

Country Position Paper

(Japan)

Dr. Shigetaka Taniyama

Vice-President of ICID

Japanese National Committee of ICID

July, 2002

Abstract

Movements of water use for agriculture in Asia which accounts for a half of global water use in all sectors and 70% of that for agriculture should be put with more significance in terms of the session theme of “The world vision for water, food and rural development in the year 2025.” Particularly, that of paddy field irrigation in the Asia monsoon region which has the largest irrigation area in the world and presently feeds more than 40% of the world population should be highlighted.

Countries in the Asia monsoon region including Japan are characterized by high precipitation and generally have steep topography and rivers as they are situated mostly in the Pacific Rim fold belt. To modify the problem and to prevent them from suffering water disasters such as flooding or collapsing landslides of steep slope, people have communally developed paddy fields and paddy irrigation systems as the best solution over the long histories. And consequently they have also established unique institutions and social customs, in which a large number of small-scale water users organize themselves into local groups to manage collectively water resources for paddy field irrigation.

It is indispensable to examine and discuss their situation and future projection with more appropriate consideration for the topographical, historical, cultural and social aspects as well as hydrological and technical ones. Therefore, the paper describes current situation and future projection of water resources and food of Japan in general and illustrates distinctive features of paddy field cultivation and irrigation in the humid Asia monsoon region. Then it poses some problems and questions about uniqueness of positive and negative externalities of irrigation in paddy farming region and also explains Japan's position with regard to agricultural water issues in terms of international economic arguments.

Contents

<i>Chapter 1</i>	<i>Water Resources and Food in Japan</i>	<i>1</i>
<i>Chapter 2</i>	<i>World Agriculture and the Potential of Paddy Fields</i>	<i>6</i>
<i>Chapter 3</i>	<i>Positive and Negative Externalities of Irrigation in Paddy Farming Region</i>	<i>14</i>
<i>Chapter 4</i>	<i>Japan's Position with Regard to Agricultural Water Issues</i>	<i>19</i>
<i>APPENDIX A</i>	<i>Elaborately Designed Agricultural Water Management Systems for Paddy Field Irrigation in Japan</i>	<i>36</i>

Chapter 1

Water Resources and Food in Japan

1.1 Precipitation

Japan is located in the Asia monsoon region, which has one of the highest precipitations in the world. Japan has an average for annual precipitation of 1,714mm, according to data gathered from 1,300 sites around the country by the National Land Agency from 1966-1995. Japan thus receives twice the world average for annual precipitation of about 970mm. However, the annual per capita precipitation is only 5,200m³/year-person, or about one fourth the world annual average of 23,000m³/year-person. Thus, Japan's precipitation is not really abundant compared with that of other countries.

1.2 Potential Water Resource

The amount of potential water resources of Japan is about 420 billion m³ for a normal year and about 280 billion m³ for a dry year.

Japan normally experiences heavy rains in the rainy season in June and July, and during typhoon season in August and September. Japan has a generally steep topography and relatively short rivers. Therefore, considerable portion of potential water resources cannot be used, and flows directly into the ocean. The amount of actual water resource differs from region to region depending on topography, geology and distribution of precipitation over time. Small islands and peninsulas, in particular, have greater per capita potential water resources due to their smaller populations, but they tend to suffer from severe drought because rainwater flows into the ocean instantly in these areas. It is therefore more difficult to develop water resources effectively in such areas.

In a dry year, the amount of potential water resource are approximately 66% those of a normal year, on average; less in Kyusyu and Okinawa, more in regions of with heavy snowfall, such as Tohoku and Hokuriku.

Precipitation data from 1956 to 1995 shows that the amount of potential water resources in dry years have declined in these years. For example, from 1956 to 1975, the amount of annual potential water resources of 335 billion m³ was equivalent to those of the driest year per decade. By contrast the same amount of potential resources was seen

every four years from 1976 to 1995. This shows a vulnerability of water shortage in these years.

1.3 Current state of Water Use

A total of approximately 88.7 billion m³ of water was used in 1998, based on the amounts taken from reservoirs. A breakdown of the total water used shows that roughly 30.1 billion m³ was used in urban areas for domestic, commercial and industrial purposes, and about 58.6 billion m³ for agricultural use.

Domestic and commercial use of water has been on an upward trend since 1975, but has increased more slowly in recent years, declining slightly in 1998. The amount of water used in industry declined until 1986, due in part to the increased use of recycled water. Industrial usage later turned upward, but has declined since 1992. Total urban water use was nearly flat until the latter half of 1980's, and has increased slightly since 1987, with changes in lifestyle and the economic expansion of the period, but has been nearly flat again since 1993 affected by the economic recession.

Use of water in agriculture is nearly flat in recent years because reductions in the amount of land under rice cultivation have been offset by an increase in irrigation for other crops.

1.4 Agricultural Water Usage

Irrigation of rice paddies, which takes up the largest portion of agricultural water usage, dropped only slightly, in spite of decreased rice paddy acreage because of the increased water use per unit area in paddies and the decreased rate of water-reuse due to the shifting from plot-to-plot irrigation to irrigation and drainage with function-separated canals. Demand for water in rice paddies is seen from mid-April through September, with peaks during tillage before the seedlings are transplanted, and in the season after mid-summer drainage. The amount of water use during tillage in particular, has risen recently. There is a small demand for water during seasons other than the ones mentioned above, for secondary crop farming and crop rotation.

Irrigation for other types of crops is expected to continue to increase because the irrigable land is increasing and in many cases, agricultural chemicals and fertilizers are mixed with the water in these upland fields. The supply of water to green-house

particularly, has increased steadily in recent years, and their growing popularity has increased the demand for water in winter.

Water usage in livestock farming is expected to continue to increase because of the growth in the number of livestock.

Aquaculture is also growing, although it accounts for a small portion of all agricultural land. Water culture, which is a form of liquid culture, is the main form of liquid culture in terms total area.

Irrigation channels and water have traditionally served multi-functional roles in agriculture and rural areas, such as supplying water to wash agricultural products and machineries, fire protection and preservation of the rural environment. To maintain and promote the use of such functions, various approaches are being taken in the improvement of irrigation channels, including establishment of recreational areas, with tree and shrubs planted along irrigation channels.

1.5 Water Supply and Demand Outlook for 2010¹⁻²⁾

Based on anticipated changes in lifestyle and other factors, it is expected that, while demand for household tap water will continue to grow, the rate of growth will show a further slackening.

Looking at industrial water use, while demand is expected to be influenced by the development of new industries and other factors, water use efficiency is expected to be improved, which should lead to only slow growth of demand for fresh water use. It is also expected that the water recycling rate will continue to improve. These factors indicate that the amount of supplemental fresh water will increase only slightly.

Based on the above, it is expected that, by 2010, annual amount of water demand in 1995, which is 30.3 billion m³, will increase by 2.2 to 2.3 billion m³, and that of steady water supply in 1995, which is 28.6 billion m³, will grow by 3.7 to 4.3 billion m³. The level of supply will meet nearly that of demand.

In terms of agricultural water, based on projections of changes in agricultural land use and demand for agricultural products, it is expected that the amount of water for paddy field irrigation will be more or less flat because, in spite of decrease of the area of paddy

fields, the unit amount of water needed to irrigate paddy fields will increase. Furthermore, it is expected that water use for upland fields will rise according to the progress of improving irrigation facilities, and that water demand for livestock will remain constant. As a result, water demand in this sector as a whole is projected to increase.

Based on the above, it is expected that, by 2010, annual amount of water demand in 1995, which is 61.0 billion m³, will increase by 2.1 billion m³, and that of steady water supply in 1995, which is 59.8 billion m³, will likewise increase by 2.1 billion m³. The level of supply will also meet nearly that of demand.

Table 1 Water demand outlook for Japan (2010) (unit: billion m³ per year)

	Annual amount of water demand	Annual amount of water supply
Urban water use	32.5-32.7	32.2-32.8
Agricultural water use	63.2	61.9
Total	95.7-95.9	94.1-94.7

1.6 PRESENT STATUS OF FOOD

As for foods, Japan is importing a large part of its consumption from abroad.

