Water Resources in Japan and the development of IWRM in Kiso River

1. Water resources in Japan

1.1 Water resources development in Japan

(1) Climate

Japan is situated in Asia Monsoon Area. The average annual rainfall is approximately 1,700mm, which is about twice the world average of 970mm. Converting this amount into that per capita, however, yields a volume of approximately 5,100m^3/year, which is only about one-fourth the world average of approximately 22,000m^3/year. This means Japan has less water resources compare to other countries.

Japan has geographical features of steep terrain and strip-shaped land, and rivers have small catchment areas with steep incline. Therefore, fluctuations in river flow are dramatic, increasing rapidly when it rains and decreasing rapidly after the rain. Seasonal fluctuations in river flow largely depend on the time of the year, increasing during the snow melting season from April to October, rainy season and typhoon season.

Transition of rainfall fluctuations in past 100 years shows decreasing trend of the average annual rainfall; especially it has been decreasing sharply since around 1970. In addition, fluctuations between extremely little rain and extremely heavy rain have been increasing in recent years.

(2) Water resources development

Municipal water needs to be supplied from rivers at a constant rate throughout a year regardless of fluctuations in river flow. However, water resources had been mainly developed for irrigation for rice cultivation in Japan, and irrigation water had a priority to be supplied when river flow was less. Therefore, there were needs to construct water resources facilities such as dams in order to have stable domestic water supply.

The purpose of water resources development is to regulate river flow by storing water in dams when river flow is large and discharging it when river flow is small so that water supply can be stable throughout a year. Additional amount of water which dams provide is called the water resources development volume.

There had been constructed 600 multi-purpose dams and 1,600 single purpose dams for agricultural, domestic and industrial water in Japan. These dams supply approximately 16.6 billion m^3 of water annually, enabling stable water supply for domestic and industrial use. At present, 30 billion m^3 of water is used for domestic and industrial water, of which 70 % rely on river water. The water resources development volume accounts for 77% of water intake from rivers, and 55% of municipal water usage. Of domestic water used in Kanto coastal area, where large population and economic activities are centered, 90% of water taken from rivers are equal to the water resources development volume.

1.2 The legal system on water resources management in Japan

The River Law was enacted in 1896 as a basic law on river management. It was thoroughly revised in 1964 and amended in 1997. The law sets the purpose of river management, classification of rivers, river administrators, water rights, river improvement plans and so on.

The legal system has been promoted with a center focus on the River Law in response to a change in social environment such as economic development, urbanization, and pollution problems. Laws on integrated water resources management had been consolidated by 1960s with rapid economic growth and urbanization in the background, and laws on pollution issues and environmental conservation has been developed since 1970s.

(1) Water Resources Development Promotion Law

Water Resources Development Promotion Law was enacted in 1961 for the purpose of securing water supply for regions with demanding needs along with the industrial development and population growth, and promoting rationalization of integrated development and utilization of water resources in river streams in order to contribute to nation's economic growth and better life, as well as protecting and cultivating water sources. The law sets to designate river systems for water resources development and formulate the Basic Plan for Water Resources Development.

(2) Water Resources Development Basic Plan

Based on the Water Resources Development Promotion Law, seven river systems, which needed broad-based water supply as industry developed and population increased, have been designated as river system for water resources development. Water Resources Development Basic Plan was formulated to promote integrated water resources and water utilization.

This plan covers approximately 17% of the national land, however, these areas are home to 51.3% (2002) of the total population and 46.7% (2000) of industry.

The plan includes forecasting water demand, setting targets of water supply, and constructing the necessary facilities, rationalizing integrated water resources development and utilization.

The plan has been revised in accordance with changes in economy and society.

2. Development of Integrated Water Resources Management in Kiso River System

2.1 An outline of Kiso River System

(1) An outline of Kiso River System

Kiso River System consists of Kiso River, Nagara River and Ibi River, so-called Kiso-sansen (Kiso Three Rivers). These rivers nearly merge at estuaries and then flow into Ise Bay. The Kiso-sansen, which used to flow in meshed pattern around estuaries, often flooded and caused serious damage to people's lives in the past. Flood control works had been taken since late 19th century, and these rivers were formed into three as they are at present.

Total basin area of the Kiso-sansen is approximately 9,100 km^2, accounting for 26% of total area of four prefectures (Nagano, Gifu, Aichi, and Mie) through which rivers run. Details of each river of the Kiso-sansen are shown in Table-1.

