Irrigation water management developed through conflicts: A case study of Kagawa prefecture in Japan

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Abstract

The case study of irrigation water management carried out in *Shimotakaoka*, Kagawa Prefecture, Japan, demonstrates a range of local practices observed over the course of Japanese water development. These practices include the advocacy of conflict resolution mechanisms at two levels (i.e. intra-sector and inter-sector), as farmers have faced many water conflicts since the early Edo Period. The resolution mechanisms valued as a type of social capital, developed through these conflicts. We may say that there were two types of resolution mechanisms at the intra-sector level, i.e. negotiations between upstream and downstream villages (intra-village) and practices such as water-right trading within a village (inter-village). This case study focuses on the latter. First, it gives a brief overview of the history of water development in Japan. Second, it highlights specific aspects of water management such as water rotation, consensus meeting for rotation, and the management of diversion devices during droughts. Although these practices supported local water-right trading, they survived even after the trading system was abolished following the advent of modern irrigation facilities such as Kagawa irrigation canals that decreased water scarcity. Finally, this paper discusses the lessons to be learnt about conflict resolution mechanisms for the next generation.

Keywords

Water conflict, resolution mechanism, Kagawa Prefecture, water-right trading, water development, social capital, intra/inter-village

Introduction

Shimotakaoka, located in Kagawa Prefecture, was confronted with water shortage, especially during the farming season, for a long time. This led to many water conflicts, which stimulated farmers to develop local conflict resolution mechanisms. The water scarcity contributed toward accumulating local rules and practices on how to divide and use water among the farmers or WUAs (water users associations) in a village. These rules and practices have undergone considerable changes against a backdrop of historical water development.

This case study of *Shimotakaoka*'s irrigation water management in Kagawa prefecture in Japan, which lists a range of historical and local practices, examines the Japanese water development situation. Ingenious experiences of the people of Kagawa Prefecture were partly focused on devising conflict resolution mechanisms at two levels—intra-sector and inter-sector. With respect to the intra-sector level, there were two types of resolution mechanisms: the negotiations between upstream and downstream villages (inter-village) and water-right trading (intra-village). This paper focuses on the latter in the context of a specific village and explores how the resolution mechanisms changed against a background of water development.

Water conflicts can be classified in different ways. In this paper, they are categorized according to both level and impact (i.e. negative or positive). Resolution mechanisms are valued as a social capital—whether intra-sector or inter-sector—and can be categorized as a positive development. A case study on water-right trading falls under the intra-sector category. First, from the perspective of striking a balance between water supply and demand, this paper provides a brief overview of the history of water development in Japan. Second, from the perspective of conflict resolution, especially in a village, it highlights specific aspects of water management during abnormally dry period, i.e. how irrigation water is rotated and how the order of water rotation is decided. It highlights specific aspects of water management such as water rotation, consensus meetings for rotation, and management of diversion devices during dry periods. Although these three aspects supported local water-right trading, they were continued with even after the trading system was abolished in the face of the utilisation of modern irrigation facilities such as the Kagawa irrigation canals that decrease water scarcity. Finally, it discusses the lessons to be learnt about conflict resolution mechanisms for the benefit of future generations.

This study relies on a variety of sources to examine water-conflict resolution mechanisms such as water-right trading, with the aim of diversifying their sources and assessing their reliability. However, since this is a historical case study, much of the information has been gathered from interviews with elderly farmers (more than 80 years old), rather than from scholarly publications.

Water development history in Japan

First, it is necessary to provide a brief overview of historical Japanese processes in water development. **Table 1** presents some of the post-War events (1945–1964) in the context of Japanese water development. This era is significant because it witnessed a dynamic final shift from micro-level to macro-level stakeholders; the entire historical sequence of events, including the above events, is too complicated to understand at first glance. Given this, three viewpoints are helpful in understanding historical water management. The first helps identify the main actor responsible for establishing water governance, engaging in hardware investment, and carrying out O & M (operation and maintenance), such as a national government (feudal or modern), villages, or farmers (Tsuboi: 1996, p 258). The second perspective involves learning about the features of water utilization, which is related to the first goal. The third viewpoint is needed to determine how the national goals of development changed from a single, agricultural object to a multilateral one. There is space only to state these significant viewpoints and to provide a rough overview, but not to apply them to the entire history of development.

