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Water use in the Japan economy in 2000: an input-output approach

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Abstract

The objective of this paper is to demonstrate a comprehensive study of the structural relationships between Japan's economy and fresh water resources, which is one of the most important environmental variables for sustainable development. To that end, we employ the concepts and indicators derived from input-output analysis.

We also extend a fresh water use database to input-output table in order to identify the water usage of each industrial sector and its fresh water coefficient. This database has the quantity information of each industrial sector's water channel uses such as waterworks and industrial water.

Fresh water coefficients for each industry is calculated by this database and used to estimate the fresh water consumption in the inducement effects, which are calculated by the Leontief Inverse. The information obtained provides a sound basis for the design of improvements within environmental policy.

Keywords: Input-output analysis, Fresh water consumption, Fresh water coefficients, Japan

1. Background

The final goal of this study is to prevent a critical water crisis all over the world in the near future. Many countries and companies will be more interested in the water usage of their economy and products. Reduced water use will be inevitable policy and company strategies, and they will try to find larger amounts of water, as well as high quality water sources from not only domestic, but also foreign regions. Fresh water trade will be one of the significant issues in the international trade. At this stage, the coverage and accuracy of water accounts is quite important in deciding the comprehensive government and company plans. However, the present water accounts in many countries provide statistics that are inadequate to carry out these purposes. Developing the in-depth water accounts framework and methodology is an urgent subject.

This paper entails one of the steps to achieve this goal. The objective of this paper is to develop an in-depth fresh water use database in order to identify the water usage of each industrial sector. It also attempts to analyze the structural relationships between the whole economy and fresh water resources in order to identify the problem of this new water database and methodology. We employ the concepts and indicators derived from input-output analysis to carry out this comprehensive study, and the fresh water use database is modified for an input-output approach.

In this study, the research findings have been implemented for the case of Japan. It is often said that Japan is water-abundant country, and there is no fear of a shortage of fresh water. However, there are some prefectures of Japan which have faced fresh water shortage and some plants were closed. Japan Meteorological Agency and Ministry of Land, Infrastructure, Transport and Tourism have done some research which predicts the fresh water situation for the next 100 years. The results show that some dams will dry up in the long term because of decreasing rainfall and snow.
In addition to this, there is substantial research for Agriculture water usage and Japanese government has created a comprehensive water account database of manufacturing sectors for a long time. However, there is no advanced framework and methodology to analyze Japan’s economy and fresh water resources.

There are, however, rare economic frameworks which provide water information about water. One of these frameworks uses input-output techniques. It is possible for input-output approach to identify the fresh water use in each industrial sector, and calculate the inducement effects of fresh water use in the whole economy. This paper constructs input-output table which is an expanded fresh water use matrix, which is called 'Water use Input-Output table', and analyze the relationship of the fresh water resources with Japan economic structure. The potential of Water Use Input-Output Table is also verified.

2. Previous research

There is little research which applies water information to an input-output framework. Some of the oldest research is that of Gray and McKean(1976), which constructed water coefficients for Colorado to identify the inducement effects of water usage. After the 1990s, studies were implemented in some countries which have huge water problems such as Spain, China and Australia.

In particular, Institute Nacional de Estadistica(INE) of Spain started to construct water accounts in 1997. This statistic contributed to some research which took into account the whole country and some regions of Spain (Durte, Snchez-Choliz & Jorge(2002), Velazquez(2006)).

However, these water accounts still have substantial problems including a lack of accuracy and completion. Also, it is impossible to estimate the water amounts used by each industry activity in an input-output framework. Previous research on this topic is considered to be critically biased.

After 2000, a new concept to solve water scarcity problem has become popular, which is called "Virtual Water" which is defined by Allan(1997). This is the fresh water amounts which it needs to provide the import goods domestically. Dietzenbacher & Velazquez(2007) extended "Virtual Water" information to the input-output framework.

In Japan, there is no study which applies water information to an input-output framework comparable to the "Virtual Water" studies. Oki et al. (2003) applied "Virtual Water" concept to the case of Japan in order to estimate the water needed to provide the agriculture goods in 100% self-sufficiency. Japan agriculture sectors used 59 billion m^3 fresh water resources to provide their goods in 2000. The result of Oki et al.'s estimate was that Japan would have needed an additional 64 billion m^3 fresh water to replace all import agriculture goods. Therefore, they need more than twice fresh water resources to reach 100% self-sufficiency. However, this study considered only main products such as paddy, beef and pulses. This did not cover all agriculture sectors. And, this did not consider the inducement effect in the whole country.

