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Blue Gold in Japan

—Policy idea on creating a new water trading system coping with expected water issues in Japan based on comparison studies—

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The World Economic Forum Annual Meeting 2009 in Davos warned that the world economy might collapse owing to a lack of fresh water within two decades if we continue to use fresh water resources at the current pace. While the focus of this annual meeting was to address the economic crisis currently facing the world, the meeting identified water shortage as one of the pending major global crises, proving that water resources have become essential for sustainable economic growth.

Efforts to deal with the growing shortage of fresh water resources might lead to the introduction of an institutional framework either for the international trading of virtual water resources or regulation of the total amount in the same way as is done for the greenhouse gas emission trading system. Japan, which is a large emitter of carbon dioxide and is also a major importer of virtual water, is again likely to experience difficulty in international water resource management as it did in the control of CO_2 emissions.

In Japan, which is a country blessed with abundant fresh water resources, many dams have been built in the mountainous regions for controlling floods and providing stable water supplies throughout the year. Large amounts of fresh water resources are currently stored in reservoirs. Because Japan is faced with a declining population, some of these fresh water resources can be allocated in the future for non-conventional purposes other than irrigation, industrial use and urban use. According to the projections of this study, the amount of unused water is expected to reach around 10 billion m^3 per year by 2040.

Alaska in the US, Canada and Turkey are well known as having an abundance of fresh water resources. While it is now only a theoretical projection, Japan also has the potential of being a country with an abundance of fresh water resources. Therefore, the export of fresh water can be considered as a new opportunity for Japan to grow during the period of a declining population.

I Introduction

1 Background

In Japan, increasing attention is being given to water business. Japan's Ministry of Economy, Trade and Industry (METI) predicts that the size of the global water market will rapidly expand from about ¥36 trillion in 2007 to about ¥87 trillion in 2025. METI set a target of winning a market share of about 6 percent (about ¥1.8 trillion). The water business discussed in Japan refers to the design, construction and operation of plants for drinking water, wastewater and seawater desalination, and primarily involves the markets for developing new facilities. METI aims to help drive the growth of the Japanese economy by meeting increasing overseas demand for water-related infrastructure.

Before we go into detail, we need to clarify the fundamental reasons for the expansion of the global water business market. The primary reason for the growing global demand for water-related infrastructure is the rapidly increasing world population. World population is increasing at an unprecedented pace. According to statistics published by the United Nations, the world population in 1950 was about 2.5 billion. Now, as of 2010, it is around 6.9 billion and is predicted to reach some 9.2 billion by 2025. Coupled with such a growing world population at the fastest pace in history, the increase in per capita use of household water and use of industrial water in emerging countries as their economies grow also tightens the water supply and demand balance. Because both total water demand and water demand per unit activity increase, total water consumption is rapidly expanding, giving rise to the need for developing water-related infrastructure.

At the World Economic Forum Annual Meeting 2009 in Davos, a warning was issued concerning the collapse of the world economy within two decades because of water scarcity if current water use trends continue. While the focus of this annual meeting was to address the economic crisis currently facing the world, the meeting identified water shortage as one of the pending major global crises, proving that water resources have become essential for sustainable economic growth. When environmental issues are discussed in Japan, a topic often talked about is the control of carbon dioxide (CO_2) emissions. Surprisingly, the issue of water is not so widely known in Japan.

In addition, the issue of virtual water has also become significant. Japan is a major importer of cereals, food and meat. While Japan does not import water, large quantities of water are necessary to produce the agricultural and livestock products it does import. Importing these water-intensive products means indirectly accelerating overseas water consumption. For instance, 3.6 tons of water are necessary to produce 1 kg of rice, and the production of 1 kg of beef requires 20.6 tons of water. In other words, importing agricultural and livestock products has the same impact as importing water.

Because most imported agricultural and livestock products come from the US and Australia, most virtual water comes from these countries. If a serious water shortage becomes a reality in the future, the issue of virtual water will become more apparent. At the same time, an international framework might be established for transactions of virtual water such as the cap and trade system for CO_2 emissions. Japan, which is a large emitter of carbon dioxide and is also a major importer of virtual water, is again likely to face difficulty in international water resource management as it did in the control of CO_2 emissions.

With the expansion of global water business markets, many Japanese companies are moving to obtain business opportunities in overseas markets. However, if we consider the basic cause for such expansion, we must have noticed a reality about which we cannot be simply optimistic. In this sense, we believe it is important to foresee the future of water business.

2 Aim

In this paper, attention is paid to the fact that domestic- and industrial-use urban water that, to date, has been stored by constructing dams is likely to yield unused water due to the future decline in population, and that the emergence of unused water is likely to cause financial issues in Japan's entire water supply-demand system. In view of these facts, this paper aims to propose social systems that are necessary to realize water exports as a new water supply system so as to avoid the issues predicted to occur in the future.

For this purpose, we estimate the amount of unused water that is expected to be generated in the future because of population decline, and clarify the potential of water exports. In addition, we identify issues related to social systems to enable water exports through comparisons between Japan's water rights systems and the current state of water transactions in Japan and those in some other countries. Furthermore, we look at the current state of water transportation in the world and try to identify related issues. Based on these analyses, we make some suggestions with respect to matters that are necessary in utilizing Japan's unused water resources.

3 Structure

Chapter II describes the methodology used to prepare this paper. Chapter III indicates the results of predicting the amount of unused water, related water rights systems and the results of international comparison of water trading systems. This chapter also touches on the possibility of water exports as well as on Japan's and global approaches to water exports. From the perspective of identifying issues in promoting water exports, Chapter IV discusses three important topics: response at the time of a water drought within Japan, competition with seawater desalination plants, and national and resource security. Finally, assuming that the ideas presented in this paper are feasible, Chapter V considers the next steps that should be taken. In particular, the need for future activities is indicated with respect to the integration of water information, the direction of a reform of water rights systems and the establishment of international rules for water transportation.

II Methodology

1 Objectives

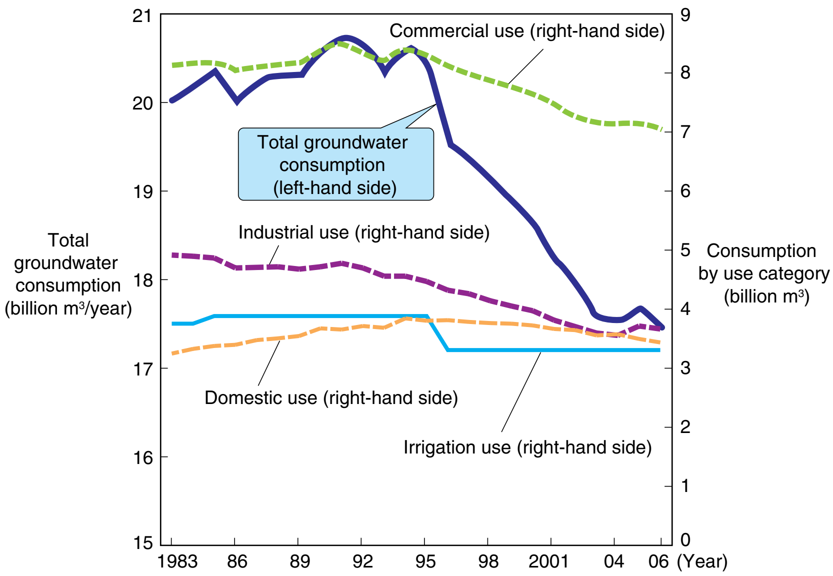
This paper covers five water sources, i.e., drinking water, industrial water, agricultural water and advanced treated wastewater, and groundwater. The focus of the discussion is on water sources that will newly emerge in the future. Technically, drinking water, industrial water and agricultural water are not water sources but refer to categories of water use. However, in these categories of water, it is predicted that water demand will decrease because of population decline and a change in the industrial structure. Such decreased portions could be thought of as new sources of water.

While advanced treated wastewater does not refer to a type of water use, the ability to treat wastewater has been greatly improved in Japan thanks to technological innovation in recent years and in order to reuse surface water and to maintain water quality in rivers, lakes and enclosed bays. Such progress in technology has made it possible to treat wastewater to a level that is comparable to surface water. In particular, advanced treated wastewater can now be considered as a new water source in urban areas. In addition, so-called guerrilla rain (sudden fierce downpours into relatively small areas) in urban areas, which has recently become a problem in Japan, is also treated by wastewater treatment plants except for rain that flows directly into rivers. Accordingly, the development of advanced treatment facilities will enable the use of rain in urban areas that is not yet fully utilized as a water source.

In Japan where alluvial plains formed because of fluvial sedimentation have spread, groundwater has traditionally been abundant and easy to use as a water source. However, during the period of high economic growth, the excessive pumping of groundwater caused ground subsidence. For that reason, the pumping of groundwater is controlled in many areas. Even at present, the Nobi Plain, Chikugo-Saga Plain and the northern part of the Kanto Plain are subject to the "Outline of Measures for Preventing Ground Subsidence." Under such circumstances, the use of groundwater continues even though the amount is decreasing. As of 1995, a maximum of 20.8 billion m^3 of groundwater was used per year. As of 2005, this amount was reduced to around 17.5 billion m^3 per year, a decrease of 3 billion m^3 per year (Figure 1).

For reasons such as preventing ground subsidence, it has been difficult to consider groundwater as a water source, especially in large cities. Recently, however, the amount of groundwater resources has gradually been restored due to reductions in the pumping of groundwater. For example, in Nerima Ward of Tokyo, the amount of pumped groundwater has been declining since around 1973. As a result, most recently, the water level of confined groundwater has been restored to a depth of 30 m underground (slightly less than 25 m above sea level)

Figure 1. Change in nationwide groundwater consumption



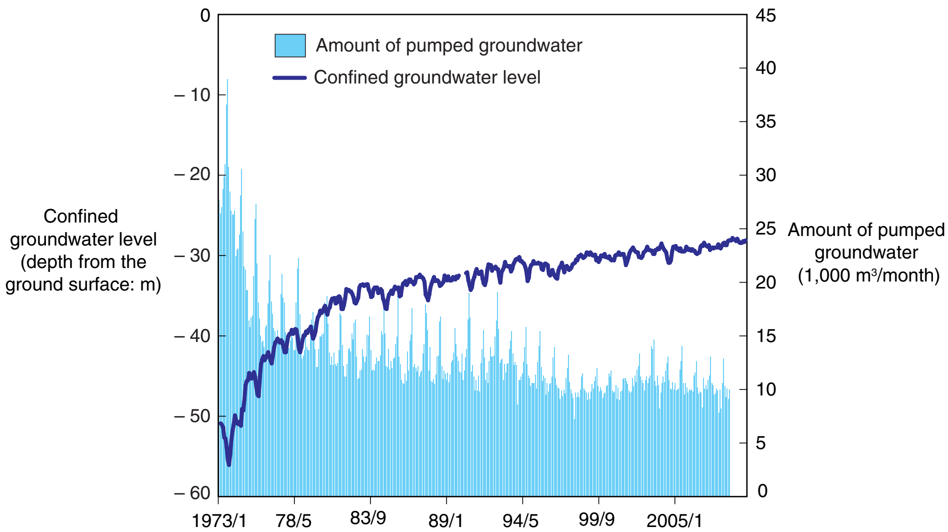
Source: Compiled based on *Heisei 21 nen ban nihon no mizu shigen—sogo mizu shigen kanri no suishin* (Water Resources in Japan 2009—Promoting Comprehensive Water Resource Management) edited by the Water Resources Department, Land and Water Bureau, Ministry of Land, Infrastructure, Transport and Tourism (AIGER Co., Ltd., 2009).

(Figure 2). Accordingly, groundwater is about to again become one option as a water source for urban areas.

While the amount of groundwater is being restored to a level that can be used as a water source, it is highly likely that damage such as ground subsidence might again be caused if groundwater is pumped at a pace similar to that during the period of high economic growth. Currently, in Japan, groundwater is regarded as "private water" (private rights) that belongs to the landowner and can be freely used except in cases where such use is regulated by ordinances, etc. or such use causes ground subsidence or groundwater pollution. If the unrestricted use of groundwater is promoted without providing rules for groundwater resource management, similar issues might again be caused. In this respect, the "public water" theory[71] has recently been advocated. This adopts the position that the government should manage groundwater resources on its own responsibility as national property from the perspective of managing fresh water resources within Japan. Accordingly, at present, it is difficult to regard groundwater as a water resource that can be used freely in the future.

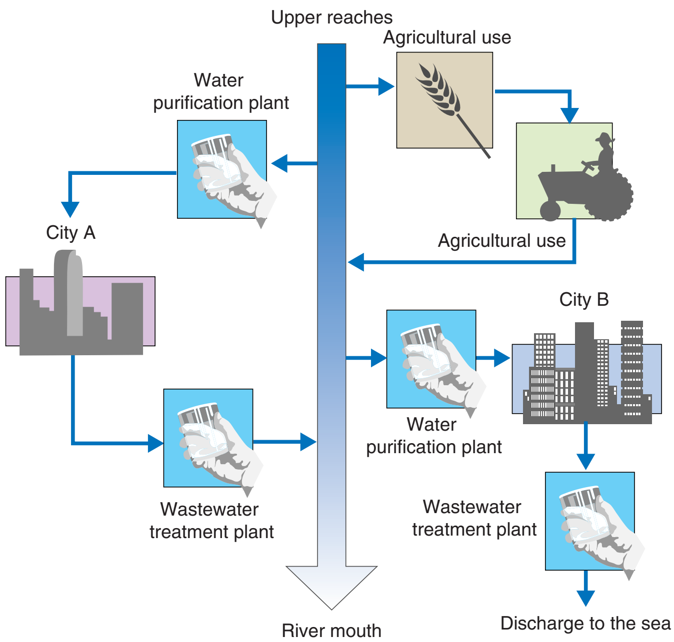
There are two points to which attention must be paid when discussing water resources in Japan. The first point

Figure 2. Confined groundwater level and pumped amount in Nerima Ward of Tokyo



Note: The confined groundwater level refers to the level of groundwater in strainers that are installed at a depth of 87 – 97 meters underground. This level indicates how much groundwater is in an aquifer that lies around the depth of 87 – 97 meters. The higher the confined groundwater level, the more abundant the groundwater in the relevant aquifer.
Source: "*Heisei 20 nen jiban chinka chosa hokokusho* (Ground Subsidence Survey Report 2008)" published by the Civil Engineering Center of the Tokyo Metropolitan Government.

