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Design principles in long-enduring institutions of Japanese irrigation common-pool resources

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Abstract

We examine how Elinor Ostrom's eight design principles that characterize long-enduring, self-governed common-pool resource (CPR) institutions apply to Japanese irrigation CPR management. The eight design principles are “(1) clearly defined boundaries”, “(2) proportional equivalence between benefits and costs”, “(3) collective-choice arrangements”, “(4) monitoring”, “(5) graduated sanctions”, “(6) conflict resolution mechanism”, “(7) minimal recognition of rights to organize”, and “(8) nested enterprises”. These design principles refer to irrigation case studies in developing countries mainly and this has aroused our curiosity to examine them in Japan, which has a highly developed economy and where irrigators self-govern their irrigation CPRs (and where the irrigation institutions have been long-lasting and stable). The non-coercive strategic presence of an external entity (the central, prefectural and local government), although the external entity has a strong economy and has invested a lot, has significantly contributed to irrigators' self-governance of their CPRs in Japan. We find that non-coercive characteristic of the external entity, while the irrigators have strong endogenous institutional arrangements, has led us to moderate design principle seven to explain Japan's case. The design principles of monitoring (appropriators' behavior) and graduated sanctions are quite implicit rather than explicit — as Ostrom has generally described these two principles — in Japan's irrigation management. With all these, we have found that Ostrom's eight design principles are basic, well configured, and unique, and when we moderate principle seven, the eight design principles together can account for the success of Japan's long-enduring irrigation institutions that the irrigators formulate to self-govern their CPRs. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

Issues concerning the management of common-pool resources (CPRs), including irrigation CPRs, have been critically debated over the past several decades. Scholars such as Gordon (1954), Demstetz (1967), Olson (1965), Hardin (1968), Hardin and Baden (1977), and Smith (1981) have advocated either a “state solution” or a “market solution”. Those who recommend a state solution principally argue that an external coercion is necessary to make individuals achieve their common interest in a group because CPR users, in the absence of an external coercive force, overexploit their resources, giving priority to individual interests over common interests in interdependent situations. Scholars such as Bromley and Cernea (1989), Fenny et al. (1990), Gardner et al. (1990), Ostrom (1990), McKean (1992), Ellickson (1994), and Schlager et al. (1994), have patronized the institutional solution (self-governance) as the best alternative. Many of them have performed a number of case studies and they have referred to several thousands of empirical case studies (Hess (1996) provides a comprehensive bibliography) to establish that users’ self-governance of CPRs is possible in many instances under endogenous institutional arrangements that the users design themselves. Many of the proponents of the institutional solution argue that when CPR management is either privatized or controlled by the state, internal institutions that the users traditionally have or can craft are adversely affected, finally leading to the users’ overappropriation of the resources. Consequently, market failure or state failure may occur with CPR management.

While some of those who suggest an institutional (endogenous) solution as a better alternative to a market or state solution admit that self-governance is not a “panacea”, they argue firmly that many case studies throughout the world reveal that CPR users’ self-governance, the mainstay of institutional solutions to CPR problems, can protect CPRs from possible degradation. Ostrom, the foremost proponent of the institutional solution to CPR problems, has suggested that eight design principles are necessary to make CPR institutions robust and long lasting. The eight design principles she has developed are: clearly defined boundaries; proportional equivalence between benefits and costs; collective-choice arrangements; monitoring; graduated sanctions; conflict resolution mechanism; minimal recognition of rights to organize; and nested enterprises (Ostrom, 1990, pp. 90–102; 1992, pp. 69–76; 1993, pp. 1908–1910). Ostrom developed these design principles primarily based on developing countries and the principles have attracted substantial attention of political scientists and scholars in other related disciplines.

Design principles are the requirements responsible for the organization of collective action. By “design principle” (in irrigation CPRs) we also mean, as Ostrom (1992, p. 68; 1993, p. 1907) has mentioned, “a characteristic” or “an element or condition” that exists to account for the success of irrigation institutions that the irrigators involved craft to self-govern and self-manage their irrigation system over a long period of time. Our present study is an attempt to examine how these eight design principles that characterize long-enduring, self-organized irrigation institutions apply to irrigation CPR management in Japan, which enjoys a highly developed economy and where irrigators self-govern their irrigation CPRs.

