

Governance, rights, and resource development costs of water: lessons from post-war Japan

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Abstract

To promote water resources development, many nations have established centralized administration such that the central government can hold an institutional authority with the ability to control water resources development and modify the modernization of water rights. This enables governments to clearly define the rights or introduce the principle of vested rights protection; however, volunteer transactions of water rights can be institutionally prohibited or restricted. The aim of this study was to analyse how the centralization of administration, or the modified modernization of water rights, has affected water resources development costs by examining the case of post-war Japan. After World War II, Japan experienced rapid economic growth with regard to water resources development because of expansive concrete dams. However, these water resources development measures caused environmental or financial problems under low economic growth circumstances. Therefore, the aims of this water policy study were to evaluate the advantages and disadvantages resulting from water resources development based on large-scale concrete dams. Policy implications for developing countries will be drawn upon in this study. Because the government is a key actor in promoting water resources development, it has an accountability and a responsibility to the citizens.

Keywords: Dams; Japan; Resources development costs; Vested rights; Water governance; Water rights

Introduction

Whereas humankind has encountered many problems related to water, for example, flood damage from Hurricane Katrina in 2005 or severe drought in California in 2015, throughout time, water has consistently been a key natural resource upon which human survival is dependent. Simply put, society cannot exist without water. Nations have improved water institutions and management approaches in order to manage this resource more efficiently. This process has been supported by water resources development, namely large-scale concrete dams. In general, dams are a useful and effective policy tool for society that stabilize the available water volume or timing of water use. However, developed

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countries have paid attention to the importance of river ecosystems or river re-creation. As shown in the case of the removal of four dams in the Klamath River basin spanning California and Oregon, there is an increasing interest in removing dams and redistributing water from offstream use back to instream use, in order to restore river ecosystems and improve water re-creation (e.g. Ho *et al.*, 2017).

Considering current social change, the concept of water governance is crucial (e.g. Organisation for Economic Co-operation and Development, 2011; Marques *et al.*, 2016)¹. ‘Water governance formally refers to the set of administrative systems, with a core focus on formal institutions (laws, official policies) and informal institutions (power relations and practice) as well as organizational structures and their efficiency’ (Organisation for Economic Co-operation and Development, 2011). To establish a better society, good water governance is required. We need to study whether current water governance, especially formal water institutions, contributes to improved social welfare.

The aim of this study was to investigate how the costs of water resources development based on large-scale concrete dams has been institutionally impacted by the centralization of administration to control surface water and modified modernization of water rights, using post-war Japan as a case study. The centralization of administration to control surface water means moving control of water resources away from locals to a centralized, formal authority. Conversely, this at least partly voids the local water use rules established as a result of negotiations among local villages in a river basin.

The centralization of administration to control surface water is also related to the modernization of water rights. If the content of water rights, such as the volume of water to be permitted, is clearly defined by the government and water use rules are clearly defined among water users, voluntary transactions of water rights result in the maximization of social welfare. However, as shown in post-war Japan, it is not a rare case that the volunteer transactions of water rights have been institutionally prohibited or restricted. The principle to protect vested water rights is often established as one of the main rules of redistributing water rights. This paper refers to such a situation as the *modified* modernization of water rights. Under the modified modernization of water rights, the ineffectiveness or inefficiency of water governance may not be remedied well, because water may not be provided to water use sectors that demand more water and are able to buy water at a higher price. Therefore, how the government has overcome such problems is a crucial point of argument.

After defeat in World War II, Japan focused tremendously on economic growth in order to overcome several problems related to militarism. In fact, water resources development had rapidly accelerated economic growth in post-war Japan. Nevertheless, water resources development also contributes to socioeconomic–environmental problems, such as ecosystem damage, or increases the fiscal burden related to large-scale concrete dams under low economic growth (e.g. Musiaka & Koike, 2009). Therefore, post-war Japan is an appropriate case to evaluate the institutional impacts on the costs of water resources development over time.

