22

Greater Tokyo, Japan

Coordinated by: The National Institute for Land and Infrastructure Management – Ministry of Land, Infrastructure and Transport of Japan (NILIM-MLIT)

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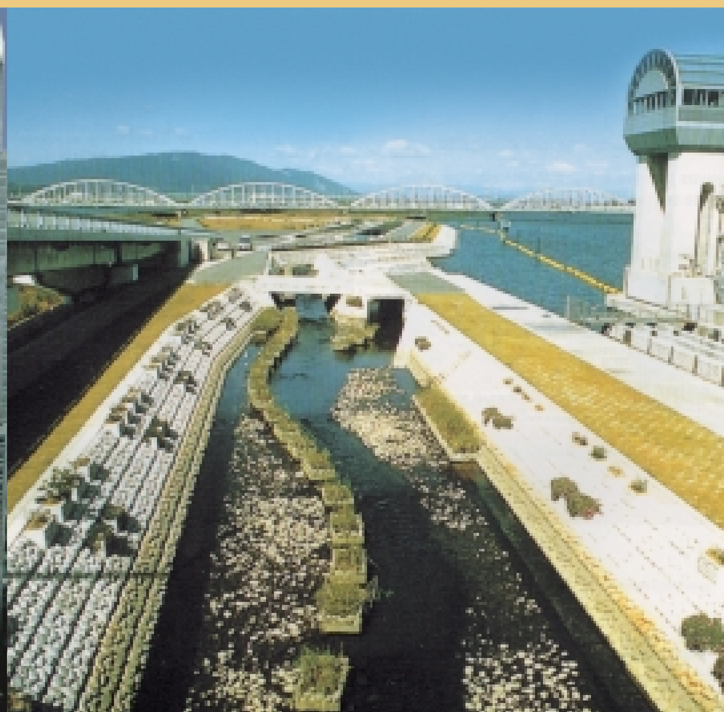
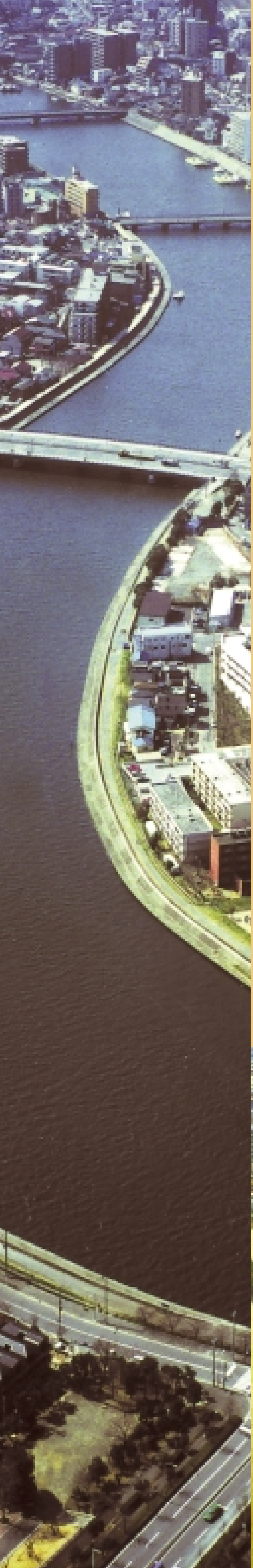
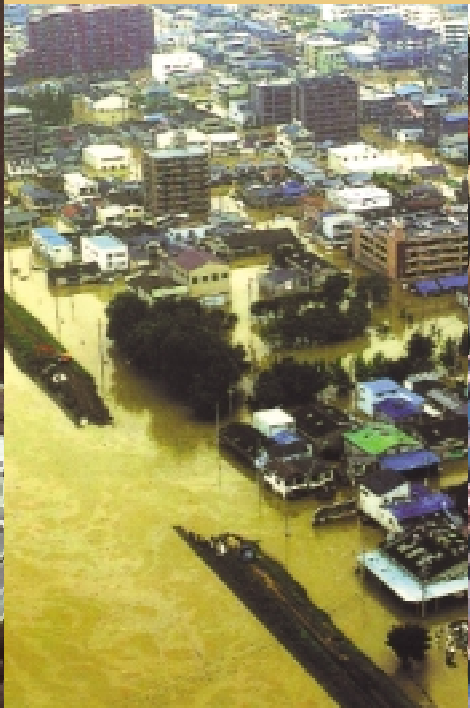




Ah, what a pleasure
to cross a stream in summer
– sandals in hand.

Buson (1716-1783)

THIS CASE STUDY PRESENTS the example of river basins that serve one of the world's most populous areas, a region of 27 million people. In addition to its extremely high density, Tokyo metropolitan is subject to seasonal floods and other hazards such as droughts and earthquakes. However, because it is a rich and industrialized country, Japan has the means – and the skills – to manage these risks using infrastructure such as dams, levees and underground floodways. There is also great emphasis placed on public awareness and disaster preparedness. The authorities have developed early warning systems that rely on the Internet, Geographic Information Systems (GIS) and hazard mapping, and there are shelters where people can take refuge. Such continuous efforts have ensured that one of the world's largest economic developments has been able to safeguard its population in the high-risks region. Other concerns include a degraded natural environment and pollution of groundwater, and many efforts, such as river restoration works, are being implemented with wide public participation.



THE GREATER TOKYO REGION (hereafter Greater Tokyo), with its densely populated megacities, includes five river basins covering an area of about 22,600 square kilometres (km^2), with a total population of 27 million and property value assets totalling about US$2.9 trillion. Due to human and industrial activities, various water-related problems have developed, and the need is increasing for better water quality, diversification, protection and improvement of the environment.

General Context

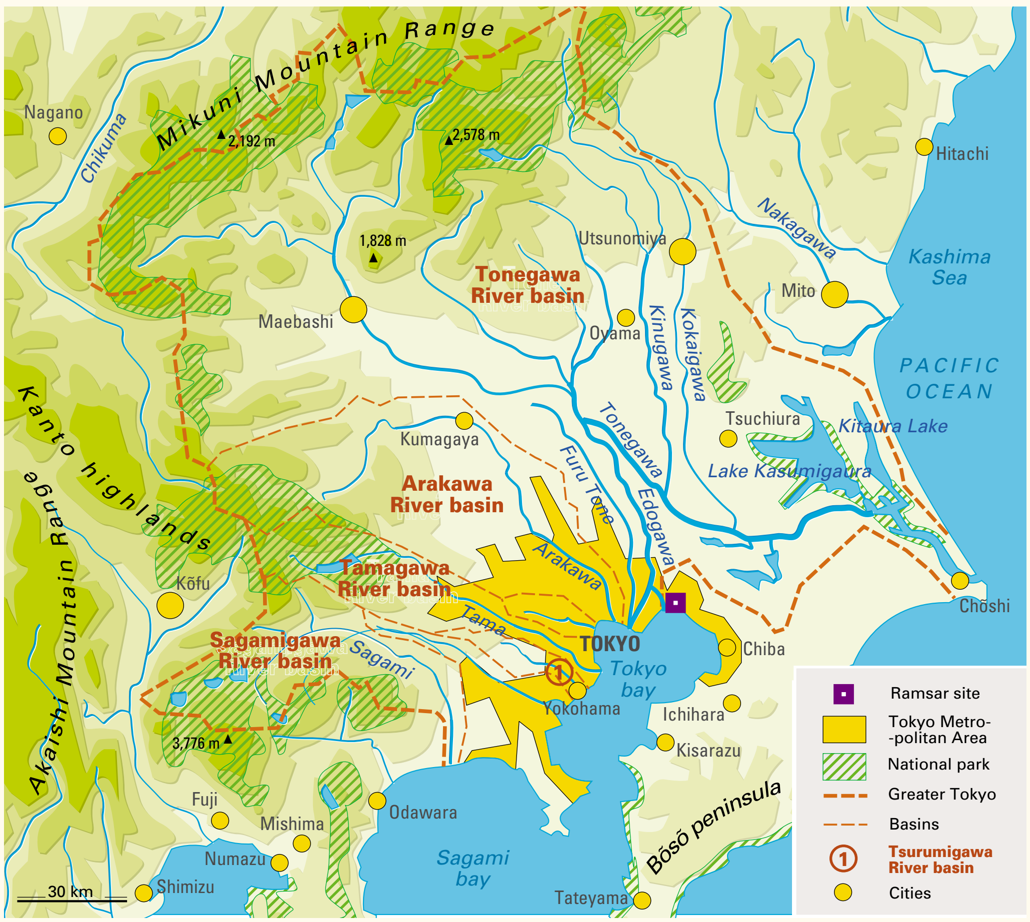
The enormous water resources needed to supply the cities and maintain the safety degree against drought are difficult to manage. In addition, groundwater withdrawal is still causing land subsidence.