We have presented a part of this study in different conferences (see, Sarker and Itoh, 1999a,b,c; Sarker et al., 1999).

2. Irrigation management policy in Japan

Historically, irrigation CPR management in most of Asia has been the responsibility of the government, with a limited role assigned to the water users (Nagata, 1994, p. 1; Mizutani and Mase, 1999, pp. 324–325). Conversely, in Japan, irrigation CPR management has been the responsibility of water users or irrigators, even in large-scale irrigation projects, with a very limited role played by the government (ibid). In the 17th century, the right to use water was not in the hands of the individual farmers but was placed under the joint control of the autonomous water supply association of each farming village and the utilization of water was governed by the association's customs (Asian Productivity Organization, n.d. pp. 6–7). When communities were established in the latter part of the Middle Ages (9th to 15th centuries), community “self-governance” of irrigation water management, after a number of disputes, came into being as the fundamental model of an orderly water management system at the terminal end of irrigation networks (Japanese National Committee of the ICID, n.d.). A characteristic of the Japanese paddy fields is that the land ownership right is private, but irrigation water appropriation is conducted in common. This characteristic is not found in other Asian countries' irrigation areas, except in particular areas such as *subak* in Bali, *tuo banda* in West Sumatra, *muang fai* in northern Thailand, *zenjera* in the Philippines, and *huengnonggye* in Korea (Mizutani and Mase, 1999, p. 325; cross-referenced to Mizutani (1992)). The Workshop in Political Theory and Policy Analysis at Indiana University has done a series of research studies on irrigation institutions of irrigation CPRs in developing countries and found that, in many cases, a farmer-managed irrigation CPR is more successful than a government-managed or external entity-managed irrigation CPR (e.g. Tang, 1992; Lam, 1998; Ostrom et al., 1999). In Japan, which has a highly developed economy, the irrigators also self-govern the irrigation CPRs, even when an external entity such as the government heavily invests in the physical capital, such as irrigation and drainage engineering works.

As post-war agriculture has been remarkably reshaped by the major economic insurgence and the vast land reforms, the government has attached much more importance to the irrigators' self-governance of the irrigation system by entrusting agricultural water-use facilities to land improvement districts (LIDs), legal corporate bodies of water users. Principally, the irrigators of LIDs craft their own irrigation institutions or restructure the traditional rules. These institutions are usually robust and long enduring.

3. Irrigation institutions, Japanese irrigation CPRs

Institutions are the rules of the game in a society (or in an organization) reflecting the socially evolved conventions or the humanly devised constraints that structure political,

economic, and social interaction (Hayami and Ruttan, 1985, p. 94; North, 1990, p. 1; North, 1991, p. 97). Ostrom (1992, p. 19) more particularly characterized irrigation institutions as “the set of working rules or ‘rules-in-use’ for supplying and using water in a particular location”. The institutions for supplying water address “provision problems” and those for using water address “appropriation” problems.

A CPR, which is a sufficiently large natural or human-made resource, can be defined based on two attributes, regardless of the property rights involved: the difficulty (involving nontrivial costs) of excluding individuals from benefiting from a good pertaining to provision problems, and the subtractability of the benefits consumed by one individual from those available to others pertaining to appropriation problems (Gardner et al., 1990, p. 335; Ostrom et al., 1994, pp. 6–7; Ostrom et al., 1999, pp. 278–279).

In Japan, large-scale irrigation systems can be characterized by these two attributes and defined as a closed-access human-made CPR in which a well-defined group of farmers have property rights and use the irrigation water in common (Ciriacy-Wantrup and Bishop (1975) have conceptualized closed-access CPRs). In irrigation CPRs, the government has usually recognized the interdependent relationship between institutions (in other words, a special form of social capital) and physical capital.

To understand the postwar management of Japanese irrigation CPRs, it is essential to be familiar with LIDs because these districts (which refer to a water users-association, not necessarily a geographic area) have played an increasingly direct and practical role in determining the irrigators’ main collective action on their irrigation system. While the formation and management policies of Japanese LIDs are similar, this paper will refer to LIDs in general and the Nishikanbara LID, a case study area, in particular.

