The Kabu-ido System:
Innovations in an Indigenous Groundwater Management Institution

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Abstract:

The purpose of this paper is to describe the function of the “Kabu-ido”, which was a groundwater management system that was used in the Tokai region of Japan from the late 19th century to the early 20th century. The implications of Kabu-ido for the commons study will also be discussed. The southern part of the Noubi Plain in the Tokai region of Japan is a low lying area that is composed of a large delta that is subjected to severe flooding. The local residents in this region developed a unique system to manage the problem of flooding that became known as the ring-levee (Waju in Japanese). However, they sometimes faced severe water shortage in years when there was low precipitation. To address these occasional water shortages, irrigation by artesian wells was expanded rapidly in the ring-levee area from the early to mid-19th century. Although the development of artesian well systems greatly stabilized the water supply within the ring-levees, it led to the accumulation of drainage water in the lower part of the area. Consequently, Kabu-ido was developed to address the conflicts related to drainage within the ring-levee systems. Kabu-ido was established as early as the 1850s and it remained in use until around 1905 to solve drainage problems and provide a method for regulating uncoordinated groundwater pumping. In Japanese “Kabu” means “privilege to do a business” and “ido” means “well”: thus “Kabu-ido” can be interpreted as meaning “privileged well” or “the special right to dig wells”. Accordingly, a study of Kabu-ido and their development can provide useful lessons for current groundwater management systems. Although previous studies have clarified Kabu-ido, they have only focused on the history and have not considered the institutional aspects of this practice. Therefore, this study was conducted to investigate Kabu-ido from the point of view of the commons study.

Keywords: groundwater, externalities, design principles, institution

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1. Introduction

Currently, excessive groundwater pumping is a growing global concern (Wada *et al.,* 2010). In Asia, for example, groundwater problems have been observed in Tokyo and Osaka in Japan and have recently been observed in Bangkok, Thailand, and Jakarta, Indonesia. This suggests that the problem occurs in conjunction with economic development and can be predicted to emerge in future areas of economic development. Excessive groundwater pumping can lead to land subsidence, which triggers other problems such as physical damage to infrastructure and exacerbation of flood damage. The discontinuation of wasteful groundwater pumping is important for disaster prevention (Jago-on *et al.*, 2009).

It is rarely known that excessive groundwater pumping was a problem in the southern part of the Noubi Plain in the Tokai region of Japan far before it was observed in Tokyo and Osaka. The Noubi Plain is a low lying area composed of a large delta that is commonly subjected to severe flooding. The risk of flooding prompted the local residents to develop a unique system that is known as a ring-levee (or Waju in Japanese). However, the area sometimes suffers from severe water shortages in years when there is low precipitation. Consequently, from the early to mid-19th century the local people rapidly expanded the use of artesian wells to provide water for irrigation and drinking in the ring-levee area. Although these artesian wells gave considerable benefits to some of the residents, it led to the accumulation of drainage water in the lower part of the area.

Kabu-ido is an institution that was created to address the conflicts related to drainage within the ring-levee systems. In Japanese, “Kabu” means “privilege to do a business” (Miyamoto 1977: 59) and “ido” means “well”; therefore, “Kabu-ido” can be interpreted as meaning “privileged well” or “the special right to dig wells”. Although Kabu-ido is deemed as a solution to a drainage problem, excessive groundwater pumping is considered to be the root cause of the problem. In this sense, Kabu-ido is an innovative precedence of a groundwater management policy; however, it has not yet been investigated in the field of the social sciences. There is no simple panacea against excessive groundwater pumping; it is a problem that needs to be addressed through continual policy improvements based on case studies. The purpose of this paper is to clarify the function of Kabu-ido, and it will then discuss the implication of Kabu-ido for the commons studies.

2. Previous studies

Kabu-ido has been investigated since the 1930s. Bekki (1932) and Nakazawa *et al.* (1936) introduced Kabu-ido as a part of their investigation of the ring-levee systems. Katano (1941), Mori (1964) and Matsubara (1968) later clarified the history of Kabu-ido in the Takasu and Fukuzuka ring-levees based on a detailed review of the original documents. Kabu-ido has

also been described in history books published by local governments in the ring-levee areas, such as Kaizu, Hirata and Wanouchi. Although these early studies were followed by recent works by Andoh (1975), Itoh and Aoki (1987) and Itoh (2002), Kabu-ido has to date received little attention. These previous studies clarified the history of Kabu-ido; however, they only focused on the process of creation and did not consider what kind of elements had helped the institution to mitigate excessive groundwater pumping.