Miyake et al. (2002) estimated the additional fresh water amounts needed when import manufacturing products are provided domestically in 1998. The resulting figure is 1 billion m^3, and it is concluded that it needs much less fresh water to produce manufacturing products domestically in comparison with agricultural products. Beyond this study, no other research considers the fresh water use of manufacturing products. However, Miyake et al.'s study also does not consider inducement effect for the whole country. There are some possible that foods and beverages sector which has in-depth relationship with agricultural sectors.

It is quite important to construct input-output table which utilizes fresh water information to demonstrate a comprehensive study of the structural relationships between Japan's economy and fresh water resources.

3. Water accounts in Japan

There are many kinds of water statistics which are constructed by a variety of organizations. The statistics of waterworks are constructed by the Ministry of Health, Labour and Welfare. The statistics of fresh water which are used by the manufacturing sectors are constructed by the Ministry of Economy, Trade and Industry. The statistics of sewage disposals are constructed by the Cabinet Office, Government of Japan. However each statistic covers only a particular field, these statistics are quite detailed and have high accuracy. In particular, the statistics of fresh water which are used by the manufacturing sectors have outstanding data. This statistic has been constructed since 1958, and the content has expanded gradually. In 2000, this provided water use information of 553 manufacturing sectors. The information of the source of fresh water is also quite detailed. It identifies the source of each manufacturing sector's use such as waterworks, industrial water, surface and underflow water, well water, others and water recovered. It does not only provide source information, but also provides detailed information for each prefecture and district. These statistics are obviously detailed and accurate; however, little research has used this useful information to analyze the actual situation of the economy, in terms of fresh water use.

4. The supply and demand of fresh water in Japan

Section 3 discusses the water accounts of Japan, which are constructed by a variety of government organizations. These statistics are combined to form the whole country's water account by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT).
The statistics of the supply side of fresh water are also constructed by MLIT. The relationship of the supply and the demand side of fresh water in 2000 is drawn below in Figure 1. The theoretical maximum water resource of Japan in 2000 was 420 billion m^3. This water resource was used in household, industry and agriculture through river and ground water. In this statistic, office use is included in the household sector. Household use accounted for 16.4 billion m^3 and industry use accounted for 13.4 billion m^3. Agriculture used 57.2 billion m^3. The total amount of water demand was 87 billion m^3. The rest of the water resources which were not used in 2000 totaled 333 billion m^3. This unused water flowed into the ocean through rivers or was stored in the ground.

(Insert Figure 1 here)

5. The framework of water use input-output table of Japan

This study applies the concepts of previous research. The structural idea of water input-output table is shown in Table 1. Additional water accounts' data is installed which is called the "Fresh Water Use Matrix." To estimate the data in this matrix, water accounts of Japan and substantial research, including that of virtual water were used. Only fresh water information is extracted from these accounts and studies, and this study aims to separate fresh water from sea water completely. Because of inadequate information on water accounts, it was quite difficult for previous research to distinguish the information of fresh water. This fresh water use matrix is composed of three parts, which are waterworks, industrial water and others. The "others" part includes all fresh water except that of waterworks and industrial water.
In addition to this component, this matrix provides the water data of each industrial sector. All previous research did not construct fresh water databases of each industrial sector. This is due to the fact that several governments did not provide detailed and accurate water accounts.

(Insert Table 1 here)

This paper provides a list of the 76 sectors in a water use input-output table. The detailed information of each sector is shown in Table 2. This table subdivides agricultural sectors and food and beverage sectors to identify the larger fresh water use sectors.

(Insert Table 2 here)

6. Methodology

This study applies scarcity value previous study such as Gray and McKean(1976). In water use input output table, fresh water coefficient of industrial sector j (w_j) is calculated by total fresh water amount of industrial sector j (W_j^T) and Control total of industrial sector of industrial sector j (X_j). These have the following relationship.

$$w_j = \frac{W_j^T}{X_j} \qquad \text{Equation 1}$$

This paper defines fresh water coefficient as the demand of fresh water amount to produce goods correspond to one million Japanese yen. This fresh water coefficient is installed in the traditional Leontief Inverse framework $\mathrm{X} = (\mathrm{I} - (\mathrm{I} - \mathrm{M})\mathrm{A})^{-1} \times \mathrm{f}$. Then we can get the following formula.

$$\mathrm{W^T} = \mathrm{w} \times (\mathrm{I} - (\mathrm{I} - \mathrm{M})\mathrm{A})^{-1} \times \mathrm{f} \qquad \text{Equation 2}$$

$\mathrm{W^T}$ is the vector of Total amount of fresh water. I is unit matrix. M is import coefficient matrix. A is input coefficient matrix. f is final demand matrix.