About 13.25 million people and 170 trillion yen (approximately US$1.36 trillion) worth of assets in property value are concentrated in 4,800 km^2 of the region's alluvial plains, often the site of substantial flood damage, accentuated by the fact that Greater Tokyo suffers the severe weather conditions of the Asia monsoon period. Changes in land use and increase in rainfall have also enhanced the danger of flood in recent years.

Map 22.1: Locator map

Source: Prepared for the World Water Assessment Programme (WWAP) by AFDEC, 2002.

Map 22.2: Basin map



Source: Prepared for the World Water Assessment Programme (WWAP) by AFDEC, 2002.

Table 22.1: Hydrological characteristics of the five river basins in Greater Tokyo

	Tonegawa (1)	Arakawa (2)	Tamagawa (3)	Sagamigawa (4)	Tsurumigawa (5)
Location	Central Honshu, Japan N 35° 32′–37° 5′ E 138° 24′–140° 51′	Central Honshu, Japan N 35° 39′–36° 10′ E 138° 43′–139° 52′	Central Honshu, Japan N 35° 32′–37° 51′ E 138° 494′–139° 46′	Central Honshu, Japan N 35° 32′–37° 5′ E 138° 24′	Central Honshu, Japan N 35° 28′–35° 35′ E 139° 24′–139
Area	16,840 km^2	2941.5 km^2	1,241 km^2	1,668 km^2	239 km
Origin	Mt. Ohminakami	Mt. Kobushi-gatake (2,475 m)	Mt. Kasatori	Mt. Fuji	Tanaka Yato (valley) (Machida, Tokyo)
Outlet	Pacific Ocean	Tokyo bay, Pacific Ocean	Tokyo bay, Pacific Ocean	Sagami bay, Pacific Ocean	Tokyo bay, Pacific Ocean
Length of main stream	322 km	169 km	138 km	108 km	42.5 km
Highest point	1,834 m (trunk of Tonegawa)	Mt. Kobushi-gatake (2,475 m)	1,953 m (trunk of Tamagawa)	3,776 m (trunk of Sagamigawa)	164 m (trunk of Tsurumigawa)
Lowest point	River mouth (0 m)	River mouth (0 m)	River mouth (0 m)	River mouth (0 m)	River mouth (0 m)
Main geological features	Mountain area: sandstone, slate, limestone from the Paleozoic and Mesozoic eras, and volcanic rocks. Plain area: Pleistocene and alluvium.	(Upper basin) Paleozoic, Tertiary; (Lower basin) Quaternary (alluvialand diluvial)	Upper reaches: the Chichibu Paleozoic and Mesozoic strata. The hilly and flat area: the loamy layer of the Kanto District. The low-lying parts: sediments from the delta and coastal sedimentation.	Mountain area: lava bed, conglomerate and volcanic ash. Plain area: igneous rock, mudstone. The low-lying parts: sediments (consisting of lithified clay, sand, silt and conglomerate).	The hilly and flat area: the loamy layer of the Kanto District. The low-lying parts: sediments from the delta and coastal sedimentation.
Main tributaries	Katashinagawa (676.1 km^2) Agatsumagawa (1,355.2 km^2), Kanna-gawa (417.6 km^2), Kaburagawa (632.4 km^2), Karasugawa (759.1 km^2), Watarasegawa (2,621.4 km^2), Kokaigawa (1,043.1 km^2), Kinugawa (1,760.6 km^2)	Akabiragawa (250.0 km^2), Irumagawa (737.3 km^2), Shingashigawa (392.3 km^2), Sumidagawa (243.9 km^2)	Asakawa (154 km^2), Hirasegawa (13 km^2), Nogawa (68 km^2), Hiraigawa (38 km^2), Akigawa (170 km^2)	Doshigawa (152 km^2), Nakatsugawa (140 km^2), Sasagogawa (93 km^2), Kuzunogawa (115 km^2), Mekujirigawa (34 km^2)	Yagamigawa (28 km^2), Hayabuchigawa (20 km^2), Toriyamagawa (11 km^2), Ondagawa (31 km^2)
Main lakes	Kasumigaura, Kitaura, Chuzenji, Imba, Tegan, Ushiku	None	None	Kawaguchi, Yamanaka	None
Main reservoirs	Yagisawa (115.5x10^6 m^3, 1967), Naramata (85.0x10^6 m^3, 1991), Hujiwara (31.0x10^6 m^3, 1958), Aimata (20.0x10^6 m^3, 1959), Sonohara (13.2x10^6 m^3, 1966), Shimokubo (120.0x10^6 m^3, 1969), Ikari (32.0x10^6 m^3, 1956), Kawamata (73.1x10^6 m^3, 1965), Kawaji (76.0x10^6 m^3, 1983)	Futase (26.9x10^6 m^3, 1984), Arima (7.6x10^6 m^3, 1984)	Ogouchi (water supply and power only 185.4x10^6 m^3, 1957)	Sagami (no flood control dam 48.2x10^{6}m^3, 1947), Shiroyama (54.7x10^6 m^3, 1964), Miyagase (183x10^6 m^3, 2000)	Tsurumigawa multi-purpose retarding basin (39x10^6 m^3, 2002)
Mean annual precipitation	1,162.6 mm at Maebashi, 1,580.1 mm at Choshi (1971–2000)	1,367 mm (1951–1980), at Chichibu	1,385 mm at Ogouchi (1985–2001)	1,658 mm at Saito bridge (1985–2001)	1,616.5 mm at Tsurukawa, 1,628.5 mm at Tsunashima (1990–2000)

Table 22.1: *continued*

	Tonegawa (1)	Arakawa (2)	Tamagawa (3)	Sagamigawa (4)	Tsurumigawa (5)
Mean annual runoff	165.2 m^3/sec at Yattajima, 220.6 m^3/sec at Kurihashi (1960–2000)	26.4 m^3/s at Yorii (927km^2) (1952–1985)	30.2 m^3/sec at Ishikawa (1991–2000)	50.0 m^3/sec at Sagamiohashi (1991–2000)	8.69 m^3/sec at Kamenoko bridge (1990–1999), 83.4 m^3/sec at Sueyoshi bridge (1983)
Population	About 12,000,000	9,046,643 (1985)	About 3,571,000 (1995)	About 1,284,000	About 1,840,000
Land use	Forest (45.5%), paddy field (18.2%), cropland (11/2%), orchard (3.3%), urban (3.7%), residential area (6.4%), water surface (5.1%), other (6.6%)	Forest (48.2%), paddy field (5.1%), agriculture (6.5%), water surface (4.0%), urban (26.5%) (1985)	Forest (59.6%), paddy field (0.7%), cropland (1.8%), orchard (0.1%), urban (31.3%), other (incl. water surface) (6.5%) (1997)	Forest (78.2%), paddy field (2.5%), cropland, etc. (2.7%), urban (9.0%), other (incl. water surface) (7.6%) (1997)	Paddy field and cropland (10%), forest (5%), urban (85%)
Main cities	Maebashi, Takasaki, Saitama, Tsukuba, Utsunomiya	Tokyo, Omiya, Urawa, Kawagoe, Chichibu	Kawasaki, Chofu, Tachikawa, Tokyo (Ota-ku, Setagayaku)	Hiratsuka, Chigasaki, Zama, Atsugi, Sagamihara	Yokohama, Kawasaki, Machida

Sources: (1) UNESCO-IHP; (2) UNESCO-IHP; (3) Kanto Regional Development Bureau, MLIT; (4) Kanto Regional Development Bureau, MLIT; (5) Kanto Regional Development Bureau, MLIT.