Kabu-ido is a self-organized institution that is run by local groundwater users (which will be discussed in more detail later on in this paper). This characteristic means that recent achievements of the commons studies will provide a useful framework for research of Kabu-ido. A central issue of the commons studies has been to investigate the component factors of institutions that enable sustainable uses of common-pool resources, such as water, wildlife and air (Dietz *et al.,* 2002:16). While nationalization or privatization have been regarded as solutions to the excessive use of common-pool resources, researchers in the commons studies have paid attention to a third method, which is self-organized collective action. However, this analytical framework has not yet applied to Kabu-ido studies to clarify their function.

This study will not only deepen understanding of Kabu-ido but will also improve the framework of the commons study. Previous studies pay great attention to the institution itself, but have failed to incorporate the social and technical factors within which institution works (Agrawal 2002: 56-57; Stern *et al.,* 2002: 477). Applying the commons study's framework to Kabu-ido research will provide a useful example that enables us to consider how those factors will influence the function of institutions for managing common-pool resources.

3. Kabu-ido

Kabu-ido was created in the ring-levee area in the Tokai region of Japan in 19th century. The area is located at the confluence of the Ibi, Nagara and Kiso rivers (Figure 1). Some ring-levees are still present in this region, forming a reverse triangle that extends 40 km from east to west and 50 km from north to south, and encompassing a total area of 1800 km^2 (Itoh 2001:3).

Although Kabu-idos used to exist in the Takasu, Fukuzuka, Tagi

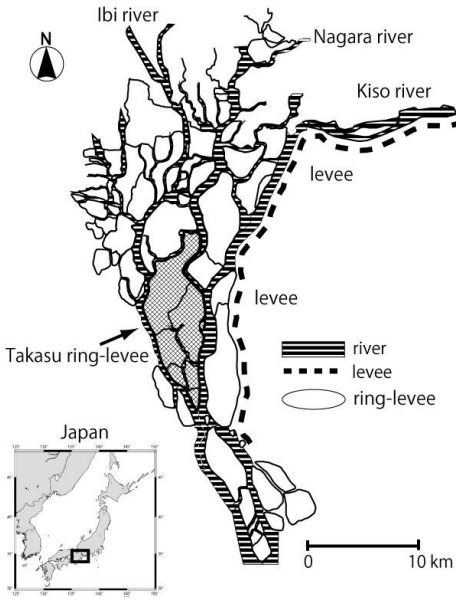

Figure 1. Ring-levees around 1870 (based on a map made by Yasuo Itoh in Nanno town(1978).)

ring-levees (Katano 1941: 56), this study has investigated Kabu-ido in the Takasu ring-levee because it is the best documented in this area.

Although the residents inside the Takasu ring-levee faced occasional flooding, they also suffered water shortages in years of less precipitation. To address this issue, artesian wells were implemented in the 19th century (Mori 1964: 918; Matsubara 1968:494). Figure 2 shows the difference in altitude within the Takasu ring-levee. Although it is very small, the northern part of the Takasu ring-levee is higher than the southern part. The artesian wells were primarily constructed in villages in the northern part, where the altitude was more than one meter above sea level (hereinafter referred to as the upper villages). Due to this geographical condition, the drained water accumulated in villages in the southern part of the ring levee, where the altitude was less than 1 meter above sea level (hereinafter referred to as the lower villages) (Kaizu town 1970a: 47). The debris from the upstream area was so large that the river bed became higher than the surface of the land protected by the ring-levee. This meant it was very difficult to pump drainage water out of the levee (Bekki 1932: 248-249, Katano 1941: 55-56). Therefore, the drainage water meant that the residents in the lower villages faced a higher risk of flooding and this had negative effects on their rice farming. Consequently, the residents of the Takasu ring-levee shared a common benefit in terms of flood control but faced a conflict of interests in terms of artesian wells and drainage water (Nakazawa *et al.*, 1936: 390).

