Part II Institutional and Economic Approach to Sustainable River Basin Governance. Chapter 6 Irrigation and River Basin Management in Japan: Toward Sustainable Water Use

Chapter 6

Irrigation and River Basin Management in Japan: Toward Sustainable Water Use

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INTRODUCTION

"Water will never be polluted while it is managed by people who have the sense of ownership over water."

by Tsuneichi Miyamoto, Japanese folklorist (Satake 1989, p.181).

Agriculture is the leading water using sector in most of the Monsoon Asian countries, Japan and China are no exceptions. In Japan it accounted for approximately 66 percent of the total water usage in volume in 2002 (Ministry of Land, Infrastructure and Transport of Japan 2002) slightly less than the 68 percent agriculture used in China in 2002 (Ministry of Water Resources of China 2002). How agricultural water is used both in Japan and China has had a serious impact on the water ecosystems in each country— particularly because irrigation water is used on vast agricultural land or stored in large reservoirs. Moreover, most big cities are located in the downstream reaches of river basins and often suffer from the water pollution and excessive water use by upstream agricultural users. To be more specific in Japan most of the irrigation water in Japan is drawn from rivers and irrigation water is used repeatedly from upstream to downstream paddies. In light of these characteristics if irrigation water is not properly managed, rivers will suffer both in terms of quality and quantity and strong water governance of rivers will not be possible. Of course, many cast doubt on the efficiency of irrigation and there are pros and cons on its impact on the environment, including the argument of multi-functionality of irrigation. In light of the central role agricultural water use plays in both quantity and quality of rivers, this paper will explore the role of irrigation management in river basin governance in Japan.

Although greatest care should be taken when comparing two countries with different political, economic and social institutions, it is internationally recognized China's current water problems relating to irrigation are following a very similar trajectory as those in Japan. This similarity partially explains the commitment of Japanese overseas development assistance (ODA) in this sector in China. For example, the Japan International Cooperation Agency (JICA) has been carrying out technical cooperation with China on the country's National Irrigated Agriculture Water Saving Program for 20 years with the purpose of promoting sustainable and productive agriculture. While other international assistance (e.g., World Bank and bilateral aid from other donor countries) has also been focused on irrigation in China, Japan's ODA is perhaps the most long-standing assistance. This research paper aims to outline the experience of irrigation management in post-war Japan to illustrate potentially useful lessons learned for modern China, which is undergoing similar water challenges.[1] Our lens into Japan's experience will focus on how the roles between government and farming communities have been divided to achieve better watershed governance, with a particular emphasis on river irrigation of paddy fields.

The content of this paper is as follows. Section 1 provides an overview of the history of Japanese irrigation and problems during and after the promulgation of the Agricultural Basic Law (ABL) of 1961, which promoted rapid modernization of farming with the goal of diminishing the

[1] One of the major precedence studies on Japanese irrigation aimed at giving lessons to other Asian countries is Tamaki et al. (1984). This paper highlights the environmental aspect of irrigation and river basin management.

income gap between agriculture and non-agriculture sectors. Chinese policymakers view the construction of more wastewater treatment facilities and modernization of irrigation infrastructure in rural areas to increase production as urgent tasks. It merits mention, however, that modern farming techniques bring not only better productivity but also—as occurred in Japan—can lead to serious negative impacts on river basin environments. Therefore, the Chinese government had best consider lessons from countries like Japan, which possesses two very relevant policy experiences in developing new strategies for managing irrigation—highlighted in the latter part of this paper. One is how the government-led Land Improvement Project (LIP) involved farmers in water management, forcing them to bear the burden of sustainably managing water resources. The second relevant experience is how the Japanese government reacted to the water problems caused by urbanization and change in water use during the post-war era. While Japan's experiences in promoting sustainable water management in rural areas have not always been successful they still hold good lessons for China today. In section 2 the Japanese government's LIP, which played the central role in irrigation policy in post-war Japan will be introduced. Within LIP this paper will focus on the function of the Land Improvement District—a structure for decentralized irrigation management—which is an example of Participatory Irrigation Management (PIM).[2] PIM is highlighted because it has generated global attention among international cooperation agencies such as the World Bank and JICA as a "principle management concept with which reform of the agricultural water sector and transfer of irrigation management to farmers" can be undertaken (World Bank Beijing Office 2002, p. 2). Finally, in section 3 this paper discusses two policy measures—the Rural Sewage Project and Agricultural Water Use Rationalization Project (AWUP)—that have been pursued in Japan to solve the problems of balancing development and economic and environmental sustainability in paddy irrigation and discussions on water management in Japan today. In the last section, the author concludes with some lessons for China.

1. Modernization and the Change of Rural Water Use

The origin of Japanese irrigation harkens back to 3rd century B.C.E. Over the centuries, successive rulers have devoted considerable financial and human resources (i.e., the labor of farmers) to the development of new paddy fields and water sources. The result of this long history of paddy construction is an impressive web of irrigation waterways covering the entire country that has modified the fluctuation of rainfall in the monsoon climate, hydrated the land, and brought stable, bountiful harvests to this island nation. In modern times while the government has taken initiative in constructing large irrigation systems keeping pace with diffusion of both machines and chemical fertilizers, water management of smaller facilities has been left to farmer water associations that utilize traditional water use and farming practices. In fact, farmers have devised highly sustainable farming by combining field cropping and livestock farming into rice production, even domestic and human waste has been taken into the cyclical use of water and land resources. This holistic approach to water use in rural areas is reflected in the Japanese language, in that until recently in rural Japan the term water has been used synonymously with the term irrigation water.

It was in the spectacular economic growth era beginning in the late 1950s into the 1960s that Japanese agriculture was totally transformed. Like many industrialized countries, rural Japan has undergone massive depopulation while urban areas have exploded with growth. This shift in population has necessitated the development of a modernized way of farming, which has totally changed villages. This transition of the agricultural sector has created a clash between the historic farming traditions and modern techniques, as well as sparked serious water pollution, water disputes, and other environmental problems, some of which remain unsolved today.

To clarify the background of Japan's water problems, the first section of this paper will

2. Any involvement of local farmers traditional community groups to the irrigation project or O&M seems to be rare in Asia, with a few exceptions of Japan, Taiwan and Bali of Indonesia (Tamaki 1976 p.34).

examine the establishment of the modern water system and then discuss the transition of agriculture and villages since the period of extraordinary rapid economic growth. The section will conclude with an introduction of domestic debates on Japan's water problems.

1. 1 Historical Aspects of Irrigation System in Modern Japan[3]

In the late 17th and early 18th centuries, Japan's feudal lords rushed into paddy development, which caused numerous disputes over scarce water in drought periods. To mitigate these conflicts, the competing local farmers created a complicated system of local water rights rules referred to as the Customary Water Use Practice[4] (Mase 1994). Though farmers were under the rule of feudal lords, their water rights enabled them to manage irrigation water autonomously. After the birth of the modern state in 1868, Regular Water Use Cooperatives—based on traditional community water management practices—were incorporated in the modern legislative system within the Water Association Law and Land Improvement Law. Moreover, most of the farmers' traditional water rights were given legal basis as Customary Water User Rights (CWUR) in the Old River Law enacted in 1896. This duality in law in water user rights created considerable ambiguity over water rights, which some have declared a "victory of Japanese agrarian society over modernization" (Tamaki 1979, p.15). In the post-war period irrigation facilities were developed under the government-led Land Improvement Project (LIP) scheme. To sum up the history of Japanese irrigation in modern times, the autonomous O&M of irrigation by farmers has been sustained while the government had played an increasingly stronger role in subsidizing and carrying out multiple projects to develop large irrigation facilities. Prior to the 1950s these formal government and traditional rural institutions to maintain irrigation were properly balanced and worked well. As elaborated below, water problems began to grow as Japan's economy exploded in growth in the 1950s and this balance gradually changed, threatening the water management systems of rivers and other water bodies.

