THEME 5 URBAN WATER MANAGEMENT: INTEGRATING APPROACHES TO RESOLVE COMPLEX ISSUES

ABSTRACT

Population concentration in urban areas, expansion of urban areas, and growth in socioeconomic activities lead to a deteriorating water cycle that affects the water environment. The ground surfaces covered with asphalt and concrete reduce the water retention capacity and infiltration into the ground. The accumulation of assets and buildings in urban areas has led to increased damage from floods and droughts. Furthermore, the negative effect of climate change on rainfall patterns has increased the severity of floods and droughts.

Structural measures alone are not sufficient to resolve these complicated issues, and cooperation from multiple areas is necessary. Thus, local governments should formulate urban planning considering disaster risks and enhance soft measures, such as regulating development activities, managing water demand, recycling water, and improving the response to disasters. Additionally, green infrastructure may produce multiple benefits, including protecting against floods, improving the environment, and creating habits. Furthermore, problems regarding the urban poor in river areas may be resolved by jointly implementing river works and housing programs. These measures can be implemented through collaborative governance with diverse organizations. While Japan has continued these efforts, it is still struggling to resolve the complicated issues brought forth by climate change.

CHAPTER 1 INTRODUCTION

> Flood damage, tight water supply, and environment deterioration exacerbated by urbanization may be resolved by strengthening governance among various related organizations and stakeholders and by implementing hard and soft measures.

Rapid population growth and economic activities may cause water-related problems in urban areas. Existing water facilities may be unable to fully supply the increased water demand, resulting in low-quality water. Land subsidence incurred by over-extraction of groundwater may also worsen flooding and inundation damage (Theme 7: Groundwater Management). The expansion of ground surfaces covered by asphalt and concrete may increase the runoff, resulting in increased flood damage. Additionally, wastewater deteriorates the water quality. However, it may be challenging to achieve the required coordination among ministries, government agencies, and local governments involved in resolving these issues. This theme describes the approaches of collaborative measures by multiple organizations in Japan.

Water resources management is closely related to the Sustainable Development Goals (SDGs), and the relationships between urban water management and the SDGs are shown in the following box.

Relationships between Urban Water Management and the SDGs:

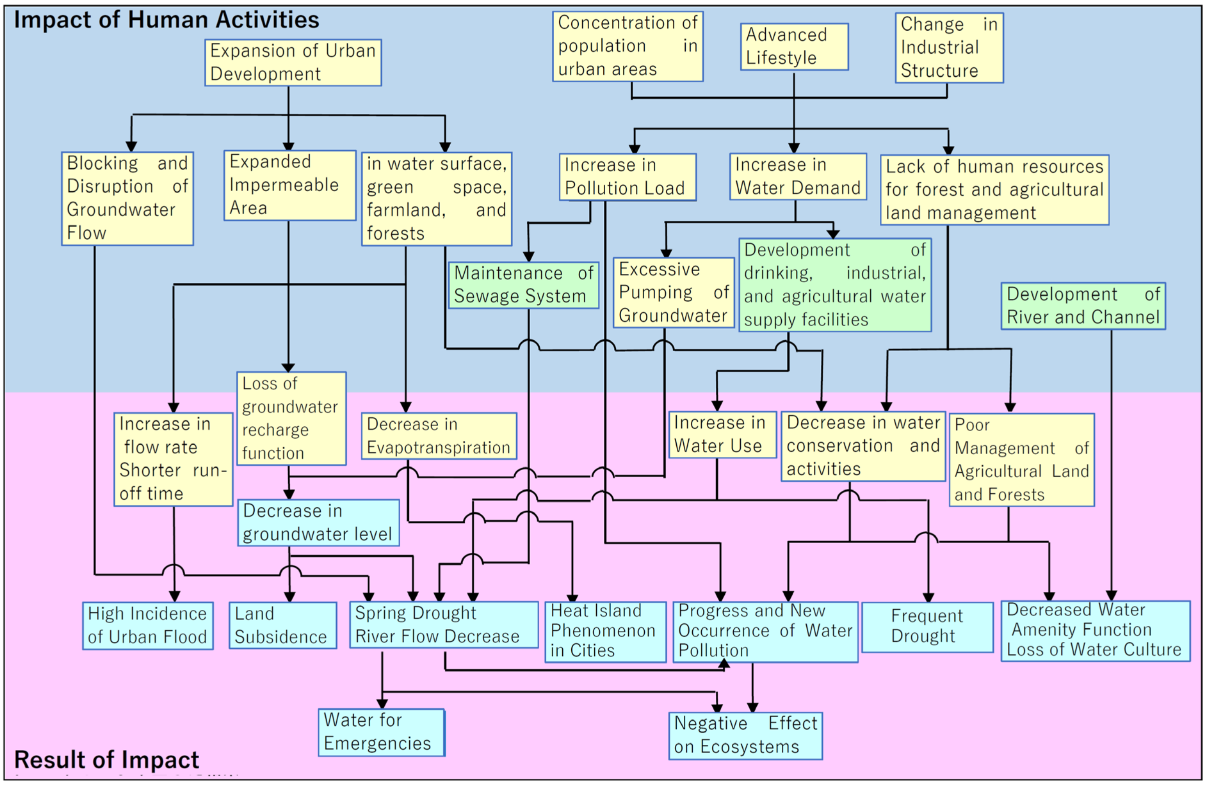
(1) Implementation of the drought and flood protection measures in urban water management is related to the following goals:

SDG6 “Water and Sanitation”: 6.a “Expand international cooperation and capacity-building support in water- and sanitation-related activities and programmes”
SDG11 “Sustainable Cities and Communities”: 11.5 “Significantly reduce the number of deaths and the number of people affected by disasters, including water-related disasters”
SDG13 “Climate Action”: 13.1 “Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters”
SDG17 “Partnership”: 17.17 “Encourage and promote effective public, public-private, and civil society partnerships, building on the experience and resourcing strategies of partnerships”

CHAPTER 2 WATER CYCLE IN URBAN AREAS

> Urbanization causes various adverse effects on the water cycle system in urban area, particularly water utilization, flood protection, and water environment. Rather than addressing each of these effects individually, a more comprehensive approach should be undertaken to restore the water cycle.

The state of the water cycle is influenced by climatic conditions, the natural characteristics of the basin (e.g., topographical and geological conditions), and various human activities in urban areas. Changes in land use, population influx into urban areas, and changes in industrial structure affect the quantity and quality of water in urban areas (Figure 2.1). Because issues related to water resources are interrelated, measures to address them should have multiple benefits. Table 2.1 and Figure 2.2 show how the measures are related to flood protection, water utilization, and environmental conservation. Urban development that combines the restoration of the water cycle with the development of urban areas is being carried out in Japan. As an example, Figure 2.3 shows the development of the Hachioji Minamino City.



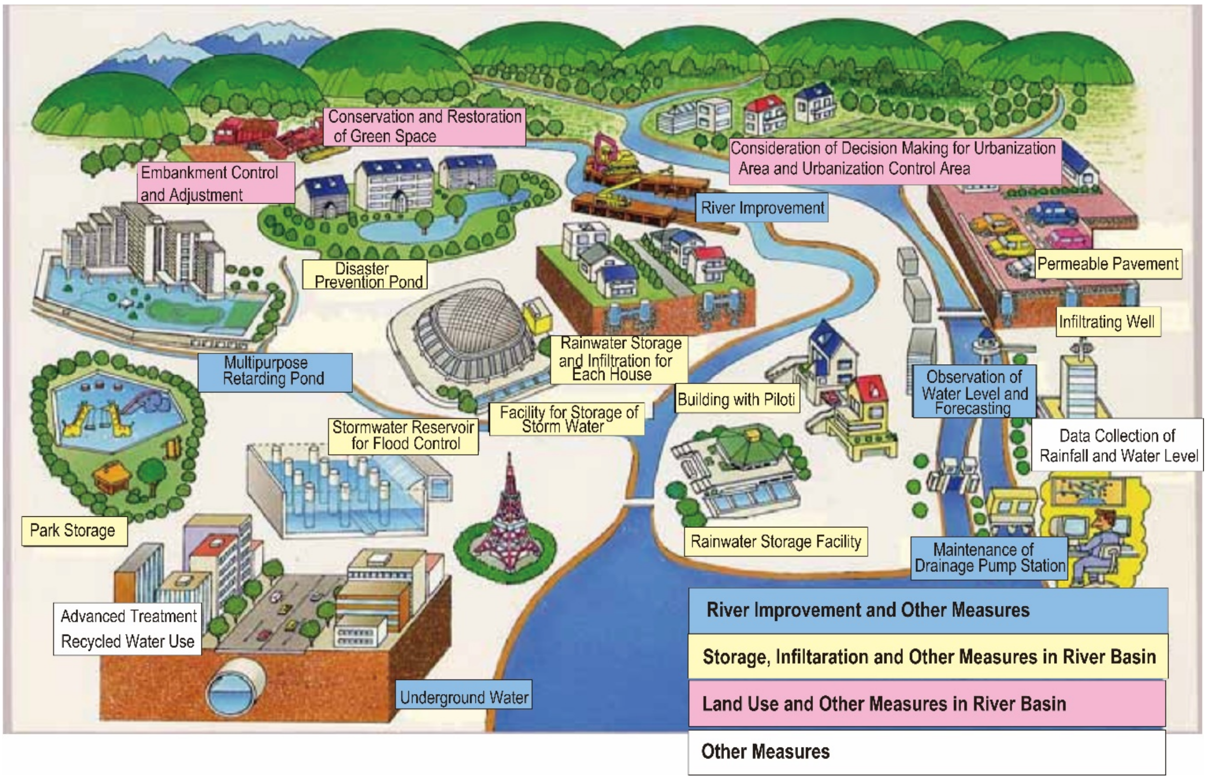
Source: "Toward the Creation of a Sound Water Cycle System." Liaison meeting of related ministries and agencies regarding the development of a healthy water environment, October 2003.

