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Japanese Irrigation Management at the Crossroads

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ABSTRACT: To achieve the goals of irrigation projects, governments need to ensure appropriate operations and maintenance. The Japanese government has established a national-level participatory irrigation management (PIM) approach since 17th century and the Japanese farmers presently operate and maintain entire irrigation systems at their own cost under the Land Improvement Act enacted in 1949. However, whether this Japanese system is relevant to other countries remains unclear. This paper aims to characterise the PIM system in detail; it analyses its background conditions and extracts implications for successful PIM methodology. To that end, we mobilised and compared all relevant information regarding legal aspects, practices and statistics. We concluded that: 1) farmers' involvement from the initial planning stages – which is a requirement of the Japanese government's application system for irrigation projects – is critical if projects are to succeed; 2) resolving farmers' conflicts and coordination in advance are the key to success; 3) while transferring all facility management to the farmer irrigation association known as the Land Improvement District (LID), the government must constantly supervise and support the LID; 4) the experiences of Japan are relevant to countries that have small-scale farming systems; and 5) there is a rapid shift underway in the primary actors of Japanese agriculture in rural villages, from many small-scale farmers to a limited number of large-scale farmers. This transformation may require reshaping the Japanese model to adapt to new circumstances.

KEYWORDS: Participatory irrigation management, *mura* (a feudal village of Japan), farmer cooperation, indirect government intervention, large-scale farmers, Japan

INTRODUCTION

To achieve the goals of irrigation projects, governments must ensure the implementation of appropriate operations and maintenance (O&M). Beginning in the 1990s, following numerous global failures in direct irrigation management by governments, especially in countries with small-scale farming systems in Asia and Africa, participatory irrigation management (PIM) became the default approach. Many attempts were made to promote PIM systems through irrigation management transfer (IMT) (Vermilion, 1997), however there remains controversy around the best way to promote PIM. Hamad and Samad (2011) examined many problematic PIM cases which failed for various reasons including low fee collection rates, upstream – downstream water allocation problems, biased decision-making, and gender issues which prevented female farmers from joining a water users association (WUA).

Based on the recognition that IMT/PIM were not spreading successfully, Mukherji et al. (2009) selected and reviewed 108 IMT cases in Asia. They found that only 47 of these were successful, paddy cases in particular being more challenging than non-paddy cases. In terms of the reason for the failures, they contended that there was a conceptual fault with the present paradigm, which required a serious rethinking on the part of the donors and national and international policy makers. As the main reason for the different rates of success of paddy and non-paddy, they suggested that, "Perhaps one of the reasons might be that non-paddy systems need a certain level of water control, which paddy systems do not. Hence, farmers growing crops other than paddy have better incentive to cooperate" (ibid: 25).

The present authors, however, think that for paddy farmers there is no problem with over-irrigation, while non-paddy farmers must more carefully control the amount of water applied to their fields. This characteristic of paddy irrigation easily leads to uneven water distribution at every level of a canal system. It is because water is generally delivered to each canal at its head based on estimated water requirements. If upstream farmers take more than its quota for their fields, and normally throw it into the drain, then downstream farmers face a deficit. Water recycling systems (Satoh and Goto, 1999) and other water control means are keys to better water management.

For rice production, which is the principal target of Japanese irrigation, the government has been employing a PIM system at the national level based on the *Land Improvement Act* (LIA) that was enacted in 1949. The Japanese government has succeeded in motivating farmers to self-manage irrigation facilities at their own cost; their impressive success in this regard raises the question, "Is the Japanese management style transferable to other cultures?" (INPIM, 1997). The Ministry of Agriculture, Forestry and Fisheries (MAFF, 2003) stressed the vital activities of Land Improvement Districts (LIDs) and put forward their belief that LIDs would provide a case model for O&M of irrigation projects in every part of the world. Swain (2005) discussed the potential lessons for India of Japan's LID water management systems, she stressed the importance of conflict resolution through negotiation, which governments can facilitate through implementing a reasonable balance between intervention and decentralisation

Nickum and Ogura (2010) provided extensive analytical information on the irrigation project system and the activities of LIDs. They pointed out that the simplification of the pricing and cost-sharing systems on a system-wide basis is a good feature that would improve transparency; they, however, questioned the area-based pricing, the high costs and the large quantities of water applied to paddy fields.

Sarker and Itoh (2001) examined the self-governance aspects of Japan's irrigation systems, applying Ostrom's eight design principles (Ostrom, 1992) to Japan's enduring institutions. They concluded that the seventh design principle was key to Japan's stable and long-lasting self-governance of irrigation and that it brought together the other seven principles. Sarker (2013) further discussed Japan's governance of the irrigation commons and concluded that its state-reinforced self-governance system is key to successfully averting the tragedy of the commons.

These scholarly works provide essential introductions to, and analyses of, the present system of irrigation management in Japan. Consideration of the applicability of the Japanese system to other countries, however, requires detailed analysis of the linkages between the factors and conditions that contribute to the Japanese system. Key to understanding the Japanese system is an appreciation of the present role of the *mura* (the lowest administrative unit in the feudal era). Therefore, this paper aims to clarify the Japanese system of irrigation management by describing its background conditions and core ideas in order to better understand the current reality of water management in Japan and to single out some lessons for other countries and, in the future, maybe for Japan itself. We also discuss recent socio-economic changes in Japan's rural society which are demanding a radical shift in the traditional PIM system; for this analysis, we rely on information collected at different administrative levels, as well as on observed practices, statistics, and on our personal field experiences in agricultural engineering and water management.

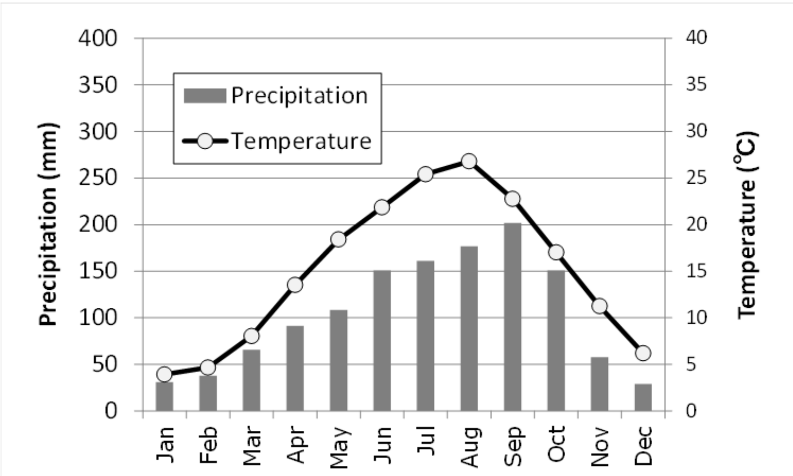
BACKGROUND OF JAPANESE IRRIGATION MANAGEMENT

Japanese settings for irrigated paddy cultivation

Japan is a long, narrow island country that stretches north to south. Its four main islands are located between latitudes 31°N and 45°N. It has a total area of 37.8 million hectares (ha) which is almost two-thirds mountainous forest. In 2018, there was 4.42 million ha of agricultural land, with land for paddy production (*suiden*, or land socially recognised and registered under the *Real Property Registration Act* specifically for wet rice production) accounting for 2.38 million ha. The rest of the agricultural land (*hatake*) was allocated to upland crops, orchards and pastures (MAFF, 2021e).

Japan has four distinct seasons over its main islands. Rainfall in Japan, as recorded between 1986 and 2015, averages about 1668 mm/year (MLIT, 2020). Due to low temperatures from late autumn to early spring, only one rice crop can be grown in most of the country. Figure 1 shows the average monthly temperature and precipitation in Kumagaya City, Saitama Prefecture, 60 km northwest of Tokyo. Temperatures range from 3.9°C in January to 26.8°C in August and the yearly average precipitation is 1259 mm, of which almost two-thirds occurs during the irrigation (monsoon) season. Japanese farmers thus generally get a sufficient amount of water for rice cultivation. Most of them prepare the land for paddy cultivation (paddling and transplanting) from late April to early June and harvest from late August to October.