Figure 3. Repeated use of river water



is that water resources are repeatedly used through the medium of rivers (Figure 3). Suppose water is used for irrigation at the upper reaches of a river, and water is taken for domestic and industrial use at the middle and lower reaches of the river. The water used for irrigation at the upper reaches is returned to the river at the middle reaches. Some of the domestic- and industrial-use water taken at the middle reaches will also be returned to the river after wastewater is treated. In this case, limiting the amount of intake for agricultural use at the upper reaches can increase the amount of water for domestic and industrial use at the middle reaches. However, the amount of intake for agricultural use at the upper reaches does not affect water availability to domestic and industrial water users at the lower reaches. Because Japan's water rights system is predicated on the existence of water being returned to rivers, it is necessary to understand the current situation of water use. In order to use unused water resources, careful discussion is required as to where and how much unused water there is and whether there is any advantage of transferring such unused water to others.

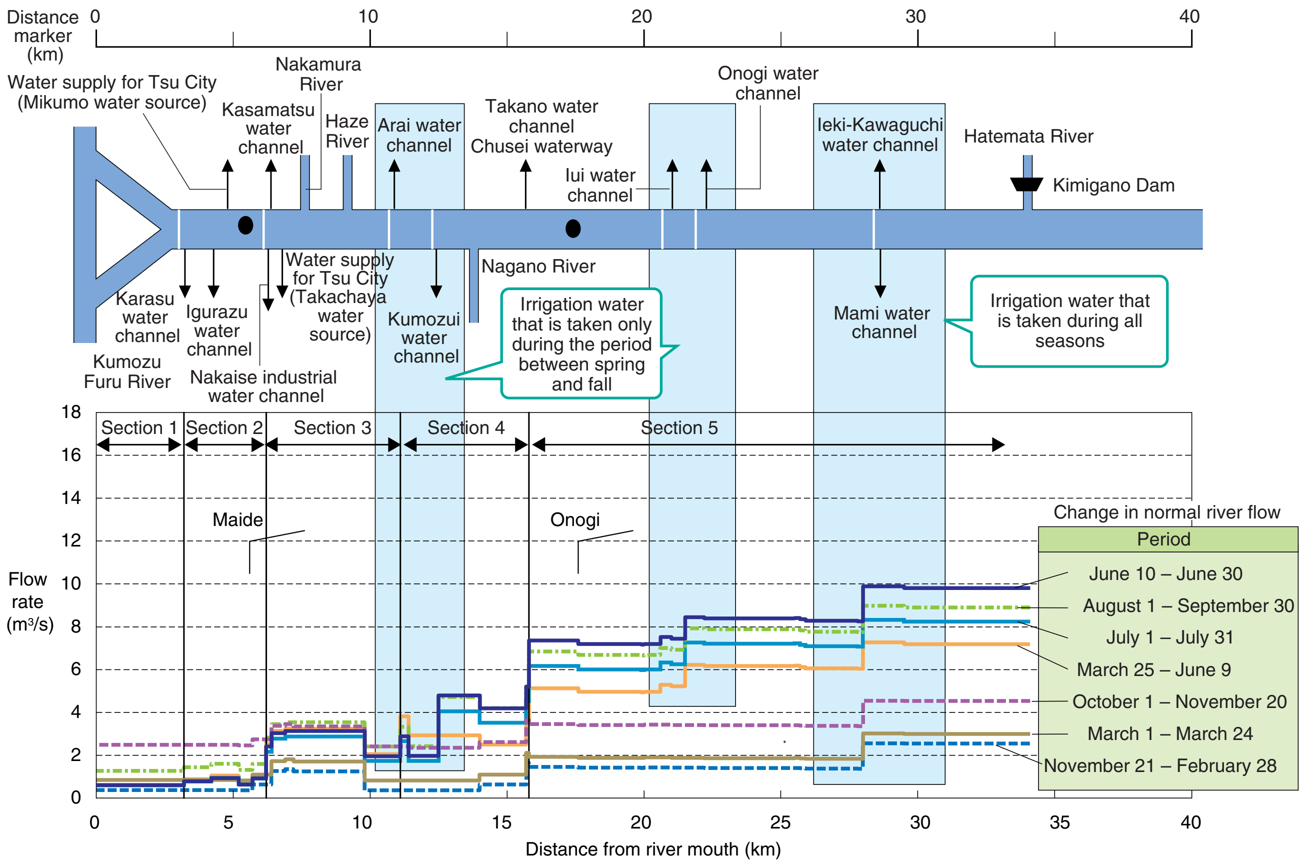
The second point is that Japan's river water levels fluctuate largely according to season. Currently, river authorities allocate water rights in consideration of seasonal changes in water for each usage purpose. Accordingly, unused drinking water and industrial water as well as recycled wastewater can be considered as stable unused water resources. On the other hand, unused water that comes from agricultural water would be an extremely unstable unused water resource (Figure 4). As such, it is difficult to consider unused water derived from agricultural water as a stable water resource.

Under these circumstances, this paper focuses on drinking water, industrial water and advanced treated wastewater.

2 Framework

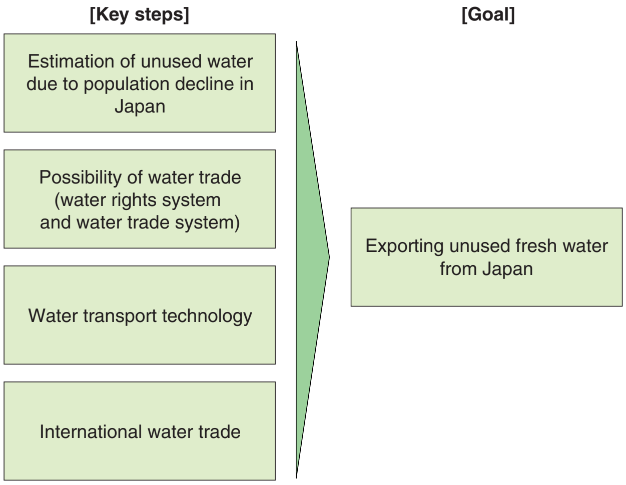
This paper employs four steps to examine the possibility of exporting unused water from Japan in the future. At the first step, we estimate how much unused water would be available in Japan in the future. Even if unused water is present in Japan, it is not possible to export such water if it cannot be freely utilized. Accordingly, at the second step, a study is made on whether water exports are possible under current water rights and water trading systems. Suppose adequate unused water is generated and water exports are found possible in terms of water rights. The issue we must consider at the third step is water transport. For Japan, which is an island country, it is not possible to transport water without a means of

Figure 4. Change in river water flow rates and water intake for agricultural use



Source: *Kumozu-gawa suikei kasen seibi kihon hoshin—yusui no seijo na kino wo iji suru tame no hitsuyo na ryuryo ni kansuru shiryo 2006* (Basic River Management Policy for the Kumozu River Water System—Materials concerning the Water Flow Rates that Are Necessary to Maintain Normal Functions of Flowing Water 2006) published by the River Bureau, the Ministry of Land, Infrastructure, Transport and Tourism.

Figure 5. Four steps necessary for exporting unused fresh water



marine transportation. At the fourth step, we identify the issues related to international approaches that have already been adopted for marine transportation of water, and examine the possibility of transporting water from Japan.

The framework of this paper consists of these four steps. We believe that marine transportation of water from Japan will become possible only when all of these four steps are successfully addressed.

3 Literature Review

In preparing this paper, we used keywords such as water rights, water trade and water export to collect related information from papers, reports published by municipalities, newspapers, journals, etc. The documents used in preparing this paper are listed at the end of this paper as references.

4 Interviews

In drawing up this paper, we held interviews with officials of the Ministry of Economy, Trade and Industry, the Ministry of Agriculture, Forestry and Fisheries, the Mie Office of River and National Highway of the Chubu Regional Bureau of the Ministry of Land, Infrastructure, Transport and Tourism, the Osaka City Waterworks Bureau, the Okinawa Prefectural Enterprise Bureau and the Tokyo Metropolitan Government. We reflected the results of these interviews in this paper where appropriate. However, the opinions expressed during the interviews do not necessarily represent the official views of each organization. For many interviewees, the theme of this paper is outside their jurisdiction. We asked for their comments on areas where they have jurisdiction principally for the purpose of confirmation. It should be noted that consensus has not yet been formed within Japan on the matters discussed in this paper.

5 Estimation Models

Especially when we estimate the future amount of unused water, we used the models explained in each of the following applicable sections with respect to drinking water, industrial water, agricultural water and advanced treated wastewater. We did not include groundwater in our estimation of the amount of unused water because at present, groundwater has not yet been fully restored to its original water level and water rights are currently vested in landowners.

(1) Drinking water

The annual drinking water supply has increased steadily with the dissemination of water service and the increase in the number of households. However, since 1990, the pace of water supply increases has slowed down and, since 1995, the water supply amount has been declining. The spread of water saving devices is seen as one of the major reasons for this decline.

The model used to estimate the future amount of unused drinking water is indicated in Formula (1). This model was created by regression analysis of natural logarithms of data on the actual amounts of water supply, the number of households and water supply coverage during the period between 1963 and 1995. All of these coefficients are at the 5-percent level, and are significant.

Usually, factors such as the number of household members, the number of cooling degree days (CDD), water shortage and the rate of population aging are considered in estimating the demand for water service. However, because these factors were not statistically significant, they are not considered in this model. For the trend of water saving (S_t), it was assumed that water saving devices became popular after 1995. Attention is then paid to the fact that there is a linear relationship in the differences between the projected values that considered only the two factors of the number of households and coverage and the actual values until 2007. Because these findings indicate the trend of water saving, "S_t" was included in the estimation formula. This "S_t" connotes both the spread of water saving devices and water conservation due to the decrease in the number of household members.

$$W_t = e^{2.128821} * e^{St} * H_t^{0.723838} * P_t^{1.781903} \qquad (1)$$

where:

H_t = Number of households
P_t = Water supply coverage
W_t = Projected amount of water supply
S_t = Trend of water saving, $S_t = 0.0137t - 0.4223$

(2) Industrial water

Currently, the annual amount of the industrial water supply is already largely below the amount of the contract water supply. This large difference is attributable to the fact that the amount of the contract water supply is based on the maximum use amount, and that the daily use amount does not reach the maximum amount.

At the current stage, many industrial water suppliers and their users do not intend to return any of the amounts for which they have already received vested water rights.[20] However, some water use plans have been shelved. Accordingly, it is projected that the difference between the maximum water amount and the daily use amount will not be discharged, except for an emergency such as a drought, and will remain as water that is allocated for the industrial water field.

Furthermore, in recent years, the actual amount of the industrial water supply has been in a declining trend. Industrial water is used approximately in proportion to GDP (gross domestic product). GDP can be estimated from the working age population and the number of households. The model to estimate the future unused industrial water amount using this relationship is given in Formula (2).

In this model, the industrial water amount to be used is estimated based on GDP, and GDP is estimated based on the working age population and the number of households. GDP is estimated by using a log-log regression model.

$$W_t^{\,i} = 0.0731*GDP_t + 112808$$
$$GDP_t = e^{-57.3342} * A_t^{5.09032} * H_t^{1.177015} \qquad (2)$$

where:

W_t^i = Industrial water use amount
GDP_t = Gross domestic product
A_t = Working age population
H_t = Number of households

(3) Agricultural water

In recent years, agricultural water (irrigation water for paddies and cultivated fields) has been rapidly decreasing. At its peak, in 1996, the amount used was 58.5 billion m^3 per year. However, recently, the amount has been below 54.5 billion m^3 per year. We assume that this decline is attributable to the following causes.

Traditionally, irrigation water and wastewater used the same water channel. By 1996, facilities were renovated to separate agricultural water from wastewater. This prevented the repeated use of agricultural water, and the amount of water necessary for agriculture increased. While, at that time, the area of cultivated fields was decreasing, the demand for water was greater than such decrease because the repeated use of agricultural water was no longer possible through the improvement of water channels, as mentioned above. After 1996, because the development of agricultural water channels was completed, the decrease in the area of cultivated fields became more prominent in numerical terms.

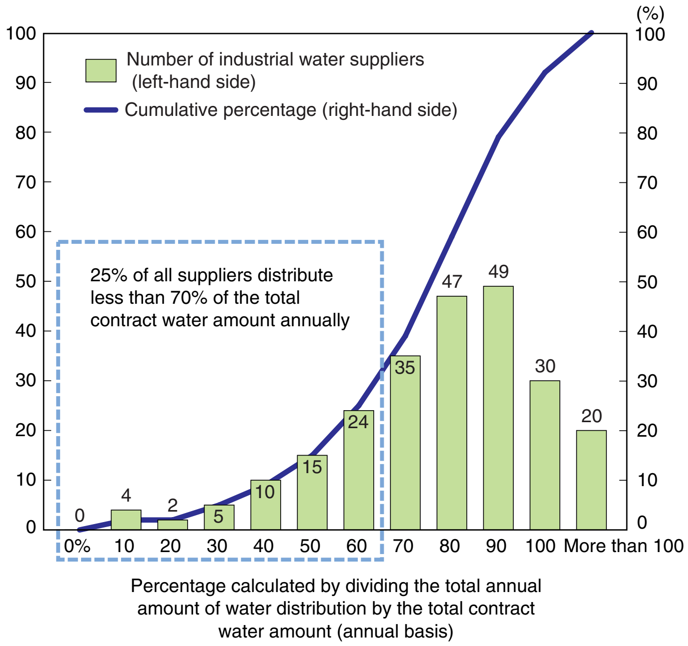
Formulas (3) and (4) are used to estimate future unused agricultural water.

