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6. Water Management Under Monsoon Climate in Asia: A Case Study of Japan

Yutaka Takahasi & Rajiv K. Gupta

1.0 Introduction

The scope of Monsoon Asia covers the territory of the countries from Pakistan through India, Myanmar, Sri Lanka, Thailand, Indonesia, Vietnam, Cambodia, Laos, Eastern China, the Philippines, Korea and Eastern Asia. It includes less than a seventh of the world's cultivated land. Japan is located at the Northeastern end of Monsoon Asia and has experienced remarkable change of hydrological cycle, during more than 100 years of rapid modernisation and urbanisation. Though most of Japan is in the temperate monsoon zone, the climate is diverse as the archipelago extends approximately 3,000 kilometres from north to south and consists of four main islands and other over small 4,000 islands.

The modernisation history of Japan since the end of 19th century and after the Second World War is an extraordinary story even in view of the hydrological changes. This paper seeks to describe the strategy of water resources development since the period after the Second World War which may be a valuable lesson to developing countries in Monsoon Asia where active development is expected in this century.

2.0 Precipitation and Climate

Monsoon Asia is generally characterised by plenty of precipitation and high humidity. Shown in Tables 1 and 2, the annual precipitation in so many cities in Monsoon Asia exceeds 2,000 mm.

Table 1. Annual Precipitation in Cities Except Japan (mm)

Chittagong	2812.4
Mumbai	2099.0
Colombo	2373.0
Hong-Kong	2223.0
Yang on	2426.1
Kuala Lumpur	2343.8
Singapore	2171.5
Ho Chi Min	1872.2

Table 2. Annual Precipitation in Several Cities in Japan (mm)

Sapporo	1129.6
Takada	2880.3
Tokyo	1405.3
Owase	4001.4
Kyoto	1581.1
Miyazaki (Kyushu)	2434.6
Kochi (Shikoku)	2582.4
Naze (Okinawa)	2870.7

Severe precipitation records are presented in Tables 3 and 4. Those torrential rainfalls are recorded mainly at the time of typhoon-passing and the rainy season from June to July. These two kinds of severe rainfall and the heavy snows in Northern Japan are responsible for major share of the flood damage, and have been particularly worrisome for rice-farmers since the beginning of Japanese history. Nagayo and Kobutsu case at the end of July 1982, shown in Table 4 brought severe damages in Nagasaki Prefecture recording 299 persons death.

Still each of the aspects of the climate is, in its own way, a natural blessing; the rains are indispensable to a good rice crop and the precipitation that comes in the form of typhoon rains and heavy snows makes an invaluable contribution to water resources in Japan.

Table 3. Maximum Daily Precipitation (mm)

City	Precipitation	Month/Day/Year
Hiso (Tokushima)	1,114	9/11/'76
Saigo (Nagasaki)	1,109	7/25/'57
Odaigahara (Nara)	1,011	9/14/'23
Shigeto (Kochi)	989	9/24/'98
Zenki (Nara)	976	9/13/'54

Table 4. Maximum Hourly Precipitation (mm)

City	Precipitation	Month/Day/Year
Nagayo (Nagasaki)	187	7/23/'82
Kobutsu (Nagasaki)	183	7/23/'82
Fukui (Tokushima)	167	3/22/'52
Fujinomiya (Shizuoka)	153	8/24/'72
Ashizuri (Kochi)	150	10/17/'44
Yamaguchi(Tokushima)	147	7/5/'72
Hakone(Kanagawa)	146	8/3/'38
Shinomisaki(Wakayama)	144	7/25/'57
Saigo (Nagasaki)	141	7/25/'57
Omura (Nagasaki)	187	7/25/'57

The four seasons are clearly divided which is a remarkable peculiarity in Japan. The socio-hydrological condition, deriving from clearly distinct four seasons, is one of the reasons creating Japanese water-related culture and literatures [1].

2.1 Rivers

Johannes de Rijke, a Dutch engineer hired during the Meiji era (1868-1911) had exclaimed, "rivers in Japan are like water falls". They are short and steep and flow rapidly and violently. The ratio of peak flow discharge to basin area is comparatively large ranging from 10 times to as much as 100 times that of major rivers of other nations. The river regime coefficient - the ratio of the maximum to minimum discharge - is between 200 and 400 which is 10 times larger than that of continental rivers (Figures 1 & 2). The water level rises and falls very quickly and the volume of sediment runoff is large.

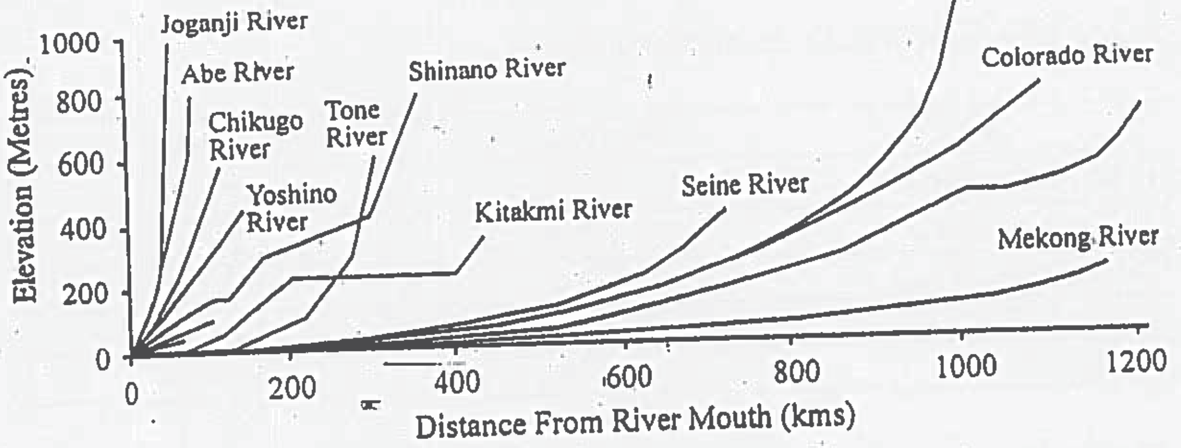


Figure 1. Rivers in Japan Flow Directly From Mountain to Sea. This Comparison With Selected Rivers Shows how Precipitously They Flow

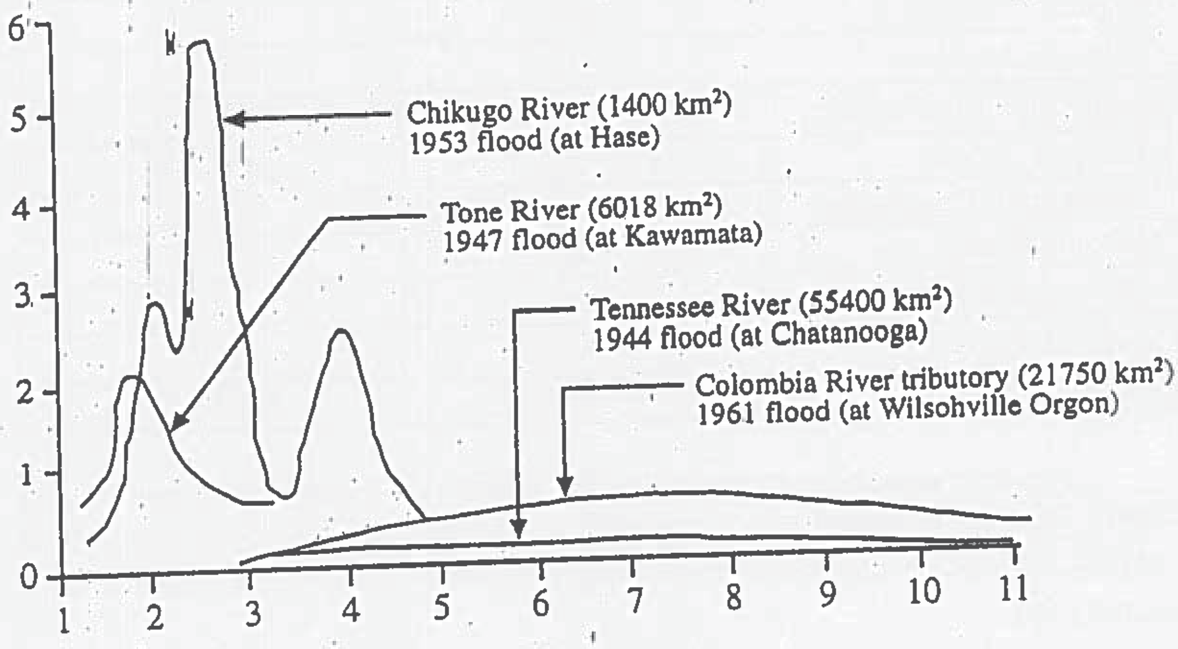


Figure 2. Floods in Japan act Like Sprinters – Short & Quick

3.0 Monsoon Asia as Rice-Producing Societies

Since the 1920s, many studies have been conducted on regional geography and socio-economic variables in Monsoon Asia, mainly by geographers, economists, sociologists and hydrologists. They have concluded that only rice-producing societies can sustain high-density populations with a result of rice cultivation (Dobby, 1966; Yoshino, 1999). In other words, rice production is most suitable cultivation for Monsoon Asia, and water use system in paddy fields is well adapted to natural hydrological cycle in this area. Over 80% of rice in the world is produced in Monsoon Asia. Amount and the percentage of the rice production in Monsoon Asian countries are shown in Table 5.

