy goes out to people in Tohoku and Kanto regions who were struck by the massive earthquake, disastrous tsunami and damage to the nuclear power plant. While it will take many years for things to return to anything approaching normal, I have the courage and the confidence to believe that Japan has wisdom and tenacity to overcome the current difficulties.

I am grateful to all these supporters. I very much hope my studies will contribute in some way to making water resources management more robust in the future.

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1. INTRODUCTION

There is no doubt that climate change is going to have impact on the hydrological cycle which is sensitive to the temperature, so it is imperative that good understanding is developed on some of the basic aspects of climate change and how it affects the extreme events that are reflected in the hydrological extremes like droughts and floods. However, there is still major uncertainty on how such impact provides effects to actual water resources management.

On 11 March 2011, when I finalized the draft of this paper, the record-breaking earthquake occurred in the north-eastern part of Japan, followed huge tsunami and accidents of nuclear plants. As the event is still going on as of this paper's submission date, it is too early to evaluate the total damage of this disaster so far, but it can be noted that the event shows the importance of considering the risks of unexpected natural disasters by constructing the robustness into management scheme and communities. A highly improbable event is deemed rare yet causes massive consequences with three principal characteristics: It is unpredictable; it carries a massive impact; and, after the fact, people receive an explanation that makes it appear less random, and more predictable than it was. "We concentrate on things we already know and fail to take into consideration what we don't know. We are, therefore, unable to truly estimate opportunities, too vulnerable to the impulse to simplify, narrate, and categorize, and not open enough to rewarding those who can imagine the impossible."[1]

There is no single recipe for robustness on water resources planning. This paper provides an analysis of actual water resources management and proposes some pilot cases for water resources management and community activities to ensure the robustness at various levels. It is addressed not only for the local leaders who organize community activities but also for policy makers who design water resources management schemes including financial reviews. Basically, there are two approaches towards robust water resources management: top-down and bottom-up. The former approaches need birds' eyes to analyze the whole perspectives of water resources management by appropriate models and indicators. The latter approaches take a more micro-view by risk sharing and consensus building process under the integrated management concept.

Integrated management for water resources or flood risks seek to maximize the benefits through the related development activities within the river basin as a whole. The benefits are derived at various levels of social and economic activities through development policy and land-use planning. Integrated Flood Management (IFM) seeks for practical aspects of managing floods within the context of Integrated Water Resources Management (IWRM). This paper comprises six chapters including this introduction.

Chapter 2 evaluates changes in rainfall characteristics due to global warming and the corresponding flood

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[1] Nassim Nicholas Taleb 2010

and drought risks, and looks into their impact to water resources management in Japan while there are major uncertainties in the adaptation to climate change and variability. Such uncertainties favor the implementation of a flexible or adaptive management, involving putting in place incremental adaptation options, rather than undertaking large-scale adaptation all at once.

Chapter 3 discusses top-down or bottom-up perspectives for vulnerability analysis to integrate climate information into water resources planning and management: the top-down perspective is based on the projections of global or spatially downscaled models with specific global or national indicators while the bottom-up one is based on the various planning tools to identify what changes in climate would be most threatening to their long-range plans or operations.

Chapter 4 discusses bottom-up perspectives for vulnerability analysis to water resources planning and management, and focuses on exploring how well policy alternatives perform across wide ranges of assumptions and uncertainties through analysis of the Japanese water resources from global perspectives, economics approach and the consensus building planning (Shared Vision Planning).

Chapter 5 discusses the robustness for water resources planning, and focuses on flood risk as an integrated approach for flood management (IFM) in floodplains, especially for risk sharing, with an actual case in practice by Takeo River Office, MLIT, Japan.

Chapter 6 concludes this paper and mentions the further steps for robustness on water resources management in the fields.

This paper does not reflect the official views or policies of the Ministry of Land, Infrastructure, Transport and Tourism, Japan where the author has been involved since 1992.

2. CLIMATE CHANGE AND WATER RESOURCES MANAGEMENT

Even the most stringent mitigation efforts cannot avoid further impacts of climate change in the next few decades, which makes adaptation essential, particularly in addressing near-term impacts[2]. This means that adaptation measures are necessary complementary actions along with mitigation. Before considering adaptation measures, it should be clarified how climate change provides the impact to water resources management.

2.1 CLIMATE CHANGE FOR WATER RESOURCES IN JAPAN

Japan is topographically and geologically prone to disasters like floods, sediment-related disasters and storm surges as it is located on the circum-Pacific orogenic zone with steep mountains and short and fast rivers. The islands are located on the eastern end of the Monsoon Asia with mean annual precipitation of about 1,700 mm.[3] Although the mean annual precipitation is twice as much as the world average, the per capita precipitation is only one-third of the world average. The steep and short rivers of Japan discharge collected water very fast to the sea, and the difference between the maximum and minimum discharges is large, making stable water use difficult. The risk of drought has increased, so endangering secured water use.

2.1.1 CLIMATE VARIABILITY AND CLIMATE CHANGE

The Fourth Assessment Report (AR4) of IPCC has concluded that warming of the climate system is unequivocal, evident from observed increases in global average air temperatures, ocean temperatures and other observations[4]. There is no doubt that climate change is going to have an impact on the hydrological cycle which is sensitive to the temperature. It is imperative that good understanding is developed on some of the basic aspects of climate change and how it effects the extreme events that are reflected in hydrological extremes.

Climate is a measure of what to expect in any month, season or year and is arrived at using statistics built up from observations over many years. Statistically, the climate is defined in terms of mean and variability of involved variables such as temperature and precipitation over a period of time. Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may result from natural internal processes within the climate system (internal variability) or to variations in natural or anthropogenic external forcing (external variability).[5]

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[2] IPCC 2007

[3] MLIT 2007

[4] IPCC 2007

[5] Ibid.

The concept of climate change is about shifts in meteorological conditions lasting many years. Climate change refers to the change in state of the climate that can be associated to the changes in the mean and/or variability of its properties and that persist over an extended period of decades or longer. The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as: a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is, in addition to natural climate variability, observed over comparable time periods. Figure 1 indicates through simple statistical reasoning how increased variability and increased mean in different combinations impact on temperature extremes. Climate change is likely to result in increases to the frequency or intensity of extreme weather events such as severe droughts, tropical cyclones and storms. The relationship between averages and extremes is often non-linear. For example, a shift in average temperature is likely to be associated with much more significant changes in very hot days. The disproportionate increase in the frequency of extreme events is not limited to the frequency of very hot days but could occur with many other climate extremes. In some instances the frequency of extreme events could increase even when there are small declines in averages – this is likely to be the case for rainfall.

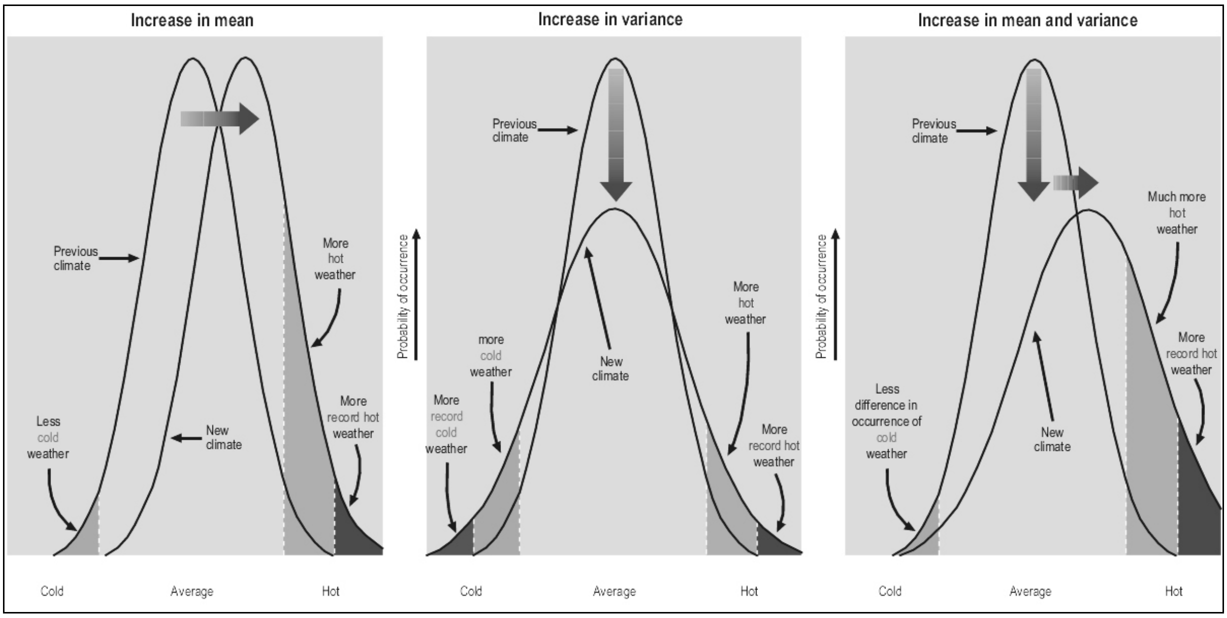

Figure 1 Climate variability and climate change – illustrated in form of probability distributions for temperatures (Adapted from Climate – Into the 21st Century[6])

2.1.2 RECENT OBSERVATION OF CLIMATE VARIABILITY AND CLIMATE CHANGE IN JAPAN

This argument of the trend in averages and the frequency and intensity of extreme weather recalls the recent rainfall events in Japan[7]. Figure 2 shows the annual precipitation in the last century in Japan. While the trend in averages decreased, its variability increased. According to an observation by the Japan Meteorological Agency (JMA), the annual average occurrence of precipitation above 50 mm per hour and

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[6] WMO 2003

[7] Water Resources Department, MLIT 2004

100 mm per hour both increased in the last 30 years. The average occurrence of precipitation above 50mm per hour increased at 233 locations in 1988-1997 and at 318 locations in 1998-2007 from 206 locations in 1978-1987 in around 1500 JMA observation locations. The average occurrence of precipitation above 100mm per hour increased at an average of 2.5 locations in 1988-1997 and 4.8 locations in 1998-2007 from 1.9 locations in 1978-1987 in around 1500 JMA observation locations.

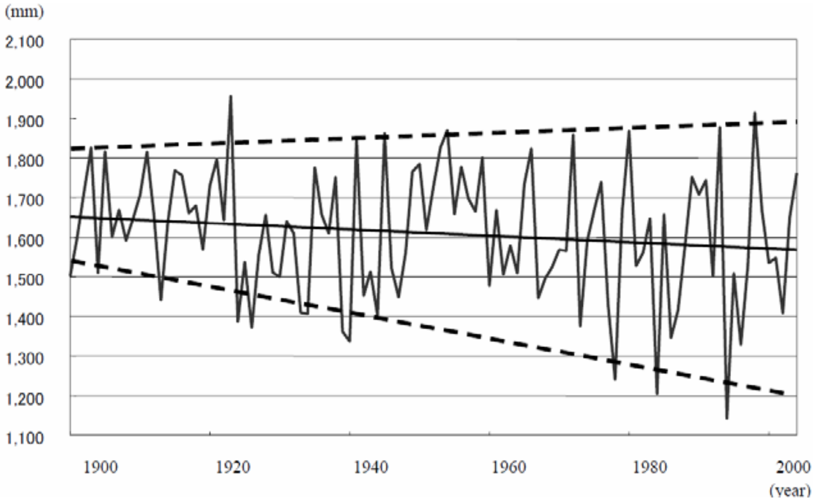

Figure 2 Annual Precipitation in the 20th Century (Adapted from MLIT White paper 2001)[8]

The effects of global warming include not only temperature and sea level rise but also precipitation changes in Japan encountered in the form of frequent occurrence of abnormally high or low rainfalls. Annual precipitation data from 51 rain gauges in Japan indicate a decreasing tendency on average, but differences between wet years and dry years have increasing and the frequency of droughts shows an increasing tendency, particularly strong after the mid-1960s. It was investigated the times of occurrence of the four highest annual maximum daily precipitations observed at 56 rain gauge stations in Japan during the past 100 years and showed that all of them occurred in or after 1940[9]. In 2004, localized heavy rains far exceeding the maximum rainfalls observed in the past occurred and inflicted tremendous damage in July and August mainly in the Niigata, Fukui and Shikoku areas.

Most estimates of what the global climate will be like at the end of the 21st century depend on the computer models and the assumptions made in their formulation. The performance of the models in simulating global warming during the 20th century is reassuring. A number of broad conclusions drawn based on a number of scenarios of the development path that is likely to be adopted by mankind. However, global climate models cannot fully provide a coherent picture of regional climate change. For practical water management related to flood and drought against influences of variation of rainfall characteristic, the results of the regional climate change prediction over the next 50 years of the regional climate change models RCM20 developed by JMA and Meteorological Research Institute (MRI) of JMA were used based on the framework of a joint study between the National Institute for Land and Infrastructure Management (NILIM) and JMA/MRI

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[8] Water Resources Department, MLIT 2004

[9] Yamamoto, R. 2003

under the Global Warming Research Initiative of the Council for Science and Technology Policy, Cabinet Office of Japan [10,11,12].

2.1.3 RESEARCH BY REGIONAL CLIMATE MODEL IN JAPAN

Wada et al. [13] first tried to assess flood and drought risks by using results of a regional climate change model with 20 km grids and daily prediction (MRI-RCM20-Ver.1) developed by the MRI of the JMA, but the result was not able to show precipitation prediction with good accuracy in eastern Japan. The model underwent a number of improvements, mainly to improve precipitation modeling accuracy, and the JMA released computation results for the present climate (1981–2000) and future climate (2081–2100) obtained from MRI-RCM-Ver. 2 (hereafter referred to as "RCM20") in 2004. Ishihara et al.[14] verified the accuracy of climate modeling and showed that the accuracy of precipitation estimates was good and that flood and drought risk assessment performed by using the RCM20 was useful. Wada, Murase and Tomizawa obtained 100-year prediction from the RCM20 and showed that there are areas, mainly in northern Japan and on the Sea-of-Japan side of the main island of Japan, where 100-year probability annual maximum daily precipitations will nearly double in 100 years[15]. However, the predictive calculations contain a degree of uncertainty because they are based on many assumptions. Nevertheless, predicting the impact of climate changes in Japan caused by global warming on water resources and assessing flood and drought risks with a clear understanding of the limit of applicability of prediction results is essential for deciding on measures to be taken in the coming years and used in making policy decisions.

In view of this, this study was conducted to evaluate changes in rainfall characteristics due to global warming and the corresponding flood and drought risks. Section (1) below presents daily precipitation and annual precipitation trends observed at rain gauge stations that have recorded data over many years. Section (2) outlines the global warming model used in this study, describes the 50-year prediction (2031–2050) procedure used and discusses modeling accuracy and the limit of applicability of the model. Section (3) deals with probable precipitation as an indicator of flood risk and presents the future flood risks of different areas based on the prediction results. Section (4) deals with annual precipitation and seasonal precipitation as indicators of drought risk and presents future drought risk trends determined on the basis of the prediction results. Section (5) summarizes flood and drought risks predicted by the climate models.

(1) Precipitation Trends in Japan

A recent tendency towards a higher frequency of extremely heavy localized rains is often pointed out. This is thought to be because, as shown in Figure 3, since 1940 annual maximum daily precipitation has

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[10] Wada, K., Murase, M. and Tomizawa, Y. 2005

[11] NILIM 2004

[12] NILIM 2004

[13] Wada, K., Murase, M. and Tomizawa, Y. 2004

[14] Ishihara, K., Kurihara, K., Wada, K., Murase, M. and Tomizawa, Y. 2004

[15] Wada, K., Murase, M. and Tomizawa, Y. 2005

gradually increased, with increasingly greater amplitude, at many locations from the precipitations observed in the first half of the 1900s. At such locations, the precipitation probability data compiled in, for example, 1950 could differ considerably from the precipitation probability data compiled in 2000. Long-term precipitation trends, therefore, were investigated by using long-term observation data provided by JMA's meteorological stations. The data used in the analysis were provided by a total of 51 JMA meteorological stations that had monthly rainfall data for 1901 to 2000 (Figure 4).

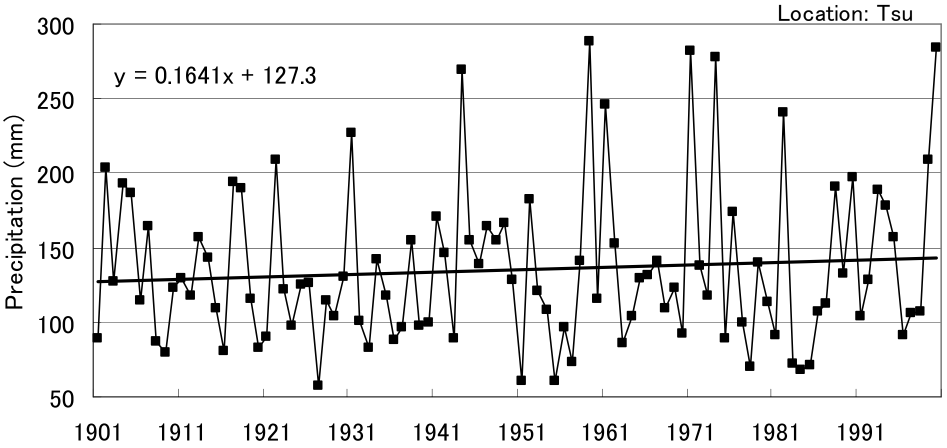
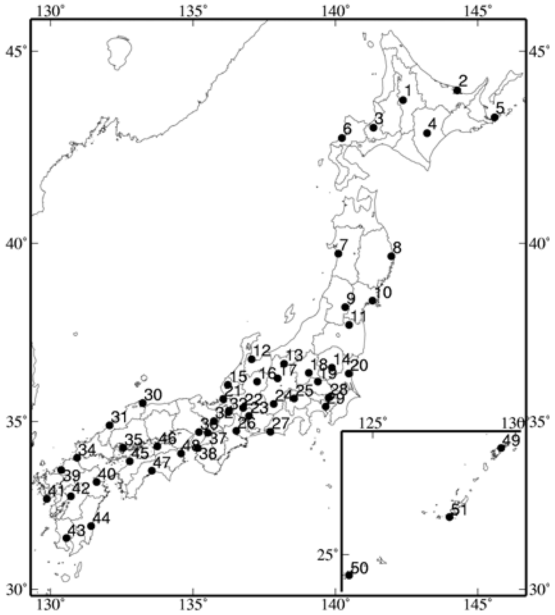


Figure 3 Annual Maximum Daily Precipitation



Asahikawa, Abashiri, Sapporo, Obihiro, Nemuro, Suttu, Akita, Miyako*, Yamagata*, Ishinomaki*, Fukushima*, Fushiki, Nagano, Utsunomiya, Fukui, Takayama*, Matsumoto, Maebashi, Kumagaya, Mito, Tsuruga, Gifu, Nagoya, Iida*, Kofu, Tsu, Hamamatsu, Tokyo, Yokohama, Sakai, Hamada, Kyoto, Hikone, Shimonoseki, Kure, Kobe, Osaka, Wakayama*, Fukuoka, Oita*, Nagasaki, Kumamoto, Kagoshima, Miyazaki, Matsuyama, Tadotsu, Kochi*, Tokushima, Naze, Ishigaki*, Naha*

Note: The 11 stations marked with an asterisk (*) have, no annual maximum precipitation data (annual precipitation only).

Figure 4 JMA 51 Meteorological Observation Stations

100-year probability maximum daily rainfall, which was used as an indicator of flood risk and as the basis for flood control planning for many Class A rivers, was considered, and its trends were investigated. To calculate probable precipitation, Gumbel distributions were applied, and trends in past changes determined by the method show the trends at different locations (Figure 5 and Figure 6). The 100-year probability maximum daily precipitation showed an increasing trend at 28 locations and a decreasing trend at 12 locations. The number locations at which an increasing trend is observed is more than twice as large as the number of locations at which a decreasing trend is observed. Increasing-trend locations are concentrated in the Aomori area and the areas to the north of Aomori, the area from Kanto to Niigata, the area from Kansai to Nagoya, and the middle and western parts of Kyushu. The rates of increase in the middle and western parts of Kyushu are particularly high.

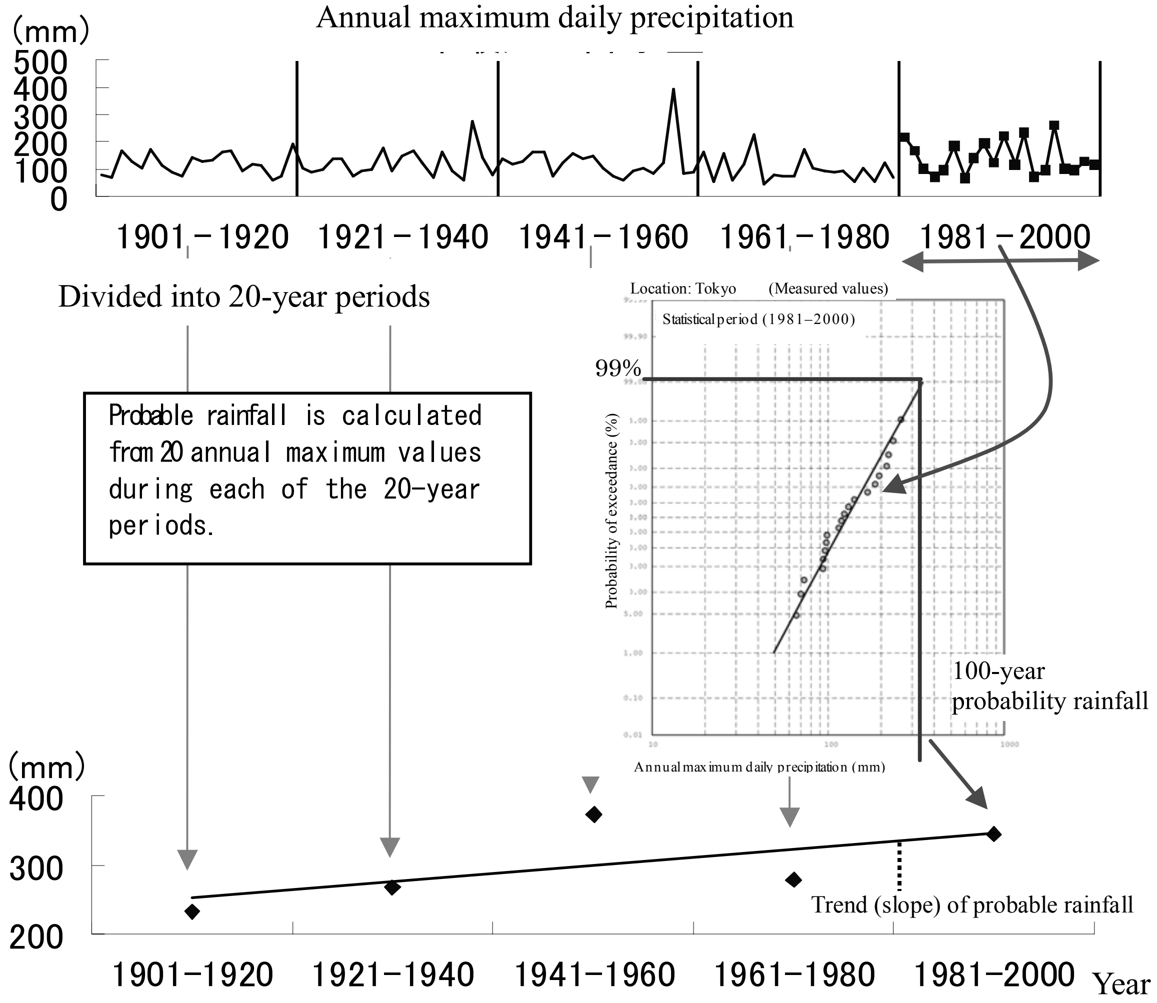


Figure 5 Method for 100-year probability trend

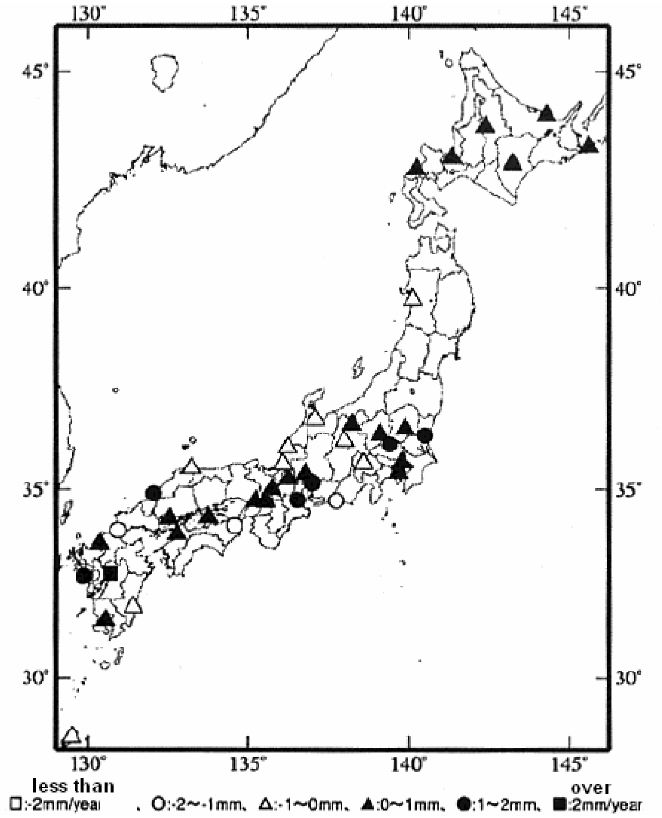


Figure 6 Trend Distribution of 100-year probability maximum daily rainfall

Annual precipitation trends together with the 1/10 annual precipitation trends, as an indicator of drought risk on the basis of water utilization planning for many of the Class A rivers in Japan, show that annual precipitation trends are negative at 44 out of the 51 locations. It indicates a decreasing tendency for total precipitation in Japan. Even at four out of the seven locations at which the annual precipitation trends are positive, the "1/10 rainfall" trends are negative. This indicates a strong tendency toward an increase in drought risk.

(2) JMA Regional Climate Model

A climate model makes it possible to calculate various climate changes by a physically founded method and develop realistic climate change scenarios based on different greenhouse gas emission increase scenarios. The type of meteorological phenomena that can be calculated and the accuracy of modeling differ from model to model. If those problems and the limits of applicability of different models are taken into consideration, useful information can be obtained concerning, for example, year-to-year changes, seasonal changes and extreme meteorological phenomena. The regional climate model RCM20 of the MRI is used here as a model for predicting future flood and drought risks.

The RCM20 is a model that uses boundary conditions derived by downscaling the results obtained by the MRI from its Second Generation Coupled Global Climate Model (CGCM2). The model similar to the JMA numerical weather model called RSM (regional spectral model) used for daily weather forecasting. For the downscaling, two-stage nesting (a method in which a region-specific high-resolution model is gradually run by using calculation results from a larger-region model as boundary conditions) is performed from CGCM2 280km resolution to RCM20 20km resolution via a 60km model. In the nesting, noise is generated near the lateral boundaries by phase differences between the models. The wave-number space connection method in which the long-wave parts of the global model are connected to the short-wave parts of the regional model is used to match the phases of the two models, minimize noise and achieve smooth connection at the boundaries[16]. Table 1 summarizes data for the RCM20 and the CGCM2.

Table 1 Climate Model by Meteorological Research Institute (MRI), Japan Meteorological Agency (JMA)

MRI-RCM20[17]

Base model	**Regional Climate Model**
Lateral boundary conditions	**60km Grid climate model (MRI-RCM60) in Asia**
Horizontal resolution	**20km**
Horizontal grids	**129 x 129**
Vertical layers	**36**
Precipitation process	**Arakawa-Shurbert, large scale condensation, convective adjustment**
Radiation process	**Long wave and short wave radiation**
Vertical diffusion	**Level 2 closure model by Mellor and Yamada**
Surface boundary layer	**Monin-Obukhov Similarity theory**
Surface and ground temperature	**Forecasting by 4-layer modeling**
Sea surface temperature	**Result of MRI-CGCM2**
Snowfall	**Diagnostic calculation**

MRI-CGCM2[18]

(Atmosphere model)

Basic model	**GCM 9603**
Horizontal resolution	**280km**
Horizontal grids	**128 x 64**
Vertical layers	**30**
Precipitation process	**Arakawa-Shurbert, large scale condensation**
Radiation process	**Long wave and short wave Radiations**
Vertical diffusion	**Level 2 closure model by Mellor and Yamada**
Surface process	**Monin-Obukhov Similarity Theory**
Ground temperature	**SiB (Simple Biosphere) Model (flora model)**

(Ocean model)

Horizontal resolution	**2.5” x (2-0.5)”**
Vertical layers	**23**
Eddy mixing	**Uniform-density surface mixing**
Vertical diffusion	**Level 2 closure model by Mellor and Yamada**

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[16] Sasaki, H., Adachi, K. and Kida, H. 2000

[17] JMA 2003

[18] JMA 2005

As the conditions for future climate calculation (greenhouse gas emission scenarios), the global climate model uses two (A2 and B2) out of the four narrative scenarios (A1, A2, B1, B2) described in the IPCC Special Report on Emissions Scenarios. With the CGCM2, the 1972 values were used as the initial values, and calculations for the years up to 2100 have been performed. Calculations using the RCM20 were performed by JMA under a global warming research initiative by using the calculation results under the A2 scenario, which basically assumes regional economic development based on self-reliance and the preservation of local identities, for 1981–2000 and 2081–2100. Predictive calculations for 2031–2050 were performed jointly by the National Institute for Land and Infrastructure Management (NILIM) and the MRI as part of their joint research. In this study, calculation results were available for a total of 60 years (1981–2000, 2031–2050, 2081–2100).

(i) Verification for monthly precipitation

The accuracy of the RCM20 in modeling monthly precipitation was examined. The results for the computation period of present climate (1981–2000) for the RCM20 indicate that the accuracy is high and so the model is useful in evaluating drought risks due to global warming. Twelve CGCM2 grid points (spaced 280 km apart) in Japan was verified for comparison with the CGCM2 in which the RCM20 was nested.

The coefficient of correlation between calculated values and measured values in each verification area was calculated from (1) the CGCM2 calculation result, (2) the average of the values obtained from AMeDAS (Automated Meteorological Data Acquisition System) observation and (3) the average value of the calculation results obtained from the regional climate model included in the grids. Figure 7 shows the coefficients of correlation calculated for different verification areas. Figure 8 shows the result of comparison in terms of the monthly averages during the period of 20 years from 1981 to 2000. As shown in Figure 7, the RCM20 results show high coefficients of correlation (around 0.9) for many areas, while the CGCM2 results tend to show relatively weak correlations for the Hokkaido and Tohoku regions. As shown in Figure 8, the calculated amounts of precipitation in summer in Area 1 (eastern Hokkaido) tend to be larger than the measured values, and, conversely, the calculated amounts of precipitation in summer in Area 8 (Kinki) tend to be smaller than the measured values. In spite of these tendencies, however, the RCM20 is mostly accurate in reproducing changes in monthly precipitation. The reason why the RCM20 outputs are greater than the measured values in eastern Hokkaido is thought to be that the distance between the eastern part of Hokkaido and the RCM20 calculation area was not sufficient, the calculation results were therefore affected by the boundary conditions. The level of accuracy of the CGCM2 in modeling monthly changes for Areas 1 to 3 was low. The calculated results for Area 10 and Area 12 were considerably smaller than the measured values.

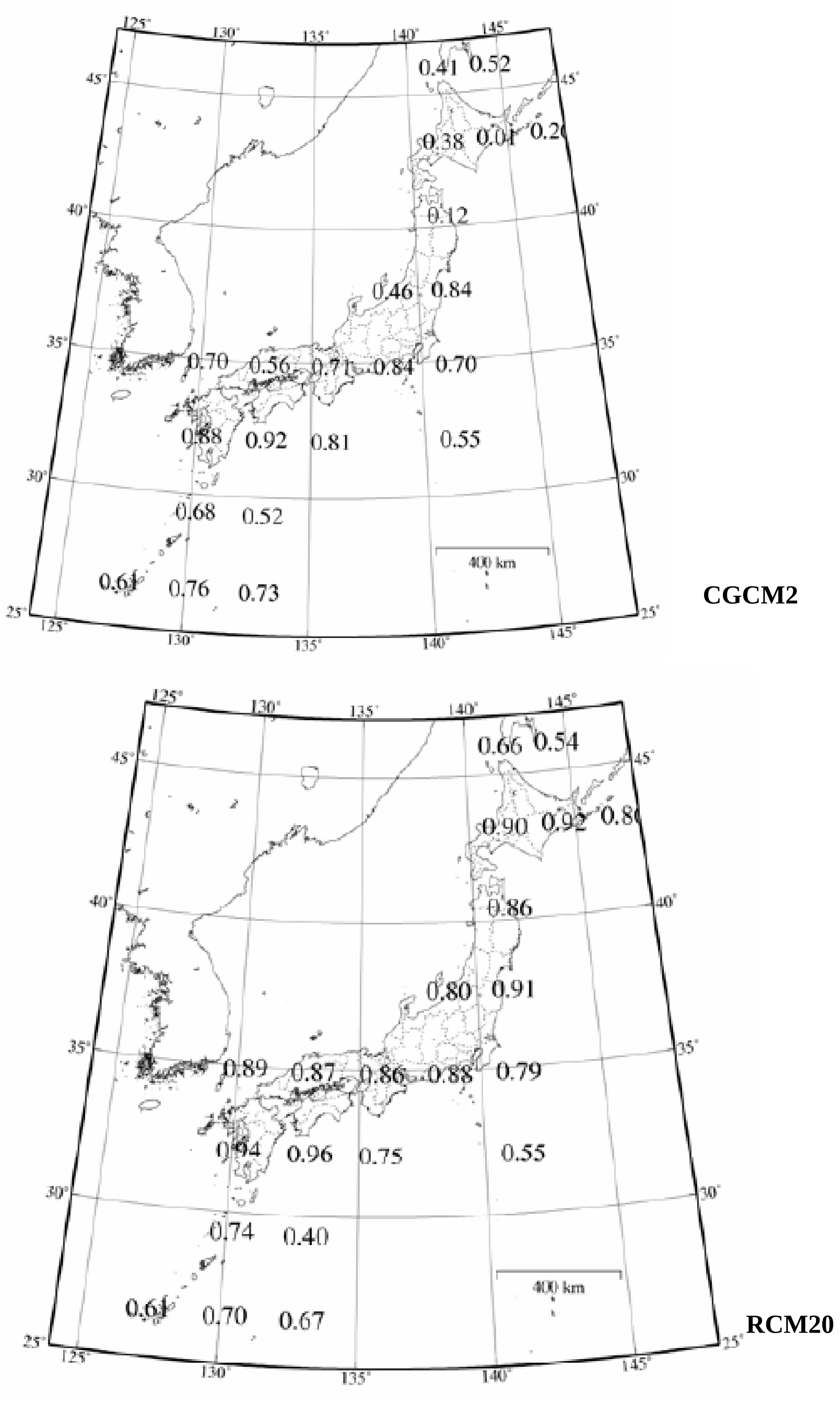

Figure 7 Coefficient of Correlation for Monthly Average Precipitation (CGCM2 and RCM20)

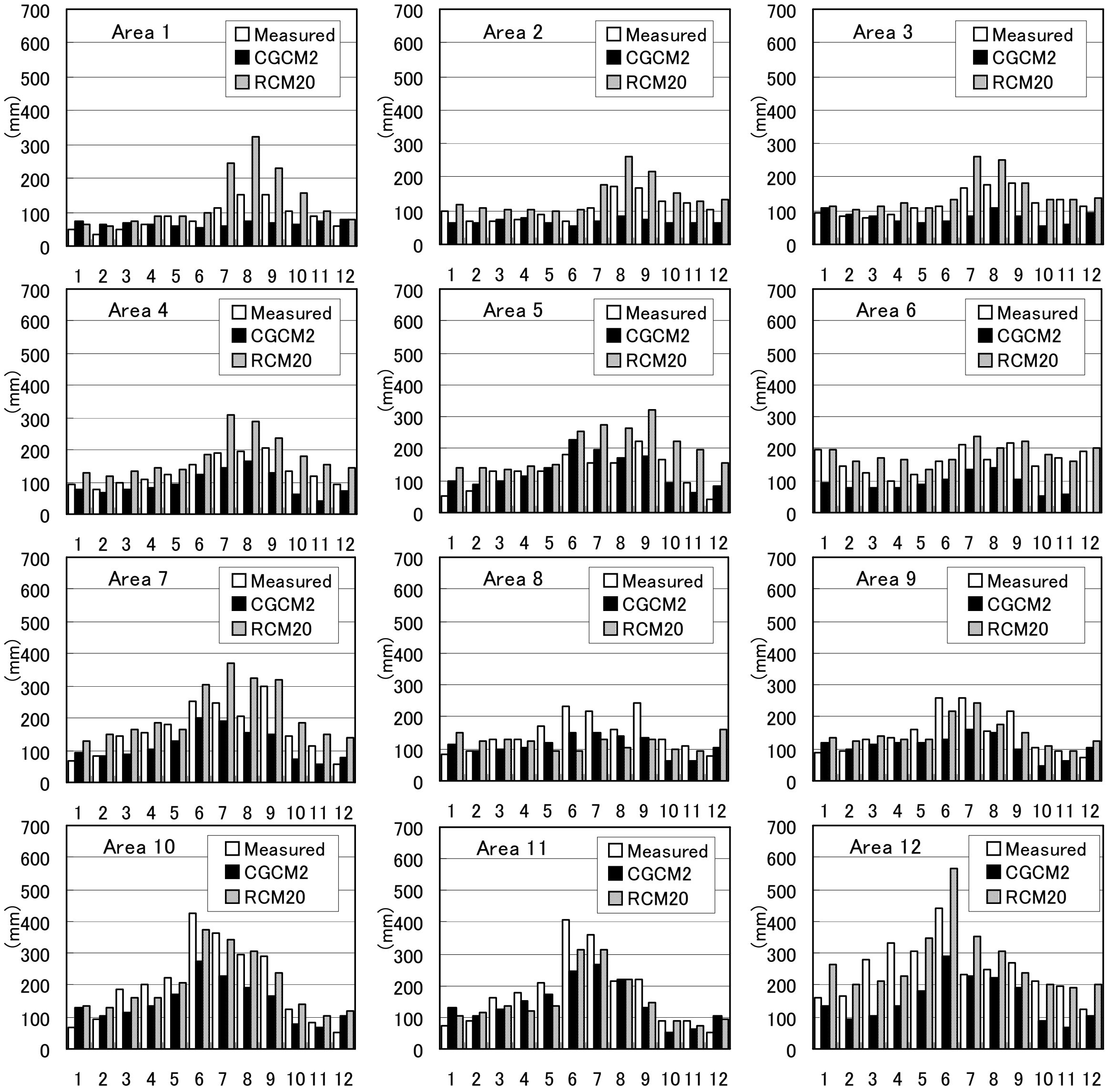

Figure 8 Monthly Average Precipitation (Observation, CGCM2 and RCM20)

(ii) Verification for annual maximum precipitation

The accuracy of calculated values of annual maximum daily precipitation in 1981 to 2000 was examined in order to evaluate the applicability of the model to flood risk evaluation. Comparison was made between the average values of AMeDAS observation results located in the CGCM2 grids and the average values of the calculated results located in the RCM20 grids directly over AMeDAS stations (Figure 9). As shown, the CGCM2 results indicate that the calculated extreme values are only 10 to 20% of the measured values. In contrast, the RCM20 results show that, although the calculated values are somewhat greater than the measured values, regional variation is small and the overall results can be deemed fairly good. The RCM20 is thought to be valid for meteorological disturbances of a scale corresponding to about five times the horizontal resolution, that is, of a scale of the order of about 100 km. It can be inferred, therefore, that phenomena contributing to the occurrence of heavy rains, such as low pressures, fronts and typhoons, were modeled with fair accuracy. Another likely reason for high accuracy of the calculated extreme values is that the horizontal resolution of the RCM20 (20 km) is by far higher than that of the CGCM2 (280 km), the distribution of precipitation intensities reflecting the ground surface configuration has been reproduced realistically.

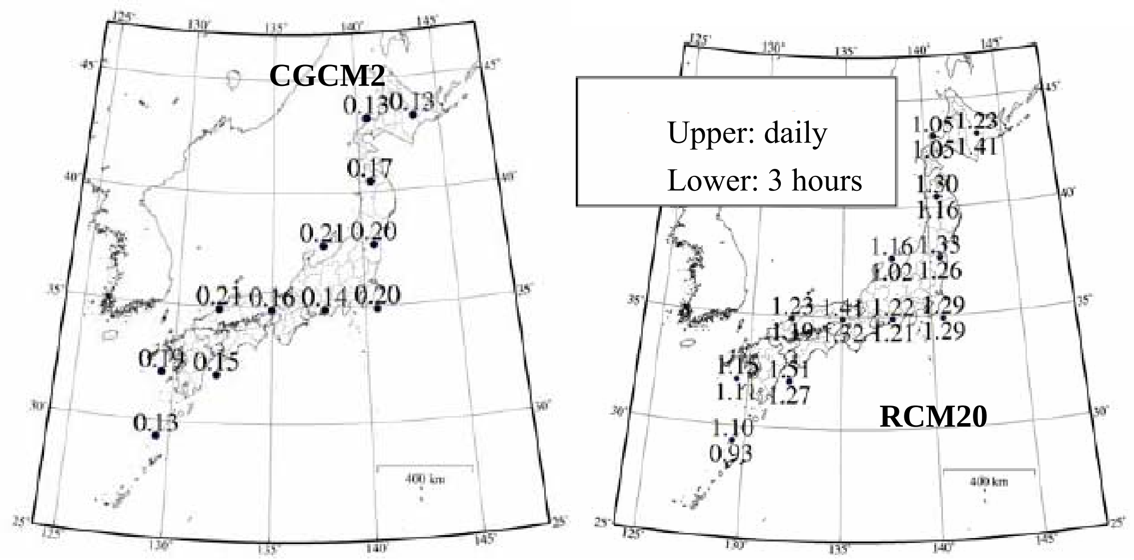

Figure 9 Annual Maximum Daily Precipitation (Calculated/Observed for CGCM2 and RCM20)

(iii) Comparison of extreme value distribution

The preceding section has shown that the accuracy of calculated extreme values given by the RCM20 is high. During flood management planning, it is fairly common practice to use probable precipitation values that can be obtained by fitting the extreme value data for a continuous period of several tens of years to the extreme value distribution. Since the RCM20 requires vast amounts of computation time and computer resources, the maximum continuous computation period used for future prediction is only 20 years. In order to enhance the reliability of 100-year precipitation estimates based on the 20-year data, it is important to pay attention to, not only the degree of agreement of the extreme values during the period, but also the similarity in extreme value distribution patterns. Comparison was made, therefore, of the distribution patterns obtained by fitting the annual maximum values to Gumbel distributions for the 20 years from 1981 to 2000. The probability density function of a Gumbel distribution can be expressed as

$$f(X) = \exp\{-\exp[-(X-\xi)/\beta] - (X-\xi)/\beta\}/\beta \qquad (1)$$

$$\beta = S_X \sqrt{6}/\pi \qquad (2)$$

$$\xi = X_m - \gamma\ \beta \qquad (3)$$

Where $f(X)$ is a probability density function for the occurrence of X; S_x, a standard deviation of X; X_m, the average of X; γ: Euler's constant (=0.57721…); ξ, a location parameter indicating the peak location; and β, a scale parameter indicating the spread of distribution.

Figure 10 shows the results of comparison of Gumbel distributions of annual maximum daily precipitation at major locations in Japan. While there are some locations such as Sapporo and Tokyo that show relatively similar extreme value distribution patterns, there are other locations such as Osaka and Fukuoka that show very different distribution patterns. In the case of Osaka, the values of β in the Gumbel distribution to which the calculation results from the RCM20 have been fitted are nearly three times as large, indicating that the annual extreme values obtained from the RCM20 vary more widely from year to year than the measured values.

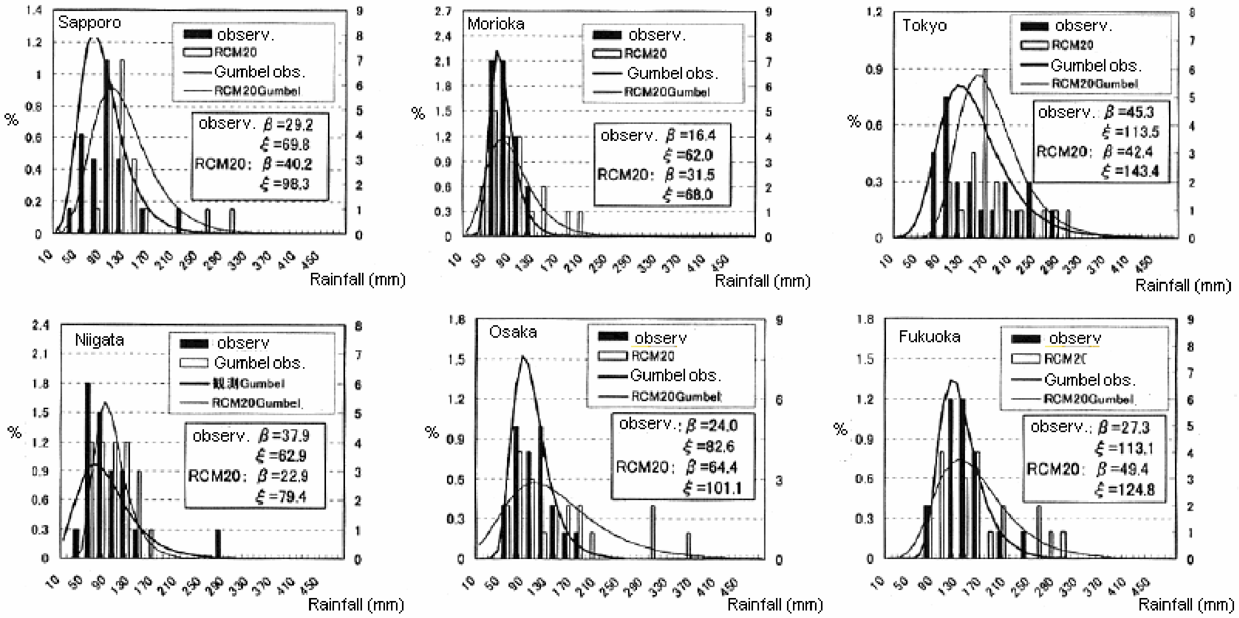

Figure 10 Gumbel Distribution of Annual Maximum Daily Precipitation (RCM20 and Observed Data)

A similar comparison was made for two-day precipitation and the β ratio for daily and two-day precipitation for major cities are shown in Figure 11. In eastern Japan the β ratio tends to be relatively low, but the probable precipitation values calculated from these results are excessively large compared with the probable precipitation values calculated from the measured values.