The next section describes how the short policy history related to water resources development in post-war Japan has changed. It especially focuses on statutes for the centralization of administration to control surface water, such as the New River Law in 1964. The following sections explain how customary and permitted water rights in Japan should be understood and outline water resources use in post-war Japan. In the Methods section, three hypotheses are presented and the methods and data for analysing the institutional impacts on the costs of water resources development are explained. In the

¹ The recent study about water governance is featured in ‘Special section on Water Governance’, *Utilities Policy*, 43, 2016.

Results section, the three hypotheses are tested using data of the project costs of dams or several elements of dams nationwide. Lastly, in the Discussion section, the resultant implications that we can draw for the field of water policy study and for developing countries currently promoting water resources development are debated.

Short policy history related to water resources development in modern Japan

Japan started rice paddy cultivation approximately 3,000 years ago, and it is thought that customary rules related to irrigation for rice cultivation, both within the village and among villages, had already been established during the Edo period, through actual historical conflicts. The customary water rights had several rules by which to decide how much water each village could extract or use from rivers. These included the old paddy principle (similar to the so-called ‘first in time, first in right’ in the appropriative water rights system), the upstream principle that upstream villages had a priority to extract or use water, and the equal use principle. The adopted distribution principle of water depended on each region’s situation, but the old paddy principle had been central. In addition, the rules to use water among actors within a village might have been dependent on the social situation of each village. Customary water rights included not only the right to use water for irrigation but also other contents of rights, such as the right to use water for drinking or cooking. The contents of customary water rights during this time were not divided clearly (e.g. [Ministry of Agriculture, Forestry and Fisheries, 1982](#); [Nakashima, 1997](#)).

The first modern water law was enacted in 1896 after the Meiji Restoration for modernization in 1868, which is called the Old River Law. This regulated statutory provision related to flood control, such as allocation costs between central and local governments. However, it did not provide any real regulatory conditions related to water use and, instead, declared that all customary water rights were recognized as permitted water rights and should be allowed by local governments. The Old River Law could not change the old order of water use based on customary water rights, and the courts recognized that customary water rights were effective as a protected legal interest if farmers would use water within the conditions outlined in the customary rules. Most court precedents had shown that customary water rights should be protected and had an equal legal position to permitted water rights under the Old River Law; however, volume should be restricted as necessary ([Ramseyer, 1989](#); [Sanbongi, 1999](#)).

After the Meiji era, customary water rights or customary water laws had been influential as the rules to regulate each instance of water use. As [Nakashima \(1997\)](#) indicated, ‘most water resources in natural streams had been already used up when this Law [the Old River Law] was enacted’, and one of the most important arguments was to promote how the volume of water should be redistributed from irrigation to other water uses. As the central government or electric companies wanted to produce more electric power to increase the wealth and power of the state, several conflicts became apparent in large rivers regarding irrigation use as customary water rights versus hydroelectric power use as new water rights. Because big cities, such as Yokohama, needed water for increased domestic use, conflicts between irrigation use and domestic use also became apparent. However, these conflicts were still a local issue, and they did not change the total structure of customary water laws. Severe conflicts between irrigation and domestic uses had become a significant social issue, especially after the 1950s ([Study Group of Irrigation Water Use, 1980](#); [Study Group of Issues Related to Irrigation Water Use, 1981](#)).

Figure 1 shows several major statutes related to water resources development in post-war Japan. As seen in the radical change from militarism to capitalism and democracy, World War II dramatically affected the sociopolitical–economic system in Japan. Given the nation’s political conditions, Japan had a thirst for peace and economic growth. The central government started to develop natural resources in earnest by enacting the 1950 Comprehensive National Land Development Law and the 1952 Electric Power Development Promotion Law. Water resources were one of the most important policy targets for national land development. The main purposes of the river control policies were for realizing flood control, developing electric power, and increasing food yields; hence, *multipurpose dams* and the concept of *comprehensive development* played a crucial role (Yamauchi, 1962; Musiake & Koike, 2009).