With respect to the second viewpoint, the features of water utilization revolve around three aspects: coordinating a local rule on how to divide water among farmers (pre-modern era); restricting the availability of developed water among stakeholders, especially among different sectors with formal or informal rules; and developing more water resources even beyond need. Given this, the period of 1945–1965, shown in **Table 1**, witnessed a change in focus from the first to the second viewpoint, while the national government became the single main actor involved in water management.

In the Edo period, when the main parties involved were farmers and the feudal government, water was utilized within the given supply and the focus was on establishing a rule to divide water, especially during abnormally dry periods (Shimura: 1982, pp 67–68). After the feudal government was overthrown by the Meiji Restoration in the nineteenth century, each farmer and village played a major role in water governance, investment, and O & M. It was in this period that LIDs (Land Improvement Districts) replaced WUAs as an additional actor—a change that lasted until the beginning of the post-war era. However, the local-based system did not change. The national goals expanded beyond the increase in food production in around 1951, i.e. power generation, industrialization, and domestic use, for which the nation’s role could not be ignored—not only as a coordinator of water development activities but also as a financier for relatively large-scale development projects. A symbolic event in the history of water development was the establishment of the Water Resources Development Public Corporation (1961) that proposed ‘basic plans’ and ‘full plans’ on the basis of the units of river systems, in order to meet public need. The next step set in when the water demand of each sector began to decrease. Since the industrial use of water decreased from the 1970s onwards, agricultural use from the 1990s, and domestic use from the 2000s, water-development principles needed to be re-examined from different perspectives (e.g. environmental) for public consensus for the approval of new projects.

Table 1 Process of Japanese water development (1945–1964)

Year	Event concerning water resources development
1945	End of WWII
1946	Post-War reforms by GHQ (General Headquarters of the Allied Forces)
1947	National projects for agricultural water utilization (four local areas), the Constitution of Japan (in effect)
1948	
1949	Act of Land Improvement Districts (enacted)
1950	Act of Comprehensive National Development (enacted), Korean War (1950–1953)
1951	Comprehensive River Development Project, Peace Treaty signed in San Francisco
1952	Agricultural Land Act (enacted), Act for electric power development (enacted) Dissolution of GHQ
1953	Serious flood disaster in west Japan
1954	High economic growth
1955	Aichi Waterworks Corporation Act Incorporated into Water Resources Development Public Corporation
1956	Membership of the UN
1957	Reclamation project in Hachiro-gata
1958	
1959	Liberalisation of exchange control
1960	Commencement of agricultural projects for infrastructure improvement
1961	Water Resources Development Promotion Law, Water Resources Development Public Corporation Law (enacted)→Basic Plan for water resources development for each river system (6 systems), for example, Tone River System (1961-)
1962	Comprehensive National Development Plan
1963	Start of project for farm land consolidation
1964	New River Law

The third viewpoint from which we can understand the water development history of Japan concerns the change in the national goals of development from a single agricultural object to a multilateral one, on the basis of river development through the 150 years since the Meiji Restoration in 1867. **Table 2** shows the changing number of irrigation dams in the order of their completion after 1603 (Dam yearbook: 2005). The construction of the dam was at its peak before the Meiji Restoration, in 1603–1867, and after the Meiji Restoration, in 1926–1945. The percentage of irrigation dams was the highest in 1900–1925, with water development gradually serving multiple purposes—an indication of rapid industrialization. With regard to the *volume of irrigation water intake* (maximum water intake times m^3/sec), 1956–1965 was a period of transition. In this period, the national government became the main body that implemented large-scale river development projects—and the highest irrigation water intake was recorded. These data have been graphically represented in **Fig. 1** that shows the transitional change in both accumulated *available storage capacity* and *volume of irrigation water intake*.