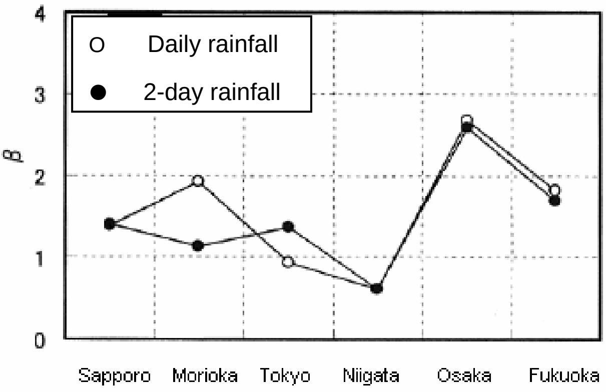

Figure 11 β ratio (RCM20/Observed) for Gumbel Distribution of Annual Maximum Precipitation

To solve this problem, a set of statistical samples obtained by standardizing data from multiple observation stations was prepared and analyzed by the method proposed by Sakurai et al.[19] Although there are no clearly defined criteria for standardizing data obtained from two or more observation stations, Kunitomo et al.[20] zoned Japan on a scale comparable to that of climate zoning and investigated probability distributions in each zone. In this study, since the smallest scale of meteorological disturbances that can be reproduced by the RCM20 is about 100 km, standardization was performed for 100km×100km areas, and a comparison of distribution patterns was made for 42 areas. The standardization was performed by using the following equations:

$$X = (x - \xi')/\beta' \tag{4}$$

$$\beta' = S_x \sqrt{6}/\pi \tag{5}$$

$$\xi' = x_m - \gamma \ \ \beta' \tag{6}$$

where x is annual maximum precipitation, x_m is the average of x and S_x is the standard deviation of x. The values used were data collected at the AMeDAS observation locations in each area.

As an example, Figure 12 shows the comparison of extreme value distribution patterns of annual maximum daily precipitation. Extreme value distributions derived from the model and the measured values show mostly similar distribution patterns. The extreme differences revealed by the location-by-location comparison have now been eliminated. It has been shown that data from different observation stations can be used for the evaluation of probable precipitation values by standardizing the data on a certain space scale. Annual maximum two-day precipitation data were processed in the same way as the annual maximum daily precipitation data, and the processed data were examined to investigate changes in the degree of similarity between the measured values and RCM20 outputs (Figure 13). The β ratio is somewhat high, but a high degree of similarity is indicated for all areas. Comparison with Figure 12 shows that evaluating on a certain space scale is an effective approach.

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[19] Sakurai, Y., Yamamoto, R., Iwashima, T., Noda, A., Yoshimatsu, K. and Kitoh, A. 1998

[20] Kunitono, M., Terada, H., Yanagihara, K. and Tsujimoto, K. 2003

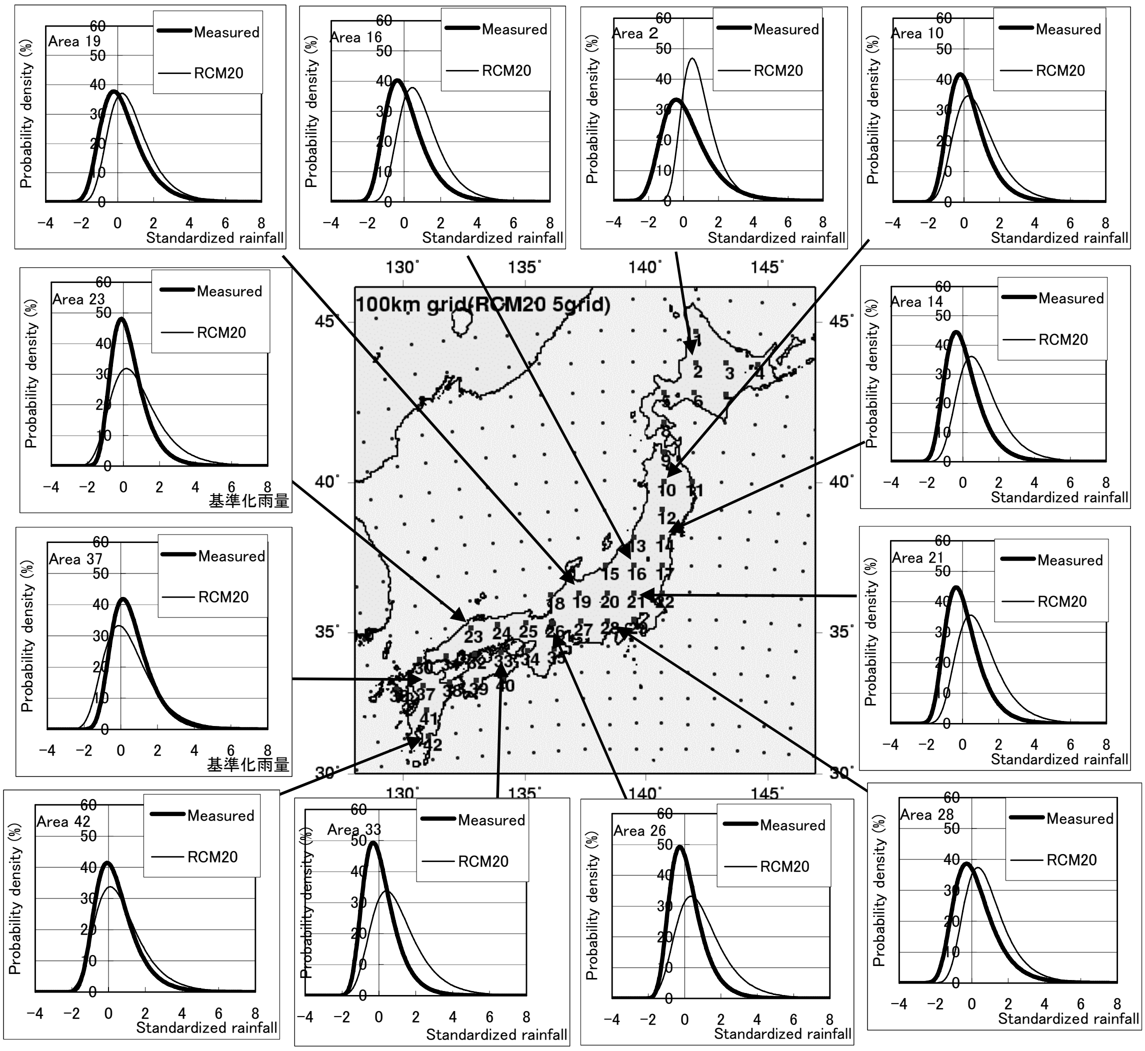


Figure 12 Comparison of Extreme Value Distribution Patterns of Annual Maximum Daily Precipitation

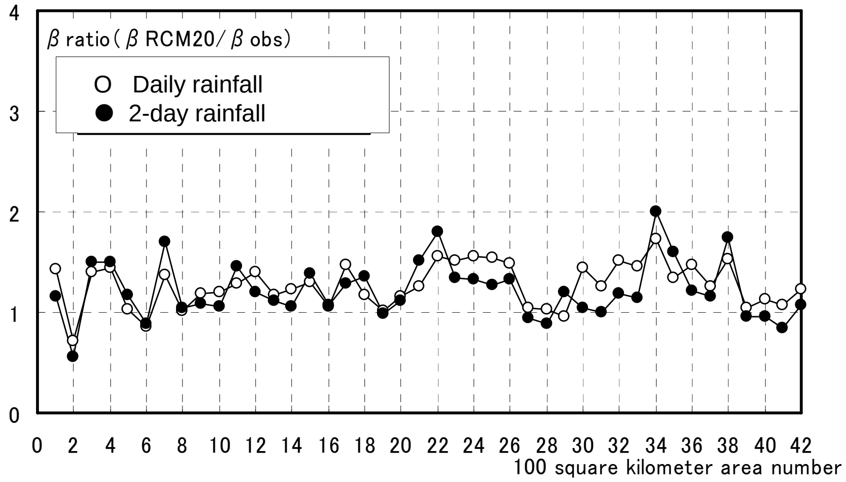


Figure 13 β ratio of Distribution Patterns of Annual Maximum Precipitation (Daily and Two-day)

(3) Prediction on Flood Risk of 50 and 100 years Later

Figure 14 shows a distribution map of 100-year probability maximum daily precipitation under the present climate conditions based on RCM20 calculation results. Figure 15 (1) and (2) show the distributions of 100-year probability maximum daily precipitation for 2031–2050 and 2081–2100, respectively. The present climate results show areas with 600 mm or more daily precipitation in the southeaster part of Kyushu and the southeastern part of the Kii Peninsula. The calculation results showing precipitation after 50 years do not show significant differences in intensity distribution patterns. The calculation results do show, however, that the number of land areas with maximum daily precipitations of 600 mm or more decreases while in the Hokuriku region probable rainfall increases. After 100 years, the tendency of probable rainfall to increase in the Hokuriku and Niigata coastal regions is even stronger, and there are even areas with maximum daily precipitations of 500 mm or more emerge.

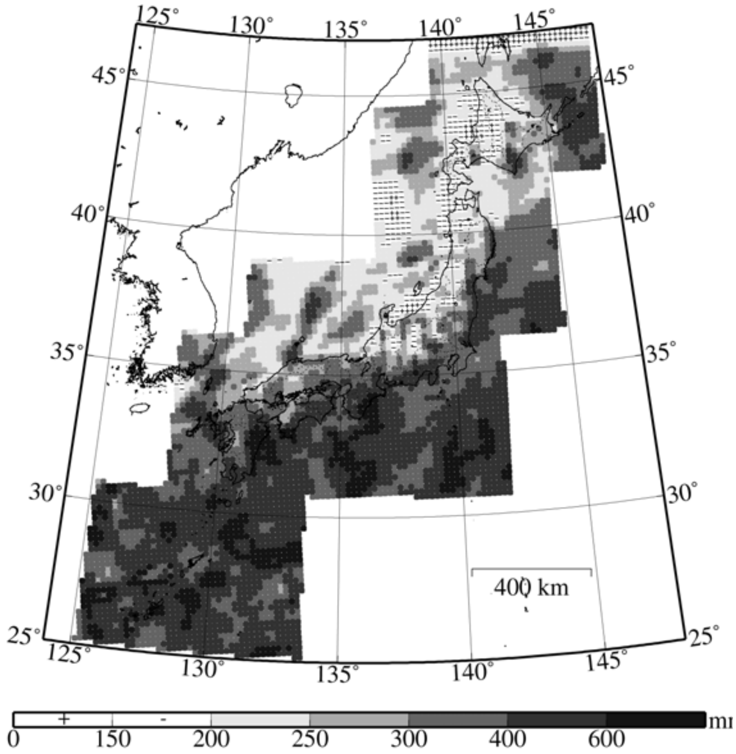
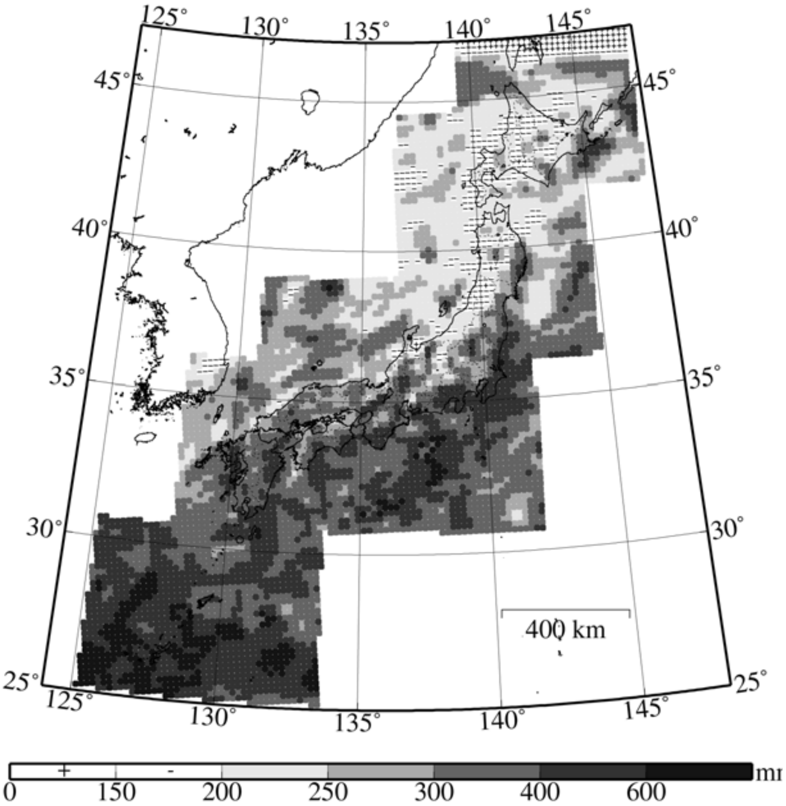
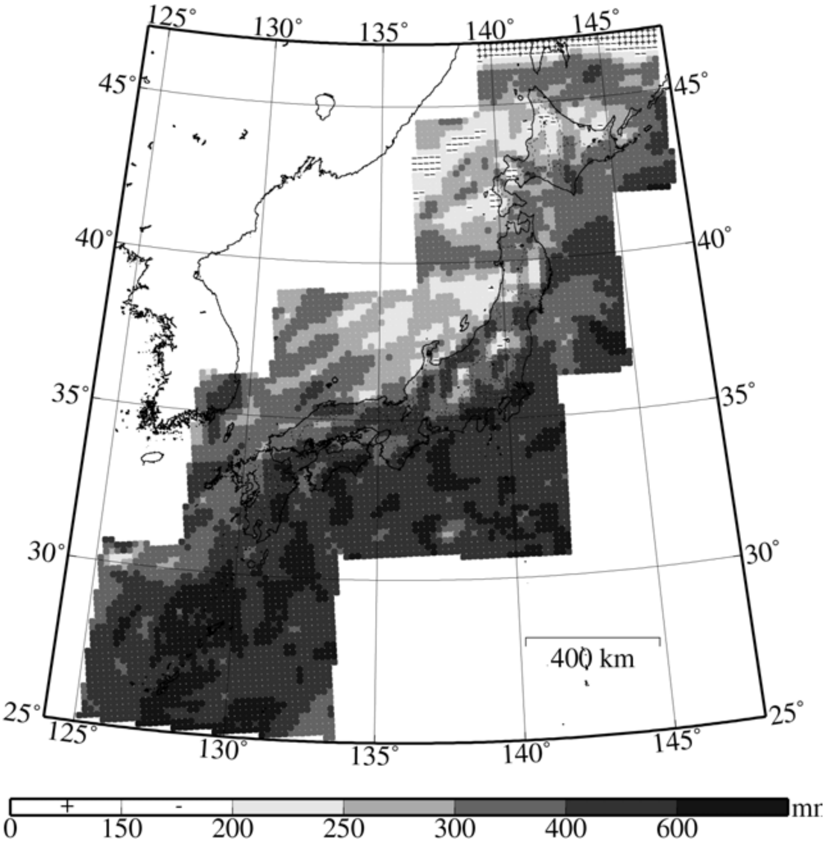


Figure 14 Distribution of 100-year Maximum Daily Precipitation in 1981-2000



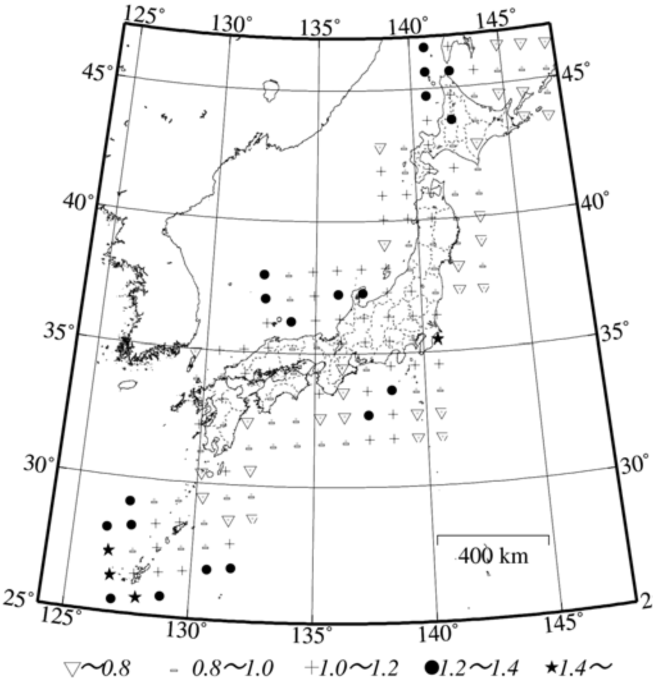
(1) 2031-2050



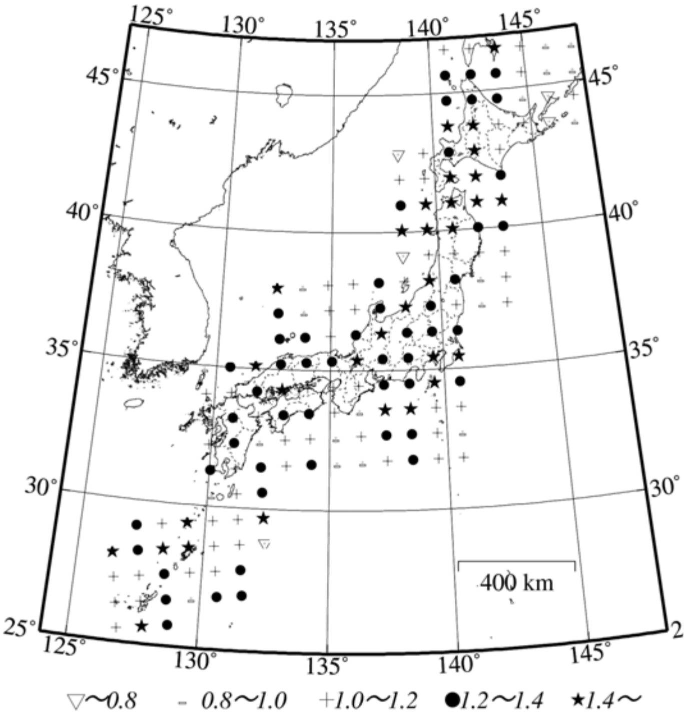
(2) 2081-2100

Figure 15 Distribution of 100-year Maximum Daily Precipitation

It is important to take averages on a certain space scale when evaluating probable precipitation by using the RCM20. In view of the fact that the minimum scale of meteorological disturbances that can be reproduced by the RCM20 is about 100 km, the 100-km grid averages of probable 100-year probability maximum daily precipitation values were calculated by using the mesh-specific probable values shown in Figure 14 and Figure 15, and the present values were compared with the corresponding values of 50 years and 100 years later (Figure 16).



(1) Ratio of 2031-2050 to 1981-2000



(2) Ratio of 2081-2100 to 1981-2000

Figure 16 Comparison of 100-year Maximum Daily Precipitation

100-year probability daily precipitation values for 50 years later show national average increases of 10 to 20%. Some areas, particularly northern Hokkaido, Kanto, Hokuriku and the Nansei Islands, show increases of more than 20%. After 100 years, the tendencies for 50 years later become even more pronounced, and increases of 40% or more occur in many areas including Hokkaido, northern Tohoku, Hokuriku and Kanto. A likely reason why increases in eastern Japan are more pronounced than in western Japan is that high pressure systems over the Pacific Ocean become stronger and move northward during global warming common to many global climate systems[21]. These tendencies resemble the phenomena observed during the heavy rains of July, 2004, in Niigata and Fukui, so these results are interesting because they indicate the possibility that the flood risk of the rivers in these areas might increase.

(4) Prediction of Drought Risk of 50 and 100 Years Later

When evaluating the influence of climate changes such as global warming on water resources, it is necessary to evaluate how streamflow is affected. In order to predict streamflow, it is necessary, not only to make highly accurate prediction of precipitation such as five-day or daily precipitation prediction, but also to perform precise hydrological runoff analysis so as to determine streamflow from precipitation. The previous section has revealed that the annual maximum precipitation in a global warming model is accurate enough for use in flood risk evaluation. Adequate verification has not yet been made, however, of the frequency of rains of different intensities or precipitation waveforms. The degree of reliability of runoff analysis is so poor that it is difficult in this study to calculate drought risk from streamflow fluctuations. Therefore, it is realistic that the direct impact of annual or monthly precipitation estimates was forecast, while ongoing efforts to enhance the accuracy of climate change forecasting and the reliability of hydrological runoff analysis are carefully noted.

Annual precipitation is not directly related to drought risk. It is not uncommon that drought can occur even in cases where annual precipitation is greater than normal year precipitation as shown by the precipitation–drought data for Tonegawa River Basin (Table 2), for example. The reason is that there are years in which two or three consecutive below-normal precipitation months are often preceded or followed by above-normal precipitation months so that annual precipitation becomes above normal. This indicates that drought risk could be overlooked unless it is considered on a shorter time scale. Seasonal precipitation was therefore used in addition to annual precipitation, for drought risk evaluation.

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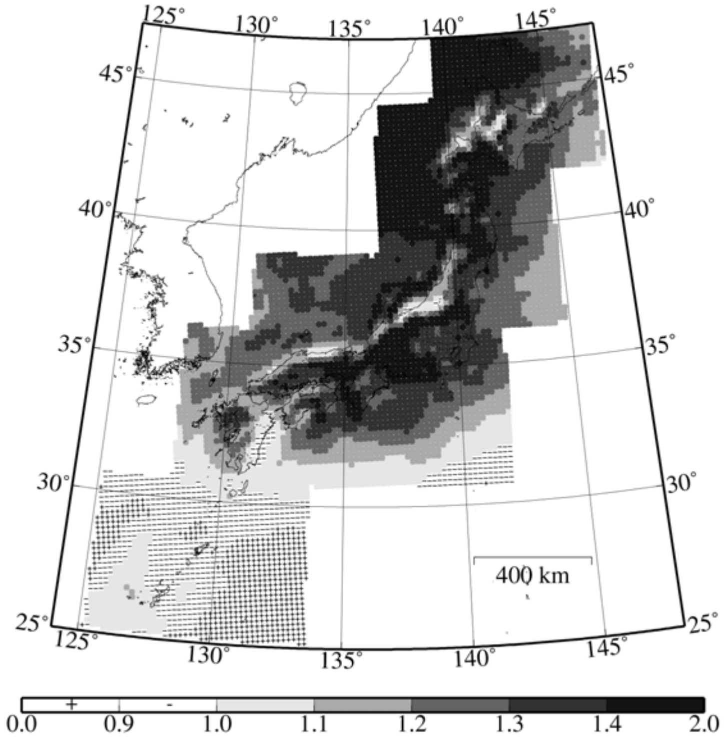
[21] Nishimori, M. and Kitoh, A. 2002

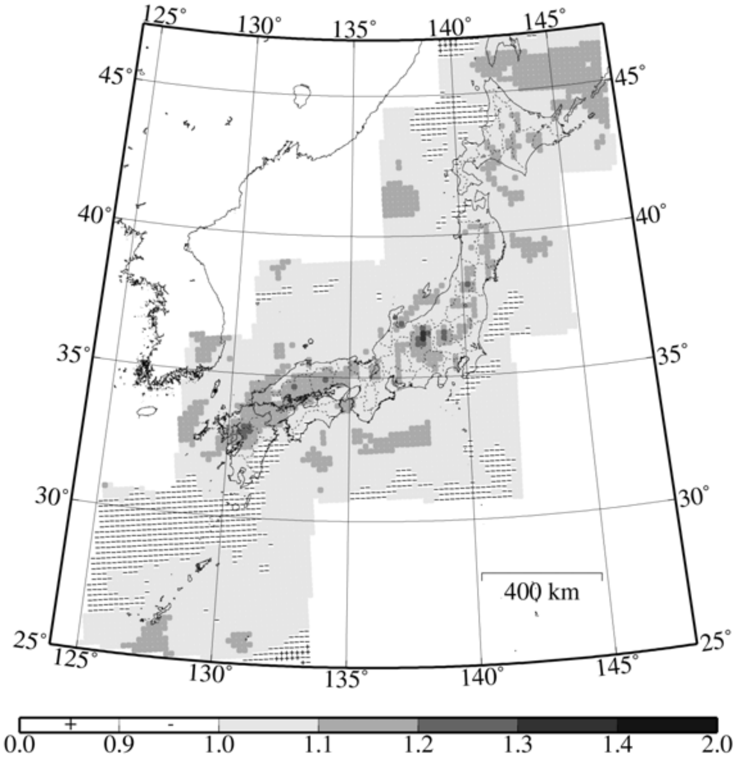
Table 2 Annual Precipitation at Maebashi and Drought Event in the Tonegawa River Basin

Year	Precipitation (mm/year)	Drought event	
1996	815.5	January to March, August and September	
1984	816.5		
1978	847.5	August and September	
1994	970.5	July to September	
1980	1060.0	July	
1995	1075.5		
1997	1078.5	January to March	
1979	1100.0	July and August	
1985	1140.5		
average	1162.6		
1983	1163.0		
2000	1163.0		
1992	1174.0		
1977	1186.0		
1987	1191.5	June to August	Total precipitation from March to June is -42% of the average
1990	1201.0	July and August	Total precipitation from May to August is -33% of the average
1986	1240.5		
1982	1275.0	July	Total precipitation from December to March is -66% of the average
1981	1283.0		
2001	1316.0	August	Total precipitation from April to July is -15% of the average
1993	1346.5		
1988	1356.5		
1991	1438.5		
1999	1495.0		
1998	1649.5		
1989	1657.5		

Annual precipitation and seasonal precipitation were calculated from the RCM20 outputs for 1981–2000, 2031–2050 and 2081–2100, and the ratio between the two periods was investigated. Figure 18 (1) shows the calculated rates of change in annual precipitation 50 years after the present, and Figure 18 (2) shows the rates of changes 100 years after the present. As shown, annual precipitation 50 years after the present is 20% or more higher than at present in many areas except on the Sea of Japan side of the country. Annual precipitation 100 years after the present is also higher than at present, but only by 20% or less. This indicates that, while precipitation may increase for 50 years, it is expected to decrease later. Figure 18 to Figure 21 show the calculated rates of change in seasonal precipitation. These figures indicate that as in the case of annual precipitation, the increasing trends of precipitation expected 50 years later will somewhat slow down 100 years from now, and that in large areas except Hokkaido, seasonal precipitation in winter and spring is likely to decrease. One of the causes of this is thought to be that, as predicted by many global climate models currently in use in many countries such as the CGCM2, weakened cold air currents from the Siberia will reduce snowfall in times of global warming. Precipitation decreases in winter and spring result in decreases in snowmelt floods in March to May in snowy regions, which give a substantial influence in agricultural water use, especially for rice paddy fields.

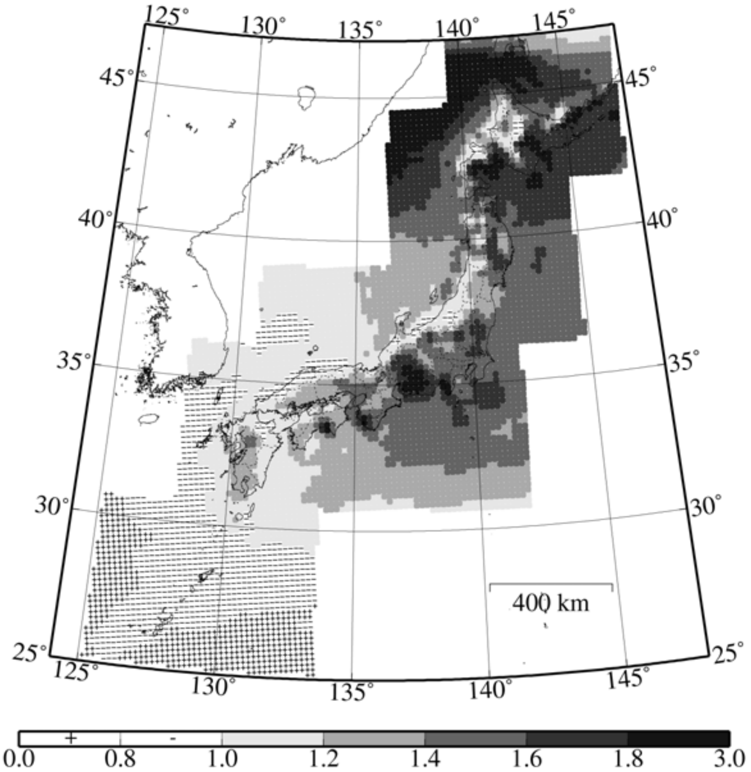


(1) Ratio of 2031-2050 to 1981-2000

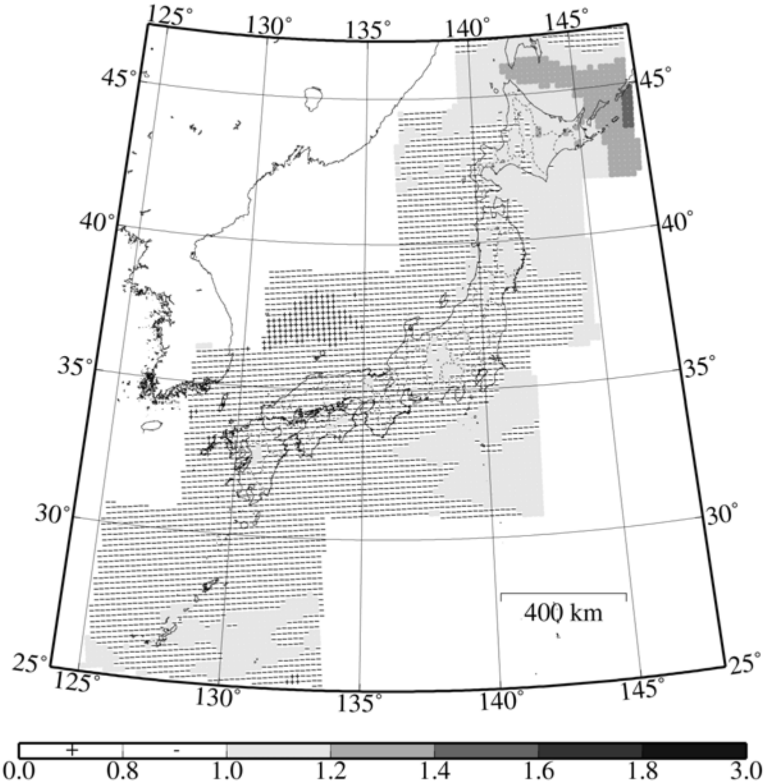


(2) Ratio of 2081-2100 to 1981-2000

Figure 17 Comparison of Annual Precipitation

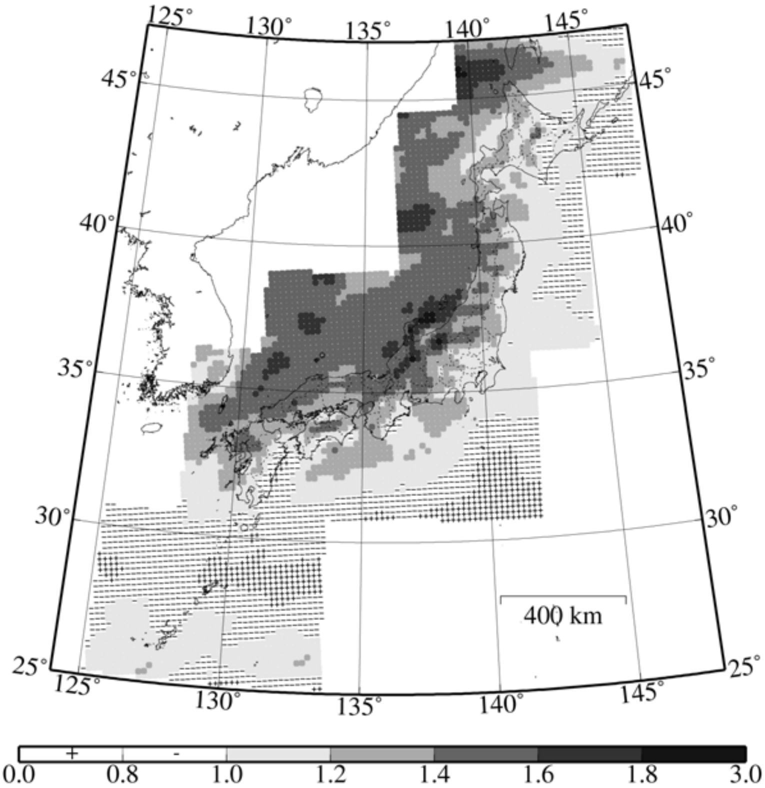


(1) Ratio of 2031-2050 to 1981-2000

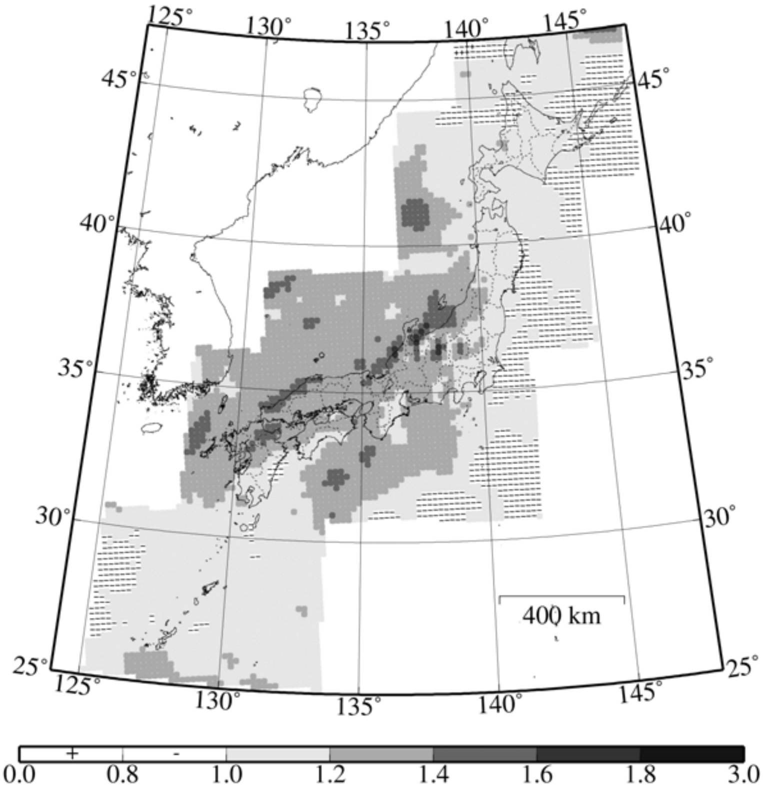


(2) Ratio of 2081-2100 to 1981-2000

Figure 18 Comparison of Spring Precipitation

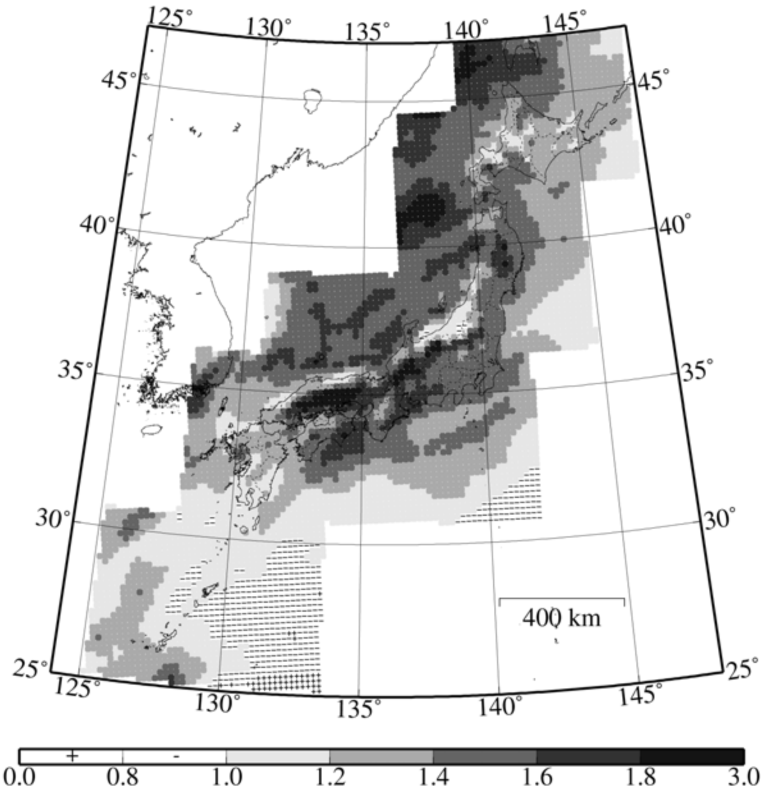


(1) Ratio of 2031-2050 to 1981-2000

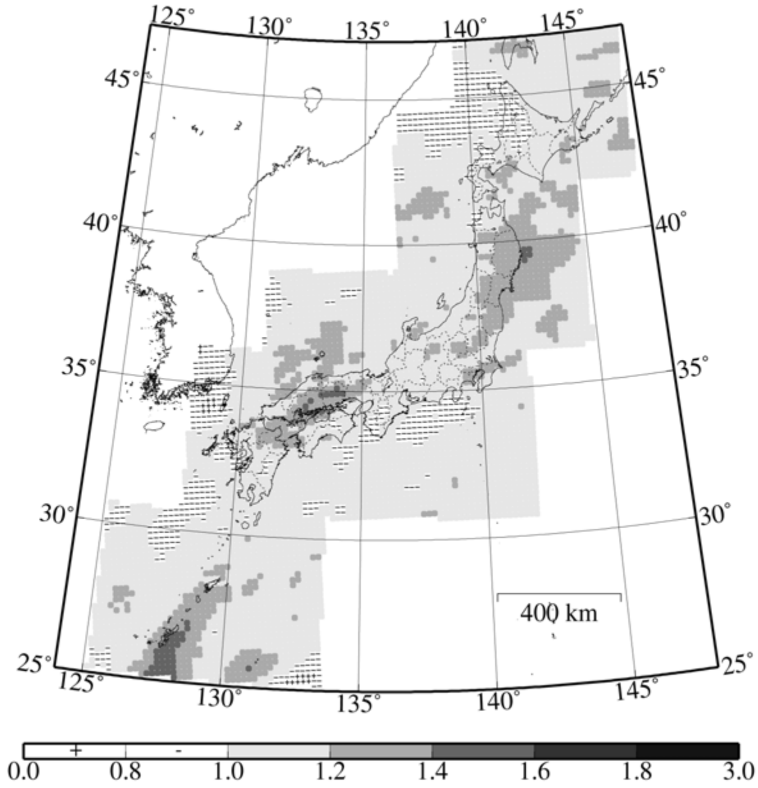


(2) Ratio of 2081-2100 to 1981-2000

Figure 19 Comparison of Summer Precipitation

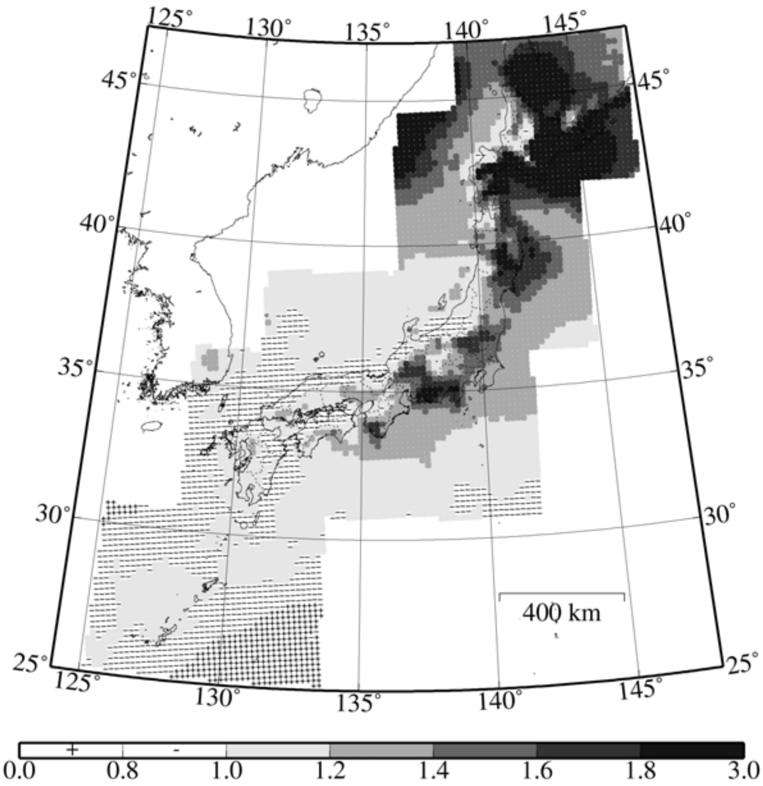


(1) Ratio of 2031-2050 to 1981-2000

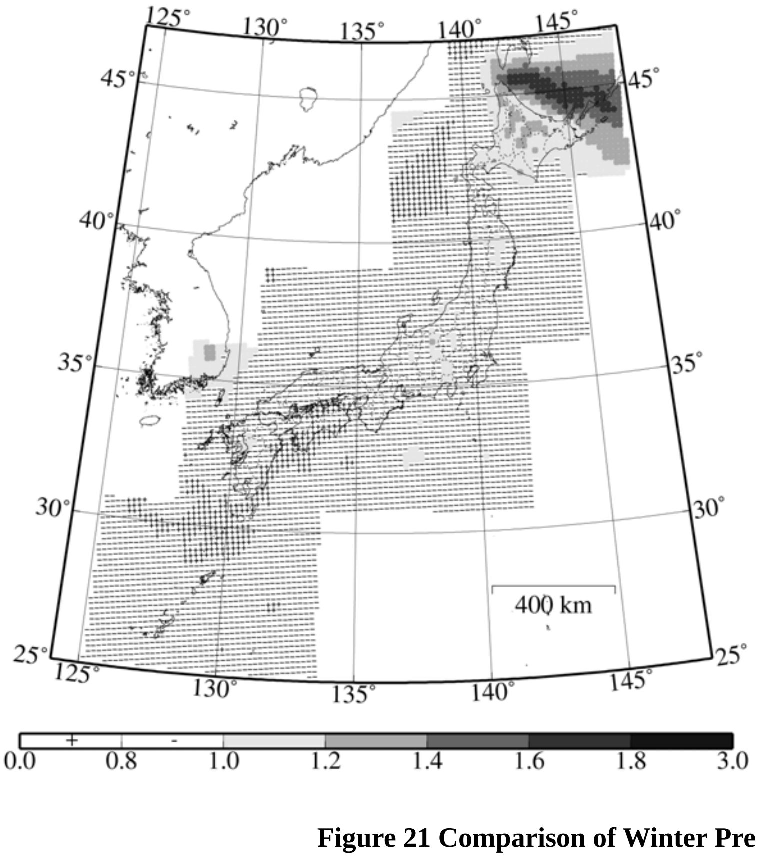


(2) Ratio of 2081-2100 to 1981-2000

Figure 20 Comparison of Autumn Precipitation



(1) Ratio of 2031-2050 to 1981-2000



(2) Ratio of 2081-2100 to 1981-2000

Figure 21 Comparison of Winter Precipitation

(5) Flood and Drought Risk Predicted by Regional Climate Model in Japan

Flood and drought risk trends in different regions under the influence of global warming have been analyzed on the basis of the results of precipitation observations collected in Japan for the past 100 years. Global warming estimates obtained from a climate model developed by the MRI of the JMA have been used to predict and analyze flood and drought risk trends in different regions as follows:

(a) Trends of 100-year probability maximum daily precipitation were investigated by using precipitation data for the past 100 years at 40 meteorological stations in Japan that had collected annual maximum daily rainfall data for the past 100 years. As a result, it has been found that the probability of 100-year floods has increased at 28 locations, and flood risk has increased accordingly.

(b) Trends of annual precipitation at 51 meteorological stations that had collected annual precipitation data for the past 100 years have been investigated. Decreasing trends were indicated at about 90 percent of those stations. At four out of the seven locations at which increasing trends were observed, it has been found that 1/10-rainfall used as an indicator of drought shows a tendency to decrease. The decreasing trends of annual precipitation and the increasing degrees of its fluctuation indicate that drought risk is growing.

(c) The accuracy of the MRI's global climate model (CGCM2) and regional climate model (RCM20) has been verified. While the accuracy of the CGCM2 in reproducing monthly precipitation trends in northern Japan and southern Kyushu has been found inadequate in some respects, the RCM20 has been found highly accurate in reproducing normal year values of regional monthly precipitation, indicating that the model can be used for drought risk evaluation that uses monthly precipitation, seasonal precipitation and annual precipitation as indicators.