The amount of irrigation water (W(t)) is estimated by using the following formula. The coefficient of determination is over 0.98, which means that the prediction is good.

$$W(t) = 0.1582*A(t) - 196.78 \; (R2 = 0.9849) \qquad (3)$$

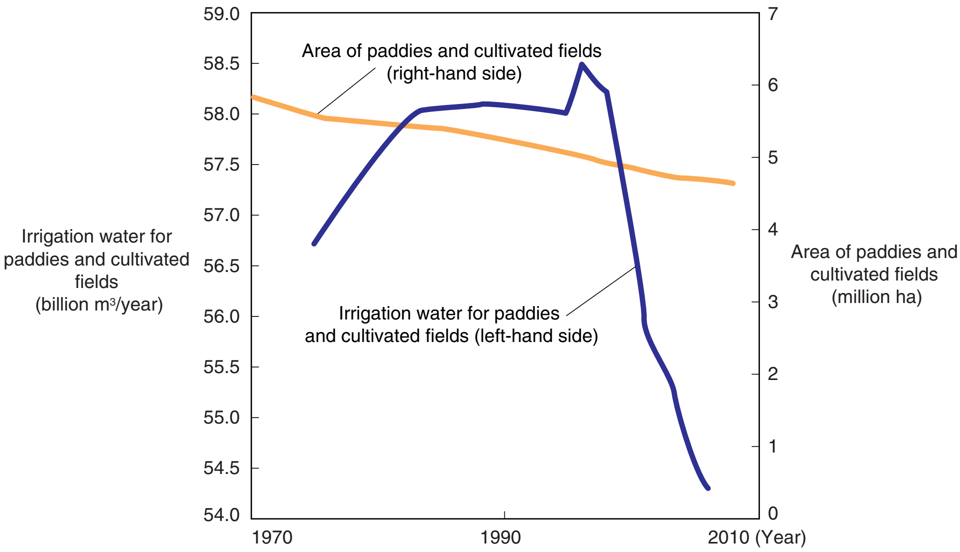
The area of paddies and cultivated fields (A(t)) is estimated by using the following formula based on the number of years elapsed from 1996 (base year = Year 0).

Figure 6. Total contract water amount vs. total annual amount of water distribution by industrial water suppliers



Source: Compiled based on "*Chiho koei kigyo nenkan* (Local Public Enterprise Yearbook)" edited by the Local Public Finance Bureau, the Ministry of Internal Affairs and Communications.

Figure 7. Change in the amount of irrigation water and the area of paddies and cultivated fields



Source: For the amount of irrigation water for paddies and cultivated fields: Compiled based on *Heisei 21 nen ban nihon no mizu shigen* (Water Resources in Japan 2009) (Reference 2-4-1; Change in the Agricultural Water Use Amount (by Use Purpose)), the Ministry of Land, Infrastructure, Transport and Tourism. For the area of paddies and cultivated fields: Compiled based on "Statistics on Cultivated Land and Planted Areas," the Ministry of Agriculture, Forestry and Fisheries.

While this is a time series model, the prediction is similarly good.

$$A(t) = -132.26 * \sqrt{t} + 5089.2 \quad (R2 = 0.9979) \qquad (4)$$

(4) Advanced treated wastewater

Finally, estimation is made for advanced treated wastewater. While both rainwater and wastewater flow into sewers, currently, advanced treatment systems are principally used for sewerage facilities that discharge treated water into Tokyo Bay, Ise Bay and Osaka Bay. Unlike water that underwent primary and secondary treatment, advanced treatment systems can purify wastewater into water of a quality that can be used as a source for industrial water under international standards. Currently, the Ministry of Land, Infrastructure, Transport and Tourism is studying the export of advanced treated wastewater overseas. [Note 1] As such, advanced treated wastewater can be considered as one of Japan's unused water resources.

While the amount of drinking water use has been decreasing due to population decline and fewer households, this means that the amount of wastewater to be treated is also decreasing. In other words, population decline and fewer households are also likely to affect the amount of advanced treated wastewater.

Because the coverage of sewerage is now less than 100 percent and the percentage of advanced treatment systems is still small, the amount of usable water resources is likely to increase, regardless of population decline and fewer households, with the increase in the coverage of sewerage facilities and that in advanced treatment systems.

Based on the current data on the coverage of sewerage facilities and that of advanced treatment systems, the logit model is used for estimation. The decrease in the amount of drinking water supply is also incorporated. Formula (5) is used for this estimation.

$$TW_t = P^h_t \times WW_t \qquad (5)$$

$$WW_t = 15554.72P_t + 0.0337598 * W_t + 24.04619R_t - 4781.44 \qquad (6)$$

where:

TW_t = Advanced treated water

WW_t = Treated wastewater

P^h_t = Coverage of advanced treatment systems, $P^h_t = 0.7683\text{Ln}(t) - 3.3009$

P^w_t = Coverage of sewerage facilities, $P^w_t = 0.0709t - 1.9286$

R_t = Ratio of precipitation to average year value

6 Data

The data used in this paper include a variety of information including data used in Section 5, data on confined groundwater and seawater desalination plant operation data. The statistics from which the data for estimation were obtained are listed below. The sources of the data other than those used for estimation are indicated at the bottom of each figure.

- "*Suido Tokei* (Water Supply Statistics)," Ministry of Health, Labour and Welfare
- "Comprehensive Survey of Living Conditions of People on Health and Welfare," Ministry of Health, Labour and Welfare
- "Census of Manufacturers (Report by Industrial Site and Water)," Research and Statistics Department, Economic and Industrial Policy Bureau, Ministry of Economy, Trade and Industry

- "Population Projections for Japan" and "Annual Report on Current Population Estimates," Population Census Division, Statistical Survey Department, Statistics Bureau, Ministry of Internal Affairs and Communications
- "Annual Report on National Accounts for FY 2003" published on the website of the Economic and Social Research Institute (ESRI), Cabinet Office, Government of Japan (Research and Coordination Division, Department of National Accounts)
- "*Gesuido Tokei* (Sewage Statistics)," Japan Sewage Works Association (JSWA)
- Data published by the Japan Meteorological Agency (JMA) were used for the ratio of precipitation

III Results

1 Projection of Unused Fresh Water in Japan

Figure 8 projects the use of drinking water through 2040 based on the actual amount of water supply in the past. Explanatory variables include the number of households, coverage and the trend of water saving. By 2040, these projections indicate a decrease in the amount of water supply to around 10 billion m^3 per year, or down about 30 percent from the current level.

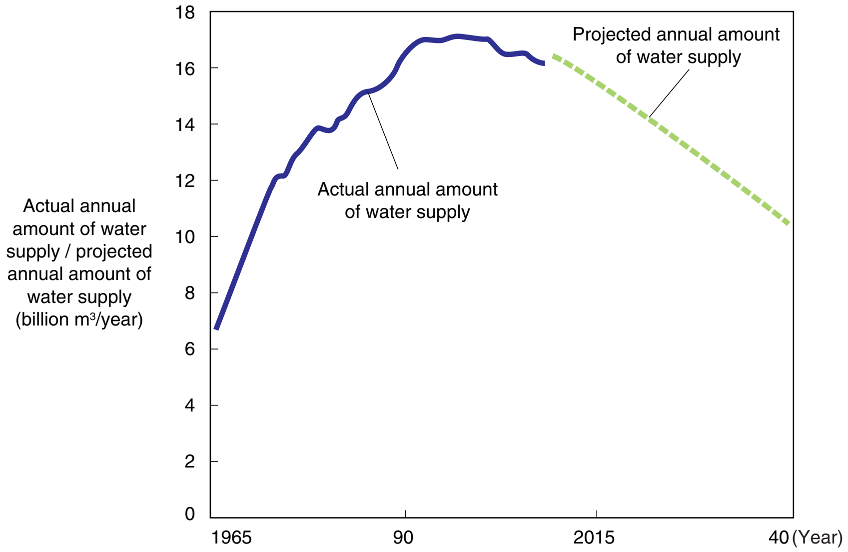
With respect to industrial water, the amount of water supply until 2040 was estimated based on Formula (2), which revealed that it would decrease to slightly more than 9 million m^3 per day, or down around 25 percent from the current level.

With respect to the field of wastewater, Formulas (5) and (6) were used for estimation. The results revealed that the amount of advanced treated wastewater will continue to increase and will be about 6.5 billion m^3 per year by 2040.

Based on the area of paddies and cultivated fields, the amount of use of irrigation water for paddies and cultivated fields in 2040 was estimated. The estimation showed that unused water amounting to 10 billion m^3 per year as compared to 2000 (6 billion m^3 per year as compared to 2010) is likely to be generated from the field of agricultural water due to the decrease in the area of paddies and cultivated fields. As is clear from Figure 6, since 1996, the amount of water used for irrigation has been decreasing at a pace that is greater than that of the decrease in the area of cultivated land. This estimation result reflects such tendency. Accordingly, attention must be paid to the possibility of an overestimated decrease in the amount of use of water.

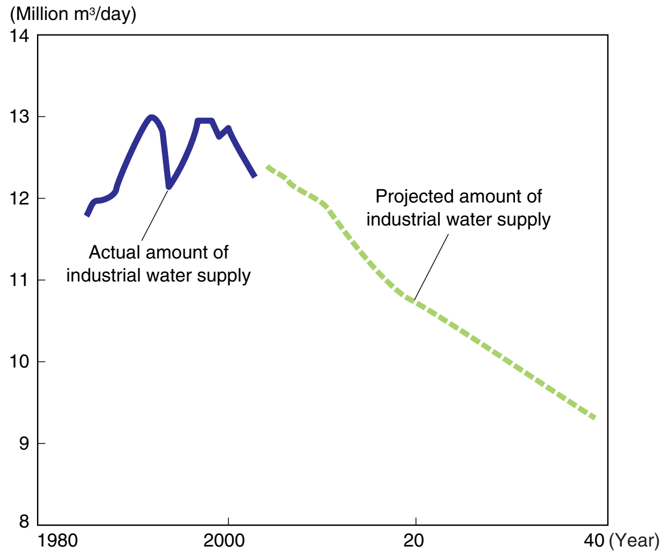
Finally, consideration is given to the possibility of utilizing the unused water resources in Japan by combining the projected amount of unused water in each field (Figure 12). As compared to 2010, the total unused water will amount to 4 billion m^3 per year in 2020, 7 billion m^3 per year in 2030 and 10 billion m^3 per year in 2040. These figures do not include "water resources that are unused but are not recognized as unused water as of 2010." In addition, agricultural water is not included in considering these unused water resources. Because agricultural water is cyclically used, it is difficult to determine whether water is unused. Even if water allocated for agricultural use is not used for agriculture, some experts point out that a certain amount of water flow is necessary to preserve the community environment and to maintain agricultural water channels. Accordingly, we did not consider unused agricultural water as unused water resources.

Figure 8. Projections of the amount of drinking water supply



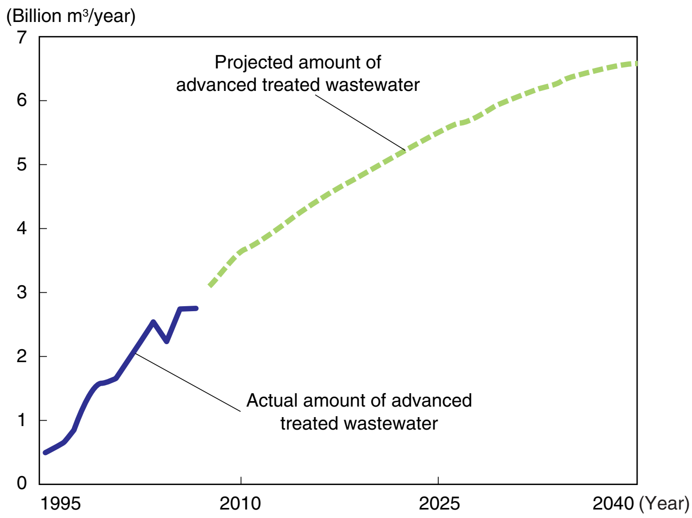
Note: Formula (1) indicated in Section 5 (1), Chapter II was used for estimation.
Source: Estimated based on "*Suido Tokei* (Water Supply Statistics)" and "Comprehensive Survey of Living Conditions of People on Health and Welfare," both published by Ministry of Health, Labour and Welfare.

Figure 9. Projections of the amount of industrial water supply



Note: Formula (2) indicated in Section 5 (2), Chapter II was used for estimation.
Source: Estimated based on "Census of Manufacturers (Report by Industrial Site and Water)," Research and Statistics Department, Economic and Industrial Policy Bureau, Ministry of Economy, Trade and Industry; "Population Projections for Japan" and "Annual Report on Current Population Estimates," Population Census Division, Statistical Survey Department, Statistics Bureau, Ministry of Internal Affairs and Communications; and "Annual Report on National Accounts for FY 2003" published on the website of the Economic and Social Research Institute (ESRI), Cabinet Office, Government of Japan (Research and Coordination Division, Department of National Accounts).

Figure 10. Projections of the amount of advanced treated wastewater



Note: Formulas (5) and (6) indicated in Section 5 (4), Chapter II were used for estimation.
Source: Estimated based on "*Gesuido Tokei* (Sewage Statistics)," Japan Sewage Works Association (JSWA); data published by the Japan Meteorological Agency (JMA) for the ratio of precipitation; and "*Suido Tokei* (Water Supply Statistics)," Ministry of Health, Labour and Welfare for the actual amount of drinking water supply.

If these unused water resources were to be sold at ¥10/m^3, a revenue of ¥40 billion could be generated in 2020, ¥70 billion in 2030 and ¥100 billion in 2040.