Figure 1. Average monthly temperature and precipitation in Kumagaya City, Saitama Prefecture (1971-2020 period)

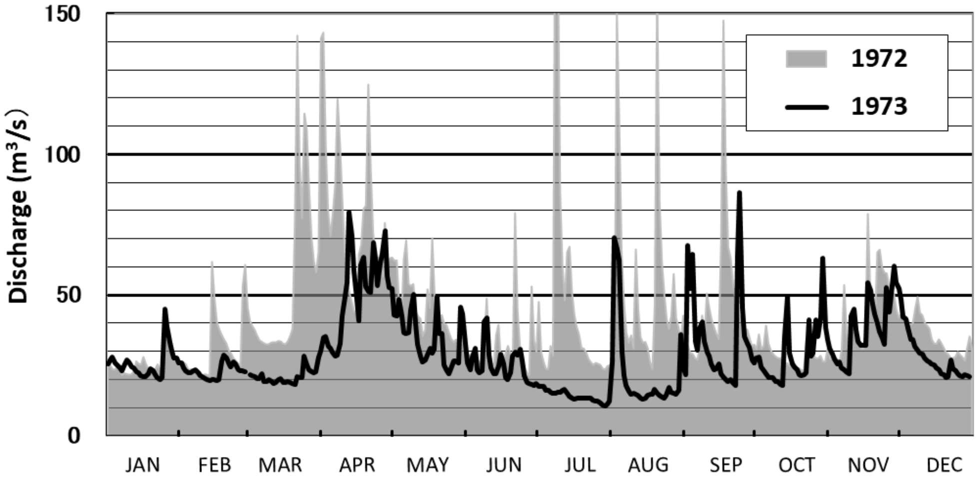


Source: Japan meteorological agency (2021)

Despite this high precipitation, around every 10 years erratic rainfall causes dry spells of almost a month; because of this, irrigation is necessary for stable paddy production. Almost 100% of Japan's suiden land has been irrigated throughout its history, while non-paddy crops have not required irrigation. We should thus not simply regard Japanese rice irrigation as "supplemental"; irrigation is a serious matter for rice farmers because without it some years they would realise no yield.

River water is the major water source for irrigation. Because of topographical conditions, Japanese rivers generally have narrow catchment basins and steep beds. High fluctuation is a special hydrological characteristic of the Japanese river flow regime. Figure 2 shows a daily hydrograph for 1972 and 1973 at the Funadabashi gauging station on the Kitakami River in Iwate Prefecture. It shows high yearly, seasonal and daily changes, including floods and droughts. 1973 was an extraordinarily dry year, with an almost 40-day dry spell in June and July; during that period, the discharge was reduced to 10 cubic metres per second (m^3/s), half of the previous year's minimum flow. Farmers must rely on such a low flow for short periods of time only but the paddy plant would surely die without irrigation. We should note that such dry spells may occur double in drought years, as seen in Figure 2. During non-drought times, rivers are an abundant water source and farmers can use as much water as they want. Because most of the diverted water – except that for consumptive use in the fields (evapotranspiration) – will return to the original river, no water shortage problems occur at those times.

Figure 2. Hydrograph of the Kitakami River at the Funadabashi gauging station, 1972/1973.



Source: Ministry of Construction (1974, 1975)

Note: The Kitakami River draws from an 868 km^2 drainage basin at the gauging station.

History of major irrigation development and management

Since rice has been Japan's most productive and stable crop, successive governments since the 17th century have tried to develop as much area as possible as paddy fields wherever irrigation water and suitable land were available. The feudal Tokugawa Era (1603-1867) witnessed a significant extension of rice irrigation in Japan. The 1.29 million ha of suiden in 1590 increased to 1.63 million ha between 1716 and 1747, and to 2.57 million ha by 1872 (Shinzawa, 1955; Matsuo, 1957). By the end of the Tokugawa Era in 1867, the area of suiden was almost 75% of its historic 1970 maximum of 3.41 million ha.

As early as in the Tokugawa Era, the low water flows in major rivers during drought were allocated almost entirely to rice irrigation (Shinzawa, 1954). As a result, serious conflicts over water allocation arose between the various irrigation groups that were diverting water from the same river. At the same time, local groups of farmers within individual irrigation projects also clashed (Kelly, 2007; Kitamura, 1950; Shinzawa, 1955).

In 1896, the new Meiji Government enacted the *River Act* (MLIT, 2008), which introduced a modern water control system and a water rights system established by the government. The water rights system required that anyone who wanted to use river water should apply for permission from the prefectural governor, who was responsible for river management in that prefecture. The enforcement regulation for the act stipulated, however, that everyone who had been using the river water till that point should be regarded as already permitted to do so; in this way, customary water rights were created in Japan.

Against the backdrop of the Tokugawa Era conflicts over river water allocations during drought, the government's issuance of new water rights to the various disputants ran the risk of strengthening their positions and thereby intensifying conflict; the government may therefore have sought to avoid becoming involved in the repeated disputes by not issuing water rights nor intervening in their traditional activities (Satoh, 2000).

In the major 1964 revision of the *River Act*, control of the country's 109 main rivers (called Class A rivers) shifted to the Central Government via the Ministry of Construction (which, after 2000, became the Ministry of Land, Infrastructure, Transport and Tourism, or MLIT). When reconstruction of diversion weirs and intake structures takes place on Japanese rivers, customary water rights are converted to ordinary water rights; capitalising on these occasions, the government places some restrictions on the use of water from these rivers, including setting maximum water rights in units of m^3/s, establishing seasonal upper limits for withdrawals, and placing limits on the total volume of water that can be diverted during the entire irrigation season.

However, this fundamental relationship between the government and water users that was formed at the beginning of the Meiji Era delineated Japan's river water management ways: According to the most recent legal interpretation of the *River Act*, in the case of drought the government is not allowed to decide and order river water allocation, it can only provide information and ask water users to consult with each other about sharing the water. Water users thus have the decision-making power as well as the duty to negotiate the matter (Article 53, *River Act*).

Irrigation management system

During the Tokugawa period, the central Tokugawa Shogunate and local clan governments developed irrigation systems; governments, however, controlled only the main facilities of these systems. During the irrigation season of 1853, for example, the Tokugawa government sent only four officers to manage the Minumadai Irrigation Project, which had a beneficiary area of around 14,000 ha and was one of the largest irrigation projects in Japan (Minumadai LID 1957); the actual practical irrigation management was entirely transferred to the relevant muras (Shinzawa, 1980; Kelly, 2007).

The governments then made the concerned muras establish a joint water users association (WUA) for each irrigation system. Governments funded the development of the irrigation systems, but farmers were required to manage the systems at their own expense and pay O&M costs. WUAs are thus a federation of muras, which are sometimes called *igumi* or *suiri kumiai* (Shinzawa, 1980).

In the Tokugawa Era, a mura typically consisted of less than fifty farming families (Fukutake, 1979). It had the collective responsibility for paying tax in kind, mostly rice. The major part of the tax was on rice production, which was calculated based on the registered acreage of suiden and the set standard yields. Shogunate or clan governments conducted area surveys and fixed the standard yields for every mura (*kenchi*) which, for that reason, had clear territorial boundaries.

The occasional droughts led to severe water shortages and, inevitably, to intense conflicts between muras. Under these conditions, solidarity among farmers within a mura was critical in order to minimise drought damage and remain capable of paying the tax; solidarity was strongly requested, and was further enforced by a form of social sanction known as *mura hachibu*, as described by Befu (1965). A mura operated and maintained irrigation and drainage canals in its territory cooperatively in order to promote the common interest of its members and defend it from other muras.

Conflicts between muras were not easily resolved, however, and on occasion resulted in physical violence. In 1609, 1621 and 1632, for example, the Shogunate government issued orders that water conflicts involving bows and guns should be severely punished on both sides (Nakamura, 1938), suggesting that the environment of Japanese irrigation management was far from congenial and peaceful. Since the 17th century, Japan has been handling such water management issues through farmer participation. The feudal mura system was abolished in 1872, and a new village system was initiated which combined several traditional muras and introduced a modern taxation system that ended the collective tax payment duty of muras. With this change, the feudal mura became just an informal group (now called *oo aza*). Muras, however, have maintained a practical function in various social activities in rural Japan; especially in terms of irrigation management, the mura still functions as an unofficial but essential unit, as described below.