(d) The accuracy of modeled extreme values has been verified for the purpose of flood risk evaluation, it has been found that annual maximum daily precipitation values obtained from the CGCM2 whose horizontal resolution is 280 km are about 20% smaller than measured values. The RCM20 gives values 20 to 30% greater than measured values, but the model has been found to be highly accurate throughout the country. Thus, it has been ascertained that the model can be used for flood risk evaluation.

(e) In order to calculate probable precipitation for use as a flood risk indicator, comparison was made of the distribution patterns of the frequency of occurrence of measured and calculated extreme values during continuous periods. The comparison revealed the existence of locations showing very different distribution patterns, indicating that when comparing present and future drought risks, it is necessary to use values averaged over areas measuring about 100 km × 100 km.

(f) Present and future probable precipitation amounts have been compared by using estimates obtained from the RCM20. The comparison revealed that 100-year probability values of daily precipitation would be higher 50 years later throughout the country—more than 40% in the northern Hokkaido, northern Tohoku and Hokuriku regions, indicating increased flood risks.

(g) The results of drought risk evaluation performed by using calculation results obtained from the RCM20 indicate that winter and spring precipitation in all regions except Hokkaido will increase under the influence of global warming and that drought risks during the snowmelt flood season might increase in some areas.

2.2 UNCERTAINTY FOR CLIMATE CHANGE[22]

The 4th IPCC report (IPCC 2007) recalls that there are major uncertainties in future climate projections, as well as in future socio-economic trends[23]. The latter are important in determining the vulnerability of social and economic systems to climate change, as well as their adaptive capacity. There are also major uncertainties over the future baseline for adaptation, i.e. in considering which emission and mitigation trajectory we are on. The 2009 international scientific congress on climate change confirmed that the (globally) worst-case IPCC 2007 scenario trajectories (or even worse) are being realized and there is a significant risk that many of the trends will accelerate, leading to an increasing risk of abrupt or irreversible climatic shifts. In Figure 22, the 21st century warming is shown as continuation of the 20th century simulations. Solid lines are multi-model global averages of surface warming (relative to 1980–1999) for three SRES (IPCC's Special Report on Emissions Scenarios) marker scenarios (A2, A1B and B1). Shading denotes the ±1 standard deviation range of individual model annual averages. The line "Year 2000 Constant Concentrations", the most flat line for the experiment where concentrations were held constant at year 2000 values, shows that we are already committed to 0.6 °C warming due to the past greenhouse gas emissions. The grey bars at right indicate the likely range assessed for the six SRES marker scenarios and the solid line within each bar indicates the best estimate. The assessment of the best estimate and likely ranges in the grey bars includes the AOGCMs (Atmosphere-Ocean coupled General Circulation Model) in the left part of the figure, as well as results from a hierarchy of independent models and observations

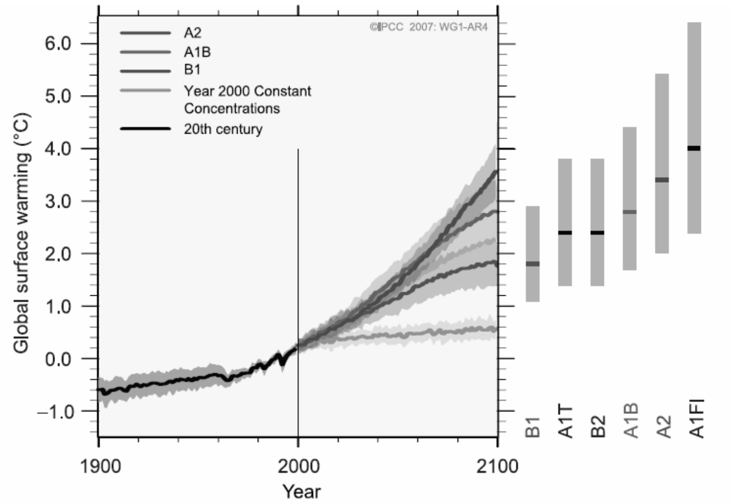


Figure 22 Best values and likely ranges of global mean warming for the time horizon of 1900-2099 relative to the control period of 1980-99 [24]

It is therefore necessary to consider a wide range of scenarios in formulating possible adaptation policy. The available information is however still fragmented, and the 2008 EEA/JRC/WHO report relies on different global scenarios and regional downscaling for about 40 climate impact indicators. The report identifies 3 basic types of uncertainty:

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[22] WMO 2009a

[23] IPCC 2007

[24] Ibid.

- **Incomplete knowledge**: Responses in systems with high levels of complexity such as biological, social or economic systems are very difficult to assess. Climate impacts can either be increased by other, non-climatic factors, or compensated by adaptation of the system, or internally compensated until a critical level of resilience is exceeded.
- **Insufficient observed trends**: Observed data and trends for many of the impact indicators often lack the appropriate spatial and temporal scale to provide the adequate level of information to properly develop and assess adaptation strategies.
- **Socio-economic developments**. The most important sources of uncertainty are human behaviour, evolution of political systems, demographic, technological and socio-economic developments. To address this issue requires using a set of global emission scenarios, such as the ones presented in the last IPCC reports, and making use of consistent regional socio-economic and climate change and impact projections as soon as they become available.

Additionally, the tools for integrated assessment of adaptation policies are still much less advanced[25] than those addressing mitigation. This delay is due to some extent to the misunderstanding and misinformation surrounding adaptation, perceived as a substitute for mitigation. However, adaptation integrated assessment poses also methodological problems, such as up-scaling from the local to the regional or national level, or measuring the vulnerability and the degree of adaptation. A description of the most relevant projects in EU is provided in the EU white paper[26].

2.3 ADAPTIVE MANAGEMENT TOWARDS UNCERTAINTY

Significant investment will be needed to tackle climate change impacts, and the need for long-term anticipation raise the question of efficiency of public spending: governments expect decisions to be based on the ‘best possible’ science. The science of climate prediction is unlikely to fulfill the expectations of decision-makers and, through over-precision, could potentially lead to mal-adaptation if misinterpreted or used incorrectly. These epistemological limits to climate prediction should however not be interpreted as a limit to adaptation[27], and climate adaptation strategies can be developed in the face of deep uncertainties. Society will even benefit much more from a greater understanding of the vulnerability of climate-influenced decisions to large irreducible uncertainties than it will from extremely expensive attempts to increase the accuracy and precision of climate predictions. An alternative approach to the conventional one based on climate prediction would therefore focus on exploring how well strategies perform across wide ranges of assumptions and uncertainties (Robust Adaptation Decision-Making).

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[25] Dickinson, T. 2007, p.1

[26] EU 2009

[27] Hulme, M. et al. 2008

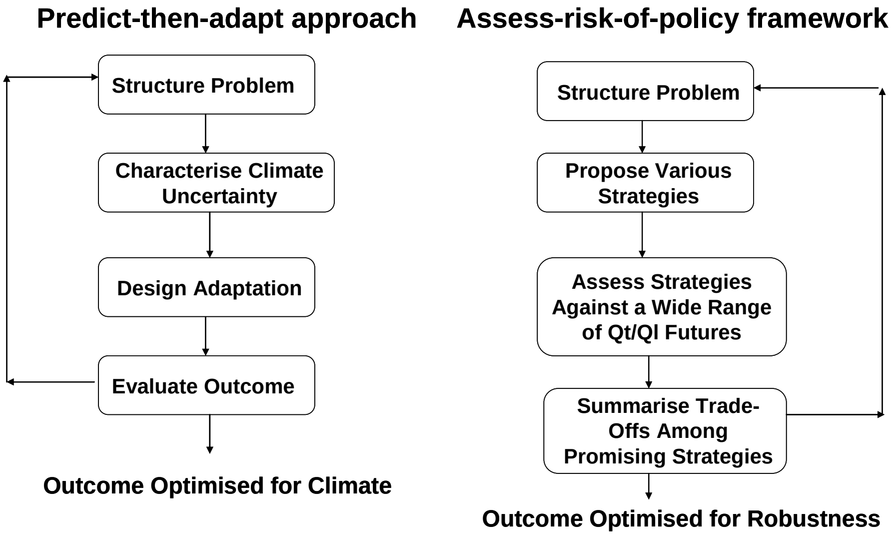

Figure 2.26 Alternative approaches for uncertainty management[28]

Given the deep uncertainties associated with long term climate change impacts and other drivers of adaptation to climate change, robust decision making methods are worth exploring, especially where there is a large portfolio of adaptation options available. This context also favors the implementation of a flexible or adaptive management, involving putting in place incremental adaptation options, rather than undertaking large-scale adaptation all at once. These measures are mainly preparations towards, or incremental introduction of, more costly or risky measures. They include the assessment of further adaptation measures that makes sense today, but as part of a sequence of responses that also allows for incremental or directional change in future, as vulnerability, knowledge, experience and technology evolve. This may also include delaying implementing specific (potentially harmful) adaptation measures while exploring options and building the necessary standards and regulatory environment.

2.4 CONCLUDING REMARK

The Fourth Assessment Report of IPCC has concluded that warming of the climate system is unequivocal, evident from observed increases in global average air temperature, ocean temperature and other observation. There is no doubt that this climate change is going to have impact on the hydrological cycle which is sensitive to the temperature. The urgency is to understand how the change affects the extreme events that are reflected in the hydrological extremes like floods and droughts. According to the analysis of observed data, the probability of 100-year floods has increased at about 70 percent of the observation stations for the past 100 years while 1/10-rainfall used as an indicator of drought shows a tendency to decrease at about 90 percent of those stations. For the prediction, the global and regional climate models predict and analyze flood and drought risk trends in different regions. 100-year probability values of daily precipitation would be higher 50 years later throughout the country—more than 40% in the northern Hokkaido, northern

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[28] Hulme, M. et al. 2008

Tohoku and Hokuriku regions, indicating increased flood risks. The winter and spring precipitation in all regions except Hokkaido will increase under the influence of global warming and that drought risks during the snowmelt flood season might increase in some areas. It should be noted that there are major uncertainties in the adaptation to climate change and variability. Three basic types of uncertainty are classified as incomplete knowledge, insufficient observed trends and socio-economic development. Such uncertainties favor the implementation of a flexible or adaptive management, involving putting in place incremental adaptation options, rather than undertaking large-scale adaptation all at once. Following issues need to be address while discussing climate change and water resources management.

- The accuracy of the MRI's global climate model (CGCM2) in reproducing monthly precipitation trends in northern Japan and southern Kyushu has been found inadequate in some respects, but the regional climate model (RCM20) has been found highly accurate in reproducing normal year values of regional monthly precipitation, indicating that the model can be used for drought risk evaluation that uses monthly precipitation, seasonal precipitation and annual precipitation as indicators.
- The modeled extreme values showed annual maximum daily precipitation values obtained from the CGCM2 whose horizontal resolution is 280 km are about 20% smaller than measured values. The regional climate model RCM20 gives values 20 to 30% greater than measured values, but the model can be used for flood risk evaluation.
- The comparison between present and future probable precipitation amounts by using estimates obtained from the RCM20 revealed that 100-year probability values of daily precipitation would be higher 50 years later throughout the country—more than 40% in the northern Hokkaido, northern Tohoku and Hokuriku regions, indicating increased flood risks.
- The results of drought risk evaluation performed by using calculation results obtained from the RCM20 indicate that winter and spring precipitation in all regions except Hokkaido will increase under the influence of global warming and that drought risks during the snowmelt flood season might increase in some areas.
- There are major uncertainties in future climate projections, as well as in future socio-economic trends. The latter are important in determining the vulnerability of social and economic systems to climate change, as well as their adaptive capacity.
- Given the deep uncertainties associated with long term climate change impacts and other drivers of adaptation to climate change, limits to climate prediction should not be interpreted as a limit to adaptation. Climate adaptation strategies can be developed in the face of deep uncertainties so would therefore focus on exploring how well strategies perform across wide ranges of assumptions and uncertainties. Such robust decision making methods are worth exploring.

3. TOP-DOWN APPROACHES TO WATER RESOURCES PLANNING

The previous chapter shows a synthesis of the physical aspects of changing climate and provides a scientific basis to support further studies of water resources impacts. However, much further work is needed to assess the multi-dimensional impacts and cascading effects on water resources affecting humans and the environment. Climate projections are being used to explore possible water supply scenarios to which water managers may need to adapt, while such scenarios include uncertainty. This chapter discusses the potential uses of the information in water resources management, including assessing vulnerabilities and creating adaptive strategies, focusing on vulnerability analysis with two pathways for integrating climate information into water resources planning and management.

3.1 TOP-DOWN AND BOTTOM-UP APPROACHES TO CLIMATE CHANGE

Climate change will affect water use and management in Japan. Change in economics, land use, environment and population growth are already affecting water management decisions. Water managers and planners currently face specific challenges that may be further exacerbated by projected climate changes, as summarized in Table 3.

Table 3 Challenges Faced by Water Managers and Projected Changes[29]

Issues	*Observed and/or Projected Change*
Water demands for agriculture and outdoor watering	Increasing temperatures raise evapotranspiration by plants, lower soil moisture, alter growing seasons, and thus increase water demand
Water supply infrastructure	Change in snowpack, streamflow timing, and hydrograph evolution may affect reservoir operations including flood control and storage. Change in the timing and magnitude of runoff may affect functioning of diversion, storage, and conveyance structures.
Legal water systems	Earlier runoff may complicate prior appropriation systems and interstate water compacts, affecting which rights holders receive water and operations plans for reservoirs.
Water quality	Although other factors have a large impact, "water quality is sensitive both to increased water temperatures and changes in patterns of precipitation[30]." For example, changes in the timing and hydrograph may affect sediment load and pollution, impacting human health.
Energy demand and operating Costs	Warmer air temperatures may place higher demands on hydropower reservoirs for peaking power. Warmer lake and stream temperatures may affect water use by cooling power plants and in other industries.
Mountain habitats	Increasing temperature and soil moisture changes may shift mountain habitats toward higher elevations.
Interplay among forests, hydrology, wildfires, and pests	Changes in air, water, and soil temperatures may affect the relationships between forests, surface and ground water, wildfire, and insect pests. Water-stressed trees, for example, may be more vulnerable to pests.
Riparian habitats and fisheries	Stream temperatures are expected to increase as the climate warms, which will have direct and indirect effects on aquatic ecosystems[31], including the spread of in-stream non-native species and diseases to higher elevations, and the potential for non-native plant species to invade riparian areas. Change in streamflow intensity and timing may also affect riparian ecosystems.
Water- and snow-based Recreation	Change in reservoir storage affect lake and river recreation activities; changes in streamflow intensity and timing will continue to affect rafting directly and trout fishing indirectly. Changes in the character and timing of snowpack and the ratio of snowfall to rainfall will continue to influence winter recreational activities and tourism.
Groundwater resources	Changes in long-term precipitation and soil moisture can affect groundwater recharge rates; coupled with demand issues, this may mean greater pressures on groundwater resources.

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[29] CWCB, 2008 p.41

[30] CCSP, 2008 p.149 and others

[31] Ibid.

Two pathways for integrating climate information into water resources planning and management are vulnerability analysis and integrated water resource planning. Vulnerability analysis includes both top-down and bottom-up perspectives[32]. In the top-down perspective, projections of global or spatially downscaled models are used to drive resource models and project resource impacts (Figure 23). The study in 2.1.2 showed one of these approaches. These top-down perspectives are still limited by the current state of the art of climate models, downscaling techniques and observations.

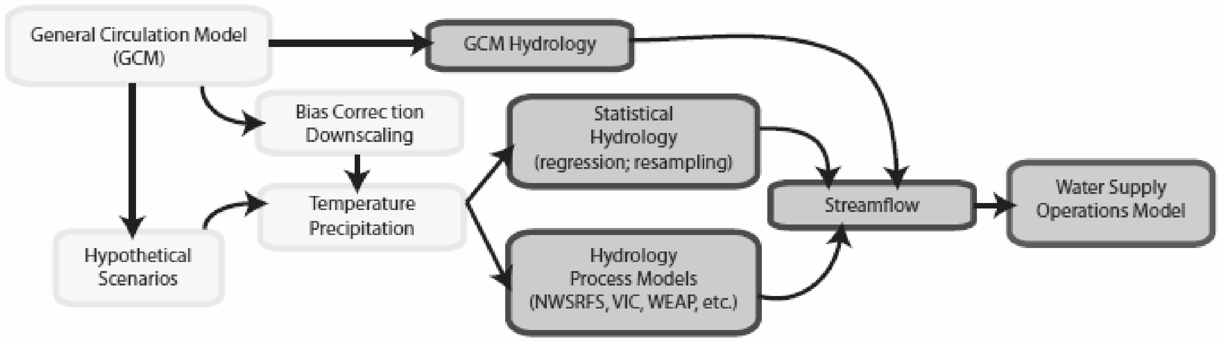

Figure 23 The Progression of Data and Models from Climate Models to Streamflow[33]

Another approach is referred to as bottom-up, illustrated in Figure 24. In this approach, water managers start with their knowledge of their system and utilize their water supply planning tools to identify what changes in climate would be most threatening to their long-range plans or operations. This is known as the threshold approach. The next step is to assess what adaptations can be made to cope and roughly at what cost. By examining the outputs of climate models or studies, water managers can then assess what is the likelihood of such system critical vulnerabilities. Climate change information can be incorporated into either top-down scenario driven or bottom-up vulnerability assessments. The assessments remain uncertainties in projections of temperature, precipitation, and runoff; model formulation; emissions scenarios; and the role of natural variability. Therefore, water managers will have to make plans based on a range of possible futures. This uncertainty suggests the necessity of long-term planning approach that integrates multiple facets of water management challenges, and is a strategy for keeping wide range of options open and maintaining flexibility in the face of uncertain futures. This strategy is important given the uncertainties about climate futures.

Although there are uncertainties regarding aspects of the science, enough information is available to support adaptation planning for risks associated with climate change variability and change. A continuing dialogue among climate scientists, water resources managers, planners, and policymakers will ensure that the robust scientific findings benefit society.

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[32] CWCB 2008, pp.40-43

[33] Ibid. p.22

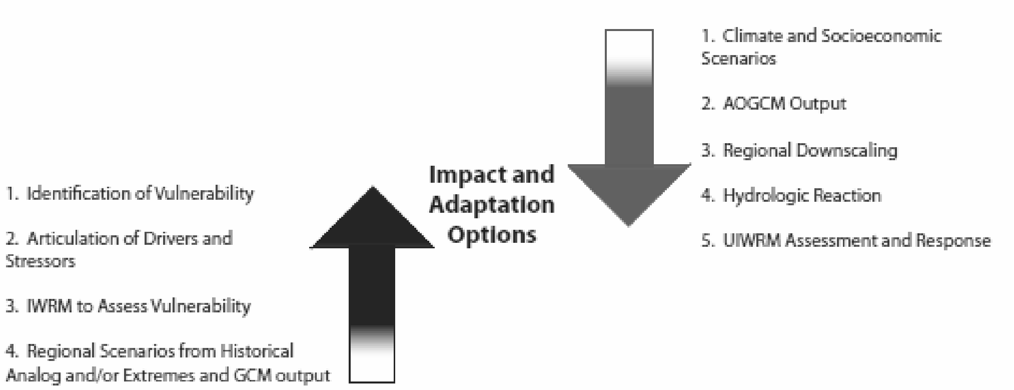

Figure 24 Bottom-up and top-down approaches to climate change assessment[34]

3.2 World Water Assessment Programme

One of top-down approaches for water resources planning can be seen in the World Water Assessment Programme (WWAP)[35]. WWAP was launched at the Second World Water Forum and has developed as a UN systemwide program under the 23 agencies of what is later referred to as UN Water. WWAP is focusing on developing indicators using new methodologies; assessing the water situation as it affects economic, social and environmental development; identifying actions to be taken at local to global levels; presenting guidelines for improving water policy and management; and helping to build capacity to make effective in-country assessments. A major output of WWAP is the World Water Development Report (WWDR). The first edition of the WWDR was released at the Third World Water Forum held in Kyoto in 2003. Through the WWAP, the WWDR monitored progress in achieving targets in such fields as health, ecosystems, industry, energy, risk management, water valuation, resource sharing, knowledge base construction, and cities and governance through seven case studies, including the Greater Tokyo region. As a member of National Institute for Land and Infrastructure Management, MLIT (NILIM-MLIT), the author worked on the case study in the Greater Tokyo region since 2001 in addition to supplying information of several kinds in the other parts of the WWDR[36,37].

3.2.1 Greater Tokyo Region Case Study for WWAP

The Greater Tokyo region (hereafter "Tokyo region") that is a group of densely populated mega-cities includes five river basins (Tonegawa, Arakawa, Tamagawa, Tsurumigawa and Sagamigawa) covering an area of about 22,600 km^2 with a total population of 27 million and total assets of about $2.9 trillion. Human and industrial activities have caused various water-related problems in the Tokyo region, prompting growing demands for better water quality, diversification and protection and further improvement of the environment. While infrastructure such as dams and levees are in use, great emphasis is now placed on public awareness and disaster preparedness. It is difficult to manage the enormous water resources needed

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[34] CWCB 2008, p.42

[35] UN/WWAP 2003, pp.481-498

[36] Murase, M. 2003a

[37] Murase, M. 2004

to supply the cities and to maintain an adequate degree of safety from water shortages. In addition, groundwater withdrawal is still causing land subsidence. In the Tokyo region, about 13.25 million people and assets worth 170 trillion yen are concentrated on 4,800 km^2 of alluvial plains, which means that floods often cause severe damage. This problem is worsened by the fact that the Asian Monsoon inflicts severe weather conditions on the Tokyo region. Changes in land use and intensification of rain storms seen in recent years have also amplified the danger from floods[38]. Furthermore, intense urbanization has caused a deterioration of water quality in the Tokyo region. Actions such as effluent control and sewage maintenance have been taken to reduce the discharge load. Consequently, water quality has started to recover in major rivers. However, the effluent concentration is still high in some tributaries, lakes and marshes. Also, environmental endocrine disruptors have appeared recently, causing additional water problems. Another rising problem is the increase of non-native species due to the importation of fishes and plants: an activity that has an impact on the ecosystem. Based on the above observation, the Greater Tokyo case study focused on the following five points:

1) Managing risk: flood risk indicators,
2) Governing water wisely: public involvement,
3) Sharing water resources: cooperation between upstream and downstream areas,
4) Water and the ecosystem: development of water quality indicators, and
5) Ensuring the knowledge base: sharing water-related information to promote cooperation.

As a measure taken to prevent serious flood damage in the Tokyo region, an easily comprehensible indicator showing the degree of flood damage risk has been developed and introduced to the public. In order to reflect the opinions of the region's inhabitants in river improvement planning, River Administrators now involve the public in the planning process. The comprehensive evaluation of various policies for the efficient use of limited water resources has been undertaken. These policies include cooperation between authorities in upstream and downstream areas and an integrated water basin approach to the hydrological cycle. Traditional water management has been supplemented by new water quality indicators developed for the Tokyo region. A more comprehensive river information system is expected to make a more effective contribution to water resources management, flood control and management of the environment.

Of the five points of the regional concern, this case study sought to propose the indicators for two aspects; flood risk and water quality. The other three aspects (governance, resources sharing and knowledge base) can more favor the implementation of a flexible or adaptive management as the bottom-up approach, which is explained in the next chapter. In this chapter, the development of indicators in the case study is discussed as the indicators can contribute to predict problems and then to solve them as the top-down approach for water resources planning.

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[38] IPCC 2001

3.2.2 Flood Risk Indicator

The average precipitation in the Tokyo region has been 1,551mm/year for the past 30 years. As described in the former chapter, the frequency of torrential rainfall of more than 100mm/day has increased significantly in Japan[39]. Located in the Asian Monsoon zone and the location of a high concentration of population and assets, the Tokyo region is highly vulnerable to flood damage. In 10 years (1991-2000), losses resulting from flood damage amounted to about 900 billion yen. The biggest losses were suffered in 1991 and 1998, when they were worth 200 billion yen and a little under 200 billion yen respectively. Flood damage has barely decreased in severity, because of the rising concentration of population and property. As a measure taken to prevent serious flood damage in the Tokyo region, an easily comprehensible indicator showing the degree of flood damage risk has been developed and introduced to the public. However, the high concentration of people and industry means that any success could be easily reversed and creates many risks.

Traditionally, construction works like levee maintenance and dam construction have been carried out as river improvement countermeasures in Japan. Thanks to levee improvement, 34.8% completed by 1985 and 45.9% by 1999, flood adjustment capacity increased from 325 million m^3 in 1985 to 685million m^3 in 2001[40]. Although embankment works have improved the degree of flood control safety, there is still fear of floods causing severe damage because of the high concentration of population and assets within the region’s river basins. Therefore, other measures are necessary to reduce flood damage. Hitherto, non-structural measures in the Tokyo region consisted of flood warnings, announcement of flood protection measures and preparations for the evacuation of inhabitants. Flood hazard maps are made public to help inhabitants evacuate smoothly. Hazard maps show danger zones, locations of evacuation areas, evacuation routes and so on in each city[41]. In response to changes in rainfall patterns that have increased the danger of floods, the Flood Protection Law was revised in June 2001. Measures to forecast floods and to guarantee smooth and rapid evacuation of danger zones gained legal foundations[42].

Yasuda and Murase have presented an example of strengthening measures against water-related disasters[43]. A method of indicating degrees of flood risk has been sought for the Tokyo region. The degrees of risk of or safety from flood damage can be represented by combinations of the flood occurrence frequency and the inundation depth so that the degree of flood risk is presented in a way that is as intuitively comprehensible as possible. This two-dimensional feature of floods makes it difficult to develop a single dimensional indicator that can represent the risk (Figure 25). The index in the legend is the Flood Risk Indicator (FRICAT) employed in Japan for policy evaluation. The FRICAT represents how many times the expected annual flood damage is bigger than the expected annual fire damage. The expected annual fire damage in

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[39] Water Resource Department, MLIT 2002

[40] The levee improvement statistics (Japan River Association 1986-2000) and flood adjustment capacity (The Japan Dam Foundation 2002)

[41] MOC 2000

[42] MLIT 2001a

[43] Yasuda, G. and Murase, M. 2002

Japan is 1,165 yen (approx. 10 Euros) per person. This is the average figure in the three years from 1998 to 2001. It was necessary to provide clear criteria for the establishment of indicators. They proposed six criteria: (1) *Relevance*- The numerical value of an indicator should directly represent the degree of "what should be measured"; (2) *Clarity*- Ambiguity and arbitrariness should be excluded from measuring with an indicator; (3) *Cost*- The cost of the evaluation by an indicator should be affordably low; (4) *Continuity*- Availability of coherent data both in historical and regional scope should be respected; (5) *Comprehensibility*- Definition/expression of an indicator should be intuitively/easily comprehensible to users; and (6) *Social Benefit*- Net social benefit that an indicator yields when it is applied should be maximized.

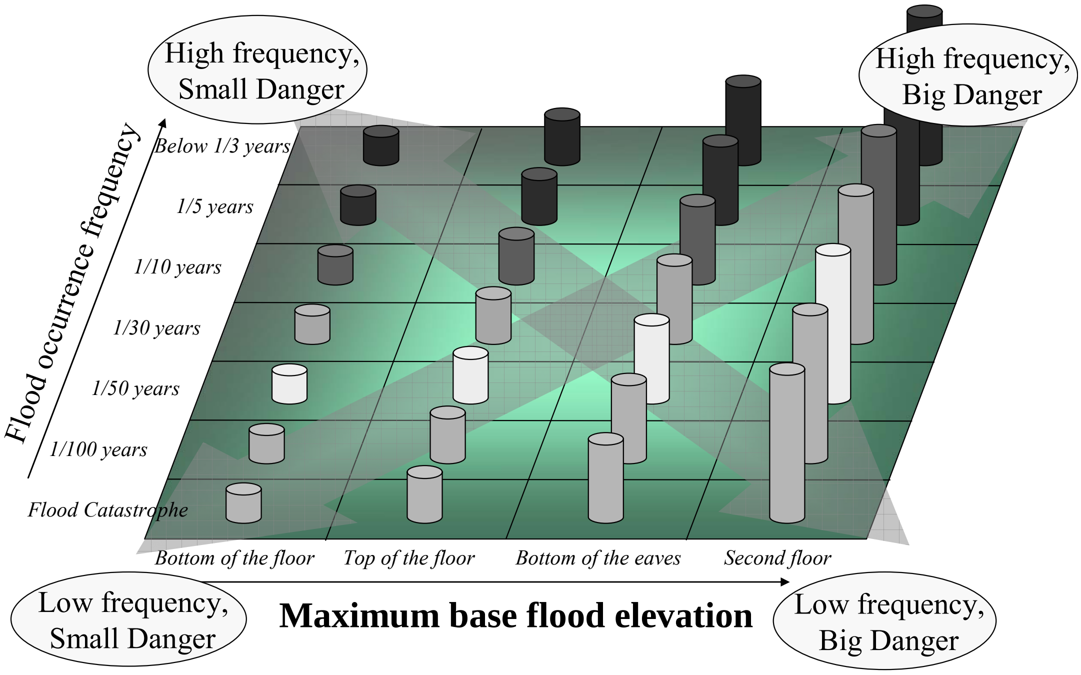

Figure 25 A Representation of the Two-dimensional Feature of an Inundation[44]

3.2.3 Water Quality Indicator

Though water quality in the rivers and lakes of the Tokyo region has improved. environmental endocrine disruptors were recently found in some rivers. It is not yet known if these disrupters have an influence on health and the ecosystem[45]. Since the people have become more involved in the water management process, it is necessary to show how the natural environment and safety of water quality are evolving. In addition to traditional water management, new water quality indicators have been developed for the Tokyo region.

Regarding water quality in the Tokyo region, the following biochemical oxygen demand (BOD) measurements were made in 1998: more than 8 mg/l in the Tsurumigawa River, about 4m g/l in the Arakawa River, and below 2mg/l in the Tamagawa River and Sagamigawa River. The levels of BOD in the Tsurumigawa River and the Tamagawa River have tended to increase while those in other rivers are stable.

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[44] Yasuda, G. and Murase, M. 2002

[45] Ministry of the Environment 2002

In the past 10 years, the worst levels of BOD were found in the Tsurumigawa River and Arakawa River (Figure 26)[46]. In 1999, chemical oxygen demand (COD) concentration was about 7.5mg/l[47]. Most of the effluent load in the Tokyo region is discharged into Tokyo bay where COD reached 247 t/day in 1999. Domestic use accounts for 70% of this load. However, due to effluent control, the amount of discharge load has decreased significantly, so the actual level has dropped by half in 20 years[48].

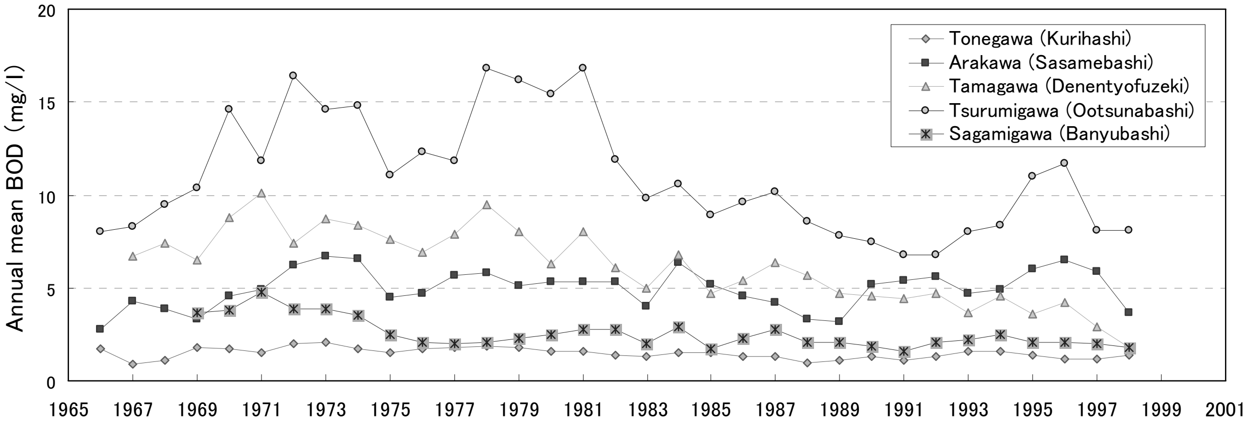

Figure 26 Variation in the Water Quality[49]

On the one hand, local governments (prefectures and designated cities under the Water Pollution Control Law) carry out regular observations accompanied by water quality surveys of public waters. The public waters covered by this survey include those in categories covered by the environmental quality standards (EQS). EQS for water pollutants are target levels for water quality to be achieved and maintained in public waters under the Basic Environmental Law[50]. On the other hand, the ‘National Census of River and Watersides’ is a monitoring tool used to evaluate the actual condition of the ecosystem. This census monitors the conditions of inhabitant species (fish and shellfish, benthic organism, plant etc.) and of human activities in and beside rivers. River Administrators started the census in 109 class-A river types (administrated by the national government) and 80 dam reservoirs in 1990, and in major class-B river types (administrated by the prefectures) in 1993. The condition of non-native species in rivers and dam reservoirs was also investigated by the census[51].

The Water Pollution Control Law establishes national effluent standards and authorizes stringent prefectural standards in order to regulate wastewater discharged from factories and business establishments into public bodies of water. The reinforced effluent regulations for factories have been effective in improving water quality, but problems with domestic effluent remain, especially in enclosed or semi-

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[46] River Bureau, MLIT 2001b
[47] MLIT 2001b
[48] Ministry of Environment 2002
[49] River Bureau, MLIT 2001b
[50] Ministry of the Environment 2001
[51] MOC 2000

enclosed water bodies like Tokyo Bay[52]. Sewage systems play an essential role in controlling the quality of public waters. In the Tokyo region, in 1999, the sewage water diffusion rate (sewage treatment district's population/all population) was 77%, and water service diffusion rate (water supply district's population/all population) was 97%[53].

Protecting the natural environment and maintaining safe water quality has become more important in water management. As the public become more involved in the water management process, it is necessary to show how the natural environment and safety of water quality are improving. Also, urbanization has motivated many people to begin to search more actively for places to enjoy nature. Greater efforts must be made to create communities where places in which people work and live are integrated with natural river environments. Existing indicators such as biochemical oxygen demand (BOD) cannot fully describe present water conditions. Based on the increased and diversified needs of water management, new water quality indicators have been developed. In 1998, a study was conducted in the five rivers of the Tokyo region to develop easily comprehensible indicators to monitor water quality conditions[54]. The River Administrator proposed indicators through the Internet and collected the opinions of the public. In this study, the comprehensibility of the indicators is considered important. The study emphasized and proposed indicators based on three aspects: people's contact with water, rich biodiversity and drinking water. Even though the indicator on rich biodiversity is still in the process of being developed, the other indicators have already been shown as combining several indices, such as faecal coliforms and transparency. Figure 27 shows a new water quality indicator for recreational use.

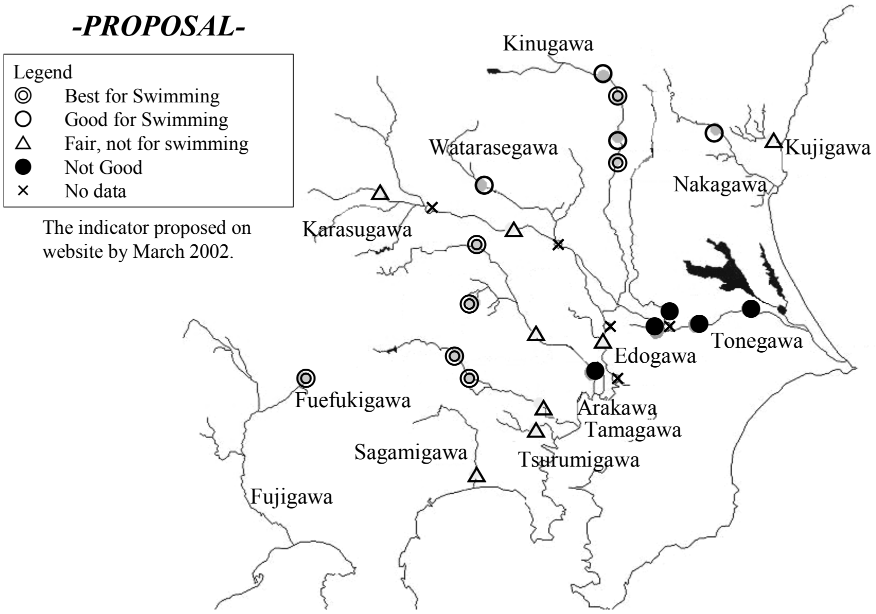

Figure 27 New Water Quality Indicator (for Recreational Use)[55]

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[52] Ministry of the Environment 2001

[53] Japan Sewage Works Association 1973-2000; MHLW 1966-2000

[54] Kanto Regional Development Bureau, MLIT 2002

[55] Ibid.

3.2.4 WWAP after the CASE Study for WWDR-1

The first edition of *The United Nation World Water Development Report* (WWDR-1) facilitated an extensive compilation of information, drawn from multiple sources, documenting the state of water, the resource and its uses through many agencies' formal and informal archives to share information from their knowledge bases [56]. The case study in Greater Tokyo region was intended to reveal the properties that are required for desirable policy performance indicators for flood risk and water quality. These contributions established an important baseline from which to move forward. WWDR-1 included more than 160 indicators in total, ranging from the global quantum of water available and withdrawals for human use to compliance with water quality standards for key pollutants and governance mechanisms to support water management. Following the WWDR-1, the second edition of WWDR in 2006 presented 62 indicators derived from WWDR-1 because of the consequences of poor data availability in WWDR-1. There was no systematic process for updating the data used for most of the indicators in the WWDR-1. Because some indicators included in the second report were identified as not useful by the source agency, 58 indicators are now listed in the profile sheets available on the World Water Assessment Programme Website (www.unesco.org/water/wwap/). UN-Water has created the Task Force on Indicators, Monitoring and Reporting to address the challenge of producing key global indicators of the state of water resources to meet the needs of policy- and decision-makers at all levels. The World Water Assessment Programme also established the Expert Group on Indicators, Monitoring and Data/Metadata Bases to support this work, specifically by promoting a dialogue between indicator users and data providers/interpreters about the feasibility of providing data for the key indicators on a sustainable, ongoing basis.

3.3 VULNERABILITY INDICATORS FOR MAJOR BASINS IN JAPAN

There have been various issues in hydrological cycles, stemmed from urbanized watersheds, changing agricultural water use and devastated forests. The issues need comprehensive approaches, including consideration of balance among various needs and social backgrounds of each watershed, in addition to traditional countermeasures. There are number of project on indicator development in the world. For instance, the DRI developed by UNDP enables the calculation of the average risk of death per country based on data from 1980 to 2000, and also enables the identification of a number of socio-economic and environmental variables that are correlated with risk to death which may point to casual processes of disaster risk[57]. For the comprehensive approaches, indicators have been developed for 109 major rivers in Japan[58,59]. These indicators comprehensively cover issues that reflect safety for floods in each watershed. Each comprehensive indicator is derived from a revised PSR model and combining them: i) pressures on watersheds, ii) watershed conditions and iii) indicators of society's response. Such an evaluation can make it possible to compare one watershed to another, to check the trend of a watershed, and to share the

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[56] UN/WWAP 2003, appendix_1

[57] UNDP 2004, p.30

[58] Murase, M., Nakamura, A. and Kawasaki, H. 2004

[59] NILIM 2005

information about the states of a watershed among all stakeholders and people in the watershed. Through the process of establishing the indicators, it became clear that more research is necessary to establish a database and to develop evaluation tools for the improvement of indicators.

3.3.1 Water Cycle and Basin Indicators

The hydrological cycle refers to the system of water circulation comprising natural water cycles of evaporation, precipitation, storage, percolation, and runoff as well as artificial water flows in water supply systems and sewerage systems. The scale of the cycle varies from individual house to international precipitation system. Water resources development should consider basin changes, such as the concentration of population and industry in cities, urbanization, increases in the incidences of urban flooding due to the expansion of non-water permeable surfaces and the decrease in rural areas. As it was expected to be inefficient for each ministry to promote measures separately in its own field in promoting a sound hydrological cycle, the ministries involved in water (Ministry of Health, Labor and Welfare, Ministry of Agriculture, Forestry and Fisheries, Ministry of Economy, Trade and Industry, Ministry of Land, Infrastructure and Transport, and Ministry of Environment) established the "Liaison Committee for the Promotion of Sound Hydrological Cycles" in August 1998, and it compiled an interim report on a common recognition of basic matters for the promotion of sound hydrological cycles in October 1999. “Sound Hydrological Cycles” are defined as the system where people’s activities are sustainable with the hydrological environment in a certain unit of hydrological process, such as a basin. For water resources planning, it is important to understand the hydrological cycle on a basin-wide scale because the water for our daily use comes from rivers, lakes, marshes and groundwater, and also because floods that occur on the basin scale. For the evaluation of basins, basin indicators are developed.

Similar to a medical check, an evaluation of a basin monitors its state or condition at each development stage. The medical check can show one’s medical state compared with the others (comparative state) and one’s condition compared with the past (historical condition) shown in Figure 28. The basin monitoring also help every stakeholder in the basin share such information.

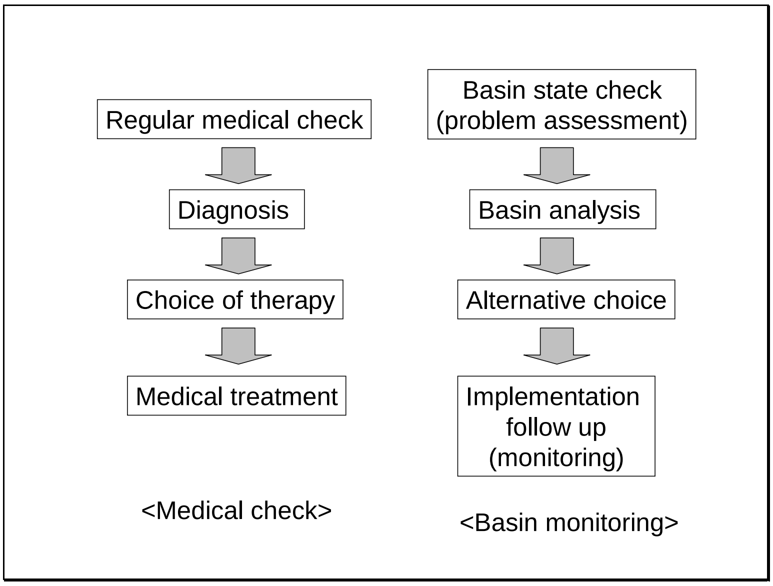

Figure 28 Medical Check and Basin Monitoring

There are some differences in evaluation methods among each step. The methods in alternative comparison or monitoring depend on the each basin's characteristics. Basin indicators can be developed for comparing states and historical conditions among basins. They can also contribute to improving understanding and taking action at basin level.

3.3.2 Examples of Basin Indicators

There are many kinds of indicator developed in the world even if here we just focus on flood risks. In the United Kingdom, the Environment Agency provides the annual monitoring of the impact of the technical advice on flood risk on planning decisions made by Local Planning Authorities as the principal national source of information[60]. The risk-based Sequential Test should be applied at all stages of planning, based on the Flood Zones (Table 4) which refer to the probability of sea and river flooding only, ignoring the presence of existing defenses[61]. It is also noted that a risk-based approach should be adopted together with a source-pathway-receptor model to planning for development in areas of flood risk requires[62]. A source-pathway-receptor model is a strategic approach using policies which avoid adding to the causes or "sources" of flood risk, by such means as (a) avoiding inappropriate development in flood risk areas and minimizing run-off from new development onto adjacent and other downstream property, and into the river systems; (b) managing flood "pathways" to reduce the likelihood of flooding by ensuring that the design and location of the development maximizes the use of sustainable drainage systems, and takes account of its susceptibility to flooding, the performance and processes of river/coastal systems and appropriate flood defense infrastructure, and of the likely routes and storage of floodwater, and its influence on flood risk

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[60] UK 2010, p.12
[61] UK 2010, pp.21-24
[62] Ibid. p.6

downstream; and (c) reducing the adverse consequences of flooding on the "receptors" (ie people, property, infrastructure, habitats and statutory sites) by avoiding inappropriate development in areas at risk of flooding.

Table 4 Flood Zones in England[63]

Zone 1: Low Probability	Land assessed as having a less than 1 in 1000 annual probability of rive or sea flooding in any year (<0.1%)
Zone 2: Medium Probability	Land assessed as having between a 1 in 100 and in 1000 annual probability of rive flooding (1%-0.1%) or between 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5%-0.1%) in any year
Zone 3a: High Probability	Land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year
Zone 3b: Functional Floodplain	Should take account of local circumstances and not be defined solely on rigid probability parameters. But land which would flood with an annual probability of 1 in 20 (5%) or greater in any year, or is designed to flood in an extreme (0.1%) flood, should provide a starting point for consideration and discussions to identify the functional floodplain.

In the USA, the Federal Emergency Management Agency (FEMA) manages the National Flood Insurance Program, which identifies and maps the national floodplains in addition to providing flood insurance and reducing flood damages through floodplain management regulations within Risk Mapping, Assessment, and Planning Lifecycle[64]. The flood hazard maps depict both horizontal and vertical data. The vertical data show the height of the water during the 1-percent-annual flood while accurate horizontal data ensure that the floodplain accurately follows ground contours.

In Japan, an easily comprehensible indicator, which expressed the degree of safety against flood damage through a combination of the flood frequency and the inundation level, was shown in the case study of WWAP (see 3.2.2).

