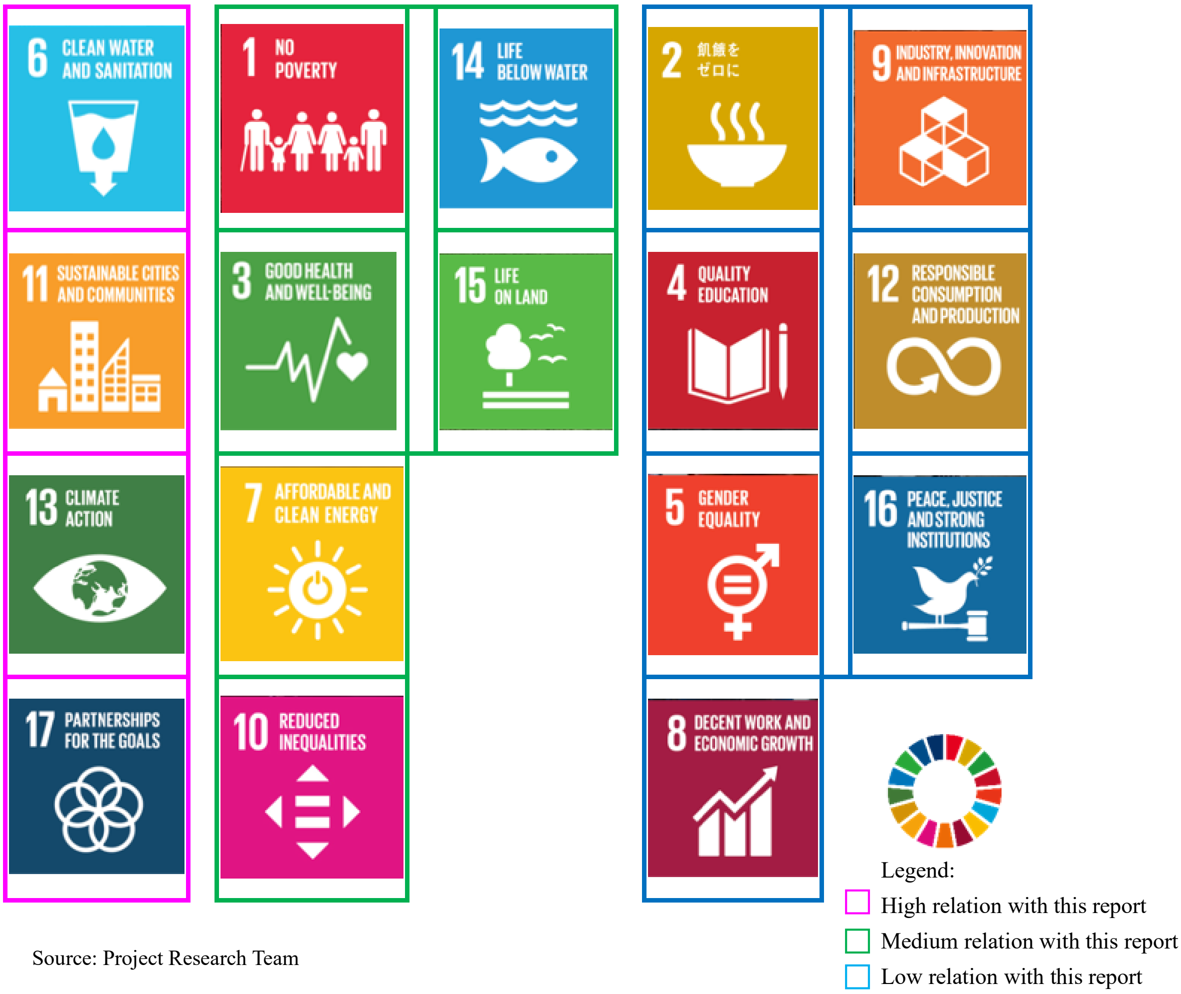
EXECUTIVE SUMMARY

CHAPTER 1 INTRODUCTION

Resolving water-related issues is crucial to achieving sustainable development. Water-related issues resulting from economic growth, urbanization, and an increasing population are becoming more severe around the world, particularly in developing countries. It is predicted that issues such as water shortages, floods, droughts, water pollution, and ecosystem degradation will intensify in severity along with climate change. Water-related issues are not only related to Goal 6 “Clean water and sanitation” but also to other Sustainable Development Goals (SDGs) (Figure 1.1). Improper and insufficient management of water use, floods, and the water environment could slow down the pace of growth and poverty reduction (Goals 1 and 8), increase tensions among regions and countries, and lead to conflicts (Goal 16). Access to clean water and sanitation services is related to infectious diseases, health, gender, and education (Goals 3, 4, and 5), while water is used for food production, renewable energy, and industrial manufacturing (Goals 2, 7, and 9). Furthermore, it is necessary to promote the development of flood-resilient cities, take measures against climate change (Goals 11, 13), and contribute to environmental protection and improvement (Goals 14, 15). These issues must be resolved through collaboration between the public and private sectors (Goal 17).



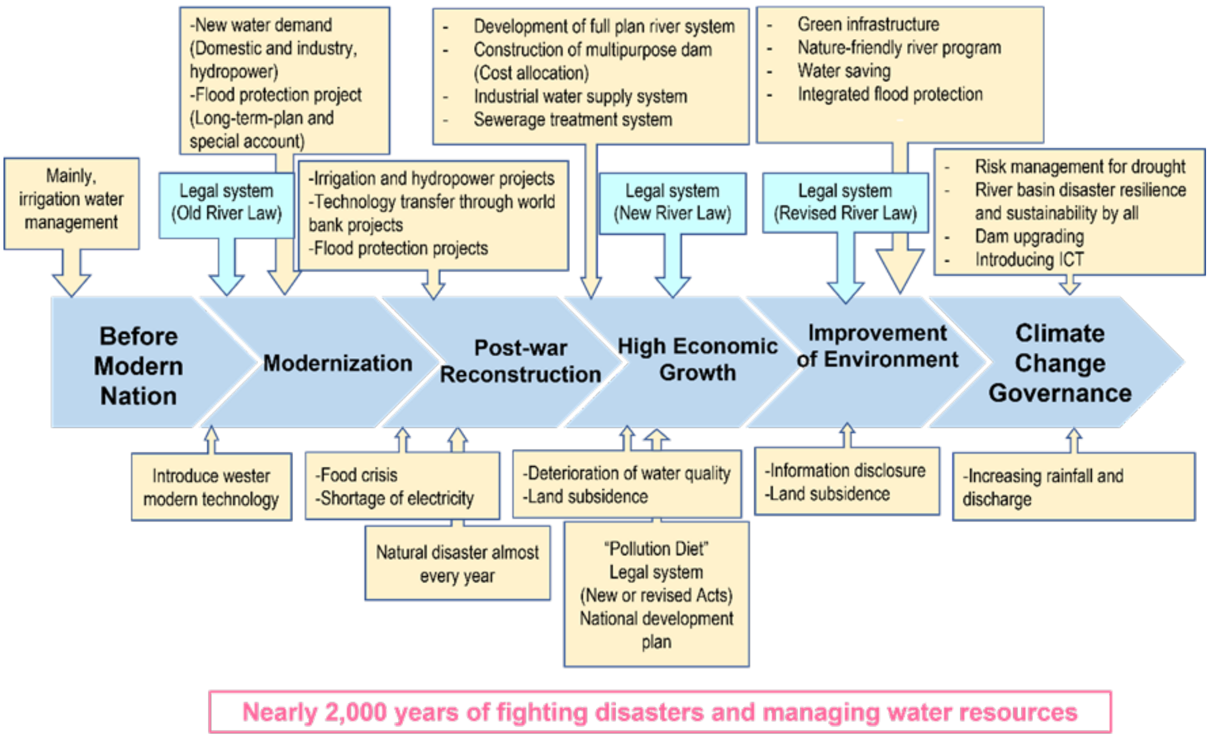
Source: Project Research Team

Figure 1.1 Relation between the Management of Water Resources and the SDGs

This report describes case studies and lessons learned from Japan's experience in water resources management, particularly in the public sector. It could contribute to assisting developing countries, which face various water-related issues in policy-making, developing institutions, and building their capacities. After the establishment of a modern nation in the late 18th century, Japan recognized that floods were the severest among water-related issues and focused on flood protection measures. Following World War II (WWII), which ended in 1945, Japan has resolved various water-related issues such as urbanization, shortage of water due to industrialization, land subsidence due to excessive use of groundwater, and water quality deterioration and health hazards caused by domestic and industrial wastewater. There is no one-solution-fits-all model for water management because each country faces different issues and backgrounds. Some countries in arid areas face difficulties such as water shortages, and some recognize groundwater depletion or pollution in water bodies as a top priority. In addition, each country or region has different customs, social cultures, and histories. Each country or region may develop its strategies by referring to appropriate experiences from the Japanese residents to meet their requirements.

1.1 Evolving Management of Water Resources to Meet the Emerging Needs along with Socioeconomic Change

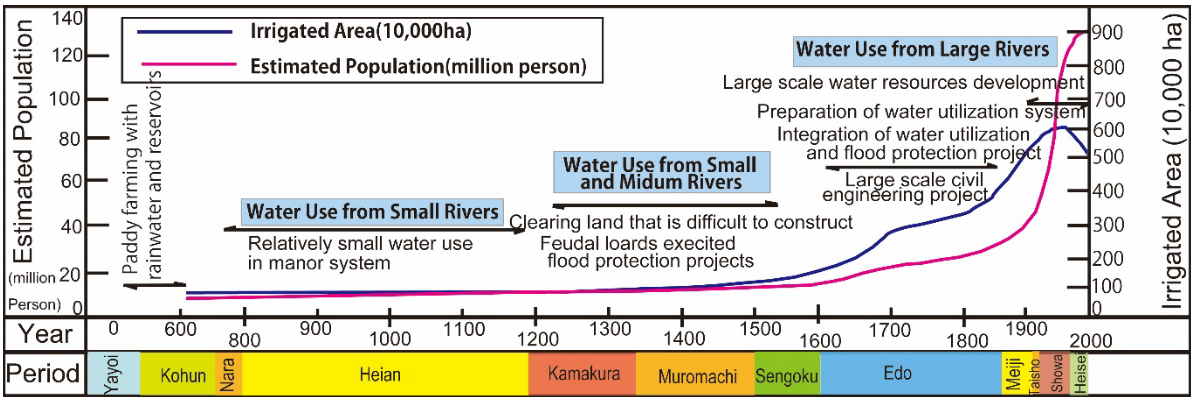
Japan has achieved quality growth to form a resilient, inclusive, and sustainable society by managing its water resources. Since its modernization, Japan has managed the changing water-related issues by introducing new systems built on traditional water management developed throughout its nearly 2,000-year history (Figure 1.2). For water management purposes, the government has developed legislation and institutions, such as formulating long-term development plans and introducing a cost-sharing method for project implementation. In response to the abovementioned issues, Japan has made efforts to introduce appropriate technologies per era.



Source: Project Research Team

Figure 1.2 Efforts for Water Resources Management in Japan

Over the past 2,000 years, Japan has fought against disasters, such as floods and droughts, and has managed its water resources. Since ancient times, people in Japan have developed land to produce food with irrigation water from rivers and implemented flood protection measures. People started constructing intake weirs, canals, levees, and irrigation ponds for over 1,500 years. Local communities (village communities) managed irrigation-water distribution and maintained facilities, constructed levees to protect communities from floods, and engaged in flood fighting. The communities created rules for water management to resolve conflicts with water. Water resource management overcame the Malthusian trap wherein the population cannot increase due to food shortages (Figure 1.3).



Source： A partial excerpt and revision of the "Farmland and Water in Japan, Ministry of Agriculture, Forestry and Fishery"

Figure 1.3 Changes in the Population and Cultivated Area

Based on its history, Japan has developed the system and practices for water resources management. When the nation was modernized through the Meiji Restoration at the end of the 19^{th} century, the national government began to resolve water-related issues from the perspective of national growth. The government implemented river works for navigation, which was the primary transportation system. As modernization progressed and flood damage became more severe, the government started a national program of flood protection. In addition, the government established water management systems by recognizing irrigation use as a customary water right established through its long history and background of past development. Local communities managed water through the distribution of irrigation water, facility management, and flood-fighting. The government initiated projects for water supply and sewerage to improve urban public health against infectious diseases.

Japan has evolved mechanisms of managing water resources to meet the emerging water-related issues along with the nation's growth and socioeconomic changes. Since 1945, following WWII, the government recognized water resources as an important sector for rehabilitating devastated national land. The government developed irrigation systems to increase food production and to support hydropower generation as the main source of electricity. In addition, the government implemented intensive flood protection and forest conservation because the forests suffered from natural disasters, causing more than 1,000 casualties almost every year.

During high economic growth, the national government accelerated the development of water resources, reduced flood damage, and supplied water for domestic and industrial use. As a result of the high economic growth, issues such as pollution-related diseases, urban flooding, water pollution, and land subsidence due to overuse of groundwater appeared one after another, and the national government was forced to tackle these issues. Following the high economic growth in the 1990s, a maturing society and the diversification of people's sense of values awakened people's interest in environmental issues. The government organizations thus embarked on improving the water environment.

River management offices (RMOs), as river administrators, are responsible entities that implemented water resources management in cooperation with relevant agencies. The river administrators were originally prefectural governors who executed river management based on the old River Law enacted in 1896. They are currently the Minister of Land, Infrastructure, Transportation, and Tourism (MLIT) for major rivers, and the prefectural governors for other rivers, as stipulated in the River Law amended in 1964.