4. Land improvement districts

An LID is a corporate, decentralized, and financially autonomous association of those farmers who self-govern or self-manage the agricultural water system in a specific area. The Land Improvement Law (*tochi kairyô hô*) enacted after World War II in 1949 abolished the prewar land improvement system and established a cultivator-based land improvement system instead. The law is important for its contribution to the development of Japanese agriculture by establishing LIDs, which are legal corporate bodies that conduct cost-sharing negotiations between the government and the water users (irrigators) involved.

While national and local governments, with the consent of beneficiary groups, undertake the major responsibilities of irrigation project works for irrigation facilities, the governments usually entrust the entire administration of these facilities to water users organizations such as LIDs rather than to local public entities. Usually, LIDs directly manage the major facilities and the village or an association organized with the consent of the villages manages the minor facilities. An LID, which is also a public association with an elected council of representatives and employed staff, has the legal authority to collect necessary costs from the irrigators. An Election Administration Commission supervises the election of the representatives at the city, town, and village levels. Initially, to apply for the establishment of an LID, more than 15 qualified farmers must be elected or

selected to participate in the project. Those qualified farmers elect or select those persons who identify the regions that will constitute the LID area, outline the project plan, and draw up the articles of the LID under the appropriate legal provision. They need also to ensure the consent of the two-thirds of the farmers in the area that an LID covers.

The applicants, after seeking the consensus of more than two-thirds of the farmers concerned, apply for approval from the prefectural government for the establishment of the LID. The prefectural governor carefully screens the application to ascertain whether the objectives of the LID are consistent with the basic principles of an LID mentioned in the law. If the prefectural government finds that the project legally fulfills the basic requirements of an LID, it will notify the concerned city, town, or village offices and make several copies of the project open to public opinion for a period of more than 20 days.

Within 15 days of the expiration date for public comment, the prefectural government will respond to any objections raised by those people whose interests are affected by the project's implementation. The government either overcomes or accepts the objections, depending on the seriousness of them. If the government is able to overcome the objections or there is no objection, it approves the establishment of the LID over a specific area. The persons who are qualified to take part in the LID project also become the association members of the district. A general meeting attended by either more than two-thirds of the whole membership or of the representatives when the council is elected is convened to confirm any revision of the articles by obtaining the consent of the two-thirds members present. Thus, upon obtaining consent, a necessary draft is made and sent to the prefectural government, which judges and approves if the revision both reflects the majority's opinion and conforms to the existing law. A farm household, irrespective of the farmland it possesses, represents a member in the LID.

An LID, which usually conducts an election once every 4 years, has the following major functions (Nagata, 1994, pp. 7–8; Hasegawa and Tabuchi, 1955, pp. 116–117):

1. Applying for or promoting a land improvement project. In order to increase the productivity of their lands, the farmers actively try to promote land improvement projects through the LIDs. National or local governments subsidize part of the project costs, while farmers bear the remaining costs.
2. Collecting money from the member farmers to repay both the project costs (subsidized by the government) and the maintenance and operation costs (usually paid entirely by the farmers).
3. Conducting operation and maintenance of irrigation and drainage facilities.

While LIDs customarily pay all the operation and maintenance (O&M) costs, the central and prefectural governments either partially or completely subsidize construction projects. The central government, prefectural government, and farmers' groups (LIDs) share the capital costs (Table 1). It is exceptional when some LIDs receive grants from the government (municipalities) to finance O&M costs because the benefits from projects such as big drainage facilities are not limited to irrigators only but to other people as well. LIDs collect O&M costs, personnel expenses, and salaries of LID officers from members every year. LIDs also collect rents from those outsiders — people and companies — who use the irrigation area, for example, to install electric posts or to discharge water from