With the expanding gap between supply and demand structures of food, the food self-sufficiency ratio has been decreasing. (Self-sufficiency ratio, which was 73% in 1965, dropped to 41% in 1997 when calculated by calorie basis.)

The ratio of the total planted acreage to the total farmland area is decreasing, and the overall vitality of core farm work forces is weakening.

Under the possibility of tightness of the world's supply and demand for food in the future we cannot ignore above mentioned situation.

1.7 Basic Plan on Food in Japan

Under such circumstance, a new insight is given to the values of food, namely that food is the fundament of our "everyday life" and the values of agriculture and rural areas that support food production should be respected, and expectations for their roles as the basis of safety and security for food are growing.

In response to such growing expectations of this age, the Basic Law on Food, Agriculture, and Rural Areas was promulgated and enforced on July 1999, as a radical revision of the Agricultural Basic Law that was established within the background of rapid economic growth. The new Basic Law introduced a new policy-making scheme under the new principles.

Basic philosophies of the new law include securing a stable food supply, fulfilling agriculture's multifunctional roles (i.e., the multiple roles that agriculture plays through stable production in rural areas), sustainable agricultural development and the promotion/development of rural areas.

Therefore the Basic Plan on Food, Agriculture, and Rural Area that was established in March 2000 describes a desirable food consumption and targets of agricultural production based on the outlook for the next ten years ahead, and prospect of security of agricultural resources, agricultural business management and structure that are required for implementation of those tasks. The plan also presents targets for a food self-sufficiency ratio such as 45%, when calculated by total calorie basis, which is to be achieved based on all of these efforts.

In the future, national and local governments, municipalities, farmers, consumers, and any other relevant parties should work together according to this Basic Plan to promote sustainable development of agriculture and rural areas, to secure stable food supply, and to fulfill multi-functional roles of agriculture and rural areas.

Chapter 2

World Agriculture and the Potential of Paddy Fields

2.1. Precipitation and agriculture

Positions on the earth can be expressed by latitude and longitude. Temperatures are dictated mainly by latitude, and the land is divided into tropics, subtropics, temperate, and frigid zones. Arable crops depend on average temperatures as well as annual deviation of temperatures. Precipitation is also different depending on the region. The land is generally divided into the following areas:

Table 2. Classification by Annual Rainfall

Classifications	Average Annual Rainfall
Arid	< 250 mm
Semi-arid	250-500 mm
Semi-humid	500-1000 mm
Humid	1000-2000 mm
Super-humid	>2000 mm

(Hitoshi Fukuda, Irrigation in the World)

The numbers in the table are total rainfalls throughout a year but we know that 1/365 of the total rainfall does not fall every day. One of the most important parameters for crops is the duration of dry weather.

Desertification progresses and agriculture generally requires irrigation in areas with an annual rainfall of 500 mm or less, unless they are in the frigid zone, because daily evaporation exceeds daily precipitation throughout the year. Such areas include North Africa, the Middle East, Central Asia, and the mid-western United States.

Agriculture in semi-humid areas consists mainly of grazing of sheep and other livestock in pastures, as well as crops such as pulse and wheat that require relatively small amounts of water. Such semi-humid areas include most of Europe, the pampas in South America, the middle and lower regions of the Huang He River in China, and the western part of the Great Dividing Range of Australia.

Asia monsoon region consisting of Southeast Asia and part of East and South Asia, belong to humid or super-humid areas, and in general have rainy and dry seasons with most of the annual precipitation falling during the rainy season. In these regions, paddy cultivation has been widely practiced since ancient times, and the area presently produces more than 80% of the world's rice supply²⁻¹⁾.

Agriculture varies throughout the world, depending on climatic and topographic conditions. This chapter discusses agriculture in monsoon Asia and in Europe where their long history will help illustrate the relationship between climatic and topographic conditions and agriculture.

2.2. Irrigation Agriculture Harnessing Monsoon Climate and Topography

The countries in Asia monsoon region, including Japan, have a long history of collective, small-scale paddy cultivation. The regions are classified into either humid or super-humid based on their average annual precipitation, but they are marked by a huge swing in rainfall in a year with dry and rainy seasons. In addition, the area generally has steep topography and rivers as it is situated mostly in the Pacific Rim fold belt. Precipitation amasses within a short period of time, so that mountain streams and middle-to-small rivers are well developed. On the other hand, stream-flow in the rivers changes sharply within a few days, causing numerous floods and droughts.

In other words, the area has abundant water but nonetheless suffers severe hydrological conditions. There is a famous anecdote about Mr. Johannis de Rijke, a Dutch engineer who came to Japan about 100 years ago to supervise flood prevention. During his stay, he made the following observation: "They are not rivers. They are cascades."

Water use in the Asia monsoon region were indispensable not only for agriculture, but for stabilizing and sustaining daily life. Paddy cultivation developed in Asia, with the development of sustainable local communities under severe hydrological conditions as the first priority. Even though there were major struggles for water between small groups located upstream and downstream, labor accumulation was promoted, equitability was sought, and individual freedom and profit were of secondary importance within the group as a whole.

2.3. Japanese Culture of Paddy Field Cultivation

Stereotypical rural scenery in Japan and other Asian countries may be paddy fields stretching as far as the eye can see or terrace paddy fields on mountain slopes. Although it is certainly pleasant scenery, paddy rice cultivation requires extensive labor in order to grow ample crops in unpredictable nature.

Even in the late 1950s to the early 1960s, 150-190 hours of labor per 10 ares was required²⁻²⁾. Furthermore, paddy rice cultivation calls for the unique and hard labor of turning over of muddy field, plowing, planting, harvesting, and binding and hanging straws in the sun. The construction, operation, and maintenance of irrigation and drainage facilities required for rice cultivation is a battle against floods and droughts, and a large amount of labor, beyond individual capacity, must be committed to the collaborative project. Therefore, local communities of village societies have been formed and developed to share this work.

A wide variety of cultures regarding paddy rice cultivation has been developed in local communities valuing villageship and equitability over individualism. As a result, ceremonies such as rice nursery celebrations, rice-planting celebrations, and rice-harvesting celebrations have developed. Village cultures are multi-faceted: be in awe of nature and appreciate its fruits; unite the local community; and promote cooperation, hard work, and efforts to prevent laggards and free-riders.

2.4. Climate, Topography, and Rivers in Europe

Most of Europe consists of semi-humid areas, judging from their average annual precipitation. Rainfall is fairly constant throughout the year, or it is even scarce during the crop-growing summer season. The topography is fairly flat, preventing rainwater from aggregating and forming small streams. As a result, there are not many steep streams or middle-to-small streams from which water can be easily taken. The natural conditions, in other words, are unfavorable for irrigation.

Europe has large rivers with ample water flow throughout the year. Still, irrigation is quite difficult, because even if water is taken from a river weir, only gently sloping topography and rivers allow land to irrigate through natural gravitational flow, which must be lower than the water level at the intake, far downstream.

As a result, irrigation has been limited in various river-mouth deltas and alluvial fans. Europe realized that the development of livestock farming and upland field cropping, such as wheat and pulses, would be good alternatives for dealing with scarce rainfall.

Such types of agriculture did not require advanced flood prevention nor labor contribution from the community, resulting in less division of water and fewer limitations on individual freedom. Under those conditions, farmers tend to be agricultural businesspeople and did not need to form such solid communities based on farming villages and irrigation. This led to a quest for productivity-valuing business strategies of individual farmers more than for collective organizations. As a result, livestock farming underwent scaling up of enclosures, or farming areas, and upland farming, in addition to the scaling up, underwent development of a high-input/high-output type of agriculture using fertilizers and agro-chemicals. The optimal examples of this can be found in the United States and Australia, where agriculture achieved even higher productivity in a short period of time by using the vast land resources.