The Water Resources Department in the government coordinates with multiple government organizations at the national level to create policies and plans. Committees at the river basin level are involved in the coordination for decision-making process as well. In 1962, the Water Resources Bureau (presently the Water Resources Department) was established to coordinate all related ministries and departments regarding water resources policies and to formulate and promote basic plans for water resources management. At the river basin level, RMOs formulate river improvement plans by reflecting the views of academic experts and residents of river basins at river basin committee meetings. The forms of river basin committees differ from basin to basin, according to the characteristics and backgrounds of each basin.

The government-formulated water resources development plans are entirely government plans with a long-term perspective and are implemented through coordination with relevant sectors and stakeholders. The National Comprehensive Development Plan (NCDP) aims to develop the country's economy and welfare, promote the development and use of stressed water resources, and build flood protection while maintaining consistency in other sectors. The cabinet decided on water resources development plans as plans above the ministry level. The government formulated plans for each major river basin to manage the water resources based on relevant data, science, and engineering evidence.

Roles and responsibilities are defined to secure finance. The national government established a system to clarify their roles and responsibilities. Local governments share the costs of national projects as project beneficiaries. The national government provides subsidies for local projects to support balanced development across the country. Farmers and users share some costs for irrigation and water supply systems. Companies have also constructed hydropower projects. Since water resources development and flood protection projects require a long period and a high cost, the government formulated long-term plans for each area with project-cost estimates towards the commitment of the long-term budget. The government promoted flood protection projects using the special account for flood protection established in 1960.

Modern science and technology have been applied to resolve water-related issues. In the Meiji era, Japan introduced modern Western technologies for water supply to cities, and flood protection by constructing continuous high levees. To date, Japan is continuing to develop and utilize technologies, including information and communications technology (ICT) such as radar and simulation technologies. Government technical officials commit not only to developing these technologies but also to policy- and decision-making.

The approach of consensus building for project implementation has continued to change (Figure 1.4). Movements against dam construction changed from opposition by affected residents to a controversy regarding the policy of water resources management. In the "Beehive Castle Dispute" over the construction of the Matsubara and Shimouke dams on the Chikugo River, dam-affected residents opposed the dam construction from 1958 to 1971.

Source: Project Research Team

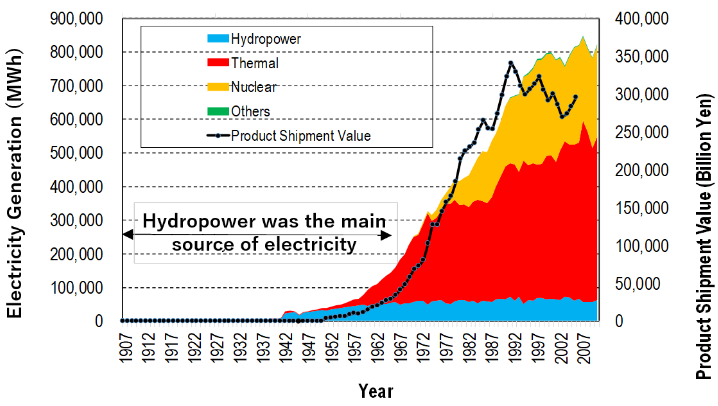
Figure 1.4 Three Public Works Projects that Affected the Water Governance

Based on the lessons learned from this opposition, the government developed legislation and financial mechanisms to support the rehabilitation of submerged communities and residents in reservoir areas. After a high economic growth, the citizens' sense of values improved since the 1980s, and infrastructure projects such as dam and weir construction became a social issue, debating the necessity of construction and environmental impacts. In the opposition movement over the Nagaragawa River Mouth Barrage, civil society groups involved political parties and the mass media and expressed their concern about the deterioration of the environment and ecosystem. This movement triggered a change in water governance, leading to progress in the transparency of the decision-making process, information disclosure, and enhanced accountability. The River Law, amended in 1997, introduced the policy of the participation of residents in planning projects. The Yanba Dam was proposed for flood protection and to provide a water supply to the Tokyo Metropolitan Area. The national government prepared its construction plan in 1967. The primary local community opposed the project and the opposition movement became a political issue. In 2009, the national government announced the cessation of construction projects. However, they re-evaluated the effects of dams on flood protection and water supply based on scientific data. The government finally decided to continue the construction in 2011, which was completed in 2020.

1.2 Japan's Accomplishment in Water Resources Management

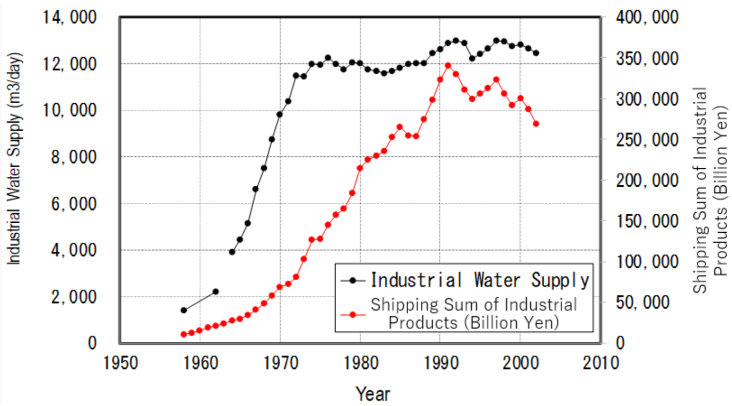
Water resources management contributes to quality growth of the nation by resolving water-related issues. This management made the country more resilient to floods, droughts, and epidemics, reduced inequality, and contributed to creating an inclusive and sustainable society in harmony with the environment. Water resources played an important role in the modernization of Japan from the end of the 19^{th} century, reconstruction from the damage caused by World War II, and promotion of high economic growth.

Water resources management supported economic growth. To cope with food shortages after World War II, the national government developed water resources for irrigation and improved farmland and irrigation-drainage systems. Food production was stagnant due to the lack of production materials. Japan then suffered a food crisis and received food aid from the United Nations. In the energy sector, hydropower was a major energy source for reconstructing the country following World War II. Hydropower covered 80% of the electricity source in 1950. Japan developed large-scale hydropower plants to meet the rapid increase in electricity demand during its high economic growth. Hydropower generation was the main source of electricity until 1965 (Figure 1.5). The government has provided indispensable water for industrial activities by establishing an industrial water supply system from the 1950s, which is separate from the municipal water supply system and a few similar systems in the world (Figure 1.6).



Note: Product shipments and other data are from establishments with four or more employees.
Source: Compiled by the project research team based on the Japan Electric Power Industry History Database (Japan Institute of Management), statistics for 60 years of the electric power industry (Federation of Electric Power Companies of Japan), and data in the Industry Section of the Industrial Statistics Data Library, Ministry of Economy, Trade, and Industry.

Figure 1.5 Electricity Generation by Type and Product Shipment Value



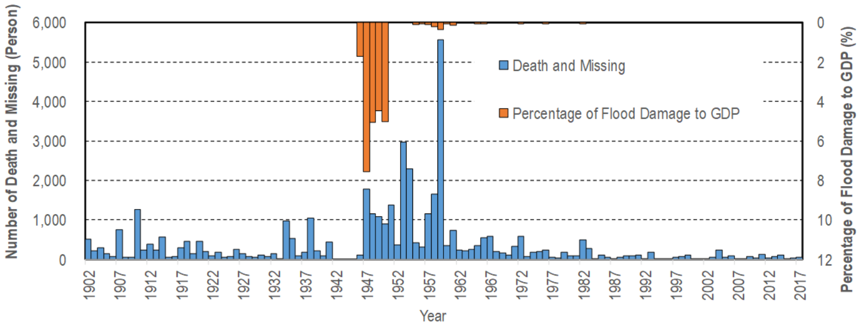
Note: The data is of establishments with 30 or more employees.
Source: Based on data from the Industry Section of the Industrial Statistics Data Library, Ministry of Economy, Trade and Industry.

Figure 1.6 Trend of Industrial Water Supply and Shipping Sum of the Contribution of Industrial Products towards Resilient, Inclusive, and Sustainable Growth

(1) Social Resilience

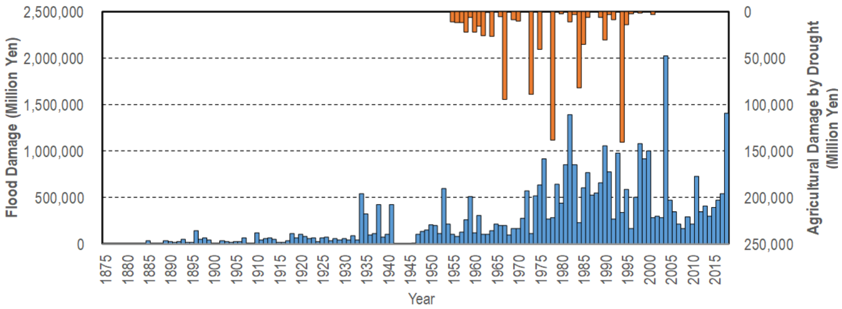
Investment in flood protection reduced flood damage. Japan is vulnerable to floods because major cities are located downstream of major rivers, and the population and assets are concentrated in these major cities. After establishing a modern nation in 1868, the government enacted the River Law and formulated long-term plans to promote flood protection projects. After World War II, flood damage frequently occurred until the 1950s with more than 1,000 casualties, and annual economic loss amounted to 1% to 10% of the gross domestic product (GDP) almost every year (Figure 1.7). The government allocated limited investments to flood protection due to the expanded military preparedness and wars since the 1930s. The flood discharge in the downstream areas increased due to the concentration of river discharge, resulting from the construction of continuous high levees on the river reaches. From the 1960s to the 1990s, the national government invested 1% of the GDP in flood protection, which succeeded in reducing the death rate due to floods. However, even today, a certain level of flood damage continues to occur, accompanied by the further congestion of the population and assets in urban areas. The country developed water resources to have a sufficient water supply, resulting in the reduction of drought damage to agriculture (Figure 1.8).

Infectious diseases were reduced through the development of water-supply systems. From the 1850s to the 1890s, Japan experienced major epidemics of cholera and dysentery. In 1879 and 1886, the number of deaths from cholera increased to over 100,000. The government established water supply systems to prevent waterborne diseases and improve sanitary conditions in cities (Figure 1.9).



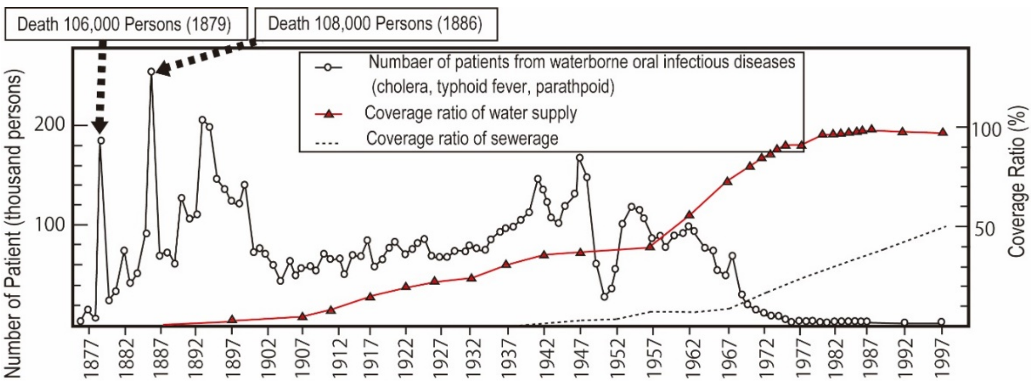
Note: Nominal GDP and amount of damages
Source: GDP data, "Changes in Japan's Postwar Finances and Future Challenges" 1946–1950, Ministry of Finance, "Annual economic report," long-term economic statistics from 1955 to 2019. Amount of flood damage and number of casualties: "Statistical survey on flood damage" 2018 MLIT

Figure 1.7 Number of Casualties due to Flooding and Flood Damages



Note: Amount of flood damage from 1875 and drought damage from 1955 (nominal damage)
Source: Amount of flood damages "Statistical Survey on Flood Damage" 2018 MLIT, Amount of drought damages "Crop Statistics Survey," Ministry of Agriculture, Forestry, and Fishery

Figure 1.8 Amounts of Flood and Drought Damages



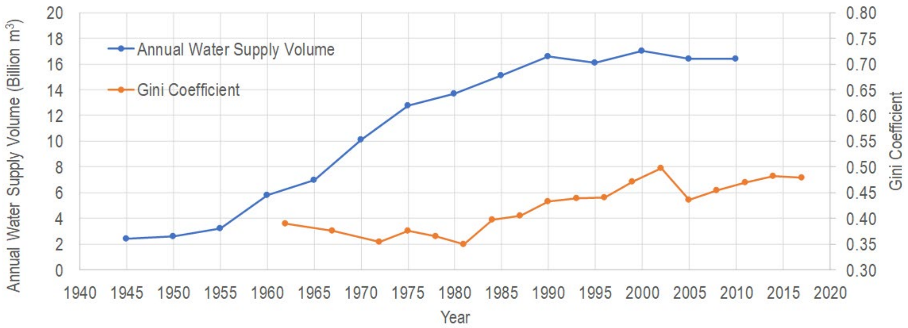
Source: "Urban Development and Public Health" Nakatsuji Hideji WHO in sight No. 44 (2010)

Figure 1.9 Number of Patients with Waterborne Oral Infections and Water Supply and Sewerage Coverage

(2) Inclusive Services

The improved water supply and flood protection supported urban development and mitigated regional disparities. During the period of high economic growth, there was a population influx from rural areas to three major metropolitan areas (Tokyo, Nagoya, and Osaka). Approximately 50% of the national population in 1980 was concentrated in these metropolitan areas. Industrialization created additional demand for workers in these areas. With the increase in urban employment opportunities, the Gini coefficient[1] dropped from 0.40 to 0.35, the income inequality was reduced, and the poverty ratio decreased (Figure 1.10). Local governments improved their water supply systems to cope with the rapidly increasing urban population. The population in the Tokyo metropolitan area doubled in 1980 compared with that in 1951. The water supply volume increased by 3.3 during this period (Figure 1.10).