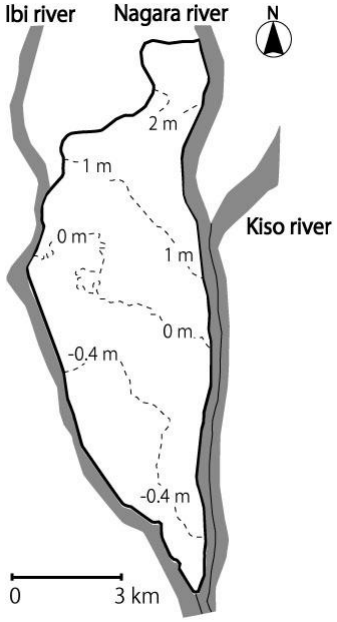

Figure2. Takasu ring-levee and its altitude (based on a figure provided by the Kaizu city education committee 2009:20.)

Kabu-ido was developed to mitigate the conflict of interests associated with the drainage water. This system was essentially built on permit systems in which the total number of wells was restricted and the residents who desired wells were required to pay a fee to obtain Kabu (i.e. the right) to drill a well. The revenue generated from these fees was then used to build and maintain drainage gates (Nakazawa *et al.*, 1936: 390-391; Matsubara 1968: 501; Itoh and Aoki 1987: 188-190).

4. Development of Kabu-ido

Kabu-ido was a self-organized institution that was created through negotiation between the upper and lower villages. In this paper, following the explanation of Mori (1964) and Matsubara (1968), the development process can be classified into three stages, which are: first, a well survey; second, the establishment of an inter-village committee; and third, rule-making (table 1).

Table 1. Development of the Kabu-ido in the Takasu ring-levee

Year	Events
1852-53	Drought hit the Takasu ring-levee.
1854	A survey was conducted to determine the number of wells.
1854	The upper and lower villages agreed on well restrictions and adopted a three-year adaptive management plan.
1860	The upper and lower villages agreed on numbering of the wells and construction of a drainage gate.
1861	The number of authorized wells was 388.
1876	The maximum number of authorized wells increased to 806.
1883	The total number of wells increased to 1421.
1905~	Kabu-ido gradually disappeared due to construction of modern drainage gates.

Sources: Documents of Flood Control Office, Kasamatsu-jinya, Mino-gundai 1861a; Katano 1941; Mori 1964; Matsubara 1968.

4-1: Well survey

The drought from 1852-1853 was the primary reason for the increase in artesian wells in the upper villages. Due to the adverse effects of drainage from the upper villages, the lower villages petitioned for the abolishment of wells in the upper villages to the local government for flood control (Documents of Flood Control Office, Kasamatsu-jinya, Mino-gundai 1854a, reprinted in Hirata town 1984: 579). Although the local government had a policy of managing water problems outside of a ring-levee (i.e. flood control), it did not interfere with water issues inside a ring-levee (i.e. drainage problems) (Kaizu town 1970a: 47). Flood control and drainage problems were regarded as the most important water issues; however, conflicts inside a ring-levee might negatively impact flood control, which was a common problem for the upper and lower villages. Consequently, when the local government implemented policies within ring-levees, they required unanimous consent from all of the villages (Matsubara 1968: 502). This policy led to the drainage problem being addressed via private negotiation among villages rather than being implemented through government

intervention.

However, it does not mean the local government did nothing. The government ordered the upper villages to check the number of artesian wells in response to a request from the lower villages. Consequently, 529 wells (472 wells in operation and 57 abandoned wells) were found in a June 1854 survey. Figure 3 shows the well locations at that time (Documents of the Flood Control Office, Kasamatsu-jinya, Mino-gundai 1854b, reprinted in Mori 1964: 920-924).

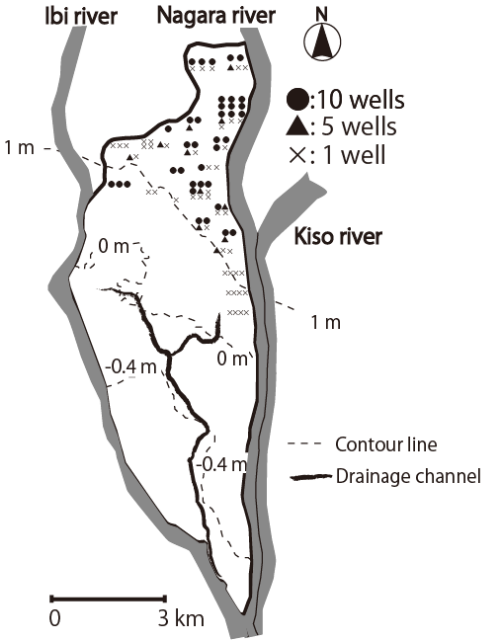

Figure 3. Location of wells in operation as of June, 1854

Source: Documents of Flood Control Office, Kasamatsu-jinya, Mino-gundai 1854b, reprinted in Mori 1964: 920-924