1. 2 Rural Change in the Years of Spectacular Economic Growth

From late 1950s to the late 1960s Japan's average annual GDP growth was more than 10 percent. Notably, while this economic boom led industrial sectors to thrive, the rate of agriculture's share of the GDP from 1960 to 1980 fell from 9.2 to 2.4 percent (see Table 1). Over the same time period cultivated land area in Japan was decreased by 10 percent. Not surprisingly, these shifts in the economy led the agricultural income to fall considerably, causing a mass exodus from rural areas to big cities and an increase in part-time farmers. To halt the decline in rural population, increase farmer incomes, and strengthen agricultural production the Japanese government enacted the Agricultural Basic Law (ABL) in 1961, which promoted mechanization of farming and expansion of farm size.

This mechanization of agriculture and significant rise in the use of chemical fertilizers and pesticides did lead to an increase in agricultural productivity—specifically, 1.4 times from 1960 to 1980 (FAO Website). The consumption of chemical fertilizer per hectare (ha) peaked at 428 thousand tons in 1979. In Japan pesticide use peaked in the mid-1970s until many, such as mercury, DDT, BHC and parathion were banned due to discoveries they caused serious human and environmental health hazards. The growth in production of Japanese agriculture between 1960 and 1980 was made possible by laborsaving technology, intensification of pesticide and fertilizer use, and farmland consolidation.[5] Japan's trends are in sharp contrast to most developed countries, which usually achieve high agricultural productivity through farm size expansion. While over the same 20 years China introduced the production responsibility system, which led agricultural productivity to triple through a rapid diffusion of machinery, chemical fertilizers, and pesticides.[6]

3. The descriptions of Japanese paddy irrigation history and CWUR are mainly based on MAFF (1960), Nagata (1971), Imamura (1977), Tamaki (1979), and Nougyou Suiri Kenkyukai (1980). Discussions on the farming technology development were drawn from MAFF(1995) and Teruoka (2003).

4. According to the survey by Construction Ministry's River Bureau in 1967, out of 1,765 registered CWUR, 79.5 percent started taking water before 1896 and 12.1 percent after 1896.

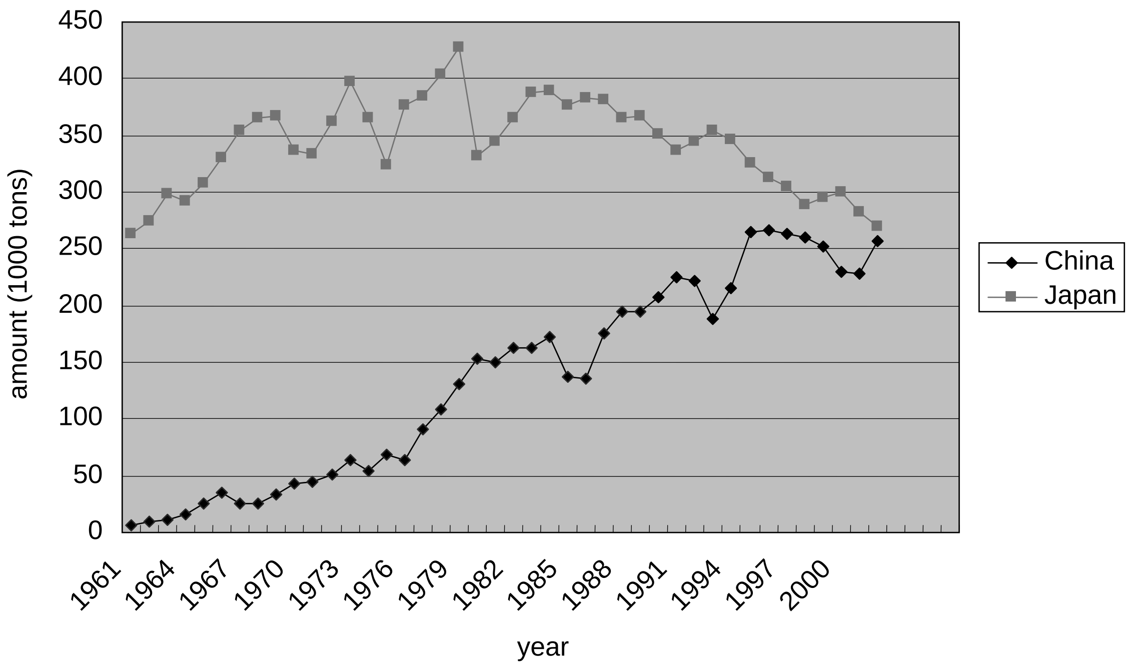
5. According to the estimates by the Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF), the public investment for the LIP over the past 80 years totals 39.5 trillion Yen, of which 60 percent was spent in the period of 1960 to 1980 (Shogenji et al. 1997, p.78).

Table 1. Change in Japanese Agriculture (1960-2000)

Year	1960	1970	1980	1990	2000
1) Rate of agriculture in GDP (%)	9.2	4.2	2.4	1.8	2.0
2) Farm households (1000 households)	6057	5402	4661	3835	3120
Farm household population (1000 people)	34546	26595	21366	17296	10467
Rate of farm household population in total population (%)	37.0	25.3	18.3	14.0	8.3
Rate of population in rural area (%)	37.5	28.8	23.8	22.6	21.2
3) Cultivated land (1000ha)	6010	5796	5461	5243	4830
Rate of cultivated land in total land area (%)	16.3	15.4	14.5	13.9	12.8
Irrigation rate (%)	41.4	51.0	50.4	50.0	50.2

Notes: 1) Figure in 2000 is based on CIA data.
2) Farm households is the sum of the number of commercial farm households and that of noncommercial farm households.
3) Cultivated land includes all kind of agricultural land such as paddy, crop field, pasture and land for permanent crops.
Source: Japan Statistical Yearbook, Bureau of Statistics, Officer of Prime Minister, Statistics and Information Department, MAFF.

Fig. 1. Consumption of Chemical Fertilizer per Hectare in Japan and China



Source: FAO.

Figure 1 shows the chemical fertilizer use in Japan in comparison to China, which is following a similar trajectory.

Mizutani (2001) describes the involvement of farmers and government in river basin management today as providing "autonomy and trusty

[6] The production responsibility system was a contract system in which farmers agreed to provide a certain amount of grain to the state, but could also grow more profitable crops to sell on the free market. While production and farmer incomes initially grew, the increased pesticides and chemical fertilizers have caused serious water pollution and health hazards throughout China (Maurer et al., 1998; Hamburger, 2002).

Table 2. Transition of Water Management

	Before Economic Growth Era	After Economic Growth Era
Form of Water Management	Autonomy	Autonomy/Trustworthy
Form of Water Use	Collaboration	Partnership
Stability of Water Supply	Low	High
The Level of Irrigation System	Traditional Irrigation & Drainage is same facility	Large-scale & sophisticated Separated
Condition of Land	Scattered and Small	Consolidated
Public Support	Weak	Strong
Freedom in Farming	Low	High

Source: Mizutani and Chen 2001, p.177.

water management" (Table 2). Since 1950 the large and sophisticated irrigation facilities constructed by the government required highly specialist knowledge and techniques to operate. Thus, large-scale Land Improvement Districts (LIDs, elaborated in the next section) often employ fulltime technical experts. He noted that coincident with the realization of stable water supply, water management has been taken away from farmers and put into the hands of technical managers, whose expensive expertise is supported by public funds, which ultimately adds to the farmers' burden.[7]

