The Paper to be presented at IASC 2011 Conference, Hyderabad India

The evolution of reservoir irrigation systems as commons in the dry climate region of contemporary Japan*

By
Aiichiro Mogi**
Keio Academic Enterprise
Tokyo, Japan

Abstract:

The purpose of this paper is to explain Japanese reservoir irrigation systems as commons through historical points and to present their transformation and contemporary challenges under industrial changes and urbanization. Also significance of the system is touched upon at the time of natural calamity and environmental threat. In Japan some regions have a fairly dry climate and are short of perennial rivers, and these have long adopted reservoir irrigation systems for rice cultivation from ancient times. Particularly in the areas facing the Seto Inland Sea (between the main islands of Honshu and Shikoku) to which Hyogo, Kagawa, Okayama and Osaka prefectures belong for example, there exist many such irrigation works. As is the case in the Asian monsoon region, rice farming under reservoir irrigation has the attributes of CPRs, requiring some level of joint management, and the social and institutional features of CPR-like practices among such systems are quite frequent. However, because industrial base of agriculture has been declining as economic structure shifts in Japan, quite drastically in the latter half of the 20th century, institutional arrangements in irrigation have also changed, resulting in inevitable alterations in the commons content. The paper begins by explaining the nature of system supporting water supply and irrigation technology. This paper then goes on to examine custom and practices undertaken in the areas of Japan with centuries of history in using reservoir irrigation and their changes. The paper concludes with thoughts about whether the commons can provide a significant basis even in the society of the present.

Key words: Reservoir irrigation system, rice cultivation, Japan, urbanization, traditional water custom and practices, new roles of irrigation reservoir

*revised after the conference (30 Jan 2011)

**Contact: mogi@keioae.com

Introduction

Although Japan is a “green archipelago” associated with a rainy season, some regions have a fairly dry climate and are short of perennial rivers, and these have long adopted reservoir irrigation systems for rice cultivation from ancient times. Particularly in the areas facing the Seto Inland Sea (between the main islands of Honshu and Shikoku) to which Hyogo, Kagawa, Yamaguchi, Okayama and Osaka prefectures belong, there exist many such irrigation works (See Exhibit 1 & 2). As is the case in the Asian monsoon region, rice farming under reservoir irrigation has the attributes of CPRs, requiring some level of joint management, and the social and institutional features of CPR-like practices among such systems are quite frequent. Such features of the commons are interconnected with how the cultivation is carried out in the real locality. In case of irrigated agriculture how the water supply is to be done is very crucial to whether the performance of the agricultural operations succeed or not. Assuming that amount of irrigated water is vulnerable to yearly climate condition, certain institutional set-ups has been adopted in order to preserve rational and equitable water distribution from far-back in centuries. Rationality and equity has been carefully paid in most of commons reality.

However, because industrial base of agriculture has been declining as economic structure shifts in Japan, quite drastically in the latter half of the 20th century, institutional arrangements in irrigation have also changed, resulting in many alterations in the commons content. Notably, urbanization and the transformation to industrial and services economy are the main culprits.

Irrigation works in Japan

Ponds, tanks and small reservoirs are the most ancient type of irrigation facilities in Japan. They were probably introduced from China, partly via Korea in about the fifth century. We call this span of time ‘Ko-fun’[1] period (the third to sixth centuries AD) in Japan. Many smaller ponds are identified as built in this period archeologically. Also technological base for building Ko-fun and the pond is said to be shared. Later in this country as feudal warrior class started building up their local bases and expanding the area of cultivated land under their control at least after the tenth century, larger irrigation networks based on small rivers and derivation canals became increasingly common. The proportion of land in Japan irrigated by ponds fell steadily.

In the total area of irrigated rice field, 87.3% depended on rivers, 11.1% did on irrigation reservoirs and 1.6 % did on others (groundwater etc) in 1996 (Uchida, 2003, p. 192). Corresponding figures for 1946, almost starting year for the postwar period, were 68.3 %, 18.3 % and 5.3 %, respectively (ibid, p191). According to the statistic of the Ministry of Agriculture, Forestry and Fishery (Exhibit 2), there were as many as 210,769 irrigation reservoirs in 1997, while 213,893 in 1989, 246,158 in 1973 and 289,713 in 1952-1954. Almost by 27% decreased the number from 1952-54 until 1997. From these figures one can say that the role of irrigation reservoirs has decreased through the postwar period, but some 10 % of rice field still use them. Their role is especially large in the areas surrounding the Seto

[1] This word means a large tomb of local lords and monarchs. Its building technology presumed to apply reservoir construction. The period attached this word represents a piece of time period in history when many tombs of Kofun are excavated later.