OECD designed core environmental indicators (CEI), which help track environmental progress and the factors involved in it, and analyze environmental policies[66]. They are included in the OECD Core Set of environmental indicators. The Core Set, of about 50 indicators, incorporates core indicators derived from sectoral sets and from environmental accounting. Indicators are classified following the PSR model: indicators of environmental pressures, both direct and indirect; indicators of environmental conditions; indicators of society's responses.

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[63] UK 2006, pp.22-24

[64] FEMA 2009, p.3

[66] OECD 2004

Murase et al. applied the PSR model to basin indicators, as a tool for top-down approach toward water resources planning, which compares state and historical condition among basins[67, 68].

Most characteristics can only been expressed as a combination of a number of indicators, referred to as an “index”. There are many methods for deriving such an index. One of the most popular methods is the combination of indicators using weight parameters. For instance, suppose water clearness (S) in a basin has linear relationships with the total population (P) and the total sewerage users (R), the parameter S can be expressed with the parameters P and R, such as $S=w_1P+w_2R$ where w_1 and w_2 are weight parameters that need to be defined. Such index S may help ranking basins, but there are some risks of misunderstanding the index as the number S itself means nothing but is just calculated by P and R. The method for deriving an index should consider clarity and comprehensibility criteria in 3.2.2.

3.3.3 Methodology for Basin Indicators

Based on the criteria, basin indicators are developed as a combination of P (human’s pressure to the basin), S (basin state) and R (human’s response factor for improvement of the basin),

$$I \text{ (basin indicator)} = R \times S / P$$

Here P/S shows the human’s pressure per basin state so the basin indicator I means the ratio of human response to the pressure. Suppose, for example, P and R respectively mean the population and the total number of sewerage users in a basin, a basin indicator S=R/P shows the rate of sewerage users in the basin. Here, the indicator S can indicate that the construction of sewerage or the decrease of population will improve S as the indicator of water quality. Of course, it is not always easy to find appropriate P, S and R, but Table 5 shows some examples of P, S and R for flood safety, water use, water quality and bio-diversity in a basin. Some trials of calculating the indicators can contribute to the development of indicators.

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[67] Murase, M., Nakamura, A. and Kawasaki, H. 2004

[68] NILIM 2005

Table 5 Example of the items for basin indicators

Indicator	PSR	Example of items
Flood safety	P	Population, Welfare
	S	Economical loss from flood, Precipitation, Water discharge
	R	Flood facility, Disaster information system
Water use (the volume of river flow)	P	Population, Water use per capita, Water consumption
	S	Flow volume, Potential water supply
	R	Volume of reservoir, Water saving rate
Water Quality	P	Pollution, Economic index, discharged volume
	S	River flow volume, Water cycle rate
	R	Pollution control, Sewerage users
Bio-diversity	P	Populated area, developed area
	S	Number of Species, Number of endangered species
	R	Control or regulation for protection, Effective preservation

3.3.4 Trial for Basin Indicators in terms of Flood Management

This section shows a trial for basin indicators in terms of flood management using the items in Table 5. Unfortunately, most of the geographical database is not classified on a basin-wide basis. Also, the date about flood facility cannot be easily obtained in rural areas. The trial focused on the 109 class A river basins in Japan, of which the Minister of Land, Infrastructure, Transport and Tourism is responsible for the administration of major parts. In addition, it is better to consider the flood policy in sub-basin level in some large basin, so indicators are calculated in 235 units. The geographic map for these units was also developed to show the indicators.

(a) Human’s pressure to a basin (P)

Items, such as population and welfare, provide the human pressure in terms of the flood management in a basin. The more population living in a basin, the higher the flood risk becomes. Thus, the concentrated population or welfare in a basin provides the pressure to the basin in terms of the flood management. Figure 29 shows the pressure to each unit using the number of population per area from the national geographical database (3^{rd} regional level mesh).

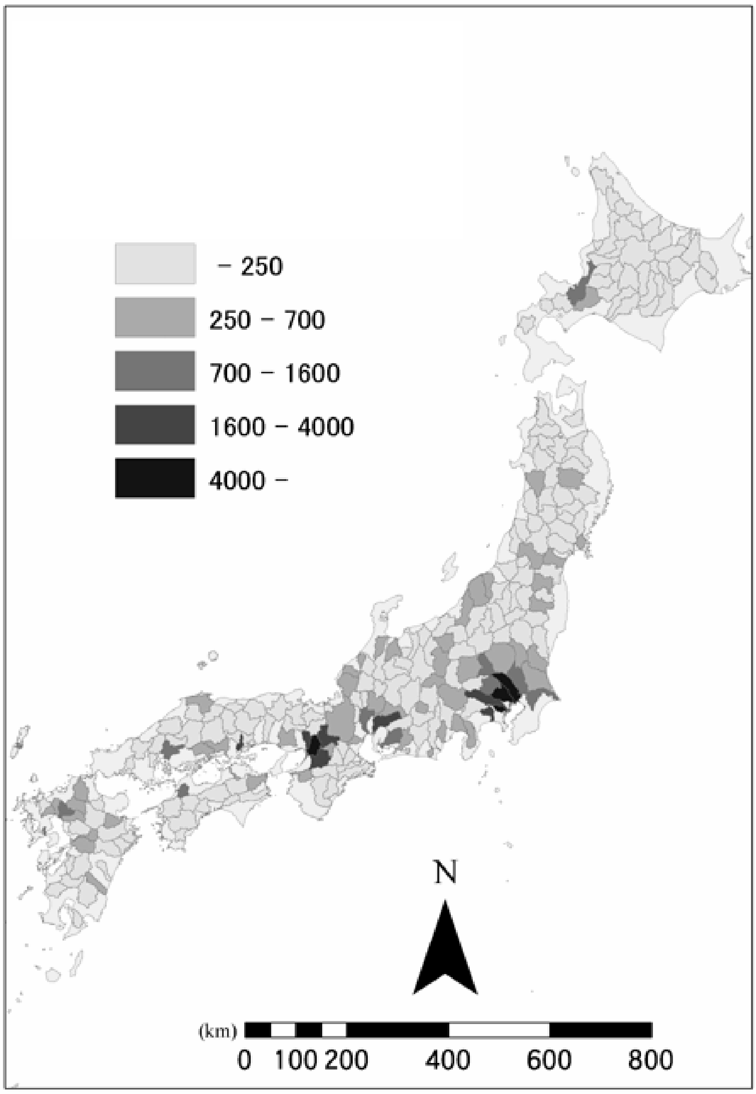

Figure 29 Population Density (person/km^2)

(b) Basin state (S)

Items, such as precipitation and water discharge, provide the basin state in terms of the flood management in a basin. The more precipitation there is over a basin, the less the capacity to absorb additional flood water becomes in the basin. Figure 30 shows the annual precipitation in each unit from the meteorological observation database (the average between 1953 and 1972). As the precipitation and basin state are co-related, the reciprocal data for each unit are applied when calculating basin indicators. It is also noted that higher annual precipitation does not always mean flooding because floods depend on the distribution of annual precipitation. Therefore, another item, such as intense rainfall and flood damage, should be sought in the long run.

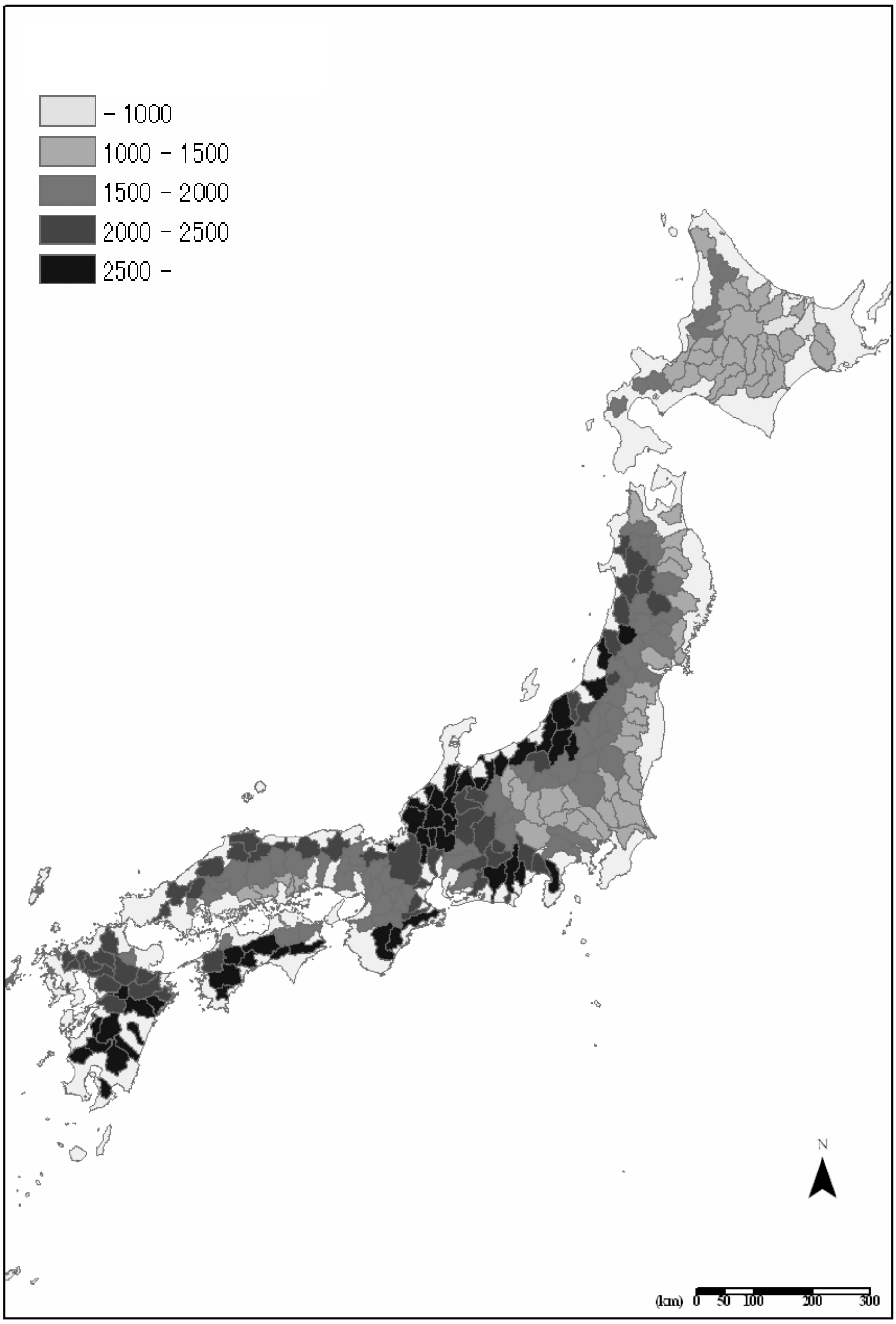

Figure 30 Annual Precipitation (mm/year)

(c) Human’s response to a basin (R)

There are variety of response items, from structural measurements such as levees and reservoirs to non-structural measurements such as warning and emergency response. Considering the limited availability of data, the flood control volume of reservoirs per area is applied tentatively for this study (Figure 31). It is necessary to seek more comprehensive items such as the ratio of design flood of protection works and potential flood in the long run. Such a study can also contribute to the argument for basin policies or basin comprehensive plans in the processes under the 1997 River Law.

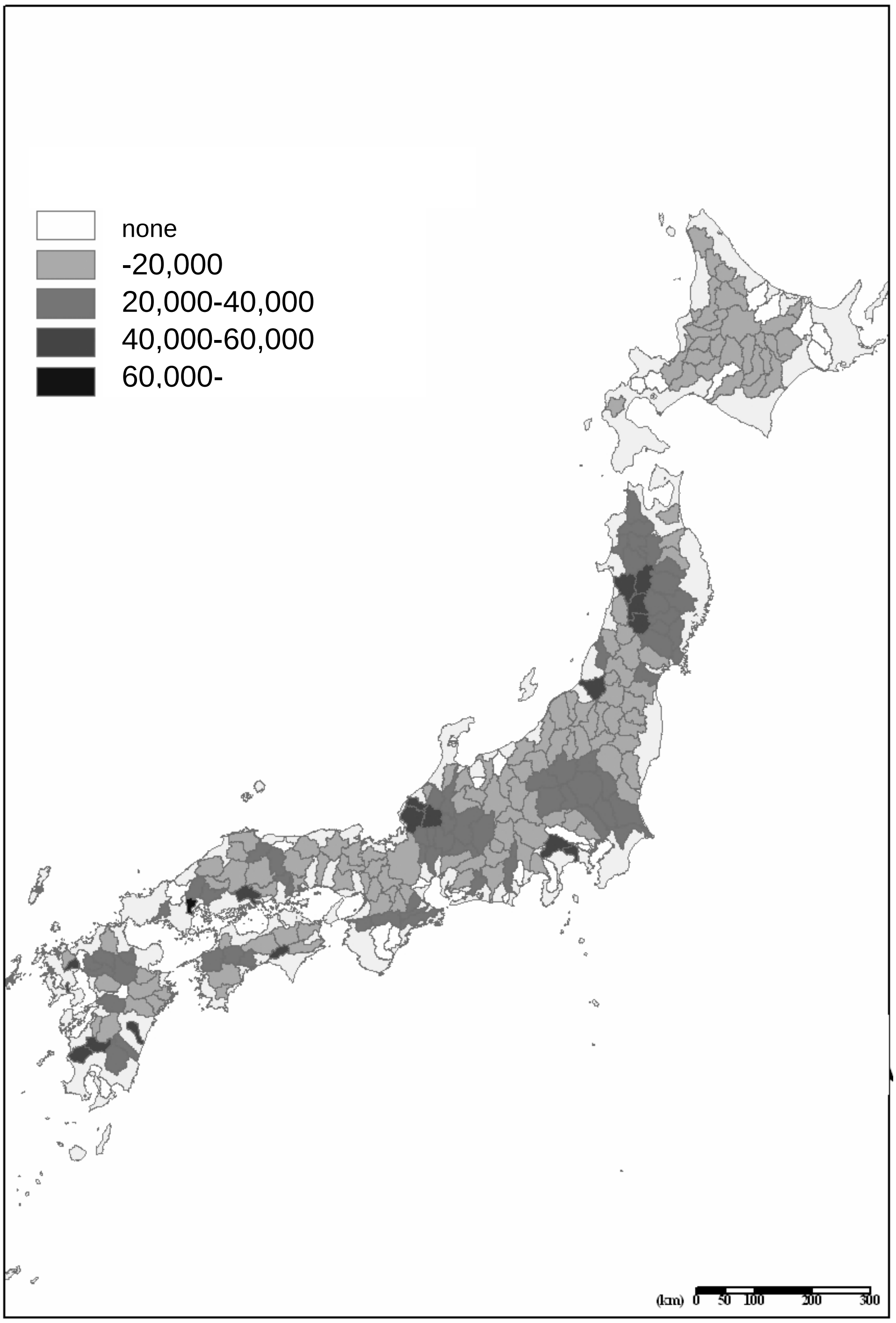

Figure 31 Flood Control Volume by Reservoirs (m^3/km^2)

(d) Combination Indicator for flood management

The items P, S and R are combined to show basin indicators for flood management by using reservoir control volume. The equation R/S x 1/P (Figure 32) is applied based on the following interpretation.

- R/S shows flood control volume per total amount of annual precipitation.
- When R/S is divided by P, the result means flood control volume per total amount of annual precipitation for an unit population density (1 person/km^2).

The greater the indicator becomes in a basin, the more safe is the basin by reservoirs' control. The effective policy for the improvement of this indicator includes more investment for reservoirs, and lower population density through land use control, etc.

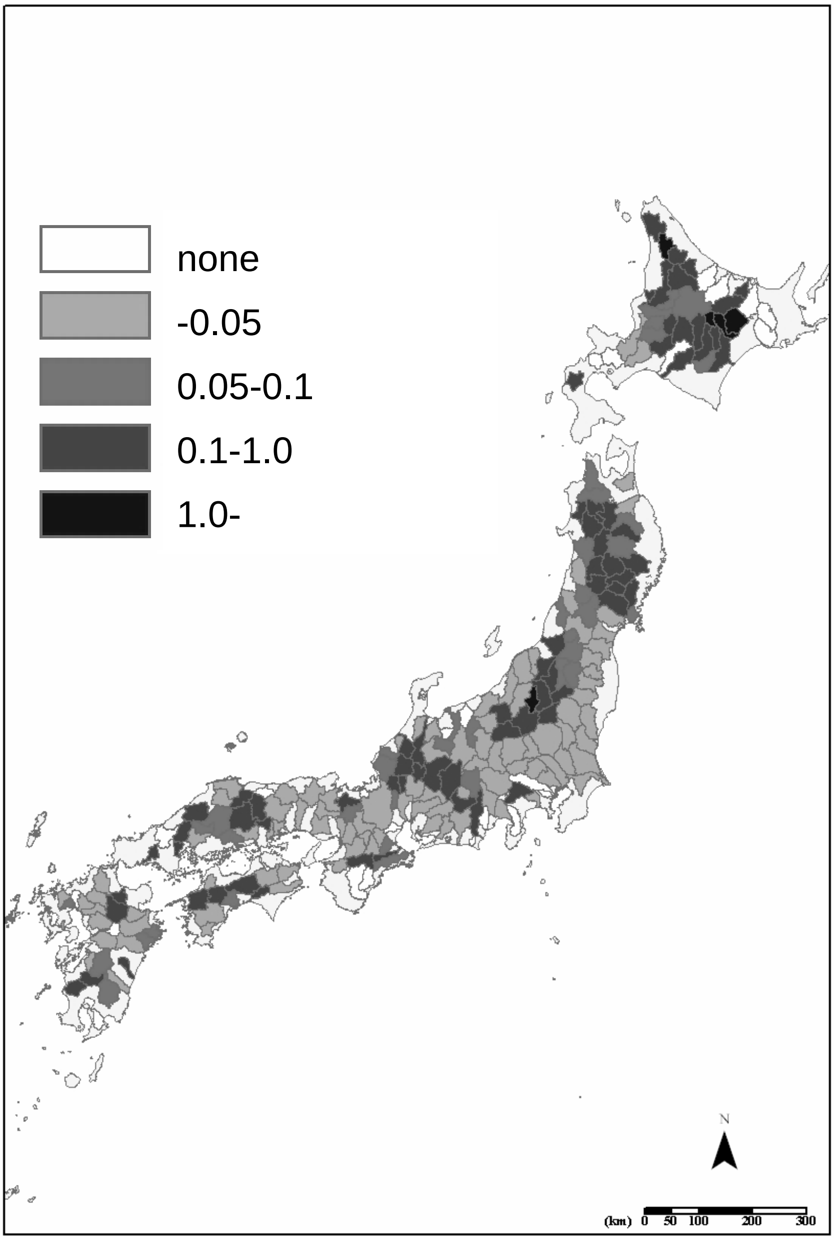

Figure 32 Basin Indicator for Flood Management by Flood Control Reservoirs

Like the indicator for flood management above, more indicators are calculated for water use, water quality and bio-diversity, through a pressure-state-response relation. It becomes clear that there is still more room for improvement for indicator development. It is difficult to find appropriate items showing each characteristic of basins. Another limitation can be found in data. However, these limitations on the knowledge and data availability do not mean indicator development is useless. Perhaps the most similar measure of development is the Human Development Index (HDI), which combines measures of life expectancy, education and standard of living in an attempt to quantify the options available to individuals within a given society[72]. Like HDI, the trial for such indicators and wide discussion through them would contribute to practical action for comprehensive water management.

3.4 CONCLUDING REMARK

There are two pathways for integrating climate information into water resources planning and management: vulnerability analysis and integrated water resource planning. Vulnerability analysis includes top-down or bottom-up perspectives. Despite the limitations of the current state of the art of climate models, downscaling techniques and observations, the top-down perspective uses projections of global or spatially downscaled models to drive resource models and project resource impacts. In another approach, using a bottom-up perspective, water managers start with their knowledge of their system and utilize their water supply planning tools to identify what changes in climate would be most threatening to their long-range plans or operations. World Water Assessment Programme (WWAP), one of the top-down approaches for water resources planning, is focusing on developing indicators using new methodologies; assessing the water situation as it affects economic, social and environmental development; identifying actions to be taken at local to global levels; presenting guidelines for improving water policy and management; and helping to build capacity to make effective in-country assessments. The Greater Tokyo region was selected as one of the seven case studies in WWAP, focusing ecosystems, risk management, resource sharing and governance. As another comprehensive approach in Japan, indicators derived from a revised PSR model and combining them: i) pressures on watersheds, ii) watershed conditions, and iii) indicators of society's response, have been developed for 109 major rivers in Japan. The following issues need to be address while discussing top-down water resources management.

- Climate change information can be incorporated into either top-down scenario driven or bottom-up vulnerability assessments. The top-down approach uses the state of the art of climate knowledge while the bottom-up approach seeks thresholds to identify and assess the risks in current water resources policy.
- WWAP's Greater Tokyo case study focused on the following five points:
  - Managing risk: flood risk indicators,
  - Governing water wisely: public involvement,
  - Sharing water resources: cooperation between upstream and downstream areas,
  - Water and the ecosystem: development of water quality indicators, and
  - Ensuring the knowledge base: sharing water-related information to promote cooperation.
- Among five points of the regional concern, this case study sought to propose the indicators for two aspects; flood risk and water quality. The indicators can contribute to predict problems and then to solve them as the top-down approach for water resources planning. The other three aspects (governance, resources sharing and knowledge base) can more favor the implementation of a flexible

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[72] HDI are available at the United Nations Development Programme (UNDP)'s website (http://hdr.undp.org/en/).

or adaptive management as the bottom-up approach.

- The Flood Risk Indicator (FRICAT) employed in Japan for policy evaluation represents how many times the expected annual flood damage is bigger than the expected annual fire damage, based on six criteria: Relevance, Clarity, Cost, Continuity, Comprehensibility and Social Benefit.
- In the Greater Tokyo case study, the River Administrator proposed indicators based on three aspects: people's contact with water, rich biodiversity and drinking water. Even though the indicator on rich biodiversity is still in the process of being developed, the other indicators have already been shown as combining several indices, such as faecal coliforms and transparency.
- Similar to a medical check, the evaluation of basins monitors a basin's state or condition at each development stage. To understand the hydrological cycle on a basin-wide scale, basin indicators are developed after analyzing many kinds of indicators developed in the world.
- As a tool for the top-down approach to water resources planning, the PSR model was applied for the basin indicators under the six criteria above. Based on the criteria, basin indicators are developed as a combination of P (human's pressure to the basin), S (basin state) and R (human's response factor for improvement of the basin): I (basin indicator) = R x S / P.
- The trial for basin indicators in terms of flood management on the 109 class A river basins in Japan are calculated in 235 units by using the population for P, annual precipitation for S and flood control volume of reservoirs per area for R. Even though there is still more room for improvement for indicator development and databases, these limitations on the knowledge and data availability do not mean indicator development is useless. Further efforts for indicator development are important.

4. BOTTOM-UP APPROACHES TO WATER RESOUCES PLANNING

A bottom-up approach to water resources planning focuses on exploring how well policy alternatives perform across a wide range of assumptions and uncertainties. Water resources are essentially for the public, so the planning has to be carried out through a public policy framework. In this framework, the investment for such policy alternatives needs the assessment of efficiency under the best possible methodology. There are various constraints in any decision-making process in water resources planning, which can be broadly categorized into: physical, financial, social, political, legal and environmental. Among these constraints, physical and financial considerations have largely been tackled through economic analysis. Economics is concerned basically with the study of how and why people make decisions about the use of valuable resources to obtain maximum benefits[73]. Though economic efficiency is not the only objective of society, economic efficiency issues can never be ignored if society is to progress. Economic analysis is an integral part of the formulation of policies related to people's development, and seeks both to simplify the complex to a level that we can comprehend and to gain an understanding of what the choice involves. However, it is impossible to have a mechanical approach that will always result in the best choice being made. Instead, the key requirement is to better understand the nature of the choices available, to address those conflicts that make it necessary and develop the understanding of the process involved. This chapter first analyzes Japanese water resources management from global perspectives, then tries to approach it from economics and then explains an approach to consensus building planning called Shared Vision Planning.

4.1 SYSTEMATIC REVIEW OF WATER RESOURCES MANAGEMENT IN JAPAN

There are wide ranges of arguments about the value of water resources in the world. Such debates were widespread in the 1990s, and the World Water Development Report in March 2003 presented the principle elements of such arguments[74]. Traditional water rights system in Japan was also reviewed there in social and historical backgrounds through the case study of the Greater Tokyo region. The population and property in Greater Tokyo are concentrated in alluvial plains, mostly below flood level, making flood damage potentially serious. Many years of flood control efforts have reduced the total inundated area and made the alluvial plains available for residential, industrial and agricultural use. Since the 1960s, increased land use has required enormous development of water resources especially for households and industry. There was a significant increase in river water use for generating hydroelectric power and for industrial and household water supply. To meet the new demands, a systematic framework for flood control and water use was established. In 1964, the institutional framework was improved by introducing an integrated river management system. A long-term plan for the development of water resources all over the country was also established. However, the increase in population and assets led to environmental problems such as the aggravation of river water quality and changes in the ecosystem, making environmental conservation an important issue. In addition, with changes in economic and social conditions, the water management system

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[73] WMO 2007, pp.5-9

[74] UN/WWAP 2003, pp.489-495

was expected to not only fulfill flood control and water resource purposes, but also provide for recreational use and habitat diversity. As people's concerns about water and the environment grow, public involvement and consensus-building with proper information have become indispensable. These changes facilitated the 1997 revision of the River Law, on which river administration is based in Japan. It also becomes essential to use the already existing facilities as efficiently as possible. Before reviewing Japanese water resources management, the discussion begins from a global perspective on valuing water related to efficient water use and water rights.

4.1.1 Discussion on Valuing Water

When water first became a topic of global concern at the Mar del Plata Conference in 1977, the emphasis was mostly on fundamental infrastructure on water such as water supply and sanitation. The value of the water could clearly be seen in the fourth of the Dublin Principle adopted in 1992[75].

- Principle No. 1 - Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.
- Principle No. 2 - Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels.
- Principle No. 3 - Women play a central part in the provision, management and safeguarding of water.
- Principle No. 4 - Water has an economic value in all its competing uses and should be recognized as an economic good.

These principles became important inputs to the UN Conference on Environment and Development (UNCED), where the Agenda 21 was adopted[76]. Agenda 21 included the protection and conservation of potential freshwater supply by the inventorying of water resources, allocation decisions through demand management, pricing mechanisms and regulatory measures, and full public participation. The Dublin Principles and Agenda 21 led into the discussion on efficiency and equity aspects of water management at the UN Commission on Sustainable Development in 1998[77], UN Millennium Development Goals[78], Hague Ministerial Declaration in 2000[79], and Bonn Ministerial Declaration in 2001[80] etc. Among them, the most significant consensus, the UN Millennium Declaration in 2000 declared as follows.

> ***III. Development and poverty eradication*** [81]
>
> *19. We resolve further:*
>
> *• To halve, by the year 2015, the proportion of the world's people whose income is less than one dollar a day and the proportion of people who suffer from hunger and, by the*

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[75] Dublin Statement 1992

[76] UN 1992

[77] UN 1998

[78] UN 2000

[79] Ministerial Declaration of the Hague on Water Security in the 21st Century 2000

[80] Federal Ministry of the Environment, Nature Conservation and Nuclear Safety, and Federal Ministry for Economic Co-operation and Development 2001

[81] UN 2000

> *same date, to halve the proportion of people who are unable to reach or to afford safe drinking water.*

These actions have facilitated wide understanding for water crises and necessary actions while the huge controversy over the term “water pricing” created. On one hand, because costs of water supply delivery have escalated, it has become clear that economic measures such as pricing in general and demand management instruments have a distinct role to play in ensuring more efficient use of water. Growing unavailability of and increased competition for water resources require water demands to be well managed, so that water is efficiently used. The important role of water valuation relates to demand management and better allocation of water among its various uses[82]. From the integrated water resources management (IWRM), it is essential to ensure efficiency, transparency and accountability in water resources management as a precondition to sustainable financial management. It is also clear, if that existing resources are being used efficiently, this will help to mobilize additional finance from national and international sources, both public and private[83].

On the other hand, however, it has been more clearly accepted that different users value water differently. From a utility perspective, the same quality and quantity of water provide distinctly different values to consumers in different parts of the world. Water represents many values to society, and understanding the complex totality of these values is an important element in IWRM. For sustainable development, it is necessary to take into account water’s social, environmental and economic dimensions and all of its varied uses. The controversy over valuing water using a pure market approach has originated from two sides: affordability by the poor and the marginalized, and externalities associated with the implementation of the fourth Dublin Principle. The real value of water still tends to be vague because economic tools cannot fully assess social/cultural values or the intrinsic economic value of water. The wide range of variation in water pricing in developed countries of the world, for example, from 0.40US\$/m^3 in Canada to 1.91 US\$/m^3 in Germany, indicates the effect of subsidies as well as the amount of freshwater per capita. The practical implications of water pricing are contentious because:

- Each water service -drinking, irrigation, hydropower, navigation, fisheries, tourism, pollution control, ecosystems- is required to be valued differently, although in some cases services are provided simultaneously.
- Social acceptance of paying for water is often low because of customary law and a long tradition of providing water at a minimum charge.
- It is in many cases practically or economically not feasible to measure actual consumption of water.
- The pollutant pays principle can often not be applied because of uncontrollable (legal or illegal) water pollution.

It is therefore important to distinguish between the value of water, which is measured in terms of its benefit

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[82] UN/WWAP 2003, pp.323-344
[83] UNCSD 1998

to the beneficiaries, the price of water (the charges to consumers) and the cost of supplying the water (the capital and operating costs of the works needed to abstract, treat and transfer the water to the point at which it is used). When aiming to meet the needs of the poor at affordable prices and to recover the costs of water supplies through tariffs, it is important to consider that water should not be sold at a price above the value placed on it by potential consumers. It will be necessary to adopt policies that provide an appropriate level of service to reconcile the need for equating water costs and prices with its value to the beneficiaries.

In these arguments, any discussion of value must take into account people's perception of the world and their cultural and social traditions, as well as economic considerations and notions of full cost recovery. Global progress is that water pricing has increasingly become an integral part of water sector management, but the value of water is still insufficiently applied in the context of IWRM. Definite progress has been made in understanding the fact that the 'value of water' has economic, social, cultural and environmental dimensions, which are often interdependent. Governments may need to provide some form of check-and-control. Subsidies for specific groups, usually the poorest, may be judged desirable within some countries, while the level of such subsidies and who benefits from them should be transparent. Although 'subsidies undermine the economic approach' and may obliterate the potential of eliminating wasteful practices and encouraging increased efficiency and conservation[84], there is a growing consensus that if the subsidized water can generate positive social effects such as maintaining the rural landscape and traditions, supporting local economies or contributing to food security levels, subsidized water charges may be justified. Available options for a better valuation of water and water infrastructure development depend very much on appropriate governance and institutional arrangements.

4.1.2 Water Right in Japan

While significant gains in efficiency may be expected by valuing water, the 'natural monopoly' characteristics of water services argue in favor of a strong public control in providing these services. It is essentially argued that control of the asset should remain in the hands of government and the users. There needs to be robust institutional structures, adequate resources and a solid understanding and assessment of freshwater resources in relation to social, economic and environmental processes[85]. For efficient water resources management, a systematic review of water rights in Japan follows. Water use in Japan is characterized as agricultural use in paddy fields, quite similar to the styles of most Asian countries. The review provides a basis for comprehensive water management in Asia.

Historical Background[86]

The population and property in Japan are concentrated in the alluvial plains, mostly below flood level, posing a risk of potentially serious flood damage. Many years of flood control efforts have reduced the total

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[84] Gleick, P.H. 1998

[85] UNCSD 2001 referred through UN/WWAP 2003, p.335

[86] Murase, M., Nakamura, A., Inomata, J., and Kawasaki, H. 2004

inundated area and made the alluvial plains available for residential and industrial use in addition to agricultural use. The concentration of population and property in such alluvial plains has created a copious demand for water resources. As a result, water resources are very tight in Japan even though such a structure of land use suffers flood risks at the same time. In order to cope with the limited available resources, the water of Japan's river has, throughout history, been dominated by a large number of river users with vested water rights. These rights were generally founded and consolidated on customary practices, regional agreements and voluntary conciliation playing a primary role in the settlement of disputes so as to avoid drawing public authorities into the conflicts. Under these conditions, water rights evolved in a long historical process as substantive social rights. The agricultural interests with their customary right of water use accounted for almost the entire amount of water used from major rivers around 1870[87].

The hallmark of this custom-based system of water use was that it tried to regulate disparate instances of water use. On the larger scale of the river basin as a whole, however, water used in the upper reaches was repeatedly used and reused in the lower reaches of the river. Irrigation ponds had a function of extending water use by collecting, storing and adjusting the water. In this way, a whole system in river basins maximized possible repetition of water use. The system was developed over the years to provide secured water availability when there was enough technology to increase the flow volume. The system was organized on the principle that old water rights had priority and that owners of established water rights would hold on to their rights with tenacity[88]. The old River Law established in 1896 mainly focused on flood control and introduced an approval system for river water. However, those who had already possessed customary rights "should be deemed as having obtained such approval (Article 11 of the Enforcement Ordinance pertaining to the River Law). In the 1960s, the Japanese economy took off at a rapid pace. The explosive expansion in water demand could not be met. Since the demand for urban water, including drinking (household supply) water and industrial water, rose on a dramatic scale, water resource issues suddenly raised to prominence. Based on this consideration, the River Law, which controlled the river administration in Japan, was revised in 1964, and all water rights became subject to a permit system. However, the customary rights of the past were subject to the permit system authorizing the use of water under the same conditions as before, which were considered as being "approved de facto" (Article 87)[89].In order to create new potential for water use through the construction of water resource development facilities such as dams, it has therefore been necessary to seek conciliation with these vested interests and file applications for development projects as constituting a new water right.

Water Rights and Water Policy in Japan

The River Law stated the water rights in the article 23 as follows:

Article 23. (Permission for River Water Use)

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[87] Sasaki, M., Senga, Y., Kawajiri, Y. and Endo, T. 1981

[88] Tamai, S. 1994

[89] MOC 1979

> Any person who intends to use the water of a river shall obtain the permission of the *River Administrator* as may be provided for in detail by the Ministry of Construction Ordinance

River Administrators, who are in charge of granting water rights, consider following factors (Figure 33):

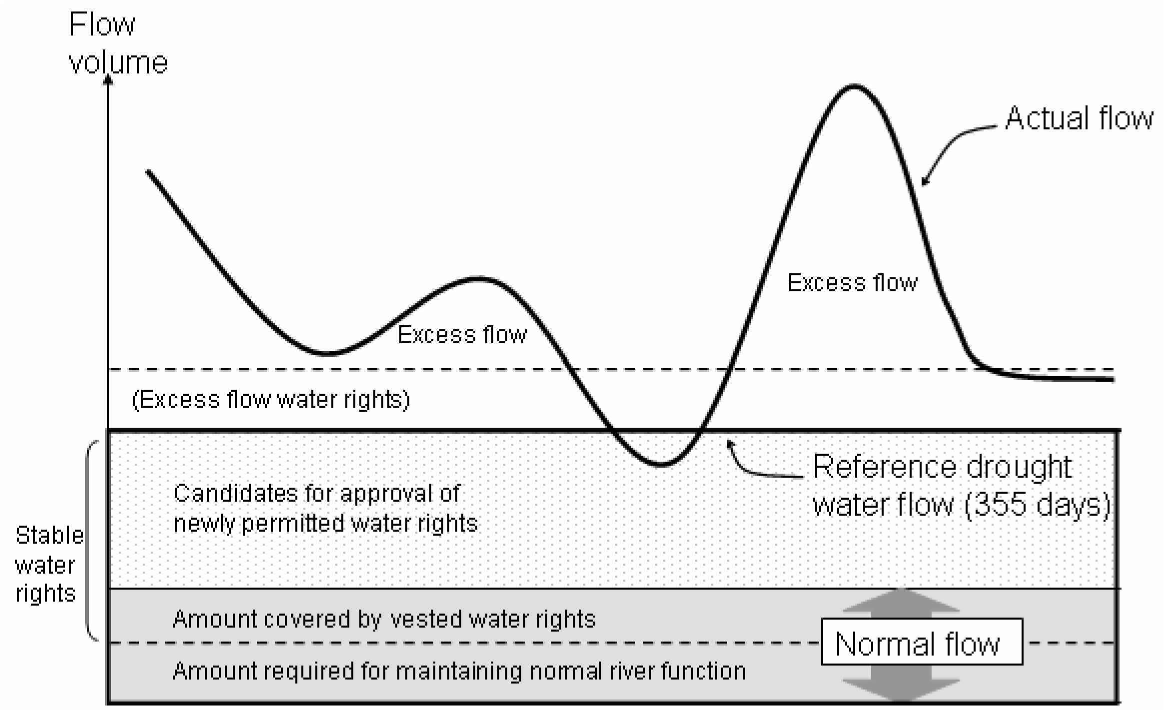

Figure 33 Water Rights System[90]

1) Security of water intake

Stable water intake must be possible in accordance with the flow conditions of the river without prejudice to the maintenance of the river's normal functions. In Japan, the practice is to grant permission on condition that the drought level of water flow (355 day flow volume) in a drought occurring at a probability of once in ten years is still greater than the normal flow volume of the river. The "normal flow" in this context is defined by allowing for the overall combination of all river functions, including the maintenance of the vested water rights, the shipping and fishing interests, and the quality (cleanness) of the water.

2) Purpose of water use and public benefit of activities

The activities for which water is used must be contributory to enhancing the living standard of the public and to increasing public welfare and well-being.

3) Practicability of water use

The operational plans for water-use activities must be reasonable and the water use itself must stand up to the relevant laws and bylaws.

4) Detriment to public benefit

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[90] Water Use Coordination Sub-Division, Water Administration Division, River Bureau, MOC 1995

The use of water must not compromise flood control or be injurious to the public benefit in any other respect.

At present, a situation has already been reached in which the drought level of flow for many of Japan's rivers is equal to, or even less than, the normal river flow volume[91]. The acquisition of new water rights is therefore dependent on the construction of water resource facilities such as dams to increase the drought level of flow of rivers. When the plan is to create new potential for water use through the construction of water resource development facilities, it is necessary to seek conciliation with those who have vested interests and file applications for development projects as constituting a new water right. However, as is the case in some areas, the development of water resources cannot keep up with demand. In such cases, the practice is to authorize temporary water rights (excess flow water rights in Figure 33) permitting the intake of water as an emergency measure only when the river flow is capable of covering the existing water use and there is a certain extra amount available. In 1994, the total volume of these excess water rights amounted to 123.918 cubic meter per second[92]. Therefore, under the River Law, customary water rights are considered as being "approved de facto" (Article 87). Figure 34 shows that the volume of "de facto" water rights is more than 30%[93].

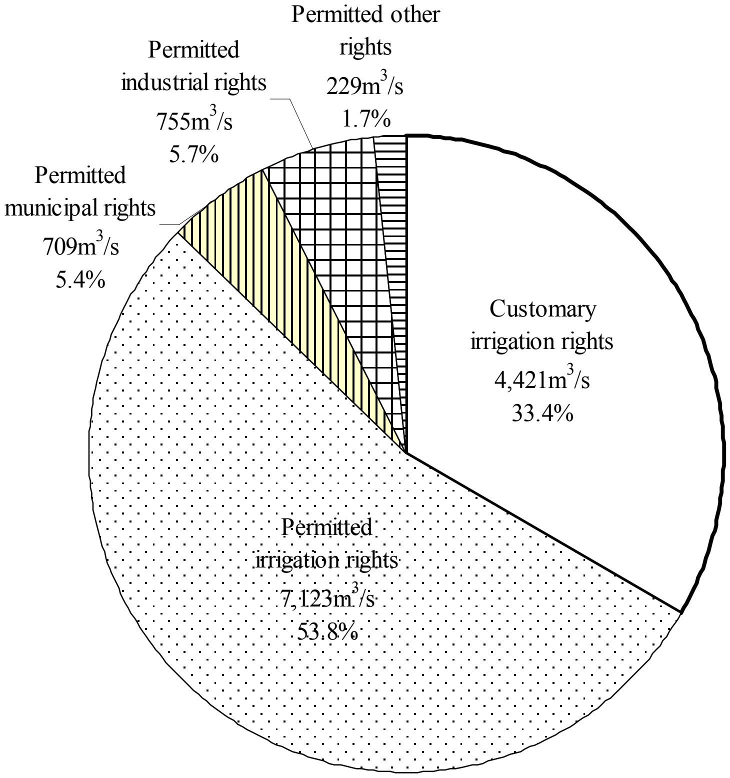

Figure 34 Specification of Water Rights[94]

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[91] Shinzawa, K. 1962

[92] MOC 1995

[93] Water Resources Department, National Land Agency 2000

[94] Ibid.

4.1.3 Efficiency and Accountability of Japanese Water Rights System

In Japan, water used in the upper reaches is repeatedly used in the lower reaches of the river, especially for paddy fields. This system can be called a sustainable water use system. Such water rights in Japan been used for a long time. However, they cannot fully adapt to all the new changes in demands and uses of water. The system needs more efficiency and accountability.

The volume of flow in Japanese rivers varies significantly because of natural conditions such as climatic and topographic factors. Water resource development was promoted from the middle of the 1960s by focusing on the stabilization of river flow conditions and on dam construction to meet the new water demand that had arisen as a result of massive population concentration in the major cities and industrial development. The success in achieving a stable supply of water had the effect of accelerating the pace of economic growth and the population drift to the large cities. This, in turn, created a new demand for water and led to a substantial increase in water use from the major rivers. The availability of drinking water supply resulted in a major population drift into the major urban regions and encouraged the construction of large-scale public facilities. Demographic changes also came into play as families became smaller with a resulting increase in the number of households. In view of this increase in water demands, efforts were made to promote the development of water resources and to use agricultural water more efficiently, such as the adjustment of cultivated fields and modification of irrigation water channels. The latter efforts make this saved water available for alternative use for city water supply.

However, it has become more difficult to implement these efforts. On the one hand, the construction of new water development facilities is becoming difficult because of the decrease in suitable sites. On the other hand, there is a controversy about agricultural water. While people insist that customary water rights, most of which are for agriculture, should be changed for alternative uses, farmers insist that such a change would lose flexibility in their use and have a harmful effect on agriculture[95]. More than 90% of water use for agriculture is for rice paddies. As shown in Figure 35, land use for flooding paddies has decreased in the decades, but the need to maintain water levels of the past for the diversion from a channel means that demand for water does not immediately decline[96] . It is also important that demand controls of water use in paddy fields are extremely difficult because of their characteristic cycle in using water[97].

There are still large numbers of provisional water rights which grant provisional rights only in respect of water resources classed as excess. These provisional water rights have not decreased remarkably, and are difficult to re-conciliate among water users. While efficiency in water use is essential, there are still large customary rights, most of which are not monitored. Collecting data, such as how much water under the customary rights is taken or discharged, is the first step for efficient water use. As people’s concerns toward water and the environment rise, public involvement and consensus building with proper information have

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[95] River Council 1999

[96] Water Resources Department, MLIT 2002

[97] Tanji, H. 2002

become indispensable. In view of these changes, the 1997 revised River Law introduced public involvement in river planning processes. Accountability in water rights is also necessary. It is important to manage water in a way that takes fully into account its economic, social, cultural and environmental values.

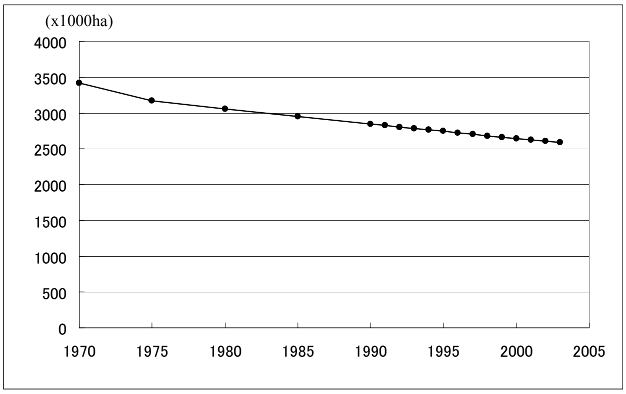

Figure 35 Trend in Cultivated Land of Paddies[98]

4.1.4 Water Resources Management and Valuing Water in Japan

The price of water can be a key determinant of both the economic efficiency and the environmental effectiveness of water services[99]. If we only emphasize efficiency in water use through water pricing, another problem may happen. Market mechanism may increase efficiency through pricing water. However, the market mechanism has not always worked when we consider poverty reduction. Based on the market mechanism, the price will be controlled by the balance between supply and demand. Rich supplies compared to demands decrease price, and poor supplies increase price. There is no room to consider poverty reduction in principle. While efficiency and accountability in water resources management has become essential, the pricing system based on demand controls are not always the best solutions. Efficiency and equity issues are very important topics in economics. Here, policy implementations are necessary for poverty reduction. It cannot be ignored that the water rights system is one of these policy implementations through protecting poverty in local agriculture. Another argument is that it is important to check whether pricing can cover these values fully. As these values vary among countries and regions, depending on natural, social conditions or historical backgrounds, it is appropriate to examine by countries or regions what values should be considered in the context of cost recovery of water services provision. In Japan, irrigation systems have been providing wildlife habitats for water species or rural landscapes through the process of creating a semi-natural environment, where human beings and nature coexist for almost two thousand years. One of the systems based on the historical backgrounds in Japan is a system of water rights.