The Ministry of Construction (MOC), which is now the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), had the authority to control rivers or lakes. The MOC enacted the 1957 Law on Specially Designated Multipurpose Dam, laying the legal foundation for the MOC, itself, to construct multipurpose dams and allocate dam use rights. This meant, essentially, that the MOC had the power to permit a legal right for pooling water into multipurpose dams instead of assigning the appropriate construction and maintenance costs to each participant of the multipurpose dam construction plan. This statute allowed the MOC to take the first step in centralizing the administration to control surface water and modifying customary water laws. Furthermore, the MOC had the intention to establish a comprehensive authority in the total field of river control policy through revision of the Old River Law (Mikuriya, 1996).

After 1960, when Prime Minister Hayato Ikeda promulgated the Income Doubling Plan, it was politically recognized that water resources should be comprehensively developed within each river system and the policy and administration for surface water control should also be changed accordingly. The central government enacted the 1961 Water Resources Development Promotion Law, which accelerated comprehensive water resources development in key river systems where they were economically crucial. Thus, water volumes allocated for domestic or industrial uses were increased, as was the case for the Tone river system, including its use in metropolitan Tokyo. The central government enacted the 1961 Water Resources Development Public Corporation Law, just prior to establishing the Water

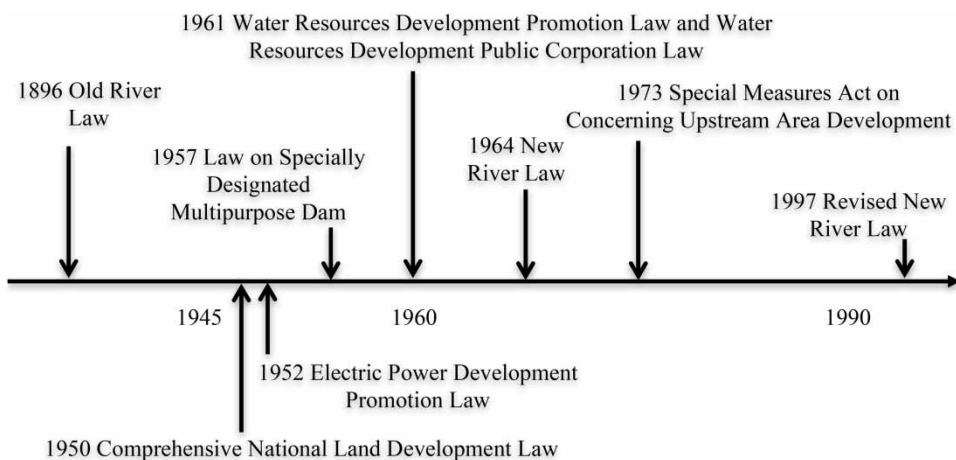


Fig. 1. Major statutes related to water resources development in post-war Japan.

Resources Development Public Corporation (WRDPC), which is the present-day Japan Water Agency (JWA). The WRDPC was the specialized organization for promoting comprehensive water resources development, and the MOC mainly had the authority to control the WRDPC (Yamauchi, 1962; Mikuriya, 1996; Musiake & Koike, 2009).

In 1964, the Old River Law was thoroughly revised, becoming the New River Law. Through the enactment process, local governments lost their authority for controlling rivers under the Old River Law, which some of them opposed. The Ministry of Agriculture and Forestry (MAF), which was replaced by the current Ministry of Agriculture, Forestry and Fisheries (MAFF), and originally had the authority to control agricultural policy including irrigation use, also opposed the law because the MAF had traditionally insisted that they, not the MOC, should control irrigation use as a part of agricultural policy. However, because of the political climate of this time, especially as it was influenced by politicians, such as Kakuei Tanaka or Ichiro Kono², there was tremendous support for the move towards one agency, i.e. the MOC, having comprehensive control of the rivers. Thus, the centralization of administration to control surface water was institutionally established in the 1964 New River Law (Mikuriya, 1996; Noda, 2015).