Furthermore, due to intense urbanization, the quality of water in Greater Tokyo has deteriorated. Action was taken to reduce the discharge load, such as drainage regulation and sewage maintenance, and the quality of water started to improve in major rivers. However, the concentration level is still high in some tributaries, lakes and marshes, and new Environmental Endocrine Disruptors have been problematic. In addition, the increase of imported non-native species of fish and plants is becoming a serious ecological problem.

Water Resources

Hydrology

The average precipitation in Greater Tokyo has been 1,551 millimetres (mm) per year for the past thirty years. During periods of drought, the average is 1,213 mm/year, which is 20 percent less than in normal years. Over the last one hundred years, overall precipitation has been decreasing. However, recently, there have been more and more rainfalls of over 100 mm/day (Water Resources Department, MLIT, 2002). Water resources in seven prefectures, including Greater Tokyo, average 374 billion cubic metres (bm^3) per year. During droughts, which occur once every ten years, the average is 247 bm^3, which is 30 percent less than normal (Water Resources Department, MLIT, 2002).

As for the water quality in Greater Tokyo, following are some biological oxygen demand (BOD) measurements taken in 1998: more than 8 milligrams (mg) per litre in Tsurumigawa River, about 4 mg/litre in Arakawa River, less than 2 mg/litre in Tamagawa River and Sagamigawa River. The BOD levels in the Tsurumigawa and Arakawa Rivers tend to increase while those in the other rivers remain stable. In the last ten years, the worst levels were found in Tsurumigawa and Arakawa Rivers. In 1999, the chemical oxygen demand (COD) concentration level was about 7.5 mg/litre (MLIT, 2001a). Generally, the water quality in rivers and lakes has improved; however, the presence of Environmental Endocrine Disruptors, chemical substances thought to affect the endocrine system, was recently discovered in some rivers. It is not yet known if these disrupters have an influence on health or the ecosystem (Ministry of the Environment, 2002). Figure 22.1 shows the variation in BOD levels over a number of years.

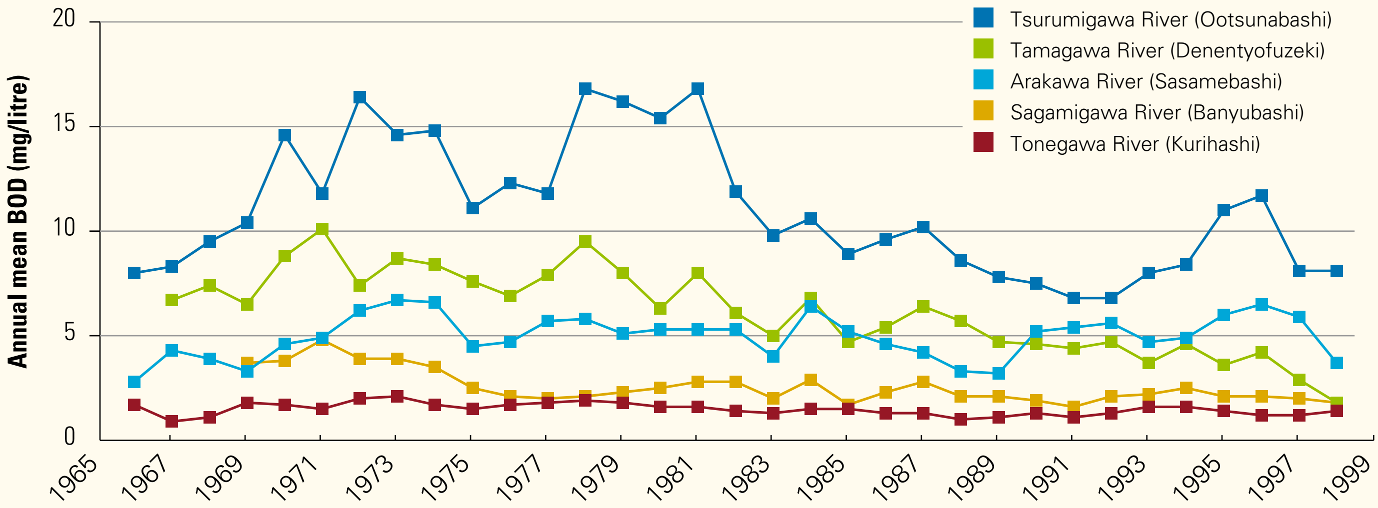
Human impacts on water resources

In seven prefectures, including Greater Tokyo, the proportion of lands used for building has increased from 13 percent in 1974 to 20.2 percent in 2000, while that of agricultural lands has diminished, going from 46.3 percent to 39.1 percent. In order to preserve the proportion of lands used for forests and woods, which has been kept stable (although only private forests have so far been counted), only agricultural lands are used for building.[1]

In April 2001, Greater Tokyo counted 183 dams with a total water storage capacity of about 2.5 bm^3. The dams are built for flood control, water supply and electricity generation purposes (Japan Dam Foundation, 2002).

1. *Kotei-shisan no Kakaku-tou no Gaiyou Chousa* (Outline of Protocols, such as Price of Fixed Assets). Taken from the web site of the Ministry of Home Affairs at http://www.soumu.go.jp/czaisei/shiryo.html.

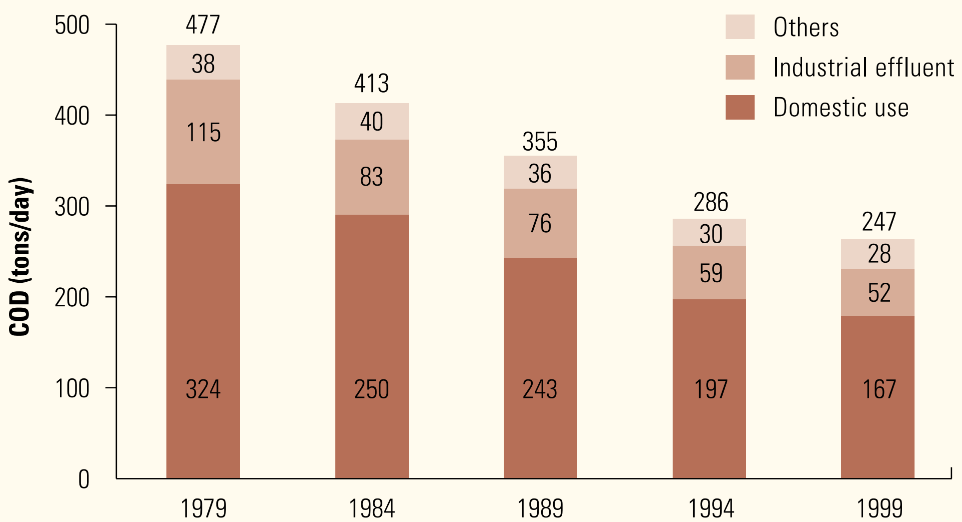
Figure 22.1: Variation in river water quality – biological oxygen demand (BOD) levels



The BOD levels have decreased since the 1970s in all five rivers of Greater Tokyo. However, the level remains high in the Tsurumigawa and Arakawa Rivers.

Source: River Bureau, MLIT, 2001a.

Figure 22.2: Variation in the chemical oxygen demand (COD) discharge load by sector in Tokyo bay



The majority of discharge load in Greater Tokyo is from domestic use, accounting for close to 70 percent of the total amount. The discharge load has drastically decreased, to about half of what it was twenty years ago.

Source: Ministry of the Environment, 2001.

Most of the effluent load of four prefectures (Tokyo, Chiba, Saitama and Kanagawa) is emptied into Tokyo bay, where the COD level in 1999 reached 247 tons per day. Seventy percent of this load is from domestic use (see figure 22.2). Due to drainage regulations, the discharge load has drastically decreased, to about half of what it was twenty years ago (Ministry of the Environment, 2002).