Table 1

Government subsidies for capital costs of construction projects^a

Type of project	Central government subsidy (%)	Prefectural government subsidy (%)	Total subsidy (%)	Shared by members of LID (%)
<i>Central government project</i>				
Large-scale irrigation & drainage	60–70	20	80–90	10–20
Land reclamation	75	12.5	87.5	12.5
Disaster prevention	60	35	95	5
<i>Prefectural government project</i>				
Medium-scale irrigation & drainage	50	25	75	25
Land consolidation	45–50	27.5–30	70–72.5	27.5–30
Integrated land improvement	50	25	75	25
Land reclamation	65	17.5	82.5	17.5
Disaster prevention	60	23	83	17
<i>Farmers' group project</i>				
Small-scale irrigation & drainage	45	–	45	55
Land consolidation	45	–	45	55
Land reclamation	55	–	45	45

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factories into the canals. In addition, LIDs collect the farmers' share of the capital costs when required.

As of 1993, there were 8096 LIDs covering an area of 3.3 million ha and including 4.7 million members (Japanese National Committee of the ICID, n.d.), and the Nishikanbara LID is one of them. The formative nature and administrative structures of all LIDs are similar in many ways.

5. Nishikanbara land improvement district

The Nishikanbara Land Improvement area is located nearly in the middle of the coastal region of Niigata Prefecture. It is an elliptic zone, 15 km from east to west, and 35 km from south to north. The Nishikanbara LID, which was established by combining five existing water users associations in 1951, is one of Japan's largest water users associations. The LID covers five villages, five towns, and two cities. At present (1999), its total farming land area is 19,103 ha (18,089 ha of paddy field and 1014 ha of upland field) and the association members total 14,199. The area is enriched with physical capital such as irrigation pumping stations/plants (about 402), drainage pumping stations/plants (472; the Shinkawa estuary drainage pump station is the largest in Asia), branch irrigation channels (607; 676.23 km), and branch drainage channels (598; 647.530 km).

The Nishikanbara LID has one main office and 12 branch offices in different locations of the area. The main LID office has two broad divisions: the Council of Representatives,

comprised of 100 elected or selected farmers (based on the 1999 election), and the Administration Bureau, consisting of 181 staff employees (as of 1999). The branch offices also have staff.

In the election of 1999 (elections take place once every 4 years), the LID members elected and/or selected 100 representatives from among themselves at the village, town, and city levels. These representatives formed the council of representatives, who then — based on the resolution at a general meeting — elected the board of directors (12 persons) and the board of supervisors (five persons). Under the elected directors, approximately 181 staff members, who are not elected but employed and/or hired, carry out the routine business affairs of the LID office. The office has two main divisions: the general affairs division (under a general affairs division chief) and the business affairs division (under a divisional manager).

6. The eight design principles

Ostrom's eight design principles explain the irrigation institutions that the irrigators of LIDs in general and the Nishikanbara LID in particular have collectively crafted to self-govern the irrigation CPRs.

6.1. Design principle one: clearly defined boundaries

As the postwar agriculture changed from a landlord to an ownership system, like other LIDs the Nishikanbara LID, as mentioned earlier, defined clear boundaries for the irrigation system. All the farmers in the area who have farmland requiring irrigation water are the members of the LID. The LID has kept the records of all the farmers' farmland area under the irrigation system, and there is no chance that non-members from other areas who do not contribute can appropriate irrigation water from this area. That is, no one can free ride.

6.2. Design principle two: proportional equivalence between benefits and costs

The management of a CPR usually encounters two broad types of problems: appropriation and provision problems. Appropriation problems, which are time-independent, are concerned with the allocation of the flow or, in other words, with the effects that various methods of allocating a limited quantity of resource units (such as irrigation water) will have on the net return obtained by the appropriators (such as irrigators). On the other hand, provision problems, which are time-dependent, are concerned with the stock or, in other words, with the effects of various ways of assigning responsibility for building, restoring, or maintaining the resource system (such as an irrigation system) over time, as well as the well-being of the appropriators. (Up to this point, the paragraph refers to Ostrom (1990, pp. 47–49)). In irrigation systems, water allocation (appropriation of irrigation water) and provisions are two major sources of collective-action problems, frequently contributing to sub-optimal performances in irrigation systems (Tang, 1992, p. 5; Lee, 1994, p. 9).