Figure 2.1 Impacts of Human Activities on the Water Cycle

Table 2.1 Measures Related to Water Utilization, Flood Protection, and Environmental Conservation 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: ◎ Highly effective measure, ○ Effective measure, △ Low effect
Source: Preparation by Project Research Team

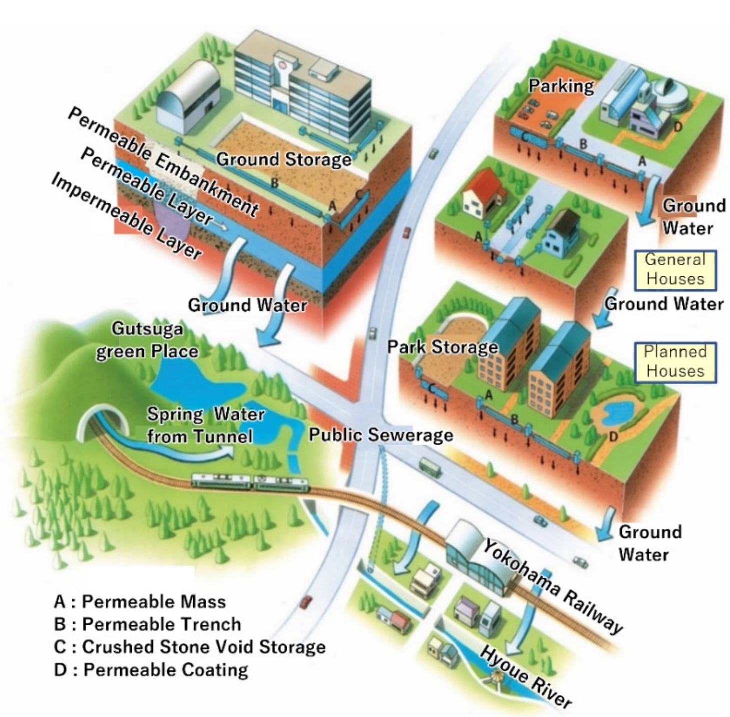


Source: MLIT Website

Figure 2.2 Image of Measures for Urban River Basin

Hachioji Minamino City

Hachioji Minamino City is minimizing the impact of development on groundwater and river flow, and maximizing the conservation of topography, flora, and fauna. One way to achieve this is by creating an "environmentally symbiotic city." The city restores and maintains a river system by installing rainwater storage facilities in schoolyards, adopting permeable pavements, and improving rainwater infiltration basins. The flow in the Hyoue River is restored and the volume of storm water runoff is reduced. The peak discharge during flood seasons in the Hyoue River reduced by 20–40% (maximum 50 m^3/s) and the discharge during drought seasons increased by 150% to 200%.



Source: UR x Green Infrastructure Case Studies UR Agency

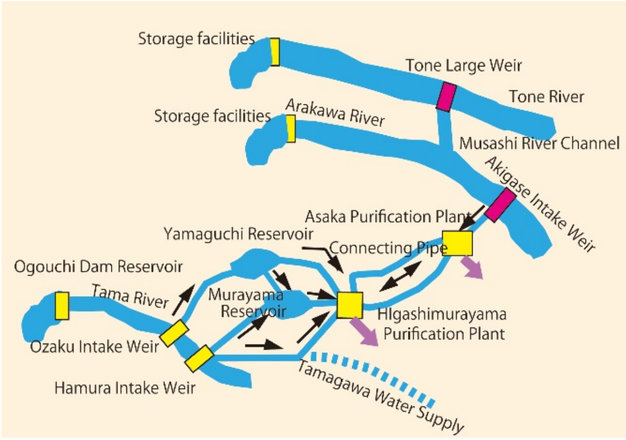
Figure 2.3 Hachioji Minamino City Water Cycle Regeneration System

CHAPTER 3 WATER UTILIZATION EFFORTS

To secure stable water supply, soft measures are implemented.

3.1 Managing Water Demand

Water resources were developed to secure a stable supply in the Tokyo metropolitan area. Governments constructed dams on the Tone, Arakawa, and Tama River systems to utilize multiple water sources efficiently (Figure 3.1) (Theme 1-1: Legislation and Organization, Chapter 2). The following initiatives are being implemented to manage water demand:

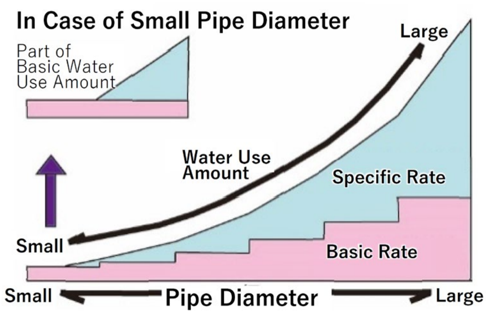


Source: Figure prepared by Tokyo Metropolitan Government Bureau of Waterworks with the addition of the Project Research Team

Figure 3.1 Wide-Area Water Resources Utilization

(1) Tariff System

The local government has introduced a gradual increase-type tariff system to encourage water users to reduce the amount of water used. There are two types of tariff system, one is unit rate increases depending on the amount of water used and the other is a two-part tariff system (Figure 3.2) comprising basic and specific rates. Basic service rates up to a certain amount are applied for low water usage from the public health perspective.

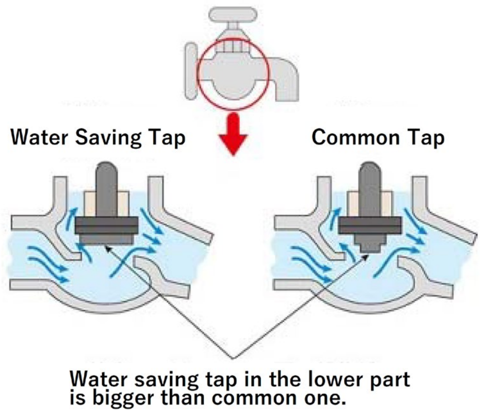


Source: Project Research Team

Figure 3.2 Two-part Tariff System

(2) Saving Water Use

The water discharge is reduced at large openings by installing water-saving taps (Figure 3.3). Various awareness-raising activities are being conducted to promote water conservation.



Source: Tokyo Metropolitan Government, Bureau of Waterworks

Figure 3.3 Water Saving Tap

i) Public Relations Activities: Kumamoto City established the “WakuWaku (Exciting) Water Saving Club” to promote water conservation through community collaboration. The mascot character “Sessui-chan” requests residents to save water (Figure 3.4).

ii) Water Day: August 1 was designated as Water Day to deepen the understanding of, and interest in, precious water resources and healthy water cycles. Local governments and related organizations collaborate to execute nationwide awareness campaigns.

iii) Water Saving Campaigns: Government organizations are conducting water-saving campaigns such as calling for water conservation on the radio and Internet.

iv) Mizu-iku (Water Education): Private companies host Mizu-iku, a program for the youth who would lead the next generation. The program encourages children to experience the wonders of nature, understand the importance of water and growing water, and then consider their role in water conservation.

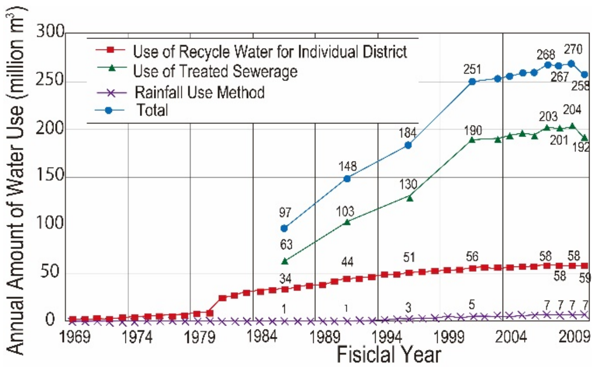
v) Ecolabeling System: The Japanese Environmental Association started an ecolabeling system in 1989. Ecolabeling is the only environmental label in Japan in accordance with ISO14024 Environmental labels and declarations. Water-saving equipment, such as water-saving toilets and taps, are certified through this system.