2 Comparison Study of Water Rights Systems

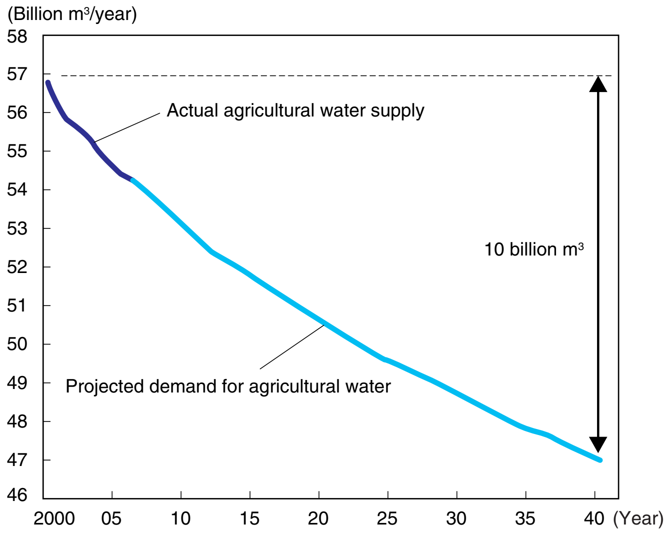
(1) Japan's water rights system

In Japan, historically, water rights had generally developed as customary water rights. Experts generally point to shared ownership or collective indivisible ownership by a village as forms of customary water rights.[69, 43]

In 1896, the River Law was enacted. This law approved customary water rights for those who already possessed customary rights. This law defined a water right as a right to exclusively use river water. Because this law gave priority to water rights that were vested earlier, a water right defined under this law had the strong nature of a private right.

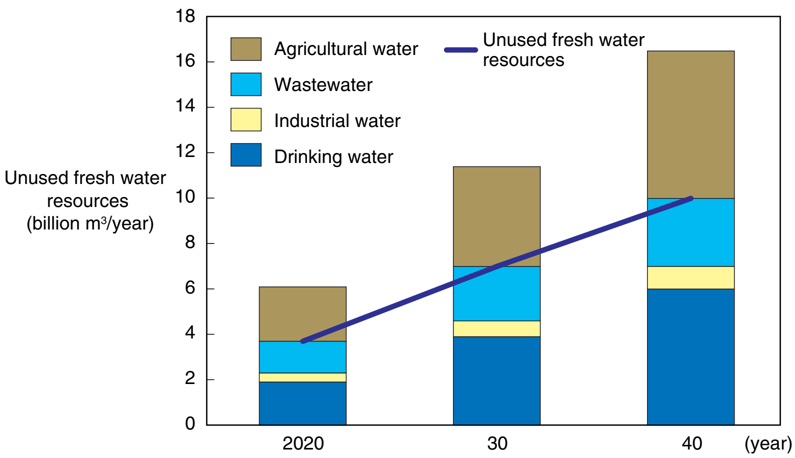
When the River Law was revised in 1964, with the takeoff of high economic growth in the 1960s, the concept of integrated management of water resources by official river administrators was adopted in view of the tightened balance of supply and demand for urban water including drinking water and industrial water. As a result, while customary water rights are considered as being de facto water rights, a permission system was basically adopted under Article 23 of the revised law (a system of permitted water rights).[60]

Figure 11. Projections of the demand for agricultural water in 2040



Note: Formulas (3) and (4) indicated in Section 5 (3), Chapter II were used for estimation.

Figure 12. Results of projection of unused fresh water resources



With respect to the nature of these water rights, the provision of Paragraph 2, Article 2, of the River Law Note 2 does not allow river water to be the subject of any private rights. It is commonly understood that customary water rights other than permitted water rights are bound by certain constraints such as limited use purposes, limited quantity and quality according to the permitted use purposes, which compromises the absolute priority that is inherent in real rights.[38] While some experts consider that customary water rights are servitude under Article 280 of the Civil Code, others point out that because the old River Law provided a provision that deemed customary water rights as permitted water rights, customary rights must be treated the same as permitted rights.[49, 50]

The former Ministry of Construction and the Ministry of Agriculture, Forestry and Fisheries do not necessarily have the same interpretation of the law concerning whether a water right is a public right or a private right. For example, the former Ministry of Construction took the position that a water right is a "public right" and required a right holder to first return the right for any unused water to a river administrator and apply for the permission of a new water right for other use purposes. However, the Ministry of Agriculture, Forestry and Fisheries construed a water right as a "private right" and approved direct transfer of a right for a fee based on Article 34 of the River Law. Note 3

Japan's water rights have the characteristics listed in Table 1.

Japan's water rights can be classified as indicated in Table 2 and Figure 13 in consideration of customary water use and stability of water intake. In particular, water intake under affluent water rights is permitted only when the water flow of a river is greater than the reference drought water flow. Japan's water rights system consists of historical customary water rights and permitted water rights. The applicable laws and ordinances adopt only a system of permitted water rights, and require political measures to be taken to convert customary water rights to permitted water rights. Nevertheless, because of the historical background, customary water rights are still effective.

Table 1. Requirements for obtaining water rights

Requirements	Description
Stability of water intake	• In view of the water flow conditions of a river, stable water intake must be possible without causing any hindrance to the maintenance of normal river functions • Water intake is permitted when the reference water amount during the drought that is predicted to occur once every ten years (meaning the water level that can be maintained for 355 days throughout the year; 355-day discharge) is larger than the amount of river water that is necessary to maintain normal river functions
Water use purposes and business content must contribute to the public interest	• Use purposes must contribute to the improvement of national life and promote public welfare
Validity of water use	• The business plan must be appropriate, and water use must be valid in light of applicable laws and ordinances
Not causing hindrance to public interests	• There is no fear of causing any hindrance to river management or other public interests

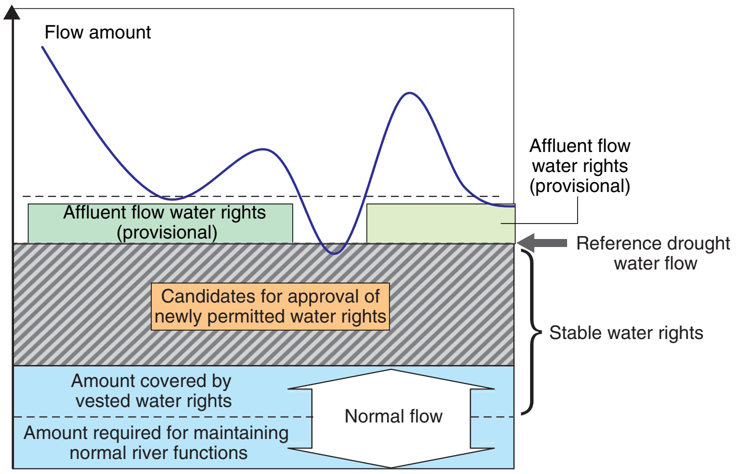
Source: Compiled based on "*Mizu no kachi hyoka to koritsuteki na mizuriyo ni kansuru kosatsu* (Study on the Evaluation of Water Value and Efficient Use of Water)," Masahiko Murase, *Dam Engineering* (April 2005, Japan Dam Engineering Center).

Table 2. Classification of Japan's water rights

Customariness	Stability	Type of water right
Yes	Good	Customary water right
No	Good	Stable water right (already vested) Stable water right (newly permitted)
	Poor	Affluent water right (provisional)

Source: Compiled based on "*Mizu no kachi hyoka to koritsuteki na mizuriyo ni kansuru kosatsu* (Study on the Evaluation of Water Value and Efficient Use of Water)," Masahiko Murase, Dam Engineering (April 2005, Japan Dam Engineering Center).

Figure 13. Classification of flow amount and water rights



Source: Compiled based on "*Mizu no kachi hyoka to koritsuteki na mizuriyo ni kansuru kosatsu* (Study on the Evaluation of Water Value and Efficient Use of Water)," Masahiko Murase, *Dam Engineering* (April 2005, Japan Dam Engineering Center).

(2) Comparison with water rights systems in other countries

This section compares Japan's water rights system with those in other countries.

Japan's water rights system focuses on ensuring the stable use of river water. In Chile, a new Water Code was adopted in 1981, which revised its water rights system. Currently, in a way similar to that in Japan, the system consists of stable water rights that are valid under all conditions and affluent water rights that are valid only when river flow is more than sufficient to meet all stable water rights. What is characteristic of the Chilean system is that water rights are defined according to categories of water use. Specifically, a distinction is made between holders of non-consumptive water rights (mostly power-generating dams that use only the potential energy of water) and holders of consumptive water rights (mostly farmers, households and industry). In Japan, because decisions are made on the water supply amount at the places where there are water supply facilities, there is no such distinction.

Table 3. Comparison of water rights systems in four countries

Name of water rights		Explanation	Japan	California (US)	Australia	Chile
Prescriptive water rights		Rights granted for the use of water that has customarily been used since before the enactment of the law; high priority is given to these rights	○	○		
Permitted water rights	**Stable water rights**	Rights granted for the amount of water that can be used even during a drought	○		○	○
	Affluent flow water rights	While water cannot be used under these rights during a drought, water can be used when there is normal river water flow	○			○
Riparian water rights		Rights vested in owners of land that is adjacent to a lake or stream; water must be used in a reasonable way without impairing the quality or quantity of other riparian rights holders		○	○	
Pueblo water rights		Rights held by municipalities. Under this right, naturally occurring surface and groundwater from the watershed can be used. Water use under this right must occur within the city limits		○		
Groundwater rights		Rights held by owners of land containing groundwater	△ (Note 2)	○		○
Appropriative water rights		Rights used when surface water is transported to land that is not adjacent to the water source		○		
Water rights for consumptive use		Rights for water for agriculture, households and industry				○
Water rights for non-consumptive use		Rights for use of water that is not consumed such as for generating hydroelectric power				○

Legend: ○ = Applicable △ = Semi-applicable

Notes: 1) Water rights that have a similar nature are treated as falling under the same category even if the name of the right and its explanation are different. 2) In Japan, because groundwater is considered to be fruit that arises from the land, groundwater is not explicitly covered by water rights. However, practically speaking, groundwater rights are considered as rights to use groundwater.
Source: Compiled based on "*Mizu no kachi hyoka to koritsuteki na mizuriyo ni kansuru kosatsu* (Study on the Evaluation of Water Value and Efficient Use of Water)," Masahiko Murase, *Dam Engineering* (April 2005, Japan Dam Engineering Center), "*Suiri ken no kantei hyoka: sono seishitsu to iten kanosei* (Appraisal of Water Rights: Their Nature and Transferability)," Yasuyuki Mizuno and Takashi Yamamoto, *Real Estate Research* (50 (3), 107 - 110, Japan Real Estate Institute, 2008), and "Water Institutional Reform and Changes in the Water Rights System in Chile," Masahiro Nakashima, *Hiroshima Journal of International Studies*, Volume 12, Hiroshima Association of University Libraries, 2006.

In California in the US, the water rights system consists of water rights derived from the ownership of land bordering a water source (riparian water rights, appropriative rights and groundwater rights) and water rights that are limited to the use of water for ordinary municipal purposes (pueblo water rights). Australia also has riparian water rights—a system of allocating water among those who possess land bordering a water source. At the same time, the Australian system also permits the use of water in land that is distant from land bordering a water source. In Japan, while the proximity of land to a water source is not considered in granting water rights, the ownership of water intake facilities is required as a condition to apply for a water right, which practically means that only entities that can access water can obtain water rights.

As such, a comparison of only four countries (Japan, Australia, California in the US and Chile) reveals that a variety of perspectives have been adopted as suitable for their respective situations.

3 Comparison Study of Water Trading Systems

(1) Water trading in Japan

In Japan, from the Edo period to the Meiji period, water was traded in some areas to allocate scarce water resources. This section introduces the trading of *bansui kabu* (rotative irrigation) shares in Sado, Niigata and the trading of *jinushi sui* (water use rights vested in landowners) in Kagawa. In modern times, however, a water right is a right allowing the use of water, but it does not involve actual ownership of the water. Therefore, a water right is not the subject of trading. When an unused amount of water becomes available, the relevant right holder returns the unused amount to a river administrator. The river administrator then grants the right to use such water to a different entity that needs the water. This is a sort of indirect trading. In an emergency such as during a drought, water users consult with each other in good faith and reach a consensus on the reallocation of water resources. The following section introduces two historical cases of water trading as stated above.

• *Bansui kabu* trading [Note 4] in Sado

The order of water intake had become a right called *bansui kabu* [Note 5] for rotative irrigation during a drought. This right is a type of customary water right with respect to the amount of water and the order of water intake.

At that time, because the area of arable land of each farmhouse was uniform, the number of *bansui kabu* shares that were set was the same as the number of farmhouses. With subsequent progress in land development for cultivation, farmhouses engaging in different types of agricultural work appeared, the number of farmhouses increased, and a gap arose in the amount of water that farmers requested. Consequently, *bansui kabu* shares started to be divided for selling. The gap in the area per share was expanded from approximately 2 – 3 *tan* (0.49 – 0.74 acres) to 1 *cho* 2 *tan* (2.94 acres). There were also cases in which water was distributed across the borders of villages.

Subsequently, in the Meiji era, the supply of farmlands and *bansui kabu* shares increased due to a decline in the number of large landowners. While farmers who had *bansui kabu* shares obtained more and more farmlands and became wealthy, other farmers who were poor had to sell their *bansui kabu* shares. If they became insolvent, they tried to keep some *bansui kabu* shares for the limited expanse of farmland that remained. Accordingly, farmers who held only *bansui kabu* shares were considered as special farmers who were in the final stages of insolvency. At the same time, when they became tenant farmers after they became insolvent, retaining water rights contributed to maintaining their status within a village as well as to the stability of farming rights.

The *bansui kabu* shares were priced based on the full cost of the water, including not only all water use expenses that represented water-related obligations such as maintenance and management expenses and facility usage fees, but also opportunity cost, external economic cost and external environmental cost.

• *Jinushi sui* trading [Note 6] in Miki, Kagawa Prefecture

Jinushi sui (water use rights vested in landowners) is a type of customary water right seen in some areas of Shimotakaoka and Ido, Kita-gun, Kagawa Prefecture. These rights to use a certain amount of water were completely separate from the ownership of land and had become a type of real right. Some experts observe that in granting water rights in the feudal period, priority was given to powerful persons such as those who had old paddy fields with high productivity, village leaders and landowners in order to ensure the collection of rice paid as rent (land tax in kind). Because of this custom, *jinushi sui* is regarded as having mortgage value or value for tenant rights, rather than monetary value. In this respect, the nature of *jinushi sui* is different from that of *bansui kabu*.