Land Improvement Districts after World War II

A registered land ownership system was initiated in Japan in the 19th century. Before World War II, peasant tenants cultivated 44% of farmland, with owner-farmers cultivating the remaining 56% (Ouchi, 1978). In 1945/1946, the Japanese government instituted land reforms which transformed most peasant farmers into landowners; thus, by 1950, 91% of farmland was in the hands of owner-farmers.

After seeing the achievement of the land reforms, LIA was enacted in 1949, and the LID system was started. Until then, two kinds of farmer organisations had been involved in the management of agricultural land and water: land readjustment associations as instituted by the 1899 *Arable Land Readjustment Act,* and irrigation associations as established by the 1908 *Irrigation Association Act*; only landowners were eligible for membership in either. In 1949, these associations were reformed and transformed into LIDs, whose members were small-scale owner-farmers. Land reform thus prepared the ground and somewhat simplified conditions for the organisation and management of irrigation.

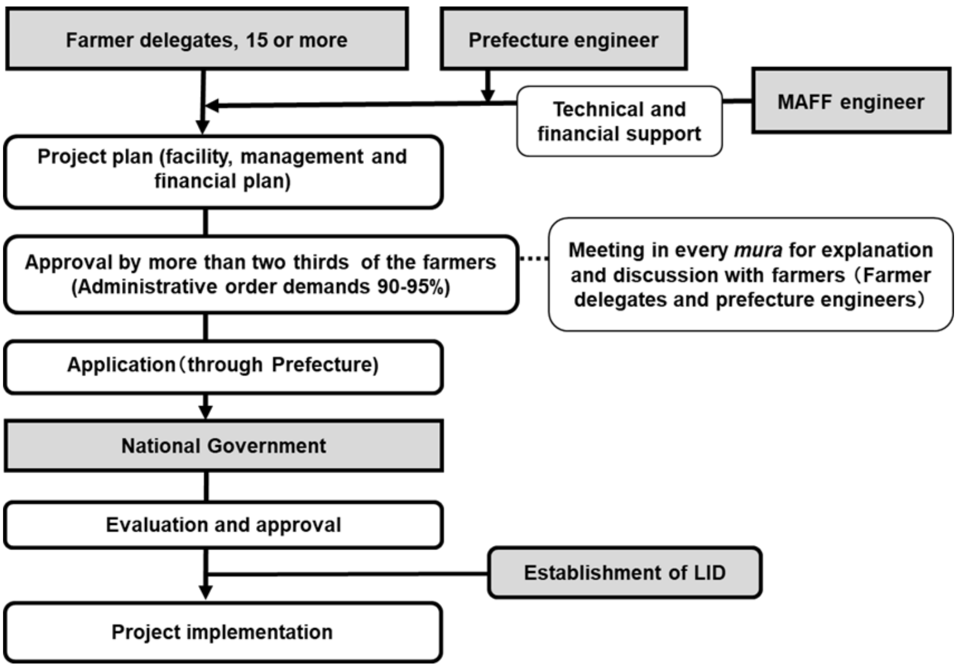
The LIA defines Land Improvement Projects as all projects that seek to improve agricultural land and water, such as construction or rehabilitation of irrigation and drainage systems, land consolidation, and even the management activities that take place after construction projects are completed. An LID is to be established for each irrigation project and autonomously managed according to the rules and guidelines provided in the LIA.

JAPAN'S IRRIGATION PROJECT FORMATION SYSTEM

Farmer involvement in irrigation projects

The Japanese government has a rigid policy of only implementing irrigation projects for which they have received a written application from the farmers concerned. This policy is based on the LIA. Figure 3 illustrates the whole (simplified) procedure for an irrigation project from initiation of discussions on the project idea to application and, finally, to implementation.

Figure 3. Outline of the procedures for a national irrigation project according to the LIA.



Note: LID = Land Improvement District; MAFF = Ministry of Agriculture, Forestry and Fisheries; mura = administrative village in the feudal era.

The idea for an irrigation project may originate from farmers, local leaders or government engineers. In all cases, 15 or more farm leaders must meet with the irrigation engineers of the Ministry of Agriculture, Forestry and Fisheries (MAFF) and the related prefecture; together they must develop a project plan, which should include all important matters such as physical, budget, and management plans. According to the national policy, the farmers must accept responsibility for the management of the facility after construction; thus, in the management plan, the LID will be the entity responsible for water management.

According to the LIA, to make an application farmer leaders need to obtain written approval from more than two-thirds of the farmers who are expected to benefit from the project. To gather the required number of consent forms, meetings to explain and discuss the project are held in every mura.

Despite the formal legal criterion of two-thirds approval, the government strongly recommends that leaders obtain agreements from 90 to 95% of the farmers who will benefit; otherwise, difficulties and inefficiencies may arise during project implementation. Once this condition has been satisfied, the application is submitted to the prefecture, and from there it is sent to the Central Government (irrigation section). It normally takes two to three years from project initiation to submission of the application. The Central Government covers all costs until the application is submitted.

In the final stages of the process, the government examines the project plans that have been submitted by candidates from across the country and determines which are reasonable. Once a plan is officially approved, work on the project begins. When the project officially starts, all the farmers who are to benefit, including those who didn't agree with the plan, must be members of the established LID; all have a duty to pay part of the project cost and the membership fee that covers the O&M costs. This compulsory participation in the project serves to maintain the efficiency of works funded by the national budget. In practice, when necessary, there is some room to make adjustments which can exclude some farms from the project area.

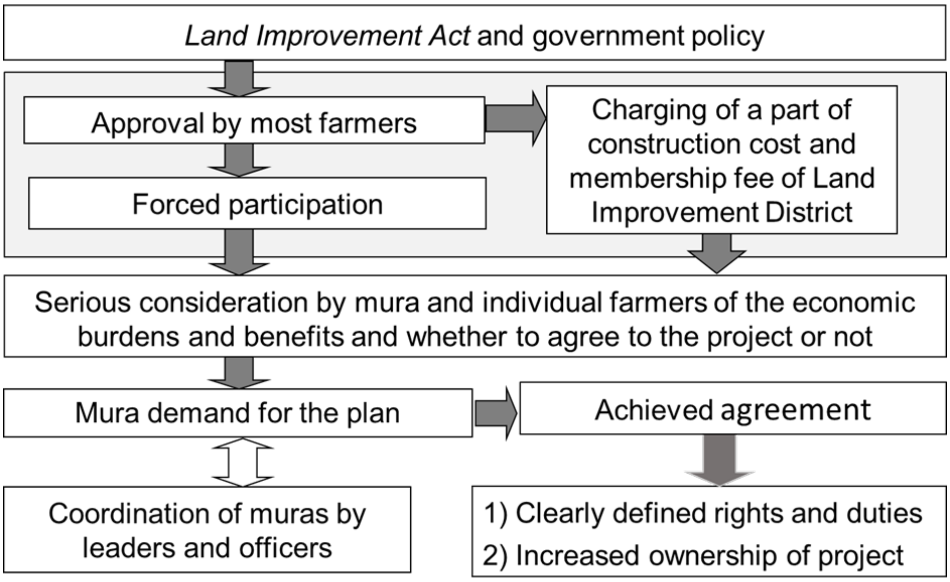
Farmers' consensus formation

In the project formation process, especially before famers give their signed approval to the project plan, the various actors generally behave in a cooperative manner which creates coordination among farmers; this results in a sense of project ownership, as shown in Figure 4. When the project plan is first presented, farmers must seriously reflect on whether they should agree to the plan. They must consider if the benefits of the project outweigh the economic burden and they may also want to negotiate in order to accrue as much benefit as possible.

Water management is one of the most critical topics for negotiation. Upstream farmers in an irrigation system have a more naturally advantageous position than do downstream farmers and most downstream farmers will thus be unwilling to join the project unless equitable water distribution is secured. However, upstream farmers cannot receive the benefits of the project if the plan is cancelled by downstream farmers and so equitable distribution is a matter of interest to them both Therefore, negotiation and approval may thus be an issue among local groups, with most members following the decision of their group.