Source: Kumamoto City

Figure 3.4 Mascot for Water Saving

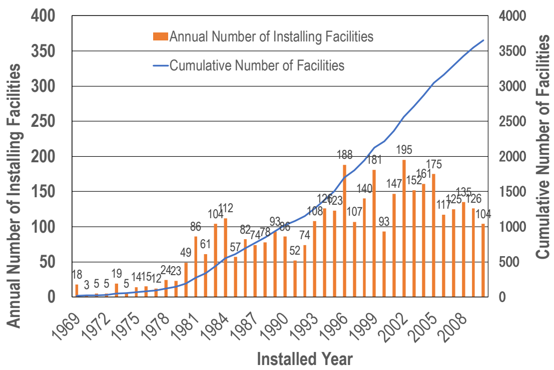
(3) Usage of Rain and Wastewater

Rainwater, recycled water, and treated sewage water were used in buildings and districts. The use of rainwater and recycled water in Japan began in the mid-1980s in areas where the water supply was limited. Figures 3.5 and 3.6 show the annual volume of water used and the number of facilities, respectively.



Note: MLIT Water Resources Department (end of 2010)
Totals may not match due to rounding.
Source： Water Resources in Japan (2013), MLIT

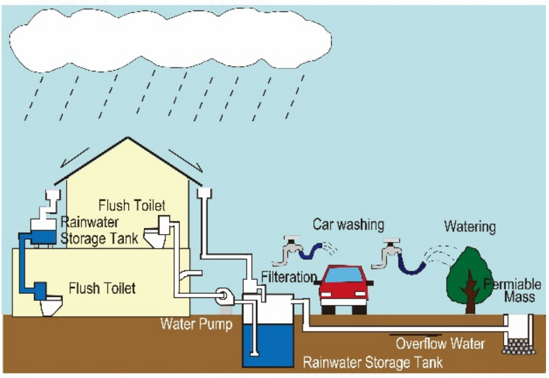
Figure 3.5 Trends in Rainwater and Recycled Water Use



Note MLIT Water Resources Department (end of 2010)

Figure 3.6 Changes in Rainwater and Recycled Water Use Facilities

1) Rainwater use: The use of rainwater promotes the effective use of water resources and contributes to controlling the outflow of rainwater into sewerage and rivers. The Act for the Promotion of Rainwater Use was enacted in 2014. Rainwater harvesting, in which rainwater is collected on the roofs of buildings and stored in tanks to be used for watering trees and flushing in toilets, is performed at individual, local, and national levels (Figure 3.7). The Ryogoku Kokugikan Sumo Stadium constructed in the 1980s has a rainwater tank that stores 1,000 m^3 of rainwater in the basement and is used for toilets, air conditioning, and sprinkling.

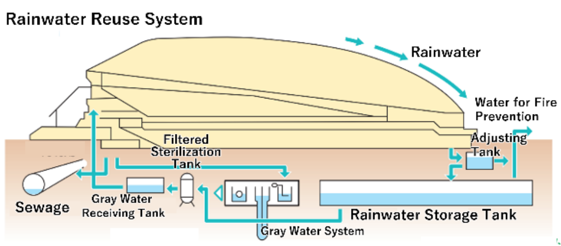


Source: Sumida Ward Website

Figure 3.7 Rainwater Reuse

Rainwater Use at Tokyo Dome

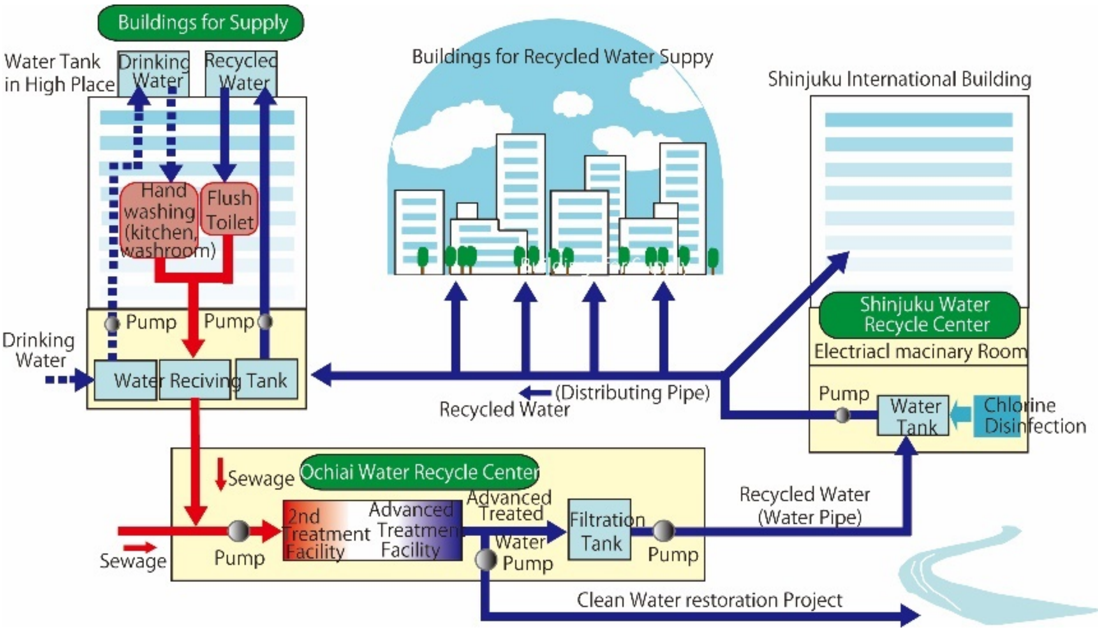
Tokyo Dome is an all-weather multipurpose stadium operating for professional baseball games, sports, and concerts since 1988. (Figure 3.8). The underground rainwater storage tank of 3,000 m^3 in the Dome stores the rainwater harvested on the roof and conveyed by the drainage system. This water is then utilized for flushing toilets and firefighting. Rainwater comprises approximately 30% of the recycled water in the Dome. The rainwater use has contributed to saving water on a large scale, including annual reduction of about 68,000 m^3 in 2007.



Source: Rainwater Use Case Studies, MLIT
Photograph and figures are provided by Tokyo Dome Corporation

Figure 3.8 Rainwater Use in Tokyo Dome

2) Recycled water: Wastewater treated with advanced treatment can be used for flushing toilets, washing cars, and cleaning drainage in buildings and areas. There are three circulation patterns: i) recycled water within the building, ii) regional circulation jointly operated by the building in small but cohesive areas, and iii) recycled water for business facilities and houses covering a large area (Figure 3.9).



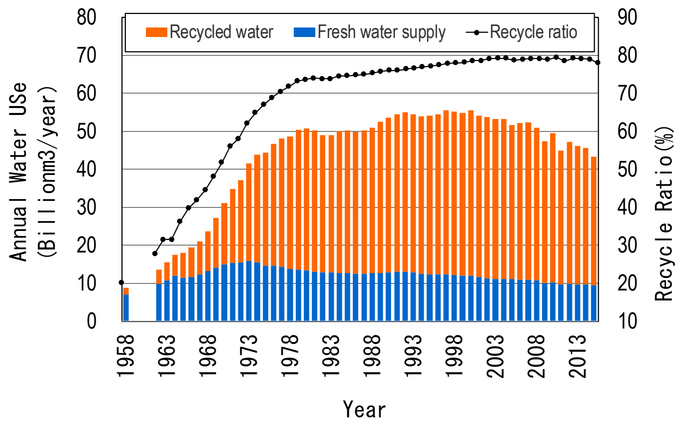
Source: Website of Tokyo Metropolitan Government Bureau of Sewerage

Figure 3.9　Recycled Water Supply System (Nishi-Shinjuku and Nakano-Sakaue Area)

3) Use of treated sewage water: Advanced treatment of sewage water allows it to be used in the same way as recycled water. The reuse ratio of treated sewage water was approximately 1.2% in fiscal year (FY) 2016 in Japan.

(4) Recycle of Industrial Water

Measures to control industrial water include 1) changing the water fee system, 2) increasing the recycling ratio, and 3) reusing wastewater. Until around 1980, the recycling ratio of industrial water increased to curb the water demand. The amount of recycled water exceeded that of the fresh water supply in 1970. In 2015, the recycling ratio was approximately 77.9% (Figure 3.10).



Note: Data of water use of business establishments with 30 or more employees excluding water used in public services
Source: Statistics from the Ministry of Economy, Trade and Industry

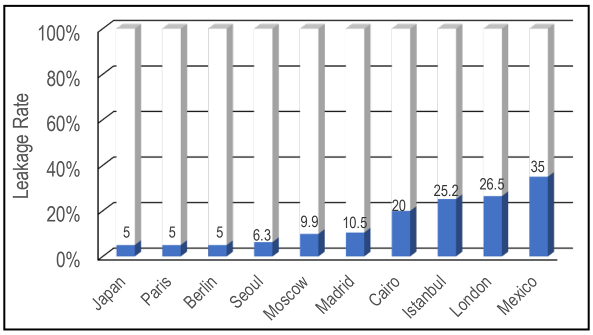
Figure 3.10　Changes in Industrial Water Usage

3.2 Improvement in Leakage in Water Supply

The effects of prevention of water leakage have similar impacts with the development of water sources. In some developing countries, the leakage rate in major cities is high. Figure 3.11 shows the leakage rates of major cities worldwide. Figure 3.12 shows the non-revenue water rate[1] in developing countries.