As such, in order to discuss valuing water in Japan, the first step for better water use should be collecting necessary data and conducting research on water rights. Drought conciliation in an emergency shows the importance of such management in water use. The 1964 revision of the River Law established a rule for

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[98] Water Resources Department, MLIT 2004

[99] OECD 1999

conciliation during droughts. The River Law, first established in 1896, introduced a unified and consistent system of water management for all forms of water use under official River Administrators. The law authorizes water rights on the basis of an assessment as to whether the public interest is served and as to whether the business activities related to the water use are relevant. The revision in 1964 facilitated the role of River Administrators to mediate and arbitrate in disputes when the water users were unable to reach an agreement in water conciliation through providing necessary information and data.

Since it is not easy to develop water resources for increased water demand, demand management is necessary. Because of the clash of interests among water users during a drought, it became clear that the drought conciliation procedures presented insurmountable difficulties. In 1958, the water users on the Tonegawa River, the most important water resource for the Metropolitan Tokyo area, were unable to come to an agreement. The River Administrator mediated the dispute and helped to resolve the issue by discharging the water stored in the hydropower dam reservoir upstream. This experience resulted in a deliberate effort to establish rules for water use coordination as a measure during extreme droughts.

The drought conciliation process is one of the management tools even though it works only in severe drought. Article 53 in the 1964 revised River Law ruled that drought conciliation should take place when the water users were unable to reach an agreement on water conciliation. The underlying principle was that the water users should seek conciliation in the spirit of give-and-take among themselves in the first instance and refer to the River Administrator for intervention in the conciliation process only when their attempts at mutual conciliation failed. The principle of giving priority to mutual conciliation was adopted for two main reasons: (1) The practice of conciliation among the water users was anchored in tradition, as water users had historically resorted to mutual conciliation in the various river basins; (2) Drought differs from flood disasters in that it gives the water users sufficient time to reach conciliation on water use[100]. Drought conciliation took place in 58 of the total of 109 major rivers, with drought conciliation councils consisting of the River Administrator and the water users concerned having been convened in 51 of them (approximately 90%). In the rest the councils consisted only of the water users.

For efficient and accountable water resources management, it is very important to examine all possible measures including water pricing, and identify the best strategy that fits local conditions or historical backgrounds in water policy. Based on the water rights, the River Administrator has tried to manage water use equitably and efficiently with respect to the historical background in Japan. For better water use, it is indispensable to collect information and research water rights in detail. Water use in Japan is characterized as agricultural use in paddy fields, quite similar to the practice in most Asian countries. A deep review of the water rights system in Japan can contribute to a more effective policy which can be applied not only in Japan but also in the other Asian countries.

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[100] River Bureau, Ministry of Construction 1997

4.2 ELASTICITY FOR WATER RESOURCES USE

While the water right system in Japan was reviewed in the previous section, another search was made to seek a methodology for valuing water as a bottom-up approach. Water resources development requires long-term investment. Each user has invested huge resources in its own projects, such as reservoir construction, depending on their own demand. As the affordable projects have been decreasing, arrangements among water users become more important. While economic analysis can be an effective tool for the arrangement, there is very little research on the economic analysis. This section analyzes water demand and price of recent domestic water use, and tries to get elasticity as an essential parameter for the analysis. Water demand and water price are analyzed from public information related to domestic water supply[101].

4.2.1 Data for The Analysis

In Japan, the Waterworks Act recognizes municipal governments as water suppliers which manage water utilities for domestic water use. There are 9,202 water utilities in Japan as of 2009[102]. For this analysis, 128 water utilities were chosen as samples of water suppliers by referring to domestic water supply statistics[103] and the website of water utilities, under two criteria given below. Under these criteria, no water utility is selected in Shimane Prefecture, so water utility managed by Matsue City is added (Table 6).

- To clarify domestic water demand, water utilities for bulk water supply, which do not supply water directly to individual consumers and provides treated water to water utilities, are excluded. Most of the water utilities for bulk water supply are managed by a prefectural government or a cooperative body organized by municipal governments.
- Water utilities, which supply water to less than 150 thousand people, are excluded because most of small scale utilities do not have enough available data.

Table 6 Sampled Water Utilities

Region	Water Utilities
Hokkaido Touhoku	Sapporo, Asahikawa, Hakodate, Kushiro, Tomakomai, Obihiro, Hachinohe Area, Aomori, Hirosaki, Morioka, Sendai, Ishinomaki Area, Akita, Yamagata, Iwaki, Kohriyama, Fukushima
Kanto	Mito, Ibaraki South District, Hitachi, Utsunomiya, Ashikaga, Maebashi, Takasaki, Ota, Kofu, Saitama, Kawaguchi, Koshigaya and Matsubushi District, Tokorozawa, Kawagoe, Soka, Ageo, Kasukabe, Sakado and Tsurugashima District, Sayama, Kumagaya, Chiba Prefecture, Kashiwa, Yachiyo, Yamabe District, Sakura, Chosei District, Tokyo Metropolitan, Mitaka, Yokohama, Kanagawa Prefecture, Kawasaki, Yokosuka, Odawara, Hadano
Tokai Hokuriku	Niigata, Nagaoka, Nagano, Matsumoto, Nagano Prefecture, Gifu, Hamamatsu, Shizuoka, Numazu, Shimizu, Fuji, Nagoya, Toyohashi, Toyota, Okazaki, Kasugai, Aichi Central District, Ichinomiya, Anjo, Nishiohazu District, Yokkaichi, Suzuka, Tsu, Toyama, Takaoka, Kanazawa, Fukui
Kinki	Otsu, Kyoto, Uji, Nara, Osaka, Sakai, Higashiosaka, Hirakata, Toyonaka,Takatsuki, Suita, Yao, Ibaraki, Neyagawa, Kishiwada, Izumi, Moriguchi, Kobe (urban), Himeji, Amagasaki, Nishinomiya, Akashi, Kakogawa, Takarazuka, Itami, Kawanishi, Wakayama
Chugoku Shikoku	Yonago, Matsue, Okayama, Kurashiki, Hiroshima, Fukuyama, Kure, Shimonoseki, Ube, Tokushima, Takamatsu, Matsuyama
Kyushu Okinawa	Fukuoka, Kitakyushu, Kurume, Saga, Nagasaki, Sasebo, Oita, Kumamoto, Miyazaki, Kagoshima, Naha

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[101] Murase et al. 2005

[102] MHLW 2009

[103] MHLW 1966-2000

The data periods for the analysis are basically determined as every five years after 1965 in order to make a reasonable comparison with current water use and identify historical trends in water use. There were severe droughts in 1978 (the Fukuoka drought) and 1994 (the Japan Peninsula drought) and some other years. The sample years for this analysis are 1965, 1970, 1973, 1975, 1978, 1983, 1988, 1994, 1998 and 2001 (Japan fiscal year, from April to March).

4.2.2 Water Demand Analysis

The analysis of water demand starts with the trend of population and number of households, follows the trend of water demand per capita per day covered by water tariff, as economic goods. Further analyses follow for the relation between population categorized by industry and water demand, and also size of cities and water demand.

(1) Population and the number of household trend

Figure 36 shows the trend of population and number of household for the total 129 water utilities. An increasing trend is identified for total water utilities.

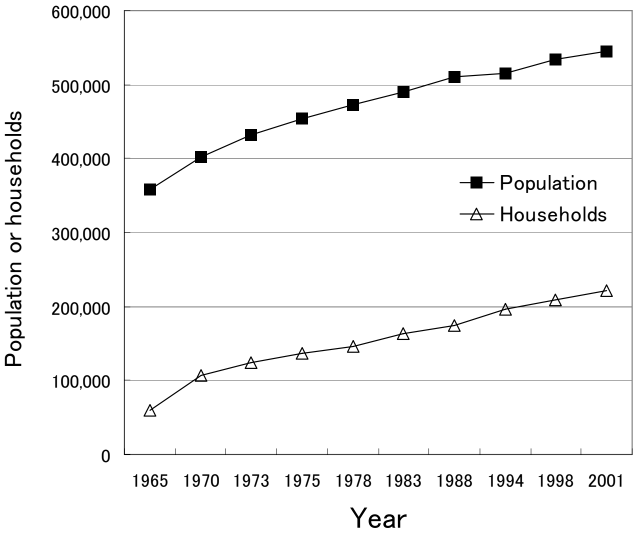

Figure 36 Trend in Population and the number of Households (average of 129 water utilities)

However, 10% of water utilities show the decrease or unchanged trend of population. Figure 37 shows the trend of the number of households for such utilities. The number of households increased while the population decreased in such cities. Therefore, the number of households has increased in almost all water utilities. The trend of population and number of households also shows that the number of people in each household decreases, making the “nuclear family” far more common in Japan.

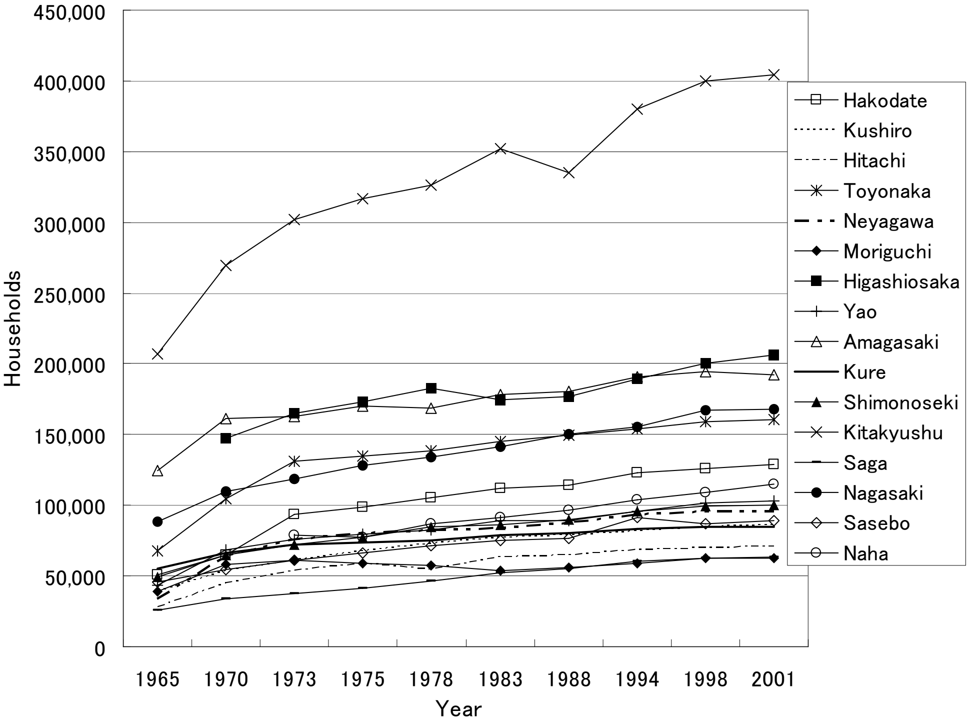

Figure 37 Trend in the number of Households for 16 water utilities

(2) Trend in Water Demand

Figure 38 shows the trend of average watar demand per capita per day for the total 129 water utilities. The water demand significantly increased between 1965 and 1970, and reached the peak in 1994, when “Japan Peninsula Drought” occurred. After 1994, the water demand decreased. It should be noted that this shows only the average of total the 129 utilities, so further observation is necessary to identify industrial structure and drought experieince of each city.

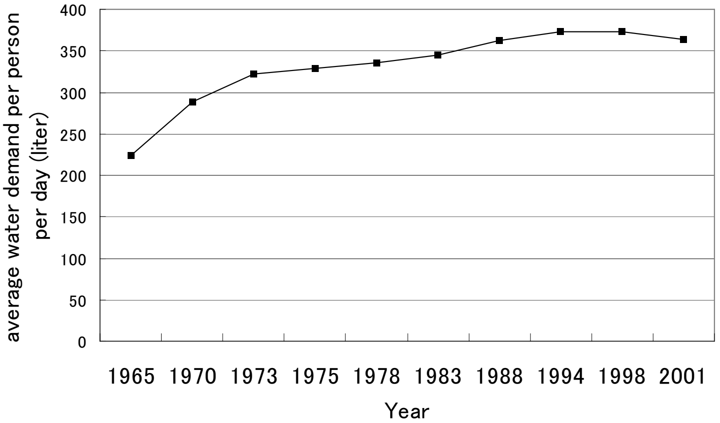

Figure 38 Trend in average water demand per capita for total 129 water utilities

To observe industrial structure and drought experieince of each city, the trend in water demand per capita for selected 12 cities; Asahikawa, Sendai, Akita, Tokyo, Niigata, Kanazawa, Ichinomiya, Osaka, Ube, Takamatsu, Fukuoka and Naha (Figure 39). These cities are selected, considering their drought experieince and location.The water demand per capita in Osaka is the highest. Those in Ube and Niigata are also very high. The demand in these cities are higher than that of Tokyo, where the size of water utilities is much larger. This means there is no relationships between the demand per capita and the size of water utility. The water utility in Fukuoka dropped in demand from 1975 to 1978, when major droughts occurred, but has slowly increased since then.

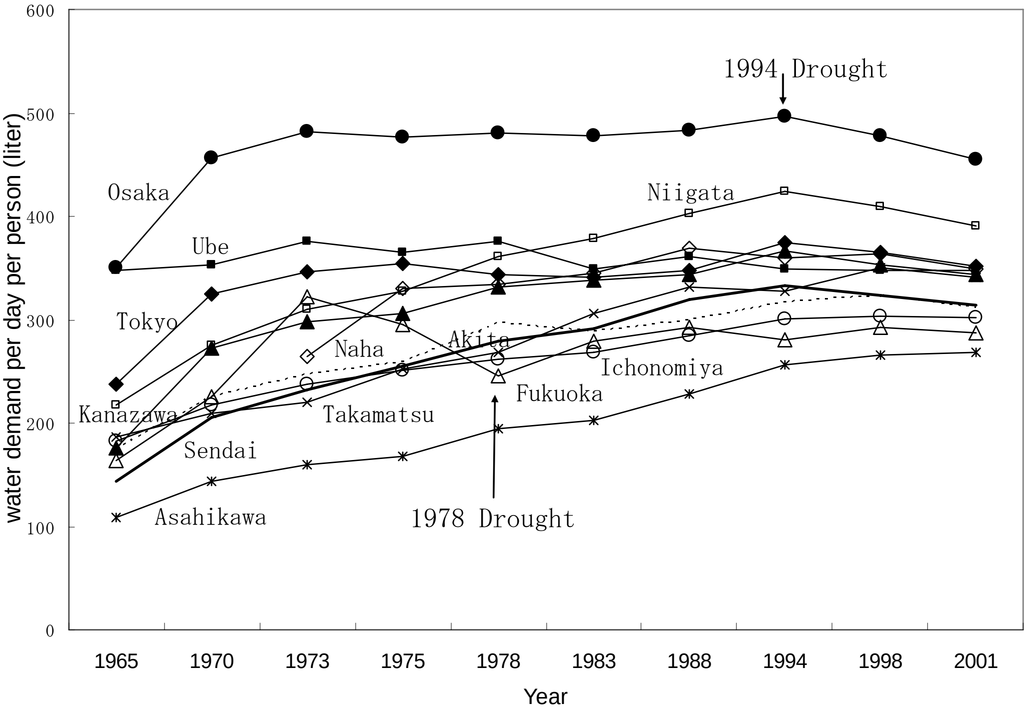

Figure 39 Trend in water demand per capita for 12 water utilities

(3) Urban Structure and Water Demand

The total population, the number of households, the day and night population ratio (the population in daytime per one in the night), the population by industrial classification (primary, manufacturing and service industries, originally classified by Colin Clark) are used as a parameter for urban structure. Figure 40 shows the total population and water demand per capita per day. The figure includes several log-approximation curves. The approximation curve for 1965 shows that the larger population the water utility, the larger the water demand per capita per day. This trend has become smaller in later years. It should be noted, however, that this tendency is not clearly identified. While the maximum correlation coefficient in 1965 was 0.38, it was less than 0.1 in 2001. So it can be concluded that a water utility which supplied a larger population generally used to show a higher water demand, but that this is no longer clear in recent years.

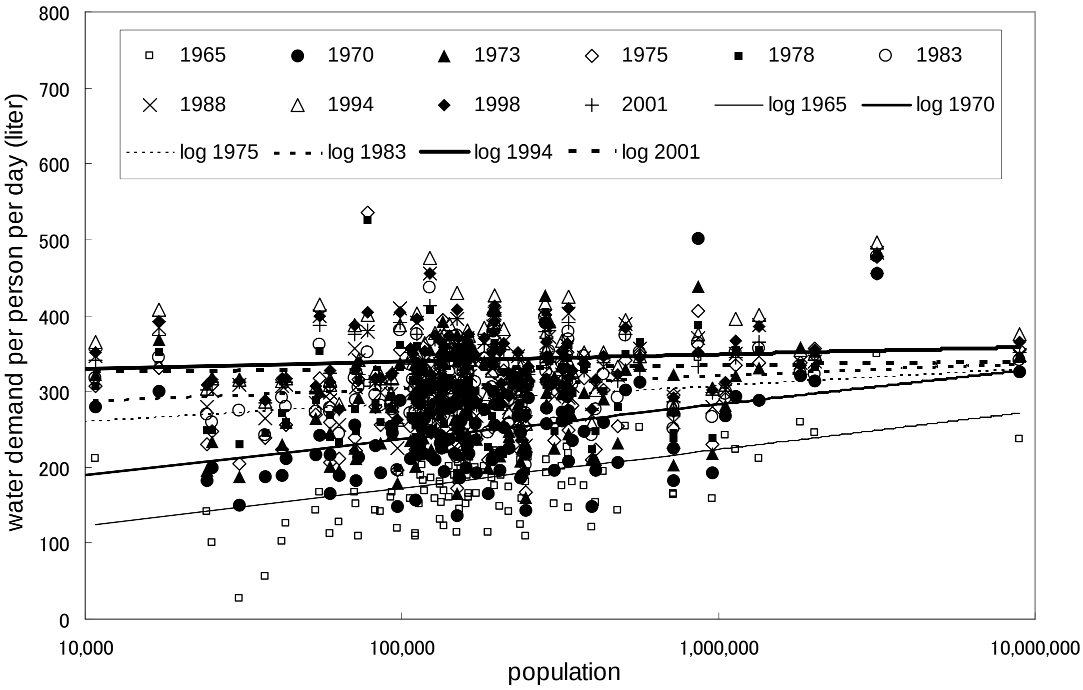

Figure 40 Total population and water demand per capita for total 129 water utilities

Similar relationships are observed for the day and night population ratio, and the population by industrial classification. The correlation coefficient for these relations are shown in Table 7. The larger the ratio day to night population (daytime population / night population) or the larger service industry population generally means higher water demand, but the table shows that the correlation coefficient are generally very small except day and night population. It can be identified that the larger day and night population shows the higher water demand.

Table 7 Correlation coefficient for water demand by fiscal year

Fiscal year	Slope (correlation coefficient)			
	Daytime / night population	Primary industry	Manufacturing industry	Service industry
1970	0.7574 (0.1114)	0.2235 (0.0346)	0.059 (0.2651)	0.0333 (0.2352)
1975	1.0331 (0.1929)	0.1192 (0.0141)	0.062 (0.2583)	0.029 (0.2272)
1978	0.9113 (0.1849)	-0.0221 (0.0022)	0.062 (0.2458)	0.026 (0.2195)
1983	1.0422 (0.2642)	0.1743 (0.0173)	0.0617 (0.2449)	0.0233 (0.2170)
1988	1.0433 (0.2646)	-0.2237 (0.0332)	0.0588 (0.2429)	0.0208 (0.2135)
1994	0.9015 (0.1908)	-0.1275 (0.0173)	0.0361 (0.1640)	0.0103 (0.1330)

Note: The slope and correlation coefficient for daytime/night is in %. The slope and correlation coefficient for industrial classification are the ratio of population (thousand) to water demand (liter) per capita per day.

4.2.3 Water Price Analysis

The relationships between water price and water demand are analyzed based on the water unit price calculated from water tariff data.

(1) Calculation of water price

In principal, water utilities apply independent account systems, so the cost of water supply should be covered by the tariffs paid by consumers. The tariff system of each water utility is designated by pipe diameter, consumer type (domestic or the other) and so on, under a progressive system (as more water is consumed, higher rates are applied)[104]. The independent system of water utilities makes it difficult to compare each other and analyze historical trend. For the comparison and historical analysis, water price of each water utility is calculated in the following condition.

- Table 8 shows the trend of average water supply per person per day. The average of seven fiscal year is 375 liters: 11.25 cubic meter per month (30 days per month). Most of the tariffs are based on a unit of ten cubic meters, and so the minimum water supply is assumed to be 10 cubic meter per month.
- The diameter of the most widely used water pipe for domestic water supply is 13 mm, so the tariff for a 13mm diameter pipe is used.

Table 8 Average water supply per person per day[105]

Fiscal year	1970	1975	1980	1985	1990	1995	2000	average
Average water supply per person per day (liter)	351	372	361	376	394	391	381	375

Figure 41 shows the trend of average unit water price for the total 129 water utilities before and after allowing for inflation[106]. The trend before allowing for inflation has increased simply, and the rate was increased after 1978, but the trend after allowing for inflation had decreased by 1975 and the rate is smaller than that before the revision. Hence, water price did not simply rise, and the rate of raise is smaller than those of other goods so the ratio of water to total domestic expenditure has become smaller.

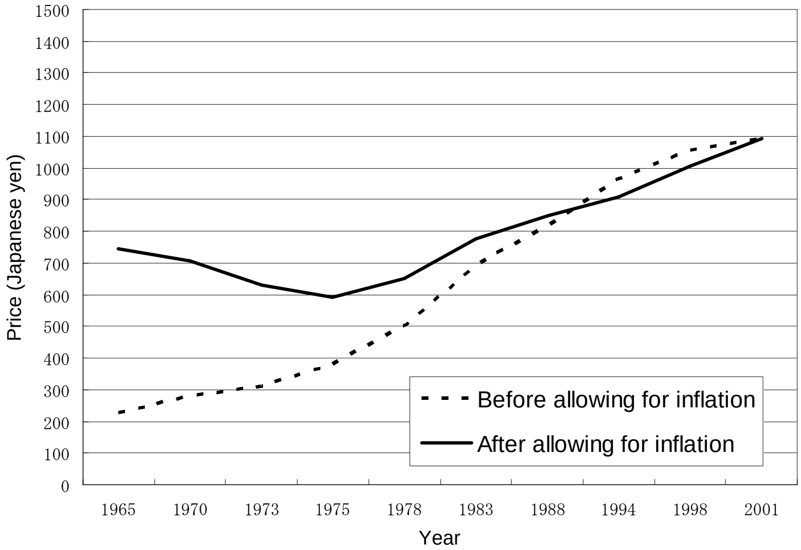

Figure 41 Trend of Unit Water Price for Total 129 Water Utilities

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[104] MHLW 2009, p.4

[105] The table is taken from MHLW 2001

[106] River Planning Division, River bureau, MLIT 2002

(2) Unit Water Price and Water Demand

Figure 42 shows water prices after allowing for inflation and water demand per person per day to analyze the relationships between water price and water demand. It should be noted that the coefficient are less than 0.5 in 1973, 1975, 1994, 1998 and 2001, but all first approximation curves are of negative slope. This means that the higher the water price becomes, the less the water demand per person per day in each fiscal year.

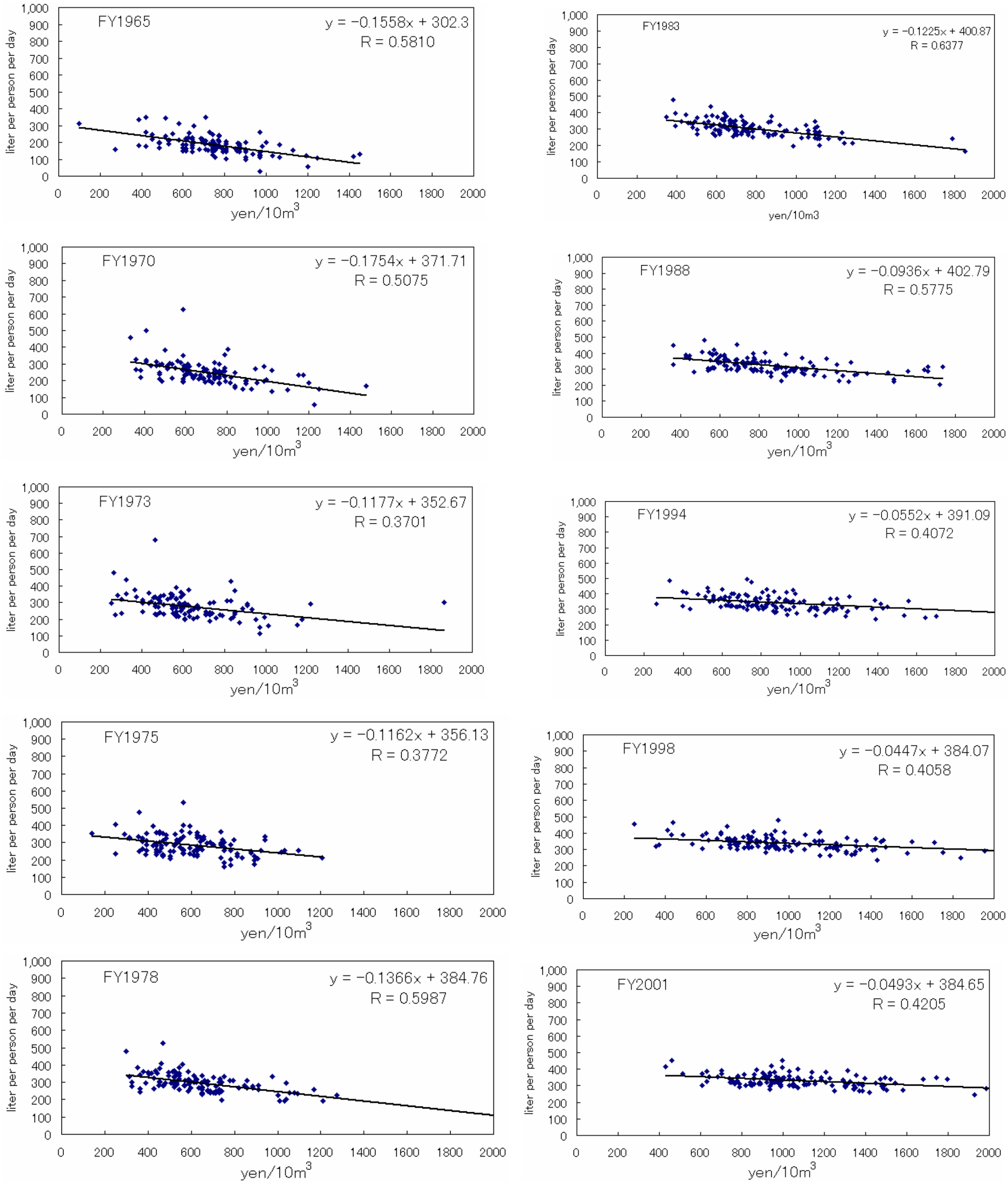

Figure 42 Trend of Unit Water Price for Total 129 Water Utilities

(3) Price Elasticity of Water Demand

To analyze the price elasticity of water demand, the water demand per person per day is plotted on the x-axis while the price of water is plotted on the y-axis (Figure 43) for each year. The dot on each year is the average of the 129 water utilities for each year. The slope gets steeper as the fiscal year progresses which shows that the impact of water price to water demand has become weaker over time.

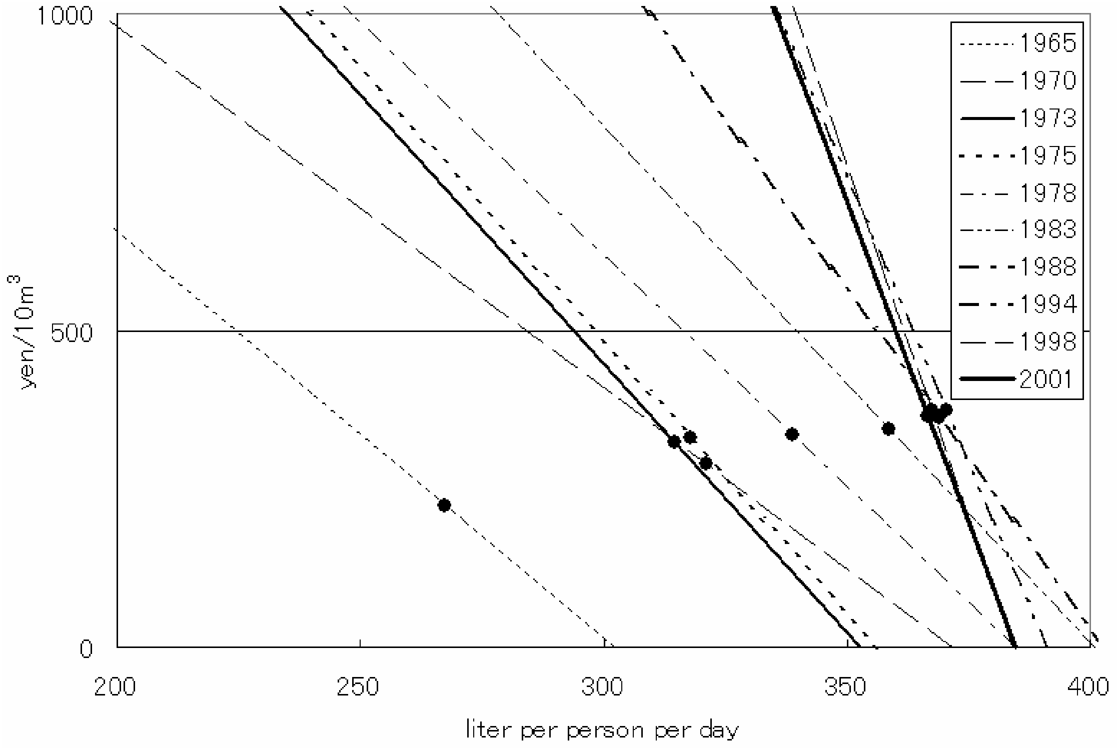

Figure 43 Water Demand Curve for each fiscal year

The elasticity of demand can be defined as differential water demand per differential price, so the elasticity of demand on each dot in Figure 43 for each year is shown in Table 9. The number of each fiscal year is calculated from the data of total 129 water utilities. This table shows the elasticity has become smaller year by year. This means that the impact on water demand of the price has become smaller. The reason can be

- The number of households increases while the size of each household becomes small.
- As people's standard of living increases, the payment for water becomes small in comparison with total household expenditure.
- The sewerage treatment works have almost been completed, and there are less impacts from the factors for water demand like living environment or life style, etc.

The short term price elasticity of water demand was calculated as 0.20 in 1960s in the USA[107]. One cannot simply compare this to the result of this study because of the difference in the calculation method, but the outcome is clearly similar.

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[107] Houthakker, H.S. and Taylor, L. 1970

Table 9 Price Elasticity of Water Demand

Fiscal year	1965	1970	1973	1975	1978	1983	1988	1994	1998	2001
Price Elasticity	0.19	0.20	0.11	0.11	0.14	0.13	0.10	0.05	0.04	0.05

4.2.4 Discussion on Water Elasticity for Demand

Focusing on domestic water use, water demand and water price are analyzed from disclosed information related to domestic water supply. This analysis uses water supply and price tariff of 129 water utilities in Japan for 10 fiscal years selected from 1965 to 2001. Even though the number of each family decreases, total water demand in many cities started to decrease from 1994, when the demand reached the highest peak. Water demand per person per day differed by the scales of domestic water supplies, but this difference has become smaller. Water demand has not increased so much and has become diversified all over the country. On the other hand, the price analysis of water supply shows the price elasticity of water demand has become relatively inelastic and approaches zero. This shows that there is a limit to managing water only through the water price. For some water supplies with high price elasticity during droughts, water pricing can be effective. However, more diversified needs should be considered for water resources management, such as water quality or uncertainty in drought risks for global climate changes. Further analysis for the other use, such as agriculture or industry, and comparison between public water supply and commercial bottled water would be important.

4.3 DIALOGUE ASSISTANCE FOR BOTTOM-UP APPROACHES

Water resources planning involves identifying and making trade-offs among various objective values deemed important to various interest groups and stakeholders. The tools in economics in the previous section are among essential methodology through valuing water. Once efficient alternatives are found, feasible solutions in the bottom-up approach requires building a consensus among these different interest groups and stakeholders.

In this section, consensus building processes for water resources planning are discussed, emphasizing public involvement in the decision-making process. US Army Corps of Engineers has developed a framework, called Shared Vision Planning (SVP), for public involvement[108, 109, 110, 111]. The SVP process can gather individual opinions through dialogue assistance for bottom-up approaches[112, 113]. In applying the SVP, three aspects need to be considered: early application, circles of influence and the institutional system. When applying the SVP early, many minor conflicts can be resolved before they become major ones. It is also important to recognize the different levels of detail and involvement that the different stakeholders and

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[108] Murase, M. 2001
[109] Murase, M. 2003b
[110] Murase, M., Kawasaki, H. and Tomizawa, Y. 2003
[111] Murase, M. and Kawasaki, H. 2004
[112] Murase, M. 2002b
[113] Murase, M., Kawasaki, H. and Tomizawa, Y. 2004

decision makers will require, i.e. the different circles of influence. This framework helps identify the diversity of views early in the planning process and through public participation throughout the process helps build a feeling of ownership in the final outcome. The SVP should also be compatible with social and cultural system. Because of the similarities of water use in Japan and other regions of Asia, such as paddy fields, case studies in Japan may also be relevant elsewhere in Asia.

4.3.1 Difficulty in Optimizing Solution

Allocation of water resources is vital to its planning. Failure in allocation results in conflicts of water use. Unfortunately, there are lots of conflicts about allocating water resources in the world. An appropriate allocation of water resources is significant in order to avoid conflicts and build consensus. In addition, as the construction of new water resources development facilities is now becoming difficult because of the decrease in suitable grounds, it is essential to use as efficiently as possible the already existing facilities in Japan. The allocation of limited resources has therefore become important in Japan. Mistakes in allocation will result in conflicts. In order to minimize these conflicts, those who are affected by allocations need to be involved in a consensus building water allocation planning process.

Theoretically, economics deal with efficiency of allocating the resources. As theoretical background for water resources planning, it is useful to review the notion of ‘optimization’ and ‘trade-offs.’ Optimization means allocating available resources with maximized efficiency. The allocation policy is called Pareto optimal or Pareto efficient if there is no way to change it that will make some member or members better off by increasing their utility without reducing the utilities of some other members[114]. An efficient allocation is when there is no way to increase one utility without reducing another utility. Figure 44 shows an example of allocating the capacity of a reservoir to flood control and environmental conservation.

Allocation A can be increased to allocation B for flood control without reducing the capacity for environmental conservation. It can also be increased to allocation C for environmental conservation without reducing the capacity for flood control. Therefore, allocation A is not efficient. On the contrary, allocation B cannot be increased for flood control without reducing the capacity for environmental conservation, and vice versa. Allocation B is therefore efficient. And there are ‘trade-offs’ relationships among the optimized allocation, such as B, C, D and E. The curve on these allocations lie is called the utility-possibility frontier (UPF). Ideally, if it is possible to measure welfare levels of the combination of environmental conservation and flood control (called social indifference curves I, II, III and IV in Figure 44), the best point can be identified at allocation D. However, it is always hard for us to find out these curves. We can only identify that allocation D is as efficient as allocations B, C and E. The ultimate purpose of water resource planning is to find out the UPF and decide one point on it by consensus.

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[114] Dorfman, R. 1993

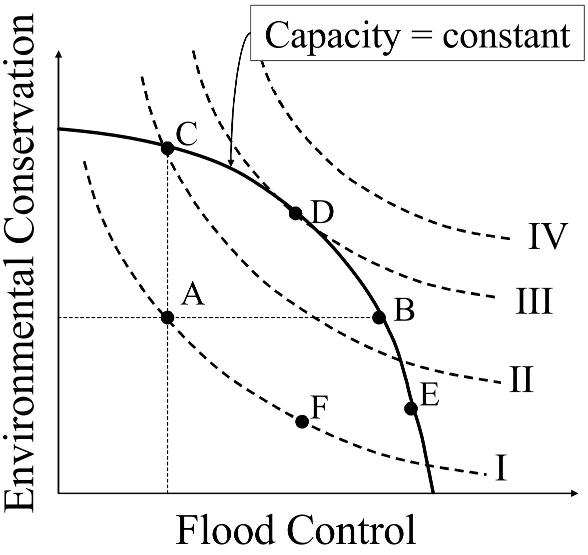

Figure 44 Utility-possibility frontier

The difficulty in planning process can be roughly summarized as two problems; how to assign values to different objectives, e.g., flood control or environmental conservation, and how to build consensus in deciding the best point on the UPF.

First, the main difficulty in allocating water resources is how to evaluate the utility of various values. Most of the values related to water resources are non-marketable. It is not easy to evaluate non-market values. Non-market value estimation relies on either (1) revealed or (2) hypothetical choice techniques. Revealed choice techniques interpret market prices paid or received for goods or services which are related to some measure of the environment, such as land prices for hedonic price analysis or travel costs for travel cost method. Hypothetical value techniques use surveys instead of market prices for related goods. The methods are generally termed the contingent valuation method (CVM), under the assumption that the survey instrument has been carefully designed to mimic a real market choice. Despite decades of research, the tools are still viewed as experimental[115].

Second, there is the so-called ‘gap’ problem. The more people become interested in environmental and other values, the more variety of value of thinking people have. Thus, people have required wider and more various interests, including not only economic interests but also environment and regional interests for water resources management. In order to account for this variety, a planning framework has been developed such as EIS, and this has become highly technical. The frameworks need more participation since people have required more opportunities for participation. Highly technical evaluation methods are difficult to understand for non-technical people. The problems can be summarized as a gap between sufficiency and understandability (Figure 45).

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[115] IWR 1996a

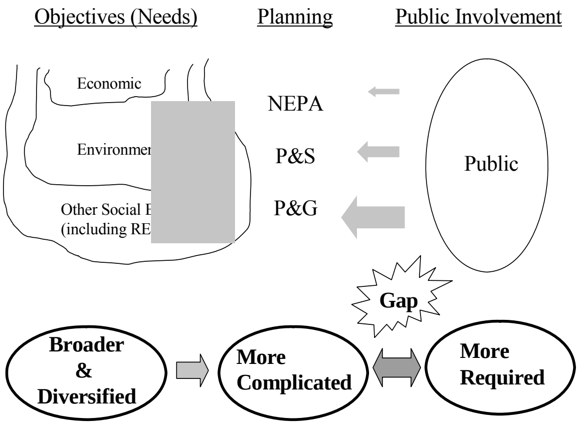

Figure 45 Gap Problem for Evaluation[116]

4.3.2 Legal Cases in the US

Efficiency and equity are serious issues in economics. For water resources planning, optimization means allocating available resources with maximized efficiency while trade-off seeks to assign values to different objectives with keeping social equity. As a public investment, a project should fulfill with its stated objectives completely, effectively and efficiently, and should be acceptable to the public. For example, a multipurpose dam should first fulfill its purposes, such as flood control and water supply (completeness). It also should be constructed and operated efficiently, at low cost and with minimum environmental impacts (efficiency). Furthermore, it should be acceptable enough for the public to approve (acceptability). Public involvement is important in accomplishing these requirements, but public involvement itself becomes more complicated when we think about the evaluation framework, and how public preferences and values are fully integrated into formulating alternative plans and making choices about alternatives. The planning and evaluation philosophies can be categorized into four distinct groups[117]:

- Descriptive - emphasizing a descriptive classification of options. No formal evaluation rules.
- Indicative - formulating and assessing problems. Multiple objective-oriented normative evaluation system (e.g. Water Resources Council (WRC)'s P&G)
- Prescriptive - prescribed standards, targets, criteria, technologies (e.g. EPA section 208)
- Proscriptive - generally single objective planning and problem solving (e.g. NEPA process, eco-restoration, hazardous waste reutilization).

In addition to the technical difficulty in evaluating various social values as discussed in the previous section, participatory decision making will be discussed by analyzing a case of environmental impact assessment in the USA. The National Environmental Policy Act of 1969 (NEPA)[118] is the one of the earliest and most influential enactments that established the broad national framework for protecting the environment in the USA. By injecting environmental concerns into much federal agency decision making in any way related to resource management and by making possible federal litigation challenging federal action affecting environmental quality, NEPA moved concern about environmental problems to a high level of public

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[116] Murase, M. 2002a

[117] Stakhiv, E.Z. 1996

[118] The National Environmental Policy Act of 1969

attention[119]. The major NEPA case chosen for the analysis here is Marsh v. Oregon Natural Resources Council, 490 U.S. 360 (hereafter *Marsh*)[120]. The Court held that an arbitrary and capricious standard of judicial review had been applied by Corps of Engineers decisions.

(1) NEPA

NEPA, enacted in 1969, requires an impact statement on major federal actions significantly affecting the quality of the human environment (section 102 (2)(C)). NEPA's basic policy is to assure that all branches of government give proper consideration to the environment prior to undertaking any major federal action that significantly affects the environment. NEPA requirements are invoked when airports, buildings, military complexes, highways, parkland purchases and other federal activities are proposed. Environmental Assessments (EAs) and Environmental Impact Statements (EISs), which are assessments of the likelihood of impacts from alternative courses of action, are required from all Federal agencies and are the most visible NEPA requirements[121]. NEPA applies to all federal actions, not only hard construction projects but also government regulations or subsized schemes with a federal connection, compared to the Environemt Impact Assessment Law (1997) in Japan which applies thirteen types of projects described in advance (Table 10).

Table 10 List of Projects subject to the Environmental Impact Assessment Law[122]

	Class-1 project	Class-2 project
1. Road		
national expressway	all	
metropolitan expressway	4 lanes or more	
national roads	4 lanes or more,10km or longer	4 lanes or more, 7.5km-10km
large-scale forest road	2 lanes or more, 20km or longer	2 lanes or more,15km-20km
2. River		
dam, weir	reservoir area:100ha or larger	reservoir area:75ha-100ha
diversion channel, lake-related development	land alteration area:100ha or larger	land alteration area:75ha-100ha
3. Railway		
shinkansen(super express train)	all	
railway, track	length:10km or longer	length:7.5km-10km
4. Airport	runway:2,500m or longer	runway:1875m-2500m
5. Power plant		
hydraulic power plant	output:30,000kw or over	output:22,500kw-30,000kw
thermal power plant	output:150,000kw or over	output:112,500kw-150,000kw
geothermal power plant	output:10,000kw or over	output:7,500kw-10,000kw
nuclear power plant	all	
6. Waste disposal site	area:30ha or larger	area:25ha-30ha
7. Landfill and reclamation	area:exceeding 50ha	area:40ha-50ha
8. Land readjustment project	area:100ha or larger	area:75ha-100ha
9. New Residential area development project	area:100ha or larger	area:75ha-100ha
10. Industrial estate development project	area:100ha or larger	area:75ha-100ha
11. New town infrastructure development project	area:100ha or larger	area:75ha-100ha
12. Distribution center complex development project	area:100ha or larger	area:75ha-100ha
13. Residential or industrial land development by specific organizations	area:100ha or larger	area:75ha-100ha

Note: Class-1 projects are large-scale projects that are required to follow the procedure of the law. Class-2 projects are ranked next to the Class-1 projects in scale for which the judgment whether to follow the EIA procedure is determined individually.

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[119] Anderson, Frederick R., Glicksman, Robert L., Mandelker, Daniel, R. and Tarlock, A.D. 1999

[120] Marsh IV 1989

[121] EPA 2011

[122] Ministry of the Environment 1997

One of the NEPA’s characteristics is its statutory mandate that NEPA imposes the “procedural” duties without any standards or baseline against which the environmental impacts of an agency’s action can be measured. Major arguments of NEPA can be summarized as follows.

- Threshold issues: Whether an EIS must be prepared or not? The category of federal connection is the first, and the timing of an action is the second. A federal action has occurred if it is an action by a federal agency. The next issue is the significance requirement, that is whether an action is sufficiently “major” or “significant” to quality under the statute. This significance requirement is more frequently contested and serves an important function under NEPA. *Marsh* also argued this issue.
- The scope of EIS: Once the EIS has been prepared, the next step is to determine what its scope is. The scope includes alternatives to the proposed action, the type of environmental impacts the statement must consider, a physical dimension of the action, and cumulative impact of agency decision making.
- Adequency of EIS: Have all environmental impacts and alternatives been considered and adequately discussed and evaluated? NEPA is designed to ensure that environmental information is available to public officials and citizens before decisions are made and before actions are taken, but there are always cases where EIS faces incomplete or unavailable information.

Marsh case will be here discussed especially for the threshold issues above related to water resources development projects.

(2) *Marsh*

Marsh is a case where four nonprofit corporations filed an action to stop construction of the Elk Creek Dam, which the US Army Corps of Engineers (Corps) designed to control the water supply in Oregon's Rogue River Basin as a part of a three-dam project. They claimed that the Corps had violated the NEPA by failing to describe adequately the environmental consequences of the project; to include a “worst case analysis”; and to prepare a second supplemental EIS to review information in two documents developed after 1980. The Corps completed an Environmental Impact Statement (EIS) for the Elk Creek project in 1971, and, in 1980, released its final Environmental Impact Statement, Supplement No. 1 (FEISS). Since the Rogue River is a premier fishing ground, the FEISS paid special heed to water quality, fish production, and angling and predicted that the Elk Creek Dam would have no major effect on fish production, but that the effect of the Lost Creek and Elk Creek Dams on turbidity might impair fishing. After reviewing the FEISS, the Corps’ Division Engineer decided to proceed with the project in 1985. The District Court denied relief on all claims and held that the Corps’ decision not to prepare a second supplemental EIS to address the new information was reasonable. The Court of Appeals reversed this decision, holding, among other things, that the FEISS was defective because it did not include a complete mitigation plan and “worst case analysis”, and, with regard to the failure to prepare a supplemental EIS, that two documents by Oregon Department of Fish and Wildlife and United States Soil Conservation Service brought to light significant new information on the effects of the Lost Creek Dam, suggesting that the Elk Creek Dam would adversely affect downstream fishing, and might be taken to indicate greater downstream turbidity than did the FEISS, so the Corps' experts failed to evaluate with sufficient care.