Inland Sea where rainfall is relatively small in comparison with other areas of Japan, and available amount of river water is small.

Exhibit 3 shows typical situations of prefectures in 1997 facing the Seto Inland Sea, such as Hyogo, Kagawa, Osaka and Okayama. In terms of numbers Hyogo is dominant. Kagawa has around 16 thousand reservoirs positioning next to Hyogo. As far as average size of reservoir is concerned, Kagawa is the largest, overtaking top position from Hyogo in numbers. When one looks at dependency ratios, Kagawa's ratio is greater than that of Hyogo, neck to neck to Osaka. Regarding dispersity of location of reservoirs in Hyogo reservoirs are densely situated in the areas facing Seto Inland Sea, including Awaji Island.

From Exhibit 4, we understand that dominant part of irrigation reservoirs is owned and managed either by hamlets (smaller that municipalities) or mutually agreed cooperatives (moshi awase kumiai), de facto institutions having no corporate status. According to Murota (2008) this fact implies that irrigation reservoirs are common-pool resources for small communities. If one investigates smaller irrigation reservoirs of beneficiary area less than two hectors, one is likely to find that much more percentage of reservoirs are owned and managed by small communities and that their autonomy is stronger than the cases of larger ones. Irrigation reservoirs are often susceptible to natural decay, earthquakes and others. Proper management of irrigation reservoir is essential for them to be free from disasters like floods. Irrigation reservoir cannot be maintained without human cares, and such cares are taken by local people in each community. If properly managed, irrigation reservoirs serve as fishing spots, place for collecting bottom mud (fertilizer), and others. In such a sense, productive ecosystem can be formed around irrigation reservoirs.

Systems supporting water supply and irrigation technology

Relating to irrigation varieties, particularly for paddy field rice cultivation, one can raise the following types.

1) water channel irrigation
2) reservoir/tank/pond irrigation
3) creek irrigation
4) groundwater use/pump-up irrigation

Although water channel irrigation is the main method of irrigation in Japan, in this paper special attention would be paid to reservoir irrigation system. Reservoir type is a measure which can adjust water supply by means of water in stock, mainly leveling the flow in response to the seasonality of rainfall. Akira Tamaki, Japanese eminent irrigation scholar, raised two features of reservoir irrigation; firstly nature of this type is independent because of short of influence and intervention from other streams; secondly it is stationary and given at the time of one phase of storage cycle; thirdly it is again independent and relatively smaller because beneficial area is relatively smaller. From organizational

point he also mentioned that equitable distribution of water is relatively kept as the first point. Secondly the way of management tends to be horizontal and unifying into purpose rather than authoritarian and power-wielding.

Next, I would like to explain the schematic links on water relationships proposed by Kazuo Morishita, irrigation engineering scholar (Morishita (1995)). According to his schema (See Exhibit 5), irrigation system is consisted of four factors, namely “water supply”, “water supply facility”, and “water distribution entity” around “water recipient area”. Water supply facility means reservoir, weir, and water channel. Water supply means required water itself and its stability and the degree of seasonality. Water distribution entity is an irrigation association in the modern period in Japan, but historically it related with regional power and its organization. In addition Morishita analyzes social dynamics affecting those factors consisting of reservoirs. Three factors, water recipient area, water supply, and water supply facility compose “civil engineering technology”. Such technology is limited by the technical standard on the natural condition of the region, such as rainfalls and geographical/geological qualifications. Combined with water supply and water distribution entity water one recipient area structures “water control technology” and “Facility management technology” with water supply facility and water distribution entity. Although irrigation reservoirs as a system are more independent than other irrigation schemes, such as in-taking river water irrigation types, they are inter-connected or inter-dependent with upstream/downstream or parallel relationship under larger regional systems including complementary functions with other recipient areas. Therefore water custom and practices developed in regional circumstances could be understood in the way that they have been accumulated historically in order to function these relationships. At the same time from the resource management point of view these systems could be grasped as “local commons”, because that water is positioned as indispensable resource for beneficiaries and joint-usage in a local defined area and that such resources are tightly managed collectively under precise rules. We can also say that such systems have attributes of social common capital supporting agricultural undertakings over the periods of time.