Table 2 Number of dams (total and subtotal of each term)

Year of completion	Number of all dams		Irrigation purpose		Available storage capacity		Volume of irrigation water intake (maximum water intake times m^3/sec)	
	subtotal	total (accumulated)	subtotal	total (accumulated)	subtotal	total (accumulated)	subtotal	total (accumulated)
– 1602	36	36	36	36	25,389	25,389		
1603–1867	472	508	472	508	64,444	89,833	7.93	7.93
1868–1899	80	588	80	588	7,751	97,584	0.18	8.11
1900–1925	200	788	161	749	85,618	183,202	4.07	12.18
1926–1945	412	1,200	289	1,038	623,682	806,884	22.06	34.24
1946–1955	219	1,419	139	1,177	1,220,263	2,027,147	60.47	94.71
1956–1965	355	1,774	150	1,327	5,180,546	7,207,693	351.56	446.27
1966–1975	327	2,101	150	1,477	3,218,732	10,426,425	375.93	822.20
1976–1985	267	2,368	97	1,574	2,421,685	12,848,110	216.74	1,038.94
1986–1993	188	2,556	88	1,662	3,666,213	16,514,323	190.71	1,229.65
1994–	587	3,143	179	1,841	7,698,721	24,213,044	495.02	1,724.67

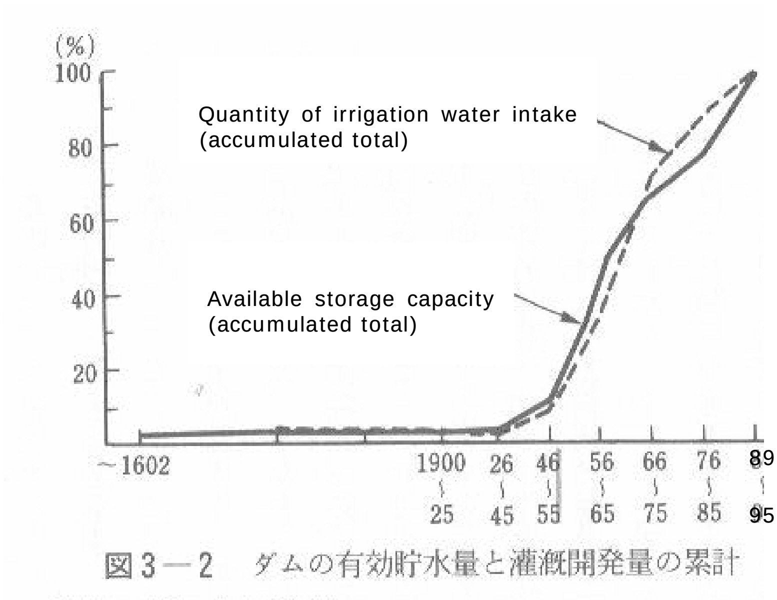


Fig. 1 Volume of irrigation water intake (accumulated total) and available storage capacity (accumulated total)

Background of the case study

Kagawa, one of the four prefectures in Shikoku, borders the Seto Island Sea and is known to witness low rainfall. Its mean annual rainfall is 1,124 mm, i.e. two-thirds of the national average (1,718 mm) (KAGAwater webpage). Since its precipitation is concentrated in the rainy season and typhoons, the frequency of water shortage has seasonal peaks in summer and winter, which causes the risk of water shortage all the year round (Matsumura, Suguya, and Kimura, 2005). To address this problem, inventive approaches to ensure water availability have been adopted since ancient times. One of these ingenious initiatives involves building storage reservoirs for pond irrigation. According to a recent observation, the number of reservoirs in Kagawa Prefecture is 16,304—the third highest in Japan and the highest in terms of density (Kagawa LID: 1998). Along with increasing the available volume of water by an accumulated skill of ‘pool and stock’, rules on how to divide water between farmers (intra-village) have been followed for a long time. These local rules and practices of water utilization can be categorized into four from a macro level: (1) intake period and the process followed by an upstream WUA, (2) division of water between more than two reservoirs, (3) rotation rule within a small unit, and (4) sharing the cost for irrigation facilities and management.