The political or social conflict between upstream and downstream communities has been one of the most polarizing social problems. Whereas members of upstream communities are required to relocate according to dam construction plans, big cities and other communities located downstream consume huge volumes of water supplied by the dams. Hence, the central government enacted the 1973 Special Measures Act on Concerning Upstream Area Development in order to establish income redistribution by redirecting funds from those who enjoyed benefits based on the dam construction plans to those who were forced to pay the consequences of such. This can be viewed as a kind of social cost related to water resources development in the form of large-scale concrete dams. In addition, as the environmental movement and the movement opposing unnecessary public works both grew, the central government revised the New River Law in 1997, which added environmental protection as one of the main purposes of the law (Musiake & Koike, 2009)³.

Permitted and customary water rights

Customary water rights are given an equal legal position to permitted water rights by the New River Law, but those who held customary water rights need to report the content of customary water rights, such as the volume or timing of water extraction. Note that mutual relations among customary water rights have often been regulated ‘not by the quantity of water, but by the physical facility of water intake: for example, water is withdrawn by specific sizes of wood works’ (Nakashima, 1997). It is difficult to quantify accurately the volume of water that customary water rights stipulate. As a result, the volume of water that holders of permitted water rights to be converted from customary water rights can

² Kakuei Tanaka was a key politician when the 1961 Water Resources Development Promotion Law and the 1961 Water Resources Development Public Corporation Law were enacted and the Prime Minister from July 1972 to December 1974. Ichiro Kono was a prominent politician and the Minister of Construction when the New River Law was enacted in 1964 (e.g. Mikuriya, 1996).

³ As of 1 April 2015, the total of aborted dam construction plans numbered 138 cases (Japan Dam Foundation, 2016).

extract or use may decrease. Thus, such conversion has been an important argument for enforcement of the New River Law after its enactment (Noda, 2015)⁴.

The New River Law adopts the old paddy principle, which means that vested water rights are more advantageous for existing water rights' holders over potential water users, in line with the fundamental distribution principle of water under non-drought conditions⁵. This principle is applied when there are sufficient river water levels, enabling all holders of water rights to extract and use the permitted volumes of water. When potential water users apply for new water rights, one of the permitted conditions is that they not infringe upon vested water rights. On the other hand, however, the New River Law does not clearly state the distribution principle of water under drought conditions, and holders of water rights in water shortage areas are required to negotiate who extracts or uses how much of the water case by case (Working Study Group of Water Rights, 2005).

In addition, the New River Law, in principle, does not approve the trade of water rights from one purpose to another, for example, transferring irrigation use to municipal use. The MOC/MLIT has taken a stance that water rights (or the volume of water for an existing water right) should be returned to the central government and be redistributed by the MOC/MLIT, if it means a transfer of water rights between different purposes (Working Study Group of Water Rights, 2005). Hence, we can evaluate that the New River Law institutionally established not only the centralization of administration to control surface water but also the modified modernization of water rights.

However, there is surprisingly no established theory regarding what kind of legal rights are classed as permitted or customary water rights. One school of thought is that both permitted and customary water rights are public rights, which are monopolistic and exclusive to other persons within the permit range, because Section 2 of the New River Law indicates that surface water is not subject to private rights, including property rights. The MOC/MLIT has maintained this position. Another school of thought is that both permitted water rights and customary water rights are private property rights, whereas surface water itself falls under the public property domain. As customary water rights have multipurpose water uses in nature, the MAF/MAFF has stood not only in the latter position, but also in the position that the New River Law affected only the content of water rights related to water extraction from rivers (e.g. Ministry of Agriculture, Forestry and Fisheries, 1982; Nakashima, 1997; Working Study Group of Water Rights, 2005).