The higher the government request for approval, the more vital the veto of downstream muras and mura groups. Under the high request, farmer leaders and irrigation officers must work forcefully to develop cooperation among the different groups so that the plan can be put into practice. In such an environment, farmers are encouraged to feel a sense of ownership of the project, and, once the agreements are reached, farmers have a clear understanding of their duties and rights.

Figure 4. Mechanism for promoting farmer coordination in irrigation projects.



Project cost sharing

While farmers must in principle shoulder O&M costs, the government and farmers share construction costs (with some exceptions depending on type of project, such as in the case of disaster recovery projects). Table 1 presents an example of typical construction cost sharing in national and prefectural irrigation projects. The classification of a project depends on the area that will benefit. If that area is equal to, or more than, 3000 ha, the project will be implemented as a national project and will thus receive more government financial support.

Subsidy ratios have varied according to the type of project and to policy shifts in changing socio-economic environments; for example, the cost-sharing ratios for national irrigation projects before 1993 were 60%, 20% and 20% for the national government, prefectural government, and LID, respectively.

We should note that these costs cover the entire expense of the project, including the costs of the main facilities such as reservoirs, diversion dams and main canals. Farmers are asked to contribute more than 10% of the total cost, which is not limited to the costs at the on-farm level. A governmental bank will provide a low-interest loan to the LID, and the availability of this loan also helps farmers decide whether to join the project. The LID will later collect money from the farmers to repay the loan over 25 years, including the deferment period.

Table 1. Typical share of project costs among governments and farmers in irrigation and drainage projects (%).

	Share of project costs (percent)	
Organisation	National project (3000 hectares or more)	Prefectural project (200 hectares or more)
National government	66.6	50
Prefectural government	17	25
Municipal government	6	10
Land Improvement District	10.4	15

MANAGEMENT OF AN LID

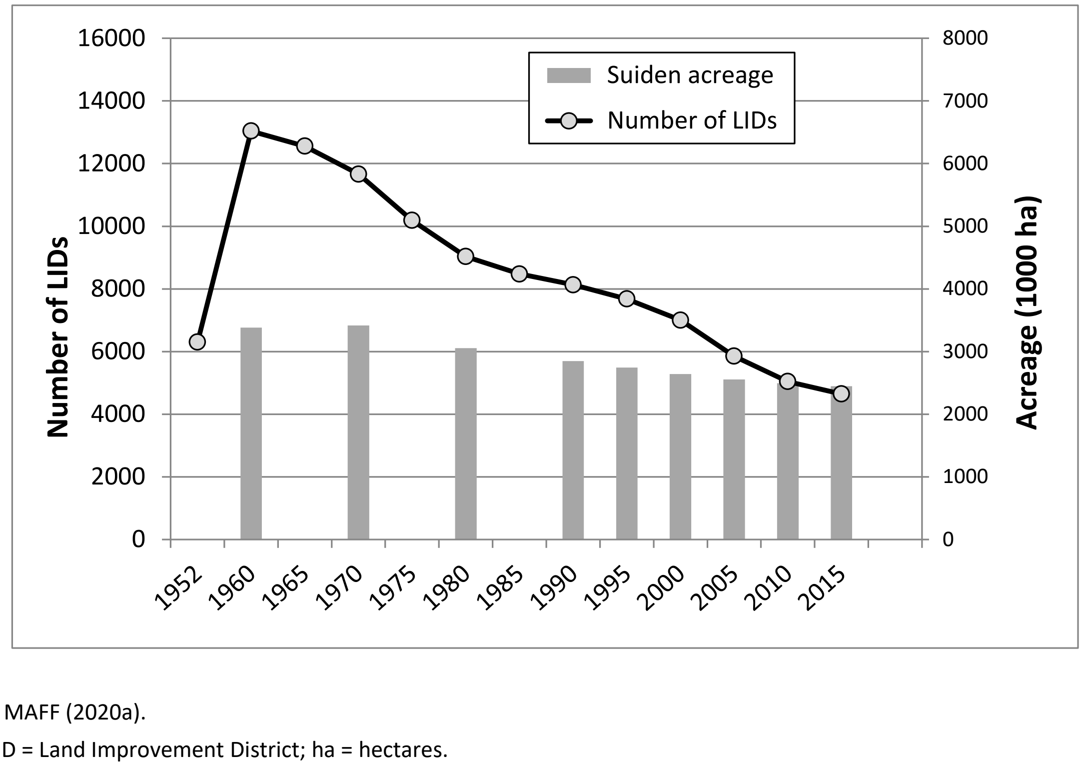
LIDs in Japan

In 2020, there were a total of 4403 LIDs in Japan, including 1257 LIDs with less than 50 ha and 16 with more than 10,000 ha (MAFF, 2020a). LIDs can vary widely in area depending on the setting, and each is managed separately and independently.

The total number of LIDs has changed over time, as shown in Figure 5. From the launch in 1949, the number increased until it reached its peak of around 13,000 in 1960; by the beginning of the 2000s, it had again decreased to about 7000. We should note that this decrease was largely influenced by the merging of small LIDs for land consolidation projects; it can also be partly attributed to the unifying of several LIDs into one for irrigation projects. In only a tiny number of cases can we find the dissolution of water-managing LIDs to have been caused by a decrease in beneficiary suiden areas.

The rapid decrease after 2000 was the result of the implementation of a policy to unify LIDs by merging them in the "21st century LID creation movement", which was conducted by the National Federation of Land Improvement Associations of Japan. This movement was begun in order to reshape LIDs in preparation for the new environment of the 21st century; in addition to merging neighbouring LIDs into one, the introduction of a double-entry book-keeping system may strengthen the management system and reduce costs. As a result of the movement, there was a 39% reduction in the number of LIDs serving less than 500 ha, while the number of large LIDs – those serving 3000 or more ha – increased by 3% (Table 2).

Figure 5. Change in the number of Land Improvement Districts and suiden areas in Japan, 1952 to 2015.



Source: MAFF (2020a).

Note: LID = Land Improvement District; ha = hectares.

Table 2. Reduction in the number of Land Improvement Districts (LIDs) by scale after introduction of LID reduction policy.

Area (hectares)	Number of Land Improvement Districts		
	2002	*2018*	*2018/2002*
Under 500	5545	3394	0.61
Under 3000	1083	868	0.80
Over 3000	188	193	1.03
Total	6816	4455	0.65

Organisational management of LIDs

Despite the wide variety of beneficiary areas, the philosophy and method of LID management is uniform across the country. The LIA provides detailed requirements for LID management based on democratic principles, where justice, equity and information dissemination are paramount. The government has prepared a template for the development of articles for an individual LID, and thus most LIDs have similar articles except for where differences are necessary based on specific LID conditions such as the number of member farmers. For the purpose of illustration, we introduce here the management of the Fukuoka-zeki LID (FLID), a medium-to-large-scale LID.

The Fukuoka-zeki irrigation system in Ibaraki Prefecture is located some 40 km northeast of Tokyo. It was first established for paddy development in 1625, downstream of the Kokai River, which is a tributary of the Tone River. The FLID (previously the Fukuoka-zeki Ordinary Irrigation Association) was established in 1951, after the 1949 enactment of the LIA. It now irrigates 2800 ha of paddy and 200 ha of non-paddy fields. The FLID has around 3000 members, which means that – consistent with the small-scale landholding size of most Japanese farmers – the average farm size is about 1 ha.

The LIA allows LIDs with more than 100 members to have a representative assembly in place of a general assembly of all members. The representative or general assembly is the highest legislative organ in the LID. Figure 6 shows the organisational chart of the FLID. Based on the LIA, the FLID drew up articles of association which specify a system for a representative assembly For the selection of the 60 representatives, the FLID set up 13 electoral districts, where every member has equal voting rights (one vote per member) and the number of representatives allocated to each district is based on the number of farmers. The representative assembly chooses the executive directors and auditors. Three separate levels of power are thus constituted, with executive directors selecting the president. The FLID office employs 12 officers, including engineers and technicians.