Thus, access to safe drinking water and health has improved. Water supply and sewerage systems were first developed in urban areas, and subsequently in rural areas. In 1980, the water supply coverage ratio in Japan exceeded 90% (Figure 1.11). The coverage ratio of the sewerage system increased from 10% in 1965 to 80% in 20191.

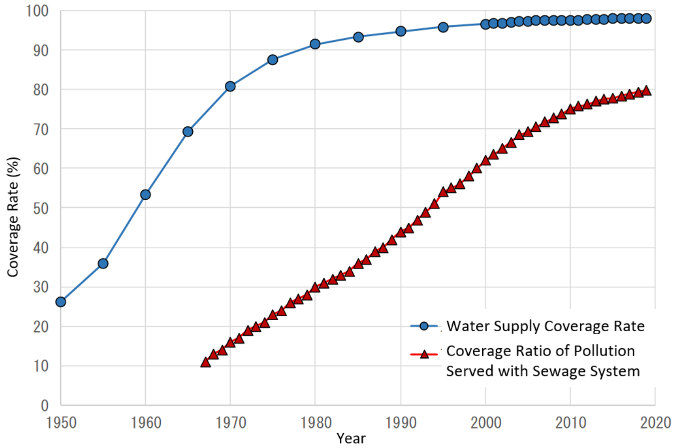


Source: Gini coefficient "Income Redistribution Survey" Ministry of Health, Labor and Welfare, Water supply volume" Introduction to Water Supply, 6th edition 2015 Water Supply Association, "Water Supply System in Japan 2007" Ministry of Internal Affairs and Communication

Note: The Gini coefficient in Japan after the redistribution of income was in the range of 0.3643 in 1990 and 0.3721 in 2017 (MHLW, https://www.mhlw.go.jp/stf/wp/hakusyo/kousei/19/backdata/01-01-08-09.html).

Figure 1.10 Annual Water Supply and Corresponding Gini Coefficients

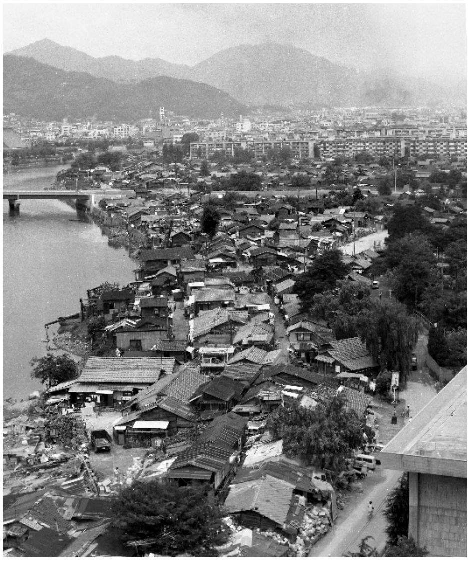
[1] The Gini coefficient is a measure of inequality or disparity in income and assets. The Gini coefficient is 0 for a fully equal society and 1 for a fully unequal society. e.g., Indonesia 0.378, Philippines 0.423, Thailand 0.364, Vietnam 0.375 (World Bank data base, 2018)



Note: Coverage ratio of water supply = total water supply population/total population. Total water supply population = tap water supply population + small-scale water supply system population + private water supply population. Coverage ratio of the population served with the sewerage system = Population of areas with sewerage systems in place/total population
Source: Project Research Team based on data from MLIT.

Figure 1.11 Water Supply and Sewerage Coverage Ratio

The living conditions of the urban poor also improved in conjunction with river improvement. The government implemented projects to support the urban poor living in and near the river area. For example, in Hiroshima, the victims and repatriates lived on the land in the Ota River, forming a slum known as the "Atomic Bomb Slum" (Figure 1.12). In the Ota River flood protection project, the government constructed public housing for low-income people and provided them with poor resettlement.



Source: "Motomachi Aioi Street as seen from the Rooftop of the Chamber of Commerce" Photo in the Bulletin of the Hirosima City Archives, No. 30, 1
Photographer: Research Group of Community Structure/Provider: The Hiroshima City Archives

Figure 1.12 Atomic Bomb Slum in Hiroshima

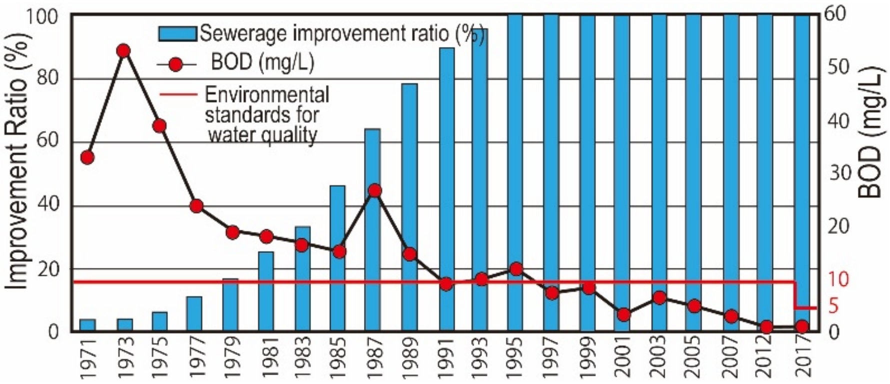
The government improved support for communities affected by projects. Adverse impacts such as loss of livelihood would occur due to resettlement caused by large-scale projects such as dam construction. Furthermore, dam projects have the characteristic that entire communities in the planned reservoir area would be submerged, which is different from those of other public works projects such as roads. To mitigate the social impact of large-scale projects, the government is required to implement measures to rebuild local communities in addition to compensation for losses. These included the development of relocation sites, support for livelihood restoration, and vitalization of tourism using the dam reservoir.

(3) Sustainability

Japan improved the quality of river water by establishing drainage regulations and constructing sewage systems. With economic growth, health hazards have worsened due to pollution-related diseases caused by factory effluent, and the water quality deteriorated due to domestic wastewater. Water resources development and flood protection works worsened the water environment and the ecosystem. Laws and system regulations for monitoring and penalties improved the water quality. Pollutant loads from factories were reduced by one-fifth from 1970 to 1989. Factories improved their production processes and wastewater treatment. Sewerage facilities and on-site facilities (Jokaso: domestic wastewater treatment tanks at household level) can reduce household pollutant loads. For example, the water quality of the Yanase River, which flows through Saitama Prefecture and the Tokyo Metropolitan Area, was improved by introducing a water purification system and expanding the sewage systems (Figure 1.13).

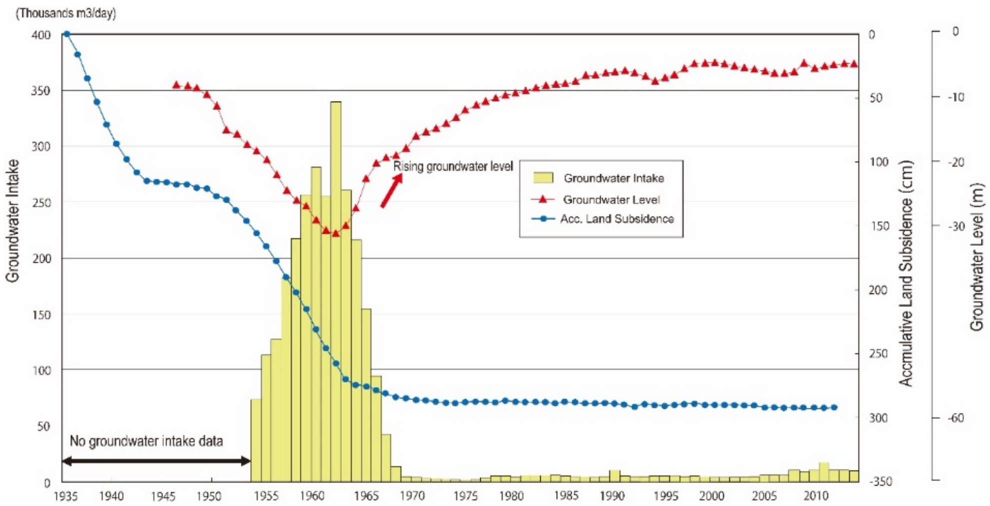
Industrial water supply systems have contributed to the cessation of land subsidence and salinization by substituting groundwater. This system can provide a large quantity of water at a lower cost. Figure 1.14 shows the changes in the amount of groundwater extraction, land subsidence, and groundwater level in Osaka City. Industrial water sources accounted for approximately 80% of groundwater extraction in Osaka City until 1960. By 2019, it had dropped to approximately 20%.

Green infrastructure is being promoted, with the expectation of contributing to ecosystem conservation and environmental protection. Green infrastructure or nature-based solutions could provide multiple benefits, such as disaster risk reduction, habitat creation, and local economy stimulation.



Note: The coverage ratio is from one of the right bank treatment areas of the Arakawa River, and BOD is the annual value (75% water quality value) at the Seiryu Bridge.
Source: Tokyo and 50 Years of Regional Sewerage System, Tokyo Metropolitan Government, Bureau of Sewerage

Figure 1.13 Water Quality of the Yanase River and Sewerage Coverage Ratio

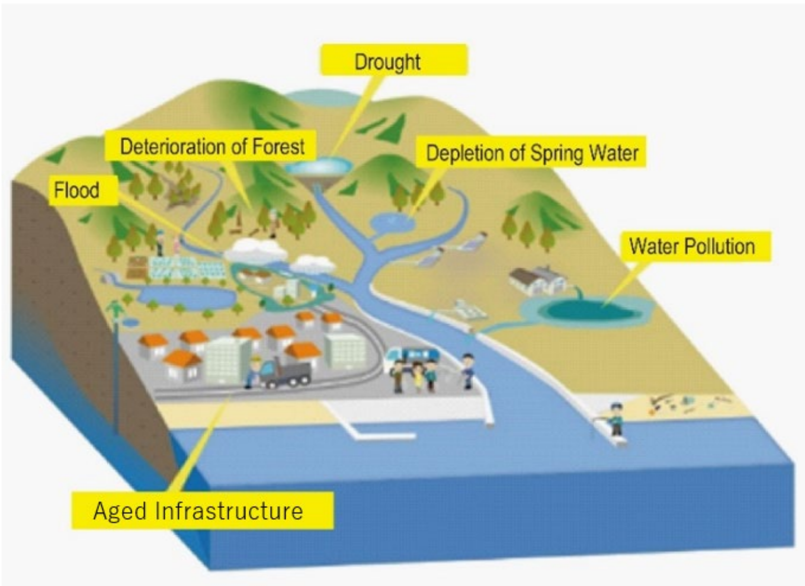


Note: Groundwater extraction data: Minato station until 1964 and Minato station II from 1965 onwards.
Source: "Report on the effective use of groundwater in consideration of the ground environment in the Osaka City area," Study Council on the Effective Use of Groundwater in Consideration of the Ground Environment in the Osaka City Area February 2019

Figure 1.14 Groundwater Extraction Volume, Groundwater Level, and Cumulative Land Subsidence

1.3 Issues for Water Resources Management in Japan

The water resources management in Japan supported the quality growth but left some issues unaddressed (Figure 1.15).



Source: Website of Cabinet Office

Figure 1.15 Issues in Water Resources Management

(1) The quick responses and flexibility were limited. Since the 1950s, pollution-related diseases, such as Minamata disease, caused health hazards. Japan prioritizes economic growth. Factory effluents are regulated in a limited manner, resulting in water pollution. The national government strengthened measures to mitigate pollution and health hazards after the Diet in 1970, called the "Pollution Diet," which convened to intensively discuss pollution control measures. In addition, it took a long time to review facility capacities to match the actual demands. Because the water demands stabilized after the high economic growth, the capacities planned for water resources development projects were overestimated.

(2) Establishment of water governance: The issue is to establish a water governance system that can quickly respond to the diverse needs of an ever-changing society. However, technology and engineering approaches are insufficient to address this issue. The various needs of the environment, ecosystems, and adaptation to climate change cannot be met by governments alone. Therefore, it is necessary to establish legal and organizational mechanisms for unified water resources management. Mechanisms are required to overcome the deficiencies existing in vertically divided administration systems and achieve cross-sectional management. A wide range of stakeholders should be involved in sharing roles and responsibilities, including other sectors, such as urban and disaster management, the private sector, and civil society organizations (CSOs). A basin water cycle council[2] should be established to maintain and restore a healthy water cycle in a river basin. Efforts are also necessary to build a mechanism to develop and implement a basin water-cycle plan.

(3) Adaptation to climate change and socioeconomic change: It is necessary to enhance the resilience and sustainability of river basins by all stakeholders who contribute to socioeconomic growth by strengthening countermeasures against water-related disasters that are becoming more severe with climate change. All parties involved in the river basin from the upstream catchment area to the downstream inundation area should collaborate to implement countermeasures. With declining birth rates and an aging population, the water resources sector should contribute to maintaining the vitality of communities, improving productivity and national growth, and promoting inclusive disaster management. In recent years, there has been an increase in flood damage to medical institutions and welfare facilities that are vulnerable to disasters, including hospitalized patients, the elderly, and the disabled. It is necessary to regulate the construction of medical institutions and welfare facilities for the elderly and disabled in high-risk areas that are prone to flooding and difficult to support and evacuate. In addition to existing structural measures, the promotion of urban development and the strengthening of disaster management are required. Risk management for water shortages is also required.

[2] Water cycle council was established to prepare basic plan for conserving the water cycle following Basic Act on Water Cycle.