Table 5. Amount of Rice Production and the Percentage to World's Total Production (1998)

	Amount of Production (million tons of unhulled rice)	Percentage to World's Total Production
China	192.97	34.3
India	122.24	21.7
Indonesia	48.47	8.6
Vietnam	29.14	5.2
Bangladesh	28.29	5.0
Thailand	23.24	4.1
Myanmar	16.65	3.0
Japan	11.20	2.0
The Philippines	8.55	1.5
U.SA	8.53	1.5
Brazil	7.31	1.4
R.O.Korea	7.31	1.3
Pakistan	6.58	1.2
Egypt	5.58	1.0
Nepal	3.64	0.6

12 countries among the largest rice producing 15 countries are in Monsoon Asia. The life-style and the culture itself in Monsoon Asia have deep relation with the water management in paddy fields, based on abundant and variable precipitation. Paddy fields play an important role in flood control by reserving the rainwater, recharging the ground water and the ecological role in a kind of wetland.

4.0 Decrease in Rice Consumption in Japan

The daily diet in Japan has traditionally been considered as consisting of staple items of food supplemented by subsidiary items. Rice has long been the staple, and vegetables, fish etc. the subsidiaries. However, the crop rate and the rice consumption recently are decreasing in Japan, as shown in Tables 6 and 7. Since 1970, the area of paddy field is decreasing.

Table 6. Annual Rice Crop and the Planted Area

	Crop (10,000 tons)	Planted Area (1,000 ha)
1950	965	3,011
1960	1,285	3,308
1970	1268	2,923
1980	975	2,377
1990	1,049	2,074
1999	917	1,788

Table 7. Annual Consumption of Rice per Person per day

Year	Amount (gms.)
1921-25	391.1
1950	301.6
1960	314.9
1970	260.6
1980	216.3
1990	191.9
1998	178.5

After the Second World War, bread became part of the diet. With the growth of the economy, there was also a great upsurge in the consumption of different kinds of meat and dairy products. With the diversification in the daily meals, the consumption of rice has been decreasing. The decrease in paddy fields means the undesirable change of the hydrological cycle, which has been keeping the water equilibrium and the water related life-style.

5.0 Modernisation and Hydrological Cycle in Japan

In the process of modernisation and urbanisation, during more than one hundred years in Japan, the hydrological cycle has changed rapidly both in flood time and low water season. It should be noted that the remarkable rate of modernisation and the economic growth since the end of the 19th century was influenced largely by massive scale of flood control works. The rapid land development in 20th century necessitated large-scale river improvement works with continuous levee systems, because the agricultural development, the industrialisation and the urbanisation were concentrated in alluvial plains which were prone to inundation.

Before the end of the 19th century, any countries in Monsoon Asia did not plan such a large-scale flood control projects because it had been considered nearly impossible to control the huge floods by even the advanced technology. In principle, they considered the best way to manage big floods was to co-exist with floods, that is, they did not live and plant the important crops in areas which were prone to inundate. The flood control projects at the end of 19th century in Japan were the first and ambitious action plans in Monsoon Asia. Practically, the large-scale flood control projects mainly included continuous levee systems, cut-off works at meandering river course, artificial floodway, construction of reservoir etc. in order to protect rice fields, industrial and urbanised areas. In other words, the main strategy was to flush out the flood flow toward the river mouth as quick as possible.

Almost all flood control works of important rivers were completed around 1930s. As a result of these works, the productivity of farmland, mainly rice fields rapidly increased without severe flood damage and the extent of regularly flooded areas in the middle and downstream reaches of important rivers diminished remarkably. Unfortunately, after the Second World War severe and frequent storm-rainfalls were caused at the passing of extraordinary strong typhoons and inflicted heavy damages. Especially the Bay typhoon in 1959, which is often compared with the 1953 big storm-surge in the Netherlands, lashed the coast of the Ise-Bay, including Nagoya, killing more than 5100 inhabitants. In this period, almost all of the important rivers in Japan experienced breaking of levees, victimising thousands of people annually. Therefore, the river works focused on flood damage control projects and the construction of multipurpose projects advanced all over Japan.

It is also important to note the emergence of an unusual type of flood disaster in newly urbanised areas during this period. The soaring population in large cities and their suburbs was an impetus to urban development, claiming lowland areas along the river course, marshes, and paddy fields which served as natural reservoirs during heavy storm-rainfalls. The first of this new type of flood disaster occurred during the Kanagawa Typhoon in 1958 in a newly-urbanised area in Tokyo. In the 1950s and 1960s when Tokyo's population spiralled, housing became an urgent problem and residential areas could not control extension of their boundaries to low land or near river courses, where the land was vulnerable to inundation.

Due to remarkable shift of population and social assets into urban areas since the period of high economic growth began in the 1960s, urbanisation has expanded in places with a high risk of disasters near lowland marshes, alluvial plains and cliffs (Figures 3 & 4). Due to increase in property values, flood damage density has risen sharply. Relentless urbanisation and sub-urbanisation has been impairing the retention and detention capabilities of nature. As a result of this, floods concentrate in a shorter time span and in a greater quantity and intensity.

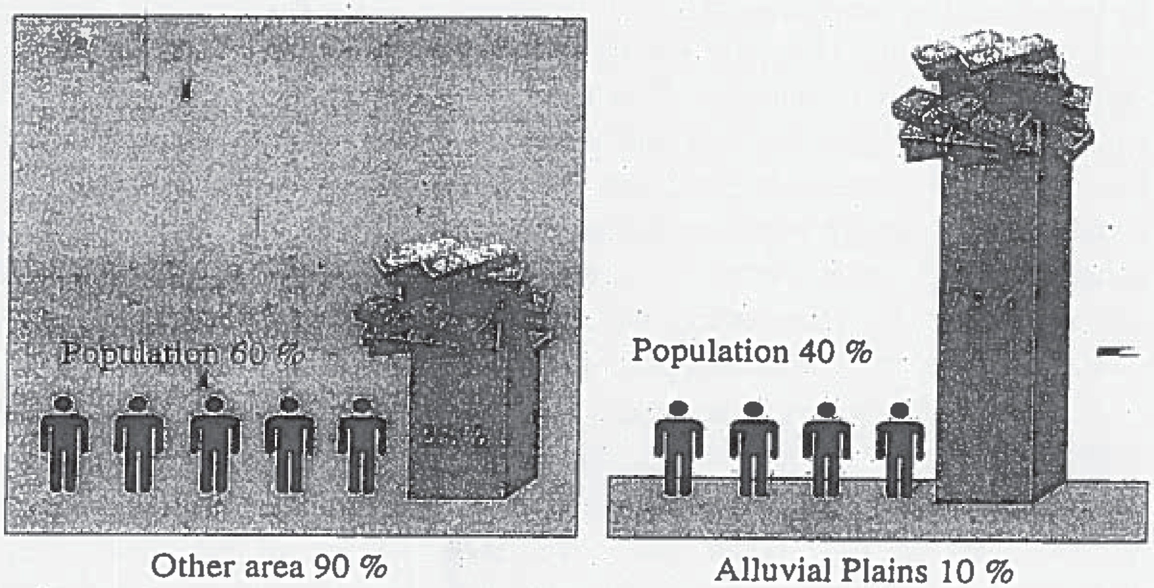
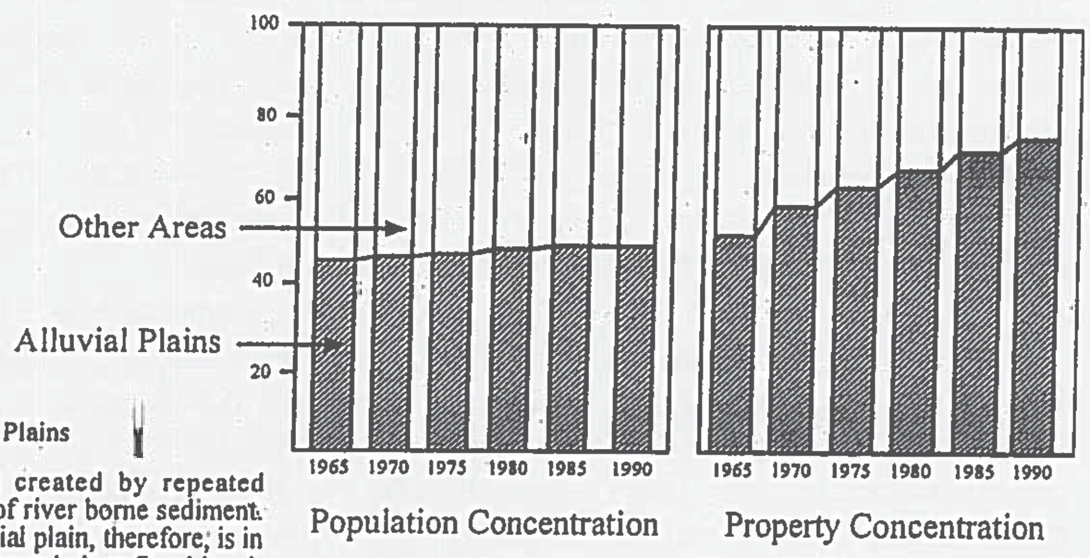


Figure 3. Comparison of Population and Property on Alluvial Plains



Alluvial Plains

A plain created by repeated deposit of river borne sediment. An alluvial plain, therefore, is in many places below flood level.