Equation 2 is capable of calculating the fresh water amounts which are induced by Leontief Inverse when final demand is one unit. This paper defines this coefficient as fresh water inducement coefficient.

In addition to this, Equation 2 is capable of calculating inducement effects when all agriculture goods are produced domestically. It is also possible to estimate additional fresh water demand to produce all import manufacturing goods domestically.

In these calculation processes, when we calculate the inducement effects when all agriculture goods are produced domestically, the vector of agriculture goods (Sector numbers are from 1 to 17 in Table 2.) in import matrix M of Equation 2 becomes zero. When we calculate the inducement effects when all industrial goods are produced domestically, the vector of industrial goods (Sector numbers are from 22 to 59 in Table 2.) in import matrix M of Equation 2 becomes zero.

7. Analysis Results

The objective of this paper is to construct water use input output table of Japan and to analyze the relationship fresh water resources with economic structures.

This section shows the results of analyzing 2000 water use input-output table of Japan. Firstly, it is developed the actual fresh water uses of each industrial sector. Secondly, fresh water coefficient and fresh water inducement coefficient are calculated and these results are summarized. Thirdly, the total fresh water amount to fulfill 100% self-sufficiency agricultural goods is calculated. Fourthly, the total fresh water amount to provide all import manufacturing goods domestically is calculated.

7-1. Actual fresh water uses of each industrial sector

The fresh water use matrix shows the share of fresh water use in each industry. The ratio of fresh water us is shown in Table 3. Left side of Table 3 shows the ratio of fresh water use in whole economy, when whole economy is 100%. The center of Table 3 shows the ratio of fresh water use in Primary industry, when Primary industry is 100%. Top 10 sectors and the rest of Primary industrial sectors are shown. In this part, the sectors which sector numbers are from 22 to 32 combine to one sector foods and beverages. Right side of Table 3 shows the ratio of fresh water use in secondary and tertiary industries, when the total of secondary and tertiary industries is 100%. Top 10 secondary industry sectors, the rest of Secondary industry sectors, and Tertiary industry are shown.

(Insert Table 3 here)

Left side of Table 3 shows the ratio of fresh water use in whole economy. The highest share industry is primary industry 84.95%. Second one is secondary industry 13.04%. Tertiary industry has only 2.01% share.

The center of Table 3 shows the ratio of fresh water use in Primary industry, when Primary industry is 100%. The highest share has paddy 68.29%. Crops for feed and forage sector is the secondary highest share 16.90%. These two sectors has approximately 85% share in whole primary industry.

Secondary and tertiary industries have the share approximately 15% in whole economy. From the right side of Table 3, the highest share is pulp, paper and paper products sector 22.27%. It follows after pulp, paper and paper products, petrochemical basic products 11.02%, iron and steel products 8.83%, foods and beverages 8.60%. These four sectors have approximately 50% share in the secondary and tertiary industries.

From these results above, it is cleared that fresh water use of primary industry especially paddy and Crops for feed and forage has the highest share in Japan. Secondary and tertiary industries have small share, however some industries shares are high, which are considered to need a lot of fresh water such as pulp, paper and paper products and foods and beverages.

The fresh water matrix also shows the distribution ways of fresh water use. This matrix divides three ways to distribute fresh water, waterworks, industrial water and others. Others section means the other way except waterworks and industrial water to distribute fresh water such as river and ground water. The result is shown in Table 4.

(Insert Table 4 here)

Primary industry which has the highest share of fresh water use has the way of distributing fresh water from others 99.97%. To be compared with this, waterworks and industrial water have 50% share in secondary industry. Tertiary industry has approximately 90% fresh water from waterworks.

7-2. fresh water coefficient and fresh water inducement coefficient

This section summarizes the results of calculating fresh water coefficient and fresh water inducement coefficient. From section 3, fresh water coefficient is the demand of fresh water amount to produce goods on correspondent to one million Japanese yen. Fresh water inducement coefficient is the fresh water amounts which are induced by Leontief Inverse when final demand is one unit. The results of fresh water coefficients are shown in Table 5. The results of fresh water inducement coefficients are shown in Table 6.