1. 3 Emerging Problems in Japan

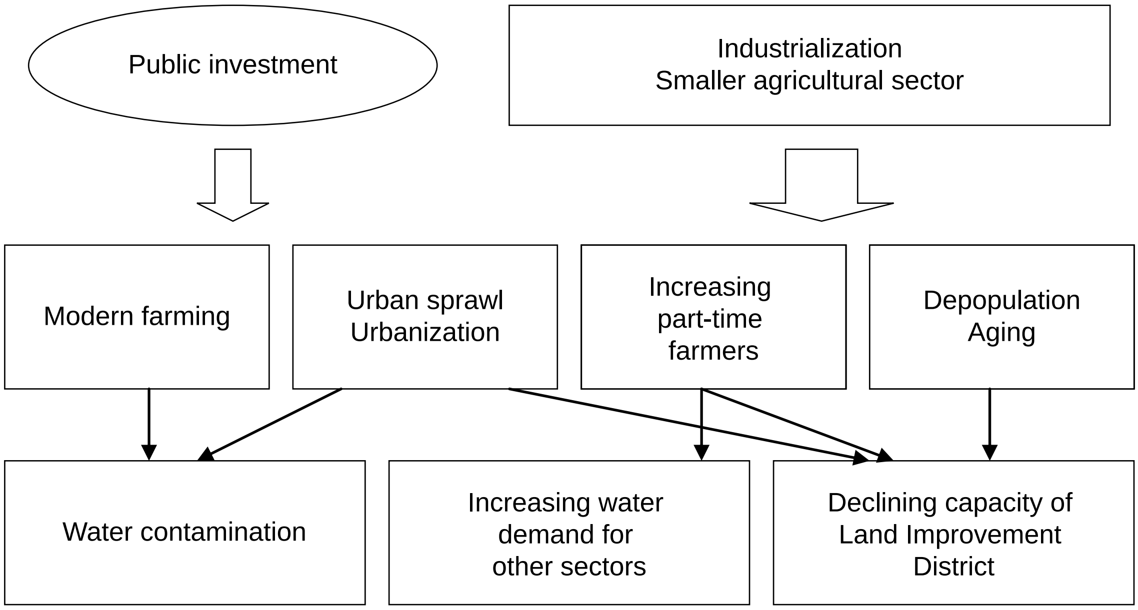
The problems all these changes of farming villages highlighted above caused in rural Japan are classified into three groups: (1) increase in water pollution by both intensified agriculture and other water users, (2) decline in the capacity of local communities to manage their water, and (3) emergence of water disputes between the farming and other sectors. Figure 2 shows the relations among major changes of farming areas and the water problems.

One of the first major water problems in rural Japan has been the escalation of water pollution due to increased competition between agricultural and non-agricultural water users. As farmers came to adopt intensive one-crop production, they started to use chemicals instead of compost and gave up traditional composition of rice production, upland cropping and livestock. These changes in farming practices produced considerable water degradation from both the growing livestock industry and non-point source pollution from farmland. Although the enforcement of industrial effluent control resulted in better water quality in Japan's rivers, non-point source pollution is still a significant polluter today along with domestic wastewater of rivers, especially closed water bodies such as lakes and bays because it is difficult to identify and control the polluter. For example, Figure 3 delineates the sources of pollution into Biwa and Kasumigaura lakes in 2000. One other serious problem regarding water pollution is the irrigation water contamination by industrial and domestic effluent in modernized and urbanized villages. The damage to agricultural land by polluted irrigation water started to increase significantly around 1950, peaking at 194 thousand ha in 1970, which represents 6.1 percent of Japan's total paddy fields.[8] The damage caused by the industrial sector was reduced due to more stringent controls enforced under the 1970 Water Pollution Control Law and other policy measures.

Talking about water pollution conservation policy in rural areas in postwar Japan, former bureaucrat of the Ministry of Agriculture, Forestry and Fisheries (MAFF) Satake (2003) pointed out that in the 1950s and 1960s Japan's agricultural administer dealt with the eutrophication of rivers as a technical problem to be solved by the construction of facilities such as separated irrigation and drainage canals and under drainage. These technical solutions were

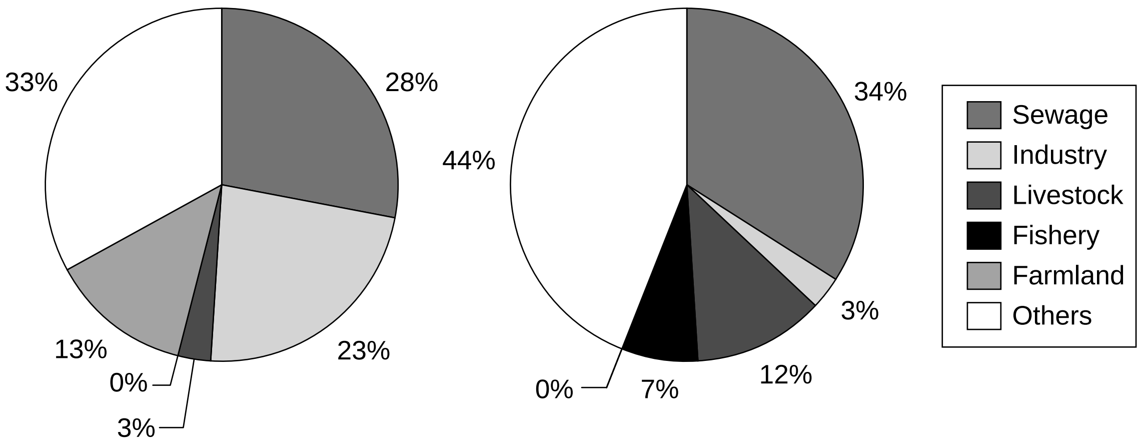
7. For a through discussion on the challenges faced by LIDs see Minagawa (2003) and Okabe (2003).
8. The major polluters were industry (39%), domestic (34%), and mines (16%) (Moritaki 1982).

Fig. 2. Challenges for Rural Water in Japan in the Rapid Economic Growth Period



Source: Author.

Fig. 3. Sources of Pollution into Biwa and Kasumigaura Lakes (COD)



Notes: 1) Left: Biwa lake, right: Kasumigaura lake.
2) There is no classification of "farmland" for Kasumigaura and "others" includes all kind of non-point source pollution like road, rain fall, farmland and forest.
Source: Okada and Peterson (1991).

built on the concept that wastewater should be removed as quickly as possible and be treated out of sight from local citizens. Setting aside the question of whether such hidden technical remedies to wastewater problems is proper, it appears that rural people's consciousness of water became weaker and they became tap water users just like their urban counterparts. Public funds for these water quality problems were very limited, so that only reactive emergency measures, such as building some farm community effluent processing facilities, not the needed drastic institutional reform, were taken.

The second major cause of water problems in rural Japan has been rapid economic growth. Economic growth is (both directly and indirectly) a powerful driver of declining capacity of water management groups in rural areas as well. Specifically, economic growth sparked rural depopulation and urban sprawl, which has brought about significant changes in rural lifestyle and water use. Though farmers day-to-day O&M of water was drastically simplified by the separation of irrigation and drainage, as well as the introduction of pipe drains, some scholars have pointed out that the capacity of a major government initiative to help improve the irrigation and development in rural areas—the LIP, described in full below—is declining because of: (1) aging rural populations (most younger farmers have long-departed for urban areas) and, (2) increasing part-time farmers (JIID 2003c and Tamaki et al. 1984).