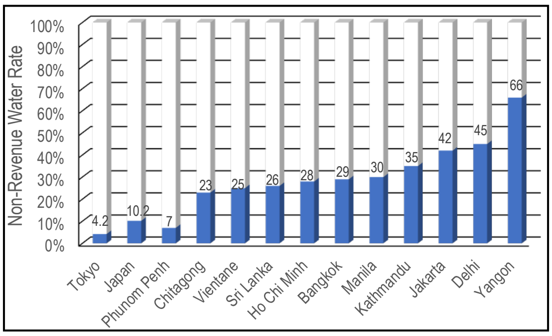
[1] Non-revenue water refers to water that cannot be collected due to leakage or theft from pipes, and since there is little data on only leakage in developing countries, the non-revenue water rate is shown here.

The leakage ratio in Japan was 26.8% in 1965 but improved to 7.2% in 2009. In Tokyo, the ratio improved from about 20–30% in the 1950s to 3% by 2008 (Figure 3.13). Leakage can be prevented by setting goals and formulating a comprehensive plan (Table 3.1).



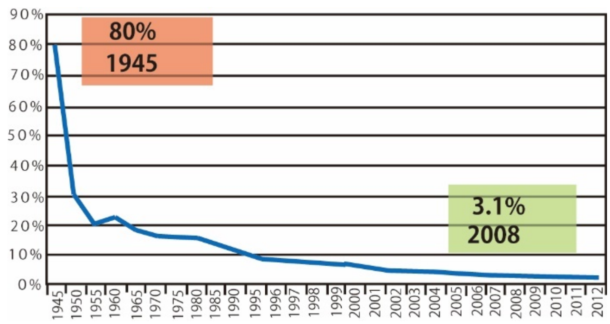
Source: Japan's Approach to Global Water Problems (2012), House of Representatives Research Office, Legislation and Survey No. 332
Statistics of Tokyo (2013), Tokyo Metropolitan Government Website

Figure 3.11 Leakage Rates of Major Cities in the World



Source: Tokyo, Japan: Water Research Center (Public Interest Incorporated Foundation), Water Services Hot News No. 543, December 16, 2016
Others: Research on International Comparison of Water Services, Japan Water Research Center, 2018

Figure 3.12 Comparison of Non-Revenue Water Ratio in Cities in Japan and Developing Countries



Source: Japan's Experience on Water Supply Projects, JICA

Figure 3.13 Changes in Water Leakage Ratio in Tokyo

Table 3.1 Leakage Prevention Measures

Measures	Item	Details
Basic Measures	Preparation	Establishment of construction system and maintenance of document and equipment
	Basic survey	Evaluation of the amount of water distributed and leaked, and water pressure
	Technology development	Improvement of pipes and equipment and development of methods to detect and measurement leaks
Symptomatic Measures	Flexible works	Immediate repair of leaks in ground
	Planned works	Detection and repair of leaks at an early stage
Protective Measures	Improvement of water distribution and water supply pipes	Replacement of pipes, maintenance of water supply pipes, prevention of pipe corrosion
	Water pressure adjustment	Maintenance of pipelines, establishment of block distribution system, measurements of water pressure
	Understanding the pipeline condition	Evaluation of pipelines through data collection and analysis

Source: Water Services Maintenance Guidelines, Japan Water Works Association 2006

3.3 Desalination

The desalination of seawater has become a technically and financially viable option to supplement conventional water resources in regions with scarce water resources. Approximately 20,000 desalination plants exist worldwide, with a total production capacity exceeding 100 million m^3/day. Approximately 7,000 plants are used for domestic water supply, with a total capacity of about 70 million m^3/day. There are 682 desalination plants in Japan, with a total capacity of 768,400 m^3/day (8.9 m^3/sec). A total of 463 plants (approximately 60%) were for industrial use, while 219 were for domestic use, mainly on small islands. The total production capacity of the latter plants was 285,600 m^3/day (3.3 m^3/sec). Table 3.2 shows large-scale seawater desalination plants in Japan. Table 3.3 shows the advantages and issues of desalination.

There are two key desalination methods: evaporation and membrane desalination. More plants used the membrane process than before because development of membrane technology is significant in (Table 3.4). In terms of cost, the construction cost of a facility with a capacity of 10,000 m^3/day or more was 100,000–200,000 Japanese yen/m^3/day. The water production cost was 100–150 Japanese yen/m^3.

Approximately 40–45% of the water taken from the sea is processed to freshwater, and the remaining 55–60% is left as concentrated saltwater and returned to the sea. Water quality standards were determined to secure evaporation residue[2] of 500 mg/L or less based on the guidelines of the World Health Organization (WHO).

Table 3.2 Large-scale Seawater Desalination Plants in Japan

Facility	Operation Start	Use	System	Production Capacity	Construction Cost
Chatan Water Treatment Administration Office, Okinawa	April 1997	Water Supply	Reverse Osmosis	40,000 m^3 /day	34.7 billion yen
Uminonakamichi Nata Sea Water Desalination Center, Fukuoka	September 2005	Water Supply	Reverse Osmosis	50,000 m^3 /day	40.8 billion yen

Source: Project Research Team

Table 3.3 Advantages and Issues of Desalination

Advantages	Issues
• Issues related to water rights are unlikely to occur. The period from planning to completion is short. • Water can be secured, regardless of drought and climate change. • Construction cost may be lower than that of conventional water supply facilities, in which freshwater is conveyed from distant dams or rivers.	• High cost for both construction and operation and maintenance. • High energy consumption. • Impact on the ecosystem due to the release of concentrated salt water.

Note: When comparing the construction costs, the desalination plant project cost includes only the construction of the plant, whereas the cost of the conventional water supply project includes the construction cost of the water source (e.g., dam), water supply facilities, water purification facilities, and water transmission facilities. If the costs of desalination plants and water purification facilities are simply compared, those of desalination plants are more expensive.
Source: Project Research Team

[2] Evaporation Residue: The total amount of suspended or dissolved material obtained as residue when water containing the material is dried by mean of evaporation. The main components of the evaporation residue in tap water are salts, such as calcium, magnesium, silica, sodium, and potassium, and organic matter. This value is determined to ensure taste since water with excessive values tastes bitter.

Table 3.4 Key Desalination Methods

Process	Method	Description	Application
Evaporation	Multi-stage flash distillation, Multiple effect distillation	Evaporate saline water to remove salt.	Almost limited to the Middle East, where energy cost is inexpensive.
Membrane	Reverse osmosis	Seawater and freshwater separated by semipermeable membrane, and freshwater moves to the seawater side (osmosis phenomenon). Reverse osmosis occurs by applying pressure that exceeds the osmotic pressure on the seawater. Water on the seawater side then moves to the freshwater side.	Highly energy-efficient and currently the most widespread method. Energy consumption has been reduced to less than one-third over the last 20 years.

Source: Project Research Team

CHAPTER 4 FLOOD PROTECTION EFFORTS

4.1 Implementation of Comprehensive Flood Protection

> Urban flood damages increase due to the increase in flood discharge and the concentration of assets by urbanization. In addition to river improvement, basin-wide measures are necessary for flood protection, while cooperation among stakeholders is crucial to implement measures.

(1) Increase in Urban Flood Damages

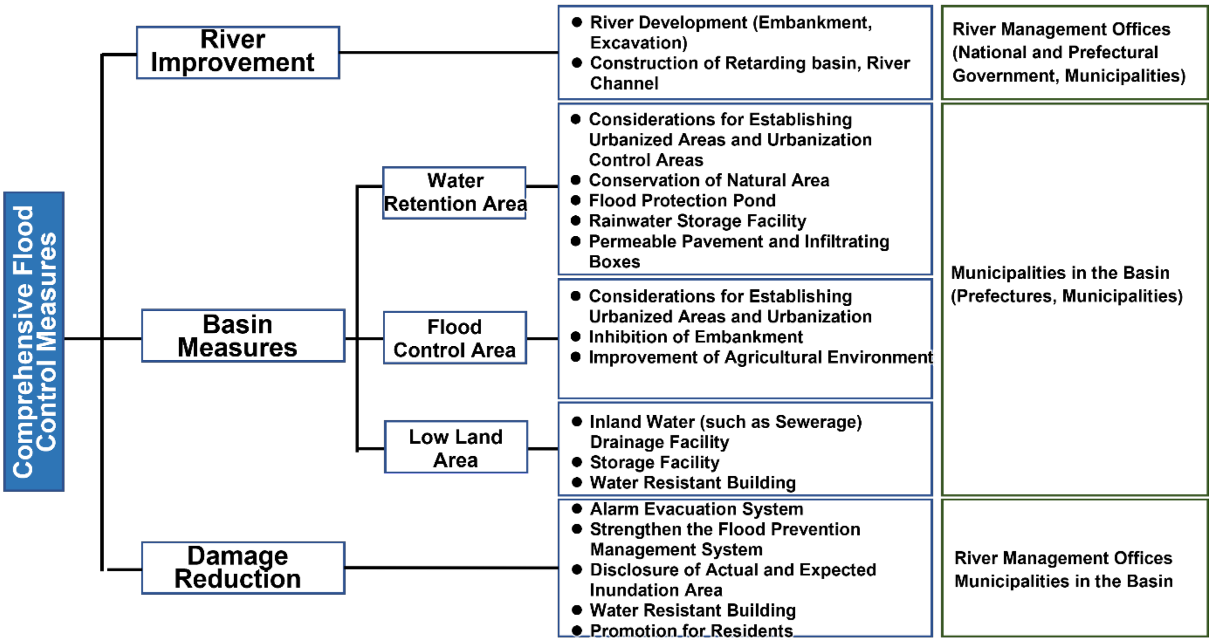
Governments should consider flood risks to promote urban development. However, urban planning proceeded without considering flood risks enough during high economic growth in Japan. Surface runoff increased because of urbanization, which deprived the runoff retarding function. Urbanization increases flood risk by concentrating on population and assets. Thus, urbanization has increased flood damage and made urban flooding a social problem. While population growth began to subside and urban development pressure decreased, the damage potential continued to increase and land use developed more intensively. Even currently, flooding occurs because of the small capacity of the drainage system. The total amount of flood damage in Tokyo over the past decade was approximately 17.6 billion Japanese yen due to floods from rivers and 42.9 billion Japanese yen due to floods from urban floods, corresponding to 71% of the total damage.