However, the intensive agriculture of the past is now a cause of environmental problems, such as groundwater pollution due to nitrogen elutriation from fertilizers. The recent introduction of irrigation technologies to upland farming is also aimed at improving profitability in individual agricultural businesses.

Climate and topography had a large effect on industries, economy, society, and culture, as well as agriculture in the region. This is still true in our globalized modern society.

2.5. Implications of Differences between Europe and Japan

The differences in the history of agriculture and irrigation have significant implications. Professor Toru Mase of Akita Prefectural College of Agriculture clearly states this²⁻³⁾:

Principles valuing equitability and sustenance of local communities over individual benefits naturally include long-term sustainable resource conservation, or the philosophy of "symbiosis" among human beings or nature and human beings. If, on the other hand, the society values individual benefits over equitability and sustenance of local communities, the "competition" principle plays a more important role and short-term profits and better efficiencies come before long-term conservation of local communities and resources.

The philosophical difference is an important point of consideration in terms of world environmental issues. Current differences in values or conflicts between "urban and rural areas" in Japan seem to have their roots in the philosophical difference.

2.6. Advantages of Paddy Fields

Paddy cultivation utilizing plenty of monsoon rainfall through irrigation can achieve very high productivity, although labor input per unit area is usually high. The optimal cereal production scenario is that of a small farming area being capable of supporting a large number of people.

In general, when the same type of crop is sequentially cultivated in upland farming, there is the likelihood of replant failure due to Euglenophyta, disease, mineral deficiency, soil acidification, and soil salinization. For more than a thousand years, however, Japan and other Asian countries have continuously cultivated single crops of rice in the same paddy fields without major failure or even decreases in output.

There must be secret advantages to paddy cultivation and sustaining irrigation over other agricultural practices. The following will illustrate them.

2.7. Characteristics of Paddy-Rice Cultivation - Secret of Soil

One of the major characteristics of paddy cultivation is that farmland is flooded with plenty of rainwater and irrigation water over a long period of time, namely during the wet-rice farming period. In the soil of paddy fields, a number of chemical and biological processes progress with a delicate balance.

Flooded paddy fields shut down the air, or oxygen, supply to the soil in order to kill all aerobic bacteria. Drainage of the pond water in the fall exposes the soil to air and anaerobic bacteria perish during oxidation of the soil. Alternating bacteria in the soil prevent abnormal proliferation of bacteria and contribute to the balance between bacteria types. Alternating swelling and softening due to water absorption and shrinking caused by dehydration, creates porous soil with higher water permeability. Water may wash the soil itself and replenish nutrients to the soil.

The annual cycle of oxidation and reduction of soil promotes chemical and biological reactions resulting in a highly developed, complex soil profile, each layer having different properties, in only 80-cm-thick soil. The soil is the major contributor to

sustainable cropping in paddy rice cultivation. It is as though flooding irrigation water and paddy field soil are in masterly orchestral harmony.

Reduction in crop yields of wet-rice cultivation in paddy fields with such activated unfertilized soil is far less than that of wheat in upland farming, as shown in Table 3.

Table 3. Yield Test Results Relative to Three-Element Area (Kawasaki, 1953) (Unit: %)

Crop	No Fertilizer	No Nitrogen	No phosphorus	No Potassium	Measured Points
Wet-rice	78	83	95	96	1,161-1,185
Wheat	39	50	78	78	822-841

2.8. Characteristics of Paddy-Rice Cultivation – Irrigation Sustaining Soil Fertility

A small reduction in crop yield without fertilization means that the soil of irrigated paddy fields is more fertile with more naturally supplied minerals and organic matter than in upland farming. A major contributor to the fertility is paddy field irrigation.

Irrigation water transports nutrients into the soil from fallen leaves and detritus in forests at the backyard of the paddy fields. Table 4 shows the average supply of major elements per 10 ares of paddy fields due to irrigation, and their subsequent absorption by the rice. The numbers are estimated based on the total amount of irrigation water during the wet-rice cultivation period in Japan, which is approximately 1,000 tons/10a, and the average quality of river water. Although the supplied elements are insufficient for rice production, except for Ca and Mg, the table clearly shows that considerable amounts of nutrients are supplied through irrigation.

Table 4. Supply of nutrients through paddy field irrigation and their absorption by wet-rice (600 kg of unmilled rice/10a) (Unit: kg)

Element	Nitrogen (N)	Phosphorus (P)	Potassium (K)	Silicate (SiO ₂)	Calcium (Ca)	Magnesium (Mg)
Supply	0.31	0.007	1.19	19.0	8.8	1.9
Absorption	12.00	2.400	12.00	36.0	1.8	12

Source: Hidetoshi Wada, "New Agrology," Asakura-Shoten, p. 173

2.9. Characteristics of Paddy-Rice Cultivation – Deoxidizing Soil, Soil Erosion Prevention, and Weed Control

Wet-rice cultivation based on paddy field irrigation has many other advantages.

The first one is deoxidizing soil. Soil of the uplands is oxidized to facilitate aerobic decomposition of organic matter in the soil. It promotes base eluviation from the soil under humid conditions and dehydration and salinization under dry conditions, so that it reduces soil fertility. In paddy field soil, on the contrary, slow decomposition of organic matter under deoxidized flood conditions contributes to sustainable soil fertility. In the case of nitrogen, which is vital to crop growth, organic nitrogen is converted into complex ammonia and is absorbed by the crop. The nitrogen is hard to eluviate due to coupling with soil particles, thereby producing less groundwater pollution. Phosphorus is also better used under deoxidizing atmosphere, so that phosphorus fertilizers can be saved.

The second point is the contribution to the prevention of soil erosion. Farmland must be leveled and surrounded by ridges in order to flood paddy fields with water. This will then contribute to soil-erosion prevention in the farmland of Asia monsoon countries with steep topography and large amounts of rainfall. This prevention is vital not only for farming, but also for national land conservation and regional sustainability. It is another reason why terrace paddy fields are frequently found in the Asia monsoon region.

Third, the flooding cultivation method contributes to weed control, which is a focus of concern in the humid Asia monsoon region with large amounts of rainfall.

The fourth point is that paddy fields are immune to the salinization that farmlands in arid and semi-arid areas often suffer from. This is due to the leaching effects of soil cleaning in addition to the large amount of rainfall in humid areas.

2.10. Productivity and Population Support Capacity of Uplands and Paddy Fields

Comparison of food productivity of grassland, upland, and paddy fields reveals that wet-rice farming in paddy fields has outstanding productivity and population support capacity per unit of farming area.

As shown in Table 5, the yield of wet-rice cultivation is 1.4 times as high as that of wheat based on rice in the husk. The apparent yield of corn is higher than that of rice, but corn is usually fed to livestock. Assuming that all corn is fed to livestock, the

equivalent food productivity of rice is higher than that of corn, with factors of 3.6, 6.2, and 9.87 for chicken, pork, and beef production, respectively.

In total, rice has outstanding productivity and population support capacity per unit of farming area.

Table 5. Cereal Production and Yield in the World

Crop	Production (1000 tons)	Cropping Area (1000 ha)	Unit Yield (t/ha)	Basis of Food Consumption (t/ha)
Wheat	583,624	215,272	2.71	2.71
Wet-rice (unhulled rice))	596,485 477,188	155,128	3.85	3.85 (nhulled) 3.08 (unmilled, with a factor of 0.8)
Corn	600,418	139,214	4.31	1.08 (feed efficiency of 4 for chicken) 0.62 (feed efficiency of 7 for pork) 0.39 (feed efficiency of 11 for beef)

Source: International Statistics on Agriculture, Forestry and Fisheries, Statistics and Information Department, the Ministry of Agriculture, Forestry and Fisheries

Chapter 3

Positive and Negative Externalities of Irrigation in Paddy Farming Region

3.1. Paddy Field in the World and Japan

Mr. Tabuchi classifies paddy fields in the world into three types³⁻¹⁾:

Type I is the traditional "climate compatible" paddy field in the Asian humid regions. The regions have been supporting the majority of their population through paddy rice cultivation since ancient times. The fields are generally small, most farms are small-scale, and the yield per unit area is rather low. It is sustainable rice cultivation compatible with the local climate, but it is labor intensive with mechanization being difficult. These regions previously relied on rainwater during the rainy season, but the recent introduction of irrigation facilities in many regions has enabled cropping during the dry season as well.