4-2: Establishment of an inter-village committee

In November of 1854, a management plan and well restrictions were implemented based on agreements between the upper and lower villages. One of these agreements included seasonal restriction. For example, the use of irrigation wells during summer was prohibited because the discharge of artesian wells tended to increase during summer in response to increased water pressure from the river flow (Matsuo 1993 : 74). This agreement also reflected the traditional “try and see” method of resolving conflicts over water use. In the method called “Mi (see)-tameshi (try)” in old Japanese, problems are solved via a feedback process that assesses the implementation of various options and that evaluates the results. In modern terms, the method is referred to as adaptive management. Through negotiations, both of the villages agreed three points. First, they would check the magnitude of damage after three years and would then determine whether or not the wells should be abolished. Second, representatives would be selected from both groups of villages for later negotiations. Third, negotiations would be conducted twice a year and the results would be submitted to the local government (Documents of the Flood Control Office, Kasamatsu-jinya, Mino-gundai 1854c, reprinted in Mori 1964: 925; Documents of the Flood Control Office, Kasamatsu-jinya, Mino-gundai 1855, reprinted in Mori 1964: 925.).

4-3：Rule-making

In 1860, the following negotiated agreements were made between the upper and lower villages:

a. Each well must be numbered.
b. Drainage gates should be constructed in the lower villages at the expense of the upper villages.
c. The upper villages cannot construct and dredge a well without consent of the lower villages.
d. If a resident of the upper villages opens an additional well, or if they dredge an existing well under seasonal restriction without permission, then the individual owner or the village is fined 10 Ryo. Before it was replaced by the yen in 1871, the Ryo was a common unit of monetary value in Japan. The modern equivalent of 1 Ryo from 1860 is 4000 Japanese yen or 40 US dollars (as of April 2013) (Ikeda and Hayashiya 1964: 204).
e. If a resident of the upper villages failed to prevent water from flowing out of a well under seasonal restriction without permission, then their well must be destroyed and the individual owner or the village is fined 5 Ryo.
f. A part of the fine (5 Ryo out of 10 Ryo in case of article e, 2 Ryo out of 5 Ryo in case of article f) can be given as a reward to a person who finds an unpermitted well. The remainder (i.e. 5 Ryo or 3 Ryo) is to be used for maintenance of the drainage gates in the lower villages.

(Documents of the Flood Control Office, Kasamatsu-jinya, Mino-gundai 1860a, reprinted in Kaizu town 1970b: 780; Documents of the Flood Control Office, Kasamatsu-jinya, Mino-gundai 1860b, reprinted in Hirata town 1984: 597; Documents of the Flood Control Office, Kasamatsu-jinya, Mino-gundai 1860c, reprinted in Gifu prefecture 1969: 1117-1119).

5. Kabu-ido from a viewpoint of the commons study

5-1: Elements of successful common-pool resources institutions

In this section, an analytical framework of the commons study will be applied to Kabu-ido. A central issue of the commons study is to search for elements of the institution that prevents wasteful uses of common-pool resources. Although there have been many studies on the topic (Agrawal 2002), this paper will focus on the design principles that were developed by Ostrom (1990: 90) who conducted many case studies to abstract some elements that could be found in common in long-enduring self-organized institutions. She called these elements design principles and they include the following items:

i. Clearly defined boundaries;
ii. Locally tailored rule;
iii. Collective-choice arrangements;
iv. Monitoring;
v. Graduated sanctions;
vi. Conflict-resolution mechanism;
vii. Minimal recognition of rights to organize; and,
viii. Nested enterprises (principle viii will not be referred to in this paper, because it is related to large common-pool resources).

5-2: Design principles and Kabu-ido

Surprisingly, these elements can be clearly found in Kabu-ido (Table 2).