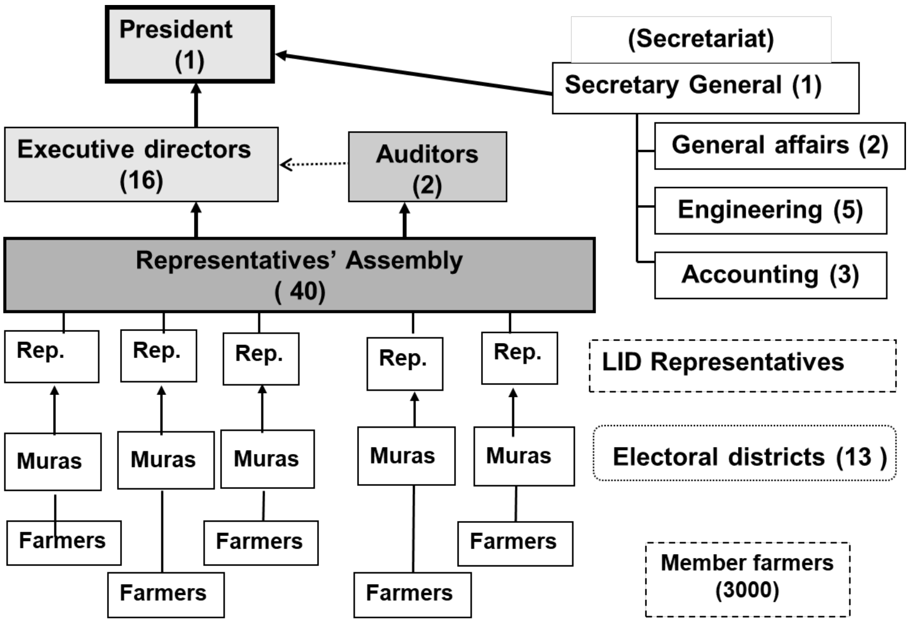
In the formation of electoral districts, the FLID employed the area's mura system, which includes 70 muras. Neighbouring muras were grouped to form the 13 electoral districts. In such a grouping, a mura should act as a unit and the farmers of a mura must not be divided, as the mura is still the basic unit for most social activities in rural Japan. At the same time, the electoral district grouping has been made in consideration of the fact that muras have common interests in water management, such as drawing irrigation water from the same canal, being upstream or downstream of the same canal, and so on. In this regard, the representatives will attend the assembly for overall LID management but are also serious about representing the districts that send them. They negotiate with other representatives regarding water delivery and take care of the irrigation facilities in their own communities.

The LIA assumes that the LID will be established as a democratic organisation in which every LID member should have an equal and independent right in every aspect of LID management. In the real management stage, however, we can say that a LID is managed based on the mura system. The election of representatives is key to LID management, but for at least the last 40 years such elections have not been held in the FLID, The reason is that in every electoral district – as a result of negotiation among the district's muras – the number of candidates running for election has been identical to the number of seats, and thus there is no contestation. In this context, the feudal mura is still functioning in present-day Japan.

The above situation also suggests that the LID is a kind of mura federation. In this regard, LIDs have been essentially unchanged from the feudal irrigation association (*igumi*) that Tamaki (1977) defined as a "mura-mura federation", although the LID is an organisation formed by independent individual members and the LIA doesn't refer to muras at all. The LID has no function to intervene in issues internal to *mura*s. For example, the discussion regarding water allocation in LIDs is one that takes place among muras, and each mura is responsible for deciding internally on its own water use (Fukutake, 1979).

Iwata and Okamoto (2000), however, questioned the concept of the mura-mura federation, suggesting that it was an overly simplified idea of the LID. They pointed out that a typical large-scale Japanese irrigation system consists of four levels of formal or informal management, from the LID at the top to the mura at the bottom. Each of these levels of organisation covers water delivery, canal maintenance, and canal management in the area. They all employ a bottom-up method for choosing their head and delegates, and members at that level follow their decisions. Matsumura and Hirota (2004) also studied the case of a stratified water management system in a large (9300 ha) LID in Isawaheiya, where 11 road and canal protection associations, or *dosuiro hogo kumiai,* (made up of a total of 257 subdivisions) play a vital role in the O&M activities of the LID. This case shows that nested enterprises – Ostrom's (1992) eighth design principle – have been functioning satisfactorily.

Figure 6. The organisation management of the Fukuoka-zeki Land Improvement Division.



Every significant matter, including budget plans and settlement of accounts, is discussed and decided on in the representative assembly and all written materials necessary for the discussion are presented there. LID newsletters describing the results of the assembly discussion and other important information are distributed to all members through the representatives and the mura system. In this manner, accountability and information disclosure are well achieved.

Membership fees are assessed based on each member's area of irrigated farmland. The present fee for paddy fields in the FLID is the equivalent of about 7% of the value of the crop yield, an amount which 99% of members can pay without fail. (The reason for the area-based charges will be discussed later.)

The Central Government inspects LIDs every three years to check whether they are being appropriately managed according to the LIA and other relevant laws; LIDs are inspected from the points of view of compliance, rationality and fitness-of-purpose, and proper handling of complaints from members is especially examined (MAFF, 2015). If necessary, the government takes action to guide the LID, however it will never give the LID direct orders on specific matters such as water distribution or selection of the president.

Water management in LIDs

As described earlier, water management in an irrigation project is totally decided on, and operated by, the LID or the farmers themselves. Mostly, however, LID officers limit their involvement to operation of the main facilities, while the other facilities are operated by local farmers or their groups. This arrangement inevitably leads to uneven water distribution, but this does not matter when the river flow is abundant, which is the dominant condition. There are two reasons for the acceptability of uneven water distribution: 1) downstream farmer groups can get sufficient water even under the condition of uneven water distribution, as long as the LID can divert enough water within their water right; and 2) most of the applied water returns to the drainage canals, which downstream farmers can then use for irrigation. Because water consumption in paddy irrigation is limited, additional water application simply results in more return flow (Satoh and Goto, 1999).

The development of water reuse systems in paddy irrigation is vital to stable water management; it increases available water and provides conflict resolution among farmers. At the basin level, water reuse automatically occurs between projects, depending on topographical conditions.

When shortages occur in the amount of water available to an LID, action must be taken. Under the free operation system, water shortages tend to be concentrated in the downstream part of the canal. When this occurs, the local farmer group begins to adjust water sharing for equitable allocation by limiting water flow to certain terminal canals. If the amount of available water is substantially reduced and such local actions are not sufficient for downstream farmers to solve the problem, resolution at a higher administrative level is necessary (Sarker et al., 2014). LID executive directors may at that point receive requests from representatives of downstream election districts, and may decide to respond to those requests by introducing rotational distribution to ensure equity. In most LIDs, the equity concept prevails in the discussion process.

The Meiji Yosui LID (MLID) is such an example. This irrigation system was developed for an area of tableland in Aichi Prefecture in 1880, with the Yahagi River as its water source. Its peak irrigation area was 8000 ha, but it now irrigates around 5000 ha. In 1971, the multipurpose Yahagi Dam was constructed upstream in the river basin, and the dammed river water was used for irrigation, water supply and industry, as well as for hydropower generation. The canal system consists of four main canals (*isuji*), 130 lateral canals (*shokanryu*) and other numerous small canals (*koyosui*). The O&M of koyosui is the responsibility of the related mura or muras.

In 1994, the MLID experienced an extreme drought. Water users in all the sectors held periodic meetings to decide on water sharing among sectors, according to the progression of the drought. As a result of these negotiations, the water-saving ratios in Table 4 were agreed upon, with higher water-saving ratios for irrigation and industry being accepted during this period. Water users thus made a concession in order to ease the negative impact on the lives of other citizens. This was the first time such a high water cut (65% of the water right), which meant 9.5 m^3/s of available water, had been undertaken.

Table 4. Water-saving ratio by sector during 1994 drought in the Yahagi River basin.