Three post-war events drastically improved the water shortage situation: the enforcement of the Agricultural Land Act (1952), the implementation of land improvement projects, and the construction of the Kagawa irrigation canal (1978). The Kagawa irrigation canal was constructed on the basis of the Full Plan for the Yoshino River system, targeted by WARDEC (Water Resources Development Public Corporation; the predecessor of JWA). It enabled the Kagawa people to use 247,000,000 tonnes of water per year for agriculture and domestic use. This brought into view several noticeable changes in water utilization in both storage reservoir systems and the local rules. Firstly, there was a surprising decrease in the degree of dependence on traditional storage reservoir systems, and some of the stringent rules mentioned above were done away with. Secondly, the traditional systems were organically linked to the modern supply system, and this linkage formed a complementary relationship in the context of water supply. As described later in this paper, the water from the Kagawa irrigation canal flows into a storage reservoir and then flows out again into a river, in order to increase the volume of flow. Concerning the first point, though spring water has been mostly used, it also flows into a river to increase the flow. Intriguingly, in the end, the tertiary canal takes water from the inflated river. In this sense, the Kagawa irrigation canal (modern) and the storage reservoirs (traditional) together serve as a supply system at both the macro and micro levels. Thirdly, a water-right trading system, which was a peculiar case (pertaining to (3), mentioned above) seen only in *Shimotakaoka* in Shikoku, was totally abandoned. Although water-right trading is now legally disallowed in Japan, several cases have been reported in the past, wherein this method was employed by farmers as one of the resolution methods for resolving conflicts over water scarcity.

Shimotakaoka is located in the middle of *Kida,* with the Sanuki Mountains that gently slope northward and are located towards the south. *Shimotakaoka*, which became a part of *Miki* City of *Kida* after a municipal merger, was the smallest village (3.9 k ㎡) in *Kida* at that time. Along the boundary of *Shimotakaoka* and *Kamitakaoka* (located in the southern upstream) the *Shin* River runs southward. This river is one of the intake sources for irrigation. *Shimotakaoka* holds four small WUAs, two of which, i.e. *Sarai* WUA (226,662 ha, 67 members, C in **Fig.2**) and *Furui* WUA (284,135 ha, 79 members, B in **Fig.2**), were surveyed recently. The annual mean temperature recorded in 2006 was 16.5 degrees, with the highest temperature being 29.5 degrees and the lowest 5.2 degrees. The annual amount of rainfall in 2006 was 1,212 mm, which was appreciably lower than the corresponding figure of 1,700 mm for the whole of Japan.