(2) Comprehensive Flood Protection Measures

Comprehensive flood protection measures address flooding throughout the basin. The government started the Promotion of Comprehensive Flood Protection Measures in 1980, targeting 17 urban rivers. The structure of this policy is illustrated in Figure 4.1. While conventional flood protection depends only on the improvement of rivers, comprehensive flood protection integrates measures for river improvement, basins, and flood damage reduction.

As the involvement of various agencies is essential, proper governance must be established. It is also crucial to coordinate the development of flood protection measures with basin development and land use planning. A basin countermeasure council was established to coordinate the related organizations. The council consists of the Regional Bureau of the MLIT, prefectural and municipal departments overseeing rivers, and other related departments, such as urban housing and land.

The council discusses specific measures for basin planning and formulates the river basin development plan. It divides responsibilities by dividing the flood discharge into the river portion to be handled by river management offices (RMOs) and the basin portion by various parties managing sewerage, land use, stormwater detention ponds, and permeable pavements. The Tokyo Metropolitan Government established its own council chaired by the Director of Urban Infrastructure Development, comprising the relevant bureaus and municipalities of Tokyo.



Source: Materials for Committee for Program Evaluation of Comprehensive Flood Protection Measures, MLIT, 28 August 2003

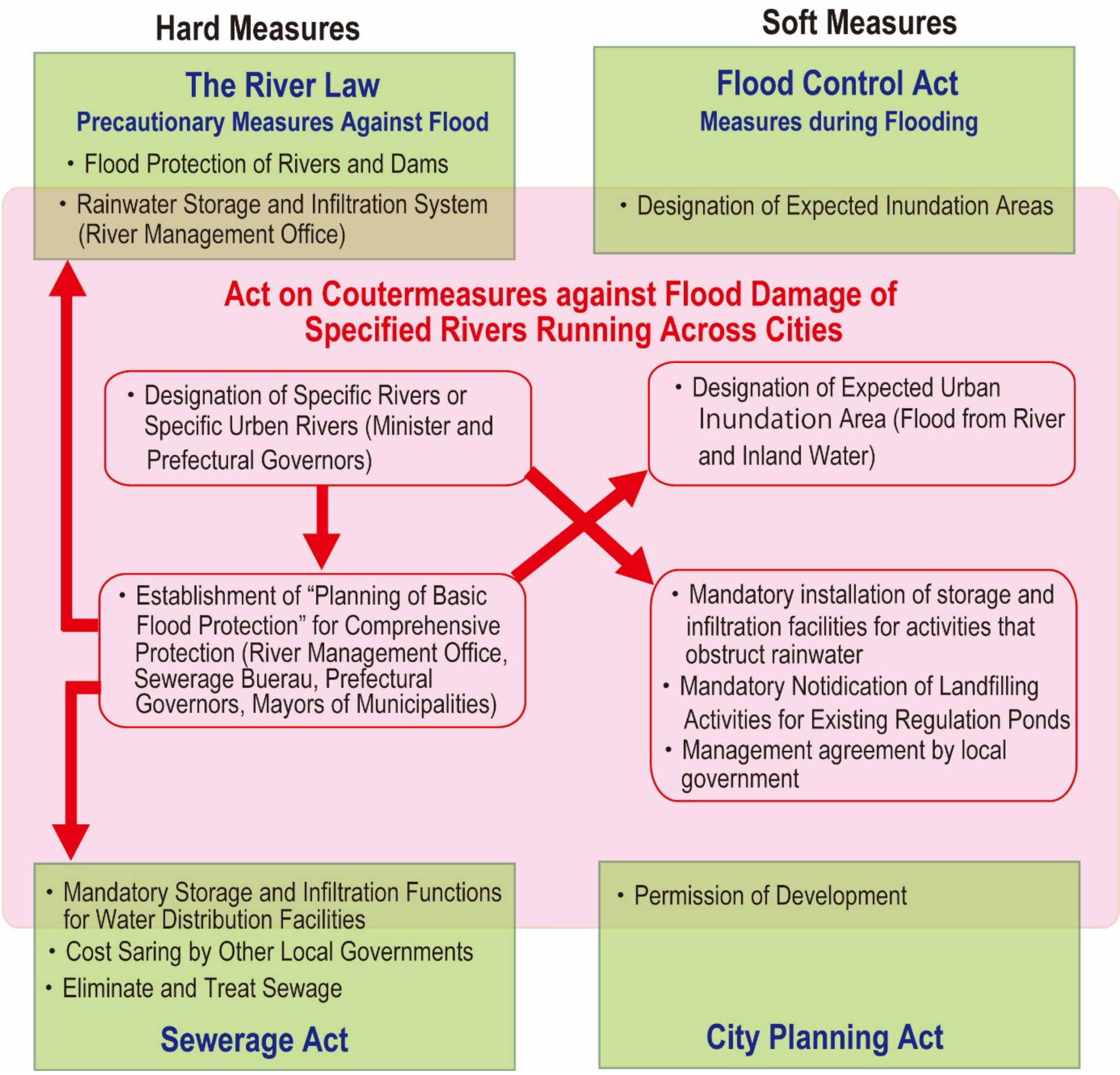
Figure 4.1 Comprehensive Flood Protection Measures

(3) Further Measures: The Act on Countermeasures against Flood Damage of Specified Rivers Running Across Cities in 2003

Although comprehensive flood protection measures had been implemented, the remaining issues still need to be resolved. The Act on Countermeasures against Flood Damage of Specified Rivers Running across Cities in 2003 aims at strengthening measures as follows:

1) Inclusion of Sewerage Bureau in the related organization,
2) Legally binding basin measures, such as maintaining rainwater storage facilities and acquiring permission to impede rainwater infiltration
3) RMOs can develop rainwater storage facilities and infiltration facilities in urban area, and
4) Expansion of regulations by ordinance.

Figure 4.2 shows the relationship between the Act and other relevant laws. The RMOs, Sewerage Bureaus, and local governments in the river basin jointly formulated an integrated river basin flood protection plan for the urban rivers designated by the Act. These measures included implementing river improvements, constructing sewage systems, improving rainwater storage, enhancing and infiltration facilities.



Source: FY2009 Policy Review results (evaluation report): Comprehensive flood countermeasures – Verification of the Implementation Status of the Act on Countermeasures against Flood Damage of Specified Rivers Running across Cities, MLIT (March 2010)

Figure 4.2 Relationship between the Act on Countermeasures against Flood Damage of Specified Rivers Running Across Cities and Other Relevant Laws

(4) Sewerage System

The Social Infrastructure Development Council reported on the medium-term objectives in 2007 to correspond to rainfall once every 10 years in important districts. The government implemented the following measures: 1) development of rainwater drainage, pumping stations, and rainwater storage and 2) development of inundation maps for preparing evacuation.

The Act on the Promotion of Rainwater Usage, enacted in 2014, stipulates that rainwater outflow is controlled by rainwater storage. The Sewerage Act, revised in 2015, stipulated the establishment of the Flood Damage Protection Area. Local governments designate areas where flood protection measures should be implemented through public-private partnerships (PPPs) in conjunction with urban redevelopment. The government can provide funds to the private sector to help construct rainwater storage facilities. Local governments can require the private sector to install rainwater storage and infiltration facilities and manage facilities installed by the private sector based on agreements.

In 2018, only 59% of sewerage systems in the Tokyo metropolitan area could treat rainfall events that occur once every five years. The metropolitan government is making efforts to respond to the rainfall that occurs once every 10 years. Furthermore, the government is developing sewerage systems, providing flood information, publicizing flood damage protection area maps, establishing evacuation and disaster prevention systems, and implementing public relations activities and warning issuances.

4.2 River Improvement in Urban Areas

> Coordination of the river improvement and the urban projects can protect against flood and improve the water environment.

The river improvement plan should integrate river and town spaces to improve the environment.

1) Shinano River: Gentle-slope levees with a gradient of 1:5 were constructed in Niigata City. In addition to disaster prevention, they are utilized as places for relaxation. Known as "Yasuragi-tsutsumi, they constitute a valuable waterfront space (Figure 4.3).

2) Motomachi visitor-oriented embankment: Riverside green spaces were created as part of the land readjustment project for post-World War II (WWII) reconstruction. Considering the landscape of the Ota River running through Hiroshima City (Section 5.4), they have become symbols of Hiroshima City as an attractive waterfront space (Figure 4.4).