(Insert Table 5 here)

Firstly, the result of fresh water coefficient is verified. When we consider the total of the whole sector is 100%, primary industry share approximately 98%. Secondary industry has approximately 2%. Tertiary industry has less than 1% share. Primary industry is by far higher percentage than the other industries. In primary industry, crops for feed and forage sector is 72,891.33 m^3. Paddy sector is 21,591.50 m^3. Other edible crops sector is 20,452.65 m^3. These three sectors are much higher than the other primary industry sectors, and occupy approximately 86% in the whole economy when the total of fresh water coefficient is 100%. In secondary industry, the five highest sectors are Synthetic fiber 639.69 m^3, pulp, paper and paper products 204.51 m^3, fertilizer 199.03 m^3, Petrochemical basic products 155.77 m^3 and Industrial inorganic chemicals 146.20 m^3. These five sectors occupy approximately 60% when the total secondary industry is 100%. In tertiary industry, personal services 7.59 m^3 is the highest sector. The fresh water coefficients of tertiary industry are quite smaller than primary and secondary industries.

(Insert Table 6 here)

Secondly, the result of fresh water inducement coefficient is verified. When the total of whole economy is 100%, primary industry has the highest share approximately 93%. Secondary industry is approximately 6%. And tertiary industry is less than 1%. In the whole economy, following six sectors occupy approximately 85% when the total of the whole economy is 100%, crops for feed and forage 72,958.41 m^3, other edible crops 25,254.27 m^3, paddy 21,600.95 m^3, sugar crops 5,450.32 m^3, animal feeds 4,191.94 m^3, and Potatoes and sweet potatoes 3,968.66 m^3. The stockbreeding industries also have high coefficients such as dairy farming sector 3,681.83 m³, beef cattle sector 1,440.65 m³, hogs sector 703.95 m³, fowls and broilers sector 190.18 m³ and hen eggs 175.80 m³. In secondary industry, food and beverages sectors have high coefficients such as animal feeds 4,191.94 m³, salt, vegetable oil and meal, flavoring sector 1,336.11 m³ and flour and other grain milled products 1,180.20 m³. It is considered that these industries have huge water use material such as agricultural produces. Except food and beverages sectors, synthetic fiber has high coefficient 647.30 m³. Next is pulp, paper and paper products sector 213.33 m³, and fertilizer 205.76 m³. In tertiary industry, every sector has quite small coefficients. The highest sector is personal services 16.18 m³. Next are medical and health services 6.41 m³ and private non-profit organizations 6.18 m³.

The results of fresh water coefficients and fresh water inducement coefficients above show that primary industry and foods and beverages sectors have high inducement effect of fresh water use. Agriculture products and stockbreeding products have different tendencies in primary industry. Agriculture products themselves need huge fresh water, however inducement effects are small. On the contrary, stockbreeding products themselves do not need a lot of fresh water amount, however inducement effects are quite huge. It means animal feeds for stockbreeding sectors need quite huge fresh water to produce. Foods and beverages sectors have the same tendency as stockbreeding sectors. Fresh water coefficients of foods and beverages are small, however fresh water inducement coefficients become quite huge. It is considered the material of foods and beverages such as agricultural products and stockbreeding products needs huge fresh water to produce.

7-3. Additional fresh water use to fulfill 100% self-sufficiency of agricultural foods

This section calculates the additional fresh water use to fulfill 100% self-sufficiency of agricultural foods. Additional needs monetary information is calculated by the statistics of demand and supply of foods which is constructed in Ministry of Agriculture, Forestry and Fisheries. The equation 2 is used to calculate the additional fresh water use, provided that the vector of agriculture goods (Sector numbers are from 1 to 17 in Table 2.) in import matrix M of Equation 2 becomes zero. The result is shown in Table 7. The total amount which does not consider inducement effect is approximately 80 billion m³. When we consider inducement effect, the results becomes approximately 113.9 billion m³. This is approximately 50 billion m³ higher than the previous research Oki et al.

(2003)'s result 64 billion m³. This amount almost equals one thirds of unused fresh water 333 billion m³. And, the addition of initial fresh water use 57.2 billion m³ in 2000 and this additional water amount gives approximately 171.1 billion m³. It becomes almost twice of the total fresh water use 87 billion m³ in 2000. Therefore, it is quite important to prepare the irrigation system to fulfill 100% self-sufficiency.

(Insert Table 7 here)

7-4. Additional fresh water use to produce import industrial goods domestically

This section calculates the additional fresh water use to produce import industrial goods domestically. Import goods monetary information comes from the import sector of input output table. The equation 2 is used to calculate the additional fresh water use, provided that the vector of industrial goods (Sector numbers are from 22 to 59 in Table 2.) in import matrix M of Equation 2 becomes zero. The result is shown in Table 8.

The total amount which does not consider inducement effect is approximately 9.4 billion m³. When we consider inducement effect, the results becomes approximately 10.1 billion m³. This is approximately 10 times higher than Miyake et al. (2002)'s result 1 billion m³. And, the addition of initial fresh water use 13.4 billion m³ in 2000 and this additional water amount gives approximately 23.5 billion m³.