The Nishikanbara LID has formulated the rules, or restructured the traditional rules, specifying the amount of water that an irrigator is allocated. If an irrigator has a greater land area, he has to pay higher water fees. The irrigators not only share the project costs but also pay O&M costs to address appropriation and provision problems. The government partially or completely finances the project costs depending on the scale of the projects, and the irrigators virtually pay the entire O&M costs according to the irrigated land that an irrigator possesses. The government's strategic investment has largely solved the hardware (irrigation and drainage facilities) provision problems. The irrigators have largely solved the software (management) provision problems and appropriation problems. The overall attempt is to maintain irrigators' proportional equivalence between benefits and costs.

6.3. Design principle three: collective-choice arrangements

To fulfill the "requirement of unanimous agreement as a collective-choice rule" (Ostrom et al., 1999, p. 282), the LID in general or a community-based "terminal water-using group" in particular conducts several discussions. The irrigators of a community-based terminal water-using group collectively participate in modifying their daily operational rules. In the case of irrigation water distribution, the main duty of the LID is to make irrigation water available at the channels, which are connected with the main rivers. A community (or a group of communities) has its own terminal water-using group, which is responsible for managing terminal irrigation and drainage facilities that cover the command area of approximately 10 ha. The group members withdraw the water from the channels to the sub-channels, which run alongside farm roads or farmlands. Then individual irrigators withdraw the water from the sub-channels to their respective farmlands. Usually a community administrative organization (for a group of communities) forms a terminal water-using group and discusses the water appropriation policy at the spring meeting, which is held each year at the beginning of the crop season.

The members of a community-based terminal water-using group work with a strong sense of community consciousness and form the operational rules-in-use that make the group the sole working agent of water distribution at the operational level. Irrigators' misappropriation of water is normally out of question, given the fact that their strong community consciousness counters any inclination to cheat each other. While the elected representatives, with the help of employees, control the overall water distribution, irrigators who form the terminal water-using group, formulate their day-to-day rules of withdrawing or discharging water.

6.4. Design principle four: monitoring

While the LID monitors the overall irrigation system, such as the overall water distribution, a terminal water-using group within the LID selects certain irrigators as monitors (or observers) to look closely at its own particular area, especially with regard to the flow or discharge of water rather than to monitor who is misappropriating water. A land-owning irrigator has to take care of his or her own land, whether sufficient water has

been received or excess water needs to be discharged. Interestingly, the cost of monitoring human behavior at the terminal level is extremely low due to the irrigators' tendency, under the institutional arrangements that have been endowed with credible commitments, to work collectively with a basis in mutual trust. This accords with Leibenstein (1984, p. 80), who argued that conventions and institutions are very often self-enforcing and may not require much monitoring (sanctioning), whereas the same rules imposed by an external authority may require considerable monitoring. This leads us to argue that endogenous, self-enforcing institutions are far more effective than the exogenously imposed institutions that are costly as well. In Japan, this design principle of monitoring human behavior at the operational level is not as explicit as Ostrom has generally emphasized it.

6.5. Design principle five: graduated sanctions

Violations of those rules-in-use that are formed to appropriate water either in general or in particular (i.e. at the terminal water-using group) are exceedingly rare because of the conventionally institutionalized group consciousness and predominant mutual trust (social capital). This kind of particular behavioral approach in a CPR can be explained by Ostrom's argumentation that she mentioned elsewhere. "At the core of a behavioral explanation are the links between the trust that individuals have in others, the investment others make in trustworthy reputations, and the probability that the participants (i.e. irrigators) will use reciprocity norms" (Ostrom, 1998, p. 12). This kind of behavioral approach draws our attention to Buchanan's (1994, pp. 124–125) argument that many people do not behave opportunistically even when the possibility of enjoying an apparent advantage is available because they act within a set of endogenous self-imposed constraints.

While the solicited physical capital (to be described in design principle seven) is there, the irrigators (or employed staff) either at the LID level or the community level attach more importance to social trust rather than to an open description of rules violations and sanctions. This is consistent with a study by Knight (1998, p. 759) who argued that when the content of social norms (social capital) ordains cooperative behavior, social actors can establish stable expectations about the likelihood that others will cooperate and then make a decision to act accordingly. In Japan, this design principle is also not as explicit as generally described by Ostrom.