Groundwater resources are widely used in the region. One tenth of the water used to supply Tokyo metropolis is from groundwater resources. Analyses of the water quality in 1998 show results lower than the standard values, except for tetrachloroethylene (a product known to carry severe health risks), which exceeded environmental standards in three out of eighty-seven measurement points (Environmental Bureau of the Tokyo Metropolitan Government, 2000).

A survey in 1999 of non-native species in Japan's rivers yielded the following results: fish represented 6.1 percent, benthos 2.2 percent, plants 11.0 percent, birds 2.4 percent, amphibians 5.3 percent, reptiles 7.7 percent, mammals 18.4 percent and insects 0.7 percent (Foundation for Riverfront Improvement and Restoration, 1999). Black bass and blue gill, which are non-native fish, were found in 40 percent and 30 percent of dams, respectively (Water Resources Environment Technology Center, 2001).

Challenges to Life and Well-Being

To meet the needs and demands of the large human and industrial activities, vast water resources and policy implementation are necessary. The following is a summary of water uses in the region. The water volumes given below represent the total seven prefectures, not the five river basins.

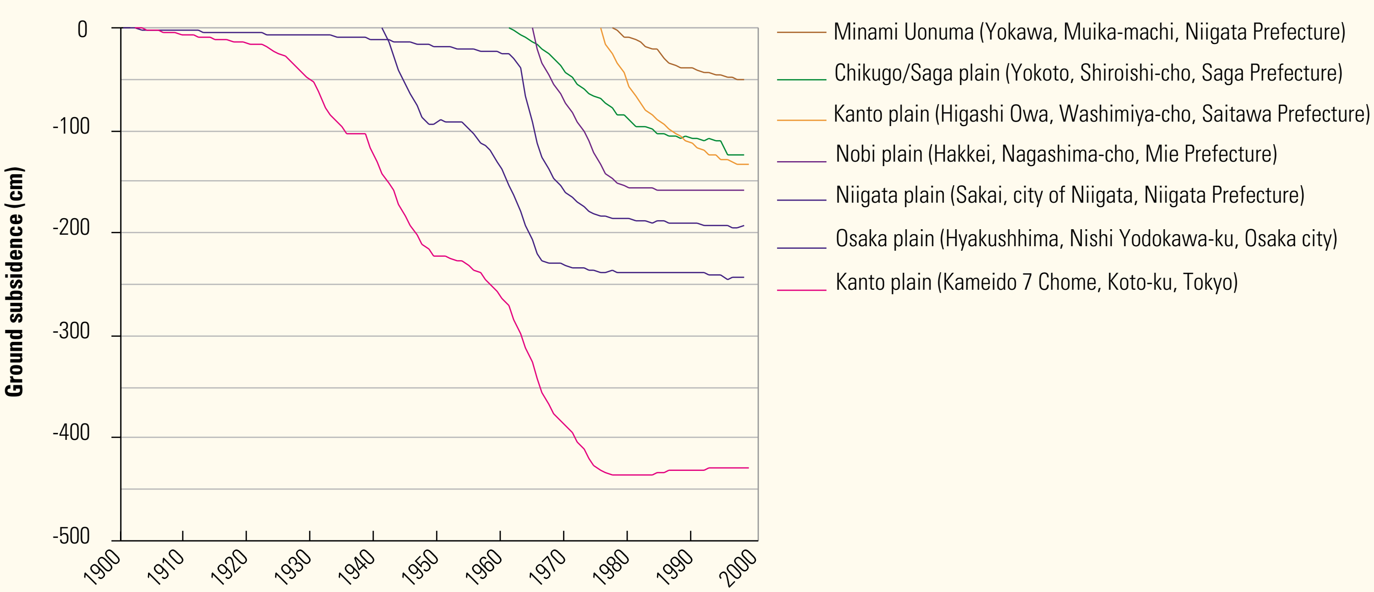
Water use in industry and cities

In 1998, the total volume of water used in Greater Tokyo was 163.5 bm^3. Thirty-four percent of this water is used for households, 14 percent for industrial activities and 52 percent for agricultural activities. The volume of water used in agriculture in Tokyo region is relatively low compared to the 66 percent used country-wide. The volume of water for households has slightly increased in recent years, while that of water used for agriculture has not changed. As for the volume of water used in industry, there is only a very slight increase, the result of massive water recycling (Water Resources Department, MLIT, 2001).

In Greater Tokyo, 44 percent of total water resources are used during normal years, and 66 percent during drought years. This percentage is twice that of the whole country (Water Resources Department, MLIT, 2001).

Groundwater resources make up 22.8 percent of total water use inland, and 13.1 percent in seaside areas. Some 45 percent of households and industries, considerably more than agricultures, rely on groundwater. So as to prevent land subsidence, groundwater withdrawals have been regulated. Limits on withdrawals of groundwater come in the form of two laws: the Industrial Water Law, which targets groundwater used for industrial purposes, and the Law Concerning the Regulation of Pumping-up of Groundwater for Use in Buildings, which targets groundwater used for cooling and other building-related purposes. Groundwater withdrawal in the northern part of the Kanto plain has decreased from 13.1 bm^3 in 1985 to 9.6 bm^3 in 1999 (Water Resources Department, MLIT, 2001). As a result, the rate of land subsidence has stabilized (see figure 22.3).

Figure 22.3: Rate of ground subsidence in cm/year



There has been a dramatic increase in ground subsidence in the Greater Tokyo region in the past century. Since the 1980s, this subsidence has stabilized. The Kanto plain has suffered particularly significant ground subsidence, and is now over 4 metres lower than it was in 1900.

Source: Water Resources Department, MLIT, 2001.

Securing the food supply

In 1998, agricultural water use in Greater Tokyo represented about 85.7 bm^3, of which 52 percent was spent on food production. Consumption of rice has decreased, while livestock products and consumption of oils and fats have increased. After 1998, though it had been steadily declining, the food production rate in Japan became stable. In addition, Japan's cereal production has been rising: this is mainly due to an increase in domestic wheat production and feed crops combined with a decreasing demand for livestock (Ministry of the Environment, 2002 and Ministry of Agriculture, Forestry and Fisheries).[2]

Protecting ecosystems

According to a 1998 survey, people's expectations for natural environment and beautiful landscapes are higher than what they were in 1990. About one hundred years ago, wetlands represented about 0.3 percent of the area of seven prefectures, including Greater Tokyo. In 1999, they represented only 0.11 percent, which is a drop of about 60 percent (Geographical Survey Institute, MLIT).[3]

Management Challenges: Stewardship and Governance

The population and property in Greater Tokyo are concentrated in alluvial plains, mostly below flood level, making flood damage potentially serious. Many years of flood control efforts have reduced the total inundated area and made the alluvial plains available for residential, industrial and agricultural use. Since the 1960s, increased land use has required enormous development of water resources especially for households and industry. There was a significant increase in river water use for generating hydroelectric power and for industrial and household water supply. To meet the new demands, a systematic framework for flood control and water use was established. In 1964, the institutional framework was improved by introducing an integrated river management system. A long-term plan for the development of water resources all over the country was also established. However, the increase in population and assets led to environmental problems such as the aggravation of the river water quality and changes in the ecosystem, making environmental conservation an important issue. In addition, with changes in economic and social conditions, the water management system was expected to not only fulfil flood control and water resource purposes, but also provide for recreational use and habitat diversity. As people's concerns about water and the environment grow, public involvement and consensus-building with proper information have become indispensable. In light of these changes, the River Law, on which the river administration is based in Japan, was revised. The revision established a comprehensive river administration system for flood control, water use and environmental conservation.

Water governance

There are several agencies in charge of governing water resources in Japan. Table 22.2 lays out the various water organizations.

Some examples of water management include some of the following elements.