Figure 4. Damages due to Flood

It must be noted that almost all urbanisation emerged from vast paddy fields which acted as natural reservoirs in Monsoon Asian areas, not only in Japan, but in other countries as well. It is possible that the countries in Monsoon Asia whose population will increase rapidly from now, will be suffering from severe new-type of flood damages in newly developed and urbanised areas, if the countermeasures against the predicted flood damages are not taken. In other words, urbanisation in these regions has led to more reduction of the flood-retention capacity than anywhere else in the world. During the high economic growth period, which corresponded with the time of rapid urbanisation in Japan, this type of flood disaster spread from large cities to the surrounding areas and local central cities where population growth lagged behind that of large cities.

6.0 Extraordinary Story on Water Management After the Second World War in Japan

6.1 Water Problems due to Heavy Industrialisation and Urbanisation

After the severe flood damage period from 1945 to 1959, Japan entered the water shortage period from 1960 to 1972. A high economic growth period marked the latter half of 1950s when a large section of the Japanese population migrated to urban areas. Though this spurt in Japan's economy was made possible because the labour population from farm and forest areas was attracted to urban and industrial areas, this also led to a rapid increase in water demand in the urbanised areas, especially in great cities as such Tokyo, Yokohama, Nagoya and Osaka and the industrial zones along the Pacific coast due to the increase in urban population, changes in life style, growing number of nuclear families, the emergence of round the clock urban activities, modern industrial advances specially heavy chemical industries (Figure 5).

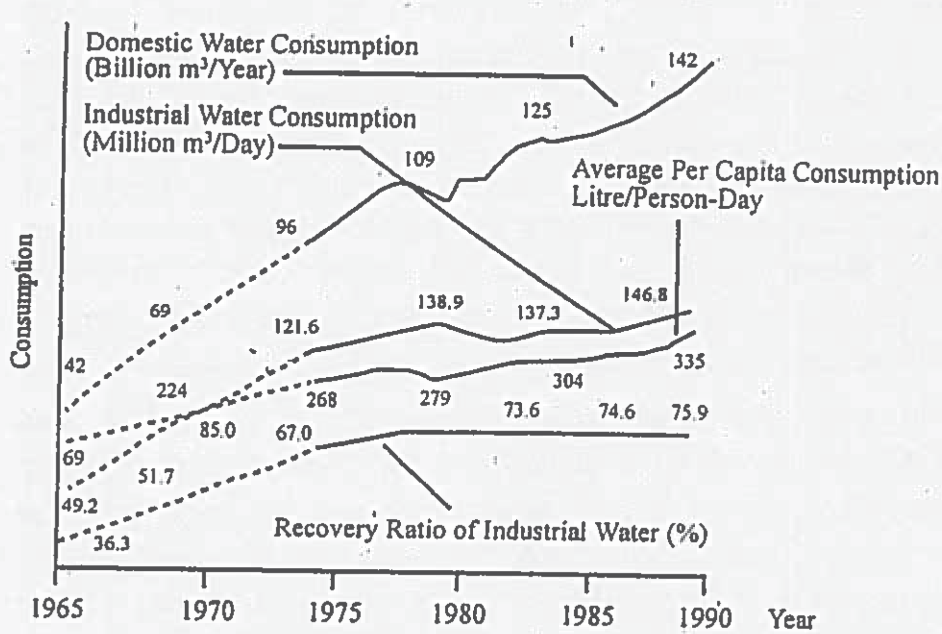


Figure 5. Trends of Water Consumption

Owing to severe increase in water demand in new industrial zones and big cities where the growth rate of population became rapid, there were water shortages everywhere in Japan during this period (Takahashi, 1993). A representative case of water shortage in important cities was the severe water deficiency experienced in Tokyo in summer 1964, just before the Tokyo Olympic Games, which was the first in Asia. The reasons for this shortage were low precipitation in the rainy season, rapid increase in water demand far beyond the predictions, and delayed development of water resources. In fact, they were anxious as to how to transport water to Tokyo including water for swimming pools, new hotels etc. for the Olympic Games.

6.2 Developments in Late 1960s

River Administration in Japan

The comprehensive river administration in Japan aims at following objectives.

I. Control river flooding;
II. Ensure availability of water for irrigation, domestic and industrial use;
III. Creation and conservation of river environment.

Japan has to its credit a very detailed River Law (Figure 6) and comprehensive administrative set-up to implement this law (Figure 7). Two agencies viz. River Bureau in Ministry of Construction and Water Resources Development Corporation (WADREC) play key role in this. River Systems deemed important for the national economy and people's lives are designated as "Class A River Systems" (Table 8), to be administered by Ministry of Construction. The others are designated as "Class B River Systems" to be administered by prefectural governors. In Japan, the entitlement to the use of river water is subject to a system known as "Water Rights". There are two types of rights, "Permitted Water Rights" and "Customary Water Rights". Permitted Water Rights are granted by the River Administrator to the water users in pursuance of the River Law, while Customary Water Rights are awarded to river water users whose usage goes back to a time before the River Law was established (in 1896). Users with Customary Water Rights are obliged to notify to the River Administrator details of their water usage such as the purpose for which river water is used, the quantity used, the conditions of usage and the intake position on the river. The majority of Customary Water Rights are for agricultural irrigation water. At present, Customary Water Rights account for roughly 60% of the water rights for agricultural water use. Since 1960s, there has been an increasing demand for domestic and industrial water and the conciliation of water rights in times of drought has become an important issue.

Due to these situations rules were established trying to protect the established Customary Water Rights and adjust water use under the New Water Law that came into effect in 1964. The Amended River Law of 1997 incorporated further measures to conciliate water use with no conflict in extreme droughts.