6.6. Design principle six: conflict resolution mechanism

When a general conflict does arise, for example, due to water scarcity between upper- and down-stream areas, the irrigators inform the LID, which is responsible for resolving the conflict. A "boundedly rational", to use Simon's (1957) words, problem-ridden individual irrigator, who may not have all the necessary information about why a certain problem, such as a shortage of water, occurs on his land, contacts the LID, which either has the necessary information or is capable of furnishing the information needed to address the problem with less transaction costs.

6.7. Design principle seven: minimal recognition of rights to organize

6.7.1. Moderated design principle seven: minimal recognition of rights to organize and non-interventionary investment in the solicited physical capital entrusted to appropriators' organizations

Japanese irrigators substantially are free to devise their own institutions unchallenged by the government with regard to both coordinating water utilization in order to ensure the withdrawing of water from the river and the control over water distribution and to conducting the operation and maintenance of irrigation facilities. The reason is that the government is aware that the rules the LID in general or the irrigators of a community-based terminal water-using group in particular continuously craft are congruent with the existing physical, social, and economic features of the irrigators. Furthermore, the government is aware that its external institutions may not match with the local conditions of an LID. When an LID convokes a general meeting or calls on irrigators' representatives to decide important affairs, the LID does not usually allow either external reporters or government agencies to attend the meeting.

While the irrigators virtually pay all the O&M costs, Table 1 shows that the government invests a large share of money in irrigation and drainage projects. When the projects are large, the government's share is very high because non-irrigators also benefit from the projects. When the projects are small and directly benefit the irrigators, the irrigators' share is higher. Although the government invests a lot, it principally entrusts all the irrigation and drainage facilities to LIDs, while irrigators usually pay all the O&M costs. Table 2 shows that LIDs manage the significant number of irrigation and drainage facilities entrusted to them. In very exceptional cases, when the irrigation facilities are huge (such as the Shinkawa drainage pumping station), the government shares some O&M costs because non-irrigators also benefit from such facilities.

Based on Japanese government's investment policies and strategic role, we would moderate principle seven as "minimal recognition of rights to organize and non-interventionary investment in the solicited physical capital entrusted to the appropriators' organization". The moderation of this design principle, however, owes much to the following statement of Ostrom (1993, p. 1911): "The proportion of successful self-organized systems can be greatly increased by the investment of central governments in general institutional facilities..." "Non-interventionary investment" means that even though an external entity invests in solicited capital, it does not intervene with the

Table 2
Irrigation and drainage facilities managed by LIDs in 1993^a

Type of facilities	Number/length	Managed by LIDs
Dams	456 (100%)	402 (88%)
Headworks	8790 (100%)	7510 (85%)
Pumping plants	25674 (100%)	23292 (91%)
Gutter gates	20523 (100%)	17220 (84%)
Water channels	221 (1000 km) (100%)	210 (1000 km) (95%)
Reservoirs & ponds	14511 (100%)	12483 (86%)

^a National Land Improvement Corporation Federation (1999, p. 68).

endogenous irrigation institutions that the irrigators craft. “Solicited physical capital” refers to those irrigation facilities that irrigators collectively welcome and about which, before making any investment in them, the government consults extensively with the irrigators as to whether they require these facilities to be installed in their CPR area or whether these facilities will be well-suited to local conditions. Entrusting to an appropriators’ organization means that the government entrusts the administration of the installed projects (solicited physical capital) to the irrigators’ organization that the irrigators collectively form, while government may remain the owner of the facilities.

We observe that, as Japanese government invests in solicited physical capital and entrusts them to the irrigators’ associations, physical capital and social capital are well-coordinated. Social capital means the shared knowledge, understanding, institutional arrangements, and patterns of interactions that a particular group of individuals brings to an activity (Coleman, 1988, extensively explained; Ostrom, 1997, p. 158). Lam (1998, pp. 202–203) has empirically shown that physical capital and social capital are intricately interrelated. A sound coordination between social and physical capital has significantly contributed to the success of Japanese irrigation management.