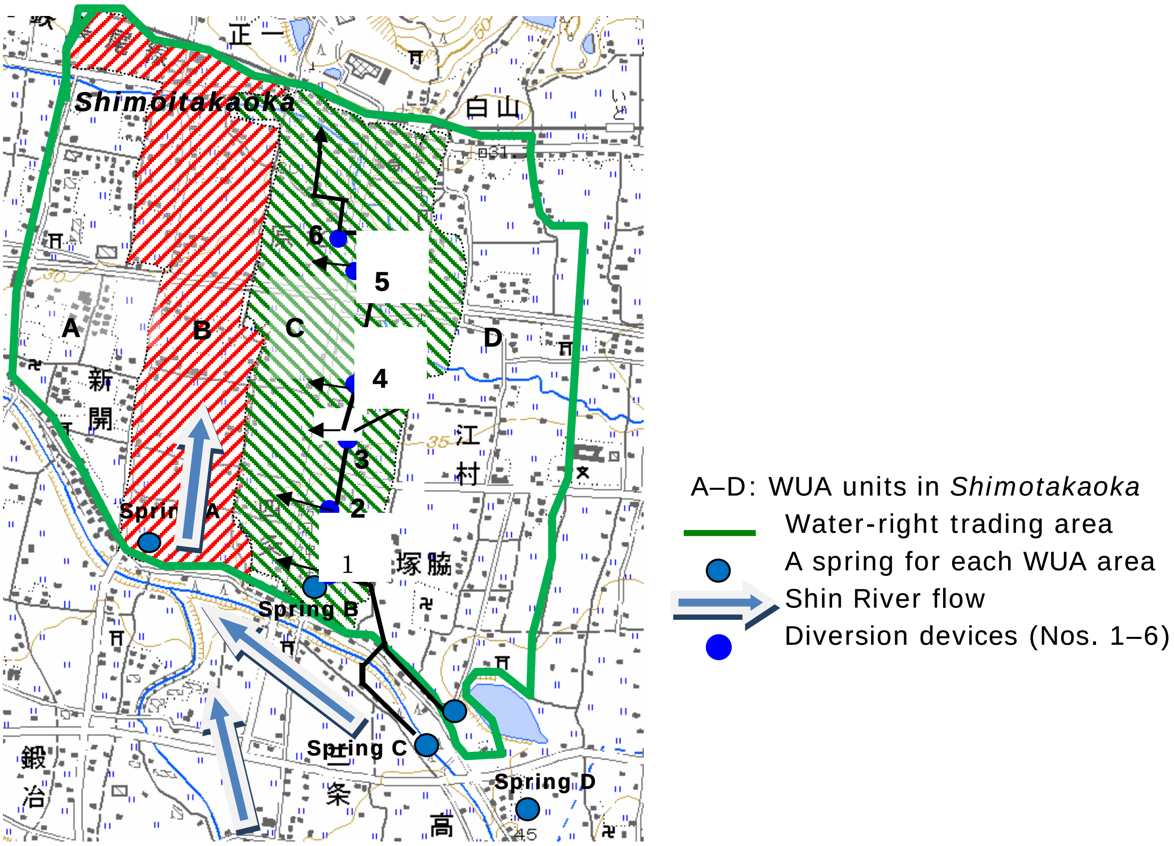


Fig. 2 A map of the four WUA areas in *Shimotakaoka*

With regard to the first (1) and second (2) local rules of water utilization mentioned above, it can be said that *Shimotakaoka* is located downstream of *Kamitakaoka* where the people were given the first priority to decide how much water to utilise from the river and storage reservoir. The people of *Shimotakaoka* could access the reservoir water only when surplus water flowed downstream after having been used by the people of *Kamitakaoka*. In this respect, *Shimotakaoka* was at a disadvantage with regard to the intake of irrigation water. This brings to light the basic characteristic of the third category of rules—how to rotate water within a small area. Water-right trading can be regarded as a part of the rotation system. These rules ((1), (2), and (3)) contributed to resolving water conflicts not only between upstream and downstream villages (inter-village) but also within a downstream village, i.e. *Shimotakaoka* (intra-village).

There are four sources of irrigation water at present: the Shin River, springs, the Kagawa irrigation canal, and water wells that were dug in 1994—a drought year. Before the 1940s, when water-right trading was still reported as relatively active, a reservoir upstream in *Kamitakaoka* served as the complementary fifth source of irrigation water. Since the principle of river-water intake is a basic principle, other sources were and are used to increase the volume of river water (See **Fig. 3**). Despite the existence of multilayered supply system, since the establishment of water management systems in the middle of Edo period, the total volume of water supply was not perennially sufficient for the downstream area. In this respect, water-right trading can be regarded as one of the important means to smooth out the imbalance in water demand and supply in *Shimotakaoka*.

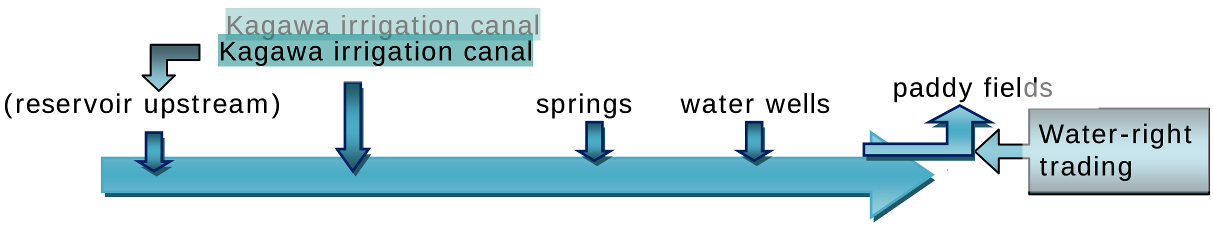


Fig. 3 Flow of irrigation water to paddy fields in *Shimotakaoka*

Classification of 'Water conflict'