Close look at water distribution entity

In the previous section we analyze the functioning of irrigation in Japan. We should pay more attention organizational aspect of Japanese situations. Irrigation management has historically been the responsibility of the water users themselves, with a limited role played by the government. In Edo period Shogunate government, including feudal lords under the control of Shogun, used rice as a form of land tax. It is important to note that the land tax was imposed on the village rather than individual farmers. Therefore the entire village was required to work together to produce rice. The villagers also worked together to build weirs, ponds, and to develop the irrigation facilities. The village was a territorial community for earning a livelihood and at the same time, a water user group, igumi or mizugumi. Several water user groups worked together to form a larger scale group in order to coordinate interests of upstream/downstream conflict. Having such traditions, it was recognized that irrigation water was managed by the farmers. Water users were responsible for paying irrigation fees that covered the entire

operation and maintenance costs. In addition to paying fees, water user groups contributed voluntary labour to keep ditches clean and cut water grasses. After the Second World War Japan introduced Land Improvement Districts (LIDs) which were vehicles for paddy field upgrading and managing water distribution. This system absorbed previous several entities and united into one status. Compared to the previous water user associations, LIDs consisted of cultivator-farmers. This feature was in contrast to the older associations which were composed of landowners. These districts were in charge of the operation and maintenance of irrigation and drainage. Financing LIDs basically consisted of member fees (water fees), but depending on what activities were carried out, public funds supported their costs. As far as water facilities and water itself were accruing benefits for cultivators, no problem occurred. As you see the situation has been changed gradually, multiplicity of water functions would cause the problem in terms of cost-benefit equity.

Transition of Japanese irrigation reservoirs

Over the latter half of the 20th century industrial base of agriculture has been declining as economic structure was changed in Japan. If you look at Exhibit 6, you can observe such phenomenon. Number of farm houses decreased very much, becoming one third in number of farmers from 1950 until 2000. Farmers' percentage of total population states only 8.9% in 2005. In the postwar period before starting rapid economic growth in Japan the portion of rice cultivation earnings covered half of total agricultural earnings. In 2005 it only states at 22.8%. Because of rapid urbanization and industrial change percentage of households whose farming as subsidiary business of total farm houses grew very much stating around 80% in this century. At the same time when one looks at the society in the farming village non-farm ratio of all villages/hamlets can be read at almost 90% at the turn of century. However some changing symptoms appeared when one looks at the figures such as the decline of percentage of the type 2 concurrent farming households. Therefore, institutional arrangements in irrigation have also changed, resulting in many alterations in the commons content. Notably participation ratio to the joint activities at unpaid basis, such as clearing ditches and waterways, cutting grass of bunds, inspecting works of water intake and waterways, and several meetings by the member, has been decreasing. Exhibit 7 shows that because of uniform reduction of rice acreage by agricultural policy and slower demand for rice consumption, water usage per acreage has steeply increased for the last thirty years in the 20th century. As you see the on-going phenomenon, real challenge undergone through this transition is that scarce nature of irrigation water which characterized Japanese rice farming in the past changes into abundance that would affect seriously the whole system. As accommodating increase of industrial and civic usage of water has been much prioritized policy objective at the time of postwar and economic growth period, irrigation water has been pressured to divert their source and at the same time plenty of development projects has been carried out. This overdevelopment throughout the country exacerbated this situation.

Sanuki region

Sanuki area in Kagawa Prefecture has a comparatively drier climate even in the rainy season and few affluent rivers.[2] Plains in the region are little steeper than average and have few marshes and only rapid streams. Therefore historically tanks and reservoirs were developed for the irrigation purpose. In Sanuki approximately 12,400 tanks are now located the most densely in Japan (See Exhibit 8). In this paper Mannou-Ike (see Exhibit 9) and its irrigation area are taken as a typical example because this reservoir is the biggest in Kagawa and still the biggest in Japan. This big pond was built in 702 by the local governor of Sanuki, which is still the largest irrigation tank (the present water storing capacity: 15,400 thousand tons) in Japan. In 821, it was heavily destroyed by a flood and the governor of Sanuki presented the petition to the Imperial Court saying that Kukai, a high priest who studied in China about mainly Buddhism but also many disciplines including scientific knowledge and skills, be commissioned as the person responsible for the repair work on the reservoir. The reason why the governor chose Kukai was that firstly he was said to be obtaining enough knowledge of engineering, at the same time Kukai had been anxious about the rural living conditions and he had been respected by the native people. The incumbent emperor Saga appointed him as a superintendend of the restoration work of the reservoir. However, the pond was repeatedly destroyed by floods in the later periods. In 1625, Nishijima Hachibei, a warrior and also an expert civil engineer, took up a repair work and completed the reservoir in 1631. Still in the later periods, it had been destroyed by flood or earthquakes several times. It was lastly repaired to the present form in 1942. Although the case of Mannou-Ike has been exceptional, much smaller irrigation reservoirs have been constructed in the Sanuki plain. Construction of small irrigation ponds became more and more of the nature of small community works.

Water usage: custom and practices

Shelving the real challenges for a while, we now look at the traditional custom and practices in the case of reservoir irrigation.