From these results, fresh water use of industrial goods becomes huge in the process of inducement effect. It is not able to neglect this result to consider fresh water use of industrial goods.

(Insert Table 8 here)

8. Conclusion

The objective of this paper is to identify the relationship of the fresh water resources with Japan's economic structure. This paper constructs a water use input-output table of Japan and analyzes the actual states of the relationship of the fresh water resources with Japan's economic structure. This research study has identified the following results.

1. Approximately 85% of fresh water in the entire economy is used by primary industry. Secondary industry accounts for approximately 13%. Tertiary industry is less than 1%. The highest fresh water use sectors within primary industry are paddy (68.29%), followed by crops for feed and forage (16.90%). These two sectors occupy a majority of fresh water use in the primary industry.

2. The results of the fresh water coefficient show that, when we consider that whole industry is 100%, primary industry has approximately 98%. Secondary industry has approximately 2%. Tertiary industry has less than 1%. The primary industry has quite a large share of fresh water use in comparison with the secondary and tertiary industries. In primary industry, the highest using sector is Crops for feed and forage (72,891.33 m^3), followed by Paddy (21,591.50 m^3) and other edible crops (20,452.65 m^3). These three sectors occupy approximately 86% of the whole economy.

3. The results of fresh water inducement coefficient show that, when we consider that the whole industry is 100%, primary industry has approximately 93%. Secondary industry has approximately 6%. Tertiary industry has less than 1%. The highest one is crops for feed and forage (72,958.41 m^3), followed by other edible crops (25,254.27 m^3) and Paddy (21,600.95 m^3). These three sectors occupy approximately 85% of the whole economy. The Fresh water inducement coefficients of primary industry and food and beverage industry are remarkably large, especially in the grain and crops for feeds and forages sectors.

4. The results of additional fresh water use to fulfill 100% self-sufficiency of agricultural foods show that it needs approximately 113.9 billion m^3 of additional fresh water. The initial fresh water use, which was 57.2 billion m^3 in 2000, and the additional fresh water needed together result in a total of approximately 171.1 billion m^3. *It becomes almost twice of the total fresh water use 87 billion m^3 in 2000. Therefore, it is quite important to prepare the irrigation system to fulfill 100% self-sufficiency.

5. The results of additional fresh water use to produce import industrial goods domestically show that the total amount, which does not consider inducement effect, is approximately 0.94 billion m^3. When we consider the inducement effect, the results becomes approximately 10.1 billion m^3. Adding this to the initial fresh water use of 13.4 billion m^3 in 2000 equals approximately 23.5 billion m^3.

It is clear from these results that the water use input-output table is a quite useful framework to identify the relationship of the fresh water resources with the economic structure. In particular, this study provides detailed information about fresh water for each sector, and detailed fresh water information and the inducement effect of each sector. The rich and detailed information of the demand side of fresh water implies the need to plan adequate government strategy for fresh water resources. There was theoretically 333 billion m^3 of unused fresh water in 2000. It is possible to produce all agricultural and industrial goods domestically from these results. However, this requires huge and long term fiscal policy to construct a more efficient water use system. Also, this study considers only the whole economy. It is quite important to identify the regional situations in order to expand the water use input-output table to establish a regional table. Not only is it important to expand to a regional table, but it is also important to modify a fresh water use matrix. There are only three sectors in this matrix: waterworks, industrial water, and others. Other fresh water uses include a variety of fresh water uses such as river, ground water and recycling water. In particular, the technology to change sea water into fresh water becomes important for establishing new fresh water resources. The framework of the water use input-output table is easily capable of expanding these elements, and provides quite valuable analytical results for not only Japan but also a lot of countries.

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Table 1　The model of the water use input-output table of Japan

Water use input-output table of Japan (1 Unit: one million Japanese yen)

	Sector *j*	Final demand	Control Total
Sector *i*	x_{ij}	F_i	X_i
Value added	V_j		
Control Total	X_j		

Fresh water use matrix (Unit: m^3)

	Sector *j*
Total amount	W_j^T
Waterworks	W_j^W
Industrial water	W_j^I
Other fresh water	W_j^O

$W_j^T = W_j^W + W_j^I + W_j^O$

Note:

1. *T* of W_j^T represents Total. W_j^T is the total of W_j^W, W_j^I, and W_j^O in sector *j*.

2. *W* of W_j^W represents Waterworks. W_j^W is the fresh water use of waterworks in sector *j*.

3. *I* of W_j^I represents Industrial water. W_j^I is the fresh water use of industrial water in sector *j*.