The most pragmatic and applicable understanding of water rights in modern Japan is that they are private and usufructuary rights as a kind of property rights, but are restricted by the government in order to protect public interests, such as environmental sustainability (e.g. Nakashima, 1997). The reasons for this are as follows. First, both water or dam use rights are fiscally recognized as intangible fixed assets. Considering this fiscal feature, we can understand that they are property rights. In fact, the MOC/MLIT has at least accepted the concept that water rights are monopolistic, exclusive, and real

⁴ Focusing on the extracted volume of water for irrigation use, where the percentage of permitted water rights in irrigation use was about 30% (5,618 m³/s), the percentage of customary water rights was about 54% (10,000 m³/s) (Ministry of Agriculture, Forestry and Fisheries, 1982). Similarly, the percentage of permitted water rights in irrigation use increased by about 67% (5,965 m³/s) as of 31 March 2014 (Ministry of Land, Infrastructure, Transport, and Tourism, 2015).

⁵ It is normal that the principle of vested rights protection is established as a fundamental rule of water allocation under non-drought conditions. In fact, this principle is recognized under the appropriative water rights system in western USA or the abstraction licence system in England and Wales.

(Working Study Group of Water Rights, 2005). Fishery rights in Japan, similar to water rights, are legally recognized as private property rights.

Second, because permitted water rights or permitted water rights to be converted from customary water rights are at least placed as rights related to only extraction and use of water from rivers, we can understand that they are not absolute property rights but usufructuary rights. Third, as seen in building regulations, even landownership is usually restricted and adjusted for public interests or other rights' holders of landownership. Thus, several restrictions to water rights, such as those related to water volume for use or extraction, are naturally justified, if they result in the increase of the total social value. Even if water rights are recognized as private property rights, the government does not lose the authority for determining river control policy.

Trends of water resources use in post-war Japan

Each water sector, including irrigation use, in Japan has traditionally depended on rivers rather than ponds or groundwater. As a result of the rapid economic growth in the post-war period, both municipal and industrial use sectors have rapidly increased their demand for water. The percentage of total annual water consumption of the total volume of rainfall ($640 \times 10^9 \text{ m}^3/\text{year}$) is approximately 13%. Total annual water consumption according to sector is as follows: irrigation use is 67%, domestic use makes up 19%, and industrial use accounts for 14%. Meanwhile, approximately 95% of the total volume of irrigation water comes from rivers: 79% of domestic water originates in rivers, and 72% of industrial water is sourced from rivers. Water use in Japan mainly depends on rivers (Ministry of Land, Infrastructure, Transport, and Tourism, 2014).

After the late-Meiji era, construction of hydroelectric power plants began, giving rise to conflicts regarding water use for irrigation versus hydroelectric energy. Based on power generation output, hydroelectricity was the main source of electricity until the 1950s, but its share in total electricity production has decreased since the 1960s. Moreover, Table 1 presents the number of dams in Japan by year of completion and by purpose of the dams, showing that approximately 62% of dams were constructed in post-war Japan. This suggests that water resources development in post-war Japan depended mainly on large-scale concrete dams. Focusing on the number of dams, according to purpose, built in post-war Japan, the percentage of dams, including those for irrigation use, is approximately 53% (Japan Commission on Large Dams, 2009).

Table 1. Number of dams in Japan by year of completion and by purpose.

Completion year of dam	Number of dams	Purpose of dam (can be multiple)	Number of dams
Before 1000 AD	9	Agricultural use	2,048
1001–1899	661	Municipal and industrial use	501
1900–1945	692	Hydroelectric power use	630
1946–1999	1,534	Flood control	650
2002–2008	162	Others	58
Total	3,058	Total	3,887

Note: If a dam is multipurpose, the purposes of the dam are counted respectively. Thus, the numerical value of dam by purpose is not equal to the numerical value of dam by year of completion.

Source: Japan Commission on Large Dams (2009).