Water usage custom were created and maintained in order to support the scheme which is described in the earlier section of this paper. The followings are the classification of water custom prevalent in Sanuki (old name of Kagawa prefectural area and still used for calling that region).

1) Receiving water custom

   In case of receiving water from sources such as neighbouring rivers and streams in order to replenish water resource of its own, “receiving water custom” takes effect. They are usually some arrangements between upstream water distribution entities.

2) Diversion custom

   In case of reservoirs having large beneficiary area, there are arrangements between members in terms of structures of diversion facility and method of diverting water. Members consist of different beneficiaries depending on the areas and upstream/downstream relations.

3) Distribution custom

[2] The annual precipitation in this area is 1,123mm (at Takamatsu, centre of this area, the annual average amount between 1971-2000). (National Astronomical Observatory, 2008).

They are custom and practices regarding ways of distribution to individual paddies. Rotational water distribution (Bansui-Sei) is a typical case devised for lessening the impact of drought situation. Well-crafted schedule (Ban-Gumi) of water supply is prepared. Also the way of water saving distribution, such as" Kiri-nagashi" (way to prevent water-logging in the paddy) or "Hashiri-mizu" (running water) is devised. Also there is a custom to employ a water distributor from the third party except for beneficiary people in order to keep water distribution objective and free from misdeed.

4) Custom at the time of Drought

There is a custom called "Mizu-Buni" in which specific water holders have right to obtain whole the remaining water when the depth of water decrease to certain level in the reservoir at the time of severe drought. Such water right is predetermined for each patch of paddies.

In Mannou-Ike particular, several rules of usage of water are in practice. In terms of remained documents we could only track back such custom to the medieval time, but such custom might have been used at the time of Kukai. As the case like the common resource such as irrigation water in the reservoir tanks, there are certain specific rules/regulations to be observed by stakeholders of the resource in order to preserve such resource. The following are the features in Mannou-Ike case.

1. Ordering of priority in using water; the crucial rule at the time of drought
2. Right of receiving water[3] at the first priority is retained by irrigators with written contracts (Shomon).
3. So-called 'Incense stick water': a way of controlling appropriation of water resources by way of firing time of a stick of incense for each irrigated paddy.
4. Annual celebration of the start of discharge of water (June)

Rotational distribution is an arrangement to keep rationality of allocating water between members of the local area. At the time of drought they set a table of shorter distribution time in order to save water. In contrast to such reasoning why "Mizu-Buni" was created? It is usually accepted that distribution custom is based on equity principle among beneficiaries; the water right is understood such as the right of "Gesamteigentum" (in German general proprietary legal terms) among all landowner of beneficiary area. Because "Mizu-Buni" itself is inequitable, why is it accepted and embedded in this society? It is suspected that in order to avoid wasteful conflicts for the sake of attaining water at the time of drought such wiser arrangement has been adopted that members should acknowledge water rights each other at the time of crucial situation according to historical experiences, preparing for the worst occasions.

Great drought of 1994

In 1975 Kagawa Canal was constructed and started its service in order to stabilize water supply in Kagawa and other drought–prone prefectures. Backed-up by ample water resource in the neighbouring prefecture and linked with the great River Yoshino of Shikoku Island this undertaking was a great leap

[3] Such portion of water is called 'Shomon-Sui' (supply of water protected by the deed) in Japanese

from civil engineering point and sustenance of water supply point not only for irrigation but also for living water and other uses. At the same time agrarian village society has been changed over period of time in the latter half of the 20th century owing to alterations in industrial structure of agriculture and urbanization. Part of water custom has been removed or changed; for example abolishment of water supply at night or traditional pond keeper status of certain families.

In the spring and early summer of 1994 Kagawa and coastal area of Seto Inland Sea suffered by the very severe drought. Responding to the crisis every beneficiary area started to adopt water-saving measures including rotational water supply custom such as Hashiri-mizu (water saving measure by which every paddy is irrigated as little as possible), night supply (once abolished), night watch and others. Particularly effective and important was that coordinating meetings between water distribution entities in order to save water. Some lucks saved this crisis and emergency measures were cancelled before the middle of summer. Enormous lessons were obtained through this drought. It was a good opportunity for related people and water institutions/communities to look back and review/value old custom and practices.

East Harima district and Awaji Island

Both areas belong to Hyogo prefecture where irrigation reservoirs are also densely located particularly in the southern part of prefecture and in the detached island.