CHAPTER 2 OUTLINES OF EACH THEME

This report explains the water resources management system in themes 1 to 3, the issues in each field important in developing countries discussed in themes 4 to 9, and the development of human resources and technology (Table 2.1).

Table 2.1 List of Themes and Issues in Each Field

Theme		Section	Flood Protection	Water Use	Environment
1. Governance	1-1 Legislation and Organization	2.1	O	O	O
	1-2 Water Rights	2.2		O	O
	1-3 Public Participation and Decision-Making Process	2.3	O	O	O
2. Plan-based Management	2-1 Management Planning	2.4	O	O	O
	2-2 River Basin Planning	2.5	O	O	O
3. Finance		2.6	O	O	O
4. Water Pollution and Environmental Management		2.7			O
5. Urban Water Management		2.8	O	O	O
6. River Management		2.9	O	O	O
7. Groundwater Management		2.10		O	O
8. Dam Management		2.11	O	O	O
9. Environmental and Social Considerations in Large-Scale Projects		2.12			O
10. Development of Human Resources and Technology		2.13	O	O	O

Note: "O" shows issues explained in this report.
Source: Project Research Team

2.1 Legislation and Organizations to Coordinate Sectors and Regions

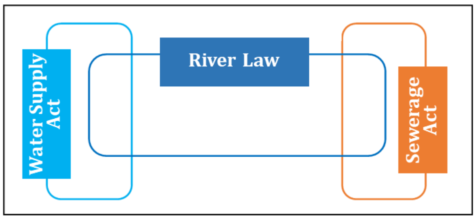
The government should establish legal systems and organizations to coordinate among stakeholders and water users, between upstream water source and downstream beneficiary areas, and between development and environmental conservation. These conflicts and confrontations are involved interests, regional conflicts, shared roles, and shared costs among many stakeholders and sectors. Water abstraction from rivers and flooding may induce conflicts between the upstream and downstream reaches, and flooding may induce conflicts between the left and right banks of the rivers. Environmental and ecological perspectives are also important for addressing conflicts.

Over the past 2,000 years, Japan has resorted to river management to make use of the water and to reduce flood damage. Since ancient times, the government has developed surface water from rivers for the irrigation of paddy fields. Activities against frequent floods are also necessary to protect residential areas and cultivated lands. Rivers are also used for transportation purposes. Based on history, laws and organizational systems were established after the establishment of the modern nation at the end of the 19th century. River water utilization and flood damage reduction are important issues. The River Law was enacted to manage river water, apart from the Water Law, which generally deals with water resources.

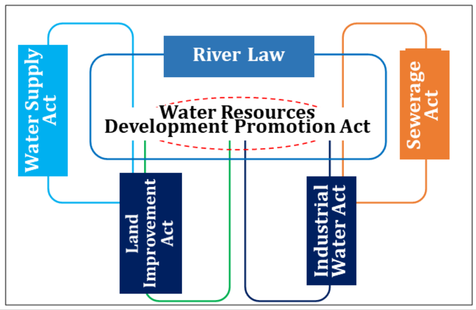
Japan transformed institutions to meet the changing needs of the country along with the nation's growth, socioeconomic changes, and climate change (Figure 2.1).

(1) **Modernization:** To promote modernization, the Meiji government, established in 1868, improved river channels for navigation systems, which functioned as the main transportation system at that time. The River Law was enacted in 1896 to mitigate the increase in flood damage caused by modernization. Local governments managed flood protection projects. In 1896, the government initiated a national flood protection project. The government enacted the Water Supply Act in 1890 and the Sewerage Act in 1900 to improve public health and prevent waterborne diseases, such as cholera, which killed over 100,000 people in 1879 and 1886.

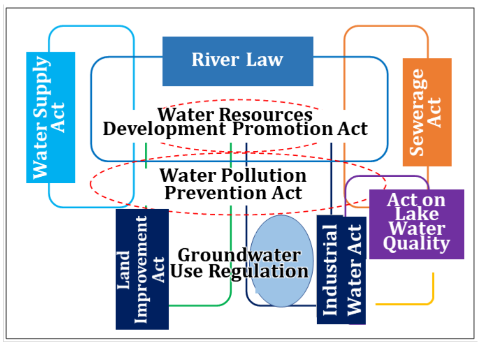
(2) **Post-WWII Reconstruction (after 1945):** Since the late 1940s, to restore the nation's devastated land, the government promoted hydropower generation and food production by developing water resources, which is one of the limited natural resources in this resource-poor country. In 1949, the government enacted the Land Improvement Act to develop irrigation facilities. Various river basins suffered unprecedented damage due to a series of floods that occurred after 1945. The government intensively implemented national land conservation projects for flood protection and watershed management.



Modernization: End of 19th Century-Mid 20th Century, Flood Prevention and Public health



High Economic Growth: Mid 20th Century to 1970, Water Resources Development



Sustainable Growth :1970-Present, Environment

Source: Modified Figure of Team Water-Japan by Project Research Team

Figure 2.1 History of the Legal System Related to Water in Japan

(3) **High Economic Growth:** The government developed water resources to meet the rapidly increasing demand for electricity and domestic and industrial water. In 1964, "water utilization" was added to the objectives of the River Law, and the government targeted river management based on the integrated river system principle. Japan established the Water Resources Development Promotion Act and institutions to promote multi-purpose facilities to develop water resources and mitigate flood damage.

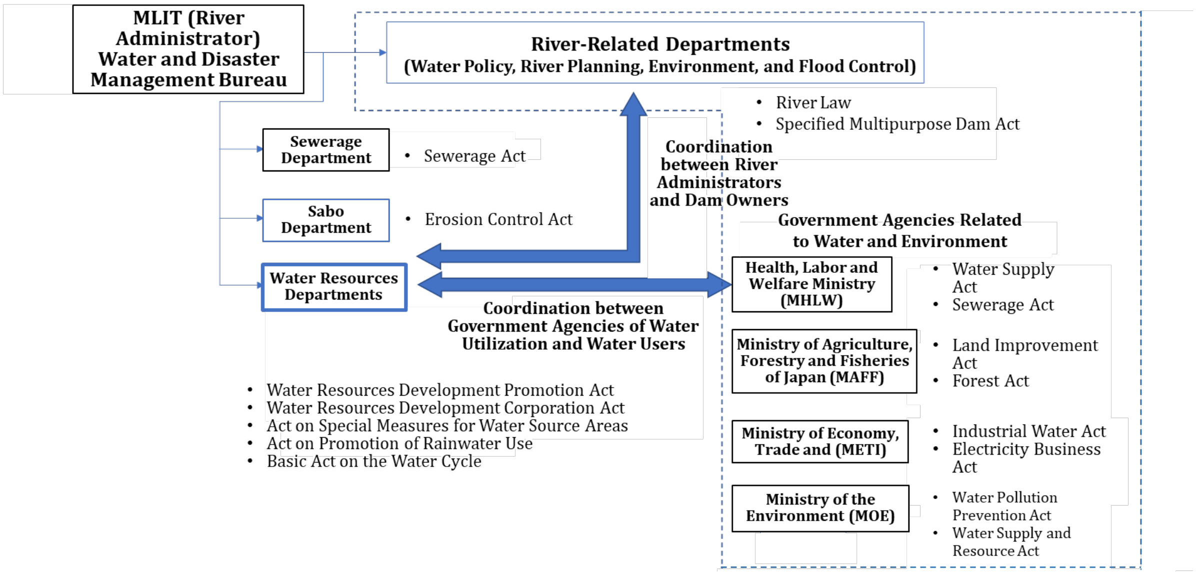
(4) **Resolving environmental issues caused by high economic growth:** Since the 1960s, the adverse effects of industrial and mine wastewater pollution became more significant. The environments of rivers and oceans deteriorated and severe health problems occurred, causing approximately 40,000 pollution victims. Many people continue to experience and suffer from pollution. This is the negative impact of Japan's high economic growth. Water Pollution Prevention Act was formulated, and the government established systems to prevent water pollution. Although the old Sewerage Act was enacted in 1900, the development of sewerage systems did not progress. Full-scale

development began after the new Sewerage Act was enacted in 1958. In 1956, the Industrial Water Act was enacted to regulate groundwater extraction and stop land subsidence, which became increasingly prominent. By the end of the high economic growth, interest in the water environment has increased due to the diversification of society values. Environmental preservation was added to the objectives of the River Law in 1997. A system was established to reflect the opinions of river basin residents when formulating river improvement plans to meet diverse needs. The water management system is being transformed, via management of the water resources by the government, to a governance system that involves relevant institutions, basin residents, and academic experts. The Basic Act on the Water Cycle was enacted in 2014 to ensure a healthy water cycle, including the use of groundwater in a comprehensive and integrated manner.

(5) **Adaptation to climate change**: With climate change, the frequency and intensity of damage caused by floods are increasing. As rivers alone cannot cope with such intensified flooding, efforts are being made to accelerate advanced disaster-prevention measures in cooperation with the national government, local governments, and the private sector. The RMOs and related agencies implemented basin-wide flood protection measures for the entire urban area and basin, based on the policy of river basin disaster resilience and sustainability. Approaches for managing water shortages have shifted from providing sufficient water to managing drought risks.

The Water Resource Bureau[3] (presently the Water Resource Department) was established in 1962 to coordinate all related ministries and departments regarding water resources policies and to formulate and promote basic plans for water resources management. The main national government agencies related to water resources are the MLIT with jurisdiction over flood protection and sewerage; the Ministry of Agriculture, Forestry and Fisheries (MAFF) with jurisdiction over irrigation water; the Ministry of Health, Labor and Welfare (MHLW) with jurisdiction over domestic water supply; the Ministry of Economy, Trade and Industry (METI) with jurisdiction over hydropower and industrial water supply; the Ministry of the Environment (MOE) with jurisdiction over ecology and water pollution; and the Ministry of Internal Affairs and Communications (MIC) with jurisdiction over local government projects (Figure 2.2).

[3] It was established in 1962 as a bureau of the Economic Planning Agency, and later moved to the National Land Agency in 1974 and to a department of the Ministry of Land, Infrastructure, Transport, and Tourism in 2001.



Source: Project Research Team referring to website of MLIT

Figure 2.2 Entities Involved in Water Resources Development and Concerned Law and Acts

The Water and Land Management Bureau of MLIT manages major rivers, and local governments manage other rivers. The Minister of Land, Infrastructure, Transport, and Tourism and prefectural governors are referred to as river administrators. The MLIT established RMOs in each river basin with the responsibility of river-improving policies and planning, river maintenance work, providing water and land occupation, and issuing permits and approvals for the construction of river structures.

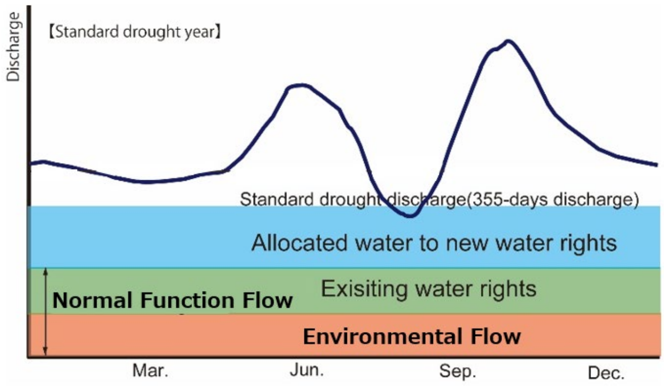
2.2 Water Use Order with Water Rights System based on Customaries and Characteristics

The government should establish a water-using order by introducing a water rights system based on past water management and the background of past development, customs, and history. Water distribution can increase the tension between areas and may lead to disputes. In Japan, violent disputes occurred regarding the distribution of irrigation water. At the time of establishing the modern legal system, the government introduced licensed water rights based on the potential of water resources. The River Law dealt with irrigation water that was already developed as customary water rights.

The RMOs manage water rights and issue licenses. In Japan, river water is a public good[4] and water users may use it to promote public welfare. Water rights are not fixed or vested but are obliged to change along with social changes, such as urbanization and increased weight of the environment value. Land ownership and water rights are separated under the River Law. The RMOs (the river management offices stipulated by the river administrator in the river law: MLIT or prefectural governor) approve water abstraction based on the following viewpoints: (1) promotion of public welfare, (2) soundness of project implementation, (3) ratio of the water abstraction volume applied to

[4] Water that is used for public purposes. Water in a lake or river that is regulated by public law.

the total river flow volume, and (4) effects on public interests. The MLIT usually sets the safety level of drought[5] "once in ten years." The flow applied for new water rights may be approved if the ten-year drought flow can cover the environmental flow[6], the flow required to meet existing water rights, and the additional flow applied (Figure 2.3). The permit period is generally ten years and should be renewed every ten years. Water users pay water rights fees. The river law stipulates penalties for illegal water abstraction.



Source: Project Research Team

Figure 2.3 Range of New Available Permits

During drought, water users coordinate their abstraction volumes at drought-coordinating committees in the spirit of co-assistance, which is fostered through the practices and history of each river basin. Coordination rules vary according to the past development history and practices in each river basin. Some examples are to set a rule of uniform saving rate in water abstraction among water users, prioritizing customary water rights, or prioritizing domestic water supply. RMOs provide the necessary information and set up meetings to ensure smooth coordination among water users.