Methods for analysing the costs of water resources development in post-war Japan

In this section, verification of the three hypotheses and explanation of the data used are attempted (the data are included in the supplementary material, available with the online version of this paper). The first hypothesis is that the project costs of large-scale concrete dams have rapidly increased over time. To promote the centralization of administration to control surface water, the MOC/MLIT and the WRDPC/JWA have constructed multipurpose dams themselves, or the MOC/MLIT has subsidized local governments constructing multipurpose dams. Thus, the second hypothesis is that the project costs of dams constructed by the MOC/MLIT, the WRDPC/JWA, or local governments with a subsidy from the MOC/MLIT are higher than the project costs of dams otherwise.

The third hypothesis is that the principle of vested rights protection has increased water resources development costs. As dams are able to produce greater water volume in comparison with natural flows, potential water users in Japan accelerated dam construction in order to avoid political or social conflicts with vested water rights' holders. In fact, many multipurpose dams have included 'unspecified water use' as a purpose, which means that the volume of water is secured for vested water rights' holders or for instream use such as environmental protection. Thus, the project costs of dams including unspecified water use are higher than the project costs of dams not including this use.

A few studies have evaluated the institutional impacts on the project costs of large-scale concrete dams. For example, Merrow & Schroeder (1991) simply analysed the relationship between the capital cost and various elements of hydropower dams, such as megawatts of capacity installed or hydraulic head, via multiple regression analysis. Ansar *et al.* (2014) analysed the costs' overrun and schedule slippage of hydropower dams, using the hierarchical linear models and independent variables such as various elements of hydropower dams or regional dummy variables.

As this study focuses on the relationship between the project costs of dams and various elements of dams (including hydroelectric power use), simple ordinary least squares (OLS) regression was adopted, in which the dependent variable is related to the costs of water resources development, and the independent variables are various elements of dams, according to Merrow & Schroeder (1991).

- By removing missing values, 680 cases were evaluated in this study.
- EZR version 1.32 was used as the statistical analysis software (Kanda, 2013).
- Data other than the deflator index were from the Japan Dam Foundation (2016). As the minimum unit of the project costs is one million JPY, note that data such as the available reservoir capacity, gross reservoir capacity, and project costs are rounded.
- Because payment costs are not available for every year, the present value of the project costs was converted based on each completion fiscal year, with the construction deflator provided by the MLIT to be named as *kasen sogo* (FY2005 = 100).

Table 2 shows the basic statistics regarding the dependent and independent variables. Several elements can be recognized as dependent variable, such as the deflated project cost or the deflated project cost per available reservoir capacity. The logarithmic transformation of the deflated project cost per volume of water to be newly developed per basin area was adopted as the dependent variable, via the result of the Shapiro–Wilk test (p -value = 0.16). Many elements of dams can be thought of as independent variables: the gross reservoir capacity (m^3), available reservoir capacity (m^3), completion fiscal year, surface area (ha), and capacity of water to be newly developed (m^3). Moreover, to test the

Table 2. Basic statistics of the analysis subject ($N = 680$).

Variable	Description	Mean	Standard deviation	Min	Max
Unit cost	Deflated project costs per volume of water to be newly developed per basin area (JPY/m ³ /s/km ²)	104,323,713,200	1,281,278,176,924	38,884	31,159,272,463,977
Available capacity	Available reservoir capacity (m ³)	13,987,413	38,047,445	14,000	458,000,000
Basin area	Basin area (km ²)	121.4	493.7	0.1	8,588
Developed water	Volume of water to be newly developed (m ³ /s)	3.99	9.7	0.0005	147.7
Gross capacity	Gross reservoir capacity (m ³)	17,610,297	49,695,906	22,000	601,000,000
Project cost	Deflated project costs (FY2005 = 100, JPY)	19,590,975,923	33,224,275,327	1,176,238	235,976,990,612
Surface area	Surface area (ha)	74.8	137.2	1.0	1,150
Year	Completion fiscal year	1981.8	16.5	1951	2015

second hypothesis, a dummy variable for the business owner of dams is introduced as an independent variable. To test the third hypothesis, a dummy variable for the unspecified volume of water is introduced.