In Japanese society, people’s “group consciousness” is widespread, implying that when Japanese people belong to a group they have a traditional habit of formulating endogenous rules to assign a higher priority to collective payoff, which finally raises their individual payoff. In rural areas, the group consciousness is much more usual and robust. Following that, when Japanese irrigators form a water users’ association, they can build up strong endogenous institutional arrangements to self-govern their irrigation CPR and government does not need to bring about external institutions to impose upon them. Such national characteristics of the Japanese people at the macro-level can explain the irrigators’ collective action nature at micro-level. This has been a prime incentive to the Japanese government to entrust almost all the irrigation and drainage facilities to their associations, although the government invests a lot in irrigation and drainage facilities. The government’s trust has also improved the irrigators’ group consciousness and management responsibility, contributing a great deal to their social capital.

While true that the highly sophisticated physical capital has made irrigation water abundant throughout the irrigation system, we doubt that irrigators’ conflicts over water allocation and distribution problems could not be solved if the irrigators did not find the physical capital solicited.

6.8. Design principle eight: nested enterprises

According to Tang (1992, pp. 38–39), we can characterize the Nishikanbara LID as a complex irrigation system, which has a production resource (dam), a distribution resource (main canal), appropriation resources (watercourses), and use resources (fields). While the main LID office monitors general situations, the 12 branch offices monitor less general situations and the terminal water-using groups monitor very specific situations. Like other LIDs, the Nishikanbara LID has received a considerable amount of investment from the government in physical capital, while the irrigators self-manage and self-govern their CPRs to address the problems that concern appropriation, provision, conflict resolution, and monitoring issues. The central, prefectural, and local governments have

recognized the autonomy of an LID to craft its own working rules that the external legal authority does not challenge.

7. Findings, policy implications, and conclusion

We find that Ostrom's eight design principles are basic and well configured. Additionally, when we moderate design principle seven, we can explain that these principles have not only contributed to the institutional robustness but also solved provision and appropriation problems of the Japanese irrigation CPRs. Ostrom's design principles are primarily based on developing countries where the government or external entities can barely afford a large investment cost in physical capital. In a developed country like Japan, where the government can sufficiently afford to invest in physical capital, design principle seven needs some moderation as we have done. The non-coercive strategic presence of an external entity (the central, prefectural, and local governments) has significantly contributed to irrigators' self-governance of their CPRs in Japan. Such a characteristic of the external entity has led us to moderate design principle seven in discussing irrigators' self-governance of their CPR in Japan. The design principles monitoring (appropriators' behavior) and graduated sanctions are quite implicit in Japan's case rather than as explicit as Ostrom has described generally. In Japan's irrigation management, the irrigators usually obey the rules that they formulate in their group and the irrigators do not usually even discuss openly the problems associated with rule violation. In spite of these minor variations, Ostrom's configuration of the eight design principles — of which a self-governance institutional solution to the (irrigation) CPR's problems is a vital point — is a unique artifact and has been of broad importance both in developing countries and in a developed country, such as Japan.

In designing those principles that make the irrigation institutions robust and enduring, developing and developed countries need to invest in physical capital either initially or later. Nevertheless, while the investment should be non-interventionary, the physical capital must be solicited by the irrigators collectively or be congruent with the irrigators' social capital, such as the socioeconomic conditions and the institutions that the irrigators have crafted or will craft. The first policy prescription that the present research can provide to donor agencies investing in large irrigation projects in developing countries is that they should invest in the physical capital that the irrigators collectively solicit. This is to strengthen the irrigators' sense of self-governance responsibility as well as their social capital that may exist in their society or that they are trying to build up. Furthermore, such solicited physical capital can be entrusted to the organization that the irrigators may collectively form to self-govern their CPRs. In Japan, the irrigators manage the solicited physical capital that the irrigators or the government or both build up. We consider it an important concept that irrigators self-govern irrigation CPRs with an external entity as that entity's strategic presence exercises no coercive force nor carries around any external institutions but instead makes a non-interventionary investment in solicited physical capital. This concept has principally led us to moderate design principle seven.

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