(3) Legal implication from *Marsh*

The Court of Appeals' conclusions that the FEISS was defective because it did not include a complete mitigation plan and a "worst case analysis" are erroneous for the reasons stated in *Robertson v. Methow Valley Citizens Council*, 490 U.S. 332[123]. This case indicated that NEPA itself does not mandate particular results, but simply prescribes the necessary process. The Court held the arbitrary and capricious standard that requires deference to agency decisions was the appropriate judicial review standard because the significance decision in this case is a classic example of a factual dispute. Yet the Court also required agencies to take a 'hard look' at the consequences of the proposed action, by helping to generate information and discussion on those consequences of greatest concern to the public and of greatest relevance to the agency's decision. This "hard look" doctrine meant that courts should not automatically defer to the agency's express reliance on an interest in finality without carefully reviewing the record and satisfying themselves that the agency has made a reasoned decision based on its evaluation of the significance or lack of significance of the new information. An agency must apply a "rule of reason" and prepare a supplemental EIS if there remains "major Federal action" to occur, and if the new information will affect the quality of the human environment in a significant manner or to a significant extent not already considered. In *Marsh*, the Court noted that the significant decision in that case was not a question of law because it did not require a new interpretation of the statute or the application of the significance requirement to settled facts. The decision on whether to prepare a supplemental impact statement was similar to the decision on whether to prepare an impact statement in the first instance. NEPA's procedural requirement can deter the arbitrary and capricious decision making with the hard look doctrine.

4.3.3 Alternative Dispute Resolution

While NEPA legal cases have contributed to defining procedural requirements, it always took a lot of time and financial resources for such legal cases once they became conflicts. As an alternative to adversarial processes such as litigation or administrative process that result in "win/lose" outcomes, an effort to arrive at mutually acceptable decisions, called Alternative Dispute Resolution (ADR) are helpful tools which can reduce the costs and delays associated with litigation. The ADR method aims to achieve a "win/win" solution is interest-based bargaining, as distinct from positional bargaining, the form of bargaining with which most people are familiar. Table 11 shows certain principles that underlie the use of ADR.

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[123] Robertson v. Methow Valley Citizens Council 1989

Table 11 General Principles for Alternative Dispute Resolution[124]

1. Define the problem, rather than propose solutions or take positions
   Everybody starts out with a different definition of the problem. People won't accept there is a need for a solution until they accept there is a problem. The solution first proposed becomes the definition of the problem.

2. View the Situation as an Opportunity for Collaboration, Not Competition
   Look for "win/win" solutions rather than "win/lose" or "winner-take-all" outcomes. By shifting the emphasis to the fact there are shared goals, it's possible to collaborate, even if some interests are not compatible or are in competition.

3. Negotiate Over Interests, Not Positions
   Because the bargaining start from positions, and then make concessions from them, the best that can occur in positional bargaining is a compromise. But people's positions are not necessarily the same as their interests. With interest-based negotiation, the possibility exists that all parties may be able to meet all their needs in the situation.

4. Employ Effective Communication Skills
   To create the circumstances for collaboration, participants need to employ communication skills that encourage collaboration rather than make others feel defensive or adversarial. Sometimes these skills are brought into the situation by a third-party who helps people communicate more effectively.

5. Design the Process to Address the Type of Conflict
   It is important to recognize a different type of conflict because very different dispute resolution strategies are needed depending on which type of conflict is involved. The five basic sources of conflict are Relationship Conflict, Data Conflict, Values Conflict, Structural Conflict and Interest Conflict.

6. "Satisfaction" Means Meeting a Mix of People's Substantive, Procedural, and Psychological Interests
   Being "satisfied" by a proposed solution means that people are comfortable with the combination of substantive, procedural or psychological needs that have been met. These three interests are called satisfaction triangle.

7. Consider a Wide Range of Alternatives
   One of the crucial preconditions to finding a win/win solution is to jointly develop a wide range of alternatives, not to stake out and defend any particular solution.

8. Agree on Principles or Criteria by Which to Evaluate Alternatives
   If all parties accept the same principle or criteria as fair, then they can see that the answer resulting from that principle is also fair.

9. Document the Agreement, to Reduce the Risk of Subsequent Misunderstanding
   Verbal agreements run the risk of misinterpretation and there can be honest differences in how an agreement is remembered. The documentation should be tailored to the complexity of the situation.

10. Agree on the Process by Which Agreement Can Be Revised
    Conditions may change in ways that require organizations to seek adjustments in agreements. Rather than create a situation where people feel the only way out of an agreement is to break it, it is better to include a mechanism for modifying the agreement within the agreement itself.

4.3.4 Shared Vision Planning

It is not coincidence that public involvement in the decision-making process can be required in bottom-up approaches for consensus building. The merits of public involvement can be summarized as follows[125].

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[124] arranged from IWR 1996b, pp. 13-19

[125] Delli Priscoli, J. 1998, pp.45-62

First, through public involvement, all stakeholders can understand the difference in values and interests, which most conflicts stem from. There are various types of conflict. Technical professionals frequently want to treat conflicts in their technical area of expertise as primarily data conflicts, but most conflicts stem from differences in values and interests. Second, public involvement can change position-based negotiations into interest-based ones. There are often winners and losers after a negotiation when they negotiate from their positions. The reason is that the position does not always consider the need of others who have a stake in the outcome. However, as collaborative problem solving, motivators, termed interests or needs, can create new options, and may solve the conflict[126]. Third, participating in decision-making processes, all participants can be satisfied with the results. Public involvement expects to contribute to the balance among procedural, psychological and substantive satisfaction.

Shared Vision Planning (hereafter SVP) is one of the frameworks for public involvement, which is developed mainly by the Institute for Water Resources, U.S. Army Corps of Engineers (hereafter IWR). Under the SVP process, water uses are modeled, and stakeholders are directly involved in the modeling process. By sharing visions, a broad range of people can build consensus and avoid conflicts. This mechanism is similar to conflict resolution through public involvement, one of the decision making process. The most significant point of SVP is that stakeholders and the public are introduced to the planning process through user-friendly models. The Shared Vision Models are simulation models of the system under study that are built collaboratively by experts from participating decision-makers and stakeholders, rather than models typically developed in isolation by technical experts. Simulation techniques are tailored to various patterns of scenarios, components of cause-effect linkages. They can be simulated in the context of “if we do this, what will happen?”[127] Thus, they are so flexible that they will accommodate various levels of uncertainty. They tend to be less mathematically intricate than many other techniques, so planners are more likely to understand and trust their results[128]. However, they do not automatically produce a preferred solution. Decision-makers must select an optimal solution among various options by themselves[129]. Simulation models do not solve the problem of evaluating against unquantitative or secret objectives, but do allow evaluation of alternatives that users believe to be addressed with these kinds of objectives. The results of simulations can be evaluated based on any stated or unstated (secret) set of criteria. IWR used STELLA II® as software that facilitates construction of these simulation models. This software is a general-purpose software package for applications in education, business, science, engineering, and other professional fields[130]. It combines four types of icon or objective: stocks (accumulation of flows, such as reservoirs), flows (steady stream, such as flows of rivers), converters (storage of mathematical expressions or data, such as dam operation rules) and connectors (linkages between other items).

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[126] Dunning, M.C. 1998, pp.135-140

[127] Loucks, D.P. 1986

[128] Goicoechea, A., Hansen, D.R. and Duckstein, L. 1982

[129] Palmer, R.N., Werick, W.J., MacEwan, A. and Woods, A.W. 1999

[130] IWR 1994a

Some case studies in the USA suggest that SVP can be a potentially effective tool for public involvement with consideration of the following three aspects; early application, circles of influence and institutional system[131, 132]. First, the time when SVP is applied is important. If SVP is applied early, conflicts can be avoided. Once a conflict happens, it is not easy to solve it. Second, it is difficult but challenging to set an appropriate target of applying SVP. SVP process can gather individual opinions through such technologies as the Internet. The SVP process helps promote diversity of views through introducing grass-root activities into a planning process. However, the mistake of selecting a tool for SVP makes it hard to build consensus. Third, SVP should match social and cultural backgrounds. Case studies are necessary. For instance, the Japanese preference for group decision-making needs SVP to work in two steps, that is, within groups and between groups. More people can participate in the planning process by each group. Within a group sharing common values, people are expected to express their opinions more easily. Therefore, SVP has to work initially within groups sharing common values and then among each group with different values. In Japan, the River Law, on which river management is based, was revised in 1997. While the consideration of river environment was added as a purpose of the law, public involvement was introduced in the planning process. A process of establishing river plans under the revised River Law is more suitable for applying SVP. The criteria for SVP will be here discussed with regards to this law.

(1) Early application

SVP can work for a “conflict avoidance approach” shown in Figure 46. SVP works in getting a variety of opinions in the plan and making many people take responsibility by participating at the initial step of establishing a river plan of the revised River Law. From the beginning of the process, including establishing a basic framework, SVP should be used based on the agreement with participants. The important thing in planning is a framework which would be applied. If the framework does not work well in identifying problems, the resulting planning process will not be effective in preventing future conflicts. If it does not work well in the public involvement, people will not respect the plan and feel any responsibility for it. According to the revised River Law in Japan, the River Administrators are required to make their own “river plans” even if there may have been no urgent problems at that time. This framework can work for this early application.

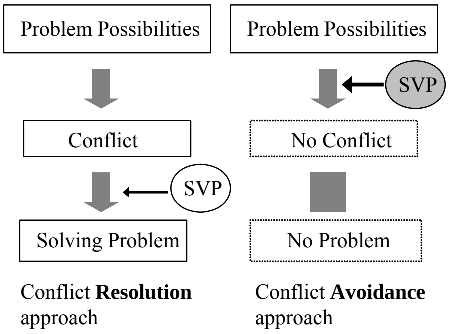

Figure 46 Planning Process

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[131] Murase, M. 2002b

[132] Murase, M. 2002c

(2) Circles of influence

Setting appropriate "circles of influence" shown in Figure 47 is important for effective planning. There are three categories: people who have primary interest in the river (e.g. municipal and industrial water supply, hydropower companies and fishermen's or farmers' unions), residents in the river basin, and people outside the basin. Although the public involvement is very important, the public should participate voluntarily. Not all people have the same level of interest in planning. The public should be provided appropriate information continuously. It is also important to keep their opportunity to know. Everyone can obtain necessary information anytime while planners let everyone know where to obtain the information. Here, it is difficult but challenging to set an appropriate target for the circles of influence. Each decision maker has to set his/her own circles of influence based on their own necessary information. The circles of influence can "help strike a balance between the effectiveness of small teams and representativeness of large teams."[133] Of course, these categories are not defined in regulations. The interaction among groups should occur constantly. Therefore, the circles of influences informally provided various ways of participation, and this variety is an important mechanism in SVP.

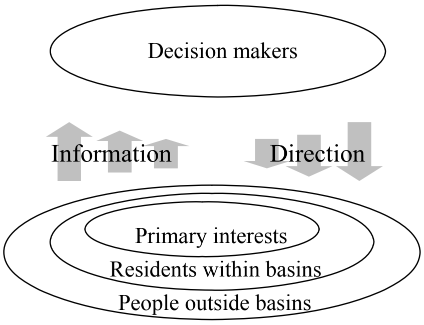

Figure 47 Circles of influence

(3) Institutional system

SVP should match the social and cultural system. Without an appropriate institutional system, SVP will not work as a coordination mechanism. The interaction between the soft and hard management is one criterion for the institutional system. The responsibilities of the institution for water management include both "soft management" such as research and monitoring and "hard management" such as project development. An appropriate institution can be characterized as frequent and intense interactions with each other. Determining functions and responsibilities of the proposed arrangement is the most important and there are "soft" and "hard" management when we think about coordination mechanisms[134]. Coordinated use of technology and social institutions can enable good water management[135]. Data in the process of monitoring river system is used effectively in the possible hard management. If people are encouraged to monitor the river (soft management) in their neighborhoods and identify problems by themselves, they will participate in solving problems (including hard management) in SVP.

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[133] IWR 1994b

[134] Kenney, D.S. and Lord, W.R. 1994

[135] Lord, W.R. 1984

4.3.5 Tools for Participatory Decision Making

Participatory decision making requires an appropriate method and process so that all stakeholders feel satisfied with a solution. Most of the basins include complex water use and stakeholders. IWR Shared Vision Models under SVP are among the examples of the tools for participatory decision making that are built collaboratively by experts from participating decision-makers and stakeholders. Simulation techniques are tailored to various patterns of scenarios, components of cause-effect linkages. Referring to the IWR models, tools for participatory decision making common in Japan were sought as a case study.

The Koishibaragawa and Satagawa tributary of the Chikugogawa River was selected for the case study. The water use in this tributary is for agriculture, industry and domestic supply. The scarcity of fountain or ground water is a matter of concern in this area. Dense and complicated water use makes it difficult to identify the availability of data, so the model was developed not only for simulation of the tributary hydrological scheme but also to check on the reproduction of tributary flow from available data. Stakeholders in the tributary brought their own data as the input for the database.

(1) Database development

The database is the fundamental item for participatory consensus building. As shown in Table 12, the solution first proposed becomes the definition of the problem for ADR. Sharing the information should be the first step towards sharing the situation and defining the problem. In order to share the information, all data were accumulated in Excel ® format.

Table 12 Data for the Case Study

Hydrological data	Flow	Daily precipitation
		Daily flow
		Ground water level
	Dam	Inflow
		Discharge
	Water quality	Dam
		River
Water use	Drinking water	Water supply area, population
		Intake and supply volume
	Industry	Supply area
		Supply volume
	Agriculture	Irrigation zone, area
		Intake by period
		Pumping volume(*)
	Sewage	Covered area, population
		Discharged volume, water quality
Water rights	Drinking water	Intake point, volume
	Industry	Intake point, volume
	Agriculture	Volume for each intake
River environment	River environment survey	
	River area survey	
	River landscape survey	
Other	Cross-section of river, H-Q	
	River GIS	
	Municipal statistics	
	Dam operation rules	
	Brochures	

Note: Pumping volume for agriculture is not measured so it was calculated from the pumps' electricity consumption.

(2) Development of simulation model

A simulation model was developed for assessing each facility's impact on the basin. It can simulate the water balance of the basin by identifying how the changes of operation rules or intakes, for instance, have an impact on the balance. The most important aspect of the model is that it can show all stakeholders' options to each other, so it can help shift position-bargaining to interest-base bargaining. It can also help documentation to reduce misunderstanding. There may be a risk of conflict stemming from the choice of model itself which happened in the IWR's case of ACT-ACF basins in the USA. It is also important to consider how easy it is to operate the model.

The model was basically constructed in the format of EXCEL ® of water system built, reviewed and tested collaboratively with all stakeholders in accordance with the database. In addition to the model, another model was also developed for comparison with the IWR's STELLA ®. STELLA II® is software that facilitates construction of simulation models pertinent to a broad range of fields. It is most simply described as a visual spreadsheet for systems analysis where the process being modeled can be readily visualized as a process rather than as a set of equations. Because of its user-friendly and object-oriented characteristics, it is expected to bridge the gap between specialized water models and the human decision-making processes. STELLA® combines four types of icon or objective: stocks, flows, converters and connectors. This software is a general-purpose software package for applications in education, business, science, engineering and other professional fields. Figure 48 shows how the four types of icon are combined in a checking account example. Each type of icon can be explained as follows.

- Stocks: Accumulation of flows. State variables to reflect time-varying (dynamic) characteristics. A mass (volume) can change in each time period in response to flows into and out of the stock (e.g. reservoir storage).
- Flows: Steady and continuous stream (e.g. stream flows, water supply diversions, reservoir releases, evaporation).
- Converters: Storage of mathematical expressions and data.
- Connectors: Mechanism to indicate the linkages between above items.

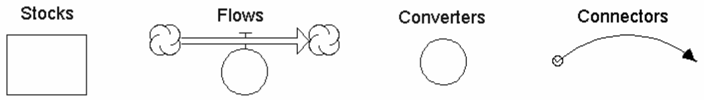

Figure 48 Components of STELLA ®

The simulation models were designed to show the basin's water balance by reproducing precipitation-discharge, intake-outflow, operation of dam or intake discharge. The tank-model was used for precipitation-discharge relationships after checking the data for the Egawa and Terauchi dams. Figure 49 and 50 show the basin modeled by Excel ® and STELLA ® respectively. These models can simulate how the flow in the river changes if the intakes or dam operations change.

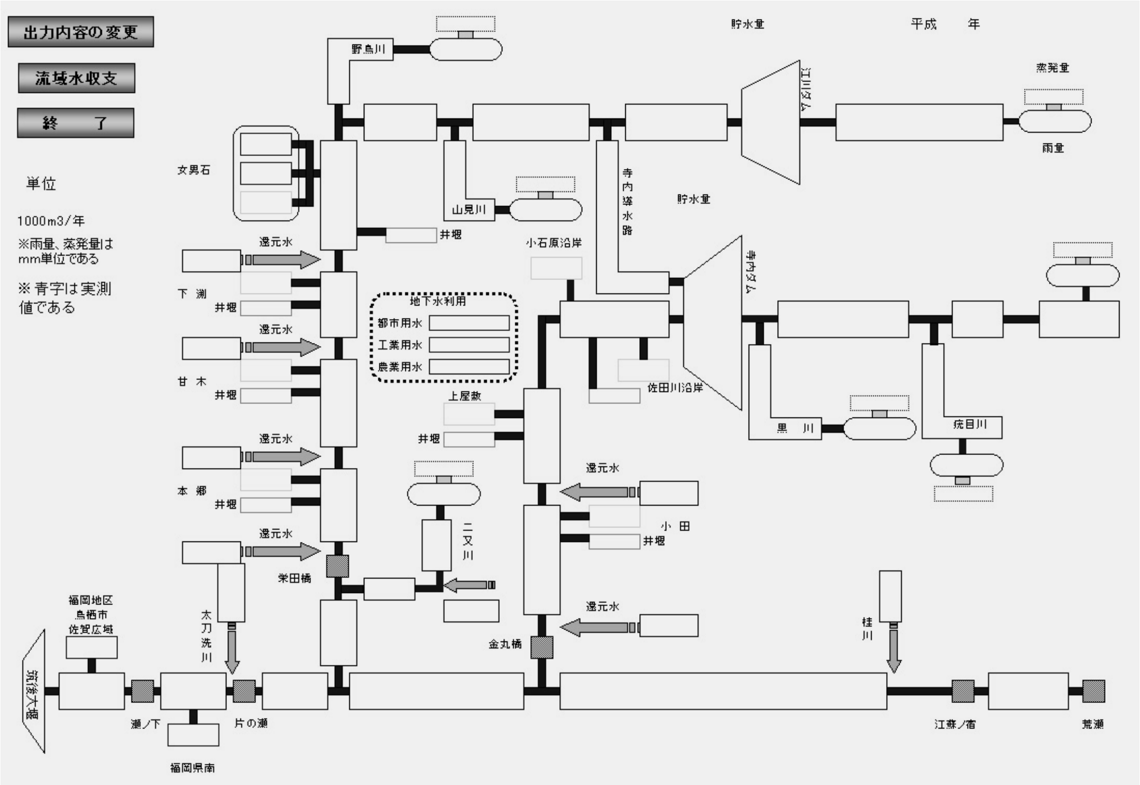

Figure 49 Excel ® model (in Japanese)

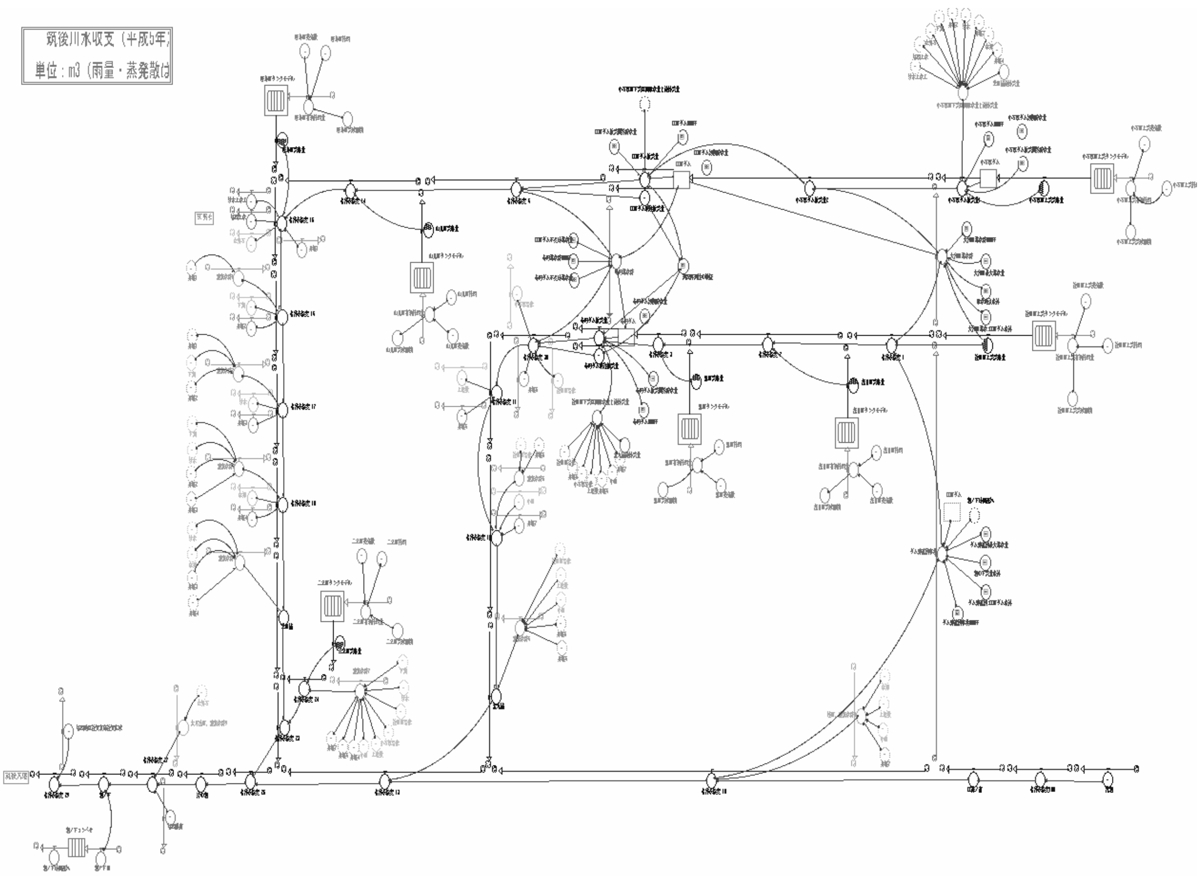

Figure 50 STELLA ® model (in Japanese)

As shown in Figure 50, the STELLA ® model can also change the points of intake or discharge graphically in more flexible way. If one point of discharge changes, for instance, it can simulate how the downstream flow changes as a result (Figure 51). From the different perspective, the comparison of Figure 49 and Figure 50 indicates STELLA ® model becomes more complicated that Excel ® and users should spend more efforts to learn how to operate the software. The model in the USA had been both praised and criticized as “being too complex and being too simplistic" and "attempting to do more than any model could do and not doing enough”.[136]

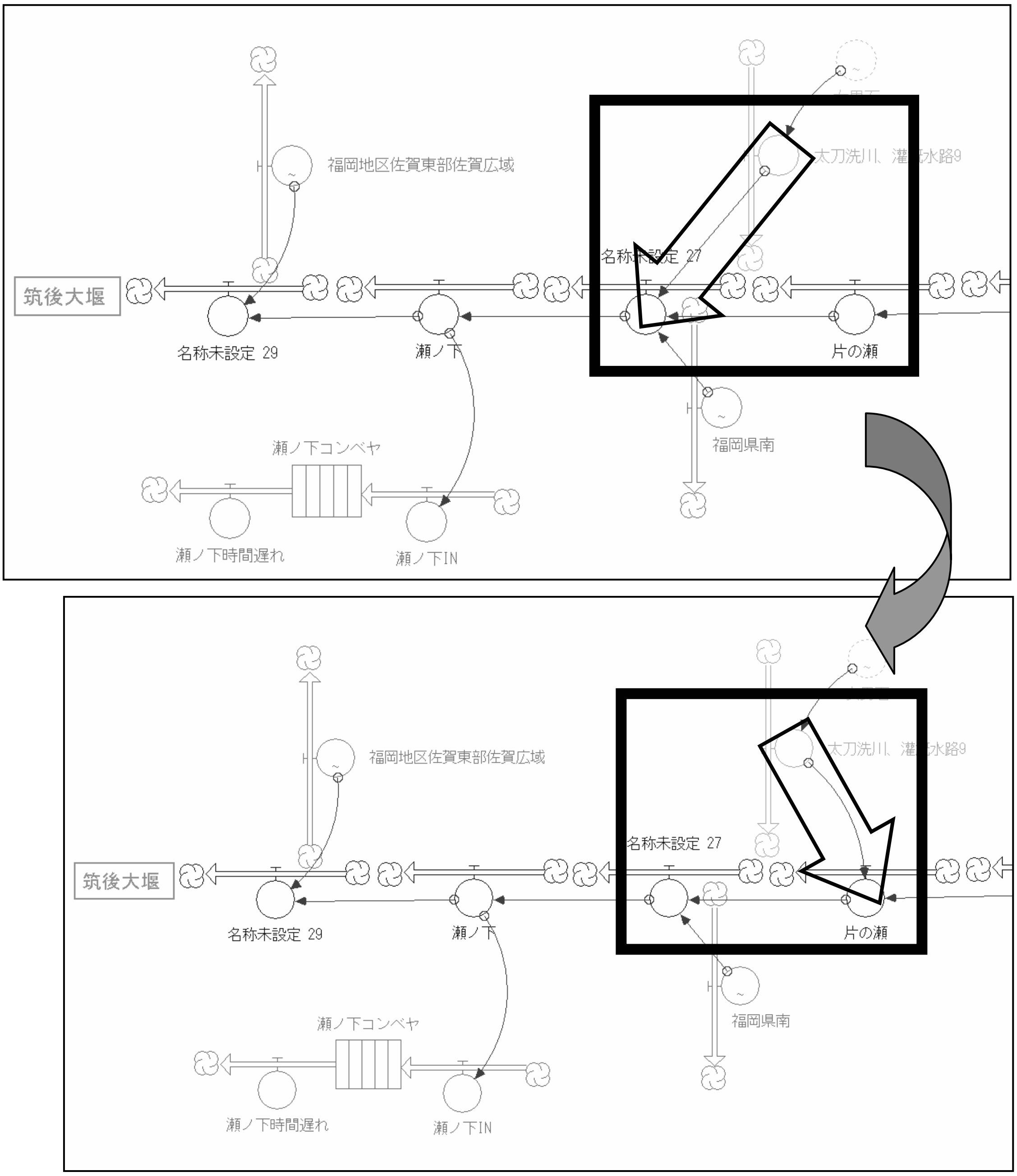

Figure 51 The image of simulation by STELLA ® model (in Japanese)

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[136] Palmer, R.N. et al. 1999

(3) Discussion of simulation models

The development of simulation models had the aim of assessing each facility's impact on the basin. The model generally evaluated from its relevance, validity, transparency, flexibility and acceptability.

- Relevance: The model's scope, functions and level of detail were appropriate to the problem setting. The models were designed to be used in negotiated decision making, so they could provide a valuable discovery process from the discovery of mutual gains.
- Validity: The model was consistently replicable and the cause and effect relationships were demonstrated in this study. The model also made the connection among model components during the model building process and made the model easy to replicate.
- Transparency: Users have effectively grasped how a system is represented in the models, assumptions and models' capabilities and limitations. Since two models were developed in the same area, each stakeholder can compare the results in transparent way.
- Flexibility: The model quickly answered "what if" questions for stakeholders. This capacity can assist in sensitivity analysis for the problems with scientific uncertainty and allow room for different views, and tradeoff analysis.
- Accessibility: The accessibility of the model can allow a number of agencies from among the planning participants to run the model and access it for independent analysis. For the case study, both models, Excel ® and STELLA ®, could be theoretically accessed, but it was not possible to access and operate the models without training.

It should also be noted that there are many uncertainties in the relationship between surface and ground water. Especially for the management of water use, more information and data for ground water is indispensable. The same area was modeled by Ground Water Analysis Program (GWAP) [137]. The model was comprised of sub-models (surface and subsurface models) in addition to the database in Table 12. The model can precisely evaluate the interaction between river and subsurface, and can also assess the cultivation water needed for paddy fields[138, 139]. The numerical results on the groundwater level and river discharge were compared with the field observation data (Figure 52).

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[137] NILIM 2006

[138] Amakata, M. et al. 2006a

[139] Amakata, M. et al. 2006b

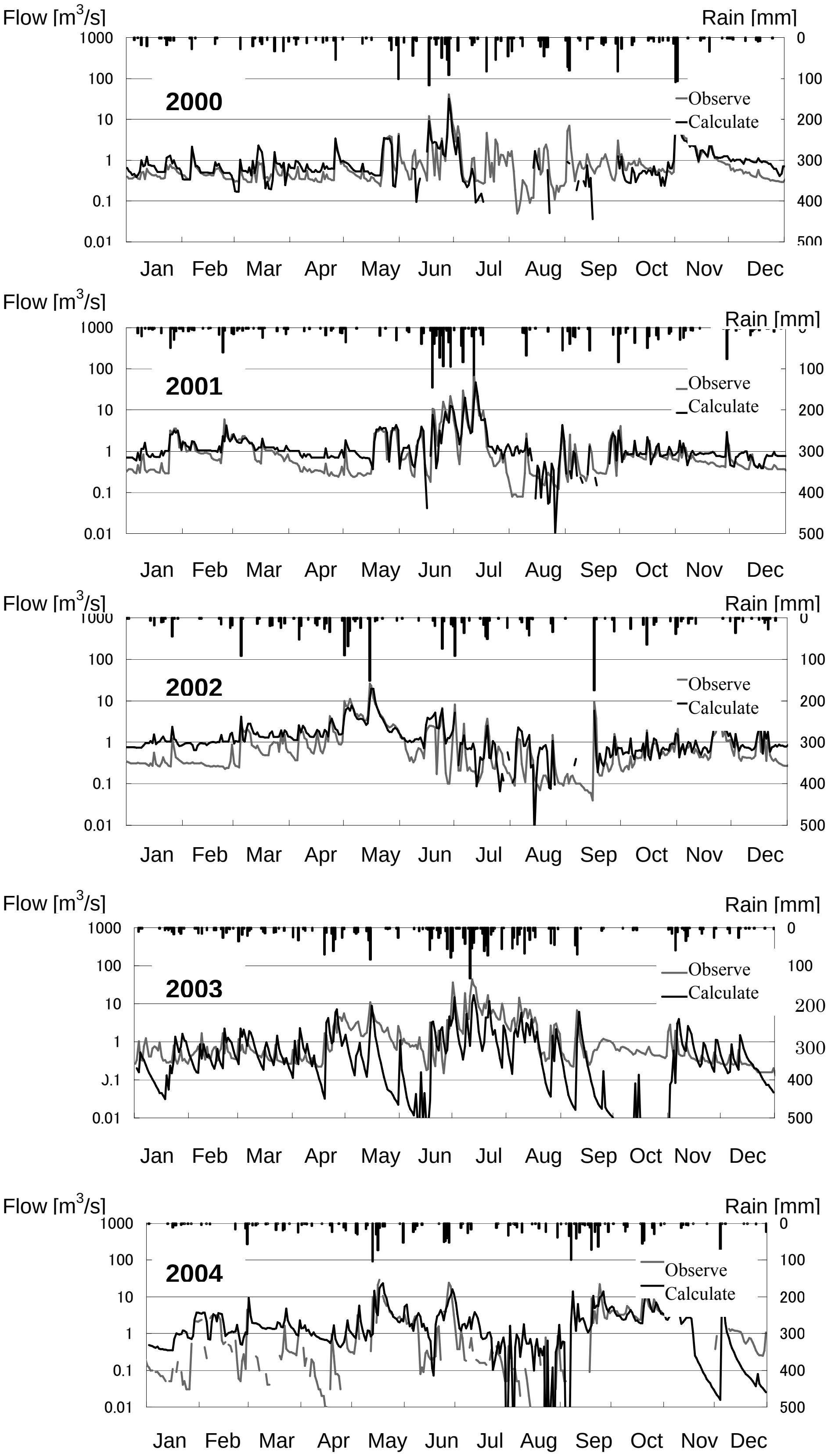

Figure 52 Comparison of River Flow Data for 2000-2004 (Satagawa River)[140]

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[140] NILIM 2006, p.72

4.4 CONCLUDING REMARK

A bottom-up approach to water resources planning focuses on exploring how well policy alternatives perform across a wide range of assumptions and uncertainties. Among various constraints in any decision-making process in water resources planning broadly categorized into: physical, financial, social, political, legal and environmental, economic analysis is an integral part of the formulation of policies related to people's development. The price of water can be a key determinant of both the economic efficiency and the environmental effectiveness of water services. Market mechanism may increase efficiency through pricing water, but it has not always worked when we consider poverty reduction. One of the systems based on the historical background in Japan is a system of water rights while it is still important to check whether pricing can cover these values fully. Another trial is to seek a methodology for valuing water as a bottom-up approach. The following issues need to be addressed for bottom-up approaches of water resources planning.

- Based on the market mechanism, the price will be controlled by the balance between supply and demand even though only the pricing system based on demand controls are not always the best solutions .
- In Japan, irrigation systems have been providing wildlife habitats for water species or rural landscapes through the process of creating a semi-natural environment, where human beings and nature coexist for almost two thousand years. The water rights system under the drought conciliation scheme in Japan is one of the policies for protecting against poverty in local agriculture.
- It is still appropriate to examine by countries or regions what values should be considered in the context of cost recovery of water services provision. In order to discuss valuing water in Japan, the first step for better water use should be collecting necessary data and estimating the elasticity of drinking water. Water demand per person per day differed by the scales of domestic water supplies, but this difference has become smaller. The price analysis of water supply shows that price elasticity of water demand has become relatively inelastic and approaches zero. This shows that there is a limit on managing water only through pricing.
- The allocation of water resources is a main part of its planning. Efficiency and equity are serious issues in economics. Optimization means allocating available resources with maximized efficiency while trade-off seeks to assign values to different objectives with keeping social equity. Failure in allocation results in conflicts of water use.
- In addition to the technical difficulty in evaluating various social values, the National Environmental Policy Act of 1969 (NEPA) in the USA is seen as one of the earliest and most influential enactments that established the broad national framework for protecting the environment in participatory decision making. NEPA injected environmental concerns into federal agency decision making where it was related to resource management. It made possible federal litigation challenging federal action affecting environmental quality and thus moved concern about environmental problems to a high level of public interest. The major NEPA case, Marsh v. Oregon Natural Resources Council, 490 U.S. 360 showed

that NEPA's procedural requirement can deter the arbitrary and capricious decision making by applying the hard look doctrine.

- While NEPA legal cases have contributed to the procedural requirement, it always took a lot of time and financial resources for such legal cases. As an alternative to adversarial processes such as litigation or administrative process that result in "win/lose" outcomes, an effort to arrive at mutually acceptable decision, called the "Alternative Dispute Resolution (ADR)" offers helpful tools which can reduce the costs and delays associated with litigation.
- Once efficient alternatives are found through economic analysis, a feasible solution using a bottom-up approach requires building a consensus among these different interest groups and stakeholders, namely Shared Vision Planning (SVP). The US Army Corps of Engineers has developed a framework for public involvement. By sharing visions, broad range of people can build consensus and avoid conflicts. This mechanism is similar to conflict resolution through public involvement, one of the decision making processes.
- The characteristics of SVP are that stakeholders and the public are introduced to the planning process through using user-friendly models. The models are simulation models of the system under study that are built collaboratively by experts from participating decision-makers and stakeholders, rather than typical models developed in isolation by technical experts.
- Most of the basins include complex water use and stakeholders, so some tools for participatory decision making can gather individual opinions through dialogue assistance for bottom-up approaches. Referred to the US Army Corps of Engineers IWR's models, tools for participatory decision making appropriate for Japan were sought as a case study.
- The water use in the Koishibaragawa and Satagawa tributary of the Chikugogawa River is selected for the case study. Dense and complicated water use makes it difficult to identify the availability of data, so the model was developed not only for simulation of the tributary hydrological scheme but also for checking the reproduction of tributary flows with available data. Since there is much uncertainty in the relationships between surface and ground water, the same area was modeled by the Ground Water Analysis Program (GWAP).

5. RISK SHARING TO ROBUSTNESS FOR WATER RESOURCES PLANNING

Floodplains provide excellent livelihood opportunities, for habitat, agriculture and commerce. Where these floodplains have been protected from frequent flooding, they have developed into throbbing economic centers. Agriculture continues to be an important source of livelihood in many countries, including Japan. The Integrated Flood Management (IFM) approach aims to maximize the net benefits from floodplains and at the same time reduce loss of life because of flooding, flood vulnerability and risks. The concept recognizes the importance of floodplains and the increasing development demands they face, while at the same time recognizing the disruptive nature of floods. IFM aims at a fundamental re-orientation of the social perception of floods from the “need to control” to the “need to manage”. It integrates structural and non-structural measures; land and water management; ecosystem preservation and development needs; and short- and long-term mitigation measures. Living harmoniously with floods is an important strategic option which provides a suitable framework for risk management towards its robustness. IFM is based on such proactive strategy of risk management through a three pronged attack on reduction of risks by reducing magnitudes, vulnerability and the exposure of the economic activities and addressing issues at all the three phases of the risk management cycle: preparedness, response, recovery and recondition. This chapter discusses the robustness for water resources planning and focuses on flood risk management as an integrated approach to flood management with an actual case in practice by the Takeo River Office, MLIT, Japan.

5.1 WATER RESOURCES MANAGEMENT AND FLOOD RISK

The geography of Japan is characterized as mountainous islands. About three-fourths of the total land area of the islands is mountains and most of the land is forest. The islands extend over 2,000 kilometer (km) in total length but spread only about 300km in width. This long, slender and mountainous geography creates short and swift rivers. The rivers carry much sediment and form alluvial plains. Population and industry continue to accumulate in the alluvial plains along rivers. Major communities have developed mostly in flood-prone areas along rivers. As a result, people and their property confront the constant danger of flood disasters. Due to the remarkable shift of population and social assets into urban areas, this urbanization has increased the risk of disasters.

This background shows that living on a floodplain offers enormous advantages although it exposes its occupants to flooding. The fertile alluvial soil of floodplains, the result of aeons of flooding, is ideal for high crop yields and the location provides good market access. Floodplains provide tremendous benefit to the socio-economic development of a society and for that reason they have been the preferred place for human settlements. Floodplains typically support high population densities, not only in Japan but also in, for example, the Netherlands and Bangladesh. The GDP per square kilometer is high in countries constituted mostly of floodplains: the Netherlands boasts the highest GDP per square kilometer in Europe. Floods also sustain ecosystems and the services that ecosystems provide. Floodplains are, of course, subjected to the risks posed by intermittent flooding, thereby extracting a price for deriving the benefits. The balancing of development needs and risks is essential, especially for water resources management in Japan. Wherever the perceived benefits from living in an endangered area exceed the disadvantages associated with the risk, society has continued to make use of such flood prone areas. Such benefits have to outnumber the costs exerted by the flood risks. There is a need, therefore, to find ways of making life and development sustainable in the floodplains, even if there is considerable risk to life and property. In order to maximize the benefits from the floodplains, the flood risks to the economic and social activities have to be reduced to a minimum, while the residual risks are managed and shared. The best approach is the integrated management of floods[141].

Integrated Flood Management (IFM) integrates land and water resources development in a river basin, within the context of Integrated Water Resources Management (IWRM[142]) and aims at maximizing the net benefits from the use of floodplains and minimizing loss of life and property damage from flooding. In developing policy-making, implementation mechanisms, consultative, coordinating and regulatory bodies, attention has to be paid to the appropriate scale at which they operate. A key tenet of IWRM is that traditional top-down approaches to management have to be supplemented by, indeed partly replaced by, bottom-up strategies to ensure that the water sector is demand-driven and can deliver welfare gains to the whole range of end users. For bottom-up strategies to be effective new institutions are likely to be needed. In many situations it will be essential to create community based organizations, which can actively participate in the development and management of water supply systems. In other situations democratically elected and representative consultative committees and market mechanisms may be the appropriate means by which users can convey their demands for water goods and services to providers. Bottom-up strategies do not mean that the complete devolution of decision-making to the local or community level is desirable or feasible; an appropriate balance has to be struck between community-level organizations and governmental bodies[143].

5.2 ROBUSTNESS FOR FLOOD RISK MANAGEMENT

Flood risks are both opportunities and threat-based risks as living on floodplains involves the risk of damage to property and/or loss of life, thus there is a potential price to pay[144]. Flood risks are also related to hydrological uncertainties. Our knowledge of the present is incomplete and generally we have only a partial understanding of the nature of the causal processes in operation. The extent of future changes cannot be predicted with certainty, as these changes may be random (e.g. climatic variability), systemic (e.g. climate

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[141] APFM 2004

[142] According to GWP (Global Water Partnership), IWRM is “a process which promotes the coordinated development and management of water, land and related resources, in order to maximizing the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.”(GWP 2000, p.22) GWP interprets “management” as including both “development and management”.

[143] GWP 2000, p.46

[144] APFM 2004, pp.16-17

change) or cyclical (e.g. El Niño). However, hydrological uncertainty is perhaps subordinate to social, economic and political uncertainties. The biggest and most unpredictable changes are expected to result from population growth and economic activity. Uncertainty and risk management are recognized as defining characteristics of choice rather than being inconveniences. It is recognized that "risk" is a social construct resulting from the accumulated or short-term effects of social and economic processes and defined as the conditions that societies perceive as troublesome[145]. The physical event by itself does not create a risk of loss, so it is the human activity that generates risk. The risk management is a necessary component of the development process, essential for achieving sustainable development. The application of a risk management approach provides measures for preventing a hazard turning into a disaster. It consists of systematic actions in a cycle of preparedness, response and recovery and should form part of IWRM. The actions taken depend on the conditions of risk within the social, economic and physical setting, with the major focus being on reducing vulnerability. Risk management also includes the efforts that are made to reduce the residual risks, involving flood sensitive land use and spatial planning, early warning, evacuation and preparation for disaster relief and flood proofing and, as a last resort, insurance and other risk sharing mechanisms.

Mathematically, risk is expressed[146] as the product of probability multiplied by consequences. Flood risks are defined as the expected losses from given flood events, in a given area, over a specified period. Consequences of exposure to flood hazard are commonly explained through a Source-Pathway-Receptor-Consequence (SPRC) model[147], which account for:

- The nature and probability of the hazard (i.e., the source);
- The degree of exposure of the receptor to the hazard (the pathway);
- The susceptibility of the receptor to the hazard; and
- The value of receptor or the element at risk (the consequence).

The susceptibility of the receptor depends on its sensitivity, the damage caused by an event of a given magnitude; and adaptive capacity, the ability of a system to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. Since the value and susceptibility of the receptor can be combined to represent the vulnerability, the construct of flood risks consists of:

- The magnitude of the flood hazard expressed in terms of frequency and severity (depths of inundation and related velocities and duration);
- The exposure of the elements to flooding; and
- The vulnerability of the elements at risk.

The exposure is often included as a factor that determines the vulnerability, but a clear distinction between the exposure and the vulnerability is maintained as it enables clear distinction between strategies that can

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[145] Judith Rees 2002

[146] UK Defra/Environment Agency 2003, p.8.

[147] Floodsite 2005, pp.3-15

be adopted to modify the pathways through engineering means from those that require consideration of social issues addressing the vulnerability[148]. As shown in Figure 53, flood risks can be reduced not only by decreasing the magnitude of hazards, but also by reducing exposure of people and their activities to flooding and diminishing the vulnerability of flood-prone society.

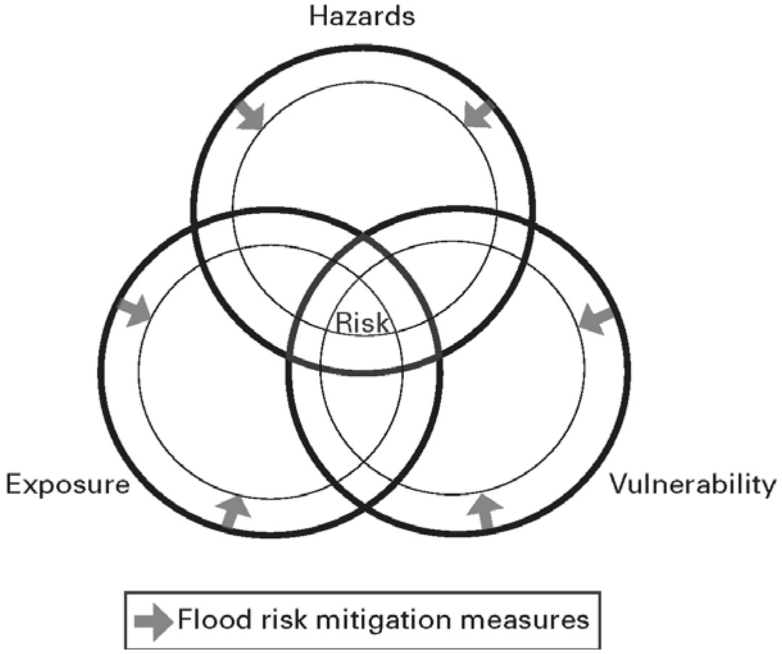

Figure 53 Construct of flood risk and its reduction[149]

As a result, mathematically flood risk is defined as follows.