As shown in Table 3, because the correlations among the logarithmic transformation of the gross reservoir capacity, the logarithmic transformation of the available reservoir capacity, and the logarithmic transformation of the submerged area are very strong, which element should be used was decided upon based on the stepwise selection of the Akaike's Information Criterion and the adjusted R -squared. The empirical model is as follows:

$$\ln \text{Unit cost} = \alpha + \beta_1 \ln \text{Surface area} + \beta_2 \ln \text{Year} + \beta_3 \text{Dummy MLIT} + \beta_4 \text{Dummy unspecified} + \varepsilon$$

where α is an intercept, $\ln \text{Unit cost}$ represents the logarithmic transformation of the deflated project cost per volume of water to be newly developed per basin area, $\ln \text{Surface area}$ represents the logarithmic transformation of the surface area, $\ln \text{Year}$ represents the logarithmic transformation of the completion fiscal year of dams, Dummy MLIT represents the dummy variable 1 if the MOC/MLIT and the WRDPC/JWA have constructed multipurpose dams themselves or the MOC/MLIT has subsidized local

Table 3. Matrix of Pearson correlation coefficients among several variables.

		1	2	3	4	5	6
1	$\ln \text{Available capacity}$	1.000					
2	$\ln \text{Basin area}$	0.701***	1.000				
3	$\ln \text{Developed water}$	0.640***	0.689***	1.000			
4	$\ln \text{Gross capacity}$	0.988***	0.765***	0.685***	1.000		
5	$\ln \text{Surface area}$	0.948***	0.783***	0.707***	0.964***	1.000	
6	$\ln \text{Year}$	-0.075*	-0.280***	-0.373***	-0.116**	-0.140***	1.000

*Significant at 5%, **Significant at 1%, ***Significant at 0.1%.

governments constructing multipurpose dams, *Dummy unspecified* represents the dummy variable 1 if the unspecified volume of water is established as a purpose of the dams, ε is an error term, and β is each coefficient to be estimated.

Results of testing the three hypotheses

The results of the OLS regression are presented in Table 4. All variables were significant, the adjusted *R*-squared was approximately 0.66, and the *F*-statistic was significant. Therefore, it was shown that this regression model was appropriate. First, because the unstandardized coefficient of *ln Year* was positive and approximately 155, the increase of 1% in the completion fiscal year significantly resulted in an increase of 15,500% of the deflated project cost per volume of water to be newly developed per basin area. The closer the completion fiscal year became to the contemporary, the more the project cost rapidly increased. Thus, it was suggested that the costs associated with water resources development have rapidly increased over time in post-war Japan.

Second, because the unstandardized coefficient of *Dummy MLIT* was positive and 0.61, the deflated project cost per volume of water to be newly developed per basin area for *Dummy MLIT* = 1 was 61% higher than it would have been otherwise. Thus, it was suggested that the project costs of dams constructed by the MOC/MLIT, the WRDPC/JWA, or local governments with a subsidy from the MOC/MLIT were higher than the project costs of dams would have been otherwise. Finally, because the unstandardized coefficient of *Dummy unspecified* was positive and 1.22, the deflated project cost per volume of water to be newly developed per basin area for *Dummy unspecified* = 1 was 122% higher than it would have been otherwise. The project costs of dams including unspecified volume of water as a purpose were significantly higher than the project costs of dams that did not include this use. Thus, it was suggested that the modified modernization of water rights had increased water resources development costs.

Discussion

In this study, the interdependencies among the centralization of administration to control surface water, the modified modernization of water rights, and the costs of water resources development based on large-scale concrete dams were investigated. To the best of my knowledge, this research is

Table 4. Summary of analytical results after testing the three hypotheses.