Table 2. Design principles and Kabu-ido

	Design Principles		Kabu-ido
1	Clearly defined boundaries	→	・Well restriction (article a, c of 1860 agreement)
2	Rules that fit local conditions	→	・Solution for drainage problem in flood-prone area
3	Collective choice arrangements	→	・Inter-village committee
4	Monitoring	→	・Well numbering (article a of 1860 agreement)
			・Reward system (article f of 1860 agreement)
5	Graduated sanctions	→	・Penalty against illegal wells (article d, e of 1860 agreement)
6	Conflict resolutions mechanism	→	・Economic compensation (article b of 1860 agreement)
7	Minimum rights to organize	→	・Non-interference policy of local government
(8)	Nested enterprises	N/A	・N/A
(9)	Social settings	→	・Lack of comprehensive flood control policy
(10)	Technological factors	→	・Immature diversion / drainage techniques

To begin with, Kabu-ido was a solution for a locally specified problem (i.e. drainage due to excessive groundwater pumping) in a flood-prone area, which corresponds to item ii: locally tailored rule. This was also a bottom-up solution that was made by direct negotiations between the upper and lower villages, which corresponds to item iii: collective-choice arrangements. These direct negotiations were prompted because local government had a non-interference policy for water issues within ring-levee, which corresponds to item vii: minimal recognition of rights to organize.

Among others, article a (numbering), b (economic compensation by the upper villages), and c (permission system) are the centerpieces of Kabu-ido. As mentioned before, 472 available wells were found in a survey of June 1854. A survey from 1861, which is only one year after the agreement was established, shows that 388 wells were registered with a number and the owners' names (Documents of the Flood Control Office, Kasamatsu-jinya, Mino-gundai 1861a). The survey of 1861 was conducted in a wider area than the survey of 1854 and it included two additional villages. Nevertheless, the number of available wells was decreased from 472 to 388. This suggests that the 1860 agreement denied the open-access characteristic of local groundwater by imposing an upper limit on the total number of wells, which corresponds to item i: clearly defined boundaries. In particular, article b played a role of soothing a conflict of interest between the upper and the lower villages through internalization of external diseconomy due to drainage, which corresponds to item vi: conflict-resolution mechanism.

The core problem of self-organized common-pool resources management is how to undertake monitoring and sanctioning not by external government but by the resource users themselves (Ostrom 1990: 93-100). It is said that the lower villages conducted monitoring activities by providing patrolmen for each other (Kaizu town 1970a: 48). Monitoring and sanctioning unauthorized wells is a public good for the lower villages in that it decreases overall drainage damages. However, in such a situation each village has an incentive to be a free-rider because each village can enjoy the benefit without making its own contribution, as long as the other villages conduct monitoring and sanctioning.

From this point of view, article a (well numbering) and f (reward system) worked as solutions for the free-rider problem. Well numbering not only imposed a cap on the total number of wells but it also reduced monitoring cost. It enabled the patrolmen from the lower villages to quickly discern between an authorized and unauthorized well, because they could easily identify wells without a number and wells with an unauthorized duplicated number. In addition, the personal reward system for well detection increases the personal benefit of monitoring activities to promote the voluntary provision of a public good. Introducing a personal reward system may provoke another free-rider problem of preparing the reward. Article f prevents this problem in advance by imposing the responsibility on the upper villages (item iv: monitoring).

Without sanctioning, monitoring has no meaning. Articles d and e shows rule of joint responsibility was incorporated in Kabu-ido. It can be inferred that the rules not only made the penalty system practical but also provided the upper village with an incentive to check illegal users from inside. Moreover, they indicate that sanctioning is graduated. It can be said the lower village thought that digging a new well or dredging an existing well would

cause much more damage than simply failing to stop water from pouring out of a well, which corresponds to item v: graduated sanctions.

Moreover, it should be noted that the amount of penalty fee has a rationale. Following article b (economic compensation by the upper villages), the upper villages collected money to build drainage gates in the lower villages. The financial record made concurrently with the 1861 well survey shows that each village paid the money in proportion with the number of wells it owned (Figure 4). The amount of money each village paid per well (i.e. the price of a well) can be calculated by dividing the total payment by the number of wells. Although the price differs among the villages, the average price of a well was 0.94 Ryo (Figure 5). In other words, it was equivalent to a pump tax. The existence of price is another proof that shows how groundwater changed from an open-access resource to a scare resource with a positive value. The penalty fee can work as deterrence against illegal pumping as long as the fee is higher than the price of a well. The penalty fee of 5 Ryo or 10 Ryo satisfies this condition.