Period	Days	Savings ratio by sector (percent)		
		Irrigation	*Water supply*	*Industry*
May 30 to Jun 4	6	30	15	30
Jun 5 to Jul 10	36	55	25	55
Jul 11 to Jul 27	17	65	33	65
Jul 28 to Aug 21	25	65	25	55
Aug 22 to Sep 20	29	65	33	65

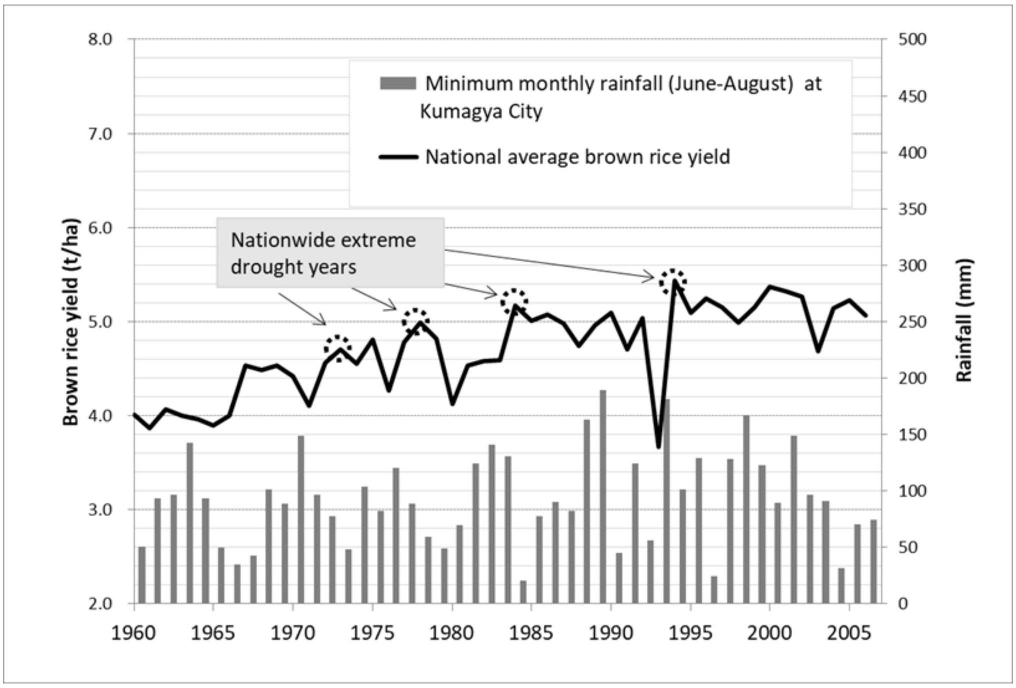
In the process of adopting this water-saving plan, the MLID decided to introduce a rotational irrigation system from the beginning. It split the four main canals into two groups of two canals, A and B, and delivered water to them alternately. According to this system, intermittent days were arranged so that the water allotment should fill the canals to capacity; this was done in order to minimise the unevenness in water distribution to the upstream and downstream regions. In addition to this water distribution, to get higher equity the rotational irrigations at the local level were conducted with the cooperation of farmer irrigation groups for the lateral canals and the small canals. As a result, almost all paddy fields achieved higher than usual yields (Tanaka, 1995).

In drought years, when available water becomes limited, no direct government orders are issued on water distribution at the river basin or on-farm level; instead, water users discuss and decide on the distribution of the common resource. The results of such water sharing among farmers can be evaluated in terms of the impact on yield. Figure 7 shows the national average yields of brown rice (irrigated) with the rainfall situation at Kumagaya City. The rainfall line represents the minimum monthly rainfall in June, July and August; the circles in the figure indicate nationwide extreme drought years: 1973, 1978, 1984 and 1994 (MLIT, 2020). We can see that yields are rather high in severe drought years, with the yield index in drought years ranging from 106 to 109, suggesting high yields. In drought years – as long as the minimum amount of water is supplied to the rice plant – it thrives on high temperatures, more sunshine, and less humidity and disease. Figure 7 therefore suggests that during drought years few farmers suffer from water deficits sufficient to cause damage. We can thus conclude that in spite of the conflict among farmers, the Japanese system has been successfully managing the irrigation commons at both the local and basin levels.

This fact may explain why LID membership fees have been estimated based on the size of landholding, rather than on the volume of water used. Under the Japanese river flow regime, water saving is meaningless when the river flow is abundant and the return flow becomes the water source for downstream users; volumetric charging thus does not make sense. In contrast, when water is in short supply, an LID equitably distributes all the water under its control among member farmers. This equity does not mean an equal volume of water per se; rather, they send water preferentially to the paddy fields in danger of being damaged by water shortages, so that everyone can harvest his fields. Therefore the LID membership fee estimated by area is rational as the payment for the guarantee of harvest.

Globally, the system for levying water use fees is a hotly debated topic. In response to the discussions on water pricing at the Organisation for Economic Co-operation and Development (Perry, 2002), Fujimoto and Tomosho (2004) emphasised that high seasonal differences in precipitation, water reuse, community and the organisation of LID have a strong impact on water pricing in Japan, undermining the rationale for the choice of volumetric charging. The Japanese concept of equity in irrigation management that was defined above strengthens the rationale for not applying the volumetric charging system in the Japanese environment.

Figure 7. Irrigated rice yields in drought years in Japan.



Source: Ministry of Public Management, Home Affairs, Posts and Telecommunications; MAFF (2021) and Japan Meteorological Agency (2021)

Joint water management

Most of the irrigation systems in Japan are managed in an integrated manner by a single LID, from the diversion dam to on-farm facilities. Many large-scale irrigation schemes in other countries, however, resort to a joint water management (JWM) system, in which main canals are managed by governments and lateral canals are managed by a farmers' WUA (Mitra, 1992; Teamsuwan and Satoh, 2009; Aarnoudse et al., 2018).

Japan began to develop its integrated large-scale irrigation projects after World War II, most of which were constructed by the Japan Water Agency (JWA). One example of this, the Toyogawa Irrigation Project (TIP) in Aichi Prefecture, is a multipurpose project for irrigation, water supply and industrial water. Completed in 1968, it was designed to benefit 16,000 ha of agricultural land, of which 5000 ha was paddy and 11,000 ha was non-paddy. The system consists of reservoirs and a diversion dam on the Toyo River, two main canals, 163 lateral canals, and many distributaries. The JWA manages the reservoirs, diversion dam, and main canals, while the responsibility for managing the lateral canals and distributaries goes, respectively, to the Toyogawa LID (TLID) and 14 local (municipal) LIDs.

As Kono et al. (2012) pointed out, the JWA asks the TLID to develop a draft of the yearly water distribution plan for the whole system, which the JWA then authorises. The JWA operates the gates of the lateral canals according to this plan. The farmers thus have the practical decision-making power and the agency operates facilities based on their decisions. JWA and TLID communicate closely in the water distribution process, fully sharing information on the state of water resources. In this method of role sharing between farmers and government, the government willingly allows farmers to discuss and decide, supporting them in reaching rational and acceptable conclusions.

KEY POINTS OF THE JAPANESE LID MODEL AND IMPLICATIONS FOR ITS APPLICATION

The Japanese model of water management fits the definition of PIM as, "the involvement of irrigation users in all aspects of irrigation management, and at all levels" (Peter, 2004). The LID covers all aspects of a project, including planning, O&M, financing, decision-making, and all levels of irrigation systems from main to on-farm levels. For most of the country, this system has been successful; however, some of its key principles, as well as the possible difficulties of replicating them, must be emphasised.

The necessity for indirect government intervention for self-governance

According to Shinzawa (1957), the most fundamental aspect of irrigation management is handling "the regional conflicts of farmers" (*chiikiteki taiko kankei*). Such conflicts mainly originate from a situation where upstream farmers have a more advantageous position than downstream farmers, which can result in inefficient water uses and conflicts that demand government intervention. Historical accounts going as far back as the 18th century document the occurrence of conflicts between muras which necessitated government intervention (Shinzawa, 1980). Based on their long experience of Japanese irrigation management, the present authors conclude that, with the exception of small irrigation systems (Ounvichit et al., 2006), a simple IMT that lets farmers and farmer groups control everything without intervention or support from a third party is unlikely to be successful.