Source: MLIT Shinano River Downstream Office Website

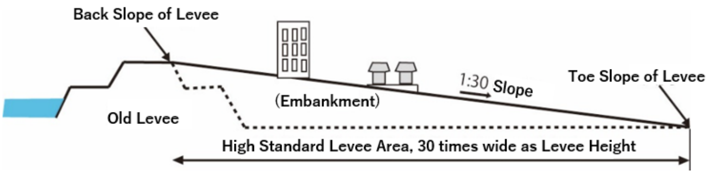
Figure 4.3 Yasuragi-tsutsumi in the Shinano River

Source: MLIT Website

Figure 4.4 Visitor-oriented Embankment at Moto Town in the Oota River

(1) High Standard Levee (Super Levee)

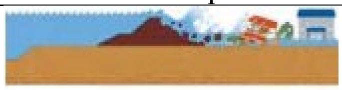
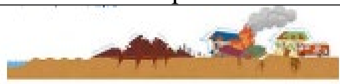
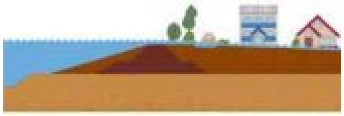
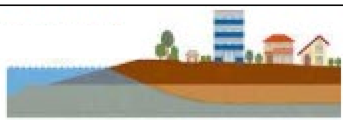
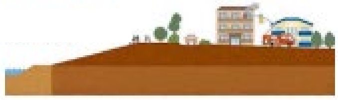
There is a risk of catastrophic damage caused by levee failures in low-lying areas, where the population and assets are densely concentrated. The national government has constructed wide and gentle slope levees, called high standard levees or super levees since 1987, to improve flood protection in large rivers. Figure 4.5 shows the concept of a high standard levee and Figure 4.6 shows their effects. The project called Heart Island SHINDEN is an example of integrated urban development



Source: Current Status and Issues of Development of High Standard Levees, Nobuhiro Yamashita, Research and Legislative Reference Bureau, National Diet Library, Reference No.831 (April)

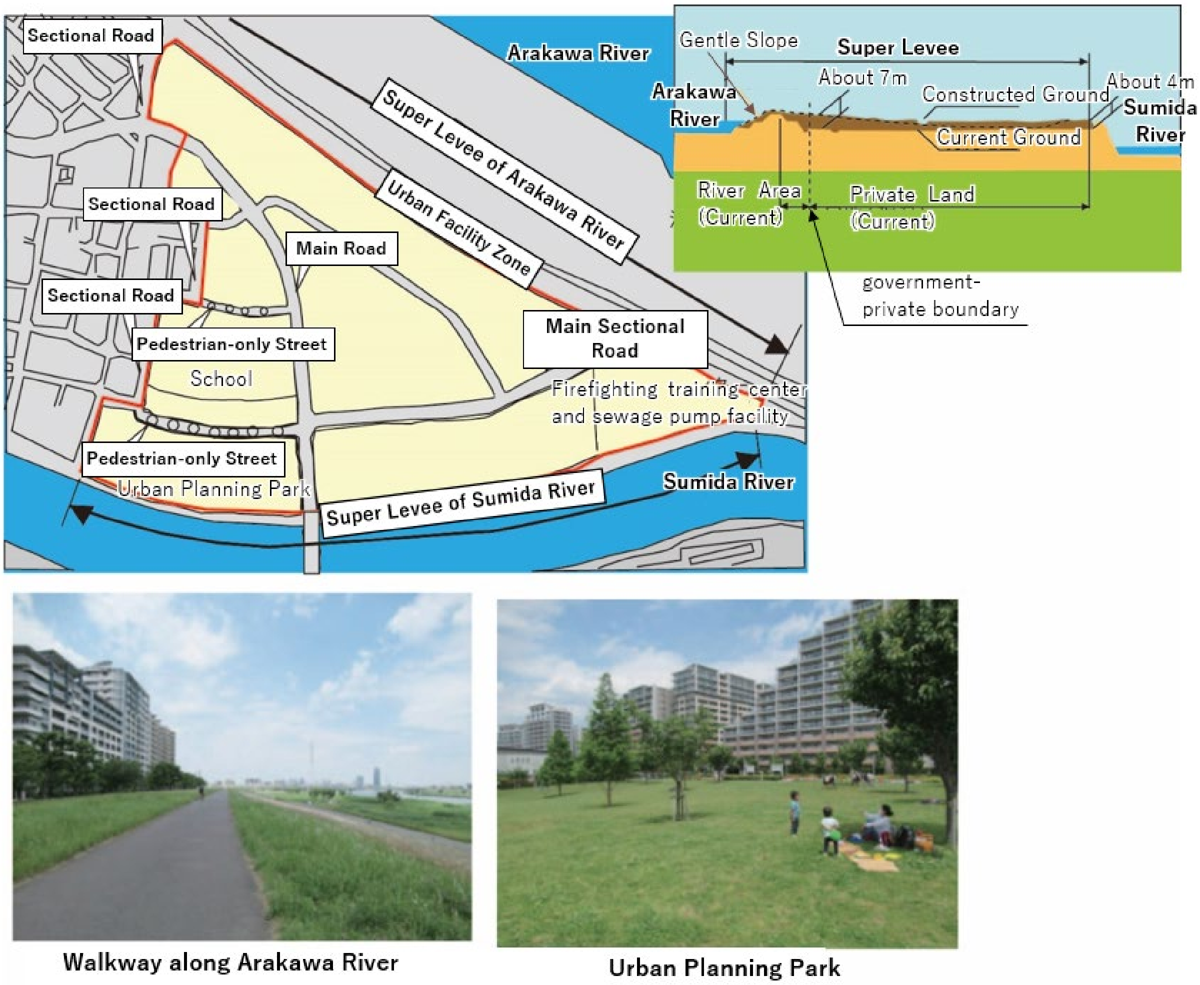
Figure 4.5 High Standard Levee Concept Diagram

utilizing water and greenery applied to a super levee. It was constructed on the land of 20.0 ha surrounded by the Arakawa and Sumida Rivers in Tokyo. (Figure 4.7).

Type	Overtop	Infiltration	Earthquake
Normal			
High standard			
	Even if water overflows, it will flow gently over the levee and prevent it from collapsing.	Even if the water infiltrates into levee, the wide levee prevents its collapse	To strengthen the ground and avoid damage with liquefaction by earthquake.

Source: MLIT Website

Figure 4.6 Effects of a High Standard Levee



Source: UR × Green Infrastructure Case Studies prepared by the UR Agency with the addition of the Project Research Team.

Figure 4.7 Heart Island SHINDEN: Urban Development Utilizing Water and Greenery

4.3 Retarding Basin, Regulation Ponds, and Underground Diversion Tunnel

> Storing flood water in facilities can effectively decrease flood damage. The sites can be used for multiple purposes for ordinary times.

Retarding basins and regulation ponds store a portion of the floodwater. As land acquisition is difficult in urban areas, sites should be effectively utilized.

(1) Myoshoji River No. 1 Regulation Pond (Shinjuku and Nakano Wards, Tokyo)

Housing complexes were developed with flood regulation ponds and parks as integrated joint projects to effectively utilize valuable spaces and reduce costs. The floor area ratio regulation was relaxed to lower the development cost. High-rise residential buildings located above the regulation ponds were constructed as piloti-type buildings (Figure 4.8). The regulation pond area is normally used for sports and recreation facilities, such as roller-skating rinks and tennis courts (Table 4.1). The park was constructed by the Housing and Urban Development Corporation (current Urban Renaissance [UR] agency) and managed by the Shinjuku and Nakano wards.

Source: Myoshoji River No. 1 Regulating Pond pamphlet, Tokyo Metropolitan Government

Figure 4.8 Myoshoji River No.1 Regulation Pond

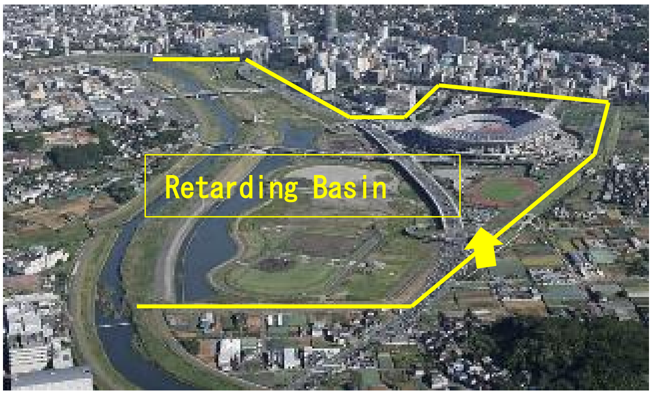
Table 4.1 Implementation Allocation of Myoshoji River No. 1 Regulation Pond

Items		Tokyo Metropolitan Government	Shinjuku / Nakano Wards	UR Agency
Land Use	Land Ownership	-	50%	50%
	Land Use	Using entire area as regulation pond	2/3 of the total area is used as a park	1/3 of the total area used as housing
	Land Acquisition Cost Allocation	42%	33%	25%
Implementation	Allocation	Construction of regulation pond, riverbank protection, outlet, inlet, management passage	Park maintenance	Construction of rental housing (piloti-type buildings)
Operation and Maintenance		Removal of sediment from riverbanks and regulation pond due to flooding	Park Maintenance	Maintenance of residential area

Source: Consideration of the establishment of a framework for river development that contributes to regional revitalization Morikawa Yoichi, et al. / Riverfront Research Institute, 2010 Research Report

(2) Tsurumi River Multipurpose Retarding Basin (Kohoku Ward, Yokohama City)

Nissan Stadium, where the 2008 Soccer World Cup final was held, is located in the Tsurumi River multipurpose retarding basin (Figure 4.9). The lower parts of the stadium were built as pilotis, and surrounding areas are used as retarding basins.