- Water supply: in principle, municipal governments are responsible for water supply, but private sectors can participate upon authorizations from local municipal governments. Since April 2002, outside organizations, including the private sector, have been qualified to conduct technical works on the maintenance of water supply systems.
- Water for agriculture: 'Land Improvement Districts' are responsible for agricultural water use under the Land Improvement Act. The Land Improvement Districts are farmers' associations, and in principle each farmer pays maintenance fees.
- River administration: under the River Law, official river administrators own all rivers for comprehensive river management. The national government (Ministry of Land, Infrastructure and Transport) manages major parts of the 109 river systems. Local governments manage the rest. The river administrators are responsible for flood control, proper use of rivers and conservation of the fluvial environment.

Water rights

The water of Japan's rivers has historically been dominated by a large number of river users with vested water rights, conferring the right to use water, both public and private. With the development of human society and disputes arising over water rights, the need arose for a legal system to regulate water use. The Japanese water rights system was then altered, and the River Law, established in 1896 and which prescribes river management, was revised in 1964. Until then, it had focused only on flood control, and the revision provided a systematic framework for both flood control and general water use. Under this law, an official river administrator manages a basin under a unified and consistent system, and with it water becomes a public resource. In order to better cope with the expanded River Law, it has been necessary to seek conciliation with the prior vested interests: the 1964 revision attempts to modify the system while at the same time taking into account and maintaining

2. See web site at http://www.maff.go.jp/.
3. See web site at http://www1.gsi.go.jp/ch2www/marsh/part/list_4.html.

Table 22.2: Water governance in Japan

Affair	Organization	Sub-section	Main laws
Water supply	Ministry of Health, Labour and Welfare	Water Supply Division, Health Service Bureau	Waterworks Law Law on Execution of Preservation Project of Water for Water Supply
Water use for agriculture	Ministry of Agriculture, Forestry and Fisheries	Rural Development Bureau	Land Improvement Act
Water conservation forest		Forestry Agency	Forest Law
Industrial water supply	Ministry of Economy, Trade and Industry	Industrial Facilities Division, Economic and Industrial Policy Bureau	Industrial Water Law Industrial Water Supply Business Law
Hydropower		Agency of Natural Resources and Energy	Electric Power Development Promotion Law
Sewerage	Ministry of Land, Infrastructure and Transport	Sewerage and Wastewater Management Department, City and Regional Development Bureau	Sewerage Law
Rivers, water resource facilities		River Bureau	River Law Specified Multipurpose Dams Law
Comprehensive and basic policies for water supply and demand, reservoir area		Water Resources Department, Land and Water Bureau	Water Resources Development Promotion Law Water Resources Development Public Corporation Law Law Concerning Special Measures for Reservoir Areas
Water quality, environmental conservation	Ministry of the Environment	Water Environment Department, Environmental Management Bureau	The Basic Environment Law Water Pollution Control Law

the permission systems of the past (Water Use Coordination Sub-Division, Water Administration Division, River Bureau, MLIT, 1995).

Developing water resources

Water resource policies should be carefully promoted from a long-term and comprehensive viewpoint. The new 'National Comprehensive Water Resources Plan' ('Water Plan 21') clarifying the basic direction for the development, conservation and utilization of water resources was settled on in June 1999. This plan provides guidelines for examining various measures concerning water resources for the target years of 2010 through 2015, forecasting water supply and demand for that period. It cites measures against disasters such as the 1995 Hyogoken-Nambu earthquake, as well as the development of policies for conservation of and improvement in the water environment, and for the restoration and nurturing of water-related culture (National Land Agency, 1999). Under the national plan, basic plans for water resources development are established in major river basins, their aim being to reach a water volume of about 258 cubic metres per second (m^3/s) in the Tonegawa and Arakawa Rivers. In 2001, 64 percent of this target had been achieved (Water Resources Department, MLIT, 2001), but more is still needed to meet prospective water demand.

Dams are one of the major tools for water resource development: meeting the demand through river and groundwater intake alone became impossible. As previously mentioned, dams are built for several purposes including household water supply, industrial and agricultural water use, electricity generation and flood control. In April 2001, after improving the water resources development facilities, the total water storage capacity reached about 2.5 bm^3 (Japan Dam Foundation, 2002).

Compensation measures for upstream inhabitants

Before proceeding with the construction of water resource development facilities such as dams, it is important to reach an arrangement with inhabitants in reservoir areas that may suffer significant effects as a result of dam construction. Various measures were designed to mitigate negative effects suffered in reservoir areas and invigorate local communities, and a Law Concerning Special Measures for Reservoir Areas has been created for this purpose (Water Resources Department, MLIT, 2001).

Drought measures

Drought conciliation councils have been established in the Tonegawa, Arakawa, Tamagawa and Sagamigawa Rivers. The conciliation takes place among the water users themselves, while the river administrator offers necessary information at the initial stage of the process, presents drought conciliation proposals and facilitates the process. For example, the drought conciliation in Tonegawa River is characterized by integrated reservoir operation. The efficient operation of several dams as one and the same water system requires consistent management of all dams (River Bureau, MOC, 1997). The Tonegawa Drought Conciliation Council was established in 1970, and comprises the Ministry of Land, Infrastructure and Transport (MLIT), six prefectures and the Water Resource Development Public Corporation (Kanto Regional Development Bureau, MLIT).[4]

Using water effectively

Effective use of water resources does not generally require new large-scale facilities to relieve demand-supply gaps, and is also important in attenuating the effects of drought. One of the examples established in Greater Tokyo is the use of water such as treated sewage, recycled industrial wastewater, rainwater and other types of non-standard water resources. These are lower in quality, but provide for such purposes as toilet-flushing, refrigeration and cooling, and sprinkling (Water Resources Department, MLIT, 2001). Actions such as the construction of water-saving residences are promoted (MOC, 2000).

River improvement measures

Levee maintenance

Between 1991 and 2000, losses resulting from flood damage in Greater Tokyo amounted to about 900 billion yen (US$7.22 billion). The years 1991 and 1998 registered the highest losses, with more than 200 billion yen and a little under 200 billion yen, respectively (equivalent to US$1.6 billion). So far, levee maintenance and dam construction have been adopted as river improvement countermeasures. The levee improvement ratio went from 34.8 percent in 1985 to 45.9 percent in 1999 and, due to such improvements, flood adjustment capacity also increased, from 325 million m^3 (Mm^3) in 1985 to 685 Mm^3 in 2001 (Japan Dam Foundation, 2002; River Bureau, MLIT, 2001b; Japan River Association, 1986-2000).

Non-structural measures

Although the embankment works improved the degree of flood control safety, large flood damage was still a threat, as most of the population and assets are concentrated in the basins. Other measures were therefore necessary to reduce potential flood damage. Non-structural measures include flood warnings, announcement of flood protection measures and the preparation of inhabitant refuges (Arakawa Lower River Work Office, MLIT).[5] Moreover, flood hazard maps are made public to help inhabitants rapidly and efficiently find refuge. The hazard map shows each city's danger zone and the location of the refuge area, specifying access routes (MOC, 2000). With the changes in the rainfall pattern increasing flood risk, the Flood Protection Law was revised in June 2001. Measures such as flood forecasting and the securing of accessible refuges in danger zones were legally supported (MLIT, 2001b).

4. See web site at http://www.ktr.mlit.go.jp/kyoku/.

Managing the environment

With the urbanization of Greater Tokyo, environmental problems arose, such as deterioration of the river water quality, changes in the ecosystem and variations in the landscape. Investigations into water quality and the ecosystem were carried out so as to monitor the actual condition of the river environment.