The third water problem is the increasing water disputes among agriculture and other sectors because of the rapidly increased water demand from industry and domestic sectors during the economic growth era. Some explanation may be needed here on why many monsoon rice producing Asia countries including Japan do not adopt a water pricing system although such system is internationally heralded as a means to help mediate disputes over water allocation. Water pricing and water market systems are successful in dry areas like California in the USA and Chile where: (1) agricultural production is on a commercial base, not like Japan where there are many miniature farms with water rights (mostly consisting of Customary Water Rights) run by families for their own consumption, and (2) the amount of rainfall is somewhat predictable so demand and supply are easily calculated, although there are difficulties in estimating water demand due to the seasonality of Monsoon Asia in Japan. Researchers at the Japanese Institute of Irrigation and Drainage (JIID 2004) pointed out five difficulties in the possible introduction of water pricing in densely populated river basins in Japan: (1) specification of beneficiaries, (2) estimation of externalities, (3) adoption of methods for bearing the maintenance cost, (4) question of whether to separate the construction and maintenance costs and (5) difficulty in how to levy the cost. In fact the Japanese government has never adopted water pricing or water market systems, choosing instead to carry out two administrative methods of water reallocation methods: (1) water saving in rural areas that are then allocated to cities during abnormal droughts, (2) permanent water reallocation through the Agricultural Water Use Rationalization Project in normal times (discussed later in the paper), in some urbanized area where agricultural water demand diminished while urban water increased.

The temporal water reallocation in Japan was utilized only in some comparatively dry regions or in times of abnormal drought in summer, for thanks to the abundant rainfall, the macro water supply in most parts of Japan usually matches the demand and the balance tends to be stable. However, the abnormal drought in 1996 sparked a national discussion on water use efficiency in the agricultural sector.[9] Not surprisingly, most of the criticisms were from the urban side—e.g., "agriculture wastes water," "agriculture won't give over water to other sectors," and "Customary Water User Rights (CWUR) are not transparent." Prior to 1950, in conventional village society strict water control rules (which included punishment for violations) made villagers work together to undertake water quantity and quality management. Today, however, CWUR make the price of irrigation water nearly zero in Japan, which means there is no strong incentive for farmers to save water. In fact when compared to 1975, agriculture water use slightly increased from 570 trillion tons to 572 trillion tons in 2000, while the paddy, the largest water use in the agricultural sector occupying 95% of the total, decreased from 3.2 million ha to 2.6 million ha. It is therefore understandable that the agricultural sector is criticized for its inefficient water use. However, some insist that it is not easy to reduce the water use in agriculture due to some technical reasons of paddy irrigation (Satoh, 1997):

(1) *Special features of rice-paddy irrigation.* The reduction of irrigation area does not directly result in the decline of required water;
(2) *Water and property rights linkage.* Water rights in Japan are usually attached to the property rights of agricultural land; and,
(3) *Desire to increase agricultural production.* Surplus water is used to compensate the underlying water demand of farmers to increase production or improve labor effectiveness.

Discussions between urban and rural sectors are not easily resolved, but neither side seems to

9. These discussions are partly based on Sato (1985), JIID (2003a, 2003b, 2004).

understand that water users on both sides are drawing from the same river basin. Reallocation of rural water to cities demands not just strict monitoring of farmers, but more importantly open dialogue among all relevant urban and rural parties. In short, communication among users will help promote more sustainable water use in both sectors.

2. The Role of Government and Farming Communities: Land Improvement Project

This section will detail the structure and the function of the government's Land Improvement Program (LIP), which has played a major role in the construction of farm roads, irrigation infrastructure, farmland consolidation, and maintenance of the farm-related facilities in the post-war period. These construction projects were highly subsidized, usually by more than 80%. The main objectives of the program are to promote effective agricultural production, revitalize rural regions, stabilize the supply of food, and conserve national land and the environment (MAFF 1997). The objectives and the composition of the budget for this program have been driven by changes in Japan's agricultural policy. In the period right after the end of World War Two the government's first major objective was to increase food production. Next in the period of Agricultural Basic Law (ABL), beginning in 1961, the government's main agricultural policy objective was to save labor and increase the productivity in light of the declining capacity of farm villages caused by: (1) a smaller agricultural sector, (2) rural exodus to booming cities, and (more recently) (3) the desire to pay more attention to rural revitalization and environmental conservation.

The following section introduces LIP with an emphasis on the role of government, the way of investment, and the cost-sharing system among water users in irrigation. This introduction is followed by a description of the structure and functions of LIP's farmers organization—called Land Improvement Districts (LIDs)— for LIDs have played the most significant role in irrigation construction and management in Japan.

2. 1 LIP and Public Investment for Irrigation

Three of the more remarkable institutional features of LIP are that this institution: (1) addresses both water and land issues; (2) has effectively organized work in both the investment and O&M sectors, which are now tightly integrated; and (3) requires that the projects are all led by the central government (Nakashima 1996). The question of why the involvement of government is so large can be explained with the special characteristics of land and water as economic capital: (1) the historical continuity of the traditional rules and titles formed in the history of Japan's rural areas, (2) the big impact of irrigation on the rural environment, and (3) the many years and uncertainty for investment into irrigation facilities. The government views LIP as a project making a socially optimum investment into land and water protection, which neither farmers nor the private sector would undertake due to high transaction costs.

The change in budget of LIP from 1960 to 1975 is shown in Table 3, which indicates that between 90 and 70 percent of the projects were covered by public subsidies. As of 1975, in these subsidized project farmers only had to bear around 12 percent of the cost. This high rate of subsidies within LIP was aimed at avoiding market failure in the construction of expensive irrigation infrastructure. Such market failure occurred in China, where construction of irrigation facilities has stagnated since 1980s (Uchida 1996), mainly due to the lack of funds and low incentives for farmers to do voluntary maintenance.

The composition ratio of LIP in the same period is shown in Table 4 and Figure 4. In short, irrigation and drainage projects occupied 30% of total LIP expenditures in the 1960s but declined in the 1970s, which resulted in the significant increase in irrigation rates from nearly 40% in the 1960s to 50% in the 1970s. In the 1970s more government investment was put into farmland consolidation, which increased to nearly 50% of the LIP expenditures due to the rapid diffusion of agricultural machinery. The main purpose of the project shifted from increasing agriculture production to laborsaving initiatives. In addition, the farmer's burden is bigger in farmland consolidation because the beneficiary of this project is more specific than in irrigation

Table 3. Burden of Government and Farmers in LIP

	Items		Total investment (trillion yen)				% in total investment			
	Year		1960	1965	1970	1975	1960	1965	1970	1975
Subsidiary project	Subtotal		870	1913	3738	8075	80.4	84.9	89.7	88.3
	National and prefectural		657	1528	2886	6692	60.7	67.8	69.2	73.2
		Loan	73	111	126	277	6.7	4.9	3.0	3.0
	Farmer		141	274	727	1105	13.0	12.2	17.4	12.1
		Loan	99	186	469	1028	9.1	8.3	11.3	11.2
		Individual	42	87	258	77	3.9	3.9	6.2	0.8
Non-subsidiary project	Sub-total		126	211	330	651	11.6	9.4	7.9	7.1
		Loan	97	160	231	518	9.0	7.1	5.5	5.7
		Individual	29	29	99	133	2.7	1.3	2.4	1.5
Project by farmers			86	130	101	419	7.9	12.0	4.5	10.1
Total			1082	2254	4168	9145	100.0	100.0	100.0	100.0