The trading price of *jinushi sui* was determined between the concerned parties. Approximately, 1 *rin* (1 centiliter) of water was equivalent to about 2 *to* (36.08 liters) of rice. During the post-war period when commodity prices soared, the price for 1 *rin* of water sharply increased to about ¥2,000. In 1935, the water for about 990 m^2 in the *sanse-sui* trading system (water trading system for 330 m^2 as a unit) was traded at prices between ¥400 and ¥500. Around 1948, when farmland reform took place, the successful bid price for 1 *rin* of water was between ¥650 and ¥1,250. In another case in 1948, 5-*se-sui* water (water for 500 m^2) was traded at a market price of ¥10,000.

In addition to *jinushi sui*, another customary water right in Kagawa is known as *mizu buni*, which refers to water quota decided according to the area of farmland and the crop yield. As such, *mizu buni* was derived from the ownership of land. This water right is considered different from water rights in other areas that have the strong nature of collective ownership by a community. A right holder could transfer unused water to other parties, or freely distribute such water to lands owned by the same landowner but located in different places to adjust for shortage or excess.

As a system that supported *jinushi sui*, “a water source register,” “a relative unit of water that flowed into the subject area during 12 hours (one shift) and changed daily,” “how to determine the flow unit,” “water distribution routes,” “a charging method of water use fees” and “pro rata fees in proportion to the quotas (¥200 per 1 *rin*)” are known. In the past, 3 *rin* of water was regarded as suitable for 1 *tan* of paddy fields. This method of calculation was changed to allocation based on the area of paddy fields after the development of the Kagawa water channel.

• Trading of water rights in modern times

In modern times, water rights in Japan are transferred either permanently or in an emergency such as during a drought. The former case, which is known as the transfer of water rights, is based on the assertion of the Ministry of Land, Infrastructure, Transport and Tourism that regards water rights as public rights. Once a water right for unused water is returned to a river administrator, such water is re-distributed to another entity who needs the water. The latter case is known as “emergency water supply.” During a drought, agricultural water and water for generating power are used as drinking water through consultation between concerned parties.[30, 31]

A typical example of the transfer of water rights is the transfer of water rights from those for industrial water or agricultural water to those for drinking water. For example, in the case of the transfer of water within the category of urban water such as from industrial water to drinking water, if such transfer involves a river system that is designated in the Water Resources Development Basic Plan, the plan must be modified.[35, 44] In addition, because such transfer necessitates a change in the policies and regulations for the management of facilities such as dams, the subsidies from competent authorities (the Ministry of Land, Infrastructure, Transport and Tourism, the Ministry of Health, Labour and Welfare, the Ministry of Economy, Trade and Industry, or the Ministry of Agriculture, Forestry and Fisheries), a prefectural government, the Japan Water Agency and the Ministry of Economy, Trade and Industry must be returned. Instead, subsidies will be provided from the Ministry of Health, Labour and Welfare.[47]

The transfer of rights for water from agricultural water involves more complicated procedures than the transfer from industrial water to drinking water.[44] A different use format is applied for agricultural water every five days. Therefore, in order to constantly secure a fixed amount of water as a source for tap water, another source becomes necessary to maintain the water level. Furthermore, because agricultural water is a water source only during irrigation periods, a water source must be separately provided for non-irrigation periods. In addition, there is a possibility that a water right might not be granted unless multiple projects (national land improvement projects, water supply business, and end-user water supply business) are implemented in parallel.

An advantage of using agricultural water is that there are many cases in which customary water rights are held for the natural water flow of a river. Accordingly, a larger amount of water can be secured as compared to the amount of water that can be secured under dam development water rights. Another identified advantage is that because the rights to use agricultural water are in many cases for water sources that have already been developed, water rights can be obtained more quickly.

Nevertheless, in areas where water demand is declining not only for industrial water but also for drinking water, there are cases where even if a user of industrial water wants to transfer its right, no other users want to accept the right, resulting in an unsuccessful transfer of water rights.[20]

In order to obtain water rights, it is necessary to pay for the costs of the construction, operation and maintenance of infrastructure such as water intake sluices and dams as appropriate for each water right. For users facing a declining water demand, greater costs could worsen their financial conditions.

As such, the transfer of water rights that functioned as a means of adjusting a gap in water demand between different use purposes in the past might no longer function in the same way as in the past in a society with a declining population where the demand for most everything is declining.

(2) Comparison of water trading between Japan and other countries

Table 3 compares water trading in Japan with that in other countries. While Australia and Chile have adopted market-based water trading systems, water rights are assigned for a long time or permanently in Japan and California where water rights themselves are not traded except in cases where there is obviously no longer a water demand.

While the trading of water rights themselves is permitted in Australia and Chile, the actual number of cases of selling and buying water rights is limited. In most cases, the transfer of water rights is temporary. Nevertheless, because Chile and Australia have water trading schemes, the trading of water rights is possible every year. In California, a drought water bank is set up during a drought to adjust water allocation on a fee basis. Only Japan uses a scheme that relies on the good faith of water users even during droughts. Accordingly, there is flexibility in Japan to consider the adjustment of water allocation for a limited period and on a fee basis.

4 Technology of Marine Water Transportation

To export water, a means of water transportation is necessary. Representative technologies of water transportation

Table 4. Comparison of water trading in four countries

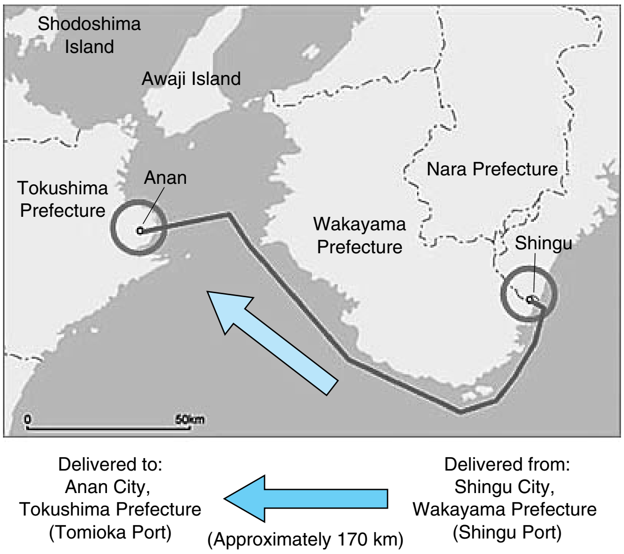
	Permanent water trading	Temporary water trading(US)
Japan	• Permanent trading is known as “transfer of water rights” • Indirect relative trading with a river administrator acting as an intermediary • The time at which a former water user generates unused water must correspond to the time at which the candidate transferee requires water	• Temporary trading is known as “emergency water supply” • During a drought, the amount of water use is changed upon consultation among water users
California	• After five or more continuous years of water non-use, water rights are abandoned or revert to the California Department of Water Resources	• Only during a drought, a drought water bank is set up to help transfer unused water saved by an existing water right holder to a person who requires water for a limited period and on a fee basis
Australia	• Water rights themselves can be sold and purchased (permanent water trading) • The amount of permanently traded water accounts for less than 1 percent of all amounts under water rights in the State of New South Wales	• Mostly, “temporary water trading” in which the usable water amount is traded for a limited period of one year is applied • The amount of temporarily traded water accounts for about 10 percent of all amounts under water rights
Chile	• The selling/purchasing of water rights is regarded as permanent trading • In terms of water amount, there are many cases of transfer from small farmers to large farmers; in terms of number of transfer cases, there are a large number of cases in which agricultural water is transferred to drinking water	• The leasing of water rights is regarded as temporary trading • Water rights are leased by determining the unit price per cubic meter for a limited period

include using natural river flow and constructing pipelines to carry water. However, these methods are economically unfeasible for moving water between different islands (such as from Hokkaido to Kyushu) within Japan or for transporting water overseas.

Commonly used methods of water transportation across oceans include a method in which water is loaded in a liquid cargo ship such as a tanker (Figure 14), a method in which water is loaded as ballast water of a large tanker or a freighter and a ballast water purification device is used to maintain water quality[74] (Figure 15), a method that uses water bags (Figure 17), a method that uses a barge and a tugboat (Figure 18) and a method in which a flexitank (flexible tank) is fitted inside a container (Figure 19).

A typical example of water transportation by a liquid cargo ship is the case of water transportation during the 2009 drought in Tokushima. The Tokushima prefectural government paid several million yen each time for a ship to transport 1,000 m^3 of water per day from the

Figure 16. Sea route used for a water transportation test between Shingu and Anan Cities

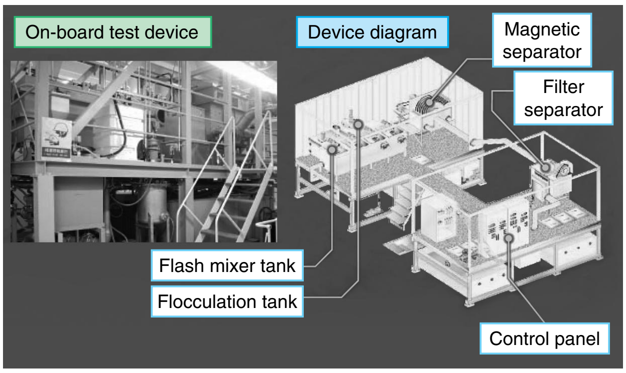


Source: Website of Monohakobi Technology Institute (MTI) (former NYK Logistics Technology Institute).
http://www.monohakobi.com/ja/topics/special/water_bag/index.html

Figure 14. Marine water transportation by a small liquid cargo transportation ship

Source: Tokushima Shimbun, June 24, 2009 (provided by Tokushima Shimbun).

Figure 15. Ballast water purification



Source: Website of Hitachi Plant Technologies, Ltd. http://www.hitachi-pt.co.jp/products/es/ballast/pdf/ballast_catalog.pdf (in Japanese)
http://www.hitachi-pt.com/products/es/ballast/index.html (in English)

Figure 17. Water bag used for water transportation

Source: Website of Monohakobi Technology Institute (MTI).
http://www.monohakobi.com/ja/research/water_bag/index.html

Figure 18. Water loaded on a barge towed by a tugboat

Source: Website of the Nagasaki Prefectural Government.
http://www.doboku.pref.nagasaki.jp/~ishiki/kassuihigai02.html

Figure 19. Overview of flexitank (flexible tank)

Source: Website of Uni-K Co. Ltd. http://www.uni-k.co.jp/

Yoshinogawa-hokugan industrial water supply that is taken from the Yoshino River system for which a 50-percent restriction on water intake was imposed to the Anan industrial water supply in the basin of the Naka River for which a 60-percent restriction on water intake was imposed. [Note 7]

The method in which fresh water is transported as ballast water of a freighter for transporting cargo or a tanker for transporting oil and LNG is already technically feasible because type approval has been granted to a ballast water purification device that is most important for the transportation of fresh water. The Ministry of Land, Infrastructure, Transport and Tourism is now studying a project of transporting fresh water as ballast water to other countries. The ministry plans to conduct a feasibility study from fiscal 2010 to fiscal 2011. [Note 8]

Water bags have already been used for commercial deliveries of fresh water from Turkey to Cyprus. Recently, in March 2007, a sea trial was conducted by the Japan Water Agency and the Monohakobi Technology Institute (MTI) to transport water by using water bags for 170 km across the sea from Shingu Port to Tomioka Port, Anan city. [Note 9] While this trial was successful, the use of water bags for water transportation as a business is now suspended because there are not many areas in Japan where water transportation is required throughout the year.

During the 1994 drought, Sakinaga Kaiun (shipping company) used a tugboat and barge in Sasebo to transport water. A tugboat and barge were also used during a drought in Nagasaki to deliver surface river water from the Shimabara Peninsula to Nagasaki, which was used as raw water for a purification plant. The method of using a tugboat and barge can be applied for a maximum distance approximately equal to that from Japan to China.

Finally, the technology of transporting liquids by fitting a water-impermeable liner inside a 20-foot container, which is called a flexitank (flexible tank), is also available. This technology enables easy transportation of bulk water in a container. While verification tests are now being conducted to transport fresh water in flexitanks, this technology has not yet been used for the business of transporting liquids other than edible oil, etc.

As explained above, water has already been transported within Japan by using a liquid cargo ship, a water bag and a barge. However, attention must be paid to the fact that such water transportation represents emergency measures primarily during droughts and that it is separately handled by a private sector company and a local government in response to a specific emergency. Accordingly, a feasibility study of water transportation as an everyday business has not yet been fully conducted.

5 Marine Water Transportation in Other Countries

In this section, we look at the current state of marine water transportation in other countries, in particular, countries that already have a history of water transportation or where studies are being made, namely, Turkey, the United States (Alaska) and Canada.

(1) Turkey

Turkey, while already exporting water to Cyprus and Israel, is also looking into exports to Libya and Syria. As its source, Turkey draws on the Manavgat River. The country has constructed facilities capable of exporting 130 million tons of water annually (Figure 20).

Turkey's transportation of water to Cyprus began when US troops were stationed there as part of "Operation Desert Storm." Between 1998 and 2002, the Nordic Water Supply Company transported 7 million m^3 of water every year using 35,000-ton water bags.11 The Nordic Water Supply Company has since been liquidated, and water is now transported using an aged tanker. [Note 10]

In May 2004, annual exports of 50 million tons of water from Turkey to Israel started. These exports, which will continue for 20 years, involve a distance of 525 km from the Manavgat purification plant (located in southern Turkey) on the Mediterranean coast to Ashkelon in Israel, with water being divided into 65 shipments each year.[13, 14] Israel constructed a 13-km pipeline from the port of Ashkelon to distribute the water within the country.[13, 14] There are plans to extend the pipeline to carry water to Jordan and Palestine.[13, 14] Because Turkey is a large Islamic country and also a member of the North Atlantic Treaty Organization (NATO), there are major security advantages for Israel in establishing a long-term, stable relationship with Turkey. Therefore, even though Israel has its own desalination plants with which it can produce water at a cost of $\$0.6/m^3$, it continues to import water from Turkey at a relatively expensive $\$0.8/m^3$.