Monitoring the ecosystem

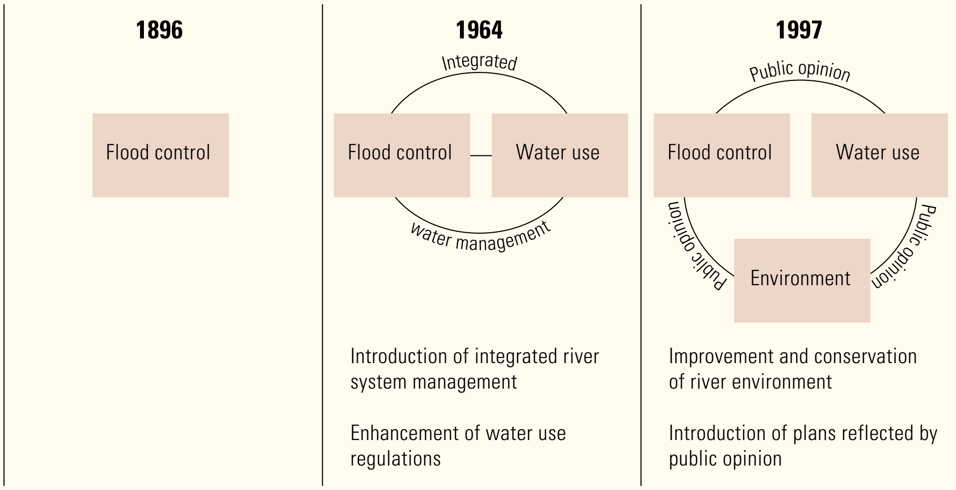
Local governments (prefectures and designated cities under the Water Pollution Control Law) carry out regular quality surveys of public waters. The waters covered by this survey include those to which Environmental Quality Standards (EQS) are applied. EQS for water pollutants are target levels for water quality to be achieved and maintained in public waters under the Basic Environmental Law (Ministry of the Environment, 2001). The 'National Census of Rivers and Watersides' is another one of the tools for monitoring the condition of the ecosystem. This census examines living conditions for fish and shellfish, benthic organisms, plants, etc., and human activities in rivers and waterside. The census started in 1990 in one hundred and nine class-A rivers (those rivers managed by the national government) and eighty dam reservoirs, and major class-B rivers (those managed by the local government) were added in 1993. The status of non-native species in rivers and dam reservoirs was also investigated (MOC, 2000). As mentioned previously, the River Law was revised in 1997. As well as the usual flood control and water use purposes, the concept 'maintenance and preservation of river environment' was included (see figure 22.4), (MLIT, 2002).[6]

Evaluating the environmental impact

In 1999, the Environmental Impact Assessment Law was implemented, and screening and scoping procedures[7] were

5. See web site at http://www.ara.or.jp/arage/.
6. See web site at http://www.mlit.go.jp/river/.
7. Scoping is the process by which a research plan is developed under the Environmental Impact Assessment Law. Screening is the process which determines the necessity of an Environmental Impact Assessment.

Figure 22.4: Revision of the River Law



Source: River Bureau, MLIT, 2001c.

introduced. The law also called for 'proper consideration of environmental preservation', including ecosystem and communication activities. Under this law, suitable environment preservation countermeasures are taken for the development of water resources and flood control facilities (Water Resources Environment Technology Center, 2001).

Improving the water quality

The Water Pollution Control Law establishes national effluent standards and authorizes more stringent prefectural standards to regulate wastewater discharged from factories and business establishments into public water bodies. The reinforced factory regulations have been effective in improving water quality, but problems with domestic effluent remain, especially in enclosed or semi-enclosed water bodies such as Tokyo bay (Ministry of the Environment, 2001). Sewage systems are one of the essential components for ensuring the quality of public waters. In 1999, 77 percent of people had access to sewage systems, and 97 percent received clean water through water service systems (Japan Sewage Works Association, 1973–2000 and Ministry of Health and Welfare, 1966–2000).

Public involvement in the river improvement plan

In addition to the preservation measures taken for the river environment, the river-planning system was radically reconsidered in the 1997 River Law revision because of rising concerns about environmental and regional needs for river improvement. By providing comprehensible information to the population and respecting their opinions, the planning process was effectively opened to public participation (MLIT, 2002).[8] In March 2001, the river improvement plan was applied first in the Tamagawa River basin, through various discussions with the inhabitants to gather their opinions, which were also collected through the Internet (Keihin Work Office, MLIT, 2002).[9] Such activities are actively conducted in other basins. For more details on the Tamagawa River Improvement Plan, see box 15.2 in chapter 15 on water governance.

Sharing information

Some database systems exist in Japan, notably the yearly report on water quality in public waters by the National Institute for Environmental Studies[10] and the water information system by the Ministry of Land, Infrastructure and Transport.[11] There are also several paper-based databases, such as *Water Resources of Japan* (Water Resources Department, MLIT, 2002), *Water Service Statistics* (Ministry of Health, Labour and Welfare, 1966–2000) and the *Report on Industrial Statistics (Industrial Land and Water),* (Ministry of Economy, Trade and Industry, 2002).

Greater Tokyo's catch-phrase, 'the water-aware country', refers to land in which any water-related information is collected, shared with the public and used in a practical way, with consideration given to different geographical settings. It contributes to water resource management, flood control and management of the environment.

8. See web site at http://www.mlit.go.jp/river/.
9. See web site at http://www.keihin.ktr.mlit.go.jp/.
10. See web site at http://www.nies.go.jp/index-j.html.
11. See web site at http://www1.river.go.jp/.

For watershed management, water information such as drainage and basin groundwater needs to be kept updated. People need higher quality services for river administration: downsizing administrative services, making river administrative services more efficient with proper information updating, privatizing some parts of services and simplifying contract procedures. In addition, river information, such as water quality and ecosystem data, has become more useful in education systems.

In 'the water-aware country', information technology is used to manage and share information efficiently. For example, when an area's flood safety degree can be calculated more precisely by information technology, human losses will be reduced through the combination of people reaching suitable refuge under proper guidance, and the river administrator's efficient operational facilities. River GIS also attempt to deal rapidly with water-related disasters, through such measures as structure maps, waterway figures, maps showing the placement of dangerous objects and a water database. To these ends, super-high-speed, big-capacity optical fibre networks are connected to the related organs in order to make the latest data in emergency situations available (Sato, 2002).

Fitting the Pieces Together

In densely populated Greater Tokyo, the water management policy can be considered a success in providing the population and industries with water, and many years of flood control efforts have reduced the total inundated area. Water resource development has focused on stabilizing river flow and meeting new water demands. However, the high concentration of people and industry makes this success fragile and risky. Flood damage has only slightly decreased, due to a higher concentration of population and property: access to a stable water supply has accelerated the rate of concentration and created a new demand for water. The need for water resource management has become more diversified. People are more concerned with the environment and nature. In addition to the water resources policy, it is necessary to establish more integrated river management suitable for sharing risk information and coping with this risk. The concept of risk management is consistent with the revised 1997 River Law, which calls for public participation and environmental consideration. The various policies relating to efficient water use will be evaluated, easily comprehensible water quality indicators developed, and a commitment will be made and enforced to restore the natural environment and to make information public. These are highly related to the participation of citizens and non-governmental organizations (NGOs) in water policy.

Managing risks

As a countermeasure to the high flood damage in Greater Tokyo, an easily comprehensible indicator showing the degree of risk of flood damage was developed and made public (Yasuda and Murase, 2002). The safety degree against flood damage can be expressed through a combination of the flood frequency and the inundation level. This two-dimensional aspect of floods renders it difficult to develop a single-dimensional indicator by which the risk can be expressed.

Figure 22.5 shows that the frequency of floods and the inundation level can be expressed by a colour and a height, respectively. The green represents low flood frequency while the red represents high flood frequency. Comparing the flood levels with the height of people and houses directly indicates a degree of safety against flood damage. Inter-temporal changes in the safety degree can also be expressed, as shown in figure 22.6.

Based on this, flood risk expression has been developed in Tokyo region. The index in the legend is the Flood Risk Indicator (FRICAT) employed in Japan for policy evaluation. The FRICAT represents how often the expected annual damage by flood is higher than that of fire. The average expected annual fire damage in Japan between 1998 and 2001 was 1,165 yen (approximately US$9.3) per person.