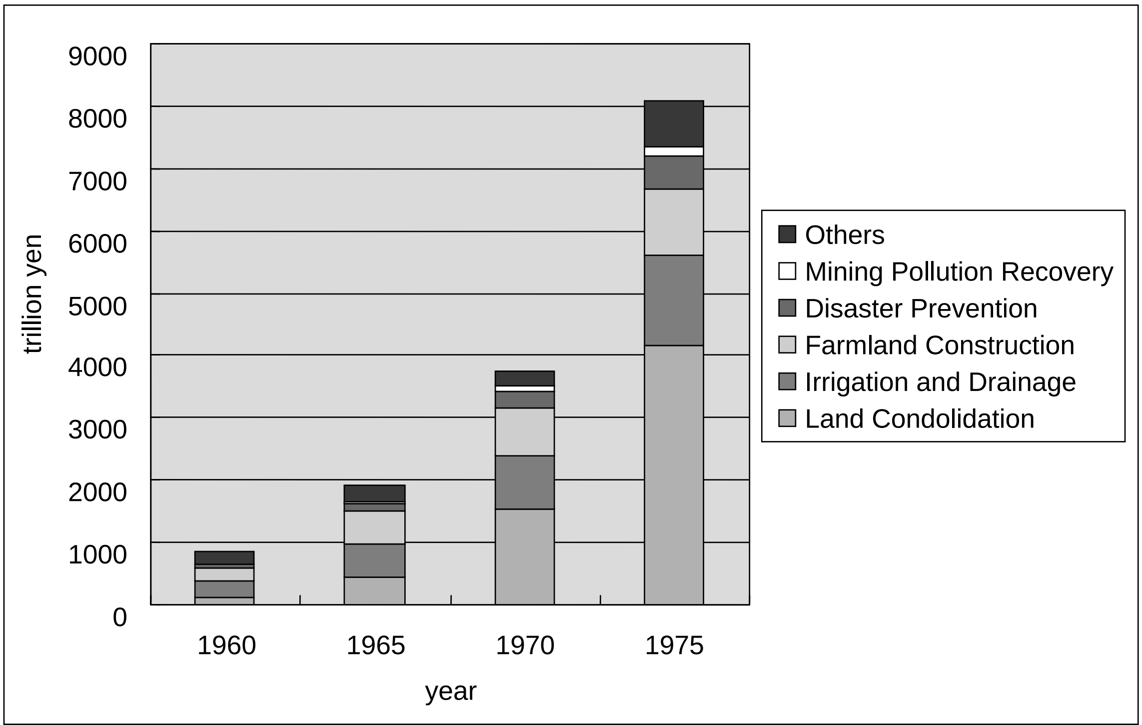
Source: MAFF, Imamura (1984, p.122).

Table 4. Budget of Land Improvement Project by Fund Source (1960-75)

	Items		Investment (trillion yen)				% in each project			
	Year		1960	1965	1970	1975	1960	1965	1970	1975
Land consolidation	Subtotal		123	449	1526	4154	100.0	100.0	100.0	100.0
	Public investment		56	293	1041	3289	45.5	65.3	68.2	79.2
		Government	49	219	757	2110	39.8	48.8	49.6	50.8
	Farmers		67	157	485	865	54.5	35.0	31.8	20.8
Irrigation and drainage	Subtotal		271	539	876	1446	100.0	100.0	100.0	100.0
	Public investment		247	491	768	1346	91.1	91.1	87.7	93.1
		Government	171	371	592	1013	63.1	68.8	67.6	70.1
	Farmers		24	48	109	100	8.9	8.9	12.4	6.9
Other projects			476	925	1336	2474	54.7	48.4	35.7	30.6
LIP total	Public investment		730	1640	3011	6970	83.9	85.7	80.6	86.3
		Government	563	1271	2291	4970	64.7	66.4	61.3	61.6
	Farmers		141	274	727	1105	16.2	14.3	19.4	13.7
	Total		870	1913	3738	8074	100.0	100.0	100.0	100.0

Note: Others includes road construction, disaster prevention etc.
Source: MAFF Nougyou oyobi nouka no syakaikanjyou (Social Accounts for Agriculture and Farms), various years, Imamura (1984, p.124).

Fig. 4. Budgets for LIP by Project



Source: MAFF, Imamura (1984, p.124).

development projects.

2. 2 The Structure and the Characteristics of Land Improvement Districts (LIDs)

LIDs are associations of farmers—beneficiaries of LIP—who were given legal foundation in the Land Improvement Law to use and responsibly manage irrigation water. Today 65 percent of Japan's irrigation facilities and 61 percent of the canals are managed by LIDs, which also cover two-thirds of the O&M costs for irrigation (See Tables 5 & 6). In principle any cultivator of land is qualified to join the LIDs, which means tenant cultivators often become the members instead of landowners.

LID is internationally known as a good example of Participatory Irrigation Management (PIM) because local farmers are involved in every stage of decision-making and cost bearing in LIP for: (1) the establishment of LIDs, (2) the irrigation facility construction plan, (3) the ex post maintenance project, and (4) day-to-day management. The day-to-day operation has a dual system in which LIDs operate the relatively large backbone premises while smaller farmer groups maintain the ending channel facing their own paddy. What is more, LID collects charges from farmers.

The procedure for the farmers' involvement in LIP from the establishment of LID to the ex post O&M project in general is as follows. The Land Improvement Law requires that more than two-thirds of a group of 15 or more local farmers be in agreement to establish a LID. Once a LID is created and more than two-thirds of the group members agree on undertaking a construction projects, any farmers who disagreed with the project are actually compelled to join in the project. The construction can commence after the LID, in collaboration with the national, prefectural, or city governments, undertakes a cost-benefit analysis. This majority rule and compulsory participation of opposition farmers imply that facility construction decision-making tends to prioritize benefits to the whole society over the interest of the individual. The construction project is usually attached to an ex post O&M project and the agreement of beneficiaries on the participation is collected through LIDs. In addition, LIDs collect the burden charge of the project from the beneficiaries as well. For the O&M part, LIDs play a leading role in managing irrigation facilities from the branch lines to the end, although large facilities, such as head works, are often under government and prefec-

Table 5. Management of Irrigation Facilities (2000)

Manager	Main facilities		Agricultural canals and drains	
	Number	% in total	Length (km)	% in total
Nation	20	1.3	94	0.5
Prefecture	241	15.7	565	2.9
Municipal government	258	16.8	6688	34.9
LID	1001	65.3	11775	61.4
Others	14	0.9	52	0.3
Total	1534	100.0	19174	100.0

Source: Land Improvement Planning Department, Rural Areas Promotion Bureau (Minagawa 2003, p.31).

Table 6. Burden of O&M cost (1996, trillion yen)

		Managed by		Subtotal	In kind	Total	% in total
		Central & local government	LID				
Paid by	Nation	49	34	83	N.A.	83	3.5
	Prefecture	295	52	347	N.A.	347	14.6
	Municipal government	209	127	336	N.A.	335	14.1
	LID	16	852	868	740	1607	67.7
Total		568	1065	1633	740	2373	100.0

Source: Land Improvement Planning Department, Rural Areas Promotion Bureau.

tural government control because they demand professional skills to operate. On the other hand, in drought periods, LID plays an important role in collecting and adjusting the information on water demand from small farmer's groups and some villages implement irrigation by rotation practice,[10] which is coordinated by the representatives of the irrigation association who instruct farmers on how to adjust water allocation among water channels or villages.

The levying system of the LIDs includes three kinds of burden charges paid by beneficiaries: special fees, current fees, and maintenance fees. The first two types are collected at the LID level. The responsibility of construction cost of irrigation facilities on the beneficiaries' side is collected as a special fee, while the maintenance cost and water fees are collected as a current fee. The current fee of an individual farmer is calculated by land area, not water usage volume, because the irrigation channel is an open system and it is difficult to know the exact water usage volume. The third type is an informal fee covering maintenance cost in the hamlet and is usually collected in the form of a resident's association fee. This type of fee sometimes takes the form of small labor, for example, mowing and dredging of small channels. It is not easy to judge whether the burden of maintenance is big or small for farmers because the load will be decided by the price of agricultural products, inflation rate and other factors, but it is said the farmer's burden has been increasing significantly in recent years.