In East Harima region particularly Inamino Terrace of diluvial type there are many ponds for irrigation for rice farming developed far back in centuries, because that terrace is short of perennial water resources (see Exhibit 10 and Exhibit 11). Coming into Meij era (1868-1912), petitions from farmers were made in order to realize later Ohgo and Yamada Canals (completed in 1919) to be built to link with perennial rivers with larger catchment areas. As changes of industrial structure have been proceeding in the postwar period, East Harima and Awaji region suffered the decrease of numbers of ponds and reservoirs. However, comparing with neighbouring Kobe area where smaller ponds are prevalent and whose area is much urbanized, the degree of decrease is much smaller in both areas. The reason is that although East Harima area has been becoming suburbanized of Osaka-Kobe city centers, the area has retained agricultural activities comparatively. In Inamino Terrace some smaller ponds tended to be abolished and unification and enlargement of ponds were taken place because of continuous maintaining of agricultural activities. As is the case with other suburban area, decrease of farming households and increase of non-farmers has become evident in Inamino Terrace, resulting the increase of new stakeholders for irrigation ponds. In Inamino Terrace many pond-councils consisting of LIDs and other stakeholders have been created in order to appreciate the environment of ponds and maintain those conditions. Now those councils are networked under name of Inamino Pond Museum which supports coordinating activities and makes research and irradiating works. This phenomenon brings about creation of newer commons. Scarce resource in this case is space and environment surrounding existing ponds and reservoirs.

Regarding Awaji Island (See Exhibit 12 and 13) this area is also inhabited with many irrigation ponds.

Because Awaji is an island and short of perennial waters, historically ponds are sources for irrigation. Great Hanshin Awaji Earthquake struck Awaji Island seriously and caused cracks and breaks in the bunds and dykes of ponds. Traditionally in Awaji Island water associations named Ta-zu (its literal meaning is “head of paddy fields”) have been activated. Members of Ta-zu are observing good tradition of custom and practices for water management. At this disaster there are fewer missing people in Awaji, comparing with other suffered areas. Also few repetition of secondary disasters occurred. Morishita and others (2005) suspected that very observant nature of people in the pond irrigation area accustomed and trained by keeping water community helped this response and behaviors after the earthquake.

Conclusion

Usually comprising resources for commons are at shortage relative to the potential demand for those resources. Commons setup is a kind of social solution for the resource allocation problem under the confined environment in which market solution cannot accommodate the problem. In Japan historically irrigation water was positioned at shortage in the drier climate region. Therefore water management had been so crucial that several devises of solutions were created in terms of commons features. Japanese experiences in the past remains rich evidences for commons working in terms of resource management in the relative strains. However one should look out for the contemporary situations along the changes of society. Because of reduction in rice farming at the latter half of the 20th century made water for irrigation purpose would become at surplus. Aspect of resource scarcity and the definition of shortage of water resources have changed. In replacing characteristic of agricultural use of water, other attributes of water combined with other uses might cause the scarcity tomorrow.

In this paper reservoir irrigation system is selected as a point for attention, because this system contributed very much to the Japanese rice cultivation in the drier area of the country from ancient times and that will continue to serve the society not only in strictly agricultural sense but in multiple uses for the society. Again in Japan reservoir irrigation system has important accumulation of knowledge in terms of relations with nature, water, and humans. At the time of severe drought past accumulated knowledge and practices helped very much according to the experience of Sanuki region in 1994. Incidences taken place in Awaji Island in Hyogo prefecture at the Great Hanshin-Awaji Earthquake of 1995 tell us the benefit of existing custom and practices of reservoir irrigation system in that region for rapid uniting of people in plight and swift recovery. Rapid urbanization in the eastern part of Hyogo near Kobe, part of dense reservoirs location, has carried out creation of pond councils consisting of old beneficiaries, residents, relating officials, discussing the changing roles of irrigation reservoir/ponds near the housing district altered from paddies in the past. Such remaining reservoirs and surrounding relationships would provide significant basis for the societies in the future.

Commons tradition today tends to submerge at routine times but emerges again and works well at the time of crisis. Also aspects of commons resources are reinterpreted for contemporary uses and contribute to new beneficiaries with necessary alterations in organizational terms such as commons councils. Commons have not died out in contemporary Japan.

References:

Beardsley, R.K., J.W. Hall, and R.E. Ward (1959), "Japanese Irrigation Cooperatives," in E.W. Coward, Jr. ed. *Irrigation and Agricultural Development in Asia, Perspectives from Social Sciences*, Cornell University Press, 1980.

The Committee on compiling the Book of Irrigation Reservoirs in Sanuki Region (2000), *The Book of Irrigation Reservoirs in Sanuki* (original in Japanese), Office of Land Improvement, Kagawa Prefecture, Kagawa.

Fukuyama, Akira (2003), *Japanese Hydrologic Situations and Regions in the Modern period* (original in Japanese), Yuzankaku Press, Tokyo.