Flood risk = Probability of potential loss due to flooding = $p[H] \times v[D] \times s[H]$

where

p [H] = probability of hazard;

v [D] = value of the elements at risk, which is a function of the development in the exposed areas and the land use; and

s [D|H] = the vulnerability of the elements at risk, which is a function of the magnitude of the hazard as well as the socio-economic construct of the exposed population.

For benefit-cost analysis of any flood management measure, estimation of potential losses has to be made for the lifetime of a particular measure. To calculate this, one needs to convert flood loss data into "potential average annual losses"[150].

Engineering of flood protection measures is based on the acceptable threshold for which the structures are designed to provide protection and reduce risks. There is still uncertainty about the reliability of hydraulic structures designed for such events. Safety of exposed population and assets remain dependent on a

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[148] WMO 2006b, p.9

[149] WMO 2006b, p.9

[150] WMO 2007, p.12

protection that can fail or be overtopped by an event of greater magnitude than that for which it was designed. Moreover, even if flood probability and risk are reduced to extremely low levels with high levels of protection, residual flood risks always remain. Efforts are made to reduce these residual risks. Eventually, if these residual risks materialize, flood loss occurs. In practical terms, under situations where flood management measures have been taken, flood risks should be treated as the "costs of taking risk". These costs include the cost of risk reduction, costs of managing the residual risks and the flood losses finally materialize as follows.

Risk Taking Cost= Risk Reduction Cost+ Residual Risk Reduction Cost + Actual Flood Loss Incurred

It may however be recognized that there are indirect costs of taking risks in terms of losses or damage to the environment (degradation, loss of environmental services etc.) as well as psychological and cultural costs, which cannot be quantified. Cost of risk taking is illustrated in Figure 54.

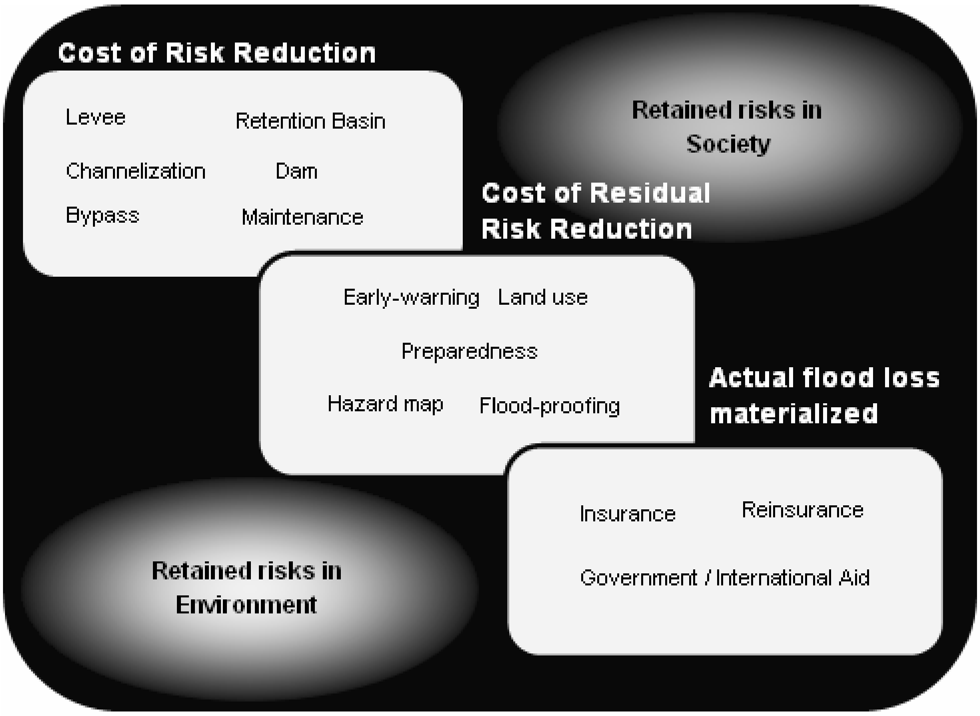

Figure 54 Cost of taking flood risks

Risk management calls for identification, analysis, assessment, control, avoidance, minimization or elimination of unacceptable risks through policies, procedures and practices. There are three strategies for risk management: risk reduction, risk retention and, as a last resort, risk transfer. Some ways of managing risk fall into multiple categories. Figure 55 illustrates the concept.

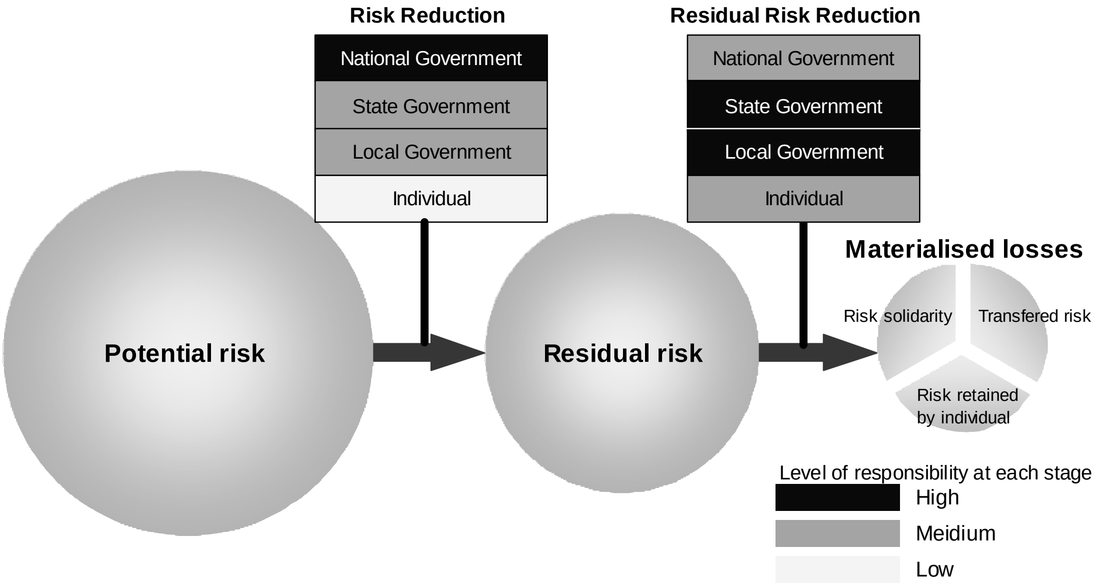

Figure 55 Managing Flood Risks

The first arrow, risk reduction, also known as loss prevention, includes activities that contribute towards diminishing the probability of potential losses. However, it is recognized that no degree of protection is insurmountable. There is always the possibility of a flood event impinging on the protected area by a flood greater in magnitude than the design flood of the protection works, called residual risks.

The second arrow, residual risk reduction, therefore, includes the efforts that are made to reduce the residual risks that involve flood sensitive land use and spatial planning, early warning, evacuation and preparation for disaster relief and flood proofing. Some of these measures are also used directly in the first level of strategies.

With all the efforts in place, flooding results in substantial losses due to damage to properties and interruption of economic activities. Such losses have the potential to increase the vulnerability of the population that is affected directly or indirectly. Some of the materialized losses are absorbed by the element at risk, also called retained risks. In order to help recovery of the affected, the other materialized risk is transferred, which entails passing a part of the risk to the public at large through national exchequer or spread internationally through the aid agencies. Another financial mechanism for risk transfer is to transfer it to another economic agent for an exchange price, called the premium.

Typically, an efficient solution requires a combination of all the three. Each of the strategies deployed has a cost and corresponding benefits, and based on cost–benefit analysis[151], it is possible to determine an optimal combination.

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[151] WMO 2007, pp.11-26

5.3 RISK SHARING UNDER INTEGRATED FLOOD MANAGEMENT [152]

The decisions to manage risks depend on how the risks are shared among various administrative entities and whether transferring of risks in time or in space is a viable option. Broadly, there are five sets of competing principles [153] that are followed in sharing the cost of risk taking in the water sector: precautionary vs reactive; uniform vs subsidiary; individual choice (market) vs maternalism; professionally determined vs political bargaining; and risk generator vs risk bearer vs taxpayer. Climate change, as a driving force in increasing flood risks and the call for "polluter pays principle"[154], adds another angle to the debate. This change has led to searching questions concerning the appropriate division of responsibility between the state and its citizens and the 'fitness for purpose' of the current appraisal, prioritization and decision-making processes.

All those within a basin, region or a country have a stake in the flood risk management system either directly by their exposure to flood risk or indirectly, contributing to the flood risks in the flood prone areas through various economic activities. The infrastructure (roads and railways), and economic activities within the floodplains facilitate economic development even beyond the basin. By virtue of their status as tax payers, they have a stake in how expenditure decisions on flood loss mitigation and relief expenditure are taken. In an urban context, with the construction of storm drainage systems, not only those that are located in the downstream low lying areas but also those that are located upstream, derive the benefit from timely evacuation of rain waters. Basin solidarity can be one of the ways to account for and compensate downstream residents for upstream watershed changes that alter flood characteristics.

The principles of cost allocation need to be set up. Based on the above considerations, the costs of taking flood risk have to be distributed not only among those occupying the floodplains and drawing direct benefits, but also among those who derive indirect benefits. For equity and fairness the costs of taking flood risks have to be appropriately shared in a transparent manner. Risk sharing is one of the risk management aspects which deals with the way the cost of risk taking are distributed among several stakeholders: the federal, state and local governments and the flood effected individuals[155]. Risk sharing includes:

- Sharing the costs for risk reduction;
- Sharing the costs of residual risk reduction; and
- Sharing the materialized risk, i.e. the losses or consequences

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[152] WMO, 2009b

[153] Judith Rees 2002, p.20

[154] According to the recommendation of Organization of Economic Cooperation and Development (OECD) in 1972, the "Polluter-Pays Principle" is a principle to be used for allocating costs of pollution prevention and control measures to encourage rational use of scarce environmental resources and to avoid distortions in international trade and investment. This principle means that the polluter should bear the expense of carrying out the above mentioned measures decided by public authorities to ensure that the environment is in an acceptable state (OECD 1972).

[155] Galloway, G.E. 1994, pp.82-83

5.3.1 Sharing costs of flood risk reduction

Risk reduction is the first step in the risk management process. Potential flood risks can be reduced either by decreasing flood magnitudes or reducing the exposure and vulnerability of the social and economic activities; this can be done both through structural or non-structural measures. It entails a variety of measures that require financial resources, the availability or otherwise of which determines the execution of possible options. Flood risks being the construct of both the physical and social aspects, that is, flood hazards, exposure of economic activities and the vulnerability of the society affected by floods, it is crucial that options to reduce each of the components are fully explored to reduce flood risks.

The exposure is the measure of the population and the assets that would be directly exposed by a flood in absence of flood protection. As such the exposure does not necessarily translate into impact. The linkage between exposure and the residual risk of impact depends upon flood protection measures. The exposed population and assets should thus be distinguished from the at-risk population and assets in the presence of protection. Exposure, however, is a useful metric as it provides the basic information needed to assess the need for flood protections.

Another approach would be increasing resilience of the society to withstand the adverse impacts. Reducing vulnerability plays a key role in dealing with residual risks and the strategy to live with floods. Vulnerability to flood hazards can be reduced to a certain extent by measures to promote resilience, adaptation and flood risk reduction. A detailed discussion on the vulnerability characteristics and measures that may be useful in dealing with them is given in WMO[156]. Reducing vulnerability also requires the analysis of the disaster in order to learn lessons and integrate corrective measures into prevention and preparedness plans.

This still leaves residual risks caused by extreme flood events that are beyond the design flood events or those which would be expected from natural climate variability. Little effort has been made to prevent further adverse impacts, reconditioning of important infrastructure and documenting events. The reduction of vulnerability through preparedness, such as early warning systems, is essential to achieving development goals.

Table 13 shows a list of options for reducing each constituent of flood risks. This is not an exhaustive list but gives a first overview on the possible means to reduce flood risk. These actions are taken depending on the conditions of risk and social, economic and physical setting.

Many view the government as responsible for protecting the public and thus expect the government to bear the cost of flood risks. Traditionally, governments take the primary responsibility for protecting the public from floods in all their aspects. As the resources come from the public funds and are in competition with

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[156] WMO 2006b

other needs of the society, governments are concerned about the fiscal implications of taking full responsibility of bearing the entire cost of flood risks. They seek measures to share the costs of risks between various tiers of government (federal, state and local) and households and businesses. It is arguable as to what extent the risk can be shared by the poor who are the principal occupants of these risk prone areas, particularly in the developing countries. A transfer of burden to an already vulnerable population cannot be justified by arguments of efficiency and loss reduction. It also invokes the fundamental question of equity and social solidarity in responding to relief to the victims of catastrophic floods. How much those in non-risk areas and the general tax-payers contribute to preventing losses and compensating victims in vulnerable communities, and to what extent should those who are located in high-risk areas bear the burden, are issues deeply rooted in the societal values and depend on the specific socio-economic and political environment.

Table 13 Options for reducing flood risks

Reduce hazard	Reduce Exposure	Reduce Vulnerability
• Retaining water where it falls (increasing infiltration, rooftop storage) • Retention basins (natural wet lands or depressions, man made e.g., school play grounds, household underground tanks) • Dams and reservoirs • Diversion channel • Land use management (e.g., house building codes in urban areas, infrastructure building practices, appropriate spatial planning)	• Structural measures on the river (dykes, river training work such as flood walls, raised infrastructures such as roads and railways) • Structural and non-structural measures/actions by individuals (flood proofing) • Land use regulations • Flood emergency measures (flood warning and evacuation)	• Physical: by improving the infrastructure, well-being, occupational opportunities and living environment • Constitutional: by facilitating equal participation opportunities, education and awareness, providing adequate skills and social support system • Motivational: by building awareness and facilitating self organisation

A mechanism for sharing the costs of risk reduction could be developed by having the federal government provide the basic protection against a minimum level, while the costs of protection against higher floods could be distributed between the state and municipal authorities. Funding of projects by the federal government puts the responsibility on all taxpayers—this is appropriate where there are countrywide benefits in terms of national security, infrastructure protection and livelihood generation. According to Ingram[157], crises creates consent and they should be used creatively and effectively to alter the current allocation of responsibilities among federal, state and local entities.

State and municipal authorities benefit from activities that provide direct revenue to them and as such, for any protection above the basic minimum, they should bear the cost of risk reduction in principle. They can also use various financial instruments such as market bonds, which can increases the state’s ability to fund

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[157] Ingram, H. 1988

large projects in the near term. The following examples show some schemes for sharing the costs for risk reduction.

In the USA, after the Upper Mississippi floods of 1993, it was recommended that cost sharing provisions be introduced for the State, Local, and tribal participation in recovery, response and mitigation activities[158]. All of those who support the risk, either directly or indirectly, must share in the management and the costs of reducing the risk[159]. The federal-state cost-share, originally 75/25, was adjusted for major disasters (Hurricane Andrew, the Midwest flooding, and Northridge earthquake) to 90/10 basis. These cost-share changes have two potential significant consequences; raising expectation of similar treatment for future disasters and losing the fundamental purpose behind cost sharing which is to increase the amount of local involvement, responsibility and accountability[160]. Flood losses actually incurred to individuals and communities can be shared by putting in place a flood insurance program that obtains its support from those who are protected. It is considered that disaster support for those in the floodplain is contingent on participation in these self-help mitigation programs.

In Japan, the River Law (1896, totally revised in 1964, last amended in 1997) has played an important role in forming policy for flood management.[161]. The River Law established the cost allocation for river administration among the central government for class A rivers and prefectural government for class B rivers. Upon a government ordinance, a prefecture government undertakes half of the administration cost for the major part of the class A river within the prefecture while central government can provide subsidy up to half of the cost for designated major works in class B rivers[162]. At times of flooding, the responsibility of flood response lies mainly with the municipality to take action for mitigating the impact of floods[163]. It is the responsibility of the prefecture to take emergency measures in the event of a large-scale disaster. In case of extreme floods, the national government provides special financial supports to the local governments[164].

In Switzerland, the role of the federal government is largely limited to the provision of financial, scientific and technical support, with cantons and communes taking on the principal duties of emergency management[165]. The federal government is responsible only for tasks that are explicitly in the Constitution. The Federal Law assigns the responsibility for flood control to the cantons, which in turn can assign this task to the municipalities or even to the riparian landowners. This means that the role of the Federal Government is to provide financial support and, as required, technical and scientific support. Financial support can be provided only if projects fulfill the objectives as given in chapter 1 of the Law. The subsidies cover on average 30 per cent of total costs and are dependent on the financial power of the canton

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[158] Galloway, G.E. 1994, pp.83-84
[159] Ibid., p.187
[160] Ibid., p.82
[161] MLIT 2009
[162] River Law in Japan, Article 59-62
[163] Flood Fighting Law in Japan, Article 41-44
[164] Cabinet Office 2009
[165] WMO 2006a, pp.87-97

and the municipality. The maximum is 45 per cent, which may exceptionally be raised to 65 per cent for restitution after flood disasters. The remaining costs are distributed between the canton (frequently 30 per cent) and the municipalities. The cantons are the executing agencies. Even if the municipalities are responsible, the technical knowledge will be supplied by the canton. The initiative for protection projects must come from the municipalities.

Some of the costs could be transferred to individuals by direct taxes. For example, the Netherlands Water Boards fully fund all operations including flood protection from a levy and tax based on the size of the stakeholders' property. The house bank approach of Dutch Water Bank is another example[166]. Individual initiatives for reducing flood risks should be encouraged even with economic incentives, but always under overall coordination of local governments and between ranges clearly identified by the same. The state could rely—but not exclusively— on increased user fees and/or assessments, applying the "beneficiary pays" principle. Additional fees or assessments could be used for operations and maintenance, for direct capital outlay, or to pay off bonds. In such cases it is important to transparently assess the proportionate benefits to each section of the stakeholders.

5.3.2 Sharing the cost of residual risk reduction

The residual risks are always present, as there is no way to provide protection against all flood magnitudes. The residual risks tend to increase with time after construction of structural measures as the economic activities in the protected areas increase with time due to a false sense of safety. This is one of the reasons why the flood damages continue to raise despite substantial investments in flood control measures. Climate change will also increase residual risks. To mitigate the adverse impacts of residual risks due to overtopping the hydraulic flood protection structures, a series of necessary measures (such as emergency preparedness plans, early warnings and disaster response actions) are undertaken in order to keep the materialized risk to a minimum. Information is needed to evaluate the flood risk in each area, the reliability of structural flood protection measures and to assess the residual risk. Land-use planning and zoning regulations such as building codes can help the local authorities to limit development in vulnerable area. Local authorities along with the State authorities are responsible for promulgating and implementing land use plans within the protected areas, including the building codes and flood proofing measures. Individuals take the responsibility by reducing their own vulnerability and implementing flood proofing measures through retro-fitting etc.

Safety of life becomes the top most priority in emergency preparedness. The consequences of materialized risks (in terms of time and location of overtopping/breach, areas likely to be flooded, the population and properties at risk) need to be assessed in advance and incorporated into disaster preparedness plans through flood risk mapping. Early warning of the impending failure/overtopping would require a close monitoring

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[166] GWP 2008, p.18

of the conditions that are likely to generate such a situation. Many of these monitoring parameters, particularly hydro-climatic, are undertaken at the basin level and beyond. Federal authorities have the responsibility to provide these at the national level.

Rescuing victims and providing assistance in case of need can be best addressed by the community based local authorities, as the community is the first to respond to the emergency situations. The community has the potential to handle response planning and emergency management and as such should be effectively mobilized for the purpose, with appropriate institutional backing. Local authorities have to share this responsibility by investing in preparedness, executing regular evacuation drills and organizing rescue and relief operations.

5.3.3 Physical Transfer of Residual Flood Risks

Transferring of flood risks, physically, where feasible, is an important option for flood risk management. It is based on the premise that protection objectives are set differently depending on the kind of land use in the protected areas. Where human lives or high material damage value may be at stake, the protection level is higher than it may be in areas used for farming or forestry. Protection objectives should be defined in relation to land use.

Traditionally, the level of protection was set without regard to the vulnerability of the land to be protected. The risk based approach[167] seeks to define optimal flood protection through an economic evaluation of damages including consideration of different uncertainties. In this approach various alternative solutions are evaluated to determine the expected economic net benefit (benefit minus the cost). Risk based approach is factored, in certain cases, by fixing different design threshold for embankments providing protection to urban and rural areas, for instance. Further, cities in richer countries have higher protection levels than those in the developing world. Physically transferring risk, like through diversion of flood waters to less vulnerable areas, can also help manage the overall flood risks. It is, however, not only the monetary value of assets that should shape that choice: equity issues between urban, rural / rich and poor neighbors, appropriate compensation through negotiations need to be added as well.

Figure 56 illustrates a hypothetical situation where an agricultural/rural area in the upstream can be used to divert and store the flood waters temporarily to prevent overtopping/ breaching of the embankments in the downstream, protecting the lower areas with dense population and economic activities. By diverting water into agricultural area, very high potential urban losses can be avoided. This may entail higher actual agricultural damages as compared to the potential agricultural damages. Such an arrangement would require additional compensation in agricultural/rural areas over and above the actual agricultural damages materialized. Such a compensation has to be agreed upon in advance at the disaster preparedness planning stage through a transparent process involving all affected and the insurance companies. The real-time

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[167] USACE 1996

operation of such a mechanism would require a close monitoring and clearly laid down decision-process supported by early warnings. The feasibility of such an arrangement would depend on the geo-physical characteristic. Some other similar arrangements could be retention of rain water in the natural or man-made depressions.

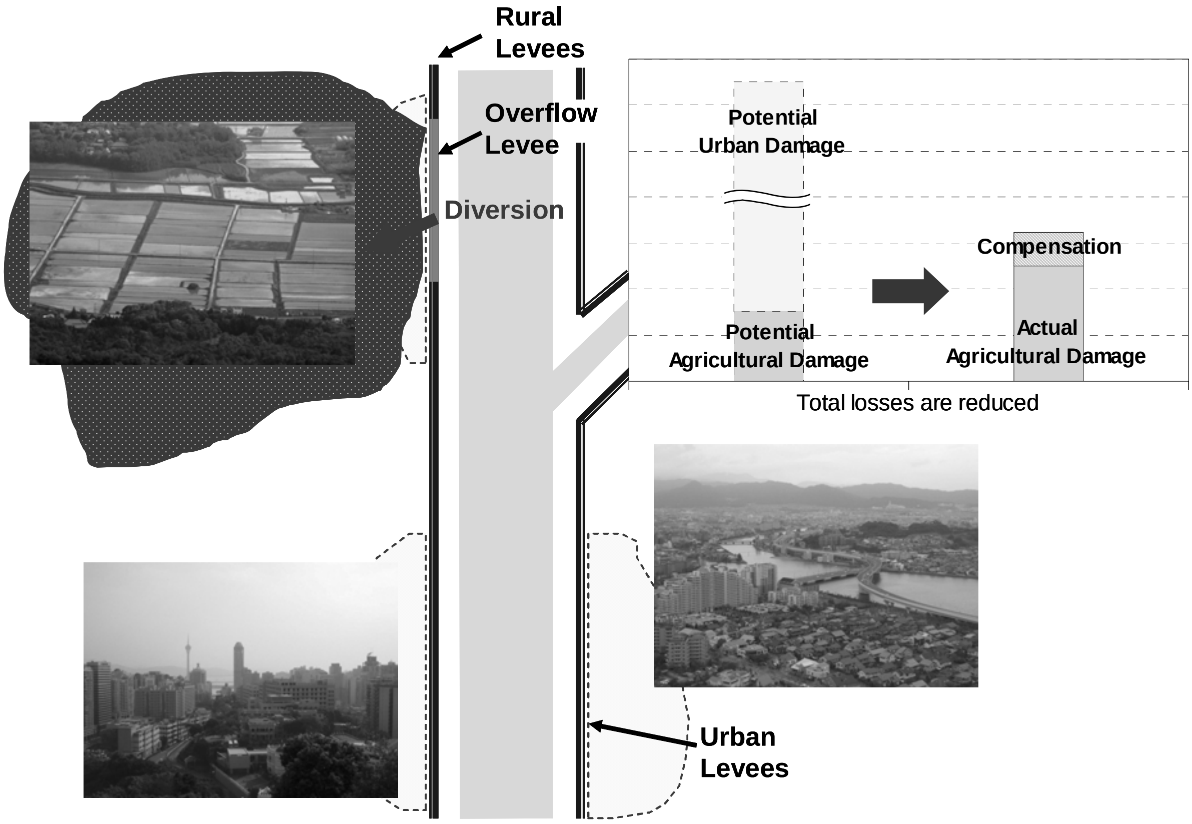

Figure 56 Physical Risk Transfer by diversion of flood water to agricultural lands

However, such a mechanism requires extensive consultations and negotiations with the communities affected. All such measures should be based on understandable, transparent and comprehensive weighing of interests. This means a compromise satisfactory for all involved must be found through communication and discussions which are realized by participatory approach. Landowners and farmers directly affected by such diversion should be closely involved in the planning of the measures as well as the financial compensation (risk transfer) mechanism that should closely be linked with the physical risk transfer. A spirit of give and take should be promoted to the extent that individual interests are compatible with general welfare. Appropriate legal frameworks should exist to facilitate such transfers.

5.4 MATERIALIZED RISK

Flooding becomes a disaster if the people at risk are unable to cope with the consequences of retaining the materialized risks. Most of the time, the poor, due to their vulnerability and consequent limited political power they are the ones who occupy the most susceptible areas and face the risk of flooding. In case of poor and vulnerable people, more often the materialized risk adds to their vulnerability. If allowed to fend for themselves, they resort to sale of personal assets and loans that are likely to push them into a downward spiral of vulnerability and poverty. There are different views with regard to who should bear the losses. Sharing the materialized risk includes formal and informal responses to expected losses such as self-insurance, precautionary savings in financial or other assets, solidarity networks and formal insurance. Public disaster relief systems (for example emergency subsistence and soft loans) are often set up to cater for victims of natural disasters. Transferring the materialized risk in time through insurance, which is a post-event compensatory mechanism at a given cost, is also a solution. Such disaster recovery is rooted in the concept of social solidarity with the victims, which is a valued public virtue that promotes a humanitarian and equitable society. Taxpayer solidarity with flood victims is typical, not only of social systems but also of market-driven economies[168]. It has a strong appeal to those who see assistance to disaster victims, even if it encourages risk-taking behavior, as promoting a humanitarian and stable society.

5.4.1 Sharing the materialized risk through risk transfer

Transferring risk through insurance is the last step in a systematic risk management process. It protects capital, enhances solvency and allows recovery, and, if designed carefully has the potential to encourage risk reduction. At the same time, while risk transfer can be very beneficial, it does not reduce the total risk because it just moves the risk either in time or to other entities. However, problems related to setting up risk-transfer schemes remain, where:

- *There is a large concentration of risk*: this is where many policies are at risk from the same event;
- *Ownership is difficult to establish*: when establishing ownership of assets lost is non-trivial, concerning, for example, fisheries, ecosystems or water supply; and
- *Damages are difficult to quantify*: it is difficult, for example, to assess the financial value of damage to livelihoods and cultural capital.

These make risk-transfer mechanisms problematic. Before reaching a decision about which risks can be cost effectively transferred, it is essential that activities are thoroughly organized to reduce risks as far as economically possible through planning to eliminate avoidable risks, and by designing resilience into systems and assets.

Small scale floods happen fairly often. Without an appropriate management, these flood risks inhibit the optimal utilization of the floodplain resources. If losses occur frequently, then the rationale for an insurance system is questionable. Moreover, small events are predictable and as such risk reduction methods are most suitable for dealing with such risks. Frequent risks require other strategies for mitigation and

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[168] In Hungary, which has experienced the transition from a socialist country to a market economy, floods and loss sharing has been discussed in terms of developing a public-private insurance system in place of 100% full compensation by the government (Linnerooth-Bayer and Vari 2003).

management[169]. As the magnitudes of flood events increase, the cost of mitigation increases dramatically making it economically unviable.

Insurance instruments are most suitable for middle layers risks. In case of low-probability high consequence events, the insurance market often fails. Particularly in situations where the risk is concentrated in relatively small areas, such as densely populated cities protected with levees as in Japan, such events require government, donors and other international institutions to provide reinsurance, also known as catastrophe insurance. Here the cover is often based on individual private insurance policies and the state involvement is only for reinsurance and/or catastrophic situations. Figure 57 depicts the potential applicability of each of the instruments depending on the magnitude of floods or losses from the floods.

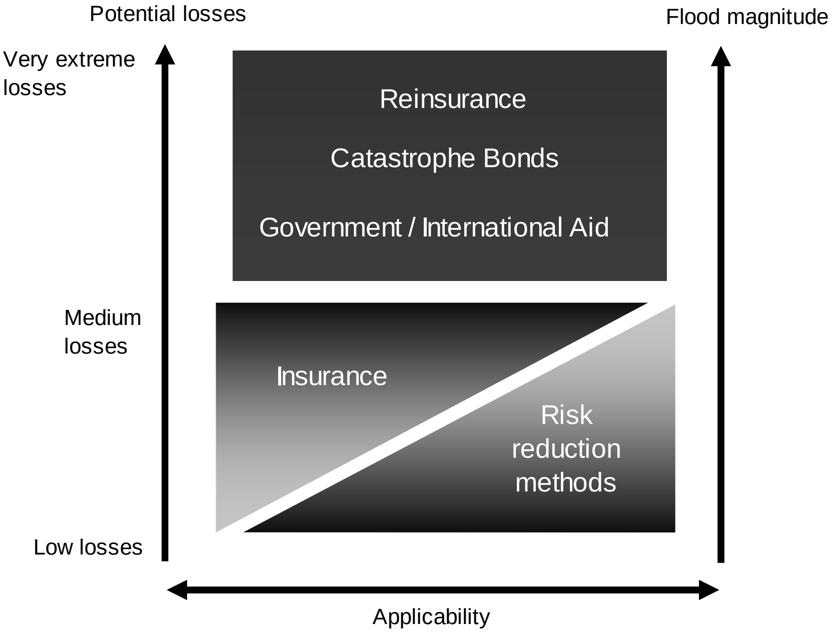

Figure 57 Applicability of insurance[170]

Various levels of insurance that exist range from informal arrangements for assistance with family, friends and neighbors, to community schemes such as micro insurance and mutual insurance based on affinity groups such as communities and trades, to formal insurance where funds are collected by a profit-making third party, to reinsurance, which accepts risks that are too severe for smaller schemes or operators to retain.

5.4.2 Traditional Flood Insurance[171]

Insurance can work only for risks that are insurable. The main principles of insurability are: risks have to be quantifiable, occur randomly and be many in number, so that variations in claims are smoothed out. From the client's side, the premiums have to be affordable and the contract has to perform reliably. These issues

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[169] USAID 2006, p.24

[170] MCII 2008, pp.7-8

[171] Swiss Re 1998

sometimes prevent insurers covering losses due to flooding, pollution, farming and gradual deterioration of assets. Key insurance principles that determine the insurability of a risk and how they measure in case of flood risks are: [172]

- ***Mutuality:*** *A large number of people who are at risk must combine to form a risk community.* In the case of flooding mutuality requirement is not met when frequently affected risks are the only ones insured. This is one of the major reasons why insurance cover against flooding is not widespread.
- ***Need:*** *When the particular event occurs, it must place the insured in a condition of financial need.*
- ***Assessibility:*** *The expected loss burden must be assessable.* While it is feasible to assess losses due to small scale floods that occur fairly often, the statistics for catastrophic flood losses are very uncertain because their probability of occurrence is small. The assumption of risk assessment in such cases is laden with high uncertainty.
- ***Randomness:*** *The time at which the insured event occurs must not be predictable and the occurrence itself must be independent of the will of the insured.*

Many countries have some form of flood insurance cover (Table 14)[173]. These insurance systems differ widely between countries in their treatment of risks. Different approaches categorized[174] as the "option" system and the "bundle" system are used. Under the "option" system, insurers extend their policy to include flooding on payment of an additional premium. This is the case of Belgium, Germany, Australia, and Italy, for example, with a very low take up. In the "bundle" system, cover for flooding is "bundled" with other hazards, such as fire, storm, theft, earthquake, etc. This system is in use in Britain, Japan, Israel, Portugal, and Spain, for example. With the bundle system, insurers charge differential rates based on intensity of risk.

Evidence suggests that, conceptually, those at risk tend to ignore the probability of the most extreme and infrequent loss events, but insurers need to load their premiums considerably to allow for them happening. This creates a gap between what buyers are willing to pay and what sellers are willing to accept for protection against very infrequent but catastrophic losses. In case the cost of the premium is relatively high, consumers will not insure. The high cost may be a signal from the private market that the risk is very high (unsustainable) or that there is great uncertainty or that the scale of operations is too small or that alternative risk management options exist.

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[172] Swiss Re 1998, p.7

[173] Paper dealing with examples of insurance schemes in different countries, contribution from Japanese Institute of Construction Engineering including JICE 2003 and Yoshioka et al. 2002.

[174] David Chricton 2008

Table 14 Various scheme of flood insurance

	Flood insurance
China	The flood insurance systems of other countries are being studied.
France	There is a nationally legalized natural disaster insurance system called "Cat Nat." Insurance rates: - Uniform rates relative to original insurance rates, regardless of such factors as the objects insured and locality. - Insurance rates rose from the initial rate of 5.5% to 9.0% as disasters increased. The current rate is 12.0%.
Germany	- Floods are considered a natural hazard which is not covered by ordinary insurance contracts. While in the former German Democratic Republic household insurances covered flood damages. There are still a number of these old contracts in place which provide insurance protection. The same applies for old contracts in Baden-Württemberg. - There are a number of insurers that offer flood insurance. The risks, however, are assessed on a single case basis by the insurer.
Japan	Private comprehensive insurance: - Insurance against natural disasters exists in the form of comprehensive insurance offered by private insurance companies and the basic contract of special fire insurance. - The national government is not involved in the administration of the insurance. Insurance rates: - Insurance rates for flood damage are uniform throughout the country, regardless of flood risk levels.
Netherlands	At present, there is no flood insurance system under which flood coverage is provided by insurance companies. The government and insurance companies, however, are discussing the introduction of a flood insurance system.
United Kingdom	There is no flood insurance system in which the national government is involved. Some insurance companies studied the feasibility of a flood insurance system, but such a system did not become a reality because the government was not necessarily positive about getting involved in insurance services.
United States	Flood insurance system: - There is a national government-run flood insurance system. - The flood insurance system is closely linked with land use regulation, and settlement in floodplain areas is strictly restricted. - In the case that a community participates in the flood insurance system, it is mandatory for flood hazard areas without levee protection to be insured, whereas it is not for areas with levee protection (either 1/100 or 1/200). Areas surrounded by levees must also be insured as they can be flooded both from landside and riverside. - CBO estimates that multiple year discretionary outlays for National Flood Insurance Program and the appropriation of authorized amount is appropriated to state and local communities. Insurance rates: - As per the flood insurance rate table prepared by the Federal Insurance Administration (FIA), rates depend on the size of the family living in the building, the size of the building, whether the building has a basement, etc.

Traditionally, insurance against floods have been limited to urban properties. Due to the high price of the policies, they have not been very popular in developing countries and have never played a significant role in developing countries. The private market will seek to segment customers, eliminating cross-subsidies. However, this may be contrary to public policy in terms of ensuring solidarity. This situation can be improved by raising risk awareness and promoting solidarity between those who are seriously at risk and those who are barely at risk, through a cooperative approach. The readiness for solidarity also depends on a public understanding of whether less risky alternatives are available or not. Where primary interest is in reducing the vulnerability and poverty reduction and agriculture is the key, there is a need to expand the application of flood insurance from property to agriculture. The experience of managing agricultural risk shows that insurance in developed countries is not always a good model for developing countries[175]. Mandatory insurance policies are viewed as a tax. However, it can be acceptable if made conditional on assistance to low income groups.

Risk-based premiums are generally opposed in poor regions. Insurance may be an option, but only by circumventing the commercial insurers with non-profit mutual arrangements. If insurers are limited in their ability to introduce appropriate risk-related variations in, for example, deductibles or premium loadings, insurance can lead to a less risk-averse culture. It is therefore vital that insurance is complemented with a risk management framework (land development, building design, construction standards, etc.) to avoid such moral hazard. The private sector can be a partner in this: the insurance industry of the United Kingdom actively engages with policymakers on flood defense funding, land zoning and construction standards; in the USA, insurers help to fund the technical training of publicly paid building inspectors; and Australian insurers assisted Fiji in setting standards for cyclone-resistant buildings[176].

Reinsurance

Natural catastrophies tend to be rare but very large events have the capacity to adversely impact the yearly profitability of the insurance company. Investors prefer a lower volatility to permit steady payments of dividends as erratic profits depress their share values. For that reason, insurance companies often resort to reinsurance. Through participation of international institutions, such as the World Bank[177] or reinsurers, some of the risk is transferred outside the country.

Reinsurance is the insurance of the insurance companies. Whenever the insurer cannot or does not want to take the entire risk, and reduce the likelihood of having to pay a large obligation resulting from an insurance claim, it resorts to reinsurance, thereby protecting itself from the losses incurred by the catastrophe. It is mechanism of insurer's transferring portion of risk portfolios to other parties. The reinsurance company receives pieces of a larger potential obligation in exchange for some of the money the original insurers receives to accept the obligation.

The functions of reinsurance are to reduce volatility, minimize taxes, underinvestment incentive, costs of insolvency and real service advantages as the traditional hedge for primary insurer[178]. Reinsurers specialize in low frequency high impact events. Because capital reserves are limited, the reinsurer has to levy a

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[175] World Bank 2005
[176] Dlugolecki, A. 2001
[177] TCIP 2005
[178] Lewis, M. and Murdock, K.C. 1996

significant uncertainty margin to cope with short-term fluctuations in occurrence and severity of catastrophies; this can be a multiple of the long-term risk premium.

5.4.3 Non-traditional financial mechanisms

Non-traditional financial mechanisms, together with insurance mechanisms, belong in a portfolio of financial mechanisms for the facilitation and support of recovery from flood events. Such non-insurance mechanisms can:

- Provide direct financing for reducing the flood risks, such as flood proofing;
- Serve communities that do not have insurance institutions in place, or an insurance culture;
- In some contexts offer a lower-cost alternative to insurance for providing post-disaster capital, especially for low-level risks; and
- Share the materialized flood risks from the poor with national and international solidarity.

One of the interesting developments in recent years has been the emergence of alternative indexed insurance risk-transfer products to handle risks which the conventional insurance industry has failed to achieve appropriate market penetration or has avoided; for example, captive or mutual insurance companies for corporate risks; weather derivatives for non-catastrophic climatic variability; and catastrophe bonds (Cat Bonds).

(1) Index Based Insurance

Typical insurance schemes are based on payment after the real verification of losses by an expert, subject to acceptance by the parties. An index-based risk transfer approaches use a proxy measurement to pay for significant economic loss. For example, if it is known that extreme rainfall or temperatures is highly correlated with agricultural production losses, then these measures can be used to proxy loss and make payments in case of loss of production. One noteworthy advantage of indexed insurance contracts is that claims management is greatly reduced, since there is no need to validate losses; they are determined by a simple objective measurement. A payment from an index based insurance contract is determined through the following five mechanisms.

(a) *Parametric*, a scheme based on physical parameters that determine if the risk materialized. For hurricanes, the parameter is wind speed. If the parameter reaches the established threshold, this triggers a loss;

(b) *Modelled losses* operate like the parametric scheme. In this scheme, a mathematical model is used with a set of parameters. The parameters are the inputs of the model. If the output of the model reaches a predetermined threshold, the financial scheme pays out;

(c) *Parametric index* is mid-way between the parametric and modeled losses mechanisms. It uses a number of observations of, for example, wind speed, at different locations, weighted to reflect the amount of business at risk in the vicinity of each location;

(d) *Industry index*, an index built using sources from the insurance industry to predict the losses in the industry. Once the industry index reaches a certain threshold, it triggers a payment.

Such an approach helps solve a variety of problems associated with the usual public-sector response to catastrophic risk and to credit constraints in developed countries, namely traditional forms of agricultural insurance and *ad hoc* disaster aid. However, experience with index based insurance is largely limited to drought or flood risk. There are only a couple of examples of their use in flood risk insurance.

(2) Catastrophe Bonds[179]

An insurer faces a large cost after a catastrophic event. To reduce the expected costs of financial distress, the insurer hedges the risk. The insurer can obtain indemnity-based reinsurance or, it can issue a catastrophe bond with a parametric trigger such as the actual magnitude and location of the earthquake or hurricane.

Catastrophe bonds (cat bonds) are capital market-based alternative to reinsurance. A reinsurance contract's payoff is usually based on the realized loss (indemnity payment). In contrast, cat bonds usually have an index or a parametric trigger. In the first case, the payoff after the catastrophic event is based on an index of industry-wide losses; in the second, the payoff is determined by certain parameters. Thus, the payoff is largely, and in the case of a parametric trigger, completely, independent of the sponsor's realized loss.

Cat bonds are high-yield debt instruments that are usually meant to raise money in case of a catastrophe. They have special conditions that states that if the issuer (insurance or re-insurance company) suffers a loss from a particular pre-defined catastrophe, then the insurers' obligation to pay interest and/or re-pay the principle is either differed or completely forgiven.

Cat bonds can be considered as another form of asset, which is acquired by the investor, for a fixed period of three to five years, who bears the default risk in return for a regular interest payment, generally at rates higher than the market interest rates to cover the possibility of default or loss of capital invested. Cat bonds act like reinsurance to remove the peaks or volatility of catastrophe risks. The principal obstacles to greater use of the capital markets are: the higher prices; the possibility of basis risk, because the bond is triggered by objective conditions, not actual losses to the insurer; unfamiliarity with the instrument; and regulatory limitations as a result of accounting rules.

In the capital market they are considered as investment opportunity that diversifies the risks away from the financial markets and into natural hazards. Cat bonds are not closely linked with the stock market or

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[179] Doherty, N.A. 1997

economic conditions and offer to investors a good diversification of investment risks. The key advantage of the cat bonds is that they help transfer risks to a large group of investors.

(3) Micro-insurance[180]

Micro-insurance is a financial arrangement to protect the low income segment of society against specific hazards in exchange for regular premium payments proportionate to the likelihood and cost of the risk involved. It has evolved in conjunction with micro-credit and uses insurance as an economic instrument at the micro (smaller than national) level of society. “Micro” does not refer to the size of the risk carrier, some are small or even informal, while others very large companies; or of the scope of the risks, which are by no means micro to the households that experience them.

In cases where the individual values insured are often small in relation to the insurance transaction cost micro-insurance could be a more suitable instrument. It can be delivered through a variety of different channels, including small community based channels, credit unions or other types of micro-finance institutions, but also by enormous multi-national insurance companies and so on. They are also useful in promoting the culture of risk reduction.

It is insurance with low premiums and low cap’s coverage and is synonymous with community based financing arrangements. “Bundled” micro-insurance contracts are provided to clients of micro-finance where insurance is linked to a loan. Communities are involved in the important phases of the process such as package design and rationing of benefits.

Community is involved in revenue collection, pooling, resources allocation and frequently service provision. Decisions in micro-insurance are made within each operational unit, rather than far away, at the level of governments, companies, NGOs that offer support in operation and so on. This instrument is particularly beneficial in developing countries. However, even in developed countries the excluded sections of the society can make use of this option. Micro-insurance schemes operate microfinance institution or community-based organization in Bangladesh, India, Malawi, Nepal, Pakistan and four Caribbean countries[181]

Micro-insurance links multiple small units into larger structures, creating networks that enhance both insurance functions, through broader risk pools and support structures for improved governance, such as trainings, data banks, research facilities, access to re-insurance etc. This mechanism is conceived as an autonomous enterprise, independent of permanent external financial life lines and its main objective is to pool both risks and resources of whole groups for the purpose of providing financial protection to all members against the financial consequences of mutually determined risks. The essential role of the network

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[180] Roth, J., McCord, M. and Liber, D. 2007, pp.1-6

[181] Provention/IIASA 2006

is to enhance risk management of the members of the entire pool of micro insurance units over and above what each can do when operating as a stand alone entity.

(4) Government Financing Instrument

There are two principal types of mechanisms available to governments to fund the costs of recovery from flooding: hedging instruments and financing instruments[182]. Insurance and capital market-based securities, where the financial risk of the losses from future disasters is borne by another party as ex ante risk transfer mechanisms, are examples of hedging instrument. On the contrary, financing instruments are arrangements whereby the government sets aside funds prior to a disaster to tap its own funding sources after the event occurs. For instance, the government implicitly self-insures by setting aside money to finance some of the recovery needs following a disaster. Alternatively, the government can mobilize its own financing sources by such policy instruments as imposing taxes, borrowing domestically or internationally, or diverting from the public budget. Alternatives for financing disaster response and rehabilitation include[183];

- a catastrophe tax,
- a catastrophe reserve fund,
- government debt instruments,
- international loans, and
- budget diversions.

These financing instruments have been traditionally used in emerging-economy countries to fund disaster recovery. However, these options may be politically difficult, such as imposing a disaster tax, or economically undesirable, such as transferring funds from other budgetary commitments. Catastrophe risk financing refers to the combination of all methods used to pay for financial losses incurred during a disaster. This has in the past in developing countries focused on post-disaster aid and lending. It is clear, however, that such “ex-post” strategies are not efficient or sufficient. Risk financing now stresses “ex-ante” (before the disaster) measures such as risk transfer and sharing. While use of ex-ante risk financing methods is increasing, during most disasters in developing countries some degree of ex-post support will always be needed[184].