Variable	Unstandardized coefficient		Standardized coefficient	
	B	Standard error	Beta	<i>t</i> -value
<i>Dummy MLIT</i>	0.61	0.29	0.09	2.09*
<i>Dummy unspecified</i>	1.22	0.3	0.17	3.99***
<i>ln Surface area</i>	−1.41	0.05	−0.63	−26.31***
<i>ln Year</i>	154.71	9.48	0.39	16.32***
Intercept	−1,150.19	71.98		−15.98***

*Significant at 5%, ***Significant at 0.1%, Adjusted *R*-squared: 0.6612, *F*-statistic: 332.3 on 4 and 675 DF.

an initial attempt in the field of water policy study. As a result of this work, it was predictably proven that the centralization of administration to control surface water and the modified modernization of water rights were major factors enabling the central government to develop large-scale concrete dams in post-war Japan. The results suggest that institutional factors, such as the principle of vested rights protection, have weakened the ability of public policy to restore balance and, instead, there has been an accelerated overdevelopment of water resources. This is an important implication for developing countries.

As emphasized in Rogers *et al.* (2002), the full costs of water such as a dam's construction cost or environmental externalities should be estimated, but this study focused only on project costs of dams because of the availability of data for evaluating nationwide water resources development in post-war Japan. With a number of detailed case studies from which to draw, the operation and maintenance costs and economic externalities owing to the amount of money to be currently paid may be estimated. Environmental externalities of water may be estimated by analysing the amount of money to be paid in practice for preventing river ecosystem degradation or with an econometric method such as contingent valuation method or travel cost method.

For example, rebalancing water use between hydroelectricity and river ecosystems has been a major political problem in the Columbia River basin in western USA. The Bonneville Power Authority (BPA), which is a non-profit federal agency for the wholesale of electricity, to be generated by federal hydroelectric power plants in the Pacific Northwest, has paid over 14.4×10^9 dollars as an accumulated value from 1978 to 2014, as a type of *necessary costs* in order to keep the plants running while providing recompense for damage done to endangered species in the area. As hydroelectricity generation must be decreased in order that endangered species can migrate back and forth between rivers and the sea, the BPA has bought the volume of electricity provided by other electricity plants, where the aggregated value is approximately 3.1×10^9 dollars (Northwest Power Coordinating Council, 2015). This is a partial estimation of environmental externalities of water resources development.

Finally, if with the modified modernization of water rights, the principle of vested rights protection is introduced but prohibitions or restrictions of a voluntary transaction of water rights between different purposes of water uses cause an increase in the costs of water resources development, the possibility of a water rights market, which has already been implemented in Australia and western USA, needs to be analysed (e.g. Garrick *et al.*, 2009). From the viewpoint of economics, the current modified modernization of water rights will be justified only if the total costs of water resources development under the current institution are the same as, or less than, the total costs of water resources development with the market mechanism. In the field of water policy study, we should increase such policy analysis further to show the possibility that total costs of water resources development with the market mechanism will be lower than the costs of it without such.

Conclusion

A strong analysis is presented in this paper. As the first case study in the field of water policy, how the centralization of administration to control surface water and the modified modernization of water rights have affected the costs of water resources development was investigated. As a result, it was predictably proven that the centralization of administration to control surface water and the modified modernization of water rights were major factors enabling the central government to develop large-scale concrete dams.

As the central government has more power and revenue, it is not difficult for it to construct large-scale dams. Furthermore, if the redistribution of water rights does not work well according to the change in social conditions, that is, ineffective and inefficient water governance is retained, it may result in social losses through an accelerated overdevelopment without an institutional brake. Large-scale concrete dams contribute not only to social welfare but also to social problems such as environmental disruption or the adverse effects on individual welfare for the victims who are required to move to another area. Thus, the government has an accountability and a responsibility to the citizens. Scholars need to evaluate whether a large-scale concrete dam project actually resulted, or would result, in the enhancement of social welfare. This is one of the most important policy implications for developing countries.

However, there were several problems regarding the lack of necessary data. For example, in this study, only the project costs of dams were used but the full costs of water need to be estimated and evaluated. If methods to estimate economic or environmental externalities of water can be devised, the field of water policy study will be enriched. In addition, if water resources development in countries other than Japan can be analysed, we can understand with greater certainty that the tendency revealed in this study has tremendous applicability.

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