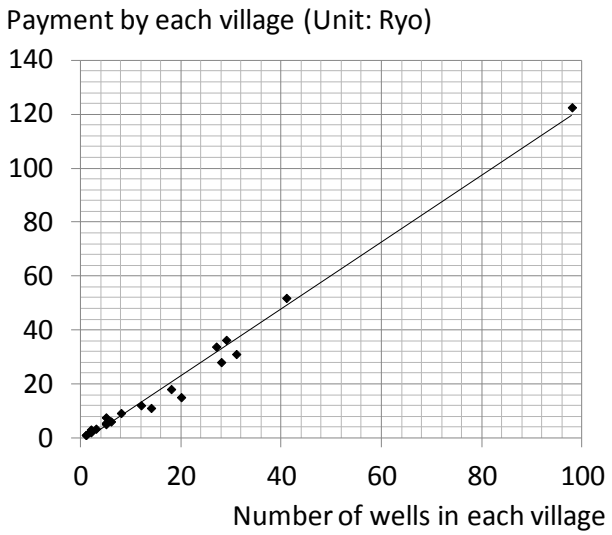

Figure 4. The relationship of number of wells and payment

Source: Documents of Flood Control Office, Kasamatsu-jinya, Mino-gundai 1861b

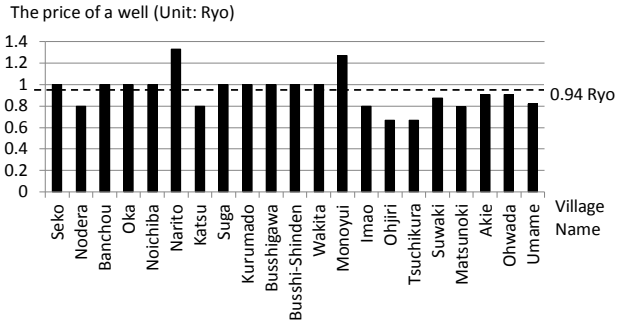

Figure 5. The price of a well in each village

Source: Documents of Flood Control Office, Kasamatsu-jinya, Mino-gundai 1861b

Last, there were a total of 406 wells in use according to the well survey of 1873 (i.e. 13 years after 1860 agreement) (Documents of the Flood Control Office, Kasamatsu-jinya, Mino-gundai 1873). Therefore, there were 18 unauthorized wells, which were destroyed at the request of the lower villages. This suggests that, on the whole, the 1860 agreement was

kept (Mori 1964: 937-938, Matsubara 1968: 498).

5-3: Societal and technical factors

Although the design principle is a useful analytical framework, it is not enough. Two additional factors should be considered to understand Kabu-ido more deeply: societal and technical factors.

Ring-levees were developed for several reasons. First, the area was prone to natural flooding. Second, the central government at the time constructed a 50 km levee on the east side of the Kiso River for military purposes. Owing to this levee, flooding concentrated on the west side of the Kiso River. Third, this area was ruled by a number of landlords in a fragmented fashion that prevented the implementation of effective flood controls. Accordingly, the local residents enclosed themselves in series of levees to protect themselves, which formed the ring-levees (Bekki 1932:234, 248-250; Nakazawa *et al.*, 1936:15-16). As mentioned before, a self-organized solution was made possible due to the local government's non-interference policy on water issues within the ring-levee. However, behind this attitude there was a societal factor, in that comprehensive flood control was lacking even though this area was a naturally flood-prone area. As Agrawal (2002: 56-57) pointed out, the study of the commons has paid little attention to historical and societal factors. Kabu-do suggests these factors exert influence on emergence self-organized institution.

The technical factor is also important. In this paper, the technological factor is defined as unskilled techniques that are used to divert and drain water. At that time, it was very difficult for residents in the ring-levee to divert water from rivers because the diversion point often turned into a location that was prone to flooding. Therefore, enlargement of diversion gate might risk the overall ring-levee (Editorial committee of a history of Wanouchi town 1981: 155). Although digging wells was seen to be a substitute, it provoked other drainage problems (as mentioned earlier).