5.5 DISASTER MANAGEMENT IN THE LOCAL BASINS

As explained in section 5.2, flood risks can be reduced not only by decreasing the magnitude of hazards, but also by reducing exposure of people and their activities to flooding and diminishing the vulnerability of flood-prone society. After risk reduction that contributes towards diminishing the probability of potential losses, mainly at government level, efforts can be made to reduce the residual risks that involve flood sensitive land use and spatial planning, early warning, evacuation and preparation for disaster relief and

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[182] Doherty, N. A. 1997

[183] Kunreuther, H. and Linnerooth-Bayer, J. 1999

[184] Provention 2009

flood proofing by community or individual level (Figure 55 in section 5.2). Vulnerability is the most crucial component of risk in that it determines whether or not exposure to a hazard constitutes a risk that may actually result in a disaster. If the potential exposure to floods becomes reality, i.e. when flood waters physically encroach on people and infrastructure, then the vulnerability of people and infrastructure is decisive for the degree of harm and damage.

5.5.1 Reducing Vulnerability and Enhancing Resilience

Vulnerability to floods is a community's proneness to be impacted adversely by flooding and is represented by the inability or incapacity of a community or a group, to anticipate, cope with, resist and/or recover from its impacts. It is the condition that determines the transformation of a hazard into a disaster. It not only impedes appropriate response but accentuates the severity of the impact that may be further exacerbated long after a disaster has struck. Vulnerability to floods is a combination of complex, dynamic and interrelated mutually reinforcing conditions that can be divided into three major groups as follows: Physical or material; constitutional or organizational; and motivational or attitudinal.[185] Social factors contribute to or influence these conditions to determine vulnerability. Some of these relevant to flood management are poverty, livelihood opportunities, cultural beliefs, human rights, gender inequalities, and special needs of weaker social groups. The following discussion addresses the vulnerability conditions to avoid a flooding event turning into disaster both at societal level as well as at individual level[186].

Physical/material conditions

Even though land development and urbanization inherently create larger risks, those in higher income groups are able to avoid or bear such risks while those with low incomes cope with them to their detriment. There is a clear socio-spatial segregation with reference to the hazard exposure of settlement locations. Since development or urbanization essentially increase population density, space gets rare and expensive, so those who cannot afford to purchase or to rent space in secure environments are consequently forced to move to cheaper places. Such locations may be found at the outskirts of town or in areas inside town where are usually prone to floods or other hazards. Two more factors aggravate this spatial marginalization. On one hand hazard prone areas are often not privately owned, and thus informal dwellers are less likely to get displaced. On the other hand, however, many urban poor are migrants from rural areas who are not familiar with the respective hazards and therefore tend to underestimate the risk of living in such exposed areas. The physical vulnerability of urban populations tends to increase as a result of the dense concentration of potentially dangerous infrastructure and substances in urban areas (bridges, solid and liquid waste, chemicals, electric facilities, etc.). Existence of health threatening infrastructure such as sewage treatment plants (usually located at very low spots), waste dumps or dangerous industries at such locations increase additionally the risk of secondary hazards and damages. Special attention in the context of human settlement locations has to be paid to socio-economic factors. Obviously healthy and young people are

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[185] WMO 2006b, p.11

[186] WMO 2008

more likely to resist physical stresses than sick and old people. On the other hand those who are familiar with a given stress situation might have developed certain adaptation techniques that allow them to cope with floods despite their disadvantaged physical condition. Similar explanations apply to infrastructure. Although concrete houses are less likely to get destroyed by floods, other more simple houses might be less vulnerable provided that they are well-adapted to floods, e.g. stilt houses. The vulnerability to flood risks in urban settlements, particularly in developing countries in informal developments can be attributed to the following factors:

- Risk prone areas are the only areas that the poor migrants are able to afford
- Failure to perceive flood risks due to lack of knowledge until a flood strikes
- Infrastructure to reduce risk is not economically viable
- Flooding (particularly local flooding) occurs so regularly that they become accustomed to living with risks

Constitutional/ organizational conditions

Informal settlement dwellers mostly in developing countries face difficulties in getting support from government and make use of institutional mechanism to the betterment of their conditions. The lack of organizational structures may lead to chaotic circumstances in times of stress whereas the existence of formal or informal organizations or institutions may constitute a stabilizing factor. In any case mutual support among community members is crucial for coping with stress situations. Such informal social networks are often the only "insurance" of the poor and are particularly important if official support is weak. Unfortunately it belongs to the characteristics of urban poverty that social networks tend to be weaker in cities than in villages. Livelihoods of people living in informal settlements, is dependent on their daily earning capacities, which is severely effected by flooding. On the other hand, those who have regular source of livelihood, their income is not disrupted by floods. Economic vulnerability prevails obviously among those households who lack financial resources and those who cannot afford or are reluctant to purchase flood insurances.

Motivational/attitudinal conditions

Reluctance towards flood preparedness and mitigation measures may be the result of lacking hazard knowledge or of fatalistic attitudes. Moreover, dependence on too much external support can reduce the individual responsibility to deal with problems in a proactive manner. Like exposure, vulnerabilities should not be considered merely as given unsafe conditions but as the result of different processes, which finally make people and their belongings more or less susceptible to the impact of hazards. Among the root causes of these processes, socio-economic factors are the driving forces, including access to or exclusion from education, medical facilities, economic opportunities, political participation and the use of natural resources. Those entitlements usually depend on the socio-cultural background of people in terms of class, ethnic origin, gender and religion. In the case of a hazardous event, access to such entitlements enable "… a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard"[187]. Such capacities are also referred to as resilience, the opposite of vulnerability.

When reinforced through certain social factors such as poverty, gender or livelihoods described above, they create a variety of complex factors that contribute to vulnerability. The effectiveness of the measures to reduce vulnerabilities and to enhance social resilience can be ensured by properly assessing vulnerability and identifying the underlying factors contributing to its increase. The decision as to what specific interventions should be carried out in a particular area to address vulnerability depends on the following factors:

- Economic activities and degree of development of the area;
- Frequency and intensity of floods in that area;
- Nature of land and land use, for example farms that might need to be flooded occasionally or developed lands that should be safeguarded all year round;
- Anticipated impacts of development activities of one place on another;
- Demand for utilization of basin resources.

Conditions determining vulnerabilities, particularly material conditions, can be improved by economic development and are influenced by a variety of public development policies, largely beyond the ambit of flood management policies. Some of the strategies aimed at mitigating conditions while addressing flood management policies are categorized into physical/material, constitutional/organizational, and motivational/attitudinal[188].

Resilience is the capacity or the ability of an individual or a community to cope with detrimental conditions. To enhance resilience, it is essential to improve the security of livelihoods, which depends on skills and the availability of alternate livelihood options during critical times. Ensuring that livelihoods are adapted to likely flood risks is one approach. Here the focus is on identifying and implementing alternate wet season livelihoods and/or means to supplement incomes. Special skill improvement programs and development training for the weaker sections of society need to be undertaken. For example, livelihood support training can provide women with the means to carry out income-generating activities from home, contributing to family livelihood stability. Providing professional tools, such as boats, fishing nets and reconstruction materials, as well as tailor-made packages that address the needs of individual families to re-establish their livelihoods, can enhance the productivity of vulnerable communities. This can be strengthened through post-disaster government/voluntary compensation schemes such as loans and micro credits designed to help poor communities get back on their feet and avoid reliance on external assistance.

5.5.2 Risk Management Combined with Mapping and Land Use Planning

A flood hazard map graphically provides information on flood inundation depths and extent, etc. in an easy-to understand format showing the places that may be at risk from flooding with or without an

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[187] Wisner, B. et al. 2004

[188] WMO 2006b, pp.11

indication of the flood probability. Flood mapping is an activity that would form an essential element of managing flood risks. Flood signs are effective means of communication of flood maps, and can even be categorized as one form of flood map. Flood risks can be reduced not only by decreasing the magnitude of hazards, but also by reducing exposure of people and their activities to flooding and diminishing the vulnerability of flood-prone communities. By sustaining people's awareness of flood risks, flood signs can have an impact on whether the people who are exposed to the hazard are vulnerable to it or not.

Sustaining people's awareness is a critical point for making mapping effective for flood management and enhancing communication with stakeholders including local inhabitants. It is not easy because the awareness diminishes with time even though people are aware of flood risks just after major floods. Rapid changes in local communities, such as urbanization, have led to a decrease in the number of residents that have experienced flood disasters. Most community residents lack information on major regional flood damage in the past and lack knowledge of projected flood water depths in the area in which they live and other facts pertaining to flood risk. Dissemination and communication with the stakeholders regarding flood mapping are essential for sustaining people's awareness.

Risk awareness means to recognize the hazard, to understand the mechanism and the impact, not to forget or repress it, and to take it into account when acting. The aims of flood signs are to promote the further dissemination of flood hazard maps, to create a heightened sense of risks and better awareness of shelters in case of floods in each community, and facilitate community participation in flood risk assessment as well as in planning and implementation of risk management measures. Flood signs play an important role in every step in flood risk management, that is, preparedness for, response to and recovery from flood disasters. It is not a new idea and neither is it difficult to install historical flood signs and link them to the possible impact (Figure 58). There are various possibilities for providing such information, such as visualization at buildings, photos of events and record of events in the neighborhood. With combinations of these possibilities, the aim is to demonstrate the risk and appropriate response.

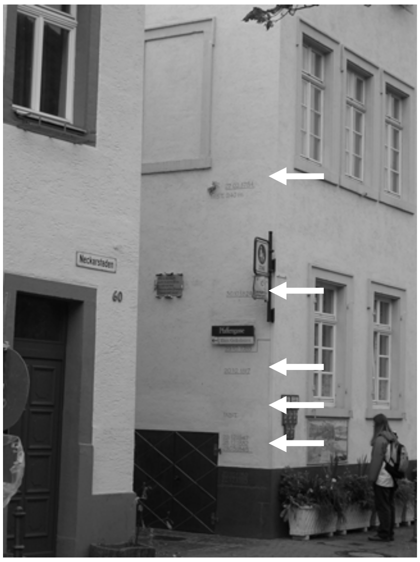


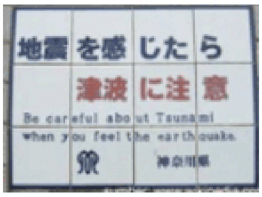
Figure 58 Historical recording for flooding in Heidelberg

The hazard of tsunami is not covered in this guideline. It is a Japanese term derived from the characters “tsu” meaning harbor and “nami” meaning wave, generally accepted by the international scientific community to describe a series of traveling waves in water produced by the displacement of the sea floor associated with submarine earthquakes, volcanic eruptions or landslides[189]. The frequency of tsunamis depends on those of submarine earthquakes, volcanic eruptions or landslides and is mostly very low. The tsunami of 26 December 2004 destroyed many cities and communities along the Indian Ocean and the lack of awareness of tsunami made the damages worse. The experience of this tsunami has facilitated activities for awareness raising and many kinds of tsunami signs are shown for risk awareness (Figure 59).

Tsunami Hazard Zone

Evacuation Shelter

Evacuation Route



Kamakura, Japan Tsunami sign

Takatoyo Beach, Japan

Nera, Japan Tsunami sign

Thailand Tsunami sign

Phuket, Thailand Tsunami sign

Tsunami Evacuation Site

Thailand Evacuation Site

Thailand Evacuation Route

Thailand Buddy Sign

Japan Evacuation Site

Japan Danger sign

Japan Shelter sign

Jalur Evakuasi Tsunami, Indonesia

NOAA Tsunami poster

National Weather Service Tsunami sign

Tsunami Ready

JTIC Tsunami Sign

Figure 59 Tsunami Signs[190]

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[189] National Tsunami Hazard Mitigation Program 2001

[190] Pacific Tsunami Museum 2008

Flood signs can be categorized as one form of flood maps. It is not a mere coincidence that an effort has been started to standardize marks for flood signs in Japan, called “Ubiquitous Flood Hazard Maps (Comprehensive Town-Wide Hazard Maps)”. Japan enhances the signs of flooding in downtown areas for the purpose of people’s understanding about flooding, showing traces of flooding and the evacuation areas and routes. The signs follow the special advisory committee for ‘signs of flooding’ and ‘designs for flooding signs’. The committee recommended guidelines for hazard mapping using such signs in the “Manual for Making Flood Hazard Maps Ubiquitous”[191]. The aim of this manual is to help bring about safe and smooth evacuation necessitated by floods and to help minimize flood damage by providing facts and encouraging the dissemination of knowledge of possible flood water depths and shelters and raising awareness of risks by displaying information on flood water depths and shelters in the form of flood-related signs in towns. Along with the recent amendment to the Flood Fighting Law, progress has been made in designations and announcements of flood-prone areas and in preparing flood hazard maps. To help meet the need for wide dissemination of flood information, the guidelines show how flood signs enable residents to appreciate the real risk of floods in their areas and provide more information on flood response required in communities. The signs include standardized marks so that travelers or foreigners can understand easily. This standardization applies to signs which show flooding levels, evacuation (areas) and levees so that travelers or foreigners who are not familiar with the local background can also understand them easily. These marks are registered in the Japan Industrial Standards (JISZ8210). There is a solid philosophy behind this approach that the wider such standardized signs are used, the more people become aware of and remember flood risks just like traffic signs.


”flooding” to show areas likely to be affected by flooding


”evacuation” to indicate evacuation building for flooding


”levee” to indicate protected residential area

Figure 60 Standardized marks for flooding in Japan[192]

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[191] MLIT 2006
[192] River Bureau, MLIT 2006

It should be noted that describing the hazards without giving advice what to do is useless. This makes people fear and just enhances repressing of the hazard. Flood signs are to be combined with visible training which demonstrates the possibility of an event and improves actions, and continuous planning and updating action plans as a part of awareness plans. In many vulnerable communities, experience shows that flood issues are not always a high priority compared to daily survival issues such as livelihood, lack of water and sanitation facilities, law and order, etc. This makes the community passive against flood risks as they are seen as remote occurrences. This makes the communities more vulnerable and sometimes more exposed to floods. To avoid such vulnerability, motivations for initiating community participation, such as socio-economic incentives and systematic training are indispensable. Better understanding begets higher aspirations among people, which is essential for motivation and sustainable ownership of the activities. Along with regular messages through the signs mentioned above, organizing community participation make communities aware of the risks and enhance their interest and motivation[193]. It is important for every stakeholder and local people to share the same vision. This will lead to a sense of shared ownership and motivate community action. The case study in Bangladesh shows the community based activities connected with regional development as primary motivation[194]. The raising of yards or homesteads through earth-fill not only safeguards them against flooding but also results in long-term livelihood benefits. Referred to the tsunami, risk reduction measures have included emergency and evacuation plans along with tsunami signs in Thailand[195]. Another case of the integrated approach for flood management combined with mapping and land use planning in Japan is shown in the next section.

5.5.3 Case of Resilient Community in Japan

As an emample of the robustness for water resource planning, there is an actual case in practice by MLIT Takeo River Office, Japan. The robust measures to reduce vulnerabilities and to enhance social resilience can be ensured by properly assessing vulnerability and identifying the underlying factors contributing to its increase. Conditions determining vulnerabilities can be improved by a coherent approach to economic development and other varieties of public development policies with progressive enhancement for local capacities including human, financial, technical, and knowledge resources. In this context, MLIT Takeo River Office developed a new contingency plan in 2004, supporting the idea that local residents can develop their community based on a risk management viewpoint, called “development of a disaster-prevention community” in daily life, through

- improving community disaster prevention capacity,
- revitalization of the local community, and
- strengthening the relationship of trust between the community and local governments (municipal and prefecture).

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[193] WMO 2008

[194] UNCRD 2004

[195] CCOP 2008

The Rokkakugawa River flows from Mt. Jinroku, Takeo City, Saga Prefecture, meets the Takeogawa River at about 26km upstream from the estuary and meets the Ushizugawa River at about 5km upstream from the estuary and flows into the Ariake Sea. The basin is located in the western part of Saga Prefecture, comprised of the three towns and three cities (about 120 thousand inhabitants as of 2009). The Rokkakugawa River meanders through the low-lying flood-prone Saga Plain. The Saga Plain is characterized as very flat low land: most parts are only 0-3 m above sea level while the tidal range of the Ariake Sea is more than 6 m. Sea water flows upstream on the rivers (29 km in the Rokkakugawa, 12 km in the Ushizugawa) at high tide, which is the greatest tidal range in Japan (Figure 61). The coastal area facing the Ariake Sea forms great tidal flats led by soil from the hinterland and tidal function. A series of land reclamation projects historically created large paddy field areas located facing the Ariake Sea. Most of the reclaimed land remains as paddy field, but some parts were converted to residential, industrial or commercial area. The hydraulic structures to intake fresh water from tidal rivers and the creek network system to control water were traditionally constructed to resolve water shortages. This creek network system was made of soil and had the functions of irrigation, drainage, and domestic use as a locally unique water management system. The mountain area is smaller than the plain area, so about 60% of the basin is an inland water area. Water resource management here has to be discussed in terms of flood, drought and water quality at the same time.

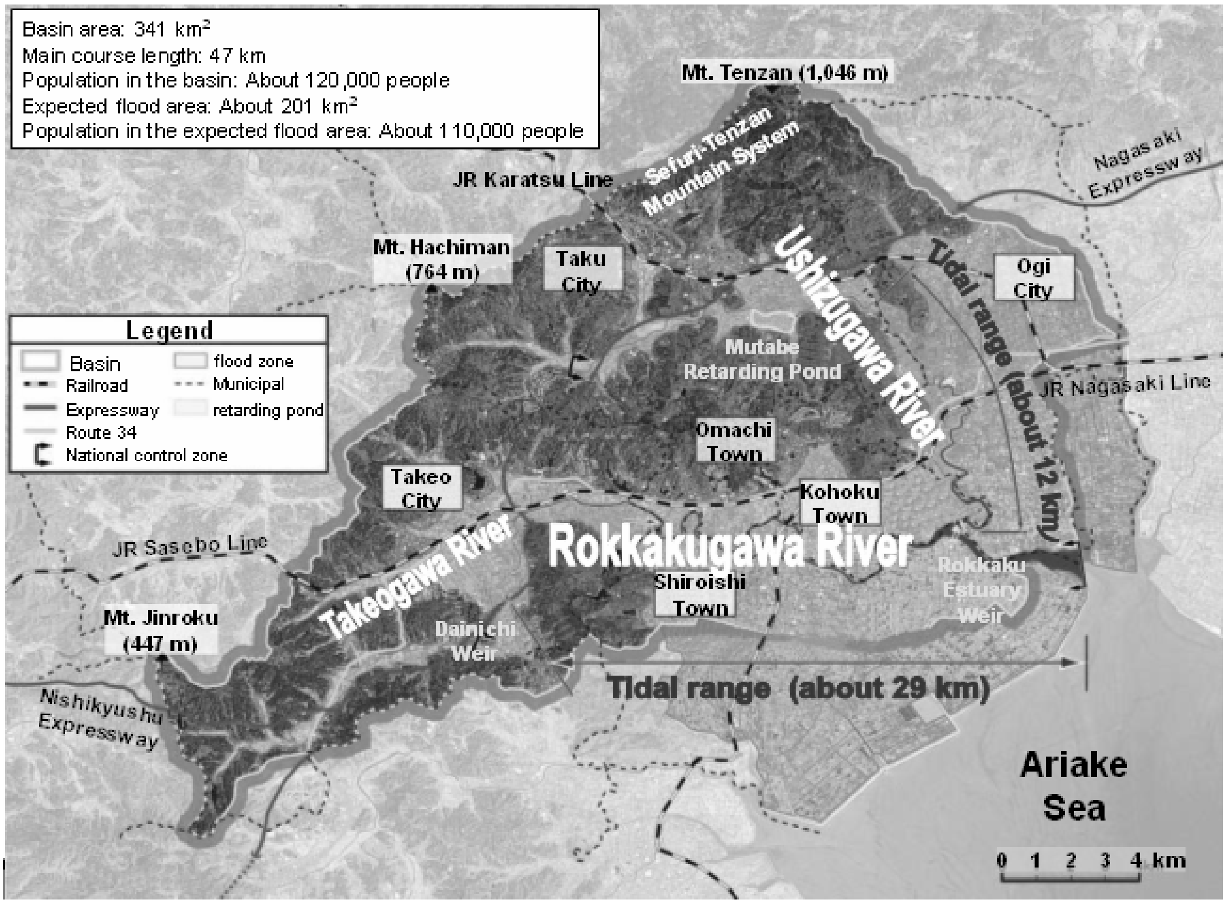

Figure 61 The Rokkakugawa River basin

There have been continuous efforts using traditional flood response mechanisms such as:

- letting floodwater flow safely by embankments,
- controlling floodwater by dams and retarding ponds, and
- discharging inland water using drainage pump stations.

Since the start of the modification of rivers under direct control in 1958, embankments and river channels have been constructed and modified weirs installed to improve the flow capabilities. The Saga plain is a lowland extension of the north Ariake Sea. It is underlain by ultra-soft recent deposit of thickness varying from 10 to 30 m. This ground covers most of the basin, so the ground has been gradually improved by means of slow banking work when constructing embankments. The basin has suffered from many floods. Major floods occurred in 1980, 1990 and 2009, but minor floods occurred almost every year. The heaviest precipitation was recorded in 1990, as the same level as the design 100-year flood of the basin. After the 1990 flood, the Mutabe Retarding Pond (area 53.4 ha, storage volume 900,000 m^3) was constructed on the right bank of the midstream section of the Ushizugawa River from 15.1 km to 16.4 km (Figure 62).

Figure 62 Mutabe retarding pond

In addition to the location of the basin, which is a lowland, some areas have even sunk more than 1 meter. As shown in Figure 61, a large part of the basin is below the level of the rivers. The discharge of water in such areas depends very much on pumping stations, so this has increased the risk of inland water flooding. The total capacity of the pumping stations is about 350 m^3/s into the Rokkakugawa and the Ushizugawa Rivers. These pumping stations are operated by River Administrator (MLIT), agriculture (MAFF) and local government (Figure 63).

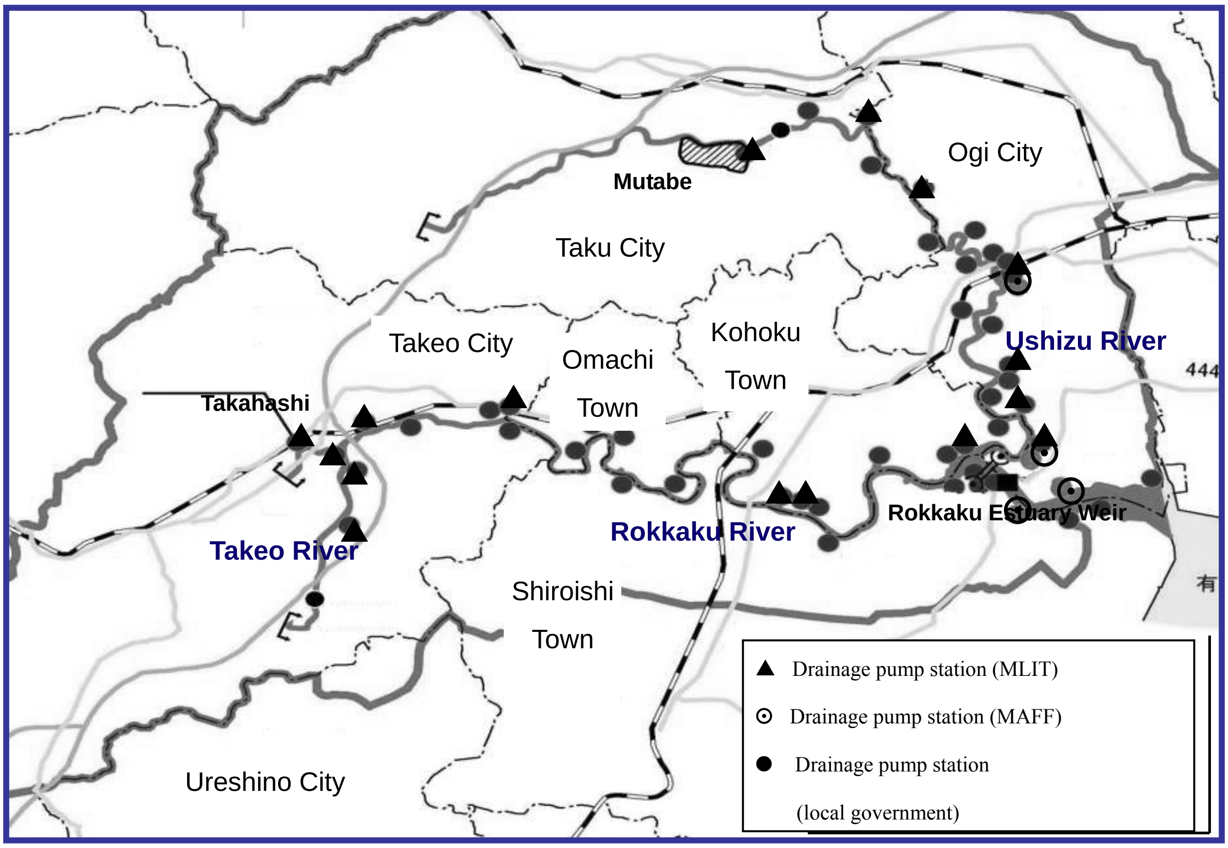

Figure 63 Drainage Pump Stations

It is clear that complete prevention of flood risks is a myth and unrealistic. To avoid or minimize the damage of flooding, non-construction measures should be combined closely with construction measures, such as dams, retarding ponds or pumping stations. As a comprehensive approach to non-construction measures, new contingency plan has been developed since 2004, supporting the idea that local residents can develop their community based on risk management in daily life, called “development of a disaster-prevention community”, through improving community disaster prevention capacity, revitalization of the local community, and strengthening the relationship of trust between the community and local governments (municipal and prefecture). The characteristic of this plan is to facilitate the communication between governments and residents from three aspects: public support (government information service), mutual aid (local flood prevention activities) and self-help (residents’ evacuation, flood proofing).

Community activities play an important role as a front-line of flood management. Community participation becomes fundamental and essential primarily for mutual aid, but it is also important as an intermediate between public support and self-help aspects. In the absence of organized community participation, most of the activities are carried out at individual or household level driven only by individual necessity. Such activities are limited in their effectiveness and insufficient to protect the community at large and individuals in the long run from adverse impacts of floods. Once the activities based on individual initiatives are pooled together and carried out in an organized manner at community level, vulnerability and risks due to floods can be substantially reduced. Community participation in flood management contributes through[196]:

- coordinating and facilitating individual efforts;
- building synergy effects and reducing costs;
- strengthening solidarity and enhancing effectiveness of cooperation within communities;
- providing a platform for consensus building and conflict avoidance;
- supplementing national and local government efforts; and
- harmonizing flood management efforts with other development activities.

Community participation plays an essential role in every step in flood risk management, that is, preparedness for, response to and recovery from flood disasters (Figure 64)[197]. It should be noted here that community participation in flood risk assessment as well as in planning and implementation of risk management measures is a key to success of flood risk management plans.

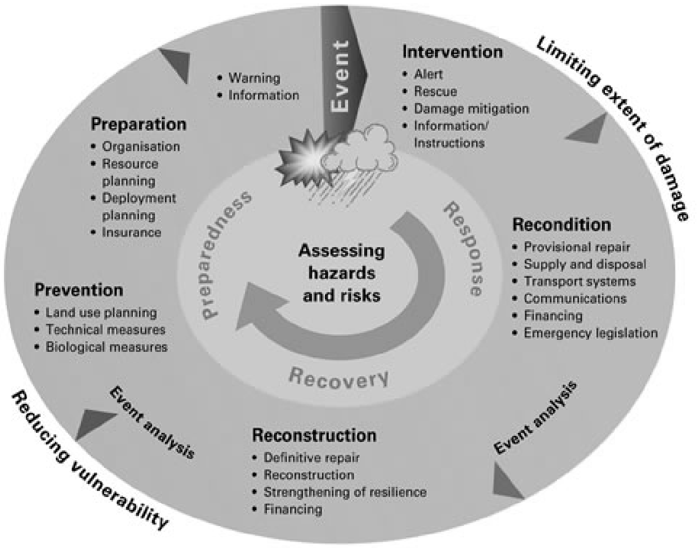

Figure 64 Risk Management Stages[198]

Preparedness

Basin-wide flood management for mitigation, land use planning and flood emergency planning are core activities at the preparedness stage. At this stage, community participation in flood management contributes to building consensus among stakeholders and creating linkage with other activities. The basin flood management plan requires participation of all stakeholders from agriculture, fishery, forest management, industry, urban development, environmental management, and local inhabitants themselves. The flood emergency plan requires the disaster management institutions to actively participate in the process. Flood management needs to be linked with other development processes, which aim at general improvement in people's quality of life and the natural environment, assuming the need to address the root causes of flood

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[196] Imelda Abarquez and Zubair Murshed 2004

[197] WMO 2008

[198] Swiss Confederation 2008

vulnerability, e.g. poverty, discrimination and marginalization. Coordination among other activities, such as land use planning, building codes, education and water use management, can be managed through the community. Through the process, materialized risks within each community can be made visible.

MLIT Takeo River Office has facilitated communities' mapping, called "My Hazard Map" under Saga-Plain emergency plan. The map combines usual (security and safety, welfare, education, environment etc.) and unusual (flooding, other disasters etc.) viewpoints of each community's initiatives (Figure 65). The process of developing a map depends on the local unique characteristics so as to enable the members of the community to confirm information that the governments do not have (Figure 66). In the Rokkakugawa River basins, eight communities have developed the maps while seven communities are in the process of their development.

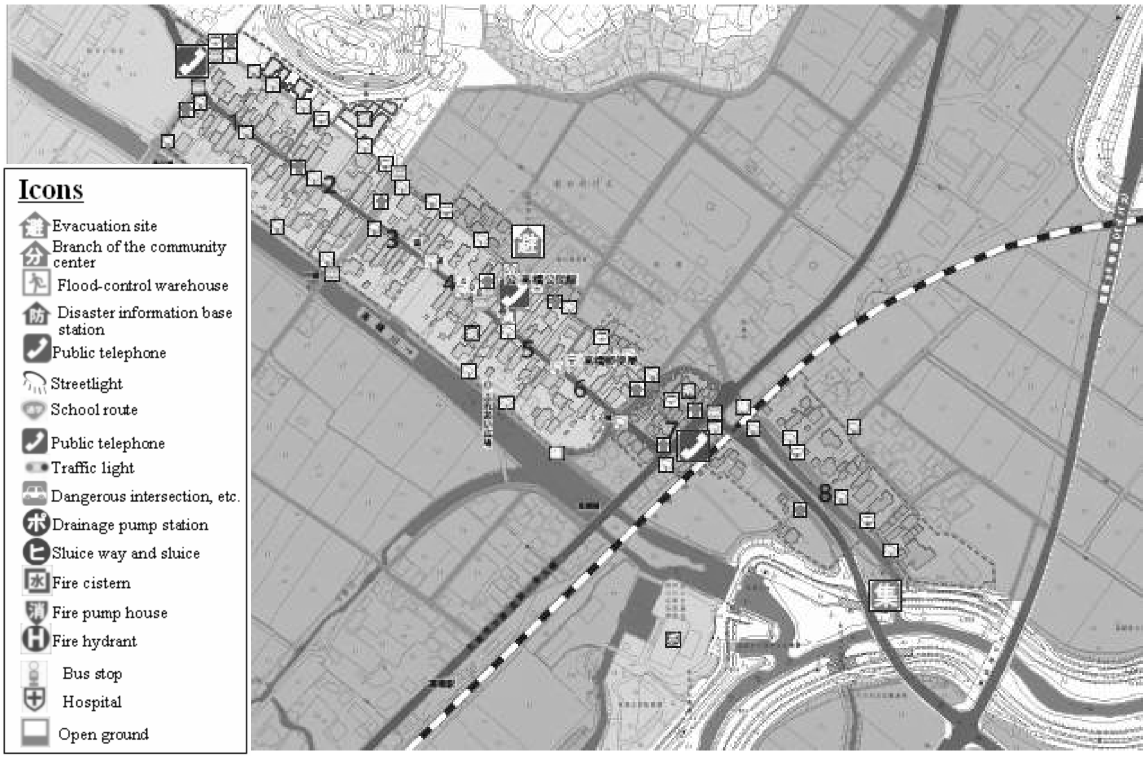

Figure 65 My Hazard Map (Asahi-cho, Takeo-city)

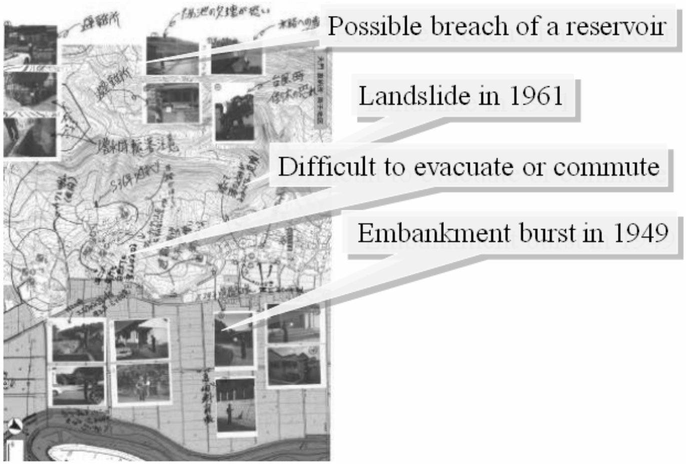

Figure 66 Example of Adding Community's Information for the Map

Response

On the one hand, various activities are undertaken, such as training, drilling and discussion related to flood management facilitates individual efforts and these develop individual capacity to respond to floods. The accumulation of individual activities leads to synergy effects to group advantage. The sharing of experiences, methodologies and tools continues to enrich practice. On the other hand, traditional activities or pre-existing resources can enhance community activities through providing opportunity on a regular basis. Regular reminders through participating community activities make it clear that responsibility for change rests with those living in the local community to ensure sustainability. Sustaining people's awareness for floods is a critical point for organizing community activities. However, it is not easy because the awareness diminishes as time passes even though people are aware of flood risks just after major floods. Sustainability of community participation largely depends on awareness of community members. MLIT Takeo River Office has supported the establishment of a voluntary disaster prevention organization to implement emergency and evacuation drills and collaborate with the related organizations such as national government, prefecture and municipals. Such organizations implemented trainings for awareness-raising among the residents. MLIT Takeo River Office also cooperates with local elementary schools to organize lessons for community disaster prevention and also used school children to disseminate the newly developed "My Hazard Map" to their family members (Figure 67). This also worked for stronger cooperation between school and community.

Figure 67 Collaboration between School and Community (Tachibana-cho, Takeo-city)

In the framework of its activity, MLIT conducted a questionnaire survey in two communities in the Ushizugawa River basin after the flood in July 2009 (Table 15). The results of the survey shows:

1. In the town where the diffusion rate of the evacuation advisory was higher, the evacuation rate was also higher;
2. A more secure means for the transmission of information is through conversations with other people; and
3. In the town where more people decided to evacuate through conversations with other people, the evacuation rate was higher.

This result shows the importance of communication. Information transmission through conversations is a securer means and can more readily lead to evacuation by the residents. Secure transmission of information such as an evacuation advisory through conversations can urge more residents to evacuate.

Table 15 Questionnaire Survey in the Basin after 2009 Flood

	Town A	Town B
Number of respondents	267	541
Evacuation rate during 2009 flooding	35%	5%
Diffusion rate of evacuation advisory	89%	76%
Way of receiving the evacuation advisory information	Radio 35% Neighbor 41% Email 4% TV, radio 12% Other 8%	Radio 61% Neighbor 11% Email 4% TV, radio 16% Other 8%
Thresholds of evacuation decision to persons who evacuated	Own judgment 28% Actual flooding 12% Recommend from neighbors 45% Evacuating neighbors 4% Compare to the past floods 11%	Own judgment 34% Actual flooding 34% Recommend from neighbors 20% Evacuating neighbors 10% Compare to the past floods 3%

Note: Both Towns A and B are the area where an evacuation advisory was issued in July 2009. The total respond rate is about 72%.

In 2011, standardized marks explained in 5.5.2 were applied in Rokkakugawa basin to improve awareness among residents and review their disaster prevention information by residents in the field (Figure 68). The project “My Hazard Map” has contributed to:

- improvement of the community’s disaster prevention capacity
- activation of the local community’s regular activities, and
- stronger relationships between the community and local governments.

Figure 68 Standardized Sign for Flooding and Evacuation (Asahi-cho, Takeo-city)

5.6 CONCLUDING REMARKS

So as to ensure robustness in water resources planning, adaptive management should be comprehensive and used in an integrated manner. Focusing on flood management, an integrated approach is applied, sharing the various risks. Where floodplains have been protected from frequent flooding, they have developed into throbbing economic centers, especially in Japan. Floodplains provide excellent livelihood opportunities, for habitat, agriculture and commerce. Integrated Flood Management (IFM) aims at a fundamental re-orientation of the social perception of floods from the “need to control” to the “need to manage”. It integrates structural and non-structural measures; land and water management; ecosystem preservation and development needs; and short- and long-term mitigation measures. Living harmoniously with floods is an important strategic option which provides a suitable framework for risk management with robustness. IFM is based on a proactive strategy of risk management through a multi-pronged attack on reduction of risks by reducing magnitudes, vulnerability and the exposure of the economic activities, and addressing issues at all the phases of the risk management cycle: preparedness, response, recovery and recondition. For equity and fairness the costs of taking flood risks have to be appropriately shared in a transparent manner. Risk sharing is one of the management aspects which deals with the way the costs of risk taking are distributed among several stakeholders: the federal, state and local governments and the flood effected individuals. An actual case in practice by MLIT Takeo River Office, Japan indicates that a critical point for making mapping effective for flood management is to build and sustain people’s awareness, especially for vulnerability reduction in terms of IFM and comprehensive risk management. The following issues need to be addressed for robust water resources management.

- Agriculture continues to be an important source of livelihood in most countries, including Japan. The Integrated Flood Management (IFM) approach aims to maximize the net benefits from floodplains and at the same time reduce loss of life because of flooding, flood vulnerability and risks.
- Risk sharing includes:
    - Sharing the costs for risk reduction;
    - Sharing the costs of residual risk reduction; and
    - Sharing the materialized risk, i.e. the losses or consequences.
- It is impossible to avoid the contentious issue of how to share the burdens placed on society from floods between different stakeholders, especially in societies which are regularly affected by floods. In the public interest, governments ultimately use tax revenues to provide to the extent possible flood defenses to reduce or prevent the risk up to a certain design flood.
- For the remaining residual risks, further public finances are utilized to a large extent in early warning, evacuation and preparation for disaster relief and flood proofing, mainly for emergency response to reduce these residual risks. Decisions must be made on how to share the cost of risk reduction among governments (central, regional and local governments), interested parties (such as private companies), communities and residents.
- Transferring of flood risks physically is an important option for flood risk management. Physically transferring risk by the diversion of flood waters to less vulnerable areas can help. With all the efforts in place, flooding will still result in losses due to damage to properties and interruption of economic activities. These are absorbed as retained risk.
- Transferring risk through insurance is the last step in a systematic risk management. This can be addressed by sharing the financial risks associated with actual flood losses between the state and all other groups affected. It is here necessary to take a comprehensive approach to distributing risks posed by flooding across the stakeholder spectrum, which includes various layers of the government, private sectors such as the insurance industry, and individual users and residents of areas liable to flooding.
- Flood risks can be reduced not only by decreasing the magnitude of hazards, but also by reducing the exposure of people and their activities to flooding and thus diminishing the vulnerability of flood-prone societies. After risk reduction that contribute towards diminishing the probability of potential losses mainly at government level, the efforts that are made to reduce the residual risks that involve flood sensitive land use and spatial planning, early warning, evacuation and preparation for disaster relief and flood proofing at community or individual level. Vulnerability is the most crucial component of risk in that it determines whether or not exposure to a hazard constitutes a risk that may actually result in a disaster.
- Vulnerability to floods is a community's proneness to be impacted adversely by flooding and is represented by the inability or incapacity of a community or a group to anticipate, copes with, resist and/or recover from its impacts.
- Planning for basin flood management for mitigation, land use planning and flood emergency planning

are core activities at the preparedness stage of management. The basin flood management plan requires participation of all stakeholders from agriculture, fishery, forest management, industry, urban development, environmental management and the local inhabitants themselves. The flood emergency plan requires the disaster management institutions to actively participate in the process. Flood management need to be linked with other development processes. The coordination among other activities, such as land use planning, building codes, education, and water use management, can be managed through the community.

- MLIT Takeo River Office has facilitated communities' mapping, called "My Hazard Map". The map combines usual and unusual viewpoints of each community's initiatives. The process of developing a map depends on the local unique characteristics so as to enable the members of the community to confirm information that the governments do not have.
- Flood signs can promote the further dissemination of flood hazard maps, create a heightened sense of risks and better awareness of shelters in case of floods in each community, and facilitate community participation. Historical flood signs contribute to people's memories of flooding through marks on building, photos of events and records of events in the neighborhood. Standardized flood signs are an innovative approach with a solid philosophy; the more that standardized signs are used, the more people can identify and remember flood risks just like traffic signs.
- Flood signs alone are not enough and should be combined with visible training which demonstrates the possibility of an event for the improvement of actions, continuous planning and updating action plans.

6. CONCLUSIONS

Practitioners of water resources management face uncertainty as to the impact of climate change while the change clearly affects extreme hydrological such as droughts and floods. Climate adaptation strategies can be developed in the face of deep uncertainties and must focus on exploring how well strategies perform across wide ranges of assumptions and uncertainties. Such uncertainties favor the implementation of flexible or adaptive management, involving putting in place incremental adaptation options, rather than undertaking large-scale adaptation all at once. Two fundamental approaches, that is, top-down and bottom-up approaches can be observed in some pilot cases for water resources management and community activities to ensure the robustness at various levels. The following issues need to be address for robustness on water resources management in practice.

- According to the analysis of observed data, the probability of 100-year floods has increased at about 70 percent of the observation stations for the past 100 years while 1/10-rainfall used as an indicator of drought shows a tendency to decrease at about 90 percent of those stations.
- For the prediction, the global and regional climate models predict and analyze flood and drought risk trends in different regions. 100-year probability values of daily precipitation are expected to be higher 50 years from now—more than 40% in the northern Hokkaido, northern Tohoku and Hokuriku regions, indicating increased flood risks.
- The World Water Assessment Programme (WWAP), one of the top-down approaches for water resources planning, is focusing on developing indicators using new methodologies; assessing the water situation as it affects economic, social and environmental development; identifying actions to be taken at local to global levels; presenting guidelines for improving water policy and management; and helping to build capacity to make effective in-country assessments.
- Another comprehensive top-down approach is being applied in Japan using indicators derived from a revised PSR model: i) pressures to watersheds, ii) watershed conditions; and iii) indicators of society's response. It has been developed for 109 major rivers in Japan. The trial for basin indicators in terms of flood management on the 109 class A river basins in Japan are calculated in 235 units by using the population for P, annual precipitation for S and flood control volume of reservoirs per area for R: I (basin indicator) = $R \times S / P$.
- A bottom-up approach to water resources planning focuses on exploring how well policy alternatives perform across wide ranges of assumptions and uncertainties. In Japan, the water rights system under the drought conciliation scheme is one of the policies promoting sustainable agriculture and combating poverty in local agriculture.
- It is still appropriate to examine by country or region what values should be considered in cost recovery of water services, recognizing that use of a pricing system based only on demand controls is not always the best solutions. Optimization means allocating available resources with maximized efficiency, while trade-offs seek to assign values to different objectives while keeping social equity.
- The National Environmental Policy Act of 1969 (NEPA) in the USA has contributed to the procedural

requirement, but “Alternative Dispute Resolution (ADR)” has offered helpful tools which can reduce the costs and delays associated with litigation. Shared Vision Planning (SVP) developed by the US Army Corps of Engineers is one of the ADR frameworks for conflict resolution through public involvement. The SVP applies user-friendly models which can simulate the system under study and are built collaboratively by experts from participating decision-makers and stakeholders. The pilot case in Koishibaragawa and Satagawa tributary of the Chikugogawa River shows the model developed not only for simulation of the tributary hydrological scheme but also for checking the reproduction of tributary flows with available data. A further model was developed for the relationships between surface and ground water.

- So as to ensure robustness for water resources planning, adaptive management should be used comprehensively and in an integrated way. Where floodplains have been protected from frequent flooding, they have developed into throbbing economic centers especially in Japan. Focusing on flood management, the Integrated Flood Management (IFM) aims at a fundamental re-orientation of social perception of floods from the “need to control” to the “need to manage”. IFM is based on a proactive strategy of risk management through a three pronged attack on reduction of risks by reducing magnitudes, vulnerability and the exposure of the economic activities, and addressing issues at all phases of the risk management cycle. Risk sharing is an aspect of risk management which deals with the way the cost of risk taking is distributed among several stakeholders: the federal, state and local governments and the flood effected individuals.
- An actual case undertaken in practice by the Takeo River Office, MLIT, Japan indicates that it is critical for making mapping effective in flood management to build and sustain people’s awareness, especially for vulnerability reduction in terms of IFM and comprehensive risk management. A hazard map and signs in the communities are tools that contribute effectively to water resources management because people can prepare for a disaster and evacuate promptly by consulting the map and signs.

There is no single powerful method for ensuring robust water resources management, so it is necessary for us to seek methods that complement the social and cultural norms of a society. My challenge in the Takeo River Office, MLIT is to take a small but important first step in this direction.

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