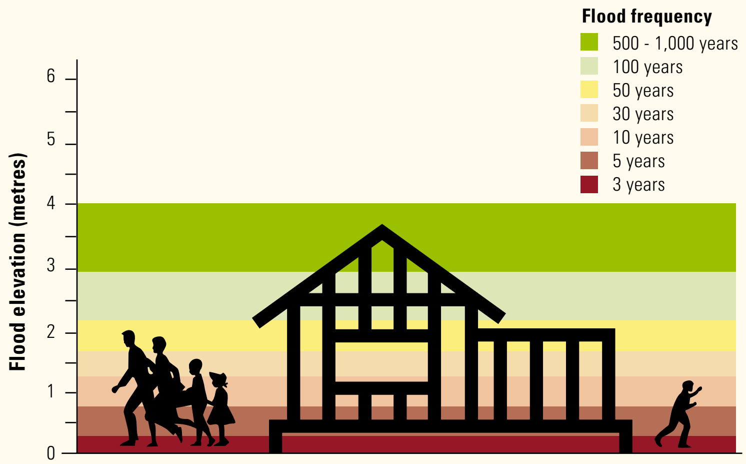
Improving water resource management

The tight water resources in Greater Tokyo must be carefully managed, as they have to meet the competing demands of a large population. It has become difficult to develop new water resources facilities such as dams. To further improve the water resource management system, an evaluation of the various policies for efficient use of the limited water resources is being carried out.

Integrated Water Resources Management (IWRM)

The combination of an increased concentration of population and industries, the expansion of urban areas, changes in industrial and social structures and changes in the climate, have all given rise to a variety of water-related problems in Japan. These include water shortages in rivers and groundwater and deterioration of the quality of water, as well as an increase in urban flood damage. The problems originate from changes to the hydrological cycle, such as a lack of infiltration or continuity between surface water and groundwater. Water authorities in Japan are divided among several institutions. In 1998, they reached an agreement on fundamental policy for restoring a healthy hydrological cycle. The policy advocates adopting an integrated water basin approach and sharing knowledge about the hydrological cycle, and encourages efforts to improve the situation in each basin. In addition, case studies were conducted in some rivers around Tokyo and Osaka to monitor and analyse problems.

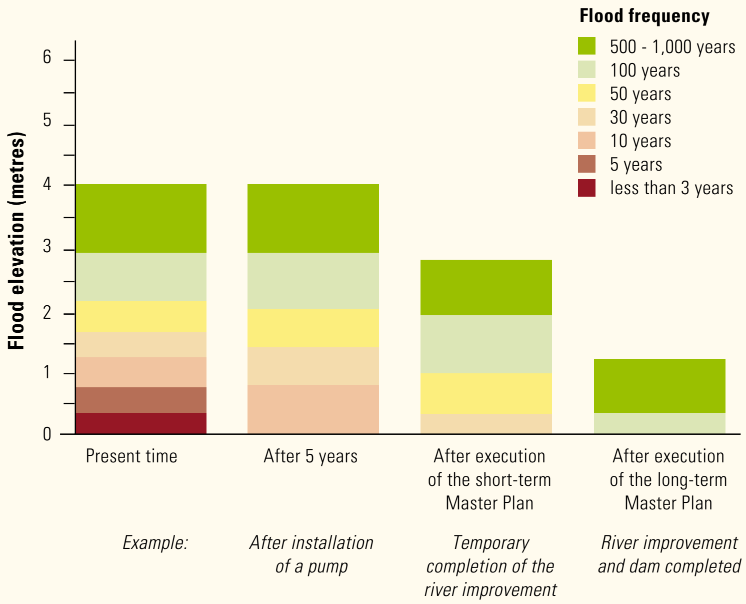
Figure 22.5: Expression of the safety degree



The frequency of floods and the inundation level can be expressed by a colour and a height, respectively. The green represents low flood frequency while the red represents high flood frequency. Comparing the flood levels with the height of people and houses directly indicates a degree of safety against flood damage.

Source: Yasuda and Murase, 2002.

Figure 22.6: Expression of the safety degree with a time variable



This figure shows how wise management can improve the safety degree against floods.

Source: Yasuda and Murase, 2002.

Use of existing facilities

As the construction of new water resource development facilities is becoming difficult due to the lack of suitable grounds, it is essential to use the already existent facilities as efficiently as possible (MOC, 1995). The Reorganization of Dam Groups is designed to redistribute the storage capacities of the existing dams by taking into consideration the particular features of each type of dam. This redistribution seeks to improve flood control and water use functions, that is, seeks to mitigate flood risk by enhancing the flood-regulating effect, and to improve the riparian environment by restoring the river's flow. The first project for this trial will start in the upper Tonegawa River (Improvement and Management Division, Bureau River, MLIT, 2001).

Upstream/downstream cooperation

Many Japanese cities have developed in downstream areas whereas water facilities were built upstream. People living in upstream areas worry about changes in their lives and jobs, and gain no benefit from the construction of dams, unlike downstream inhabitants. To deal with this problem, measures for the reservoir area development were taken, based on the Act on Special Measures for Reservoir Area Development implemented in 1974. In September 1999 however, a meeting about measures taken for this development highlighted the need for good management of water resources, and for the cooperation between authorities in upstream and downstream areas. In this meeting, the importance of basin management was also raised (MOC, 1999).

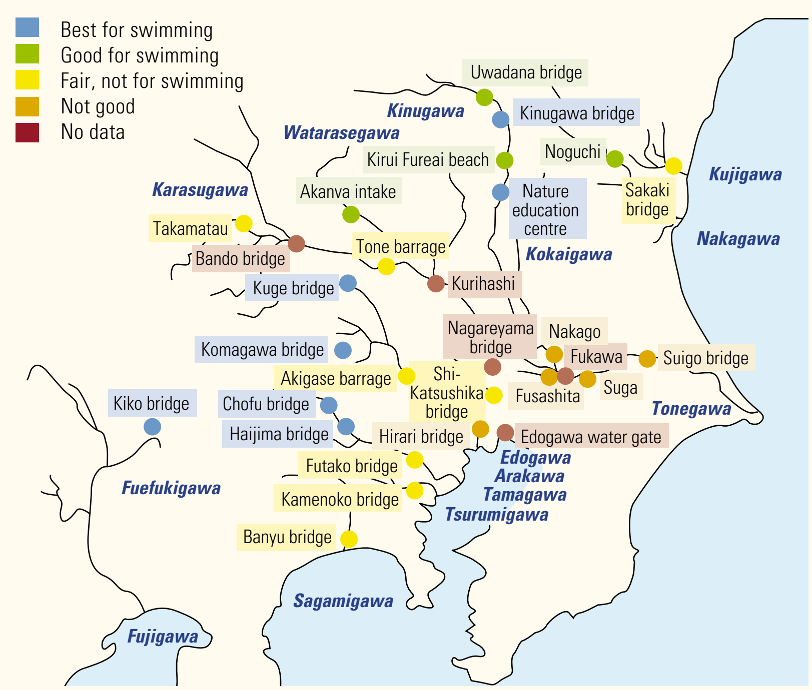
Coping with diverse needs

Protecting the natural environment and quality of water has become more important in water management. With people more involved in the water management process, it is necessary to make the process of improving the natural environment and water quality as transparent as possible, with full disclosure of all information. Also, with urbanization, many people have begun to search more actively for places to enjoy nature. More effort must be made to create communities where the places in which people work and live are integrated with a natural river environment.

Developing a water quality indicator

Existing indicators such as BOD levels cannot fully describe the present water condition. In 1998, a study was conducted in the five rivers of Greater Tokyo for the development of easily comprehensible indicators to monitor the water quality conditions, and new indicators are being developed (Kanto Regional Development Bureau, MLIT, 2002). The river administrator proposed indicators through the Internet and collected opinions from the public (see map 22.3). Comprehensibility of indicators is considered important, and the study emphasized and proposed indicators based on three aspects: people's relationship with water, rich biodiversity and drinking water.

Map 22.3: Proposed new water quality indicator for recreational use



This proposed water quality indicator clearly and efficiently shows the public which areas in Greater Tokyo are suitable for recreational use.

Source: Kanto Regional Development Bureau, MLIT, 2002.

Project for nature restoration

To cater to the population's diverse needs, especially with regards to the natural environment, projects for nature restoration have been implemented. These include the restoration of river meandering, improvement of riverside woods and the restoration of wetlands by frequent flooding, for better habitats along rivers. Such projects are being applied all over the country (Prime Minister of Japan and His Cabinet, 2001). The restoration project of dried wetlands started in the Watarase retarding basin of Tonegawa River (River Bureau, MLIT, 2001c).