4. *O* of W_j^O represents Other fresh water. W_j^O is the fresh water use of other fresh waters in sector *j*.

Table 2　The sectors of water use input output table (76 sectors)

1	Paddy	39	Petrochemical basic products
2	Wheat and barley	40	Synthetic fiber
3	Potatoes and sweet potatoes	41	Drugs and medicine
4	Pulses	42	Final chemical products (except Drugs and medicine)
5	Vegetables	43	Petroleum refinery and coal products
6	Fruits	44	Plastic products
7	Sugar crops	45	Rubber products
8	Crops for beverages	46	Leather and leather products
9	Other edible crops	47	Non-metallic mineral products
10	Crops for feed and forage	48	Iron and steel products
11	Other inedible crops	49	Non-ferrous metal products
12	Dairy farming	50	Fabricated metal products
13	Hen eggs	51	Machinery and equipment
14	Fowls and broilers	52	Electrical machinery and apparatus
15	Hogs	53	Motor vehicle
16	Beef cattle	54	Ship building and repairing
17	Other livestock-raising	55	Railway cars and repairing
18	Agricultural services	56	Aircraft and repairing
19	Forestry (Inc. Hunting)	57	Other transportation equipment
20	Fishing	58	Precision instruments
21	Mining	59	Other manufactures products
22	Meat and meat products	60	Construction
23	Dairy products	61	Electricity, gas, Steam and hot water supply
24	Processed and marine products	62	Water supply
25	Grain milling	63	Industrial water supply
26	Flour and other grain milled products	64	Sewage disposal
27	Noodles, Bread, Confectionery	65	Other sanitary services
28	Canned or bottled vegetables and fruits, Vegetables and fruits preservation	66	Commerce
29	Salt, Vegetable oil and meal, Flavoring	67	Financial and insurance services

30	Other foods	68	Real estate services
31	Beverages	69	Transport
32	Animal feeds	70	Communication services
33	Tobacco	71	Public administration and education
34	Fabricated textile products	72	Medical and health services
35	Pulp, paper and paper products	73	Private non-profit organizations
36	Printing and publishing	74	Business services
37	Fertilizer	75	Personal services
38	Industrial inorganic chemicals	76	Non-elsewhere classified

Table 3 The ratio of fresh water use

Whole economy is 100%		Whole primary industry is 100%		Total of secondary and tertiary industries is 100%	
	%	Top 10 sectors	%	Top 10 secondary industry sectors	%
Primary industry	84.95%	Paddy	68.29%		
		Crops for feed and forage	16.90%		
		Fishing	7.14%		
		Vegetables	3.28%		
		Potatoes and sweet potatoes	1.28%		
		Sugar crops	0.62%		
		Other edible crops	0.53%		
		Wheat and barley	0.43%		
		Forestry	0.42%		
		Dairy farming	0.31%		
		Other primary industry sectors	0.80%		
		Total	100.00%		
Secondary industry	13.04%			Pulp, paper and paper products	22.27%
				Petrochemical basic products	11.02%
				Iron and steel products	8.83%
				Foods and beverages	8.60%
				Electrical machinery and apparatus	4.24%
				Fabricated textile products	3.70%
				Synthetic fiber	2.97%
				Non-metallic mineral products	2.69%
				Plastic products	2.67%
				Final chemical products	2.49%
				Other secondary industry sectors	15.14%
Tertiary industry	2.01%			Tertiary industry	15.38%
Total	100.00%			Total	100.00%

Note:

1. Left side of Table shows the ratio of fresh water use in whole economy, when whole economy is 100%

2. Center of Table shows the ratio of fresh water use in Primary industry, when Primary industry is 100%. Top 10 sectors and the rest of Primary industrial sectors are shown.

3. Right side of Table shows the ratio of fresh water use in secondary and tertiary industries, when the total of secondary and tertiary industries is 100%. Top 10 secondary industry sectors, the rest of Secondary industrial sectors, and Tertiary industry are shown.

Table 4 Distribution way of fresh water of each industry

	Waterworks	Industrial water	Other fresh water use	Total
Primary industry	0.03%	0.00%	99.97%	100.00%
Secondary industry	6.88%	39.50%	53.62%	100.00%
Tertiary industry	90.07%	1.78%	8.16%	100.00%

Table 5 Fresh water coefficient (Top 20 sectors and some tertiary industry sectors)