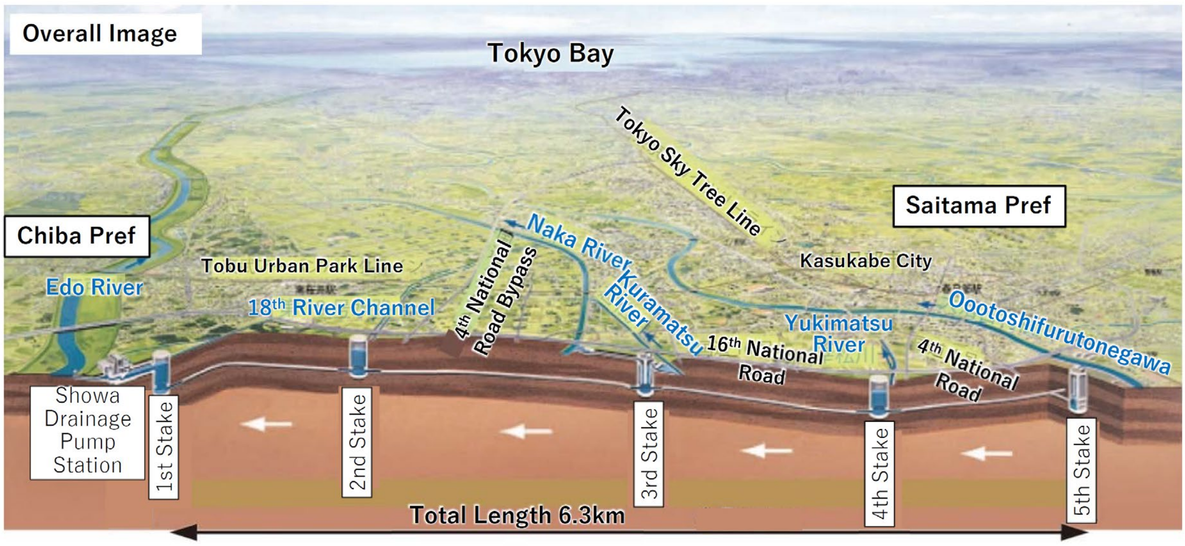
Source: Tsurumi River Multipurpose Retarding Basin Pamphlet (edited), MLIT with addition by Project Research Team

The photo is the view from the direction of the arrow on the picture provided on the left side.
Source: MLIT Keihin River Office Facebook

Figure 4.9 Tsurumi River Multipurpose Retarding Basin

(5) Underground Diversion Tunnel

Underground diversion tunnels are constructed in large cities, where land acquisition is difficult. The metropolitan area of the outer underground diversion tunnel (Figure 4.10) is one of the world's largest underground floodways, built 50 m below the ground surface. The tunnel reduced the number and area of inundated houses. The river basins of the Nakagawa and Ayasegawa rivers are surrounded by large rivers such as the Tone, Edogawa, and Arakawa Rivers. The small river gradient makes it difficult for water to flow into the sea in a short time, and the water level does not decrease easily during flooding.



Source: MLIT Edogawa River Management Office Website

Figure 4.10 Overall Image of the Metropolitan Area Outer Discharge Tunnel

CHAPTER 5 IMPROVING WATER ENVIRONMENT

Improving the water environment requires an approach from multiple perspectives, including water quality, discharge, ecosystem, and the use of waterfront spaces.

5.1 Development of Green Infrastructure

Developing green infrastructure can achieve various effects, such as disaster management, improvement of living and waterfront environments, conservation of ecosystems, promotion of regional development, and mitigation of climate change.

Japan has promoted green infrastructure or nature based solutions, which uses natural functions for disaster risk management. Green infrastructure can resolve water related issues in urban areas also (Theme 4: Water Pollution and Environmental Management, Section 5.4).

(1) Umeda River: Umeda River is a tributary of the Tsurumi River in Yokohama City. Works restored continuity between the forest on the slope and the river (Figure 5.1). The right bank was excavated to secure the flood flow capacity. The excavation was conducted along the contour lines of the topography. Consequently, the width and slope of the riverbank vary among places. Gabions covered with soil were placed as revetments on the hillside slope to recover vegetation. The waterfront was developed to provide a safe place for children to approach and play (Figure 5.2).

Before construction: plank hurdle revetment

Renovation: gabion revetment on right bank

Half year after construction: vegetation recovered on the gabions covered with soils

Thirteen years after construction: the natural connection between slope and river is maintained.

Note: The yellow oval lines show the construction area of the gabion revetment.
Photograph: provided by Yoshimura Shinich (Yoshimura Shinich Watershed Planning Offfice)
Source: Nature-friendly River Works Reference Book, Riverfront Research Center

Figure 5.1 Example of Nature-friendly River Works

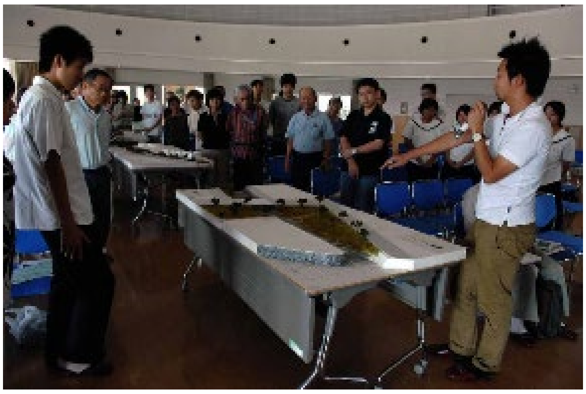
(2) Kamisaigo River: Fukutsu City, in Fukuoka Prefecture, restored the Kamisaigo River as a nature-friendly river. The river is a typical urban river with concrete revetments (Figure 5.3), scarce living creatures, and poor accessibility. The connection between the river and community was weak. Local citizens and Kyushu University discussed the river plan, tree-planting, and management system (Figure 5.3). At present, children play in rivers and people walk around on the riverfront. The local community cleans the river and cuts grasses. The river is also used in environmental education for elementary school children (Figure 5.3). Environmental improvement work is underway to create nature-friendly rivers by citizens themselves.

Source: Yokohama City Road Burau River Department

Figure 5.2 Waterfront Environment Established by the Project for Waterfront Schools for Fun

Pre-renovation

Post-renovation



Planning with thorough citizen participation

Frequently used for environmental studies by children

Photograph: Provided by Yoshimura Shinich (Yoshimura Shinich Watershed Planning Office), Hayashi Hironori (Kyusyu University)
Source: River Law Amendment 20 Years Nature-friendly River Management Promotion Committee, 1st Pamphlet: Specific Examples of Nature-friendly River Management (No. 1), MLIT

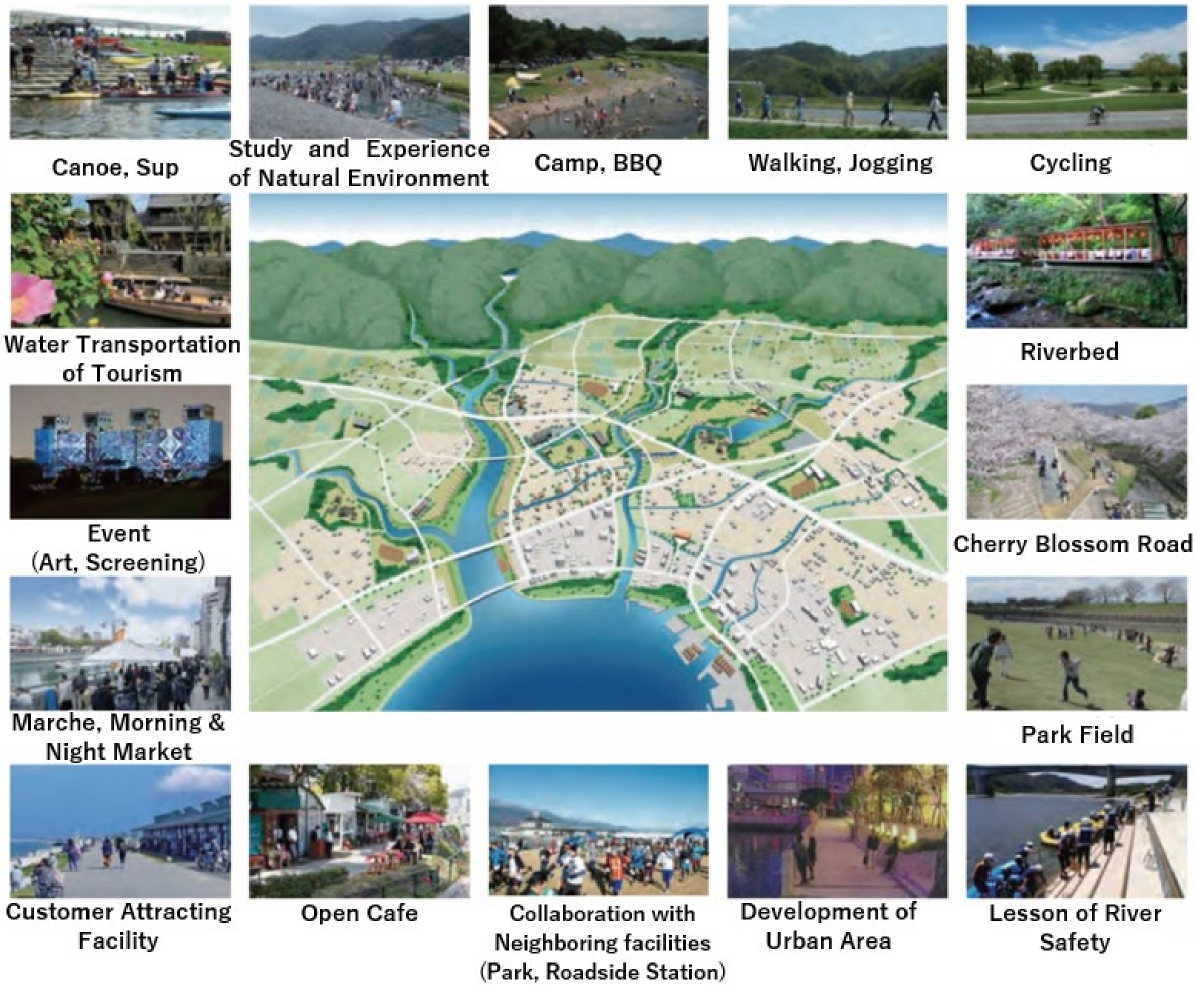
Figure 5.3 River Restoration Works of the Kamisaigo River, Fukuoka Prefecture