Non-structural measures of risk mitigation

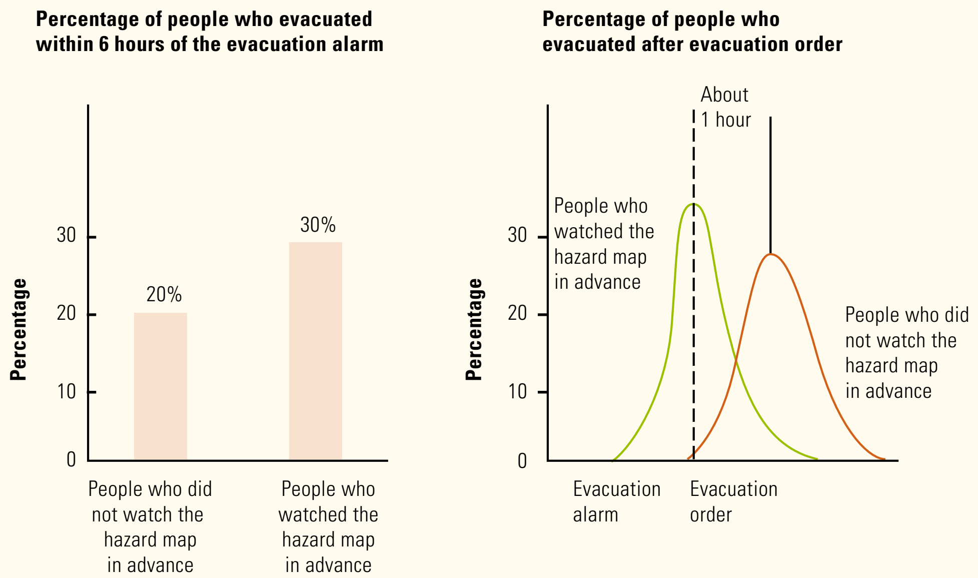
Water resource management includes 'hard' and 'soft' management. A hazard map is one of the tools for soft management; it enables people to prepare for disasters and evacuate promptly. Figure 22.7 shows the effect of hazard maps. There is a clear difference between people who watched the map in advance and those who did not. Efficient and comprehensive soft management measures, such as hazard maps, are ensured by the information systems. In Japan, the river administrator processes and provides information to governmental agencies and local residents so that appropriate river management and flood defence measures can be taken.

Conclusions

Greater Tokyo houses one of the world's largest populations and industrial spreads, much of which is set on flood plains and other high-risk areas. In order to mitigate flood damage and to ensure a better quality and security of life in the metropolis, the government of Japan has invested large amounts of money in new technologies, structural measures and greater public information services. Development of comprehensible indicators has also been one of the main priorities in the region. Water is of varying quality in the five rivers that make up Greater Tokyo, with BOD levels sometimes significantly above recommended standards. However, as both this and other environmental matters become increasingly important in the public eye, more and more efforts are being made to control any potential problems.

Greater Tokyo is an area where the public has found a voice in matters of the environment, as the population is frequently consulted and involved through discussions, meetings and media such as the Internet. Although the region faces many challenges, including floods and droughts in a great many urban areas with millions of yen worth of assets, the development of such initiatives as have already been implemented feasibly meets and overcomes many of the challenges that lie ahead.

Figure 22.7: Effect of hazard maps on public safety



Public awareness of the hazard maps significantly increases safety during floods: 50 percent more people made it to the refuge areas after having watched the map.

Source: Katada Laboratory, 2001.

Box 22.1: Development of indicators

Establishing indicators based on clear criteria is essential for future assessment. The Greater Tokyo case study team proposed the following six criteria: relevance, cost, comprehensibility, clarity, continuity and social benefit (Yasuda and Murase, 2002). The indicators proposed by the World Water Assessment Programme (WWAP) are discussed in the following table. Some indicators are too vague to be calculated.

Challenge areas	Greater Tokyo indicators
SURFACE WATER	• Average water use/water resources normal years: 44%; drought years: 66% • Precipitation inland parts: 1,549 mm/year Precipitation seaside parts: 1,535 mm/year
WATER QUALITY	• Pollutant load in Tokyo bay (not whole basin) was 286 tons/day in 1994. • Biological oxygen demand (BOD): Tonegawa: 1.8 mg /litre Arakawa: 4.4 mg/litre Tamagawa: 2.6 mg/litre Tsurumigawa: 10.4 mg/litre Sagamigawa: 2.1 mg/litre
GROUNDWATER	• Dependence on groundwater inland parts: 22.8% seaside parts: 13.1% • Groundwater withdrawal: northern part of Kanto plain: 960 million m^3 • Degree of dependence of households on underground water: 18.7%
PROMOTING HEALTH	• Number of houses with sewage: 12,052,059 • Percentage of houses with water supply: 97.3% • Investment in water supply: 778,098 million yen • Investment in sanitation: 2,732,671 million yen
PROTECTING ECOSYSTEMS	• Urbanization rate: 13.0% (1974), 20.2% (2000) • Percentage of wetlands: 0.11% • 1 Ramsar site (Japan has 11 sites)
WATER AND CITIES	• Water supply: 97.3%; sanitation (sewage): 76.9% • The basic total pollutant load control system is being applied to Tokyo bay, not the whole Tokyo region. • Pollutant load from household wastewater in Tokyo bay was 167 tons/day in 1999.

Challenge areas	Greater Tokyo indicators
WATER AND CITIES	• Comprehensive flood control measures are implemented through the establishment of the Council for comprehensive flood control measures for individual river basins and through the formulation of basin development plans that include improvement of the environment.
SECURING THE FOOD SUPPLY	• Self-sufficiency ratio in food (all Japan data for 1999) • Self-sufficiency ratio in calorie supply: 39 • Self-sufficiency ratio in staple food cereals: 58 • Self-sufficiency ratio in cereals: 26 • No data at regional level. • Volume of virtual water import: 43.86 bm^3/year.
WATER AND INDUSTRY	• Industrial use of water by total developed water in Tonegawa and Arakawa basins: 25.4% (2000) • Amount of manufactured goods shipped (yen)/amount of water used (m^3): 6,092 yen/m^3 • Ratio of recycled water use: 85.4% • Basic total pollutant load control system is being applied to Tokyo bay, not the whole Tokyo region. • Pollutant loads from industrial wastewater in Tokyo bay was 52 tons/day for 1999.
WATER AND ENERGY	• Amount of annual output/capacity of dam plant for generation of electricity: 9.0 kWh/year/m^3 • The amount of water use for cooling/ amount of water used for industry: 78.9%
MANAGING RISK	• Number of people living within 100-year flood area in Arakawa basin: 2,148,360 people
SHARING WATER	• Industry: 15.4% • Agriculture: 66.1% • Households: 18.5% • Formal policy exists. In addition, drought conciliation are held to conduct a constant water supply during drought.

Box 22.1: *continued*

Challenge areas	Greater Tokyo indicators
VALUING WATER	• Water rate per household: 2,316 yen/month (1999, all Japan) • Water rate per capita: 861 yen/month (all Japan) • No available data on water use by amount of income. • Percentage of water charge/average income: 0.4% • Percentage of water charge/average consumption expenditure: 0.7% • Effective storage capacity of dam/population: 60.3 m^3/capita • Effective storage capacity of dam –flood control storage/population: 49.2 m^3/capita
ENSURING KNOWLEDGE	• Effective computerized system of hydrometeorological data collection exists. • Most data are maintained on local government bases, not on basin-wide. • For transparency, a disclosure law was enacted in 1999, and effective database systems have been developed.
GOVERNING WISELY	• Amount of water resources investment/ population: 3,334 yen/year (2000, all Japan) • Various comprehensive policies such as basin management exist. • River Law exists, revised in 1997. • Institutional cooperation for healthy hydrological cycle started in 1998 (e.g. the River Improvement Plan)

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