There could be various ways of classifying water conflicts. Dorcy and Riek (1987) grouped together the sources of conflicts from the perspective of environmental disputes, and Mostert (1998) developed the idea further and aimed at water conflicts in general. Later, he focused it on the topics of international freshwater management (Mostert:

2003). Although many authors refer to water conflicts as a transboundary issue, little attention has been paid to domestic conflicts at a micro level. This is partly due to some contextual factors such as the difference in socio-economic situations, organizational structures, and cultural characteristics (e.g. ‘feminine’ or ‘masculine’ culture) (Hofstede: 1991).

Following up on the peculiarities in each case would take us beyond the scope of this paper; therefore, it is necessary to focus on a general historical dimension of internal water conflicts and categorize them according to two factors. The first factor concerns whether the conflicts were within an agricultural sector or between sectors (i.e. industrial sector, electric power sector, domestic water sector, and agricultural sector), and the second factor pertains to the kind of impact (i.e. negative or positive) that a conflict had on society. It is noteworthy that from a historical perspective, a negative impact has often contributed to the development of a conflict resolution mechanism, which has been seen as a positive impact in this paper. In this sense, not all negative impacts are negative; in fact, there is potential for an impact to change from negative to positive by the accumulation of rules and practices. Yamaoka et al. (2008) has studied the synergistic effects between experience in water governance and social capital and has shown that local experiences contribute to effective water distribution even in modern Japan. Ostrom (1990) referred to a well-developed court mechanism for environments with an acute shortage of resources, which led to conflict. Similarly, in the case study of *Shimotakaoka*, severe water scarcity resulted in the establishment of local rules for distributing water (inter-village and intra-village). In this sense, both negative and positive impacts are two sides of the same coin, and the former can lead to the latter by the implementation of rules and practices. Next, we shall focus on a positive aspect in the context of a case study within a village. With respect to the positive aspect within villages, we will expound briefly (owing to space constraints) to the significance of negotiations. These negotiations mainly determine the relationship between upstream and downstream villages along a river or canal.

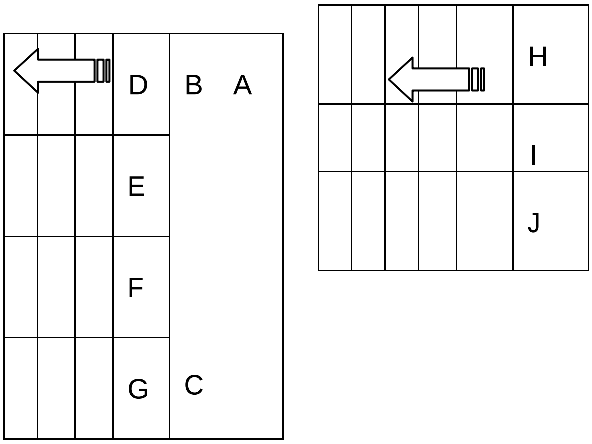
Table 3 Categorization of internal water conflicts

	Water conflicts: intra-sector or inter-sector		
Impact	Inside the agricultural sector		Between sectors
Negative	Competition in water use		
Positive	Development of resolution mechanisms		
	Intra-village i.e. water-right trading	Inter-village i.e. negotiations	socio-economic institutional development, especially in a drought period

Positive aspect of intra-village conflicts

With respect to the positive aspects of intra-village conflicts, it is seen that *Shimotakaoka* followed the practice of water-right trading to reduce the imbalance in water demand and supply. It is well known that, today, water-right trading is not legally permitted in Japan, because of the fact that water is regarded as a public commodity by law. However, before the enforcement of the new River Law, several trading cases with several common characteristics had been reported. One of them was the detachment of water right from land ownership that resulted in separate trading processes. In general, as water right and land ownership are inextricably linked, land transfer is accompanied by water-right transfer. There are, however, several exceptions to this rule, and the case of *Shimotakaoka* is one of them.