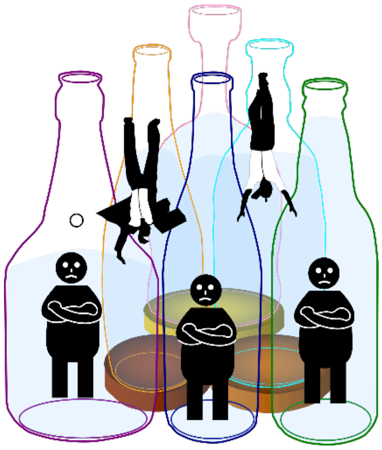
By establishing systems for the transfer of water rights[7], water resources can be managed effectively. Water rights are being transferred from agricultural use, with declining water demand, to urban use, with increasing water demand. In the Tokyo Metropolitan Area, with further increase in population, water rights were transferred to urban water from irrigation users through renovation projects of irrigation canals. The water supply offices bore the cost of these renovations to obtain water rights. Water trading with financial compensation has not been practiced in Japan.

Farmers' associations (irrigation area improvement and management associations) manage irrigation facilities. The farmers set rules for water allocation within the irrigation area and manage irrigation facilities. Public institutions operate their facilities to ensure fairness and effectiveness. The operating funds of the farmers' associations are levied by members.

[5] Drought flow is the river flow that does not fall below this value for 355 days a year.
[6] The maintenance flow is the discharge (flow rate) that must not impair the normal functioning of the river, such as the environment and ecosystem, and is determined in consideration of the protection of flora and fauna, fisheries, scenery, and maintaining the cleanliness of the flowing water.
[7] When, for some reason, the full amount of the permitted water right is not needed, the difference between the required amount and the permitted amount is reduced, and the reduced amount is diverted to other purposes. The party reducing the water abstraction should go through the procedures for reduction and the party increasing the water abstraction should apply for the additional water right.

2.3 From Government Management to Building Water Governance

In promoting water resources management, water governance[8] should be established according to the actual conditions of each river basin and the local community. It is difficult to meet the diverse needs of an increasingly complex society when the government manages consensus building among the stakeholders. Some needs cannot be met by a vertically segmented administration system in which the responsibilities of each ministry and the laws under their jurisdiction are clear (Figure 2.4). Building water governance requires the participation of residents and CSOs in the decision-making process, disclosure of information on projects for this purpose, clarification of the role and responsibility of related agencies, and accountability of the government.



Note: The bottles are governments. Citizens fall through the gap in the bottles.
Source: Japan Water Forum, Takemura Koutaro

Figure 2.4 Vertically Segmented Administrative Model

The controversy over the Nagaragawa River mouth barrage provided an opportunity for water governance reform. With the end of the period of high economic growth and the diversification of citizens' values since the 1980s, there has been an increase in the number of cases in which the environmental impacts of public works, such as dams and barrages, became major social issues. Opposition to the construction of the Nagaragawa River mouth barrage gained momentum with their concern about deteriorating the environment and ecosystem, involving political groups and the mass media, and became well known throughout Japan. The MLIT, as the river administrator, decided to disclose relevant data on water quality, hydrology, and the environment. Eight roundtable meetings were held in public to discuss the issue, but the parties did not compromise, and the operation of the barrage was launched. These have enhanced the transparency and accountability in the decision-making process of infrastructure projects.

In Japan, the river basin committee is established in each river basin to formulate "river improvement plans" for flood protection, water utilization, and environmental conservation. The 1997 River Law stipulates a river improvement plan that indicates the goals and specific contents of river improvement to be implemented over the next 20 to 30 years. The opinions of academic experts are collected, and public hearings are held to reflect the opinions of residents in the river basin. River basin committees operate under a variety of institutional designs so that the committees vary among river basins.

[8] Water governance is a concept that includes water management for flood protection and water use and a basic sense of values and principles based on organizations and communities, such as respecting the will and human rights of the people, legality, reliability, and transparency.

Innovative efforts were made to establish water governance in the Yodo River. The Yodo River flows into the metropolitan areas of Osaka and Kyoto, which have been the center of growth in Japan since ancient times. The river basin committee was established in 2001, and experts and residents proactively participated in discussions on an equal footing (Figure 2.5). The national government usually serves as the secretariat of the committee by selecting committee members, preparing draft plans, and directing discussions. However, in this committee, the secretariat role was entrusted to a private company as a third party, and the preparatory committee selected committee members. A wide range of issues related to floods existed in the river basin, and the committee discussed environment conservation and water utilization instead of discussing specific projects to avoid unnecessary conflicts among members. This approach provided an opportunity for expert members to learn the need for environmental as well as engineering viewpoints. A conflict of opinions occurred in dam construction between the national government and the committee, and the river improvement plan was not formulated. This committee was suspended in 2007.

Source: Yodo River Basin Committee

Figure 2.5 The 85th Committee (April 8, 2009, Hirakata City)

Information disclosure is essential to establish water governance through citizen and stakeholder participation. Information disclosure enables government agencies to communicate with CSOs. The Information Disclosure Act, enacted in April 2001, allows anyone to request the disclosure of all administrative documents. The MLIT provided guidelines for resident participation in 2003 and formulated appropriate infrastructure plans by applying the guidelines in cooperation with residents and stakeholders while disclosing information on infrastructure projects from the planning stage. Outlines of infrastructure projects and their annual budget implementation are accessible on websites.

There may be more than one correct answer to resolve issues by coordinating stakeholders' opinions, and the attitude to keep looking at the most preferable answer is most required. Residents' participation in the process of decision-making for infrastructure projects is often lengthy because of the various opinions of the residents. Even though it is quite difficult to reach a unanimous agreement, efforts to find the most preferable solutions for all residents and stakeholders are required, expecting that the project will contribute to the region's interests and for which accept.

A review of the projects is necessary for keeping with socioeconomic changes. In particular, large-scale projects often require a long period of implementation, and socioeconomic conditions may change. Thus, each country should introduce adaptable and flexible mechanisms. In Japan, at the re-evaluation stage, the government decides to "continue" or "discontinue" the project at three major stages: application for a new project, re-evaluation during implementation, and post-evaluation after completion.

It is important to strengthen the cooperation between the public and private sectors and local communities for environmental conservation and disaster prevention (Figures 2.6 and 2.7)**.** The government can support these activities through financial support, training, and awards. Local communities and residents need to prepare for disasters in accordance with local conditions. The private sector can provide solutions to various issues by utilizing its resources.

Source: Outline of Typhoon No.18 in September 2013, Kinki regional development bureau, March 2014

Figure 2.6 Overflow in the Downstream River

2.4 Water Resources Management positioned in a National Development Framework

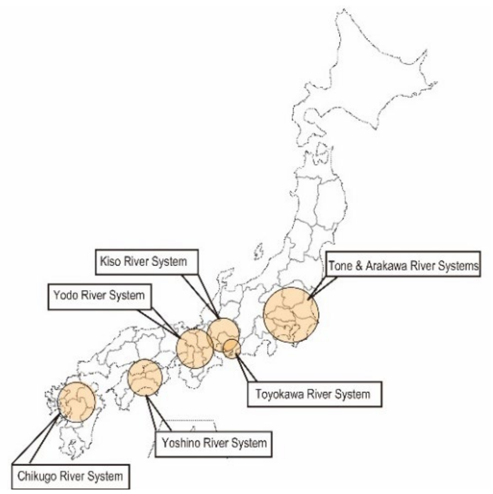
Source: Tree Planting for Fish Breeding Campaign Regain the 100-year-ago natural beach

Figure 2.7 Tree Plantation

The water resources development plan should be a consistent framework of higher-level plans, such as the national development plan. Water resources management is essential to achieve resilience, sustainability, and inclusive growth. If water resources management is not undertaken properly, problems such as floods, droughts, and environmental deterioration may occur and affect the growth of the nation. In Japan, water resources development was promoted as the core issue of comprehensive regional development for reconstruction after World War II. After 1945, population pressure was so strong that the supply of basic commodities, such as food and energy, was short. Because water was the only available natural resource, the government developed it for hydropower and irrigation. During the high growth from the 1950s, the Japanese government formulated the National Comprehensive Development Plan (NCDP) to indicate the basic direction of national land development from a long-term perspective. Each revised NCDP include water resources management as the key issue of national development.

National plans for water resources management can contribute to efficiently implement projects. Water resources-related projects require a long period from planning to construction. In addition, after completion, the project operation and effects (benefits) last for a long time. Plans with a long-term perspective are essential. The plans regarding water resources may be formulated as an upper-level plan for a country above the ministry level. These plans are not just to present a list of projects but should also explain the goals, effects, and inputs to solve the issues based on the actual data to ensure policy implementation.

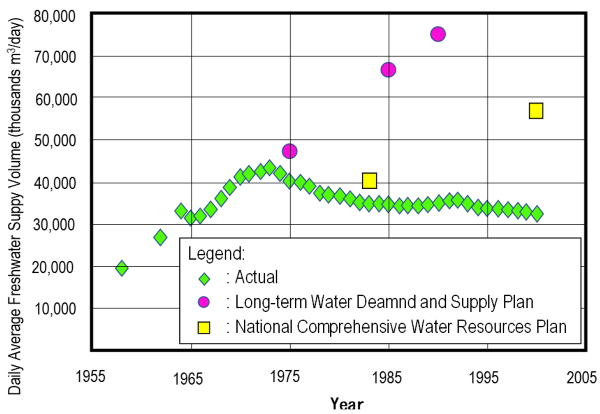
The Japanese government formulates the Basic Plan for Water Resources Development (full plan) for designated river systems. The plan provides comprehensive water resources management, indicating (1) the demand projection of each water and target of water supply, and (2) the necessary facilities to be developed to achieve the supply target. A cabinet attended by water-related ministers, finance ministers, and planning ministers approves this as the national plan above the ministry level. During the high growth, the water demand increased drastically due to the significant development of industries, the rapid increase and concentration of the urban population, and the improvement of living standards. In accordance with the Water Resources Development Promotion Act (1961), the national government designated seven river systems as water resources development systems that require wide-area coordination of water supply and water resource development (full plan river systems) (Figure 2.8). Approximately 50% of the population and industrial activities are concentrated in the full planning of the river systems, which cover approximately 17% of the country's area. The Water Resources Department,[9] which belongs to the MLIT, prepares draft plans as the secretariat for coordinating with related ministries and prefectures.



Source: Prepared based on MLIT Website data

Figure 2.8 Location Map of the Full Plan River System

All plans require a review mechanism. Water demand changes along with socioeconomic changes and technological progress. Planned projects also require changes. In Japan, the high economic growth ended in the 1970s, and, owing to the efforts of reusing industrial water and decreasing water consumption, the deviation between the long-term projection of the water demand and the actual demand became significant (Figure 2.9). It was pointed out on the long-term sector development plans that "the resources allocation tends to be almost fixed, and it is difficult to timely reflect the economic trends and financial status to the development projects."



Source: Analysis and Evaluation of Japan's Water Demand Forecasting System, Nishioka Takashi, Nasu Shingo

Figure 2.9 Comparison of Projected and Actual Water Demand in Japan

9 Burau that develop plans for water resources

Formulating a long-term plan contributes to securing a budget for long-term project implementation. Since water resources development projects and flood protection projects take a very long time to complete, it is necessary to get a commitment to the long-term budget in place of allocating the budget for each fiscal year. In Japan, the national government formulated its first long-term plan for flood protection after experiencing a great flood in 1910. Budgets were estimated for each river basin and flood protection projects were implemented. To manage the accounting work for these projects, the national government created the Special Account for Flood Protection, independent of the general account. In 2003, this long-term plan was integrated into the Priority Plan for Social Infrastructure Development along with eight other sector plans.

Under climate change, the flood management with a comprehensive and multi-layered approach by various stakeholders throughout the river basin (Figure 2.10), and the "risk management" for droughts are required. Conventional structural measures such as levees and dams are no longer sufficient to intensify flood disasters under climate change (Table 2.2). The Japanese government has initiated the "river basin disaster resilience and sustainability through all" programs using the following approaches:

(1) Flood protection: structural measures, irrigation ponds, rainwater infiltration, and flood storage in urban areas
(2) Exposure reduction: regulate urban development in hazardous areas, and
(3) Disaster resilience: cooperation with the stakeholders for disaster response and reconstruction.

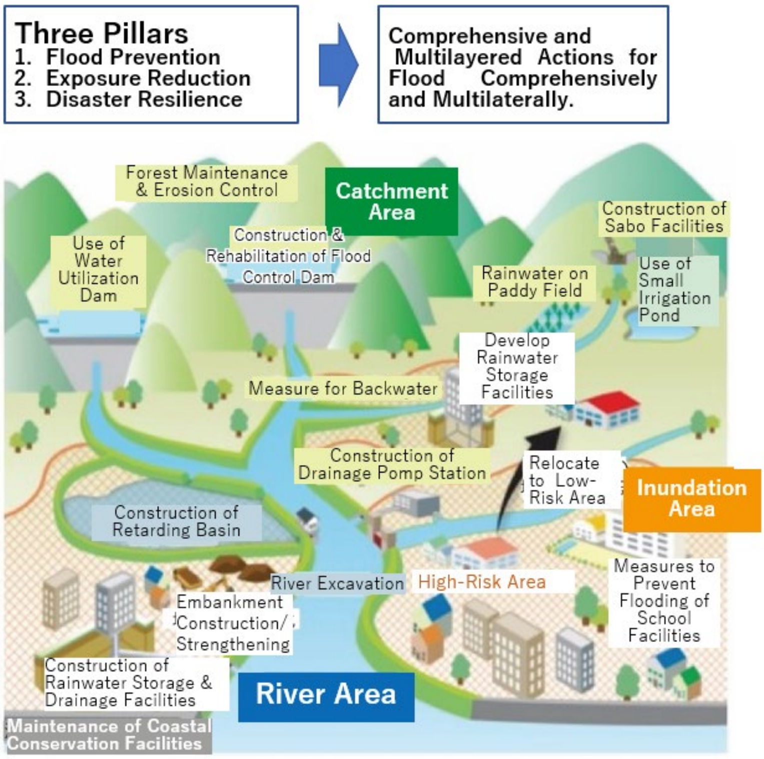
The risk-managed "stable water supply" is the key to thoroughly utilizing existing facilities and ensuring the functioning of the overall system through coordination of structural and non-structural measures. A stable water supply requires advanced technology, such as the latest observation technology and ICT, to forecast uncertain future climate change.