Despite the contribution of the Land Improvement Program (LIP) in reducing maintenance costs of irrigation facilities, the capacity of LIDs has been declining because of the growing percentage of elderly in rural areas, rural depopulation, increase of part-time farmers, and

10. A typical customary water use practice for controlled water distribution at timed intervals. Depending on the region, it was either carried out on an annual basis (in the case of pond or small reservoirs) or only in times of drought (in case of river-based irrigation).

urbanization. What is worse, in recent years, farmers tend to separate off in two groups, full-time commercial farmers who actively expand farm size by borrowing land and small noncommercial part-time farmers. These two groups have different economic incentives towards irrigation water. This mixed structure cannot allow farmers to bear equal burden of land improvement. For example, in the case of tenant cultivators serious questions arise as to who should pay the burden of improving the land. There is the possibility that farmer's irrigation burden is becoming larger due to the growing internationalization of Japanese agriculture.

3. Policy Measures for Water Conservation in Rural Japan

This section will first discuss the policy measures that have been undertaken in Japan to solve Japan's rural water quantity and quality problems. Next this section will introduce two projects that were created to address rural water problems in Japan: (1) the Rural Sewerage Project that deals with the water pollution, and (2) Agricultural Water Use Rationalization Project (AWURP) that targets the transference of irrigation water to other purposes. As water management in rural area had been dealt with within the LIP scheme under agricultural policy, LIP itself had been transformed as the government has changed agricultural policy to reflect the transition of Japanese agriculture.

As the alternative of the former Agricultural Basic Law of 1961, the Japanese Diet passed the Basic Law on Food, Agriculture and Rural Areas in July 1999, which "outlines the principles and directions of Japanese agricultural policy for the 21st century" (Honma 2000, p.12). This new law contains three principles, namely: (1) securing a stable food supply, (2) sustainable agricultural development, and (3) development of rural areas. The second principle in particular highlights the maintenance and promotion of natural cyclical function of agriculture through securing the proper use of agricultural chemicals, fertilizers, and livestock manure, which was not covered in the previous law. Of course, some of the project under LIP—including the two projects described below—has changed reflecting the new agricultural law to which sustainable use of land and water resources was added as one of the main objectives.

3. 1 Water Quality Conservation: Rural Sewerage Project[11]

The rural sewerage project started in 1983 to construct rural effluent treatment facilities for the conservation of river water and improvement of the rural living environment. This project handles not only the consevation of irrigation and public water by building sewage systems but also, in some regions, by supporting water recycling treatment and the use of organic fertilizer.

This ambitious project targets the development of water treatment facilities and compost centers,[12] which the prefectural governments and LIDs run. The water treatment and compost projects are rather small in scale—serving a range of 20 households to 1,000 people on the ground. Such small, decentralized wastewater treatment often costs less than a big, broad-based plant. In 1997, the rural sewage project targeted 2,000 districts and succeeded in treating a total of 150 million square meters of effluent a year. Most of the treated water is reused downstream for irrigation (See Table 7). The compost sector is gradually expanding and almost half of the irrigation districts are using the compost on farmland today.

The rural sewage project was implemented as one of the components of LIP when it was under the supervision of Ministry of Agriculture, Forestry and Fisheries (MAFF). It was not until the late 1990s that two other ministries—the Ministry of Health, Labor and Welfare and Land and the Ministry of Infrastructure and the Transportation—joined MAFF in sewage processing issues in order to promote the integrated man-

11. This section is written based on *Kokyo Toshi Journal* (2002) and Taniyama et al. (2000).

12. Since its establishment, the rural sewage project has gradually enhanced its services reflecting changing needs in rural communities. In 1995, a rebuilding program was institutionalized as the beneficial areas expanded and the number of aging premises increased. In addition, in 2000 an initiative to build facilities to reuse the treated water as general service water was added to the project's scheme.

Table 7. Recycling of Treated Water

	Destinations of treated water	Number of districts	% in total
For agricultural use	To accequia	989	75.0
	For irrigation	5	1.0
	To river with intake facilities	212	16.0
	To irrigation pond	3	N.A.
	Subtotal	1209	92.0
No recycling	To river without intake facilities	84	6.0
	To the sea	10	1.0
	Others	8	1.0
Total		1311	100.0

Note: The data is from the districts which joined the project before 1992.
Source: Taniyama (2000).

agement of Japan's river basins. These three ministries submitted a joint instruction on the basic principle of establishing a sewage facilities development plan in 1997, which led to a liaison conference meant to spark local governments to draft comprehensive future plans on sewage processing. Since 1999, these three ministries have guided 12 cities and towns in creating and executing effective sewage management plans.

3.2 Water Quantity Control: Temporary Water Transfer and Agricultural Water Use Rationalization Project

As mentioned in the first section of this paper, there are two types of water transfers in Japan—negotiations between parties in times of drought[13] and the permanent transfer through the official Agricultural Water Use Rationalization Project (AWURP).[14] The first type is usually a temporary transfer in cases of drought, carried out in *the spirit of sharing* advocated in the River Law, which primarily puts precedence on older water rights. In drought periods farmers give surplus water to the river administrator who directs it to other, usually urban and industrial, sectors. The increase in O&M cost in transporting this water saving is not usually born by urban side therefore the cost became a significant burden for agricultural water users. In the drought period or in some perennially dry areas, there are some methods to save and reallocate agricultural water temporarily. In the drought of 1994, for example, agriculture sector pooled 120 trillion cubic tons, which was 65% of the total pooling of water, sometimes restricted withdrawal by more than 70%, for more than 100 days (see Table 8), while the expenses of LID, or farmers' water use association increased by 30% to 80% compared to the normal year (JIID 2003b). Why do farmers save water so much through intensive management of water while there is no compensation for all this hard work during droughts? The author cannot give readers a clear-cut answer to this question but the answer is most likely linked to two key characteristics of the rural water sector: (1)

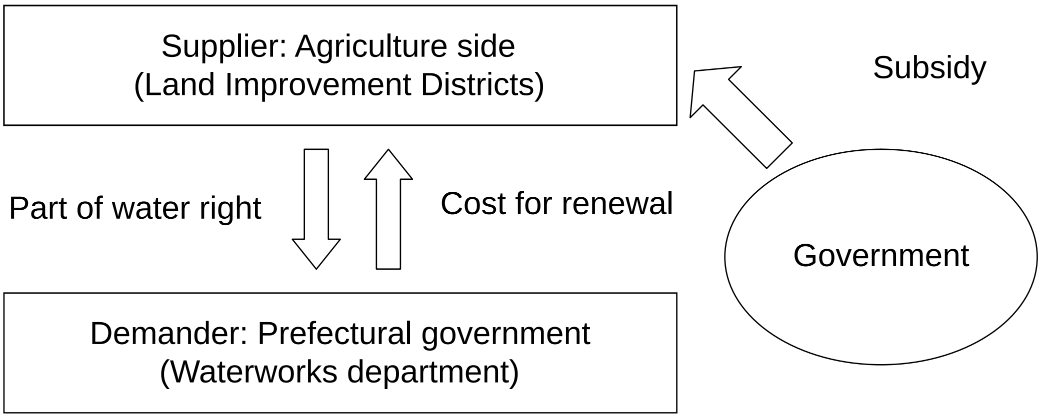
Table 8. Pooling of Agricultural and Domestic Water Supply During 1994 Water Shortage

	Domestic	Agriculture
Pooled value (million m³)	1354	12183
% in total	10	90
Number of cases	18	34
% in total	34.6	65.4

Source: JIID (2003b).

13. Temporary water transfer in drought in 1996 is fully described in Ministry of Construction (1997), JIID (2004).
14. Information in this section on the AWURP is mainly based on JIID (2003a, 2003b, 2004) and Moritaki (2003).

Fig. 5. Agricultural Water Use Rationalization Project



Source: Author.

the existence of traditional network of local community for water management, and (2) public investment in the form of various subsidies to rural areas to support farmer's income.