Type II is the modern "high productivity" paddy fields developed in the dry regions of the United States and Australia. Typically, large farms practice rice cultivation in large paddies over vast land areas with irrigation. Although it has high productivity, Type II may lead to depletion of irrigation water sources, salinization problems, excess application of agro-chemicals and fertilizers, destruction of the environment, and water pollution. It inherently has the most potential concerns among the types in terms of long-term sustainability.

Type III is the presently-evolving paddy fields in countries such as Korea and Japan. They were previously another Type I paddy fields, but mechanization is now under way with paddy field consolidation and development of irrigation drainage in order to improve labor productivity and yield-per-unit area. At first glance, this may seem to be aiming at a Type II, high productivity, United States type of paddy fields, but it actually is highly sustainable paddy cultivation based on the Asian climate. The goal of this type is to become "high-productivity" and "climate-compatible and environment-friendly" paddy fields.

3.2. Soil Salinization in Arid and Semi-Arid Lands

There are two types of irrigation: paddy field irrigation, with the merits described in the previous chapter, and upland field irrigation which infiltrates water to upland fields on slopes.

The most serious impediment to crop growth under arid climate conditions is water deficiency in the soil. Water supply is essential to agriculture under such conditions in both paddy and upland fields.

In Egypt, where ancient civilization flourished, periodic inundation by the Nile River supplied fertile clay soil and water. In Mesopotamia, well-developed irrigation agriculture supported another ancient civilization in the Tigris-Euphrates Valley. Under arid climate conditions, moisture in the soil may rise to the surface through capillary action carrying salts from deep soil, because daily water evaporation exceeds rainfall. Inappropriate irrigation will result in the soil salinization in the topsoil making the land totally infertile. A number of examples exist where once fertile land became wasteland or desert.

In order to prevent soil salinization, plenty of water should be irrigated to ensure constant downward infiltration of water moving down into the soil in addition to the water absorbed by plants. Another prerequisite to having an adequate amount of downward infiltration water is good soil drainage. Addressing such needs, however, requires a large amount of irrigation water, or negative externalities to the downstream may result: salts eluviated from upstream soil may increase drainage salt concentrations, making it difficult for the downstream areas to receive agricultural water with sufficiently low salt concentrations. Therefore, care must be taken when expanding irrigation areas in dry land.

In humid regions, on the other hand, plenty of rainfall ensures sufficient downward infiltration water that carries salts to lower levels of soil, leading to little soil salinization in both paddy and upland fields. Topography in orogenic zones results in rapid river flow which leaches only a small amount of salts and leads to little soil salinization. In other words, irrigation in humid regions is highly sustainable water use without negative externalities in terms of soil salinization.

3.3. Sustaining Healthy Water Cycles in the Reaches

Being in humid regions, Japan and other Asia monsoon countries experience almost no soil salinization or exhaustion of river and groundwater due to irrigation. Paddy field irrigation, the major form of irrigation in the regions, and paddy rice cultivation is often seen to produce positive effects on culture, society, and economy rather than as a source of negative externalities.

The life of irrigation water begins at the source of the river where rainwater from the forests converges into rivers. Water is taken from a weir installed at a river, then it flows through irrigation canals into paddy fields, and is utilized in paddy-rice cultivation. Only a small portion of irrigation water for paddy fields is actually absorbed by the crop. Most of the water leaches the soil during downward infiltration, returns to a river via groundwater or drainage canals, and is re-utilized downstream before being discharged into the sea.

With about 50 to 75% of the water taken from a river eventually going back to the river, the water intake upstream is sustaining a healthy water cycle in the reaches, as well as producing positive externalities for water use downstream.

Even internationally distinguished water experts may not be well aware of the above facts, and there is the persistent misunderstanding that paddy field irrigation uses too much water judging from the examples of negative externalities and the comparison with upland field irrigation in terms of water usage.

3.4. Contribution to Preservation of National Land

In Japan, because of the plentiful, fluctuating precipitation, steep topography, and steep river gradients, it is an important task to prevent sediment runoff in order to preserve the national land. Forests and mountains have played an important role: in business, in sabo, conservation of watershed, and flood prevention. Paddy fields contribute to prevention of soil erosion because they require the development of terrace fields and surrounding ridges, and the ridge slopes are covered and properly managed. Their unique functions include flood prevention and conservation of watershed by holding a large amount of water and allowing it to flow down slowly even during a heavy rainfall.

Agricultural irrigation and drainage canals may also purify water with waterweeds in channels and plants on the slopes, and may take drainage and flood water coming from

sources other than paddy fields and then safely transport it downstream. Paddy fields also contribute to the rural landscape by enhancing amenities with swampy areas and by enriching waterside ecosystems.

The above public-interest functionality of agriculture irrigation facilities in Japan may be equivalent to 4.5 trillion yen per year³⁻⁴⁾.

3.5. Paddy Fields are an Incubator of Ecosystems

Countries in the monsoon Asian region, including Japan, develop and sustain the natural environment with plenty of water through paddy cultivation, leading to excellent biodiversity. Taking insects as an example, it is interesting to note that more than 1,600 species are confirmed to inhabit the Minumatambo paddy fields in the outskirts of the large city of Omiya, while there are usually around 150 species of insects in upland fields and grasslands³⁻³⁾.

It is indeed a simple question. It should be more advantageous for microorganisms, insects, and their predators, such as birds, if the land holds shallow fertile water well-warmed by the sun to reduce fluctuations in air temperatures than it is to have dry land from spring to summer or fall and there is a large fluctuation in temperature day and night. Paddy fields provide an excellent biological environment to nurture rich ecosystems. It is similar to a vast wet land of 2.8 million hectares, or 28,000 km², emerging every year from nowhere. Creatures are well aware of this and those who lay low in nearby mountains and storage reservoirs during the winter will come up to the fertile paddy fields when farmers start flooding the fields.

It must be noted that such a fertile incubator of ecosystems may become a graveyard of creatures depending on the strategies used to modernize agriculture in order to save labor in terms of canal development, agro-chemical inputs, and fertilizing management.

3.6. Landscapes with Paddy Fields – Alluvial Plains, Alluvial Fans, and Terrace Paddy Fields

All Japanese alluvial plains and fans have well-developed paddy fields. The landscape there is the same as the wetlands in the spring. Agricultural irrigation and drainage canals propagate through the landscape similar to a vascular system. In the fall, it is rich with gold ears of rice. Terrace paddy fields spreading on mountain slopes nearly to the top make people wonder where the irrigation water comes from and they go up to the

top to find a small storage reservoir accompanied by frogs. This is probably the typical landscape of Japan.

No such natural environment nor landscape existed before the existence of paddy fields. In other words, the typical landscape of Japan is a landscape developed around a water ecosystem created and developed by paddy fields and irrigation over more than 2000 years. It is sometimes called "secondary nature" and it has its own value that primary nature does not have.

3.7. Development of Sustainable Irrigation Agriculture and Society

International water issues concentrate on unsustainable cases often found in dry or semi-arid regions, especially those having negative externalities. This tends to result in the misunderstanding that agricultural water, or paddy field irrigation in particular, is wasting a precious water resource. Of course, negative externalities produced in an irrigation case should be calculated in the agricultural business costs for both dry and humid regions.

Not all irrigation in arid and semi-arid regions produces negative externalities, and not all irrigation in humid regions is without negative externalities. The same is true for positive externalities. It should be noted that irrigation in arid and semi-arid regions is fundamentally different from that in humid regions even when they are both used for paddy fields. They are far different if one is paddy field irrigation in a humid region and the other is upland field irrigation in an arid or semi-arid region.