Table 2.2 Rate of Change in Rainfall, Flow Rate, and Flood Frequency due to Climate Change

Climate Change Scenario	Rainfall	Flow Rate	Flood Frequency
2°C increase	Approx. 1.1 times	Approx. 1.2 times	Approx. 2 times
4°C increase	Approx. 1.3 times	Approx. 1.4 times	Approx. 4 times

Note: The target rivers are those managed by MLIT, and the average values are shown. Discharge (flow rate) was calculated based on the runoff model used for each water system.

Source: Proposal for Flood Control Planning in Light of Climate Change, Revised Edition, MLIT, April 2021



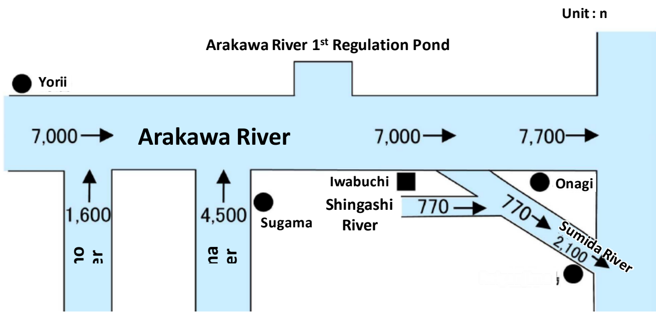
Source: MLIT Website

Figure 2.10 Schematic Diagram of River Basin Disaster Resilience and Sustainability by All

2.5 River Basin as a Unit of Water Resources Management

The governments formulate water resources management plans according to basin characteristics and regional customs. These include formulating a water resources management plan with consistency among the related sectors throughout the river basin and setting the improvement targets to optimize river facility development and water management from the perspective of the overall river basin. The hydrological data are essential for developing management plans. If the observation data are insufficient, satellite observations, past marks, and hearsay should be recorded.

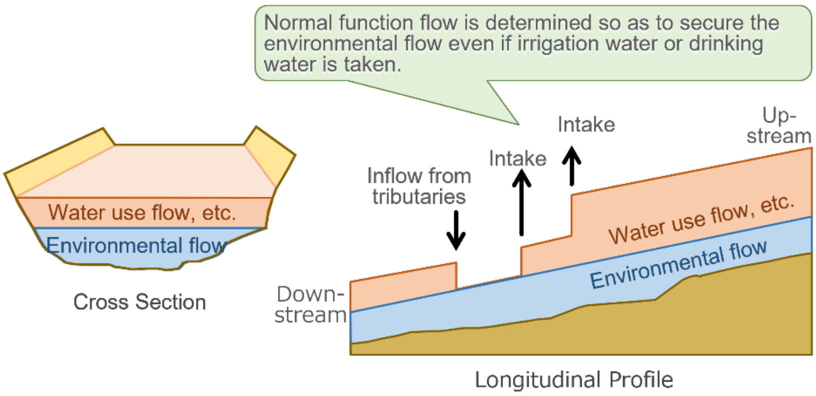
The safety level of flood protection should be set according to the importance of protected areas. The safety levels of the flood protection plan were expressed as the probability of the target flood level (probability year). Major rivers flowing through socioeconomically important areas require high safety levels. For example, the Tokyo Metropolitan Area and Osaka City have the highest target levels once every 200 years. Figure 2.11 shows the planned flood discharge of the Arakawa River, which runs in the Tokyo metropolitan area.



Note: Flood protection level 1/200
Source: Website of Arakawa Upstream Basin Office, MLIT

Figure 2.11 Planned Flood Discharge of the Arakawa River

The safety level (probable year of drought frequency)[10] should be set as the target for the water management plan. Governments formulate a plan to ensure the normal function of river flow, including the new demand for water use and environmental conservation of the river. In Japan, the safety level against drought is generally defined as a drought level of approximately once every ten years. If the natural flow in a river is insufficient, water storage facilities are constructed. The normal function flow includes not only water used for irrigation and domestic water supply but also a wide range of environmental flows (Figure 2.12) for (1) navigation, (2) fishery, (3) tourism, (4) maintenance of clean water flow, (5) prevention of salt damage, (6) prevention of blockage of estuaries, (7) protection of river management facilities, (8) maintenance of the groundwater level, (9) landscape, (10) habitat of animals and plants, and (11) securing rich interactions between people and rivers.



Source: Preparation of the Project Research Team based on the Hyogo Prefecture website

Figure 2.12 Image of Setting Normal Function Flow

A master plan and an action plan should be prepared to improve the river. The River Law revised in 1997 requires the preparation of a river development plan in two stages. "The Basic Policy for River Development" is a master plan for the comprehensive management of water resources, providing policies for (1) flood protection, (2) water use and maintenance of river flow functions, and (3) improvement and conservation of the river environment. It includes the target of flood protection, capacity of facilities for flood protection, planned river water level of the target flood, river discharge to maintain the normal function of the river flow (water use, function of river flow, and river environment), and environmental management. Basic policies cover the principles of managing the environmental issues of ecosystems, scenery, water quality, and recreation. "The River Improvement Plan", which is an action plan, specifies the concrete contents of improvement actions, including specific individual projects for 20 to 30 years. The RMOs formulate the River Improvement Plan upon consultation with a council, such as a river basin committee, and considering opinions from related residents, local governments, and academic experts.

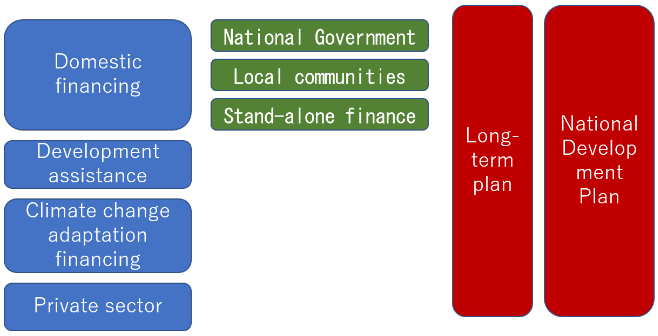
The RMOs understand the issues and needs of the field. The RMOs should understand the issues and needs of local communities in the field and prepare measures together with these communities. To collaborate with various stakeholders in water resources, disaster management, urban development,

[10] Indicators of water intake safety against droughts when using river water.

environmental conservation, and agriculture, the RMOs are required to build trust relationships with the relevant organizations and local communities in the field. The MLIT has an RMO for each river basin and branch office under the RMO to coordinate with stakeholders and establish mutual trust.

2.6 Cost Sharing according to Responsibility and Role

Governments should provide financing investments and involve the private sector in investing in water resources management (Figure 2.13). In Japan, public funds consist of general funds from national and local governments and special accounts. The local government has historically conducted flood protection projects and irrigation pond construction. At the end of the 19th century, the national government started directly implementing flood protection projects as modernization progressed. Local governments have implemented water supply and sewerage projects, while companies have implemented power generation projects. Projects of the national government require the local governments to bear the cost as project beneficiaries. Water supply and sewerage projects also require users to bear the costs. Table 2.3 and Figure 2.14 show the sharing of the project costs.



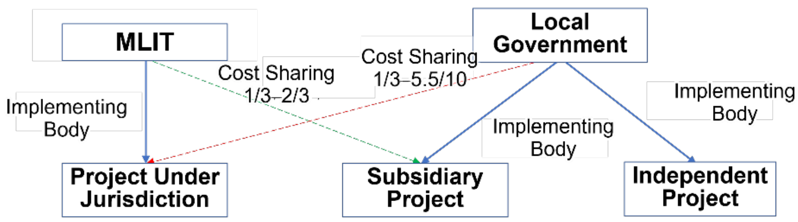
Source: Ishiwatari, M. and Akhilesh S. "Good enough today is not enough tomorrow: Challenges of increasing investments in disaster risk reduction and climate change adaptation." Progress in Disaster Science 1

Figure 2.13 Finance for Water Resources development and Management

Table 2.3 Sharing of Project Cost

Purpose	River Class	Share of Expenses
River improvement	Class A	National Government (MLIT) 2/3, Prefecture 1/3
	Class B	National Government (MLIT) 1/2, Prefecture 1/2
Irrigation		Beneficiary 1/10, for remaining portion: National (MAFF) 3/4, Prefecture 1/4
Water supply		Government subsidy (MHLW) 1/2～1/3
Sewerage		Public sewerage: Main pipeline 1/2, Wastewater treatment plant 1/2 or 5.5/10 Regional sewerage: Main pipeline 1/2, wastewater treatment plant 1/2 or 2/3
Industrial water supply		Government subsidy (METI) within 40%
Hydropower generation		Paid by the power company (Power companies collect and recover the costs from subscribers of electricity use.)

Source: Excerpts from the River Law, Specific Multi-Purpose Dam Act, and "Rivers in Japan," Ministry of Construction.



Source: Preparation of the Project Research Team

Figure 2.14 Cost Sharing in Projects under the Jurisdiction and Subsidiary Projects

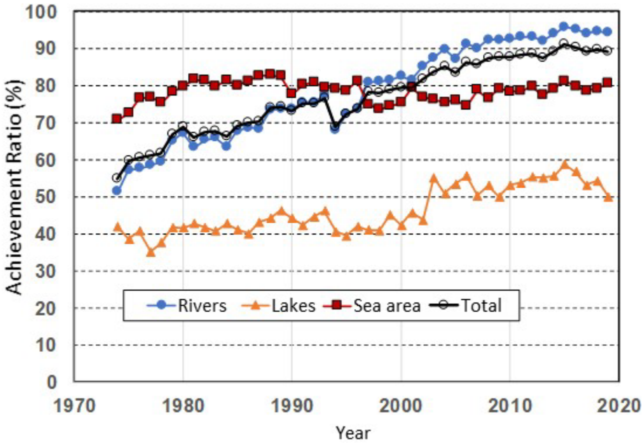
Investments are arranged by mobilizing various sources. In Japan, each organization shares the costs of the construction and maintenance of multipurpose facilities. The share of the cost is determined based on the benefit obtained for each purpose, that is, the construction cost of a single-purpose facility and the capability to pay for each organization. To reduce the financial burden on local governments, the Water Resources Development Public Corporation procures funds for the fiscal investment and loan programs (FILP) on behalf of local governments, and the local governments repay these loans after the facilities are completed.

The government should also consider public-private partnerships (PPPs) for managing facilities. PPP is widely used in water supply and sewerage projects and is classified into four types: (1) outsourcing, (2) design building (DB), or design building and operation (DBO), (3) private finance initiative (PFI) (traditional method), and (4) PFI (concession method). By adopting PPP, projects achieve efficient management by utilizing the know-how of the private sector. In Japan, the PPP method has been introduced to sustain services. The business environment of water and sewerage services is deteriorating as the population continues to decline and facilities are aging.

2.7 Effective Water Pollution Control and Environmental Conservation

It is necessary to establish a legal system to prevent environmental degradation. During high economic growth, water pollution caused by factory effluent and mine drainage led to the outbreak of diseases caused by pollution, such as Minamata and Itai-itai, which caused severe health damage to tens of thousands of people. Some patients are still suffering from them till date. The Water Quality Protection Act and the Industrial Water Act were enacted in 1958. But these acts had limited effects because regulated water areas were limited; there was no sanction for violation of effluent standards, and the number of restricted pollutant items was limited. In 1970, a "Pollution Diet" was held to discuss environmental pollution issues and measures, and several legislations against pollution passed the diet. The local governments set even stricter standards by ordinances than the national legislations. The local governments can conduct on-site inspections on factories and advice remedial measures to private companies.

Treatment facilities such as sewerage systems and on-site treatment systems, Jokaso, are developed according to population density and topographical conditions. The local governments installed sewerage systems in population-dense areas. Jokaso, an on-site treatment system, at the household level is used in rural areas. By 2019, the environmental standard (BOD) in rivers nationwide is achieved at 94.1%. (Figure 2.15)



Source: Water quality measurement results for public waters (2019) Ministry of Environment

Figure 2.15 Improvement of River Water Quality

The degradation of water quality in closed water bodies requires measures against non-point source loads, where pollution discharge sources cannot be specifically identified. These measures should be implemented in closed water bodies such as lakes, marshes, inland bays, and inland seas surrounded by land, improving water quality is a challenge. The non-point source load needs measures in (1) the source areas of loads such as urban areas, farmland, and forests; (2) the water channels and rivers, and (3) the closed water bodies where the load reaches. The measures in urban areas include sewerage systems, cleaning roads, underground infiltration facilities, and rainwater storage. Measures in agricultural areas include improvements in irrigation management and implementation of proper fertilization. The achievement ratios[11] of the water quality standards for lakes and marshes as of 2019 were 50.0% and 80.5%, respectively. These are far less than the 94.1% achievement ratio for rivers.

The national government has promoted "Nature-friendly river programs" since the 1990s to conserve and restore the natural environment in rivers. While ensuring safety against floods, the governments preserve the diverse natural environment to a considerable extent with minimized alterations of rivers to restore the good natural environment.

Utilizing the traditional technique. Traditional construction methods are nature-friendly because the materials include wood, bamboo, and stone, which are harmonized with the surrounding nature and topography. Traditional methods include (1) initiating flood control works such as "Seigyu," (2) submerging fascine mattresses in water to protect riverbanks, (3) preserving riparian forests to mitigate flooding, and (4) putting up weirs with large stones. In Afghanistan, irrigation water intake weirs made of large stones were constructed by using the Yamada weir in Kyushu as a model and applying a similar design to their system (Figures 2.16 and 2.17).