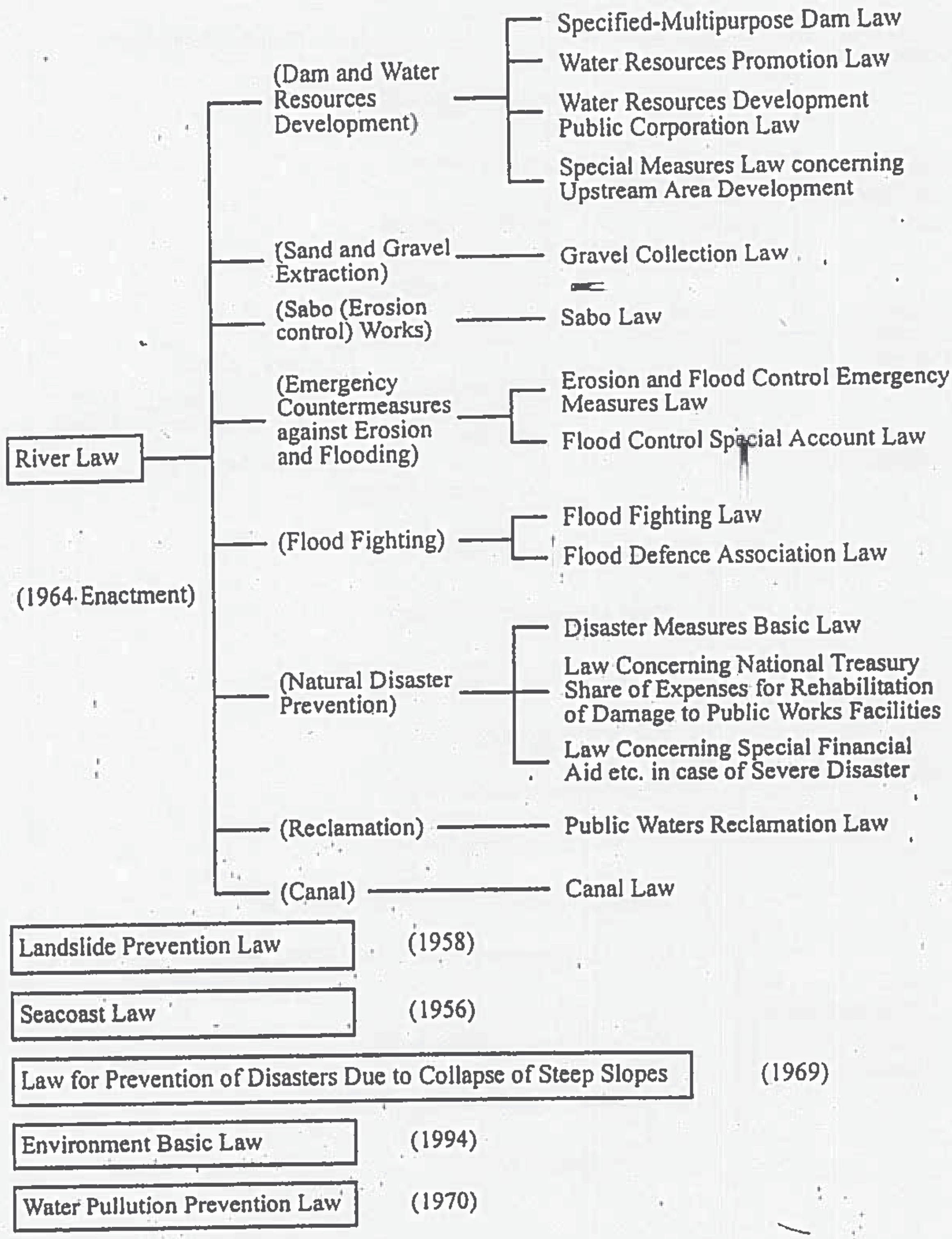
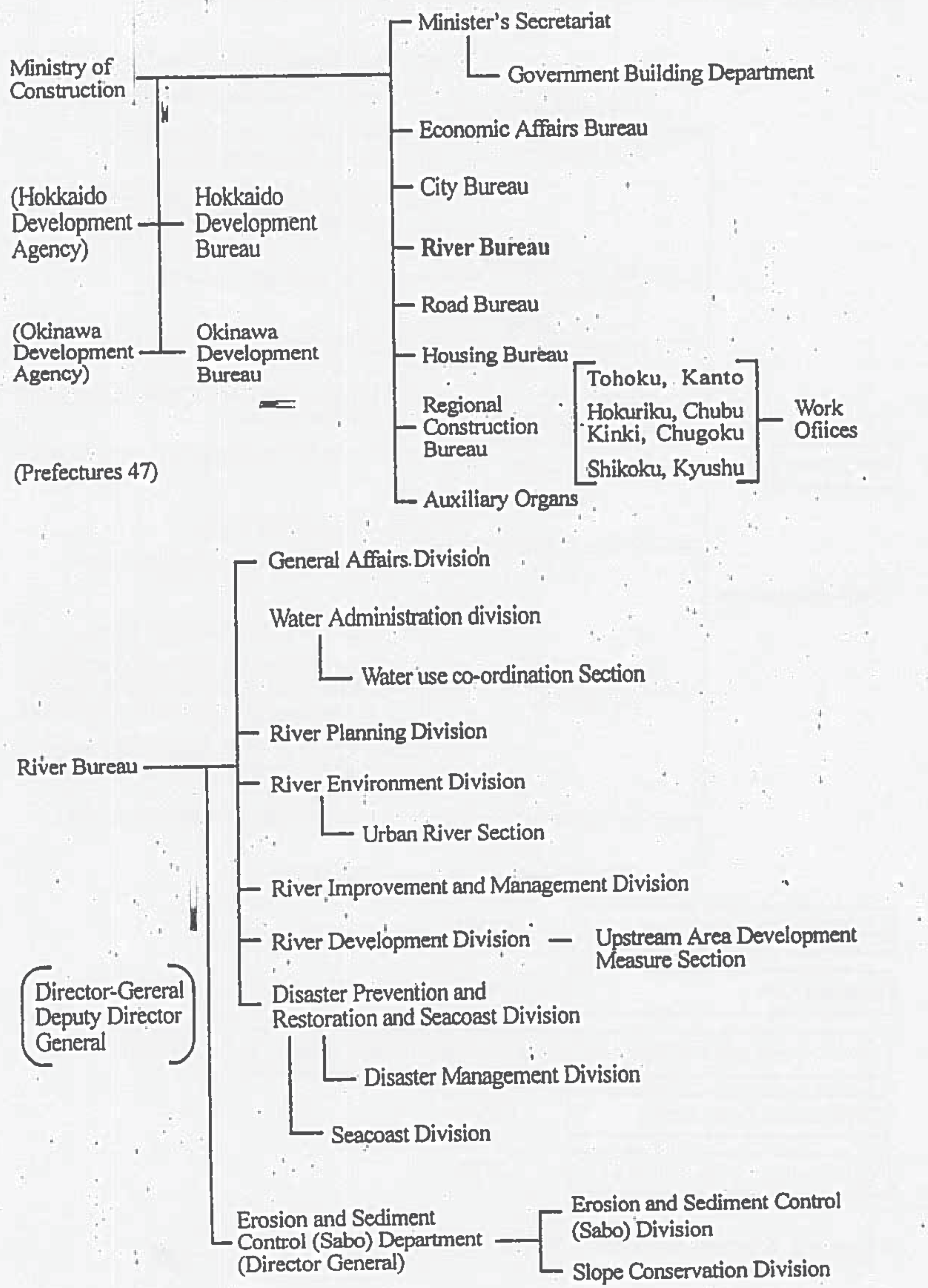


Figure 6. Statutes Related to River Administration



Note: This figure explains the administrative set-up before the reorganisation affected sometime back.

Figure 7. Administrative Set-up

Table 8. Class A (Major) Rivers in Japan

River [1]	Catchment (Area Km ^{2})	** Total Length of Main Stream Channel (KM)	Observation Point	Catchment Area Upstream of Observation Point (Km ^{2})	Discharge (m^3/s)			Observation Period
					Mean Annual	Maximum	Minimum	
Tone [tohnay]	16,840	322	Kurinashi	8,588	190	1,207	68	1938-92*
Ishikari	14,330	268	Ishikari Bridge	12,697	520	4,482	99	1954-92
Shinano	11,900	367	Oliya	9,719	451	2,094	23	1951-92
Kitakami	10,150	249	Tome	7,684	252	1,788	252	1952-92*
Kiso	9,100	227	Inuyama	4,684	211	1,984	67	1951-92*
Tokai	9,010	156	Moiwa	8,277	206	2,938	45	1954-92
Yodo	8,210	75	Hirakata	7,281	210	2,308	58	1952-92
Agano	7,710	210	Maoroshi	6,997	328	2,200	59	1951-92
Mogam	7,040	229	Takaya	6,271	296	2,446	64	1959-92*
Teshio	5,590	256	Maruyama	4,685	223	2,302	57	1971-92
Abukuma	5,400	239	Tateyama	4,133	112	2,389	42	1956-92
Tenryu	5,090	213	Kashima	4,880	190	1,054	65	1938-92*
Omono	4,710	133	Tsbakigawa	4,035	194	1,765	67	1938-92*
Yoneshino	4,100	136	Futatsui	3,750	183	1,609	28	1956-92*
Fuzi	3,990	128	Kitamatuno	3,536	47	619	0[2]	1960-92

(1) Class A rivers whose catchment area is 2,000 Km^2 or more, whose main stream channel length is 100 km and for which continuous discharge observation data are available. Discharge values are 1992 data.

(2) Rounded the actual value to the nearest figure.

(3) Others

* Data obtained during the observation period are not completely continuous.

** The length of the channel which has the greatest discharge. In Japan, this is roughly the same as the length of main stream.

6.3 Dams

Therefore, dams in Japan are an integral part of a holistic scheme designed to provide sustainable water supply and mitigate flood damages. The other components are widening of channels and embankments, creation of detention basins and floodways, city inundation countermeasures like underground discharge channels, water reservoir and storm sewers, construction of high standard embankments (super levees) etc.

As of 1997, there were a total of 2,620 completed dams and 559 under construction (Table 9).. Ministry of Construction, River Bureau and Water Resources Development Corporation mainly undertake multipurpose dam projects (Table 10). Seven river systems (Tone, Toyo, Kiso, Yodo, Yoshino, Ara and Chikugo) have been designated for water resources development by WADREC by way of constructing dams, estuary barrages (both for storing river water and prevention of salinity incursion to create brine free fresh water zone), canals etc. These dams have ensured the supply of water throughout the year. In the event of extraordinary drought, water is supplied first by ordinary dams and then, as water use is co-ordinated, by low flow augmentation dams. Inter-basin water transfers are planned to mitigate water shortages in water scarce areas. Small capacity dams with a copious in-flowing water volume in a large river basin are linked with the large capacity dam with a small in-flowing water volume in a small river basin by creating an interconnecting waterway to store water that is used in drought situations by inter-basin transfer through specially created water conveyance channels. The effectiveness of dams in controlling floods in Chikugo basin area has been studied by National Land Agency. A flood in 1953 caused serious damages in Chikugo basin. However, due to Matsubara and Shimouke dams completed after that, the damages caused by 1979 flood was much smaller than the 1953 flood (Figure 8).