In addition, Turkey is negotiating with Libya to provide 100 million m^3 of water annually. Although Libya has built its own desalination plants, the Libyan water authorities are considering imports of water from Turkey to supplement the output of the plants. Again, although Libya can desalinate seawater at a cost of $0.5/m^3$, the cost of water imported from Turkey is estimated to be $0.8/m^3$.[1, 2]

Thus, the export of water from Turkey is not simply based on an economic issue in terms of cost, but is also closely related to the diversification of water resources and international politics.

(2) United States (Alaska)

The Alaskan state government was the world's first government to recognize that in the 21st century, its abundant water resources could be exported commercially.[11]

Within Alaska, water shipments and exports are centered on the City of Sitka (Figure 21). Although Sitka owes its prosperity to the pulp industry, the closing of the pulp mill of Alaska Pulp Corporation in the mid-1990s, which consumed 500,000 gallons of water daily, led to the availability of large quantities of unused water.[16] In the past, a Canadian firm, Global H20 Resources, paid the city each year to hold an option on this unused water.

In December of 2004, Sitka signed a contract with Quest Imports International LLC, a beverage distributor, to sell 40 million gallons of water for 1 cent per gallon.[16] This contract provides the city's general fund with $400,000 in revenue. Even if this amount of water were to be removed, it would only be akin to cutting off a small stream feeding into a large river.[16] Sitka holds two water certificates from the state, each allowing the city to export 12.5 million gallons of water per day.[16] However, because of reasons such as that regulations for shipping bulk water often do not exist, it is difficult to ship this water to the East Asian market.[16] Even in Europe, bureaucracy is also a problem. Despite regulations on bottled water being in place, similar regulations have not yet been established for bulk water. Therefore, it is not known what requirements the European governments might impose.[16] In addition, the export of water from Sitka to the West coast of the United States faces severe cost competition from desalination plants.[12] Transport of water to American ports is regulated under the Jones Act, which requires American ships and crews, and is much more expensive than it would be between Sitka and foreign ports where the Jones Act does not apply.[16]

Figure 20. Exports of bulk water from Turkey

Figure 21. Website introducing water export by Sitka, Alaska

Source: http://www.sawmillcove.com/water.html

A project of exporting water from Sitka was also proposed in 2009. S2C Global Systems, Inc. formulated a plan to buy unused water from Sitka and to send such water to nations bordering the Arabian Sea through Tiger Maritime and Management Ltd., and signed contracts with concerned parties.[1] Unfortunately, however, just like many other similar ideas, this plan has yet to be actually realized. At the beginning of 2010, S2C Global Systems, Inc. announced that it would export water from Sitka to India. The water will be bottled in India, and then sold in the Middle East.[3, 4]

In this way, Alaska and the City of Sitka have been actively promoting the export of their water resources. However, talks have not proceeded because of the issues of cost and the lack of regulations governing the export of bulk water.

(3) Canada

Like Alaska, Canada has abundant fresh water resources, and has made several attempts to export water. Specifically, companies including Western Canada Water, Snow Cap Water, White Bear Water and Multinational Resources have all attempted to export water from British Columbia. Notable is a Texas company that intended to export an amount of water equivalent to Vancouver's annual consumption to California by using 12 to 16 supertankers.[11] Currently, however, all of these contracts have been annulled by the Canadian government (Table 5).

Canada and the United States are members of the North American Free Trade Agreement (NAFTA). As such, once the export of bulk water takes place, it will not be regarded as being a natural resource but, rather, it will be handled as a specific commodity, which will be included in the items covered by free trade. The Canadian government is concerned that it could become impossible for the government to oversee the utilization of the country's water resources.[14]

On the other hand, some experts point out that in Quebec, Manitoba and Newfoundland, exporting water to the United States would greatly benefit the economies of these provinces and would lead to economic development.[13, 14] For example, by selling its unused water at a cost of $0.65/m^3$, which is equal to the currently lowest cost of desalinated seawater, Quebec could bring in annual revenues of $65 billion.[10] It is also reported that the Canadian oil industry is interested because it could draw on its expertise in liquid transportation for the transport of fresh water and that the appearance of a water commodity market could be expected.[14]

Within the Canadian government, the Department of Foreign Affairs and International Trade (DFAIT) considers that "even if water is traded as a commodity in the same way as marine products, the Canadian government still has the right to control the trade."[13, 14] As such, discussions and negotiations are still underway between provincial governments that want to stimulate their local economies through water exports and the federal government that gives priority to the control of water resources.

At the same time, there are already cases in which unused water is transported from Canada to the United States, such as from British Columbia to Point Roberts in Washington, and from Coutts in Alberta to Sweetgrass in Montana. In these cases, however, it is understood that water was transported as part of the Friendship Agreement, rather than as water exports.[10]

As described above, the situation in Canada can be characterized by the provincial governments and private sector companies looking to fresh water exports to revitalize local economies. However, from the perspective of natural resource security, the federal government currently prohibits such exports.

IV Discussion and Analysis

When we consider the issues related to the transportation of unused water, we find that the problem can be broken down into three major issues. The first issue is how to address water shortages during a drought in a region in Japan; the second is competition with seawater desalination plants; and the third relates to the security of the exporting and importing countries. These three issues are discussed in the following sections.

Table 5. Attempts to export water from Canada to the US

Year	Province	Outline
1998	Ontario	Toronto and Nova Corp obtained permission to export water from Lake Superior for a period of five years
1998	British Columbia	A Californian company, Sun Belt Water lodged an appeal with the Canadian government based on Chapter 11 of NAFTA. This was in response to the annulment of a contract signed in 1991 between Sun Belt Water and the government of British Columbia to export billions of gallons of water. Sun Belt Water filed a $10.5 billion claim against Canada
2001	Ottawa	The International Boundary Waters Treaty was added into Canadian Federal Law, reflecting the agreement between Canada and the United States not to divert water from borderland rivers that arise in Canada but which flow through both countries
2001	Newfoundland	Under pressure from the Canadian federal government, the Newfoundland government rejected the McCurdy Group's proposal to export 60 billion liters (13 billion gallons) of water annually from Gisborne Lake

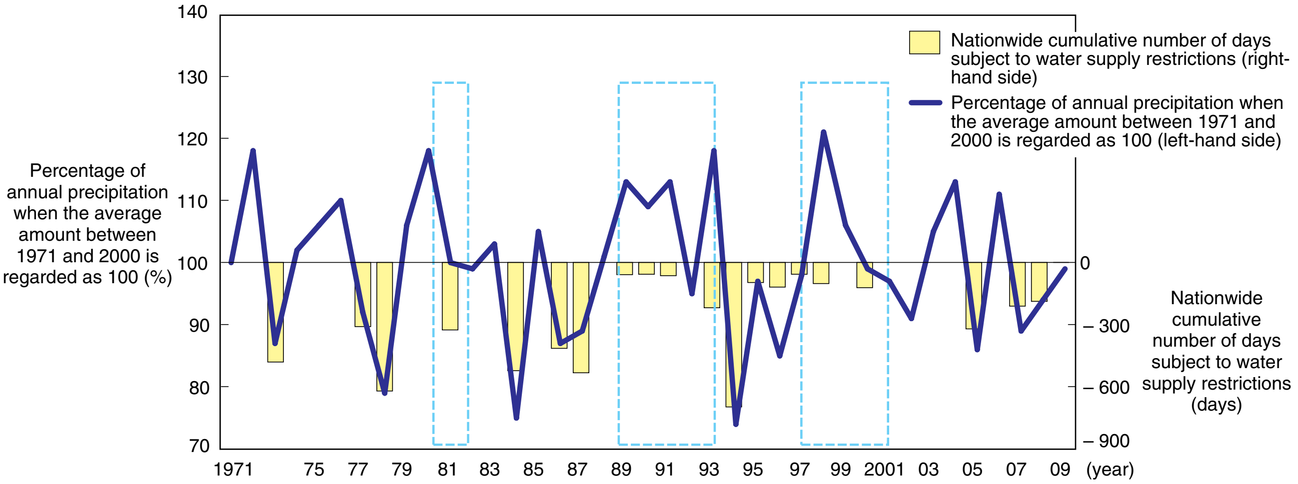
Source: Compiled by the author based on "Paul Michael Wihbey (2004a), Canadian Water: Vital Natural Resource and Tradable Commodity, The Global Politics of Energy, January, 14 - 18."

1 Japan's handling of water shortages during a drought

In considering the export of unused water from Japan, we have to assume that there would be periods of water shortages when there would be no unused water, casting doubt on the stability of water exports. Actually, in those years when certain areas experience severe water shortages, rainfall levels tend to be below normal across the country (Figure 22). On the other hand, as indicated by the dotted squares in Figure 22, there are years when rainfall exceeds the average for the country as a whole, yet certain areas experience water shortages.

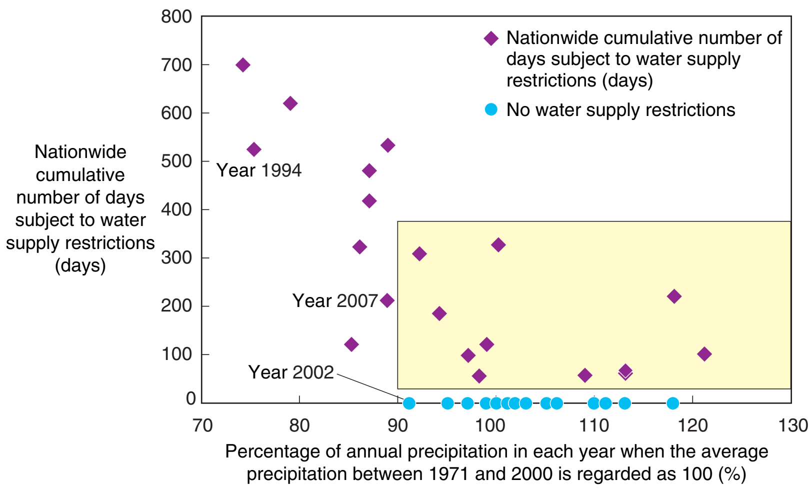
Figure 23 compares changes in annual rainfall and the occurrence of water shortages. When we look at Figure 23, we can see that even in those years in which the annual rainfall was around 90 percent of average, no water shortages occurred. On the other hand, there were years when water shortages occurred despite the rainfall being 120 percent of average. Thus, a water shortage is not merely the result of the country's overall rainfall being below average because local shortages can occur even in years when the overall rainfall is actually above average. From this perspective, therefore, for the shaded portion in Figure 23, water supply restrictions could possibly be eased through the transportation of water within the country. Actually, in 2007, while Shikoku experienced a water shortage, rainfall in the southern part of Kyushu and the eastern part of Tohoku was relatively high (Figure 24).

Figure 22. Changes in annual precipitation and number of days subject to water supply restrictions



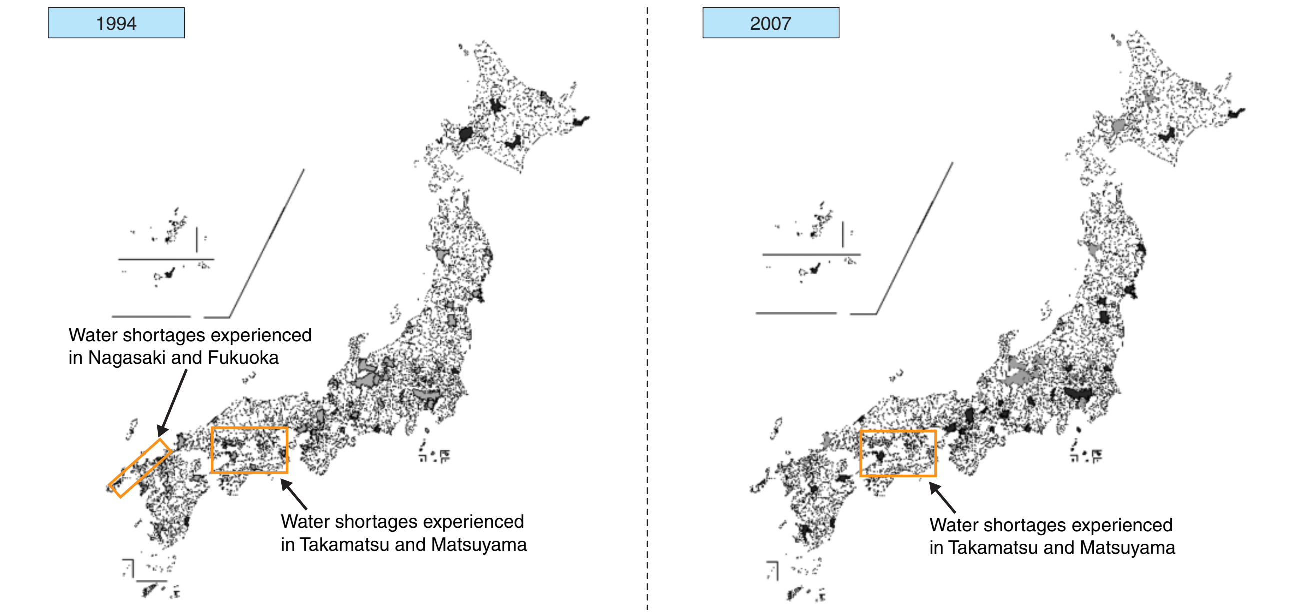
Source: Calculation of the percentage of annual precipitation is based on the website of the Japan Meteorological Agency; calculation of the nationwide cumulative number of days subject to water supply restrictions is based on *Heisei 21 nen ban nihon no mizu shigen—sogo mizu shigen kanri no suishin* (Water Resources in Japan 2009—Promoting Comprehensive Water Resource Management) edited by the Water Resources Department, Land and Water Bureau, Ministry of Land, Infrastructure, Transport and Tourism (AIGER Co., Ltd., 2009).