	Sector	m^3
10	Crops for feed and forage	72,891.33
1	Paddy	21,591.50
9	Other edible crops	20,452.65
7	Sugar crops	5,440.46
3	Potatoes and sweet potatoes	3,960.79
20	Fishing	2,854.18
2	Wheat and barley	2,348.10
4	Pulses	1,512.70
5	Vegetables	999.66
8	Crops for beverages	686.12
40	Synthetic fiber	639.69
15	Hogs	389.27
12	Dairy farming	261.98
19	Forestry (Inc. Hunting)	225.67
35	Pulp, paper and paper products	204.51
37	Fertilizer	199.03
17	Other livestock-raising	158.96
16	Beef cattle	156.56
39	Petrochemical basic products	155.77
38	Industrial inorganic chemicals	146.20
	～	
75	Personal services	7.59
	～	
71	Public administration and education	5.44

Table 6 Fresh water inducement coefficient (Top 23 sectors and some tertiary industry sectors)

	Sector	m³
10	Crops for feed and forage	72,958.41
9	Other edible crops	25,254.27
1	Paddy	21,600.95
7	Sugar crops	5,450.32
32	Animal feeds	4,191.94
3	Potatoes and sweet potatoes	3,968.66
12	Dairy farming	3,681.83
20	Fishing	2,884.88
2	Wheat and barley	2,409.87
4	Pulses	1,558.22
16	Beef cattle	1,440.65
29	Salt, Vegetable oil and meal, Flavoring	1,336.11
26	Flour and other grain milled products	1,180.20
5	Vegetables	1,008.85
17	Other livestock-raising	851.98
15	Hogs	703.95
8	Crops for beverages	698.54
40	Synthetic fiber	647.30
19	Forestry (Inc. Hunting)	232.35
35	Pulp, paper and paper products	213.33
37	Fertilizer	205.76
14	Fowls and broilers	190.18
13	Hen eggs	175.80
	～	
75	Personal services	16.18
	～	
72	Medical and health services	6.41
	～	
71	Public administration and education	6.18

Table 7 Additional fresh water use to fulfill 100% self- sufficiency agricultural foods

Sectors	Additional needs	Fresh water coefficient	Additional fresh water use
	1 million yen	m^3	m^3
Paddy	412,251	21,591.50	8,901,116,633
Wheat and barley	1,314,887	2,348.10	3,087,492,212
Potatoes and sweet potatoes	1,119,583	3,960.79	4,434,432,751
Pulses	1,274,880	1,512.70	1,928,514,392
Vegetables	1,036,891	999.66	1,036,536,737
Fruits	1,514,406	13.56	20,537,954
Sugar crops	256,097	5,440.46	1,393,285,268
Crops for beverages	100,351	686.12	68,853,188
Other edible crops	339,468	20,452.65	6,943,021,533
Crops for feed and forage	697,506	72,891.33	50,842,133,129
Other inedible crops	246,786	96.92	23,919,616
Dairy farming	873,392	261.98	228,814,879
Hen eggs	37,389	2.09	78,215
Fowls and broilers, n.e.c	1,022,140	5.07	5,180,470
Hogs	461,720	389.27	179,732,008
Beef cattle	1,076,100	156.56	168,477,913
Other livestock-raising	48,670	158.96	7,736,759
Total			79,269,863,658
Inducement effect			113,905,947,908

Note:

1. The monetary information of import prices is based on the statistics which are provided by Ministry of Agriculture, Forestry and Fisheries.

2. Inducement effect is calculated by equation 2.

Table 8　Additional fresh water use to produce import industrial goods domestically

Sectors	Import prices	Fresh water coefficient	Additional fresh water use
	1 million yen	m^3	m^3
Meat and meat products	1,225,554	28.65	35,117,925
Dairy products	126,150	50.29	6,343,476
Processed and marine products	1,515,825	18.09	27,424,638
Grain milling	32,716	0.21	7,002
Flour and other grain milled products	122,474	6.35	778,259
Noodles, Bread, Confectionery	419,635	19.88	8,340,717
Canned or bottled vegetables and fruits, Vegetables and fruits preservation	183,142	71.24	13,047,689
Salt, Vegetable oil and meal, Flavoring	175,729	118.81	20,879,023
Other foods	436,319	27.35	11,932,309
Beverages	124,758	33.55	4,185,504
Animal feeds	586,170	9.57	5,607,992
Tobacco	3,118,017	2.04	6,354,245
Fabricated textile products	1,868,224	71.13	132,887,873
Pulp, paper and paper products	89,438	204.51	18,291,108
Printing and publishing	59,606	3.50	208,728
Fertilizer	228,950	199.03	45,567,300
Industrial inorganic chemicals	11,016	146.20	1,610,547
Petrochemical basic products	1,141,941	155.77	177,876,370
Synthetic fiber	33,794	639.69	21,617,566
Drugs and medicine	529,465	39.68	21,009,744
Final chemical products (except Drugs and medicine)	697,704	48.72	33,991,273
Petroleum refinery and coal products	1,854,537	24.04	44,592,278
Plastic products	371,783	35.52	13,206,579
Rubber products	373,157	26.40	9,852,839
Leather and leather products	643,585	8.55	5,503,368
Non-metallic mineral products	397,180	43.92	17,445,395
Iron and steel products	451,278	70.25	31,702,748
Non-ferrous metal products	1,858,017	38.82	72,134,565