5.2 Improving Waterfront

Improving the waterfront environment can attract tourists, thereby leading to regional revitalization.

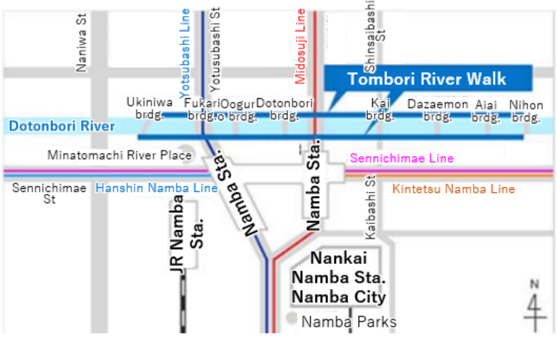
New values may be created by uniting the "river" and "town." Specifically, river spaces may be used for regional revitalization and tourism promotion by utilizing the resources and creative "wisdom" of the region. To this end, municipalities, private businesses, residents, and RMOs should collaborate with a developmental approach. Kawamachi Zukuri (River-Town Planning) aims to revitalize the community and improve the local brand (Figure 5.4).

In Dotonbori River located in Osaka downtown, a promenade was built, which was called "Tombori River Walk." (Figure 5.5). In addition to water purification, local organizations participated in this River-Town Planning project. Since its opening in 2013, it has been crowded with tourists.



Source: Guide for Formulating a River-Town Development Plan, 1st Edition, MLIT, March 2020

Figure 5.4 Possible Developmental Sceneries Achieved through River-Town Planning



Location Map **Night View of Dotonbori River**

Source: MLIT Website (Photograph: Riverfront Research Center)

Figure 5.5 Example of River-Town Planning along the Dotonbori River

5.3 Sewerage Improvement

Sewerage systems play an important role in forming healthy water cycles in urban areas.

Sewerage systems collect, treat, and discharge rainwater and sewage (Theme 4: Water Pollution and Environmental Management). Sewerage systems in Japan aim to 1) prevent inundation damage, 2) eliminate sewage and secure public health, and 3) preserve the quality of water in rivers and seas. As residents have more opportunities to encounter waterfronts, they have more interest in surrounding water areas such as rivers and canals, and want a rich water environment.

Local governments are improving the combined systems to drain sewage and rainwater in the same pipes. The inflow to the sewage treatment plant exceeded the treatment capacity of the plant during heavy rainfall events. The excess inflow is discharged directly into the rivers without being treated.

5.4 Response to the Urban Poor in the River Area

The living conditions of urban poor in the river areas could be improved by promoting relocation to affordable housing with flood protection works.

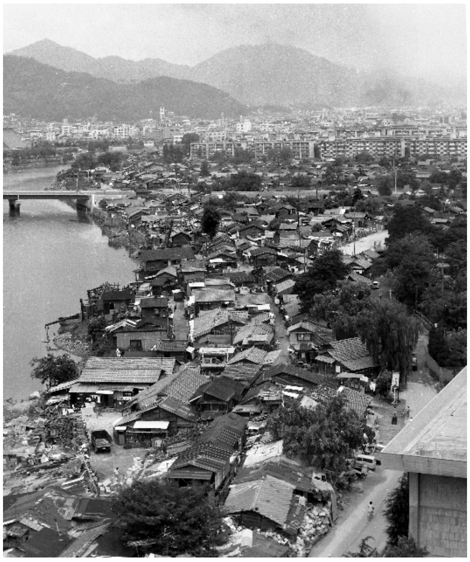
Urban poverty is increasing in cities in developing countries. The population in rural areas has moved to large cities to seek employment. Insufficient houses in urban areas have led people to build huts on river areas, slopes, and public land unsuitable for habitation.

Following the end of WWII in 1945, many people lived on the riverside in Japan. In Hiroshima City, the people comprising war victims and repatriates lived in a place known as Atomic Bomb Slums, located along the mainstream of the Ota River. (Figure 5.6). More than 4,500 high-rise housing units (up to 20 floors) have been constructed, including improved housing,[3] to accommodate residents. Parks and riverside green spaces have been secured, and infrastructure facilities such as shopping centers,

[3] Improved Housing: Rental housing constructed under Residential Areas Improvement Act, 1960. In densely populated areas, the MLIT designated the removal of poor or dangerous housing at high risk of impact from disaster-related damage, or inaccessible for fire trucks in the event of fire. These rental houses were built for residents who would otherwise lose their living space because of this removal.

elementary schools, and meeting areas have been established. The land has been developed into Hiroshima City Central Park and Ohta-Motomachi embankment (Figure 4.4).

In recent years, vagrants (homeless) have temporarily settled in the water channel area of rivers (Figure 5.7). In the Arakawa River, the RMO has been conducting joint patrols with police, relevant municipalities, and welfare departments.



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

Figure 5.6 Atomic Bomb Slum in Hiroshima

Joint Patrol　　　　Before and After Guidance to the Homeless

Source: Efforts to respond to homelessness in the lower Arakawa River, Arakawa River Office, Onagi River Sub-branch, Ooyama Takeshi, MLIT.

Figure 5.7　Measures to Address the Homeless in the Arakawa River

CHAPTER 6 LESSONS LEARNED

(1) **To ensure coexistence with the environment and resolve various urban related issues, the water cycle should be restored.** The concentration of urban population, expansion of urban areas, and increase in socioeconomic activities have caused deterioration of the water cycle in urban areas. These affect various areas in terms of the quality and quantity of water, the riparian environment, and groundwater. Organizations were concerned about the need to collaborate to restore the water cycle.

(2) **To cope with water demand due to the influx of the population into urban areas, water demand management and water recycling should be promoted.** Water demand could be managed by tariff systems and other software measures. The reduction of water leakage and use of rainwater and recycled water should be promoted. A review of the production process and recycling water is also required for industrial water supply.

(3) **To mitigate the flood damage in urban areas, comprehensive measures should be taken.** Urbanization caused a decline in water retention capacity and an increase in peak flood discharge. Flood risk is increased by climate change. Thus, integrated approaches to improve river facilities, river basins, and flood damage mitigation should be undertaken. Cooperation among related organizations should also be consolidated.

(4) **To conduct efficient development, the private sector's expertise should be utilized.** For example, parks and piloti-type housing complexes were developed above regulation ponds to store floodwaters in Tokyo. The government organizations provided incentives to the private sector. This has enabled the effective use of expensive land in urban areas.

(5) **To improve the water environment, multiple approaches should be taken in terms of water quality, discharge, ecosystems, and recreation.** A decline in water quality during high economic growth in Japan has resulted in ecosystem deterioration, and residents have avoided access to rivers. Various efforts to improve the water environment have been implemented to integrate "river space" and "town space," improve the waterfront environment, and conserve the ecosystem. Flood protection facilities have also contributed to urban development by providing recreational functions. Involving the local community and private organizations in implementing these initiatives was necessary. This collaboration led to the creation of a good space uniting the "river" and "town," which promoted tourism and rejuvenated the area.

(6) **Developing green infrastructure can achieve multiple benefits**. Flood protection works contribute to achieving various objectives using natural functions. These objectives include disaster management, improvement of the living environment and waterfront, conservation of ecosystems, promotion of regional development, and mitigation of climate change.

(7) **To improve issues of the urban poor in rivers public housing should be provided with river improvement works.** There were many slum areas along rivers in urban areas in Japan during post-WWII periods. Japan resolved these problems by providing affordable public housing for the urban poor with implementing flood protection works.