Figure 23. Water supply restrictions that could be eased by the transportation of water within the country



Source: Calculation of the percentage of annual precipitation is based on the website of the Japan Meteorological Agency; calculation of the nationwide cumulative number of days subject to water supply restrictions is based on *Heisei 21 nen ban nihon no mizu shigen—sogo mizu shigen kanri no suishin* (Water Resources in Japan 2009—Promoting Comprehensive Water Resource Management) edited by the Water Resources Department, Land and Water Bureau, Ministry of Land, Infrastructure, Transport and Tourism (AIGER Co., Ltd., 2009).

Figure 24. Distribution of nationwide precipitation in drought years



Note: The shaded portions in the above figure indicate whether the precipitation at each observation point in 1994 or 2007 is larger (heavily shaded) or smaller (lightly shaded) by using the following precipitation as the base: "precipitation in 2002 when even though the annual precipitation was less than the average in the previous ten years, no water shortages occurred" or "the average precipitation" whichever is smaller. While there is not necessarily a correlation between small or large precipitation and the occurrence of a drought, when certain areas experience water shortages, other areas experience relatively large precipitation.
Source: Compiled based on *Heisei 21 nen ban nihon no mizu shigen—sogo mizu shigen kanri no suishin* (Water Resources in Japan 2009—Promoting Comprehensive Water Resource Management) edited by the Water Resources Department, Land and Water Bureau, Ministry of Land, Infrastructure, Transport and Tourism (AIGER Co., Ltd., 2009).

At the same time, however, Figure 23 also suggests that in those years when the rainfall is less than 90 percent of average, there is inevitably a water shortage somewhere in Japan. Actually, in 1994, when the rainfall was less than 80 percent of average, most areas of Japan had rainfall that was less than that in 2002, when although the annual rainfall was less than average, no water shortages occurred. Even in this year, however, Hokkaido experienced relatively high precipitation.

While it is not clear whether climate change might cause frequent water shortages, building new water storage facilities to guard against shortages in an era of a declining population incurs huge expenses. As Japanese society continues to age and medical expenses increase, there is a limit on the public funds that are available for water resource management and flood control. To make the most effective use of these limited funds, rather than developing new water sources, a practical means of transporting water available under various categories by sea should be introduced so that in the event of a water shortage, water can be brought from locations where there are no shortages. This method would enable domestic water demand to be satisfied for relatively little investment.

2 Competition with seawater desalination plants

For those countries that are plagued with water shortages, there is actually no need to import unused water from Japan. Many countries are introducing their own seawater desalination plants where wastewater is actively recycled, with Singapore being a typical example. Whether a country chooses to use such facilities or to import water depends on a combination of factors such as "level of water demand," "cost differential," "political opposition to depending on another country for water, which is an essential resource for life" and "the ecological damage that a concentrated saltwater discharge can cause."

There are, however, limits on the introduction of seawater desalination. Desalination techniques include "evaporation," "reverse osmosis," "electric dialysis," "LNG regasification" and "pervaporation." Because evaporation, LNG regasification and pervaporation require either a means of heating or cooling, a thermal power plant or LNG facility must be located in the vicinity. Moreover, because reverse osmosis and electric dialysis consume large amounts of electricity, a reliable source of heat and/or power is necessary. Furthermore, in those areas where geographical features are such that the outflow of concentrated saltwater cannot dissipate easily, recent years have seen the ecological impact caused by concentrated or high-temperature saltwater.[15]

In Japan, although the islands of Okinawa Prefecture would seem to be obvious candidates for receiving shipments of fresh water, large-scale desalination plants have already been set up there. So, is there any need for water shipments to this part of the country?

To provide an answer to this question, we examined the possibility of transporting water to these areas by looking at the operating state of the Okinawa Prefectural Enterprise Bureau's seawater desalination plant in Chatan, Okinawa.

Even though Okinawa Prefecture has set up a desalination plant with a daily capacity of 40,000 tons, most of the sources used for drinking water are dam reservoirs, streams and groundwater, with only a small proportion from the desalination plant (Figure 25).

Consequently, the operating rate of the desalination plant varies greatly between slightly more than 10 percent to slightly less than 45 percent (Figure 26).

These low operating rates have a direct influence on the unit cost of producing fresh water at the desalination plant, which varies between ¥150/m^3 and ¥500/m^3 (Figure 27).

The published unit manufacturing cost of a desalination plant usually assumes an operating rate of 100 percent. It is appropriate to construct desalination plants in regions where they will be used to full capacity to satisfy the demand for fresh water such as in the Middle East. However, in regions where rivers and dam reservoirs are also available as water sources and desalination plants are used to compensate for emergencies such as droughts, it is likely that the construction of a desalination plant could become a costly water source development project.

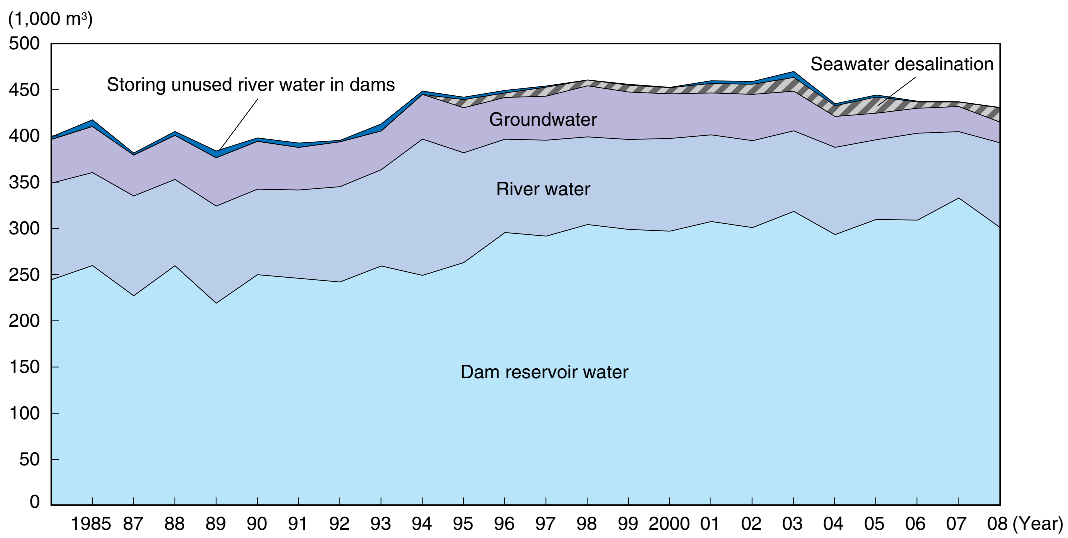
Because seawater desalination plants are generally intended to be used to offset water shortages, these plants are expected to be used increasingly when water intake from rivers and reservoirs that are fed by rainwater runoff is not possible. Actually, when we look at changes in the total amount of water obtained from various water sources and compare such changes with changes in the amount of water used that is derived from seawater desalination plants (desalinated seawater) and river water, groundwater and water in reservoirs (water derived from rainwater), we find that in the years 2000, 2004 and 2006, when the total amount of water obtained from various sources was less than that in the preceding year, the amount of desalinated water used was also reduced. In these three years, rainfall was relatively abundant. On the other hand, in 2003 and 2008, when the annual rainfall was lower than average, the amount of water supplied by the desalination plants increased relative to that of the preceding year (Figure 28).

Thus, in countries like Japan where drinking water is sourced from both surface water and desalination plants, desalination plants, in which economic benefits are only realized when running constantly and at full capacity, are actually used as backups to guard against water shortages.

Of course, we would have to fully investigate the possibility of utilizing unused water in other areas of Japan. Nevertheless, in introducing desalination plants, the plant capacity should be limited to that with which the plant can run constantly at full capacity, rather than pursuing the maximum capacity that would be needed during a period of water shortage. If a water shortage occurs, the water supply can be economically assured by combining shipments of water with desalination. In this case, water shipments are thought of as being a form of insurance.

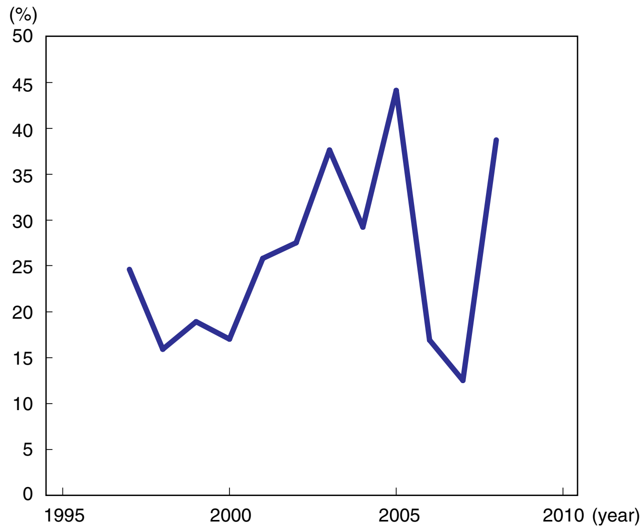
Differences in the costs of desalination and transportation depend on location. In the case of water shipped from Turkey, for example, the difference in costs is between \$0.1/m^3 and \$0.2/m^3. In the United States, the cost of desalination is between \$0.8 and \$1.5. At these levels, it would be possible to transport water from areas where there is an abundant amount of unused water and a large water distribution cost is not required at a cost that is comparable to the production cost of a seawater desalination plant (Table 6).

Figure 25. Average daily amount of water intake in Okinawa by fiscal year and water source



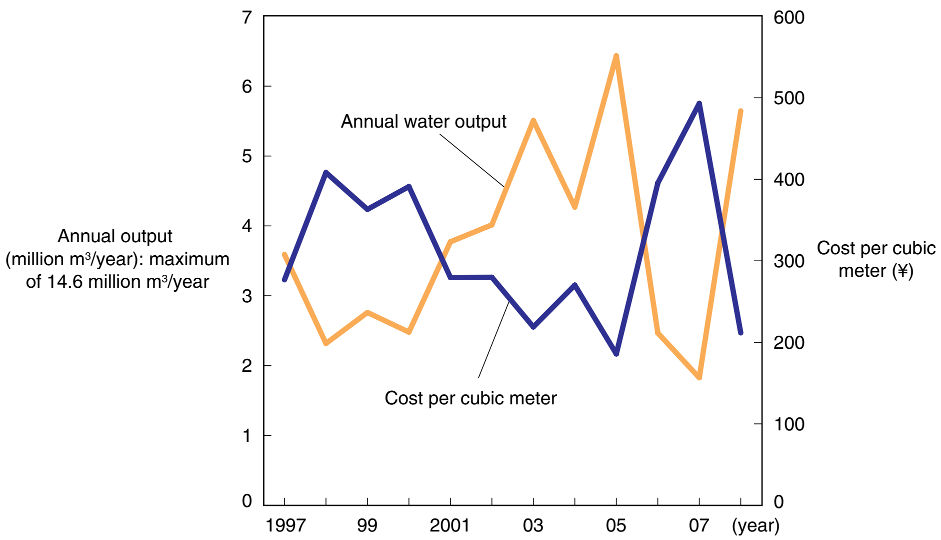
Source: Compiled based on materials published by the Okinawa Prefectural Enterprise Bureau.

Figure 26. Operating rate of seawater desalination plant in Chatan, Okinawa



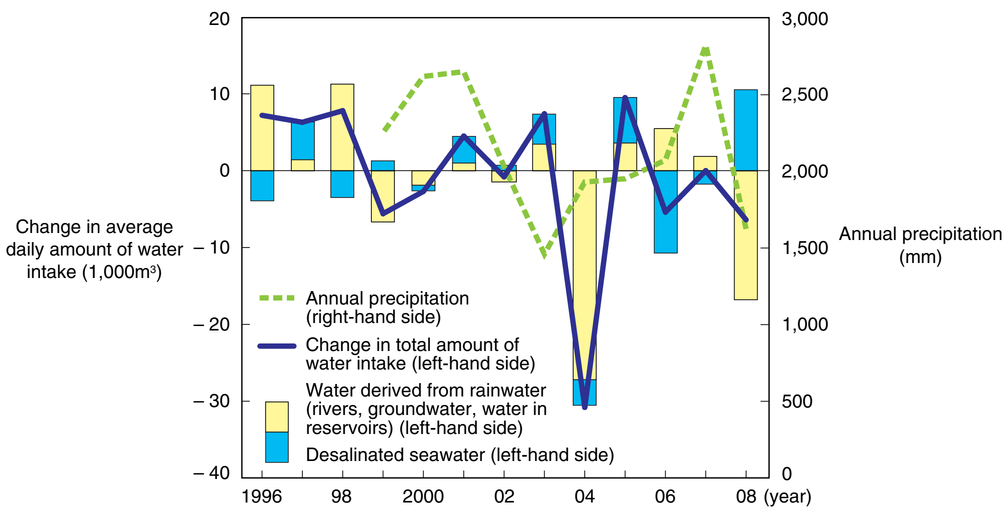
Source: Compiled based on materials published by the Okinawa Prefectural Enterprise Bureau.

Figure 27. Annual water output of seawater desalination plant in Okinawa and cost per cubic meter



Source: Compiled based on materials published by the Okinawa Prefectural Enterprise Bureau.

Figure 28. Changes in total amount of water intake by water source and year in Okinawa



Source: Compiled based on materials published by the Okinawa Prefectural Enterprise Bureau and the Japan Meteorological Agency.

Table 6. Market prices of water

Region	Price level (US$/m³)	Notes
Cyprus	0.55	Transportation cost from Turkish mainland
Israel	0.55 – 0.60	Estimated cost of tanker transport from Turkey
Canada	0.40	Usual cost of drinking water including distribution cost
USA	0.16 – 0.65	Usual cost of drinking water
	0.80 – 1.50	Cost of drinking water supplied from seawater desalination plant
Germany	1.80	Usual cost of drinking water
Saudi Arabia	4.00	Estimated cost of seawater desalination
Newfoundland	1.35 – 3.00	Cost of tanker transportation to Florida, Texas and Caribbean nations

Note: $1m^3$ = 1,000 liters = 265 US gallons.
Source: James Feehan, "Report of the Ministerial Committee Examining the Export of Bulk Water," Government of Newfoundland and Labrador, 2001.