Ikegami, Koichi (1996), "Semantics of Irrigation ponds as Citizen Commons (original in Japanese)," *Annual Studies of Rural Society*, The Japanese Association for Rural Studies, Nosangyo-Son Bunka Kyokai, Tokyo.

Kelly, W.W. (1982), *Irrigation Management in Japan –A Critical Review of Japanese Social Science Research*, Cornell University East Asia Papers, No.30.

Kitamura, Toshio (1973), *Historical Research on Irrigation and Water Custom and Practices in Japan, General Survey Section and Individual Area Studies* (original in Japanese), Iwanami-Shoten, Tokyo.

Mogi, Aiichiro (1994), "Commons in the World" (original in Japanese), Uzawa, H. and A. Mogi eds, *Social Common Capital –Cities and the Commons-*, University of Tokyo Press, Tokyo.

Mogi, Aiichiro (2008), "A Missing Link: Transfer of Hydraulic Civilizations from Sri Lanka to Japan," in *Learning from Ancient Hydraulic Civilizations to Combat Climate Change, Proceedings of the Regional Pugwash Workshop in Honour of Jayantha Dhanapala*, Sri Lanka Pugwash Group, Colombo.

Morishita, Kazuo (1995), Unification of Agricultural Water Use Organizations in an Irrigated Area by Reservoirs (original in Japanese)," *Journal of the Agricultural Engineering Society, Japan*, Vol.63 No.1, pp.37-42.

Morishita, Kazuo and others (2005), "Behavior toward Disaster Prevention and correspondence to Hanshin Awaji Great Earthquake in area of depending irrigation tanks (original in Japanese)," *Journal of the Agricultural Engineering Society, Japan*, Vol.73 No.2, pp115-120.

Murota, Takeshi (2008), "A New Role of Common Spaces for Environmental Conservation in Japan," A paper presented at IASC 2008 Conference.

Nagamachi, Hiroshi (1995), "Summer Drought in 1994 and a Counter-measure by Kagawa Water Operations (original in Japanese)," *Journal of the Agricultural Engineering Society, Japan*, Vol.63 No.1, pp.59-62.

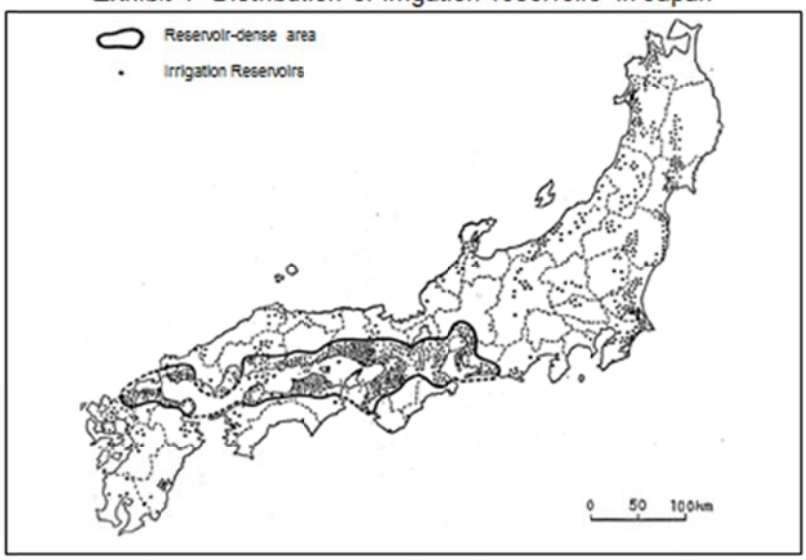
Ostrom, Elinor (1993), "Design Principles in Long-Enduring Irrigation Institutions," *Water Resources Research*, Vol.29, No.7, pp.1907-1912, American Geophysical Union.

Sarker, Ashutosh and Tadao Itoh (2001), "Design Principles in long-enduring institutions of Japanese irrigation common-pool resources," *Agricultural Water Management*, Vol.48, pp.89-102, Elsevier.

Sugiura, Mikiko (2004), "A study on distribution of irrigation water by Marugameiino LID of Japan in a dry period with the framework of Common Pool Resources (CPRs) (original in Japanese),"

Transactions of Rural Planning, Journal of Rural Planning Association, special issue, Vol.4.
Takeyama, Masujiro (1958), *A Study on Irrigation Reservoirs* (original in Japanese), Yuhikaku Press, Tokyo.
Tamaki, Akira (1983), *On the Structure of Water Society* (original in Japanese), Ronsosha Press, Tokyo.
Tsuboi, Nobuhiro (2003), "Structuring a New Water Society (original in Japanese),'" *Agriculture and Economy*, Vol.69(4), Showado, Kyoto.
Uchida, Kazuko (2003), *Disasters on Irrigation Ponds and Conservation of Regional Environment in Japan* (original in Japanese), Kaiseisha Press, Tokyo.