According to a research paper on customary water use in Kagawa Prefecture (Kagawa Prefecture: 1949), a water right in *Shimotakaoka* is a quasi-real right that is entirely separate from land ownership and very unique even in Kagawa Prefecture. It is said that this customary water-right system was started in the middle of the Edo period when the demand for water for cultivation exceeded the supply. The water rights in *Shimotakaoka* were noted down in a ‘ledger’ that was kept at a village office. The water ledger contained the name of the owner, his/her quota of water, and its transfer record that was similar to that of land registration (**Fig. 4**). One of the significant similarities identified is that the transfer of a water-right was recorded on the basis of the source of water (See item A in **Fig. 4**). Since another contract of water right besides the land lease contract was required, a landlord could divide his/her water rights between peasants in a manner that is beneficial to them. However, since more water meant a bigger burden of land rent, one can safely state that a water-right trading system partially supported the landlord system. When the ownership of land and water rights differed from one another, it resulted in another trade so as to balance the demand and supply.



A: Source of water (e.g. spring A–D)
B: Quota
C: Owner’s name
D: Date of revision
E: Reason of revision
F: Owner’s address
G: Owner’s name in case of a change
H: Date of transfer
I: Present quota
J: Remarks

Fig. 4 A template of a water ledger (left: front page; right: back page)

The important point to note is that a unit of water-right trading (and water rotation) is not an absolute quantity (e.g. m^3); instead it is a time-based quantity that indicates a whole river’s flow for 12 hours. The idea of relative volume is the basis of a trading system.

Water-right trading essentially consists of two elements that are still in use even after the trading system itself was abandoned: (1) a water-rotation system and an annual consensus meeting about the order of rotation and (2) diversion devices and gates as hardware. Concerning the first point, in *Shimotakaoka,* there are a total of four irrigation canals, each of which was assigned to a particular WUA area (i.e. a village), and all the members of the WUA are divided into nine groups for periods of 12 hours. Therefore, it took four and a half days (i.e. 12 times 9 equals 108 hours) for the 9 groups in each WUA area to finish all water rotations. As mentioned above, since a unit of water-right trading (and water-rotation) is a relative quantity indicative of a river’s flow for 12 hours, all water rotations in each WUA area consists of 9 units of rights. Each unit is divided into 10 small units, and furthermore, a small unit is divided into 10 minimum units. The water-right trading was implemented by using these three units. Apart from the volume, the order of water rotation is decided by an annual consensus meeting of each WUA with the aim of addressing the complaints of all members. In relation to the second point, irrigation water from a spring via the Shin River has about five to six diversion devices to send water to each patch of the field (See **Fig. 2,** C). Each device is well-built in order to level out the irrigation water surface and to distribute the water according to the order of water rotation. It may be worth pointing out that a water fee, which is imposed on a WUA member besides the transfer cost of water rights, is levied by a ‘quota base’ (i.e. how many water rights a farmer has), and not by a general ‘area base’, as is done in most areas of Japan. The most likely explanation for this is that this peculiarity stems from a characteristic of water-right trading cases, i.e. the detachment of water right from land ownership, which represents the essentials of water-right trading.

I wish to emphasize on the point of how the water-right trading system has influenced historical water development. As mentioned before, three post-War events, especially the construction of the Kagawa irrigation canal (1978), alleviated local water scarcity. Since water development is a process aimed at increasing the water supply, the alleviation of water scarcity that supported local conflict resolutions is the primary reason for the changes in the local trading system. Although the two constituents of trading, i.e. water rotation and diversion devices, are still functional, the trading system itself has been abandoned. Besides the abolishment of the local practice, the quota-base water fee—imposed on WUA members as O & M for water management, in addition to the transfer cost of water rights themselves—has been influenced by the area-base method. To be precise, quota-base charging developed from the idea that a water right was a fundamental right of a farmer and not his/her farmland ownership. In contrast, since payment by a beneficiary of the Kagawa irrigation canal constitutes an all area-base system that regards land ownership as the primary point of reference, it burdens the beneficiaries in proportion to the size of the farmland area. In this respect, even after the abolishment of the local trading practice, a quota-base charging system for water fee and an area-base charging system for beneficiaries coexist. The interesting point is that since the former had been gradually influenced by the latter and farmers had started to view each rotation by an area-base system, the unit of water rotation (i.e. 12 hours for one rotation in each group) fell below 12 hours in reaction to the decrease in the area of the paddy fields.