The Japanese government also recognises the importance of the management aspect of an irrigation project. Funds invested in a project can be paid back only through effective irrigation management. To that end, the goal is the highest irrigation efficiency through proper water distribution, and the long-term and efficient functioning of a facility through adequate maintenance. Recognising that if farmers are left to freely handle and manage irrigation systems they are unlikely to achieve such an ideal state, the government needs to intervene regularly in LID activities.

The Japanese system of applying for irrigation projects conveys a clear message that the opportunity presented by the construction of an irrigation project can be used to promote farmer cooperation. Japanese farmer cooperation has developed not because of any favourable natural conditions, but through intentional policy management. Through the application system, the government allows conflicting farmers to negotiate with each other directly. Through such negotiations, they come to know each other better and to reach agreement on water management. This helps develop the social capacity of farmers to solve problems with less government interference.

While the project application system is useful for developing project consensus among farmers, it may not be easy for international lending organisations to use it elsewhere, because several years are required between the initiation of the project and its official start. The positive impact of ascertaining facts should be emphasised, however – an element which is built into the application process. The in-depth understanding of the project plan, water availability, and facility function will support farmers in the rational management of water. It may help them develop a sense of their rights and duties and may minimise discrepancies between expectations and reality. The extended time before the actual start of a project can thus be effectively used to build the capacity for good management.

As Sarker (2013) articulated, the Japanese management of common waters could be termed "state-reinforced self-governance": a type of water management by farmers where the government supports firmly but intervenes only indirectly. For the sustainable self-governance of WUAs, the authors specifically suggest that government intervention should include: 1) outlining the preferred targets of WUA activity, 2) guiding WUAs towards the targets, 3) preparing a support system for better management as an incentive for farmers, and 4) auditing the WUA regularly to determine whether its activities are adequate. These are general principles; however, what actions should be adopted, and how intensively, will depend on the individual case and the practical situation.

Subsidies to get approval for a project from a majority of farmers

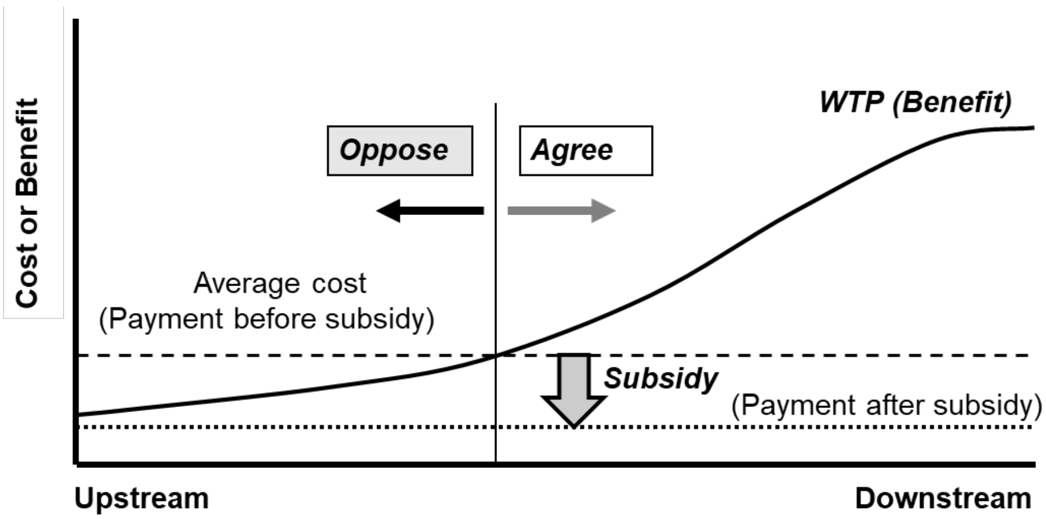
Agricultural subsidy is a controversial issue as there are concerns regarding its negative effects on world markets; this is the case despite US$ 536 billion in subsidies being disbursed each year between 2017 and 2019 in 54 countries that were studied (OECD, 2020), including subsidies of irrigation projects. It is therefore worth considering the impact and role of subsidies in Japanese irrigation projects.

Any project needs to be economically worthwhile in order to be implemented by a society; this means that the benefit (*B*) must be larger than the cost (*C*), ($B/C > 1.0$) (Watkins et al., 2021). As the project may include many farmers, however, it is important to address the problem of differential benefits accruing to different farmers, which leads to differences in willingness to pay for a project. In the case of rehabilitation projects, for example, upstream farmers are generally in a position where water is easily accessible and the rehabilitation is thus of less benefit to them; this can leave them less willing to pay for the project.

As a policy, project costs are in most cases recovered equally over beneficiary areas; under such conditions, some people's willingness to pay may be lower than the levied cost payment. Such people will not view the project favourably, which could be a serious obstacle to reaching an agreement involving a majority of farmers. The government must overcome this problem if it is to achieve national goals. Government subsidies or contributions to the project are one effective approach. As shown in Table 1, the Japanese government adopts a subsidy policy for irrigation projects.

Figure 8 is a conceptual illustration of why it is not easy to get a majority of supporters to agree on an irrigation project involving many different farmers, even under the condition of $B/C > 1.0$; it further shows how subsidies can work to overcome this problem. Note that the figure simply supposes, as an example, that the benefit increases along the canal from upstream to downstream.

Figure 8. Impact of subsidy on increasing the number of farmers who agree.



Japan understands that the benefit of irrigation projects has two aspects: achieving national targets (for example, increased national capacity for food production), and benefitting farmers. This is one reason why the government implements a subsidy policy but requests that farmers contribute to projects.

The social unit of irrigation management

It is a matter for debate whether the Japanese model of PIM is applicable or transferable to other countries. If the Japanese model is dependent on Japanese indigenous conditions, it may not be easily generalisable (Satoh et al., 2013). We consider that the basic principles of the model are based on internationally relevant factors: the principles of democracy, equity, information dissemination and so on, as discussed above. But if it is indeed true that some conditions may be specific to Japan, we suggest that not all the requirements need to be identical to those in Japan for the model to be applied elsewhere.

The mura, for example – which, as we have seen, plays a vital role in Japanese water management – is a point of discussion when considering the applicability of Japanese experiences to other countries. Almost every country has a village system for administration; clearly, however, such systems cannot resemble the system of muras in place during the feudal period in Japan which, as described above, forced solidarity on their members. From the point of view of modern-day irrigation management, the Japanese mura functions as an irrigation unit that includes some 50 farmers. One of the most basic problems in water management by farmers is regional conflict, for example upstream – downstream water distribution. In this regard, mura members have common interests which they clearly recognise. Mura delegates from every region gather in the LID to discuss and decide on questions of water management, with indirect support from the government through the LIA.

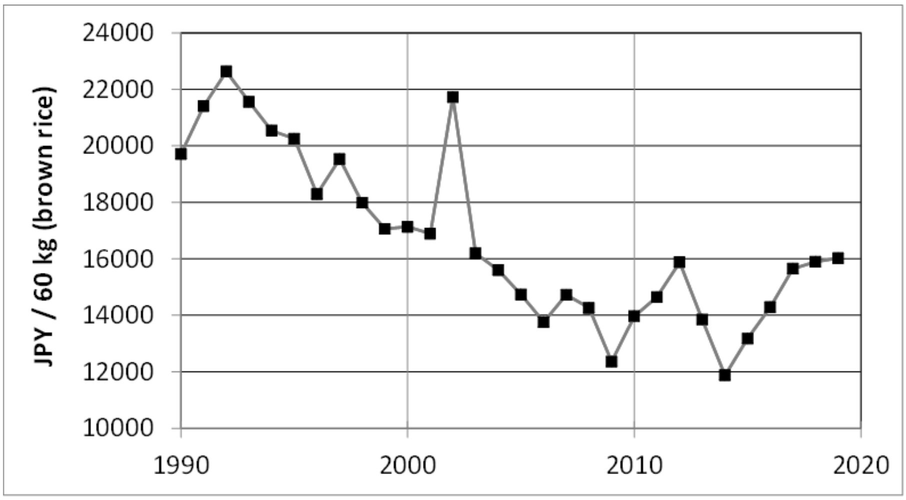
It is important to establish irrigation social units and, through education and training, to convey the advantages and disadvantages of these units to their members along with the fundamental principle of equity in water management. A full understanding of the project, complete information dissemination, and a prepared discussion platform are fundamental to achieving this. The government offers support to LIDs for improving their management skills, using various opportunities for training to inculcate a deeper understanding of water and society. This is one of the ways farmers can develop their capacity for self-management, which ultimately helps the government achieve its goals. Farmers prepared in this way are more likely to work effectively in managing the WUA and creating their own operational rules.