A global rule must not be applied ignoring these differences, nor should a successful scheme in one region be applied to another without significant examination. Short-term "competitiveness" should not be valued greater than long-term "sustainability", with excessive confidence in market mechanisms and disregarding positive and negative externalities.

Chapter 4

Japan's Position with Regard to Agricultural Water Issues

4.1. Is Paddy Field Irrigation Wasting Water?

A persistent argument exists both internationally and domestically that paddy field irrigation is wasting water. The reasoning is as follows:

- (1) Paddy cropping by ponding uses a large amount of water per unit production compared to upland field cropping.
- (2) The amount of agricultural water is not reduced though the irrigation area is decreasing due to the reduction and conversion of agricultural land. This is a criticism often argued in Japan.
- (3) Maintenance and management of irrigation canals is more difficult compared to other sectors in many developing countries.

Some arguments may be based on a misunderstanding of paddy field irrigation in humid areas. The following sections will clarify that.

4.2. Water Required to Produce One Ton of Cereal

Paddy-rice farming is said to require 2,000-3,000 tons of water to produce one ton of crop, while 1,000 tons of water is required in upland field farming. This difference leads some international organizations to criticize that ponding in paddy-rice farming is wasting water⁴⁻¹⁾.

What is the real picture? In fact, apparent water consumption of ponding in paddy-rice farming is approximately twice as much as in upland field cropping. Is it true that the growth of rice in wet cultivation consumes that much water?

An important point to consider is that "the amount of water used" in farming is different from "the amount of water consumed" by crop growth. The gap is particularly wide in ponding in wet-rice farming.

Simply stated, a part of the water "used" can be "re-used" downstream, but water "consumed" or absorbed by the crop and then evaporated, cannot be used again.

Table 6 shows the amounts of water required to grow rice in wet farming and for other major crops to produce 1 g of crop on a dry basis. Paddy rice requires slightly more water than wheat and sweet potato, but less than soybean.

Table 6. Amount of water required to grow crops

Crop	Required water (g/dry crop weight)
Paddy rice	295
Soybean	429
Wheat	191
Sweet potato	248
Upland rice	309

Hasegawa, Kanto Higashiyama Agricultural Experiment Station

4.3. Where is Water Unabsorbed by the Plant Going?

Where is the water going that was not absorbed by the paddy? There are several paths. A portion of the irrigated water infiltrates the soil, becoming underground infiltration water that supports and activates the soil. Another portion of the irrigated water flows out to a drainage canal and is used in the next paddy field. Still another portion may become groundwater or may flow back to a river, and then be taken in and utilized downstream in a wide variety of ways not limited to agriculture. This was discussed in Sections 3.3.

The subsequent utilization of water downstream, of course, does not justify excessive use of water for agriculture.

The canal system used in paddy field irrigation poses some inherent reasons for using a large quantity of water. The main reason is for operation.

4.4. Operation Water to Maintain Water Level

Open canals and pipelines are adopted as water channels, and open canals are favorable due to their lower construction costs and easy maintenance if the topography allows water transportation by gravitational flow. Gravitational flow does not require pump

operational costs, such as electricity charges, and is especially advantageous to agricultural water by decreasing operation and maintenance costs.

Open canals, however, require additional operation water or water-level sustaining water. Not only the amount of water, but also water levels at each diversion point, is very important for transporting irrigation water to paddy fields through open canals. The water must be maintained above certain levels to be appropriately diverted to smaller canals and introduced to paddy fields. To ensure the appropriate water levels, a certain amount of water constantly needs to flow through canals, regardless of actual water usage. This is the water-level sustaining water and it is the main reason why changes in paddy field area and required amount of water are not proportional, and why the required amount of water may be constant even when the area of the paddy field decreases. On the other hand, water may be taken in because of a lack of rain, but then never used in the paddy fields, and subsequently returned downstream when the paddy fields receive rain.

The only possible solution for the problems above is to convert all open canals to pipelines such as those used for public water supply. Although pipelines do have a high water-use efficiency, they have their drawbacks: huge construction costs and severe damage incurred by the ecosystem in the canals. An agricultural water distribution system must cover a wide area, and a pipeline system similar to the water supply system would incur enormous costs. In addition, maintenance and recovery from an accident would be more difficult, particularly because the agricultural water system generally employs tree-type piping.

4.5. Leakage and Overflow Due to Careless Management

Many developing countries are suffering from water loss, such as leakage due to careless management. This is because major irrigation facilities have been constructed with aid from international organizations without establishing responsibilities for operating and maintaining the facilities by the farmers or developing farmer organizations for management of the facilities.

Farmers have difficulty regarding the irrigation facilities as their own facilities and tend to think of themselves as just the users, not managers in a region where experience is scarce in building, operating, and maintaining irrigation facilities.

Presently, the World Bank and various other organizations are promoting Participatory Irrigation Management, but it will take some time to change the mind-set of the farmers.

Japanese farmers have a long history of construction, operation, and maintenance of agricultural irrigation facilities. However, farmers are now struggling with management costs of agricultural water and cannot practice adequate management in some areas; dynamism in rural areas is waning due to depopulation of rural villages, migration from towns into villages, aging of farmers, erosion of workforce, and waning of agriculture.

4.6. Hardware and Software Must be Seen as a Set

Irrigation hardware is agricultural irrigation facilities, while irrigation software is LIDs and farmers' labor provided for water management. An important point here is that the quality of irrigation hardware and software has significant effects on the amount of water used for irrigation.

Increasing water-management efforts, for example, will reduce the amount of irrigation water. Rotational irrigation employed during a drought illustrates this very well (See A.4, APPENDIX A). Rotational irrigation has the potential to reduce the amount of water to as low as half the current level. In order to achieve this reduction, however, various water-management efforts are required.

Employing a pipeline system similar to the public water supply system and installing hydrants and water-flow meters at all diversion points, will significantly reduce the amount of water used, but requires an enormous capital investment.

In other words, there is a trade-off relationship between the amount of water used, the quality of irrigation facilities, and the management costs. It is impossible to simultaneously improve all the parameters and it is impossible to determine the optimum amount of agricultural water per unit area.

Property may be positively utilized as illustrated in some cases in Japan, where deteriorated agricultural irrigation facilities were renovated by the Agricultural Water Restructuring Project to upgrade existing facilities. The reduced amount of water, or newly-generated excess water is used in urban areas and, as a result, the effective water rights of 7 million people were transferred from agriculture to public water supply throughout Japan.

The examples proved that the farmers' water management organizations developed around LIDs are very important, together with improvement in irrigation and drainage canals and other facilities, in order to have higher water productivity in industrialized countries such as Japan, as well as the developing countries in monsoon Asian.

4.7. Cost Recovery/Full-Cost Pricing

There is a long history of arguments on the economics of agricultural water, starting with the issue, what kind of goods should water resources be regarded as?

Cost recovery/full-cost pricing and transfer of water rights are discussed in this and following sections.

Some developing countries supply agricultural and public water free of charge. Even in countries that do not impose direct charges, water users may see water as a valuable resource if they pay some price for the water, either with money or by providing unpaid work for the operation and maintenance of irrigation canals and public water supply systems. The biggest problem occurs when the national government or other agent operates and maintains the water system and the operation and maintenance deteriorates due to causes such as financial difficulties. Politicians usually make the matter worse by avoiding charging water users in order to not displease voters. Thus, deterioration of facilities and inappropriate management causing leakage, will increase.

This is a problem that is currently happening in developing countries. Introduction of cost recovery is now a focus of attention, because it can motivate raising water utilization efficiency and water savings by putting the operation, maintenance, and other costs onto water users. It will reduce the financial burden of the government of developing countries and may attract additional construction investment from overseas.

An important point that should be considered is the level of cost recovery. The most extreme case would be to recover, from water users of agricultural, domestic, and industrial water, all costs including construction, operation and maintenance, and external environmental, or negative externalities costs. Establishing water charges based on the most extreme case is called "full-cost pricing."