Exhibit 1 Distribution of irrigation reservoirs in Japan



(Source) Research Council on Regional History ed. *The Complete Book on Japanese Industrial History - Summary*, p95, University of Tokyo Press.

Exhibit 2 Change of numbers of reservoirs by prefecture between 1952-54, 1989, and 1997

Prefecture	Numbers					
	1952-54		1989		1997	
		Composition		Composition		Composition
Hyogo	55,685	19.2%	53,100	24.8%	47,596	22.6%
Yamaguchi	16,761	5.8%	12,482	5.8%	11,785	5.6%
Nara	13,767	4.8%	5,978	2.8%	5,757	2.7%
Kagawa	12,416	4.3%	16,158	7.6%	15,990	7.6%
Okayama	10,570	3.6%	10,284	4.8%	10,304	4.9%
Subtotal	109,199	37.7%	98,002	45.8%	91,432	43.4%
Country Total	289,713	100.0%	213,893	100.0%	210,769	100.0%

(Source) Tameike Daicho (Irrigation Pond Ledger) (1991,2002), Uchida, K. (2003)

Exhibit 3 Features of irrigation reservoirs in Japan

Prefecture	Numbers		Numbers (surface area over 2ha)		Area of Paddies		Area of Prefecture		Capacity (surface area over 2ha)		Density		Average Size	Dependency		Ratio of Paddies over Total Area
	①	Composition	①	Composition	③ ha	Composition	④ ha	Composition	⑤ Thousand m³	Composition	①/③	①/④	⑤/①	⑤/③	⑤/④	③/④
Hyogo	47,596	22.6%	6,608	10.4%	81,300	2.8%	633,6	22%	174,181	5.8%	0.58	5.67	26.45	2.15	0.27	9.7%
Yamaguchi	11,785	5.6%	1,968	3.1%	50,300	1.8%	611,3	1.6%	46,154	1.6%	0.23	1.93	23.84	0.93	0.08	8.2%
Nara	5,757	2.7%	1,567	2.5%	30,200	0.7%	369,1	1.0%	21,596	0.7%	0.29	1.56	14.04	1.09	0.06	5.5%
Kagawa	15,990	7.6%	2,108	3.3%	31,000	1.1%	1,877	0.5%	120,607	4.1%	0.52	8.52	58.26	3.96	0.65	16.5%
Osaka	11,306	5.4%	1,432	2.3%	13,400	0.5%	1,898	0.5%	91,446	1.7%	0.84	5.96	39.93	3.54	0.27	7.1%
Okayama	10,304	4.9%	4,348	6.8%	66,000	2.3%	7,113	1.9%	115,998	3.9%	0.15	1.45	26.68	1.75	0.16	9.3%
Subtotal	103,690	49.3%	22,108	34.8%	315,600	11.0%	37,567	9.9%	569,475	19.3%	0.35	2.76	25.75	1.80	0.15	8.4%
Country Total	210,769	100.0%	63,591	100.0%	2,866,000	100.0%	377,930	100.0%	2,946,712	100.0%	0.07	0.56	47.17	1.05	0.08	7.6%

(Note)

1. This statistic is based on the survey conducted in 1997
2. Density: ①/③ denotes reservoir numbers per paddy area; ①/④ denotes reservoir numbers per the area of prefecture.
3. Average size: Water capacity per reservoir
4. Dependency: ⑤/③ denotes water capacity per paddy area; ⑤/④ denotes water capacity per the area of prefecture.

(Source) The Committee on Compiling the Book of Irrigation Reservoirs in Sanuki Region (2000), Uchida (2003)

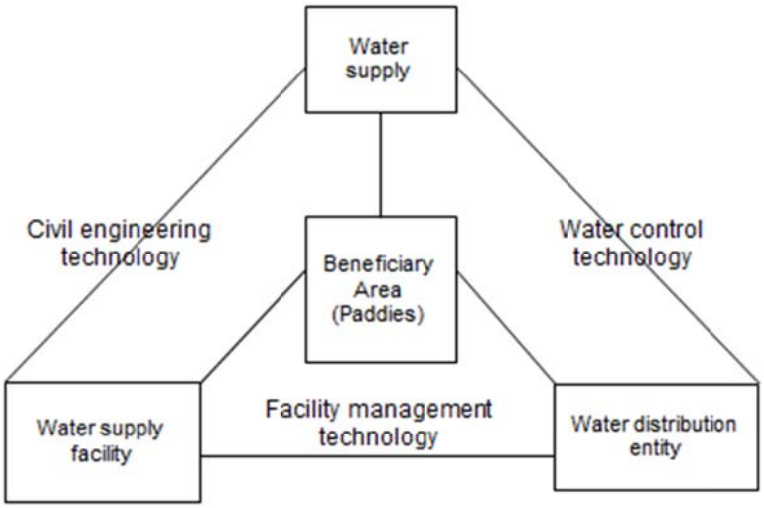
Exhibit 4 Numbers of owner and manager of large irrigation reservoirs in Japan (1989)