Lessons for future generations

Conflict resolution mechanisms can be applied to any locality encountering water scarcity in two ways: water-right trading (intra-village) and negotiations (inter-village). This paper focuses on the former and adopts a case-study approach based on the basis of the transition of the water development situation in Japan. Since the mechanisms have been changed by the alleviation of water scarcity owing to water development, water-right trading itself has been abolished, as mentioned above. Despite the changing circumstances, the sub-mechanisms of trading—water-rotation systems, annual consensus meetings for an order of rotation, and the management of diversion devices—continue to exist and are utilized even today for irrigation management by local farmers. Although the case is distinct in the sense that water rights were separated from land ownership, we may say that historical water development that influenced water management in this case was rather general. The historical Japanese development processes for water utilization, as we have seen, have three steps: coordinating a local rule on how to divide the available water among farmers (pre-modern era), distributing the available developed water among stakeholders, especially among different sectors with formal or informal rules, and developing more water resources even if the demand exceeds the need. This case shows the transition from a pre-modern era to the next.

Sub-mechanisms such as water rotation systems are managed by a WUA unit of that has been a traditional unit of a locality. We may say that the sub-mechanisms of water-right trading are the result of the accumulation of social capital. As Putnam (1993) pointed out, social capital refers to the features of social organizations such as networks, norms, and social trust that facilitate coordination and cooperation for mutual benefit. In this case, water-rotation systems, annual consensus meetings for an order of rotation, and diversion devices are deemed to be a part of social capital in the area. It is interesting to note that these accumulated experiences and practices that were regarded as social capitals had contributed to local water management, which emerged as a local conflict resolution mechanism during droughts. Although water-right trading lost its importance because of reduced water scarcity and was abandoned in the process of water development, it seems reasonable to suppose that the remaining social capitals have potential for future water development. Yamaoka et al. (2008) has shown the existence of a double spiral of the synergistic effects between experiences in governance and accumulation of social capitals (**Fig. 5**). The same observation applies to this paper.

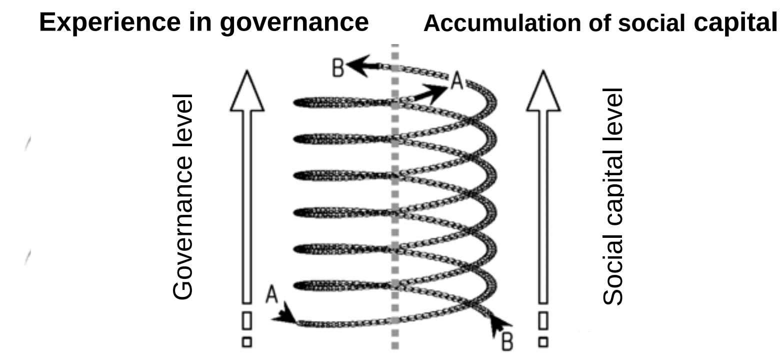


Fig.5 Double spiral of synergistic effects between governance level and accumulation of social capital in the paddy rice irrigation system

In terms of the features of water utilization, Japanese water development has been categorized into three steps. Present-day Japan, however, has entered a new stage after having developed more and more water resources. One point of controversy concerns the question of who will govern water resources as the main actor. This question is posed against a background of problems like aging and decrease in population, which not only mean less manpower, but also fewer beneficiaries who can be charged for the profit. The public authority has been the main governing body for the last 100 years, and it advocates a small government. In view of this, it expects communities to play a significant role in water governance. Considering the fact that local conflict-resolution mechanisms were sustained by practices understood as social capitals, they can offer many practical implications of what is necessary for communities that have the capacity to address conflicts and develop themselves through conflicts to act as autonomous units of water governance in the future.

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