4.8. Full-Cost Pricing is Inevitable

It is not only the actual issues in developing countries, but also expectations of the method that fuels debate on full-cost pricing. There is a persistent argument in international discussions that water is an economic good and, as such, full-cost pricing should be one of the economic principles to follow.

Of course, requisite water for the survival of people must be provided as a basic good even when no costs can be recovered. It is a humanistic proposition. Other water can be regarded as economic or environmental goods.

It seems to be natural, therefore, to apply full-cost pricing on a variety of utility water, including agricultural water, and it is rational, in general, for the beneficiaries to pick up the costs.

But there are several points to consider before coming to a conclusion on the matter:

First, the beneficiaries of water as an economic and environmental good must be clearly identified. Economic beneficiaries of agricultural water, for example, are primarily farmers, but other economic units may benefit from the water. Environmental beneficiaries are apparently local communities or the entire population of the country.

Second, there is the issue of how to evaluate negative externalities. One possible solution is internalization of external costs.

The third point is how water users would cover operation and maintenance costs. Water users may pay the manager of the facilities for the service provided, or they may cover the cost by providing labor when they themselves are managing the facilities.

Fourth, the capital investment in facilities, and their operation and maintenance costs, should be treated either separately or in combination.

Last, but not least, there is the issue of how to collect the water charge derived by considering the above points. The charge may be per unit amount of water used, or it may be a fixed annual price per unit of farmland.

4.9. Beneficiaries – Positive Externalities in Paddy Field Irrigation

Agricultural water is, of course, allocated for agriculture, but it may also be used for other purposes; most of the water introduced into paddy fields is infiltrated into groundwater or returned to the river, and then used again downstream as agricultural water, as well as public water supply and industrial water. Paddy field irrigation, taking much more water than upland field irrigation, has a higher capacity to produce positive externalities or benefits in the form of water use downstream.

Let's look at the reach of the Echi river flowing from the east shore of Lake Biwa as an example. Its abundant groundwater, due to paddy field irrigation, was supplemented by approximately 100 million m³/year of agricultural water taken from the newly constructed Eigenji irrigation dam. The additional groundwater reaches approximately 50 million m³/year, which is half of the supplementing water^{4.2}). In 1998, 40 million m³/year of the water was used in the public water supply for the city of Yokkaichi in the lower reaches, as well as for industrial water for a variety of factories established after the Eigenji dam was completed.

In this case, the groundwater in the lower reaches is an economic good and is utilized in economic activities, but the users do not pay for the dam construction or for the operation and maintenance costs: the beneficiaries are free riders. They would have to pay extra electricity charges and the capital investment on pumps and other facilities if paddy fields are converted to other uses that result in a lower groundwater level.

Paddy field irrigation may be multi-functional, benefiting land preservation and providing utility water in the area in addition to domestic water. It may provide landscapes, such as streams in the spring, and it may provide preservation of the environment and ecosystems, and prevention against soil erosion. In such a case, the general public in the area, or even the whole country, can be regarded as the beneficiaries. Water in this case is an environmental good that is not used in specific economic activities, but nonetheless, the beneficiaries are free riders. Reducing paddy fields will result in reducing the benefits that water can provide as an environmental good.

In order to be equitable, the beneficiaries enjoying the positive externalities of multi-functional water use must share in the dam construction and operation and maintenance costs. A realistic mechanism is to collect water charges from the free-riding beneficiaries in the form of a tax, and subsidize the dam construction and operation and

maintenance of the system, because benefits are difficult to identify or difficult to evaluate for market pricing.

4.10. Scope of Costs – Negative Externalities of Paddy Field Irrigation

On the other hand, use of agricultural water in agriculture may generate some load on the external environment; this is called negative externalities.

Full-cost pricing for agricultural water should include the costs for negative externalities if the economic activity, irrigation, is generating the diseconomy.

For example, farmers using agricultural water must pay the environmental restitution costs if irrigation eluviates salts, agro-chemicals, and fertilizers from farmland, and if contaminated agriculture drainage is causing adverse effects on the external environment. This follows a "polluter pays" principle, and should be effective in reducing the use of water resources causing negative externalities.

Internalization of negative externalities costs requires cost evaluation; however, it is difficult to evaluate or trade in the existing market. Therefore, a system to evaluate such costs must be developed. Such cost may be agreed upon among stakeholders through negotiation based on disclosed information.

4.11. Sharing of Operation and Maintenance Costs in Farmer Participation Management

For public water and industrial water supply in general, a governmental agent or a private corporation performs operation and maintenance, and then collects water charges from the water users. For agricultural water, however, water users may pay the manager of the facilities for the service provided, or they may internally cover the cost by providing labor when they themselves are managing the facilities.

The Japanese LID system of managing agricultural irrigation facilities features both methods (See APPENDIX A). The administrator, an LID, collects operation and maintenance charges from its water user members. When an LID manages entire agricultural irrigation facilities, it calls for labor from its members through its subsystems, community-based organizations. The types of labor include clean-up of

canals before starting water flow in the spring, dredging of storage reservoirs, and daily clean-up of tail-end canals.

The same practice is applied to cases in which an LID manages major facilities and contracts village-based and community-based organizations to manage minor facilities. In such a case, individual members provide labor through the village-based and community-based organizations. In Japan, the multi-layered managing structure for agricultural irrigation facilities provides the labor necessary for the operation and maintenance of the facilities, which should be regarded as operation and maintenance costs, and ensures proper distribution of agricultural water, even during a severe drought when the required costs temporarily rise dramatically.

Overall operation and maintenance costs, including both operation and maintenance charges and unpaid labor in the farmer participation management program, may be quite different depending on high water/droughts and the severity and frequency of disaster damages to the facilities. Many assumptions are required to properly estimate the costs, and it is almost impossible to determine generally applicable costs.

4.12. Balance Between Capital Investment and Operation and Maintenance Costs

The cost of agricultural water resources that should be recovered is the total of the capital investment on the facilities plus the operation and maintenance costs during their service life. The theory of economics dictates, however, that capital investment, a long-term marginal cost, and operation and maintenance costs, short-term marginal costs, require different handling.

On the other hand, as already described in Section 4.6, there is a trade-off relationship between the quality of irrigation facilities and required management power. Put simply, if much money is spent on the former, then less will be spent on the latter, and vice versa. Therefore, balancing the long- and short-term costs is always an argument.

Now, let's assume that the capital investment and the operation and maintenance costs can be handled in the same way through a certain conversion, and that a balancing point minimizing their total is achieved. The theoretical cost to be recovered is the total of the capital investment plus the operation and maintenance costs at the optimal point, and the negative externalities discussed in Section 4.10. The grand total will be recovered in full-cost pricing, but it should be distributed to all stakeholders, considering the positive

externalities and free riders discussed in Section 4.9, and the effective contribution of the operation and maintenance costs discussed in Section 4.11.

4.13. Charge Per Unit of Water Volume or Per Unit Area of Farm Land

As discussed above, the first difficulty in the full-cost pricing method is determining appropriate water charges. The next point is the unit to which the water charge should be applied: per unit of water volume used or per unit area of farmland under irrigation.

Japan and the Asia monsoon region generally have substantial precipitation during the growing period, and the timing and quantity have a large affect on the demand of agricultural water. Irrigation is practiced in the region where everybody wants to have water during long, dry weather, but one heavy rainfall washes out the demand.

A water charge per unit of water volume does not work well when demand for agricultural water, or the shadow price of water, fluctuates wildly.

One of the major purposes of introducing full-cost pricing is to motivate water savings. However, water savings have no significance if the excess water produced is merely discharged into the ocean without being used by other water users during high-water conditions. On the other hand, water charges must be temporarily set at a very expensive rate in order to promote water savings during a drought.

It is now clear that practical application of full-cost pricing, appearing to be valid at first glance, still has many challenges to overcome. There are numerous theoretical problems, and local situations must be examined and considered when configuring a practical institution. Even the merits and demerits of full-cost pricing are not all identified. Therefore, in the meantime, we propose focusing on the urgent issue of how to pass operation and maintenance costs, currently borne by the public sector, onto the users, an issue now receiving much attention in many developing countries.