[11] Water quality measurement results for public waters (2019), Ministry of Environment

Source: Website of Kouhu River and Road Office

Seigyu (Groin)

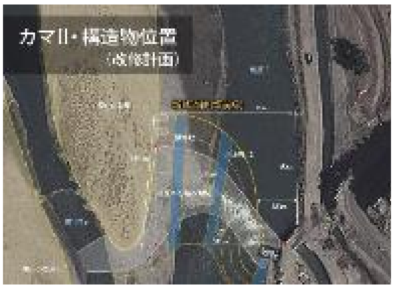
Source: Website of Shinanogawa Downstream Office

Fascine Mattress (Riverbed and Riverbank Protection)

Source: Website of Hokkaido Regional Development Bureau

Riparian Forest

Figure 2.16　Traditional Construction Method



Kama II Weir (Afghanistan)

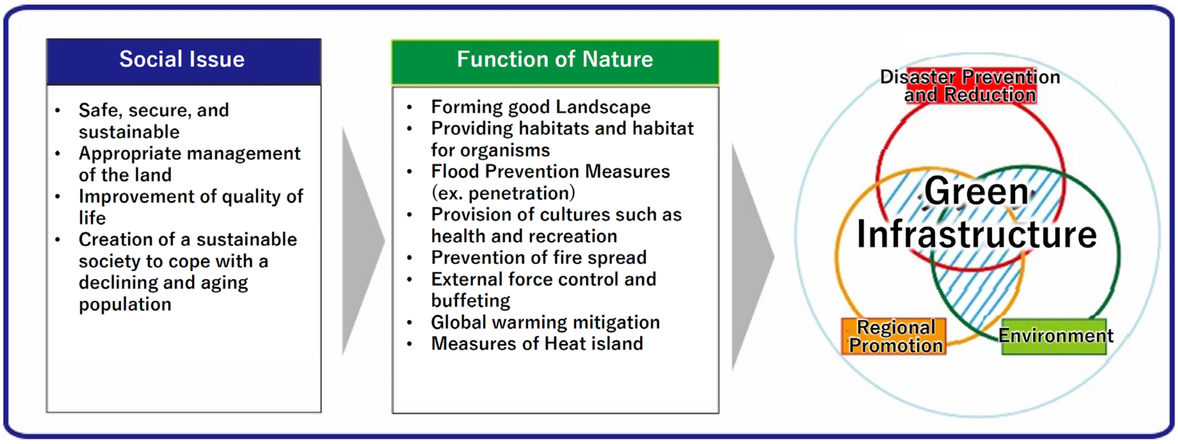
Yamada Weir (Japan)

Note: In Afghanistan, Kama II Weir has constructed an irrigation intake weir based on Yamada Weir, which has been in use in Japan since the Edo period.

Source: Kana II weir; Website of Peshawar-kai, Yamada weir; Proved by Asakura City

Figure 2. 17　Overseas Weirs using the Traditional Construction Method

Green infrastructure has diverse effects on disaster mitigation, the environment, and regional development, leading to the achievement of the SDGs. Green infrastructure is an initiative to create sustainable and attractive national land, cities, and regions by utilizing the functions of nature (Figure 2.18). In Japan, governments have developed many infrastructures and land uses involving nature-based solutions in their design and construction to address local issues.



Source: Green infrastructure portal site MLIT

Figure 2. 18　Scope of Green Infrastructure

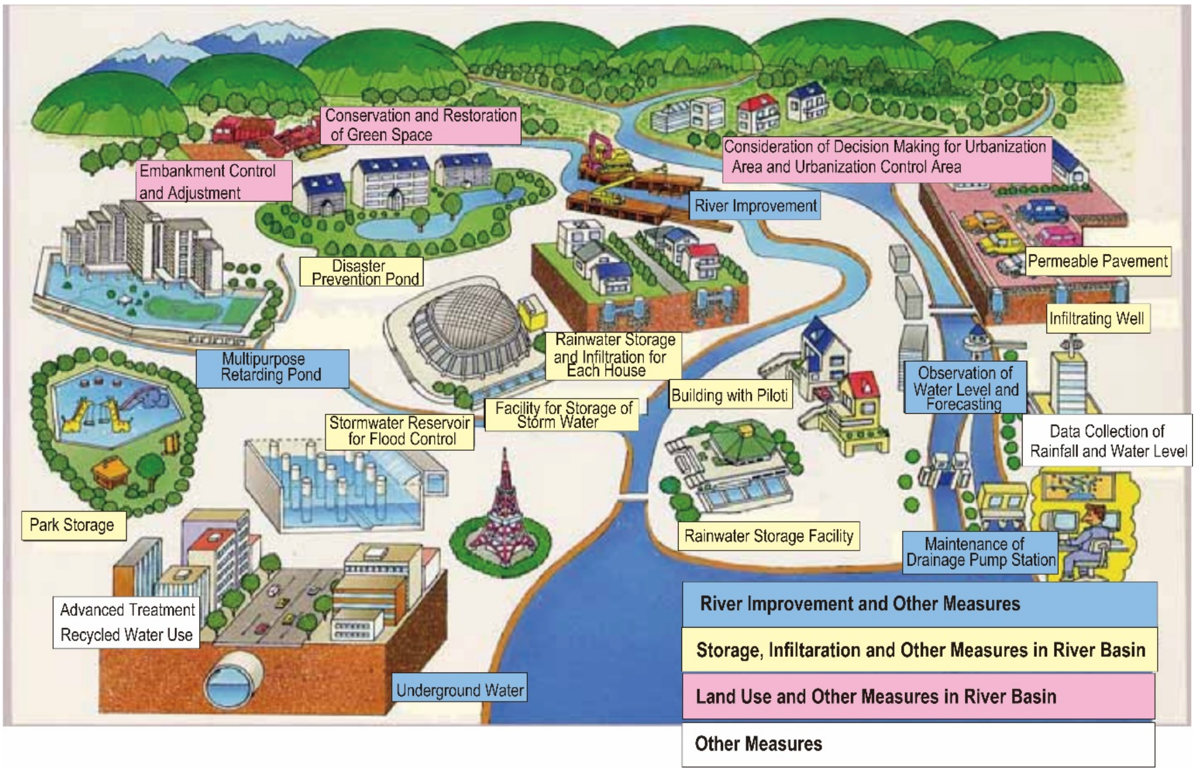
2.8 Improvement of the Urban Water Cycle

The water cycle should be restored to coexist with the environment to ensure water utilization, flood protection, and environmental conservation. The concentration of population in urban areas, expansion of urban areas, and increase in socioeconomic activities have deteriorated the water cycle and caused various impacts on water quality and quantity, the riparian environment, and groundwater. As a wide range of issues may have a cascading effect, collaboration among multiple fields and sectors is required to resolve these issues (Table 2.4 and Figure 2.19, respectively).

Table 2.4 Measures Related to Water Utilization, Flood Protection, and Environment in Urban Areas

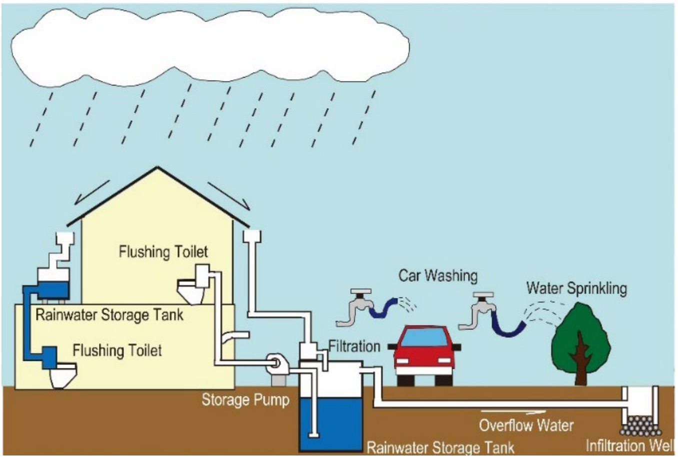
Measures	Water Utilization	Flood Protection	Environmental Conservation	Remarks
1. Water Utilization				
1.1 Water fee system	○			Setting a higher fee for high volume users
1.2 Water-saving tap	○			Control of water use by each household.
1.3 Reduction of non-revenue water rate	○			
1.4 Rainwater harvesting (water use)	◎	○		It also reduces runoff during floods.
1.5 Recycled water use	○			
1.6 Sewerage high-treatment water use	◎		○	High-treated water is reused for environmental purposes.
1.7 Use of recovered water for industrial use	○			
1.8 Seawater desalination	○		△	Desalination plants return water with a high salt concentration to the sea
2. Flood Protection				
2.1 River improvement (Construction of levee, dredging of riverbed)		◎	○	Example is the super levees being built in Tokyo.
2.2 Retarding basin, multiple retarding basin		◎	○	It is used as a facility for other purposes.
2.3 Permeable pavement and permeable groundwater infiltration	○	◎		Contribution to groundwater conservation
2.4 Underground storage		◎		Energy is required for drainage.
2.5 Underground River		◎		
3. Water environment				
3.1 Nature-friendly River program		○	◎	
3.2 Sewerage system maintenance		◎	◎	Decrease in water quality during floods due to discharge of sewage and rainwater by same pipe.
4. Public awareness campaign	○	○	○	Link with all initiatives.

Note: ◎Extremely effective as a countermeasure, ○Highly effective as a countermeasure; △Low effectiveness as a countermeasure
Source: Preparation by Project Research Team



Source: MLIT Website

Figure 2.19 Image of Measures for Urban River Basins

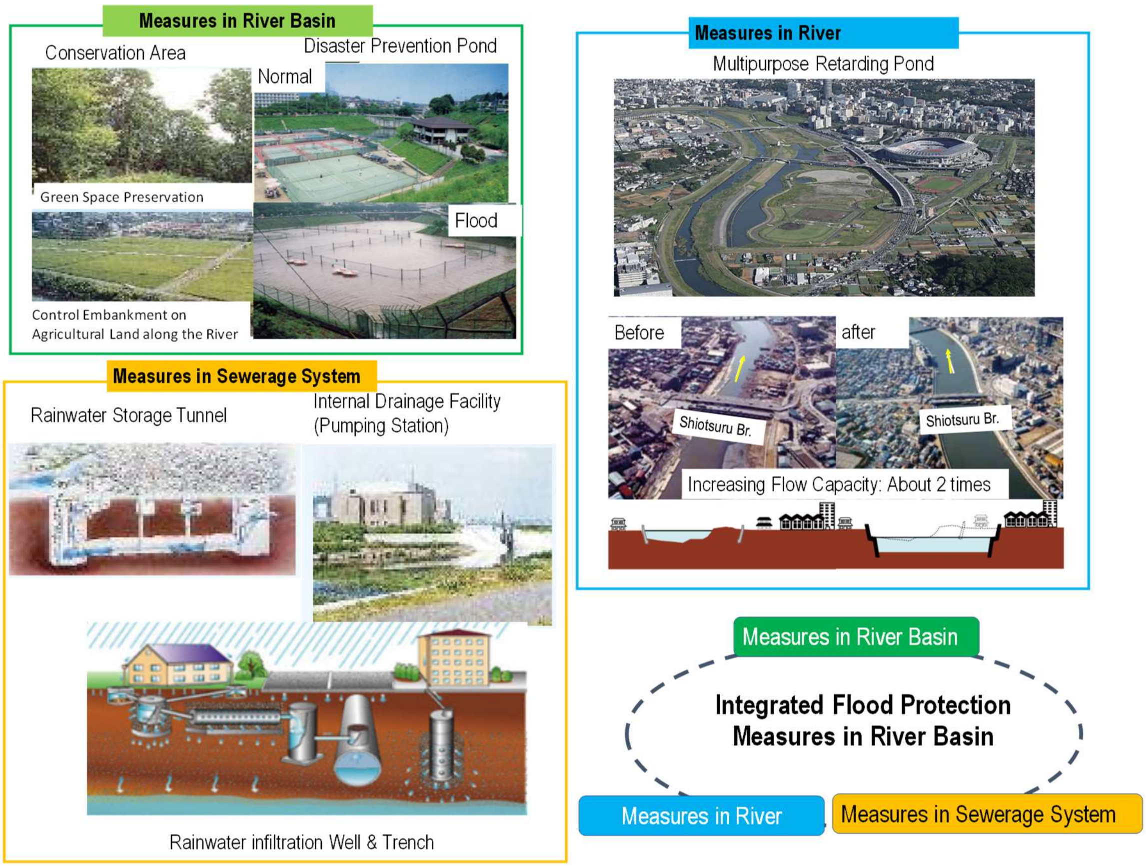


Source: Sumida-ward website

Figure 2.20 Rainwater Use

Demand management can save water and benefit multiple areas. Local governments adopt a progressive tariff system, in which the unit water fee increases as the amount of water usage increases. In addition, they encourage the use of water-saving taps in households and public awareness campaigns regarding water conservation. The average leakage ratio of the water distribution system was as small as 5%. Rainwater, recycled water in individual buildings and districts, and treated sewage water are used (Figure 2.20). Approximately 11.2 million m^3 of rainwater is used annually for toilet water, sprinkling, and other purposes, such as for firefighting and landscaping. The Ryogoku Kokugikan Sumo Stadium in Tokyo installed a 1,000 m^3 rainwater storage tank underground, which is used for toilets, air conditioning, and for sprinkling water. Industrial companies have reduced the amount of fresh water for industrial use. The amount of recycled water exceeded the revised water supply volume after 1970, and as of 2015, the recycling ratio was 77.9%.