THE CHANGING SITUATION OF RURAL VILLAGES IN JAPAN: IMPACT ON IRRIGATION MANAGEMENT

After World War II, because of land reform, most mura members became small-scale owner-farmers. It is this condition which is the background for the LID system. Since the 1980s, however, many small-scale rice farmers have quit mainly because of falling rice prices and the resulting decrease in income compared to what they could earn through employment in other industrial sectors. Figure 9 shows the change in the producer price of rice since 1990 (after deflation; 2015 = 1.0). The price of rice declined by almost 45% between 1992 and 2009, and the 4.37 million households engaged in rice farming in 1985 decreased by almost 50% to only 2.15 million in 2015 (MAFF, 2021a). Rice was the main crop for small-scale, part-time, mostly older farmers whose average age increased with every passing year. The average age of farmers who were mainly engaged in agriculture in 1995 was 59.6; this went up to 64.2 and 67.0 in 2005 and 2015, respectively.

Under these circumstances, the government enacted the *Food, Agriculture and Rural Areas Basic Act* (FARABA) in 1999 (MAFF, 2021b); it set a policy target of enlarging the size of agriculture businesses so as to lower rice production costs and sustain the income of farmers such that it was not less than the income in other economic sectors. This target has been kept. The latest version of the Basic Plan for Food, Agriculture and Rural Areas (BPFARA) (MAFF, 2021c), which is the action plan for FARABA and is revised every five years, specifies that business farmers should have an 80% share of farmland management in the future.

Figure 9. Evolution of the producer price of brown rice.



Source: MAFF (2020b).

Note: JPY = Japanese yen.

Most of the farmers who quit lease their suiden land to large-scale farmers in or outside of their mura while themselves continuing to live there. As a result of this shift of small farmers out of rice farming, the number of large-scale farmers and their farm sizes are increasing. Since agricultural land is firmly controlled in Japan by the *Agricultural Land Act* (enacted in 1952) and other related laws, such farm lands including hatake have not been easily repurposed. Table 5 shows the change in the ratios of agricultural land managed by different-scale farmers.

Table 5. Change in the ratio of agricultural land managed by different-scale farmers

	Agricultural land (percent)							
Year	Under 1 ha	1 to 5 ha	5 to 10 ha	10 to 20 ha	20 to 30 ha	30 to 50 ha	50 to 100 ha	More than 100 ha
2010	14.4	34.2	9.7	9.0	6.5	9.4	10.7	6.1
2015	11.9	30.2	10.3	10.1	7.2	10.3	11.8	8.2
2020	9.3	24.9	10.1	10.9	8.0	11.7	13.4	11.7

Source: MAFF (2021a).

Note: ha = hectare.

This table shows the rapid development of large-scale farmers, including mura-based farming associations and agricultural corporations. The former is a farming organisation based on the mura (*shuraku eino*), which engages in agricultural production and shares the benefits cooperatively; most limit their activities to inside their mura territories while some federations of neighbouring shuraku eino have emerged. In most cases, shuraku einos manage all of their fields, including suiden and hatake, in such a way as to make full use of the members' land, labour, and time. Some farmers in the mura may not join such shuraku eino and instead continue to farm as individuals, seeking benefits without any relation with any mura system. We can also find some individual farmers having increased their farm size through individually collecting farmlands from small-scale farmers; some of them still operate family-run farming.

The cost of leasing suiden land is usually about one bag (60 kg) of brown rice per 0.1 ha, where the average yield is about 8 bags per 0.1 ha. Large-scale farmers have been trying to accumulate as much land as possible in order to enlarge their farms; recently, however, in some regions they have been hesitating to incorporate scattered small pieces of land into their operations as that does not suit cultivation with large machinery. This leads to an increase in abandoned farmland which, in 2015, totalled 423,000 ha of suiden and hatake (MAFF, 2021d). To prevent such abandoned farmland and rededicate it to domestic food production and increase the labour productivity of large-scale farmers, the government has begun promoting land consolidation projects in order to enlarge the size of paddy plots (MAFF, 2021d).

With regard to the scale of farming, we should focus particularly on the organisations that are managing more than 50 ha of land, since most may inevitably relate to territories of at least two muras. In such cases, farmers will need to manage water in muras that are not familiar to them.

A case in point is Kobayashi Farming Inc. in Mie Prefecture, which manages 290 ha of suiden over 30 mura territories. Due to the unwritten water management rules of each mura, the company experiences no small number of difficulties in securing sufficient and timely amounts of water for their fields; the unwritten nature of the rules by which mura farmers operate the irrigation canals make operations particularly difficult, requiring the company to expend much time and labour on water management and giving rise to many conflicts with mura members. In an effort to solve this problem, the company decided to follow the traditional system by hiring and paying local farmers to manage the mura water issues as necessary.

The conditions described above suggest that the O&M of irrigation systems based on mura rules no longer applies to the new environment of trans-mura-boundary farming. The traditional irrigation management system thus becomes an obstacle to the new direction of Japanese agriculture.

In addition to such water distribution problems, these trends raise the question of which LID members should shoulder O&M costs – the small landowners or the large-scale farmers who are renting the land. At present, former small-scale farmers who have quit farming continue to hold the LID memberships. Another question to be addressed is whether the one-member-one-vote decision-making system is effective when the range of farm sizes has grown so dramatically (Onimaru, 2019).

In 2018, to address this situation and in an attempt to adjust to the new conditions, the government amended the LIA. Regarding water management, it created a new article (Art. 57.3.2) which requires that every LID that manages irrigation must develop a written regulation on water use adjustment among its members; it further stipulates that the regulation must include a method for deciding on water distribution and disseminating information on water delivery, based on a principle of equitable and appropriate water distribution.

These amendment relating to irrigation management seem to have a clear goal: the modernisation of traditional water management from a system based on muras to a system whose basic unit is the individual farmer. At present, the government requests LIDs to provide accountability on water management. This revision was the first step. More modifications of the LIA may be needed in the future in order to modernise the basic principles of the traditional LID system. Clearly, big challenges lie ahead for Japanese irrigation as it enters a new world after several hundred years of a mura-based irrigation system.

CONCLUSION

After an irrigation project is completed in Japan, the responsibility for all facilities (including the diversion dam and main canals) are transferred to farmer LID associations which manage them at the farmers' expense. This system has been in practice nationwide.

The Japanese government has a clear policy to implement only irrigation projects that have garnered prior agreement on the explained project plan (including irrigation management) from a high percentage of the farmers who will benefit. This system promotes farmer cooperation and involves the farmers in all aspects and at all levels of the irrigation project. The LID is an autonomous entity with an assembly of democratically elected representatives that acts as its legislative organ.

The Japanese government recognises the importance of effective water management in obtaining a satisfactory return on the investment in an irrigation project. It therefore has a robust interest in irrigation management at the terminal level. It conducts regular audits of LIDs, while providing guidance and support such that an LID can manage water in line with government goals. Indirect intervention is an essential part of this process.

This Japanese model of irrigation management was developed for small-scale farming systems. From the organisational viewpoint, the traditional village mura plays a vital role as an irrigation unit whose members share a common interest and compete with other units. From this viewpoint, the experiences of the Japanese model can be suitable for PIM systems in other countries with similar conditions.

In Japanese rural areas, most small farmers have quit farming or will stop in the near future and a limited number of large-scale farmers will replace them. The Japanese model will therefore need to be reshaped in order to adapt to new circumstances. This is clearly a historical transformation and a major challenge.

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