4.14. Rational Reallocation of Water Resource through Market Mechanism

One more controversial point in economics is the rational reallocation of water resources through the market mechanism.

Growing world demand for water has tightened supply and demand, and now water resources are a rather precious commodity. The theory that a water market should be established to trade water rights at fair market prices and that water should be rationally reallocated to improve efficiency of water utilization resulted from much debate on the issue.

This argument seems to be valid in general, but again, its applicability is quite different depending on the overall supply and demand for water resources and fluctuations in each region.

The rational reallocation of water resources, which is the target of introducing a water market, is the efficient reallocation of limited resources from low productivity sectors to high productivity sectors. Put simply, the objective is to transfer water rights for low productivity agricultural water to sectors such as public water supply in urban areas that can afford higher water prices.

Behind this reasoning is the idea that diverting agricultural water, which accounts for 70% of world water use, will enable new water demand to be met without constructing dams that adversely affect the environment. The new water demand may include water for urban areas, as well as environmental water, and even agricultural water itself.

4.15. Types of Water Rights

Water rights refer to the right to take and use water from a river.

Water rights are not a universal concept; some Islamic countries, for example, prohibit the trading of water. There are two types of water rights in the state of California in the United States: one is riverside water rights on land bordering a river; and the other is water rights allowing the use of water resources available by developing a dam or other facility.

Japan has the River Law, originally enacted in 1896 and amended several times, which governs water rights. The law stipulates that authorization of the river administrator, i.e. water rights, is required in order to take water from a river by constructing facilities. There were a number of irrigation canals that took agricultural water from a river with intake facilities even before the law was enacted. Such agricultural water was assumed to have been authorized by the law, and such rights are called institutionalized water rights.

Water rights are authorized on a first-come-first-served basis if the applied water rights have public aspects and necessity, and if there is available water. Naturally, older water rights have higher priority over new ones, putting more emphasis on the history and public aspect of water use.

4.16. Transfer of Water Rights

Authorized water rights will be returned to the river administrator when no longer required. It creates excess water and allows the river administrator to give authorization to new water right applications based on applicable criteria.

The whole process is called the transfer of water rights, or permanent transfer. Although the transfer of water rights is referred to as a bilateral transfer because it is not completed through the market, it is not exactly a bilateral transfer. True bilateral transfers of water rights between water users do exist, but they are illegal transfers and their extent is unknown.

The River Law requires that water resources be distributed based on the spirit of mutual concession during a severe drought⁴⁻³⁾. That is, all water users should save water and yield their own rights to each other based on the spirit of mutual concession, when water resources become scarce. However, to be a basic good or life good, older and upstream water rights generally have higher priority.

It may seem as if water rights are partly transferred to others. This is called temporary transfer of water rights and an example of this was seen during the severe drought of 1994.

4.17. Transfer of Water Rights through a Water Market

It is natural to consider that water rights can be traded between water users who have returnable water rights and those who want to have new rights. It is also natural to consider introduction of a water market will enable the most efficient transfer by establishing rational prices to maximize social welfare through the market mechanism.

This will work in some regions, such as in the state of California in the United States. There, the total amount of water resources available during summer, the high season for water utilization, can be determined in advance by the amount of water kept in the dams during the spring (due mostly to a dry summer). In this case, the balance between

supply and demand for water resources can be uniquely determined. Each water user can then likely work out a water utilization plan and procure water rights for the year in the market.

On the other hand, the Asia monsoon region, including Japan, generally has substantial precipitation during the summer period, and the timing and quantity greatly affect the demand for agricultural water during that period. There may be too much rain, but a severe drought may occur and drive up the water value.

All water users in the world will not draw up their water-use calendar and buy water rights for the coming year, although it is theoretically possible. Rather, water users will try to hold water rights as much as possible to avoid the risk of receiving complaints from end users.

The only possible implementation of a water market is to have a daily auction of water. This would effectively be a temporary transfer of water rights rather than a permanent transfer. Major risks inherent to such a scheme include a sector with large capital strength driving weak sectors out of the market, and future and speculative trading of water rights.

The water market in Japan and in other Asia monsoon region would be invalid without a substantial safety net.

4.18. Prerequisite for Water Market Entrants

The state of California in the United States could have a successful water market, because prospects for the market are well prepared. As for agricultural water, large farms commanding several hundred hectares of farmland could each be the smallest unit to enter and trade water rights in the market. Diversion flow may be measured and controlled at the intake to each farm.

As for public water supply to the urban areas, there would be no problems because each end user has a water meter. Water supply business can be structured to set water prices according to the traded price of water rights each year.

As discussed in Section 4.16, however, the Asia monsoon region, including Japan, would have difficulty establishing a water market for permanent transfer. Assuming that a temporary transfer water market is successfully established, there is the problem of

equitably distributing water and collecting appropriate water charges with hundreds or even thousands of farmers taking water from one water intake that is controlled against water rights. In order to solve the problem, each farmer must have a water meter at an individual water intake point in order to control and measure water flow.

There must be enough justification to implement such a costly scheme in order to establish a temporary transfer water market.

4.19. Examples of Agricultural Water Diversion in Japan

In Japan, an increasing amount of agricultural water is diverted in a variety of schemes to public water supply in the urban areas, or for other purposes without water markets to freely trade water in a river or to trade water rights.

Temporary transfer is practiced through a higher water-savings rate for agricultural and industrial water than for domestic water, during a severe drought. The amount of water to be diverted may be specified instead of setting different water-savings rates. In such a case, the increment in costs, i.e. labor increment in water management, may be charged from agricultural organizations to the beneficiaries. There is no permanent transfer of water rights in these cases.

An example of permanent transfer, as discussed in Section 4.6, is the diversion of agricultural water through the Agricultural Water Restructuring Project. In the project, agricultural water is saved through measures such as converting canals to pipelines in order to achieve a high water-utilization efficiency, and the excess water that is produced is diverted for urban use. Costs of canal renovation are usually shared by agricultural and urban beneficiaries in proportion to their water use.

In other words, Japan has proved that water rights can be diverted through bilateral transfer without water markets. It is important that Japan should present the merits and rationality of the scheme and examine its applicability to the countries in the Asia monsoon region, with similar conditions, in cooperation with the countries.

4.20. Pros and Cons of Money Transfer in the Bilateral Transfer of Water Rights

There are pros and cons of money transfer in the bilateral transfer of water rights.

Pros include:

- (1) Money transfer would be an effective incentive to the provider of water rights to promote water-right trading.
- (2) It should be clearly institutionalized in order to provide transparency following the existing reality in which money is actually transferred in the case of water diversion.
- (3) The weakening LID financial base may be supplemented as allocation of agricultural water would be reduced with the renewal of water rights due to decreasing farmland.

On the other hand, cons include:

- (1) Excess promotion to divert agricultural water may have adverse effects on hydrological cycles in river reaches. Agricultural water used in paddy fields is not just for consumption, and most of the water taken from a river is eventually returned to the river for re-utilization downstream. This contributes to the water environment, groundwater, and stable river flow.
- (2) Farmers would tend to feel guilty about selling their water rights for money after their ancestors had earned and maintained the water rights.
- (3) Monetary compensation would certainly contribute to the LID financial base, but in the long term, LIDs' presence in the local community would decrease.
- (4) It would be difficult to gain public acceptance on trading river water because river water is regarded as public property under the River Law.

4.21. Messages from Japan to the Water Problems

The 1st and 2nd WWFs were held in Marrakesh, Morocco in 1997 and Hague, the Netherlands in 2000, respectively. In the past, the discussions focused, of course, on agricultural water, which dominated world water use with a share as high as 70%.

However, the arguments on agricultural water use concentrated on dry and semi-arid regions, leaving humid regions behind. We must send out clear messages on irrigation in the monsoon Asian region and other humid regions in terms of its high sustainability, large capacity (making up about half of world water use), and the significant impact it has on world water and food issues.