Table 9. Status of all Dams in Japan

	Completed	Under Construction	Total
Number of Dams	2,620	559	3,179

Table 10. Profile of Dams Which Ministry of Construction is in Charge (1998)

Items \ Jurisdiction	Ministry of Construction	WARDEC	Local Governments (Subsidised Projects)	Total
Number of Completed Dams	87	23	282	392
Number of Under Construction Dams	95	15	185	295
Effective Capacity (Million m^3)	3,715	3,716	2,847	10,278
Flood Control Storage (Million m^3)	2,048	1,883	1,368	5,299
Maximum Station Output (1000 KW)	5,510	690	2,550	8,750

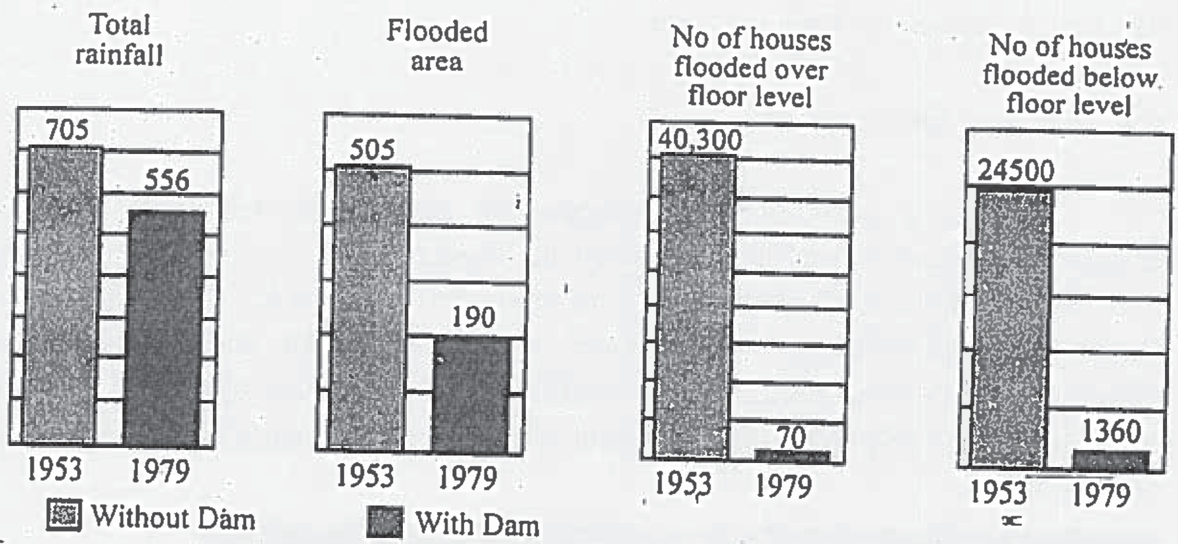


Figure 8. Flood Control Effect of Matsubara and Shimouke Dams

In case of Gosho dam in Kitakami river basin, it has been studied (Shoshi & Inoe, 2000) that as a result of the improvement of safety against flooding, some flood prone areas of Kitakami river became available for human activities such as residence and industry. There was almost 25% increase in the population of Morioka City, located in the downstream area and the industrial trade of the city also sharply increased from 59 billion Yen in 1980 to 247 billion Yen in 1995.

Recently, a Follow-up System Related to the Management of Dams and Other Structures as a Post Project Appraisal System has been established by River Bureaus. It involves conducting of surveys by Regional Construction Bureau about operation of dams, impact of surrounding environment and on regional societies and to suggest measures for future improvement by monitoring sub-committees (Figure 9).

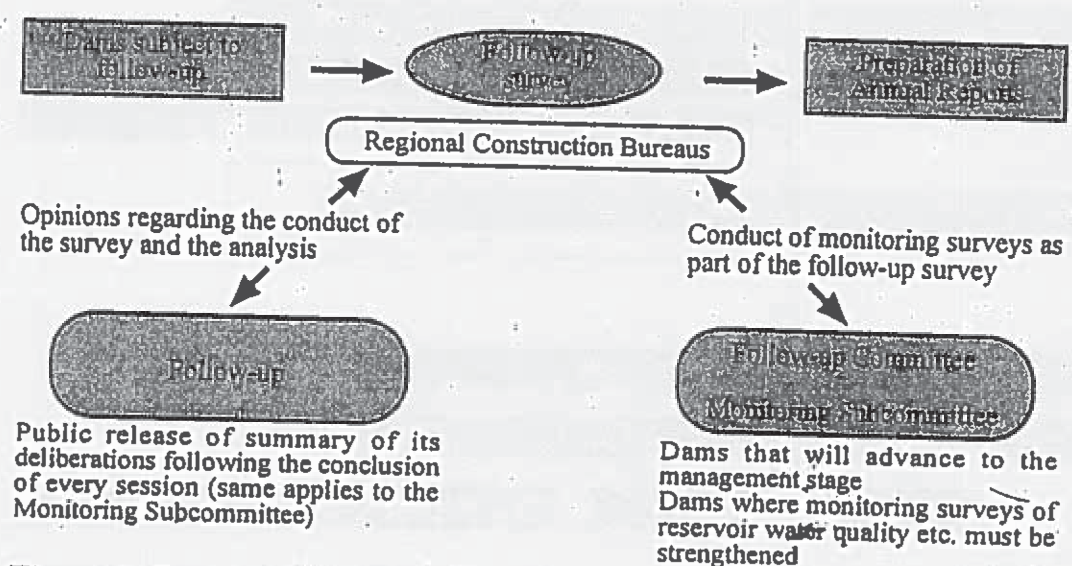


Figure 9. Outline of the Follow-up System

6.4 Dams and Environment

There is a very elaborate process for making environmental impact assessment in case of multipurpose projects (Figure 10). It involves consultation with local people, local government, environment agency etc. It also includes 'environment in cultural scientific side', namely all human activities in areas where a multi-purpose dam is to be constructed. The possible impact of dam on the composition of population, economic activities etc. are studied by simulation techniques etc.

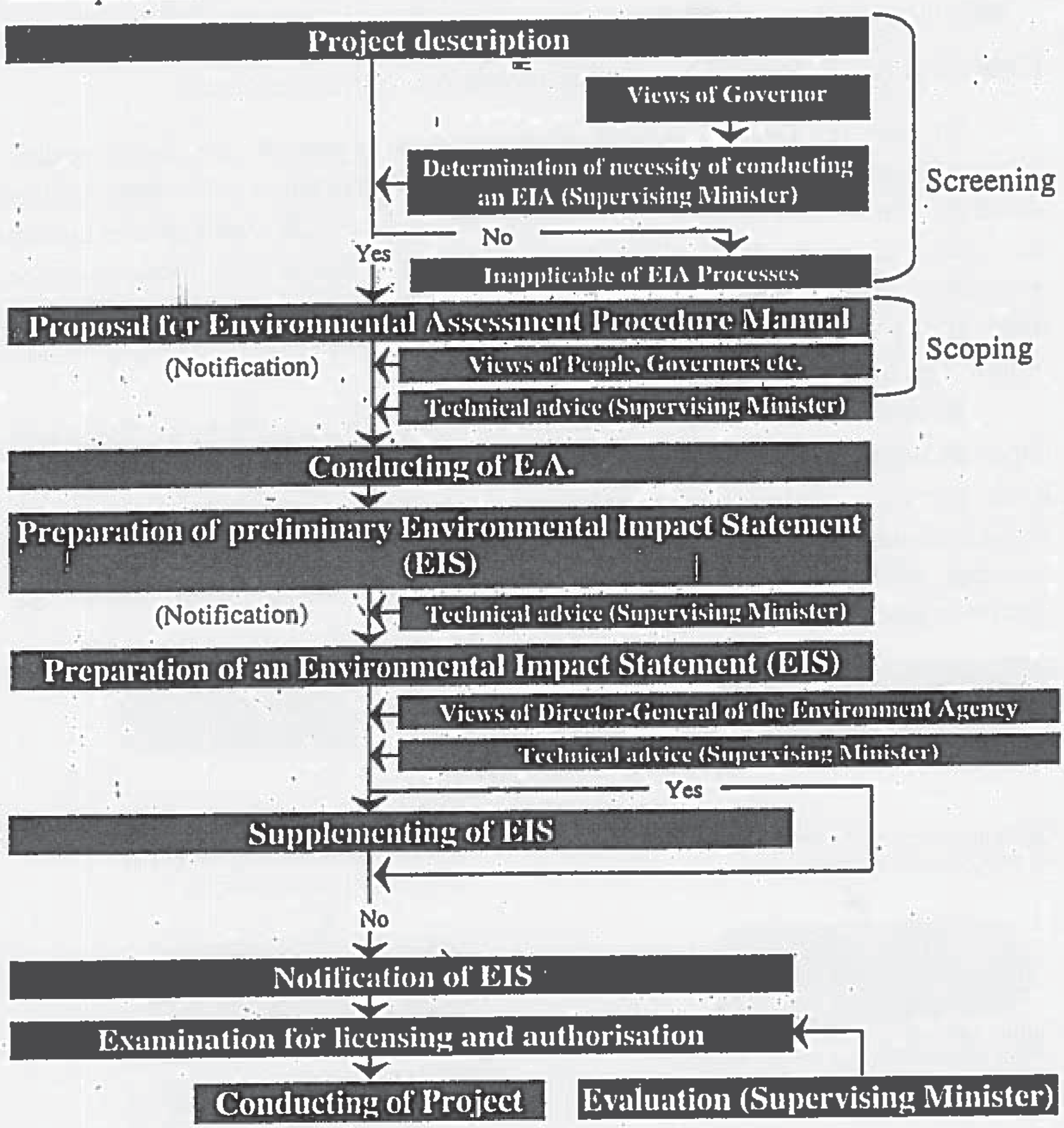


Figure 10. Procedure Flow of Environment Impact Assessment (EIA)

Special efforts have been made in completed schemes for conservation of rare species of birds like Golden eagle, Hodgson's hawk eagle, Goshawk etc., restoration of seed fields to support wildlife, construction of fishway[2] to suit various species, preservation of water quality[3], afforestation around the reservoir and plantation on the reservoir slope and provision of recreational facilities such as sports fields, waterside parks, walkways and observation platforms etc. Detailed surveys are also carried out for monitoring the effectiveness of environmental measures undertaken as part of follow-up system (Figure 11).