The average annual rainfall of the Kiso-sansen differ from place to place; 2,131 mm at Makio Dam, upstream of Kiso River; 2,005 mm at Chusetsu, midstream of Nagara River; 3,049 mm at Fujihashi, upstream of Ibi River.

Table-1 Details of the Kiso-sansen

	Kiso River	Nagara River	Ibi River	Total
River basin area (km^2)	5.275	1,985	1,840	9,100
Mountain area (km^2)	4,917	1,470	1,382	7,769
Plain area (km^2)	232	445	404	1,081
Total length of main stream (km)	227	166	121	514

Basins of the Kiso-sansen are the third urbanized and industrialized regions, covering Nagoya Metropolitan Area, which has population of approximately 2.2 million, and Chukyo Industrial Zone, which is famous for textile and automobile industries. Development of these regions has been highly supported by abundant water resources of the Kiso-sansen.

(2) History of water resources development of Kiso River System

Kiso River runs through fertile Nobi Plain, and its water has been utilized mainly for agriculture for many years. The oldest record describing rice cropping in Nobi Plain dates back to the third century BC. Kiso River used to run in meshed pattern through Nobi Plain, and its water was utilized for agriculture. A great flood in 1586 formed river channels, which became prototypes of present the Kiso-sansen. Development of irrigation canals at left bank of Kiso River began when flood damage was mitigated due to the large-scale embankment work at left bank in 1954 and its reinforcing work in 1608. Three irrigation canals were developed, and approximately 1,000 ha of new field were also developed in 1600s.

Development of irrigation canals at right bank of the river began after the flood control project implemented in late 19th century. The first full-scale irrigation canal was Hashima Canal, which was completed in 1932.

Since it was difficult to supply river water to rice paddies situated above Kiso River, having no other rivers and lakes, rainwater was the only water source in the area. During 1950 and 1955, local farmers constructed pump stations to pump water from Hida River, a tributary of Kiso River, as well as irrigation canals.

The first conduit type power station was constructed to meet power demand in urban area and to fill power shortage caused by urbanization and industrialization in late 19th century. There have been 58 power stations constructed along Kiso River generating a total power of approximately 2.16 million kW.

Development of water facilities for domestic and industrial water in the area began with an intake from Kiso River to Nagoya for domestic use in early 20th century. Although there was increasing demand for industrial water along with rapid economic growth in 1960s, ground water was supplied for it rather than river water from Kiso River. Over pumping of ground water resulted in ground settlement across Nobi Plain, caused approximately 1.5 m of subsidence in downstream of Kiso River. Restrictions on pumping ground water were imposed in 1960s and 1970s, then water source was switched from ground water to river water.

(3) Needs for integrated development in Kiso River System

Kiso River has been supplying water to Nagoya since 1913. As population grew in the city, new facility for intake was built at Kiso River in 1939. Population of Nagoya and surrounding municipalities continued growing along with economic progress, and water demand also increased. It was difficult for the region to find a new water source for domestic use other than Kiso River. Irrigation water for rice paddies has been taken from Kiso River for a long time; therefore, water resources development such as constructing dams was necessary to ensure water source for domestic use in the region. The regional government adopted an integrated water resources management plan, which enables to enhance efficiency of water by constructing dams and canals, for basin's versatile development.

(4) Aichi Canal

Aichi Canal Project was designed to supply water for irrigation, domestic and industrial use to Chita Peninsula and Eastern Owari region, where water shortage was major problem, in late 19th century when modernization and industrialization were in progress. The project became a dead issue once as social situation changed; however, the construction of canal was launched in 1955 and completed in 1961 under strong pressure from local residents.

This was the first large-scale integrated water resources development project in Japan, whose purposes were irrigation and land development for utilizing water resources of Kiso River as well as providing domestic and industrial water to 38 municipalities both in Gifu and Aichi.

The purpose of constructing Aichi Canal was to develop the region covering Gifu, plain area of eastern Nagoya and Chita Peninsula, in an integrated manner using water resources of Kiso River efficiently. The project includes irrigation, domestic water, industrial water and power generation projects.