3 National and Resource Security Issues

When we look at the case in Japan as well as those in other countries, we realize that in order to export water, we must consider not only whether water transportation is technically possible (technical aspects) and economically viable (economic aspects), but also the following perspectives: the conservation of water resources on the side of an exporting country and the issue of security that might be jeopardized by relying on another country for vital water resources on the side of an importing country (resource security). Moreover, the issue of national security is also involved because ensuring resource security can contribute to regional stability.

The issue of resource security can be discussed from two perspectives: the first concerns the conservation of fresh water resources; the second relates to stabilizing the import of other mineral and energy resources by utilizing fresh water resources.

As is clear from the posture of the Canadian government, those countries that export fresh water give priority to the preservation of their fresh water resources and satisfying their domestic demand. In particular, those countries that depend on glaciers, groundwater and fossil water for their fresh water supplies must regard those resources as being finite, which requires the countries to strive to ensure sustainable exploitation of their resources. In this respect, Japan is blessed. Thanks to mountainous land surrounded by the sea, most of the water used in Japan originates from rainwater runoff. Furthermore, among the large amount of water stored in dams that were constructed for the purposes of water supply and flood control during the period of high economic growth, there will be unused water that could be utilized because of the declining population. As a result, the issues identified by environmental NGOs (non-governmental organizations) in other countries such as the drying-up of groundwater and changes in the fluvial environment need not be of much concern.

On the other hand, an importing country would want to avoid relying on a specific single country for fresh water, which is vital for the lives of its people. Especially, when fresh water is imported from a neighboring country in very large quantities, an exporting country would be able to exert some degree of control on an importing country. Because of such concern, a consensus would not be reached on the import of water within a country unless similar quantities of fresh water can be imported from multiple countries. In such case, the areas of discussion will necessarily go beyond resource security and extend to national security.

Israel currently purchases water transported from Turkey at high cost. The purpose behind this purchase is that Israel aims to ensure security in this region by strengthening its ties with Turkey, which is a large Islamic country and a NATO member. It is desirable that fresh water resources be skillfully used as a diplomatic card to strengthen regional security. However, if the card is played wrongly, there is the danger of the occurrence of a dispute. This is where the ability of politicians comes to bear.

As mentioned above, the export of fresh water involves some major political issues. Therefore, before any efforts by municipal governments or private sector companies, an agreement must first be reached between the national governments. Notably, as pointed out in the case of Alaska, currently, there is no international framework for the export of bulk water. Before such an international mechanism is in place, a bilateral agreement should first be used to specify the technical requirements regarding water quality and the method of transportation, as well as determining backup sources to draw on in the event of water shortages. In the future, it will be necessary to handle these matters under multilateral agreements or even at the World Trade Organization (WTO).

Despite such an international situation, resource security is not an issue in Japan. If the technical and economic issues can be solved, a municipal government or a private sector company can play a central role in transporting water. Nevertheless, because water transportation will be required primarily during periods of drought, considerable efforts will be necessary to develop a scheme that does not incur loss as a minimum condition, which is required by private sector companies.

V Concluding Remarks

By 2040, the amount of unused water resources in Japan is expected to reach around 10 billion m^3 per year.[22, 23, 24, 25] Even now, the amount of water being supplied for domestic and industrial use has been falling. Of course, it is necessary to make provisions to guard against risks such as droughts. However, if we fail to act to deal with unused water in normal years, the performance of water supply and sewage service businesses will deteriorate, which might lead to increased charges for water and sewage services. There might also be a danger of deterioration in the maintenance of water resource facilities such as dams and reservoirs.

For drinking and industrial water supply service companies, the options of returning their water rights to the authorities and downsizing their facilities are still available. Actually, we can already see cases of downsizing these facilities in response to a falling population and declining industries.[21] However, for the national and prefectural governments that manage dams and reservoirs, doing away with dams is difficult from the viewpoint of flood control. Moreover, for those companies providing industrial water, it is also difficult to easily downsize facilities in consideration of any chance of increased demand in the future.[20] Accordingly, by making efforts to generate profits from unused water by some means, it is necessary to address the issues of the management performance of water companies and to cover the costs for the operation, maintenance and improvement of flood control facilities such as dams.

There are many different strategies for utilizing unused water. For example, we could aim to attract industries that use large amounts of water such as the paper manufacturing industry to Japan. However, in Japan where domestic demand is shrinking due to a falling population, it is difficult to consider attracting industries that use large amounts of water as a realistic solution. Accordingly, as a second-best choice, the authors believe that there is no alternative to considering the shipping of unused water to those regions of Japan that are suffering from water shortages, and then to other countries that lack a sufficient supply of water.

To efficiently transport water, it would be necessary to establish a water rights system and a water trading system. Experts in favor of the establishment of such systems argue that a pricing mechanism based on full cost pricing should be introduced for water distribution to promote the efficient use of water, and at the same time, water rights should be re-allocated according to solvency through the water market.[17] On the other hand, opponents of this concept believe that "buying up and holding off selling water rights in the water market will lead to an increase in the price of water, enabling those holding the water rights to profit immensely,[48]" "water management that is not well thought-out such as the thinking that water can be transferred simply for a fee might result in abuses,[30, 31]" "during the periods of drought when water resources run short, water must be distributed with an eye to fairness, which is something that a free market mechanism is unable to assure; this could be one case of 'market failure'[58]," "it is impossible to prevent a stock shortfall in water resources in certain climate regions[59]" and "the use of perched groundwater should be restricted because it cannot be quickly replenished.[59]" Japan needs to establish a new water rights system and a new water trading system that take both of these views and opinions into account. For example, water rights [Note 11] that are traded in the world or were traded in the past in Japan are water rights themselves. However, water rights that will be traded in the future for the export of water are assumed to cover only those rights for currently unused portions among water rights that were already vested in existing right holders. At present, water rights are allocated in anticipation of the maximum amount of use by a right holder. However, such maximum amount of water is not used daily. The authors suggest the adoption of a system whereby the unused portions are made the object of trading so as to utilize water resources effectively. [Note 12]

In Australia and the Middle East, because there are currently insufficient water resources to support mining operations, the transportation of water is expected to supplement such insufficiency. Furthermore, in the future, fresh water resources shipped from Japan could also be used as fresh water to support the operation of plant-growing factories that are expected to be built in areas where there is little rainfall. Even if the export of water itself is not profitable, it could form the basis for bartering for mineral resources such as rare metals, oil, natural gas, coal and iron ore. In that way, Japan would be able to secure resources such as coal, iron ore and oil at advantageous terms. Furthermore, the cultivation of farm products using both fresh water exported from Japan and Japanese seeds and seedlings would enable the sales of high-quality Japanese farm products, which would result in increased income from licensing intellectual property rights and also increased profit from the sales of fresh water. By combining these possibilities, the overall profitability of a water export project could be increased, making the realization of water exports more likely.

To promote water trading and water transportation, it would also be necessary to develop financial products related to water trading such as futures trading and forward transactions. In addition, given that there would be a need for a system whereby exports could be halted when priority must be given to domestic water demand such as during a drought, rules must be established to enable the suspension of water transfer overseas or export. At the same time, an information system would be required to support these activities (Figure 29).

Moreover, as was identified in the case of Alaska, there is currently no international system for regulating the marine transportation of bulk water. In the future, the Japanese government needs to work with the governments of those countries that have already attempted to export their fresh water resources such as Turkey and the Sate of Alaska in the US in order to establish an international framework for overseeing the export of water.

In this paper, we have discussed the export of water as an effective means of utilizing unused water resources in Japan in order to resolve issues related to the large amounts of unused water that are expected to arise as a result of Japan's falling population. A worldwide ethical theme that is likely to emerge is that "water resources should not be made the object of an investment game." However, there will be a limit to the degree to which global water-related problems can be resolved by only grant aid programs. Assuming that the preservation of human life takes top priority, the introduction of capital and investment from the capital markets will help solve the problem of water shortages. At the same time, the distribution of water resources will have to be optimized in order to ensure sustainable economic growth.

Japan is faced with a falling population and, as a result, will see its economy shrink. Under such circumstances, how should Japan, which must import much of its food and energy, survive? The export of water resources could well be Japan's only remaining option.

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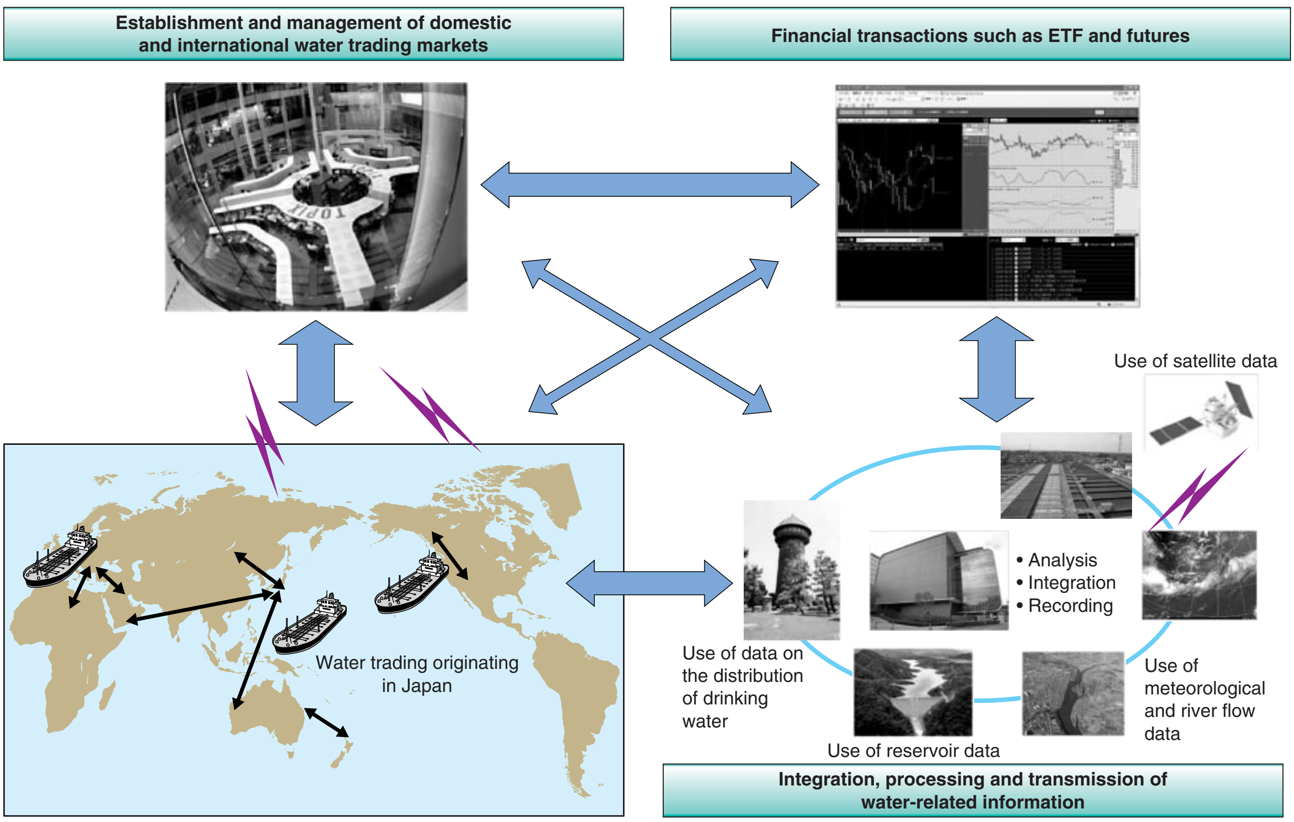
Figure 29. Water trading and water information system supporting water transportation



Note: ETF = exchange traded funds.

Notes:

1 Asahi Shimbun, morning edition, July 6, 2010.

2 Paragraph 2, Article 2 (Principles of River Management) of the River Law: The water of a river cannot be subject to any private right.

3 Article 34 (Transfer of Right):
1. Any rights obtained based on the permission stipulated in Articles 23 through 25 shall not be transferred without approval of a river administrator.
2. A person who succeeds to the right based on the approval stipulated in the preceding paragraph shall succeed to the status based on said permission that was given to the transferor.

4 Mikiko Sugiura (2005), "*Bansui kabu baibai no rekishishi nini miru 'mizu' torihiki no yoin* (Factors of "Water" Trading as Seen in the History of the Trading of *Bansui Kabu*)" *Mizushigen kankyo kenkyu*, 18, 1 – 14, Japanese Association for Water Resources and Environment.

5 "*Bansui*" refers to using a reduced amount of water rotatively during a drought when a normal amount of water cannot be used; Yutaro Senga (2001), "*Mizushigen no chiiki shigen / kokyozai tositeno seishitsu ni tsuite* (Nature of Water Resources as Community Resources and Public Property)," *Journal of the Japanese Society of Irrigation, Drainage and Reclamation Engineering*, 69(8), 843 – 847, The Japanese Society of Irrigation, Drainage and Rural Engineering.

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7 Tokushima Shimbun, June 24, 2009.

8 The Environmental News, April 5, 2010;
http://kankyomedia.jp/news/20100405_10326.html

9 http://www.monohakobi.com/ja/topics/special/water_bag/index.html

10 From an interview with MTI.

11 Japan's water rights are those for the use of river water, and are based on the River Law. Similar rights are stipulated in the Law on Specified Multipurpose Dams. These rights to use dams are those that enable the use of dams for the amount permitted under the vested right. These rights to use dams are identical to the rights to use facilities. The rights to use dams are given the nature of real rights under the Law on Specified Multipurpose Dams, which permits the transfer of such rights.

12 However, when water rights are affluent flow water rights, water intake is limited to the level where a river's normal flow can be maintained. Accordingly, it is impossible to take the unused amount of water, which equals the difference between the amount of water permitted under a water right and the amount of daily water intake.

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