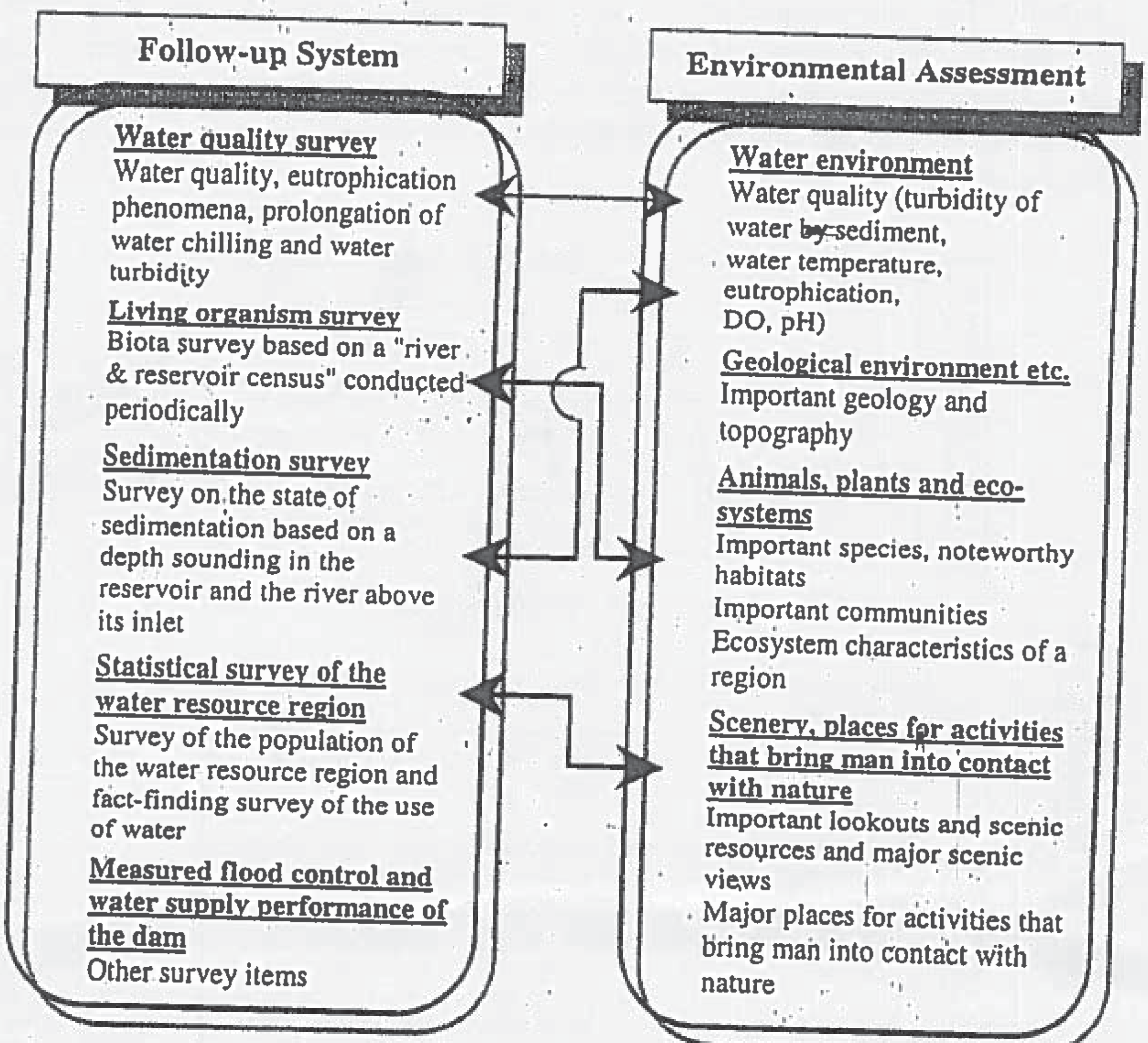


Figure 11. Follow-up System and Environmental Assessment

The 1997 amendment of the River Law laid down a framework for comprehensive river improvement plan with full local participation (Figure 12). The Ministry of Construction conducts a "National Census on River Environment" and various other environmental and land use surveys for a regular and continuous assessment of the State of environment of rivers and of the flora and fauna living in and around them. These censuses include six types of studies, including fish and plant studies and investigations into the river characteristics such as rapids and deep water and the patterns in which the river space is being utilised. The results of these surveys are reconciled with the views of the local residents and of academic experts and are used in devising the "Master Plans for River Environment Management", which lay down basic policies for the comprehensive and systematic implementation of projects relating to conservation and creation of river system environment with a rich bio-diversity in the river as a habitat and breeding ground for wildlife; achieving a sound water cycle; and re-establishing the relationship between the river and its region.

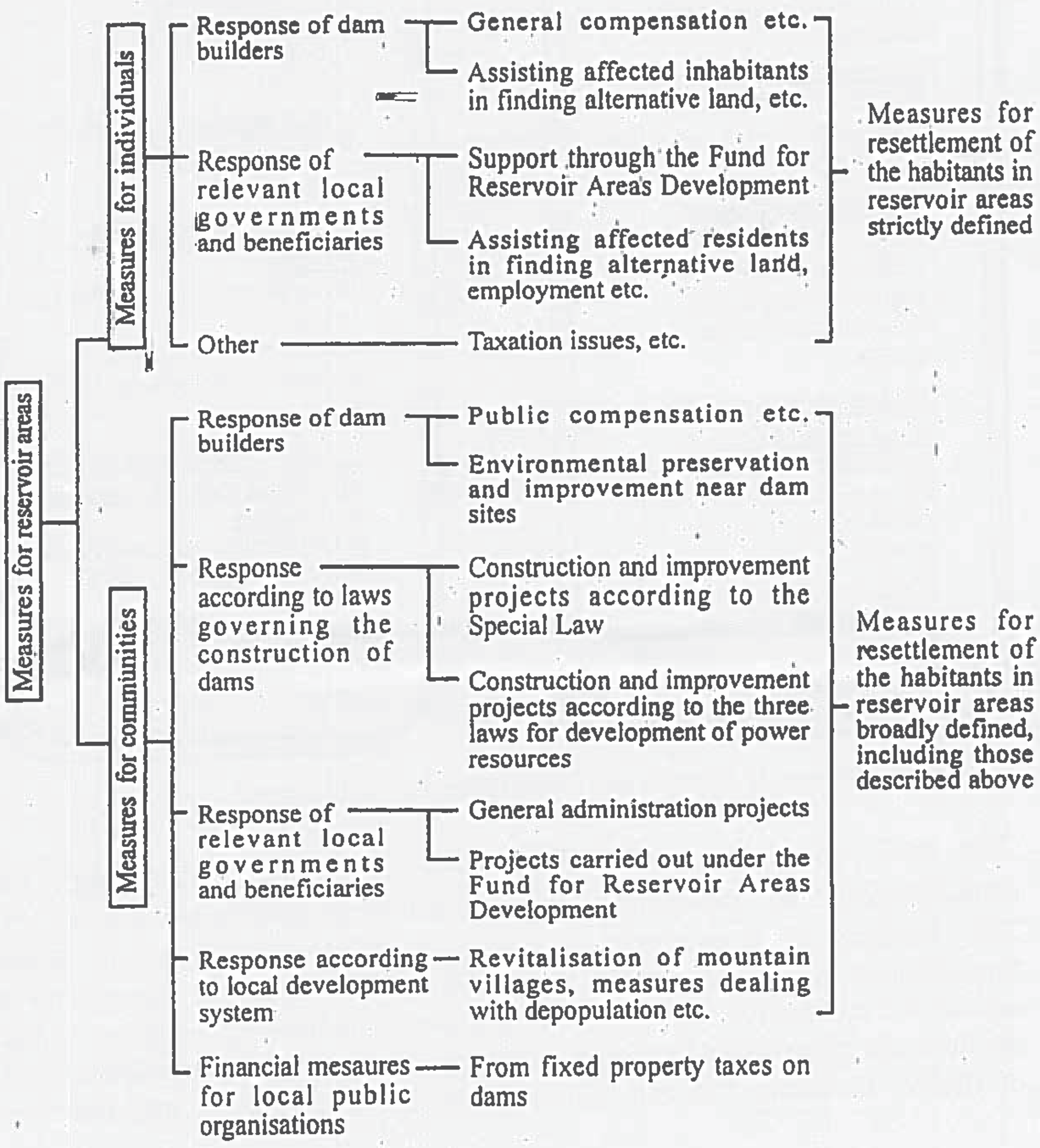


Figure 12. The 1997 River Law Amendment Makes Incorporation of Local Opinions a Mandatory Pre-requisite

Under the "Home Town Rivers" projects, support is given to municipalities for creation of an attractive and culturally sophisticated community seamlessly blending with river space development and thereby restoring the importance of rivers as community symbols. Diverse environment has been created by creation of groins on large rivers while the lower water channels of small rivers have been made to meander in order to create pools and rapids thereby providing habitats for plants and animals. *Emergency Action Plan for Improvement of Water Environment (Clear Water Renaissance 21)* aims to improve the water environments of rivers, lakes and dam reservoirs which have particularly adverse effects on the environment of drinking water. "Learn rivers" education programme provides experimental learning at a river, a learning ground for nature studies, the construction of river museums[4] and so on and thereby heightens the interest in river and its environment among young and old. Nature Symbiosis Research Centre[5] has been founded to establish sound principles and methods for man's symbiosis with natural river and lake environment. Another effort lending sustainability to environment is erosion control against sediment disasters and landslides connected with typhoons, torrential rains and volcanic eruptions[6].