The project was also the first water resources development project in Japan to have foreign currency on loan. Aichi Canal Public Corporation (present Japan Water Agency) steadfastly undertook the whole project, while it was common that various entities, such as national and local governments and local residents, were involved and worked separately for one project. The project was completed in five years, which was relatively short, and shortened work period highly increased efficiency of investments. Early completion of the project attributes to establishment of Aichi Canal Public Corporation as the only implementing body with power and control, investing long-term

fund efficiently, putting large number of construction machinery, as well as rationalizing designs and construction methods and improving economic efficiency by introducing latest technology.

Water for Aichi Canal comes from Makio Dam, located at upstream of Kiso River and whose effective storage capacity is 68 million m^3. Water is taken from Kaneyama Intake and distributed to beneficiary area through the main canal, whose total length is 112 km; the branch canal, whose total length is 1,012 km; and two regulating reservoirs.

The total project expense was 42.2 billion yen, and it was financed by borrowing in Japanese and foreign currency. Japanese yen was from the government such as national grant and foreign currency, which equals to 1,449 million yen, was from International Bank for Reconstruction and Development (World Bank). The borrowing from World Bank was spent for getting technical aid and importing construction machinery.

Since the project was for multi-purpose, the project expense was borne by national and local governments, local beneficiaries as well as utility companies.

Aichi Canal was planned to distribute water for irrigation use at the volume of 28.600 m^3/s (30,700 ha), for domestic use at 1,007 m^3/s (6 cities and 15 towns, design population served is 2.8 million), for industrial use at 0.693 m^3/s (Southern Nagoya Coastal Industrial Area), and for power generation at13.6 million kWh/year.

(5) Kiso River System Water Resources Development Basic Plan

Local administrative agencies related to water resources management in the Kiso-sansen region and municipalities discussed about measures needed for formulating permanent provision for water utilization and implementing integrated water resources management with total comprehension of the Kiso-sansen, and "Kiso-sansen Water Resources Development Plan" was formulated in 1965.

Kiso River System was designated as a river system for water resources development in 1965 based on Water Resources Development Promotion Law. Kiso River System Water Resources Development Basic Plan was formulated in 1968, fully adopting Kiso-sansen Water Resources Development Plan.

Forecasting water demand and setting targets of water supply for the long-term in Nagano, Gifu and Aichi are included in the Basic Plan in consideration of social trends.

The Basic Plan has been changed as follows: Water Demand and Supply Plan, Kiso River Canal Project, Mie Canal Project, Nagaragawa Estuary Barrage Project were adopted in 1968; Water Demand and Supply Plan was amended, and Agigawa Dam Project, Tokuyama Dam Project, Misogawa Dam were adopted in 1973; Aichi Canal Stage II Project was adopted in 1982; Water Demand and Supply Project was amended, and Nagara Canal Project was adopted in 1993; Kiso River Canal Facilities Reconstruction Project was adopted in 1996; Tokuyama Dam Project and Kiso River Canal Facilities Reconstruction Project were amended in 1997.

At present, overall review of Water Demand and Supply Plan, which have been changed along with the change of social trends, are on progress considering conditions with high possibilities of drought due to climate change.

Aichi Canal has made enormous impact on the region. Comparing the data in 1963, when right after the Project had completed, and 2000; value of agricultural crude production became approximately 2.81 times larger from 25,566 million yen to 71,810 million yen; water supplied population became approximately 6.21 times larger from 195,000 to 1,212,000; shipment value of manufactured products became 12.96 times larger from 325.9 billion yen to 4,224.4 billion yen. Such development is attributed to utilization of water resources of Kiso River under Integrated Water Resources Management (IWRM).

3. Japan Water Agency

3.1 Role and Activities of Japan Water Agency

Japan Water Agency (former Water Resources Development Public Corporation) was established in 1962 under the Water Resources Development Promotion Law to implement water resources development projects based on basic plans prepared for river system in urgent need of extensive development, in order to enhance economic activities and improve the living standard of the people in Japan.

Japan Water Agency has been constructing many large-scale dams, estuary barrages, water level controlling facilities for lakes and marshes and water channels to help promote water utilization and flood control in seven major river systems (Tone, Ara, Toyo, Kiso, Yodo, Yoshino, and Chikugo) designated as river systems for water resources development, as well as to manage completed facilities.

The feature of Japan Water Agency is to implement multi-purpose and large-scale projects from the beginning of development to operation and management of completed facilities in a comprehensive and integrated manner.

Japan Water Agency is the only agency with advanced technologies and broad experiences on dam and canal projects, implementing projects while coordinating with various stakeholders including related ministries and agencies, prefectural governments and water users.