	Owners		Managers	
State	9,901	14.38%	79	0.12%
Prefectures	366	0.53%	117	0.17%
Municipailties	14,626	21.25%	7,683	11.16%
Land improvement Districts	3,526	5.12%	6,839	9.93%
Hamlet or Mutually agreed Cooperatives	33,657	48.88%	47,756	69.36%
Private peersons	4,968	7.22%	5,698	8.27%
Others	1,807	2.62%	681	0.99%
Unknown	0	0.00%	0	0.00%
Total	68,853	100.00%	68,853	100.00%

(Note) Large irrigation reservoirs here mean the ones of which beneficiary areas are equal to or larger than 2 hectares. Land Improvement Districts are created based on the Land Improvement Act of 1951. It is a modern form of traditional irrigation association in Japan.

(Source) Uchida (2003), p193.

Exhibit 5 Schematic links on water use relationships



(Source) Morishita (1995)

Exhibit 6 Transition of farming/village situation of the post-war period in Japan

year	1950	1970	1990	2000	2005
(1) Number of farm houses (Thousands)	6,174	5,402	2,970	2,336	1,963
(2) Farmers' percentage of Total Population	44.8%	25.4%	14.0%	10.6%	8.9%
(3) Rice cultivation earnings over total agricultural earnings	51.9%	38.6%	28.6%	27.5%	22.8%
(4) Extra-agricultural income over total farm house income	31.7%	63.5%	73.0%	82.1%	64.0%
(5) Percentage of households whose farming as subsidary business of total farm houses (Type 2 concurrent farming)	50.6%	84.4%	84.1%	81.8%	77.4%
(6) Non-farm ratio of all villages/settlements	24.7%	54.2%	83.8%	89.3%	n.a.

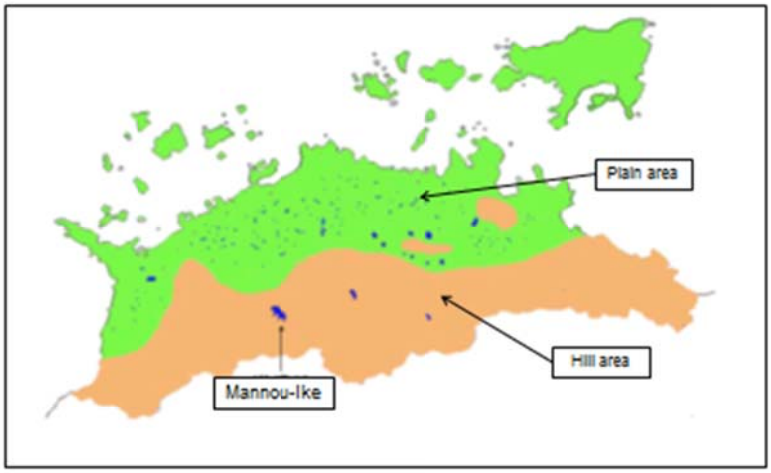
.(Source) Agricultural Census (various year), Ministry of Agriculture, Forestry, and Fishery.

Exhibit 7 Rice acreage vs agricultural water usage in Japan

	unit	1968 (A)	2000 (B)	(B)-(A)
Area of paddy fields	1,000ha	3,435	2,641	-794
Rice acreage	1,000ha	3,171	1,763	-1,408
Agricultural water usage	billion m^3	57	59	2
Water usage per rice acreage	m^3 / acreage	180	332	153

.(Source) Ministry of Agriculture, Forestry, and Fishery of Japan

Exhibit 8 Mannou-Ike and other reservoirs in Kagawa prefecture



(Source) Seijo Gakuen University (translated from Japanese text).

Exhibit 9 The aerial view of Mannou-Ike

(Source) Mannou-Ike Land Improvement District.

Exhibit 10 The map of Inamino Terrace

(Source) Yahoo map.

Exhibit 11 Ponds in detail at Inamino Terrace

(Source) Geographical Survey Institute of Japan.

Exhibit 12 Ponds located at the western Awaji Island

./(Source) Yahoo map.

Exhibit 13 Detailed map of Sonode hamlet in Awaji Island

./(Source) Geographical Survey Institute of Japan.