The amendment of the Land Improvement Law in 1972 enabled surplus irrigation water to be transferred to other sectors in a smoother way under what is called AWURP. Under this law urban water users bear a part of the renewal cost of irrigation facilities and are given a part of the water right from the agricultural users in return (see Figure 5). The ratio of the cost will depend on the ratio of benefit each side will receive in the transfer project. The government gives the non-agricultural/urban side the water right, for which they must reimburse the relevant LIDs. The agricultural water users can rebuild or remodel the irrigation facilities at a lower cost by giving up a part of their water right to urbanites. Although AWURP has enabled the permanent transfer of water rights in some suburban regions of Japan by giving economic incentives to both urban and rural water users, the project has not been fully successful because: (1) it is one of the components LIP, in other words, since LIP gives a huge amount of financial support to farmers one cannot provide a pure economic incentives to both sides; (2) as the Japanese economic growth has slowed down, the water demand from the industrial side decreased that there are fewer transfer projects these days; and (3) the impact on river ecosystem due to the water reallocation is not emphasized in these transfers.

4. Conclusion

As we have just seen above, the Japanese national government has invested huge amounts into land improvement projects in a concentrated and well-planned manner throughout the country's rapid economic growth era. The goal of such investment has been to develop a modern, laborsaving, highly productive agricultural sector and to diminish the domestic income gap between rural and urban areas. This investment achieved the primary objective at the expense of becoming both directly and indirectly the cause of serious water problems such as water pollution in rivers and lakes by: (1) supporting urbanization and modernization of farming, (2) weakening power of traditional farmer community-based water management, and (3) decreasing the interest in rural communities in local water by separating water treatment from communities. Many other countries have also faced these challenges caused by the modernization of agriculture and villages, thus it is not surprising that in Japan such negative aspects of rural development have been ignored as the country's economy boomed.

This paper discussed some of the policies the Japanese government has implemented to address water challenges in rural areas. The positive and negative aspects of these policies hold four valuable lessons for China, which also is facing major difficulties in reforming rural water management while also protecting river basin ecosystems.

(1) Harmonization of Agricultural and Environmental Policies

Agriculture is an industry deeply connected to the regional environment, especially water. Policymakers must therefore design institutions for regional resource management from a broader point of view. Future irrigation investment planning should not only stress short-term increases in higher agricultural production, but also a comprehensive vision that includes long-term improvement of rural society and river basin conservation. Regardless of how much further Japan and China industrialize, maintaining their vast rural areas will be crucial in order to protect land and water resources, as well as the welfare of rural society. Strengthening food production capacity is one of the most urgent issues facing China today, and food production policy should not be discussed separately from river basin governance.

(2) The Role of Government and Farming Communities

The LIP system in Japan has been supported by vast public funding and contains large modern irrigation projects while also maintaining historical small water management practices by farmers (e.g., in the LIDs). The strong government intervention in construction of irrigation facilities in Japan prevented market failure for the most part and thus promoted high agricultural productivity while the autonomous water management has kept the relationship between local water and its users tight. But, as described in the precious section, the LIP scheme is facing limitations in balancing the role of government and farmers due to the declining significance of agriculture in the national economy and the weakened power of farming communities both in labor and financial potentiality because of aging and rural exodus. China is likely to be at an earlier stage of rural modernization and financial support from the central government will attempt to gradually increase to improve irrigation, but it is unlikely enough money will be invested.[15] To create a sense of ownership and promote sustainable rural water management, the Chinese government needs to establish a scheme for collecting funding and labor from farmers. While in general the Chinese government has not enthusiastically embraced the concept of strong farmer organizations, there have been some experiments in China (with World Bank funding) to create farmer associations to improve irrigation management and maintenance. There exists a need for comparative study and further analysis on various PIM schemes that international aid agencies are implementing in China, regardless of their success. Many such PIM projects have been modeled on LIP in Japan and other countries.

(3) Treatment for Water Pollution

Irrigation has both positive and negative externalities—the former refers to the so-called multi-functionality of irrigation, the latter is water pollution and other problems.[16] It is quite difficult to prevent the water pollution from non-point sources like farmland. Measures should be taken to address such pollution at the earliest stages of modernizing rural areas, especially in areas where farm runoff flows into lake and bays, for once they are contaminated the pollution will last long and potentially cause irreversible damage to the water ecosystems. Limiting the use of chemical fertilizers and pesticides, perhaps by increasing organic farming methods, is recommended. Ultimately, as pollution worsens this will causes a decrease in available water and become a new cause of disputes over water allocation, which is becoming increasingly common in China. The development of the proper method of estimating the positive and negative externality of irrigation on quality is an urgent issue to ensure transparent governance and building partnerships between villages and cities.

(4) Water Reallocation among Users

The accumulation of the Japanese experience of technical, political and economic measures in water transfer from irrigation could be introduced abroad, particularly in Monsoonal Asia where governments find it difficult to adopt the water pricing system or water market models because of the uncertainty in the volume and

15. To mitigate the income gap among regions, large-scale irrigation districts in China were constructed in western and north central regions (Iijima & Suzuki 2001, JIID 2003c). Notably many of these irrigation districts are in ecologically fragile areas plagued with poverty—due in no small part to water shortages and pollution problems. The Chinese leadership's concern about the growing poverty in rural areas and maintaining sufficient grain stores led the central government in the late 1990s to substantially increase financial support for irrigation projects, which had heretofore been mainly funded at the provincial level (World Bank 2002).

16. In Japan the bad effect of irrigation on the environment is not high in the public's consciousness. Instead, many see irrigation as more environmentally friendly than other uses (Shogenji 1998).

seasonality of rainfall. In Japan there is some black box in the efficiency of irrigation water and this uncertainty provokes distrustfulness between urban and rural water users in the same river basin. So correct information on water supply and demand within a river basin is required in designing transparent institutional scheme. Moreover, strong communication and cooperation among water users, water administers and various government ministries are crucial for proper water allocation and river basin governance. While not discussed in this paper, it is crucial to provide a scientific basis to water governance through the development of reliable environmental impact assessments of water reallocation project, which is a future challenge in Japan as well.

References

FAO. FAOstat. http://faostat.fao.org/. Rome: FAO.

________. 1961-2003. *Production Yearbook.* Rome: FAO.

Latz, Gil. 1986. *Contemporary and Historical irrigation in Japan: Selected Terminology and Illustrations.* Tokyo: Toyota Foundation.

Hamburger, Jessica. 2002. "Pesticides in China: A Growing Threat to Food Safety, Public Health, and the Environment." *China Environment Series* Issue 5. Washington, DC.: Woodrow Wilson Center: 29-44.

Honma, Masayoshi. 2000. "The New Agricultural Basic Law and Trade Policy Reform in Japan." In *A Way Forward for Japanese Agriculture?* Pacific Economic Papers Vol.300. Canberra: Australia-Japan Research Centre.

Iijima, Takashi, and Naoto Suzuki. 2001. "Chyugoku no mizushigen to sessui kangai (Water Resources and Water Saving Irrigation in China)." *Journal of the Society of Irrigation, Drainage and Reclamation Engineering* Vol.69, No.4: 363-366. (in Japanese)

Imamura, Naraomi et al. 1977. *Tochi kairyou hyakunen shi (100 Years of Land Improvement).* Tokyo: Heibonshya Press. (in Japanese)

Japanese Institute of Irrigation and Drainage (JIID). 2003a. *Suido no chi wo kataru: 21 seiki ha mizu no seiki (Wisdom of Land and Water: 21st century, the century of water.).* JIID Books Vol.1. Tokyo: JIID. (in Japanese)

________. 2003b. *A Message from Japan and Asia to the World Water Discussions: Mutually Recognizing Diversity of Irrigation in Arid and Humid Regions.* Booklet prepared for the 3rd World Water Forum. Tokyo: JIID.