Japan will host the first WWF in Asia and, as the hosting country, it must encourage active participation of Asian countries, present Asian experience in sustainable use of

land and water in our long history, and contribute to solving world water and food issues.

Bibliography

Note: Most of the following literature is in Japanese.

- 1-1) "Water Resources in Japan, 2000", Water Resources Department, Director-General's Secretariat, the National Land Agency
- 1-2) "Water Plan 21", Water Resources Department, Director-General's Secretariat, the National Land Agency
- 2-1) "World Statistics on Agriculture, Forestry and Fisheries, 2000", Statistics and Information Department, the Ministry of Agriculture, Forestry and Fisheries of Japan. Data are quoted from FAO STAT Land, FAO, 2000.9.1.
- 2-2) "Production of Rice and Wheat", the Ministry of Agriculture, Forestry and Fisheries of Japan
- 2-3) "Asian agriculture - Agricultural Villages and Water", Toru Mase, Kou-2001, Yamazaki Agricultural Institute
- 3-1) "World and Japanese Paddy Fields", p.109, Toshio Tabuchi, Yamazaki Agricultural Institute, published by the Rural Culture Association, 1999
- 3-2) "Macroscopic Effects of Agricultural Water Use", JIID, 1998
- 3-3) "Symbiosis of Cities and Villages, 2001", the Ministry of Agriculture, Forestry and Fisheries of Japan, published by JIID
- 4-1) "Different Backgrounds in Development of Paddy and Upland Field Irrigation", Toru Mase, material on "World Water Issues" for the 22nd Symposium on International Issues, the Japanese Society of Irrigation, Drainage and Reclamation Engineering
- 4-2) "Development History of Echi River", the Editing Committee for Development History of Echi River, the Kinki Regional Agricultural Administration Office, 1984
- 4-3) Article 53 of the river law, water rights coordination during a drought, and Article 53-2, exceptional water rights during a drought

APPENDIX A

Elaborately Designed Agricultural Water Management Systems for Paddy Field Irrigation in Japan

Sustainable paddy production in Japan is supported by elaborately designed agricultural water management systems, in which the correct amount of agricultural water can be delivered at the correct timing. Annual usage of agricultural water in Japan reaches approximately 59 billion tons on an intake basis, 55,600, 2,700, and 500 million tons of which are for paddy fields, upland fields, and livestock farming, respectively^{A-1)}. Irrigation facilities in Japan include 1,000 dams, each with 100 ha or more of irrigation area, 210,000 storage reservoirs, and approximately 400,000 km of irrigation and drainage canals to provide agricultural water to more than 20 million paddy field plots throughout Japan.

Sustainable development of paddy field cultivation has always accompanied proper management of agricultural water which is exercised based on strict enforcement of water rules formed over the long history of paddy cultivation. The basic rules include a customary principle of "older water intake rights are better observed than younger ones," a practice of sharing responsibility in water management, and a practice of rotational irrigation among farmers to save water during a severe drought. In other words, agricultural water in Japan is managed according to the socially agreed-upon rules among all relevant parties based on the water right system developed through disputes over water.

A.1. Head Works (Weir), Canals, Storage Reservoirs, and Dams

First, let's look at why agricultural irrigation systems are required. Water resources are unevenly distributed in seasons and locations and it is not constantly available at any time and locations. In addition, paddy fields are also unevenly distributed. Fluidity of water resources makes it very difficult to deliver the correct amount of water with the correct timing. Therefore, irrigation systems are required.

An irrigation system requires a headwork, or weir, at the top to withdraw water from a river. The normal water level of a river is lower than the surrounding farmlands, and

water is dammed to overcome the elevation difference. The water is then introduced into an irrigation canal, which transports the unevenly distributed water to paddy fields. There are two types of canals: open canals and pipelines. Japan has steep topography and river, and water can be delivered by flow through open canals. Historically, therefore, extensive open canal systems have been developed in Japan. In recent years, pipelines with pump stations have been installed in order to supply water to upland fields and orchards on a hill or when the topographical gradient is too small to allow for natural flow. Drainage canals drain excess water from farmlands to a river. Dams or storage reservoirs may be built to store surplus river water during heavy rain and to supplement the water supply during water shortages due to insufficient natural river flow.

A.2. Agricultural Water Management Organization - Land Improvement Districts

Facilities and structures for irrigation and drainage have been developed and maintained since ancient times to practice stable and efficient paddy cultivation.

A canal network and structures can be compared to the vein system, with which water flows from an intake to each field parcel through canals, and then from paddy to a public water body such as rivers by way of drainage canals. The stock of water facilities and their management efforts are enormous.

The enormous task of managing such water systems is carried out by the Land Improvement Districts (LIDs) that organize farmers. The Land Improvement Act of 1949 established the framework for LIDs, formerly known as Water Users Associations. The legal base gave LIDs the right to take on construction, rehabilitation, and management of irrigation facilities in a designated area, as well as mandatory membership and the compulsory power to collect costs.

LIDs are also known as the fourth type of local government in addition to cities, towns and villages, with two distinct characteristics: an agricultural organization in local communities, and an autonomous coordination organization concerning land and water use at the local level. LIDs are an executing body for land improvement projects, as well as a management body for developed facilities. LIDs in Japan now number 7,294 and their membership has reached 4,430,000 as of 1998^{A-2)}.

A.3. Multi-Layer Configuration of LIDs and Village Communities

An important device to facilitate effective agricultural water management by LIDs is a consensus-building mechanism of community spirit, developed through a long history of Japanese society, under which water management system functions in each community.

Close cooperation has been promoted between an LID and community-based organizations even when the LID manages entire agricultural irrigation facilities. In other cases, an LID may manage only major facilities and contract village-based and community-based organizations to manage the minor facilities.

As illustrated, management of irrigation facilities is decentralized and multi-layered. The involvement of a variety of management institutions enables flexibility in distributing the correct amount of agricultural water during ever-changing situations, such as high water, drought, and disasters.

A.4. Rotational Irrigation during a Severe Drought

This sophisticated system of management is fully mobilized during a drought. The term, drought, generally refers to a shortage of domestic and industrial water. In this section, focus is given to measures taken in the agricultural sector during a severe drought, which is a drought due to abnormal weather conditions with less rainfall than anticipated in the water utilization plan, or a drought that may occur once in every 10 years.

During a severe drought, all water users, including those in the agricultural sector, try to save water. The primary design criteria of irrigation facilities are to efficiently distribute a large amount of water at the lowest cost. It requires enormous efforts and labor of several folds, however, to delicately control and save water under low discharge conditions.

Water management is easier with an abundant supply. During a drought, in contrast, water intake is controlled little by little at each water-intake facility throughout the water system from the tail end to the primary canals, using practices such as reuse of water with a pump, backwater, and rotational irrigation, which refers to the method of using irrigation water in a designated turn and will be described in detail in the coming volumes. It is a daunting task of saving water in contrast to public water supply systems,

in which controlling opening of primary hydrants and tail-end taps can easily regulate the water flow, and the water consumption of each user is easily measured with meters installed at the end water users.

During the drought of 1994, stringent water savings were imposed on 500,000 ha of paddy fields throughout Japan, with a high cost and with labor provided by farmers^{A-3)}. It may be argued that the prior appropriation right, which has been institutionalized mainly as a customary water right over a long time and maintained with labor and efforts, should be observed even during a drought. However, drought adaptation operation is possible only when all water users agree and cooperate based on "the spirit of mutual concession," (or river water for everybody) stated in Clause 53 of the River Law.

Successful drought adaptation operation requires that all water users including those of agricultural water pay respect to others' efforts, establish close cooperation relationship among water users, and discuss necessary adaptation rules even at normal times.

Bibliography

Note: Most of the following literature is in Japanese.

- A-1) "Water Resources in Japan, 2000", Water Resources Department, Director-General's Secretariat, p.366
- A-2) Survey by the Ministry of Agriculture, Forestry and Fisheries of Japan
- A-3) Survey by the Ministry of Agriculture, Forestry and Fisheries of Japan