6.5 New Environmental Awareness

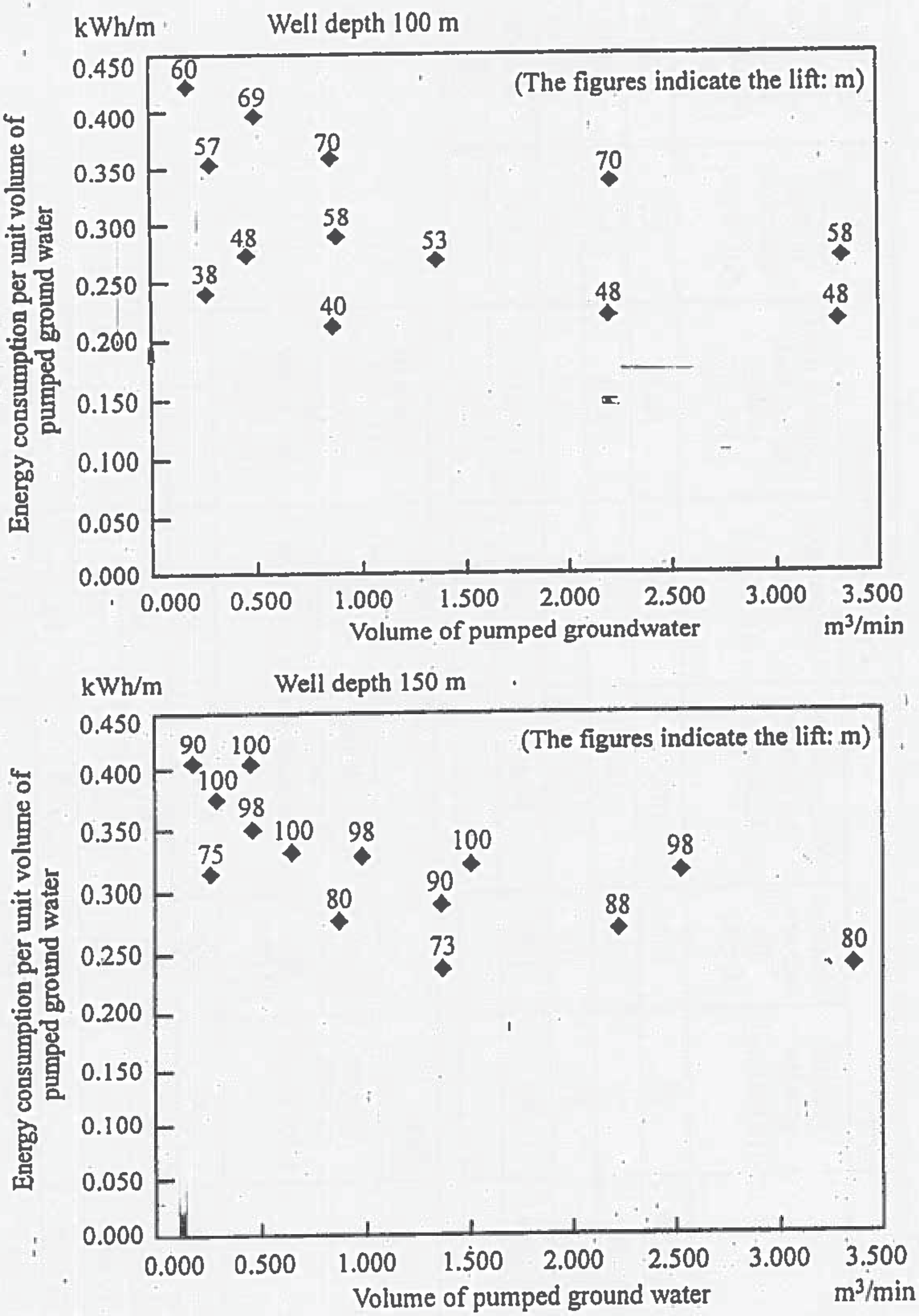
The global environmental developments like fixation of reduction targets for green house gas emissions for developed countries decided in *Kyoto Protocol* (target for Japan: 6% reduction over the 1990 level of emissions by the period 2008 to 2012); the *Dublin Declaration on Water and Sustainable Development* adopted at the *International Conference on Water and Environment*; the *Agenda 21* (Section 18 - *Protection of Quality and Supply of Fresh Water Resources* prescribing the necessity for sustainable development and assessment of effects of climate change on water resources); the deep concern for global warming, desertification, deforestation, depletion of ozone layer and their impact on water resources, expressed at *United Nations Convention on Climatic Change, Convention to Combat Desertification* and *Convention on Biological Diversity* - all have been effectively integrated in perspective planning for water resources development in Japan. The specialised institutions like Environment Agency, Ministry of Construction, Public Works Research Institute, Hokkaido Development Agency's Public Works Research Institute etc. have conducted detailed studies on the effects of global warming on total evaporation, precipitation, snow accumulation, sea level, acid rain and their ultimate effect on total quantity and quality of surface and ground water resources and also effects on demand for water utilisation. It has been predicted that doubling of carbon dioxide in atmosphere will lead to halving of snow accumulation, with thawing beginning about 2 months earlier and ending about 2-3 months earlier, leading to decrease in water flows from April to June which is critical from irrigation point of view. According to another estimate a 3°C temperature rise will lead to 1.2% - 3.2% increase in water demand requiring around 400 million cubic metre water in three cities of Asahikawa, Nagoya and Naha (which amounts to the volume of water supplied by around 15 average sized dams). All such research is being used for comprehensive water resources development planning in Japan.

The current (hydro) philosophy in Japan is to link water resources development with energy consumption (output) in the overall framework of global warming. An interesting comparison has been made, on carbon dioxide per m^3 of water developed by dams, desalination and pumping from ground by National Land Agency on the assumption that carbon dioxide of 0.0977 kgc develops for 1 kwh of energy power. It has been estimated that electrical energy converted into the volume of carbon dioxide produced for 1 m^3 of developed water was 0.006 kgC/m^3 in case of five recently constructed dams (Table 11), up to 0.06 kgC/m^3 for JIS specified deep well submersible pumps (100 metres and 150 metres deep) with an assumed service life of 7 years (Figure 10) and 0.52 kgC/m^3 for desalination calculated on the assumption that the electrical energy used for desalination is 5.3 kwh/m^3 (not including the electrical energy used for the construction of desalination facilities). This provides environmental justification to the current Japanese emphasis on development of water resources by constructing dams.

Table 11. CO_2 Produced by Development of Water Resources by Dams

Dam Features		Date			Cumulative volume		CO_2 produced in dam operation (10^6 KgC)	Volume of CO_2 per unit water volume developed (Kg C/m^3)
Height (m)	Type	Volume of dam (10,000 m^2)	Planned service life (year)	Water volume developed (100 million m^3)	Construction stage (10^6 KgC)	Concrete used for the body of dam (10^6 KgC)		
155	Gravity dam	175	100	107.8	15.3	50.3	4.7	0.0065
111	Gravity dam	51	100	52.6	7.7	19.1	4.7	0.0060
70	Gravity dam	67	100	97.2	9.6	24.3	4.7	0.0040
70	Gravity dam	43	100	39.4	4.0	16.6	4.7	0.0064
					9.1	27.6		0.0057

Dam Features		Date			CO_2 produced in dam operation (10^6 KgC)	Volume of CO_2 per unit water volume developed (Kg C/m^3)
Height (m)	Type	Volume of dam (10,000 m^2)	Planned service life (year)	Water volume developed (100 million m^3)		
140	Rock-fill dam	890	100	13.0	195.5	4.7
155	Gravity dam	175	100	107.8	197.2	4.7
111	Gravity dam	51	100	52.6	179.1	4.7
70	Gravity dam	67	100	97.2	192.4	4.7
70	Gravity dam	43	100	39.4	101.6	4.7



Note: Trial calculations made by the National Land Agency were based on data from "Materials Regarding Standard Production Rates in Well Drilling Work", published by the Japan National Well Drilling Association and JIS Handbook on Pumps, published by the Japanese Standards Association.