________. 2003c. *Kangaihaisuijigyou chiku no kanritaisei (Management System of Irrigation and Drainage District).* Chyugoku no tochikairyou (Land Improvement in China) Vol.19. Tokyo: JIID. (in Japanese)

________. 2004. *Suido no chi wo kataru: Sekaitekina Muzugiron no ba heno nihon ajia karano hasshin (Wisdom of Land and Water: Message from Japan and Asia to the International Discussions on Water.).* JIID Books Vol.3. Tokyo: JIID. (in Japanese)

Kokyo Toshi Journal. 2002. *Nougyou shyuraku haisui jigyou handbook (Handbook for Rural Sewage Project).* Tokyo: Kokyo Toshi Journal. (in Japanese)

Mase, Toru. 1994. *Mizu ga tsukutta ajia (Asia, Made from Water).* Tokyo: Ienohikarikyoukai Press. (in Japanese)

Mauer, Crescencia; Chanhua Wu; Yi Wang; and Shouzheng Xue. 1998. "Water Pollution and Human Health in China." *China Environment Series* Vol. 2. Washington D.C.: China Environment Forum: 28-38.

Minagawa, Yoshitsugu. 2003. "Tochikairyou shisetsu no ijikanri wo meguru kadai (Challenges for the Maintenance of Land Improvement Facilities)." *Nouchihou Kenkyu* May 2003: 29-41. (in Japanese)

Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF). various years. *Nougyou oyobi nouka no syakaikanjyou (Social Accounts of Agriculture and Farm).* Tokyo: MAFF. (in Japanese)

________. 1995. *Showa nougyou gijyutsu hattatsu shi (History of Technological Progress in Showa Era),* Vol.1, 2, 7. Tokyo: Rural Culture Association. (in Japanese)

MAFF, Land Bureau. 1960. *Nihon nougyou to mizu riyou (Japanese Agriculture and Water Use).* Tokyo: Suirikagaku kenkyujyo. (in Japanese)

MAFF, Regional Planning Section of the Structural Improvement Bureau. 1997. *Kaisetsu Tochi kairyo no keizai kouka (Description of the Economic Effect of Land Improvement).* Tokyo: Taisei Press. (in Japanese)

Ministry of Construction of Japan, River Bureau. 1997. *Drought Conciliation and Water Rights: Japanese Experience.* Tokyo: Infrastructure Development Institute.

Ministry of Land, Infrastructure and Transport, Water Resources Division, Land and Water Resources Bureau. 2002. *Nihon no mizu shigen (Japan's Water Resources).* Tokyo: Ministry of Land, Infrastructure and Transport. (in Japanese)

Ministry of Water Resources of China. 2003. *China Water Resource Bulletin 2002.* Beijing: MWR.

Mizutani, Masakazu, and Jing Chen. 2001. "Daikibo kangai shisutemu no bunkenteki kanri (Decentralized Management of Large Scale Irrigation System)." In *Monsun Ajia no mizu to shyakai kankyou (Water and Social Environment in Monsoon Asia),* ed. Kazuko Fujita. Tokyo: Sekaishisoushya Press. (in Japanese)

Moritaki, Kenichirou. 1982. *Gendai nihon no mizusigen mondai (Water Resource Problems in Japan of Modern Times).* Tokyo: Chyobunshya Press. (in Japanese)

Nagata, Keijyuro. 1971. *Nihon nougyou no suiri kouzou (The Water System of Japanese Agriculture).* Tokyo: Iwanami Shyoten Press. (in Japanese)

Nakashima, Yasuhiro. 1996. "Tochi kairyo seido to seihu no yakuwari (Land Improvement Project and the Role of Government)."In *Kawaru shyokuryou, nougyou seisaku: shijyo no kinou to seihu no yakuwari (Food and Agricultural Policy at crossroad: the market function and the role of government),* ed. Shinichi Shogenji. Tokyo: Daimindo hakkou Press. (in Japanese)

Nougyou Suiri Kenkyukai. 1980. *Nihon no nougyo yousui (Japanese Agricultural Water).* Tokyo: Chikyushya Press. (in Japanese)

Okabe, Mamoru. 2003. “Henyou suru mizu kanri sosiki: mattan suiri sosiki no kinou teika (Water Management Association in Transition: the weakening of smallest irrigation association).” In *21 seiki mizu kiki: nou kara no hassou (21st Century Water Crisis: Message from Agriculture.),* ed. Yamazaki agriculture research institute. Tokyo: Rural Culture Association. (in Japanese)

Okada, Mitsumasa, and Spencer A. Peterson. 1991. *Water Pollution Control Policy and Management: The Japanese Experience.* Tokyo: Gyosei.

Satake, Goroku. 1989. *Nousei, Tochi, Mizu: sono tenkai houhou to kadai (Agricultural Policy, Land, Water: Future Development and Challenges).* Tokyo: Souzou Shobo Press. (in Japanese)

________. 2003. “Kokudo mizu kankyou to nougyou suiri: seisakuron no shiten kara (National Environment and Irrigation: From the Policy Perspective).” In *21 seiki mizu kiki: nou kara no hassou (21st Century Water Crisis: Message from Agriculture.)*, ed. Yamazaki agriculture research institute. Tokyo: Rural Culture Association. (in Japanese)

Satoh, Masayoshi. 1997. “Nougyou yousui no tokusei to kongo no arikata (The Feature of Irrigation Water and its Role in the Future).” *Journal of Water and Environmental Issues* Vol.10: 1-8. (in Japanese)

Sato, Toshiro et al. 1985. *Mizu wo ikasu: suiri chitsujyo no shintenkai (Make the Best Use of Water: New Order of Water Management.* Tokyo: Tsukuba shyobo. (in Japanese)

Shogenji, Shinichi et al. 1997. *Nougyou keizai gaku (Agricultural Economics).* Tokyo: Tokyo University Press. (in Japanese)

________. 1998. *Gendai nougyou seisaku no keizaibunseki (Economic Analysis of Modern Agricultural Policy).* Tokyo: Tokyo University Press. (in Japanese)

Tamaki, Akira. 1976. *Fudo no keizaigaku (The Economics of Climate).* Tokyo: Shinhyoron Press. (in Japanese)

________. 1979. “Nihon inasaku kangai shyakai no Kindaika (The Modernization of Japanese Paddy Irrigation Society).” In *Kangai nougyou syakai no shyokeitai (Various Forms of Irrigation Agrarian Society).* Tokyo: IDE Press. (in Japanese)

Tamaki, Akira; Isao Hatade; and Naraomi Imamura.1984. *Suiri no shyakai kouzou (Social Structure of Irrigation).* Message from Japanese experience series, United Nations University project. Tokyo: United Nations University Press. (in Japanese)

Taniyama, Shigetaka et al. 2000. *Atarashii mizukankyou no soushyutu: nougyou shyuraku haisui system to sono gijyutsu (Creating New Aquatic Environment: Rural Sewage System and its Technology).* Tokyo: Rural Culture Association. (in Japanese)

Teruoka, Shyuzou. 2003. *Nihon no nougyou 150 nen: 1850-2000 nen (150 Years of Japanese Agriculture: 1850-2000).* Tokyo: Yuhikaku Books Press. (in Japanese)

Uchida, Tomoyuki.1996. “Chyugoku: Shisen shyo Seito heigen no jirei wo chyushin to shite (China: A Case Study of Chendu Plain in Sichuan Province).” In *Ajia no kagai seido: mizu riyou no kourituka ni mukete (Irrigational Institutions of Asia: toward efficient water use),* ed. Kenzo Horii, Takashi Shinoda and Hirokazu Tada. Tokyo: Shinhyoron Press. (in Japanese)

United Nations. Various years. *Statistical Yearbook.* NY: United Nations.

World Bank Office, Beijing. 2002. *Participatory Irrigation Management By Farmers: Local Incentives for Self-Financing Irrigation and Drainage District in China.* Beijing: World Bank.

World Bank. 2002. *China Country Water Resources Assistance Strategy.* http://www.worldbank.org.cn/English/Content/cas03.pdf.