Demand for well construction did not disappear in the upper villages because the diversion technique remained poor. Consequently, when a drought once again occurred in 1876, new wells were added in the upper villages without permission from the lower villages. To address this problem, both villages reached the following compromise: the lower villages allowed the total number of wells in the upper villages to increase to 806 and the upper villages paid for the construction of three new drainage gates. In addition, sanctions against rule-breaking were discussed and both sides agreed that if the upper villages constructed additional wells without permission from the lower villages then all existing wells would be destroyed. From 1883 to 1885, the 806 wells were decreased to 421 and an additional 1000

wells were proposed in exchange for improving the drainage gates in the lower villages. Consequently, the total number of wells rose to 1421 (Mori 1964: 938-945; Matsubara 1968: 499-500) (Figure 6).

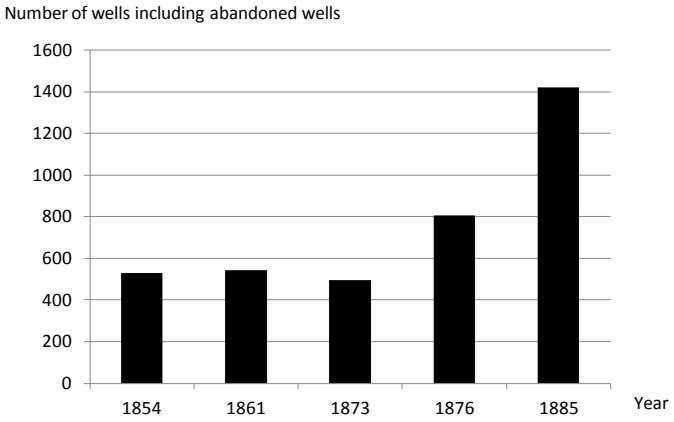

Figure 6. Change of well numbers in Takasu ring-levee
Source: Documents of the Flood Control Office, Kasamatsu-jinya, Mino-gundai 1861a; Mori 1964; Matsubara1968.

The main characteristics of Kabu-ido are the restrictions that it placed on the total number of wells and the economic compensation that was paid from the upper villages to the lower villages. The new agreement loosened the previous part but tighten the latter part. The main function of Kabu-ido was to solve negative externality related to drainage by making the upper villages pay the external cost. From this point of view, it can be said that the function of Kabu-ido remained intact even after the new agreement.

The influence of drainage technology is, however, much clearer. In 1903, a watermill-drainage machine was installed in Takasu ring-levee, motor-drainage machines followed soon after. These technological developments made drainage considerably easier than before, and hence, the necessity of restricting the number of wells in the upper villages decreased. Consequently, the Kabu-ido system disappeared 40 years after it had been created. Furthermore, this change was also promoted by the fiscal system. First, the local residents paid the construction cost of the new drainage machines. The effects were much greater than had been expected, and they found that they could get subsidies from the government (Kaizu association for promoting education 1981: 146; Kaizu town 1984: 183-184). This resulted in the end of the Kabu-ido system. Therefore, it can be said that Kabu-ido was an institution created under the limitations of a pre-modern drainage technology.

6. Conclusion

The purpose of this paper is to clarify the function of Kabu-ido and to then discuss the implication of Kabu-ido to the commons study. Kabu-ido was a self-organized institution that was developed to solve a drainage problem that had been triggered by excessive

groundwater pumping. It was created around 1860 and it lasted for about 40 years. In this paper, Ostrom's (1990) design principle was used as an analytical framework. Kabu-ido satisfies all of the elements within the design principle. In particular, Kabu-ido enabled local people to mitigate the external diseconomy related to drainage without intervention from an external authority by introducing a well-numbering system, a reward for detection of illegal wells, and a penalty fee system with joint responsibility. This attempt to apply design principles to Kabu-ido also improves the analytical framework proposed by the commons study. Although previous researchers on the commons study have paid little attention to societal and technological factors, Kabu-ido suggests that these factors may exert significant influences on the creation and maintenance of a self-organized institution.

A major cause of excessive groundwater pumping is the ill-defined property rights for groundwater resources. However, it is difficult to set up and enforce clear property rights for groundwater because its exact extent is not always clear. In the 19th century, the problem that the residents within the Takasu ring-levee faced was determining how to restrict the number of groundwater users, how to restrict the pumping volume, and how to manage the well construction technology through institutional arrangements. These problems are similar to current problems, such as land subsidence and groundwater pollution. Accordingly, Kabu-ido, which was in use more than one hundred years ago, still provides useful information that is applicable to current groundwater management policy.

Acknowledgments

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