Figure 10. Energy Consumption per Unit Volume of Pumped Ground Water

7.0 Resettlement & Rehabilitation (R & R)

A very detailed legal and financial mechanism has been evolved in Japan, for R & R purposes. Initially, in the 1960s, during construction of Matsubara and Shimouke dams controversies got generated relating to resettlement issues. However, the "Law on Special Measures for the Reservoir Area Development" enacted in 1972 has been regarded as an institutional framework in achieving social acceptability of dam projects in Japan (Inoe, 2000). It lays down what can reasonably be termed as National Policy for Rehabilitation for people facing displacement due to dams, specifying detailed framework of life reconstruction measures (Figure 11). Conventional measures provide compensation to individuals. According to "Standard Regulations on Compensation for Losses by the Acquisition of Land for Public Purposes", the Dam Developing Agency and local land owners conduct negotiations regarding compensation for income from land and the relocation of buildings[7]. The law also calls for the "Reservoir Area Development Plans" needed to improve the environment and the industrial infrastructure in the reservoir area. The money to cover implementation of the special measures is provided by local governments, subsidised by the Central Government and in some cases partly borne by the downstream beneficiaries, to some extent. Efforts are made to have residents upstream and downstream benefit equally from the dam projects.

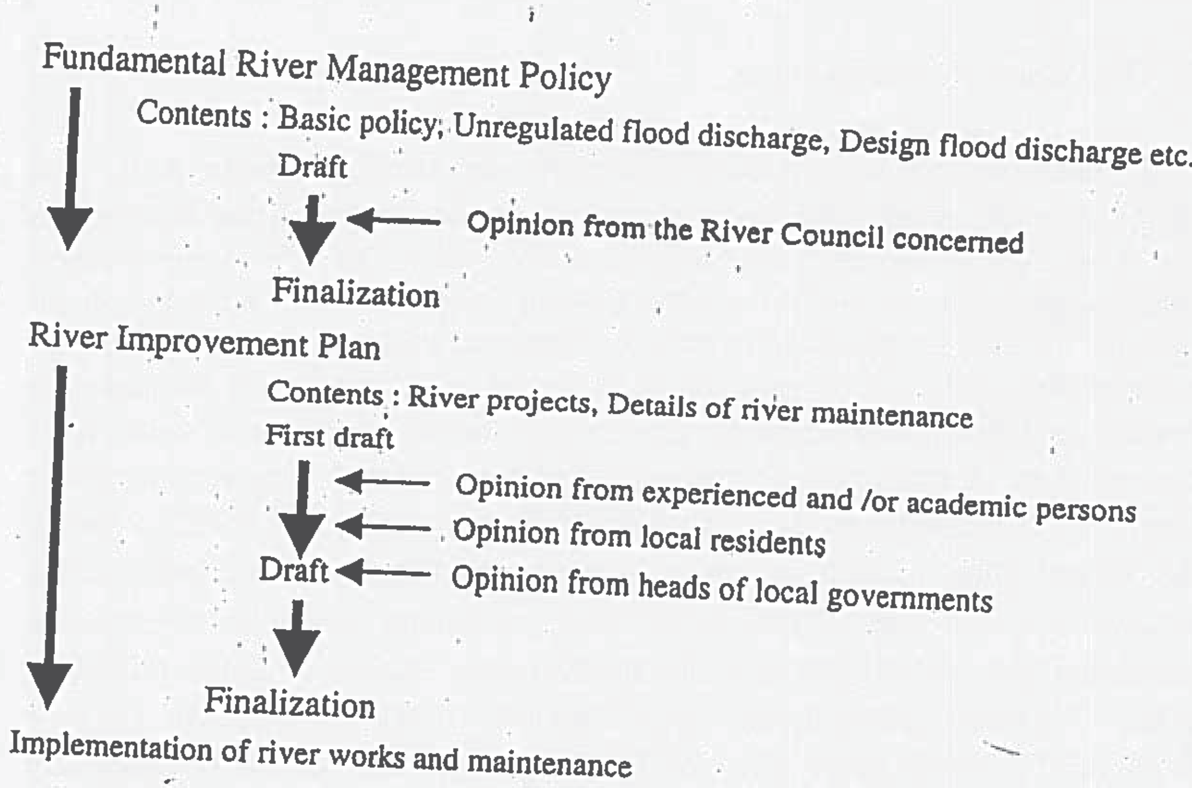


Figure 11. Life Reconstruction Measures

In 1976, the *Fund for Reservoir Area Development System* was established supported mainly by local governments. A number of projects have been implemented by using such funds. They consist primarily of measures to rebuild the lives of people (e.g. interest payment subsidies for alternative land and funds for counselling services), subsidies for local revitalisation projects (e.g. construction and improvement of roads and basic production facilities), and exchanges through recreational activities between upstream and downstream communities.

The main reason why the dam projects under this institutional framework have been successful has been the early involvement of potentially affected people in the planning process and cooperative action between the dam building agencies, local governments and local people through mechanisms like Resettlement Councils, Liaison Associations etc.

Capacity building programmes are also carried out for public welfare officers who are involved in the task of assisting the project affected people in rebuilding their lives. These welfare officers learn basic counselling skills and study tax laws and case histories for people who already have rebuilt their lives in other inundated areas. These programmes have been made available since 1990 in order to improve the human resources capacities for resettlement & rehabilitation.

7.1 Dam Controversies in Japan

Japan has not been immune to controversies relating to large dams. The most noticeable of them has been the one relating to Kawabe River Dam which has been going on for last almost thirty years. Twelve environmental organisations, farmers, the Kuna River Fishing Cooperative and other individual citizens have been opposing this dam. In 1966, more than eight hundred farmers petitioned the Ministry of Agriculture in charge of Kawabe River Reclamation Project questioning the irrigation benefits and the higher prices of water from the new dam. However, these objections had been rejected. The Kawabe River Dam Project Deliberation Committee established in September, 1995 to review the project's plan, voted to continue the project in August, 1996. However, the protests still continue. There are no strong anti-dam groups with extensive horizontal and vertical linkages like the Narmada Bachao Andolan (NBA) in India. However, International River Network (IRN), Environment Defence Fund (EDF), Green Peace etc. have their regional outfits generally registering anti-dam protests now and then.

8.0 Conclusion

During the half-century after the Second World War, the main topics of interest in water-related sciences and technologies such as hydrology, water resources planning and management and the like have changed with the socio-economic requirements and the engineering capabilities mentioned above. During the years 1945-59, research emphasis was on flood forecasting, levee protection, evaluation of flood damage, etc. From 1960-73, the focus was on the prediction of water demand planning of water resources development, sedimentation in reservoirs, and strategies for preventing water shortages. In the years following 1977, the environmental topics related to water pollution, aesthetic design of the river front, ecological balance between river works gained prominence. The river water management in Japan has experienced so many difficulties, from flood damage to environmental topics through water shortages, successively during the half century. The Japanese experience may be taken as a lesson for the world of water management especially for developing countries in Monsoon Asia, where urbanisation has just started and where similar difficulties are expected to arise.

Notes

1. Haiku is a typical short-poem produced in Japanese climate and hydrological situation. A feature of haiku is inclusion of a "season word", which is absolutely necessary, referring to an animal, plant, event or customs of the representatives of each four seasons and a New year as a special happy time.
2. At Nagara River Estuary Barrage various types of fishways, such as those with attraction flow, of lock type and with natural pebbles known as "rippling fishway" have been created to facilitate fish to migrate up and down the river.
3. Measures include river projects such as river purification and water flow preservation channel projects, sewerage projects such as basin based sewer system and other related measures such as water purification projects for waterway.
4. The Sekiyado-jo Museum is located on a super-dam constructed by the Ministry of Construction at Sekiyado-cho in Higashi Katsushika-Gun in the surroundings of the Tone River and Edo River. The theme of its exhibits is the "River and its Industry." It presents in an easy manner the way people have lived in the Tone River basin throughout history. The industry and culture that has emerged from the history of floods and flood control in the Tone River basin is rooted in the river.
5. It studies the relationship between the habitat, changes in flow rate and wildlife ecology and also the relationship between differences in shoreline pattern and water quality. Research on the theme "River Development with nature" focuses on river flow maintenance, and development of lake water purification technology using

nature's cleansing action. The Centre is located on Kitaka region of Kiso river in Hashima-cho, Hashima-gun, Gifu prefecture.

6. The steps being undertaken include projects to control debris flow (Sabo dams, Mountain reinforcement, Sabo channels), landslides (water channel improvement, pilings, underground drainage), slope failure (retaining walls, crib works and flow of volcanic material (dikes, energy dissipators).
7. In Japan, the private property is very zealously guarded by law. Authors' interactions with officials of River Bureau, Ministry of Construction revealed that this has resulted in protracted negotiations with local resources and local governments many a times leading to litigations in Courts. And in many cases, this has resulted in extraordinary delays in execution of projects.

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