Comprehensive measures are required to manage urban floods. It is difficult to mitigate flood damage through mere river improvement as the land necessary for the improvement works is difficult to acquire due to the high density of houses. The RMOs should collaborate with other related departments and agencies for the execution of hard and soft measures in urban areas, such as the construction of flood regulation ponds and infiltration facilities, and the development of warning and evacuation systems (Figure 2.21). The establishment of water governance is important in collaboration with a wide range of institutions and CSOs. Governments could effectively implement flood protection facilities in cooperation with the private sector. For example, the Myoshoji River in Tokyo introduced the construction of parks and pilot-type housing complexes above the flood regulation pond to effectively use expensive lands.



Source: Tsurumi River Multi-Purpose Recreation Area Brochure, Tsurumi River Management Office, MLIT, Photo: River channel training "Key points for river development in Tsurumi River", Tsurumi River Management Office MLIT

Figure 2.21 Integrated Flood Protection Measures in the Basin

Green infrastructure has a variety of functions in urban areas. River improvement projects using green infrastructure not only mitigate flood damage, but also enhance habitat, reduce costs, and provide recreational spaces. An adjacent elementary school conducts an environmental learning program with a group of citizens in the Kamisaigo River in Fukuoka Prefecture (Figure 2.22). Improving the work in urban rivers contributed to the regional economy and tourism in Osaka (Figure 2.23).

Source: Fukutsu City

Figure 2.22 Green infrastructure, Kamisaigo River, Fukuoka Prefecture

Source: Japan Riverfront Research Center

Figure 2.23 Urban Development Integrated with the River Space, Doutonbori River

2.9 Management of River Water and Land

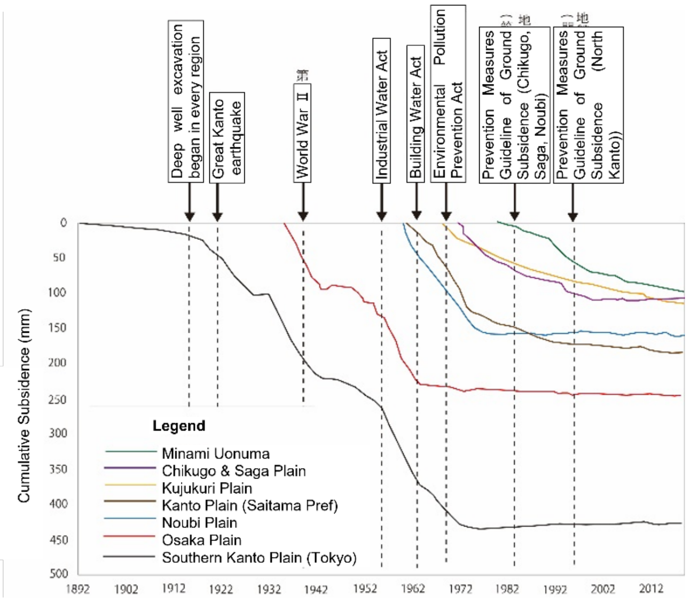
The national government has established a legal system and organization to properly maintain and manage river water and land. In Japan, the RMOs define river areas and manage land, including privately owned land and water on the river. The RMOs located on the sites promote water management by permitting the occupation of land, collection of river materials, construction of structures, excavation of land, floating down bamboos, and navigation through locks. Penalties are imposed on illegal river-use activities.

Collaboration with the local communities is essential for river management. The RMOs collaborate with CSOs in activities such as river cleaning campaigns, environmental and disaster management education on rivers, and surveys and research on river environments.

The national government has established a management system for rivers and river structures. During a flood event, the RMOs patrol rivers and facilities and operate dams and gates. The RMOs announce flood forecasts and notify relevant organizations of flood information. The RMOs also support the flood-fighting activities of local communities. The RMOs should regularly conduct patrols of the river facilities, weeding, removal of obstacles, visual inspection, and operation checks of gates at normal times.

2.10 Management of Groundwater

Excessive extraction of groundwater lowers the groundwater level, resulting in land subsidence, structural damage, flood damage, and saltwater contamination of the groundwater. Land subsidence is an irreversible phenomenon resulting from the consolidation of underground clay layers due to the drainage of water contained in the clay layers. In Japan, river water has been used for irrigation purposes for a long time. An increased demand for water for domestic and industrial purposes encourages the use of groundwater. Large volumes of groundwater were extracted for domestic and industrial uses owing to the increase in population and industrial production. The most severe land subsidence occurred in major cities such as Osaka and Tokyo, with some areas sinking more than 20 cm in a year, reaching a cumulative total of more than 5 m (Figure 2.24).



Source: Overview of Land Subsidence in Japan in 2019, Ministry of the Environment, Water and Air Environment Bureau (2019 March)

Figure 2.24 Changes in Land Subsidence at Representative Sites

For sustainable management of groundwater, extraction should be regulated, and alternative water sources need to be developed. The national government established legislation to regulate groundwater use. Local governments formulated their ordinances. An industrial water supply system was established by developing alternative water sources for surface water shifting from groundwater.

The conservation and management of groundwater are realized by considering regional characteristics. The sustainable management of groundwater requires the accumulation of observed data. Kumamoto City, with a population of over 700,000, relies on domestic groundwater. Local governments, companies, and residents work together to conserve groundwater based on observations and research.

Groundwater quality management prevents harmful substances from infiltrating into the ground. Groundwater contamination is quite difficult to remove. Therefore, underground water quality standards should be established. Regular monitoring based on standards is performed. If anomalous values are observed, people should be warned of groundwater use, and contamination in wells should be investigated.

2.11 Dam-Safety Management and Operation

Because dam failure would cause damage to the downstream areas, strict dam construction and safety management processes are essential. The national government has developed policies, established organizations for safety management, and carried out human resource development. The dam operator obtains approval for the project from the supervising authority and permission for construction from the MLIT. Approval is required at each stage, such as the planning, design, completion of construction, and formulation of operating rules.

Dam discharge during flooding should be determined by considering the safety of downstream areas. The maximum dam discharge should be set as no damage to the downstream area, which is called "harmless discharge". Dam discharges should not cause a sudden rise in the water level on the downstream reaches to allow people to evacuate from inside the river area. In Japan, the guide for the rising limit in the water level is set at 30 cm in 30 min due to dam discharge. Before releasing the dam discharge, the dam office notifies residents and recreational users of safety issues in the river area via speakers and patrols. The dam office records hydrological observation and operation data and reports them to the RMO.

The dam discharge should always be released within the flood inflow to the reservoir. If the reservoir is expected to be unable to store any further water, then the dam discharge should be equal to the flood inflow. Because an accurate estimate of the inflow flood is difficult, it is important to improve the rainfall and water level observations of the tributaries upstream of the dam reservoir.

Dams for water supply may also be used for flood protection by improving the operation rules. Because rainfall can be predicted more precisely owing to advanced technology, the dam office can release the water stored in the reservoir for irrigation, urban area use, or hydropower, to create the capacity for flood protection before flooding. The government should make agreements with water users to create a reservoir capacity for flood protection through pre-release. The government should compensate these water users if the reservoir capacity does not recover to the normal level after the pre-release owing to less rainfall than the forecast.

The national government should support to reinforce the aged irrigation ponds (Figure 2.25). Once the irrigation ponds collapsed, the downstream area experienced significant damage. Japan has approximately 210,000 irrigation ponds. Approximately 75% of these buildings were built more than 150 years ago. Due to the aging population in the farmland, the farmers' associations weakened. The national government enacted an act for a financial subsidy system for pond reinforcement.

Source: Causes of the Break of Fujinuma Dam, Emergency debriefing one month after the great east Japan Earthquake by Tohoku University

Figure 2.25 Failure of the Fujinuma Dam

Integrated operation of multiple dams within the same river basin may achieve efficient water resources management. The integrated operation coordinates the water supply, considering the dam location, reservoir capacity, and characteristics within the river basin. For example, the Tone River Dams Integrated Management Office conducts operations commanding nine dams in the Tone River System (basin area: 16,400 km^2) to supply water to the Tokyo Metropolitan Area. Water supply priority is given to dam reservoirs that have a larger basin area than the reservoir capacity. This means that these dams may recover reservoir water faster once they are emptied.

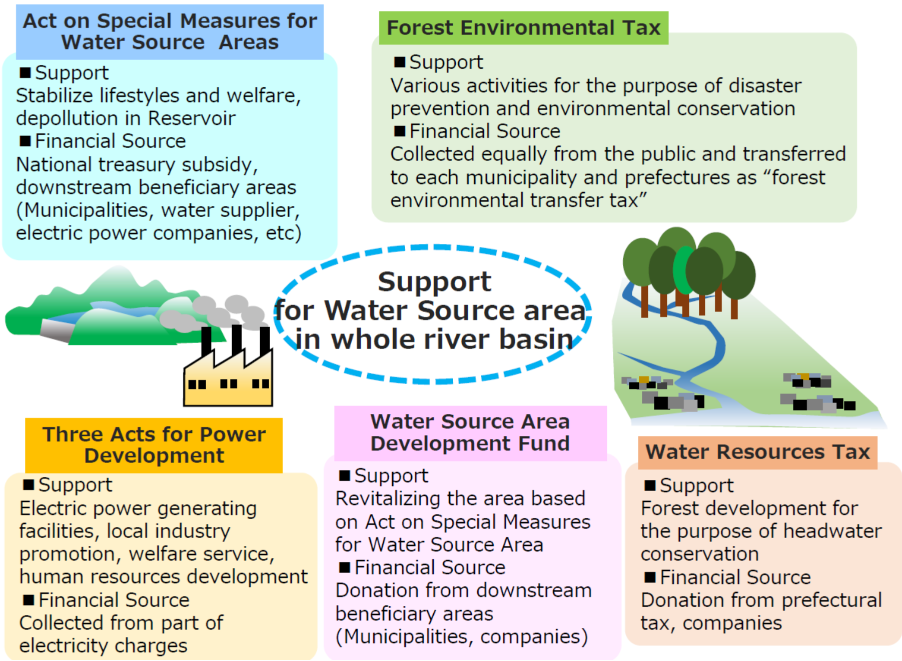
Advanced technologies can be effectively utilized in existing dam facilities. In Japan, dams are enhanced by increasing the reservoir capacity with dam crest raising (Figure 2.26), increasing the dam discharge capacity with additional facilities, installing hydropower equipment, and adding sediment discharge facilities.

Source: Sapporo Development and Construction Office, Hokkaido Regional Development Bureau

Figure 2. 26 Cross-section of the Body of the Shin-Katsurazawa Dam Photograph of Construction Works

2.12 Environmental and Social Considerations of Large-Scale Projects

The government should support the rebuilding of local communities submerged by large-scale projects to avoid fracturing or disappearing (Figure 2.27). The system, including financial resources, is established so that relocated residents and water source areas can become beneficiaries of the project. Essentially, water resources development projects improve people's lives; however, they also have negative effects on some communities and ecosystems. Therefore, it is necessary to rebuild submerged communities and mitigate environmental damage. In Japan, legislation stipulates financial support for public projects, such as roads, water supply, sewerage systems, and housing development, as well as tax reductions for relocated residents. The Water Source Area Development Fund was created to support livelihood reconstruction and regional development that the public works budget could not cover. Contribution of the downstream local governments and of other entities that receive the benefits of dam financing is added to this fund. This fund is used to support the revitalization of water source areas and the development of human resources, tourism programs, and sales channels for local products. In the upstream and downstream exchange projects, residents of the downstream area visit the water source area and deepen their friendships through cleaning activities and sports exchanges (Figure 2.28). In 2001, the government introduced a water resources tax as a local tax to finance the conservation of forests and a stable supply of quality water in the water source area.



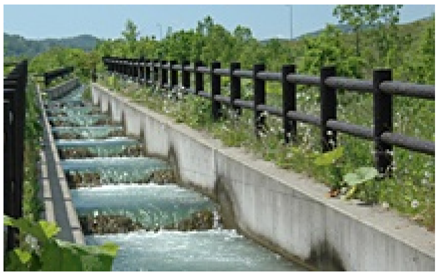
Source: Preparation by Project Research Team

Figure 2.27 Support for Water Source Areas in the River Basin

Source: The Tone River Dams Integrated Management Office website

Figure 2. 28 Activity of Environmental Conservation with Residents in the Water Source Area of the Tone River

Environmental impact assessments are conducted in large-scale projects and various environmental measures are implemented to avoid or mitigate adverse impacts. Water resources development facilities have a significant impact on the natural environment because they are artificially stored in naturally circulating water and block the circulation of materials. In Japan, the measures cover: (1) ecosystem conservation through biotopes and fish ladders (Figure 2.29), (2) reduction of the impact of water release against cold water and eutrophication, and (3) forestation in water source areas.



Note: By installing an overflow bulkhead with a notch in a staircase pattern at the part where the height difference is large, the fish can run upstream with stops along the way.

Source: Website of Hakodate Development and Construction Department, Hokkaido Regional Development Bureau, MLIT

Figure 2.29 Fish Ladder of the Pirika Dam

2.13 Human Resources Development and Technology Development

In the Meiji era, the Japanese government promoted technological learning by inviting foreign engineers. Engineers who returned to Japan after studying abroad took the initiative in public works and trained their successors during the Meiji era. Currently, the university-enrolling ratio is 49%, and universities supply civil engineering graduates to society. On-the-job training is the basis for human resource development. Off-the-job training includes training, participation in lectures and seminars, the acquisition of technical qualifications, and academic society activities.

The national government should develop and disseminate this technology. National research institutes and associated organizations conduct a wide range of research and publish research output. They are also used to prepare various guidelines and manuals.

Mechanisms should be established to utilize the technologies developed by private companies. Government agencies request private companies to submit technical proposals/bids for public works. These are comprehensive bid evaluations from the viewpoint of quality assurance. Each company conducts its research and development. The MLIT promotes technology development by companies through public invitations to perform research and development in the river as well as implementation of innovative management.