Fabricated metal products	364,547	14.66	5,343,248
Machinery and equipment	2,680,351	5.02	13,446,650
Electrical machinery and apparatus	8,037,783	11.70	94,068,267
Motor vehicle	1,203,162	6.73	8,098,954
Ship building and repairing	32,361	7.79	252,106
Railway cars and repairing	8,625	2.03	17,539
Aircraft and repairing	559,217	7.19	4,020,776
Other transportation equipment	71,867	5.12	368,088
Precision instruments	1,077,821	12.01	12,941,641
Other manufactures products	1,563,958	9.00	14,080,044
Total	34,275,856		940,154,374
Inducement effect			10,075,341,948

Note:

1. Import prices are calculated from Input output table.

2. Inducement effect is calculated by equation 2.

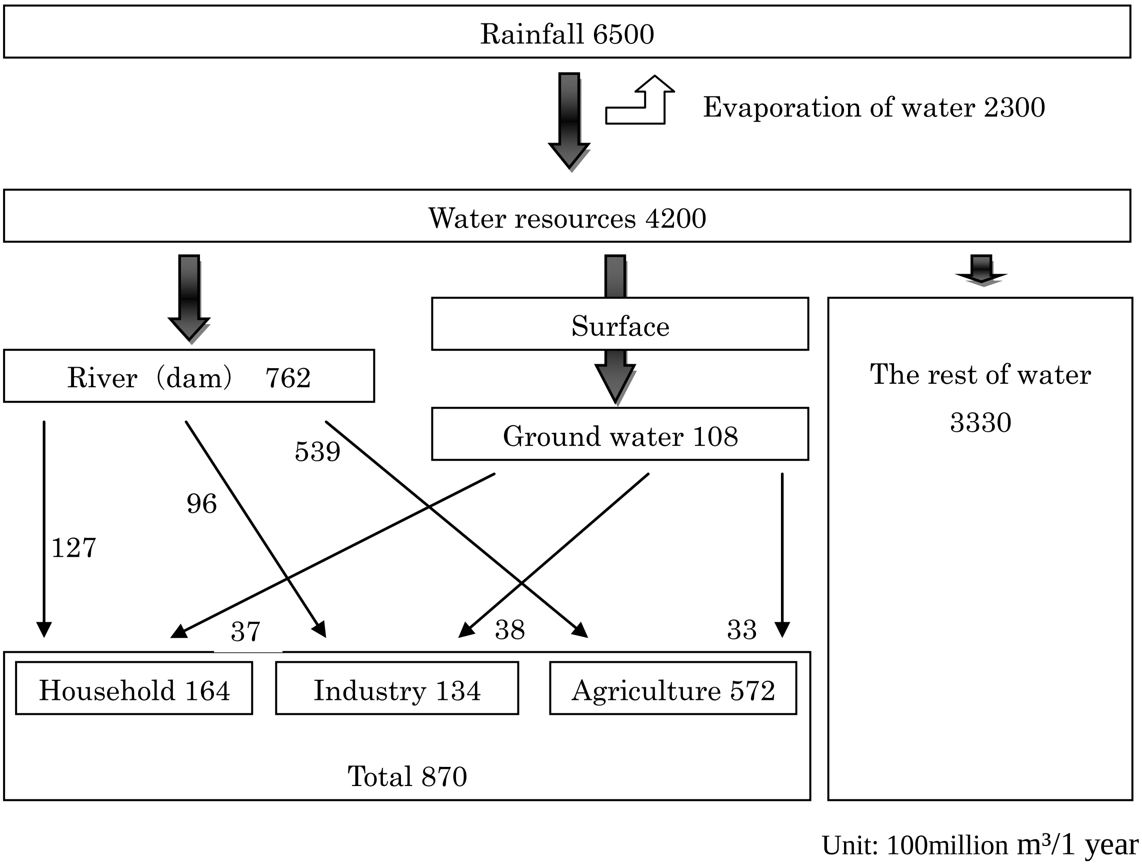

Figure 1　The demand and supply of fresh water in Japan

Source: Ministry of Land, Infrastructure, Transport and Tourism, Water Resources Department (2008)