Water Footprint Analysis in Kanto basin zone, Japan by compiling the Kanto Interregional Input-Output Table

Taku Ishiro
Ryutsu Keizai University, Faculty of Economics, Lecturer
210 Hirahata, Ryugasaki-city, Ibaraki-prefecture, Japan
e-mail: ishiro-taku@rku.ac.jp

Abstract

We have a detailed picture of water inducement of Kanto region, Japan as water footprint. To analyze water footprint in Kanto region we compile the Kanto Interregional Input-Output Table. Previously we have interregional input output table in Japan among Kanto Hokkaido Tohoku Chubu Kinki Chugoku Shikoku Kyushu and Okinawa made by Ministry of Economy Trade, and Industry. However we don't have interregional input output table within the Kanto region, compared to Kinki region which is made by KISER. Therefore it is significant to compile the Kanto Interregional Input-Output Table. We decide the range of Kanto region, Tokyo Kanagawa Chiba Saitama Ibaraki Gunma Tochigi Niigata Nagano Yamanashi and Shizuoka. Therefore we compile the Kanto Interregional Input-Output Table as 11 regions by 28 sectors. Kanto region include Tokyo Metropolitan area which have 30 Million inhabitants.

Basically the estimation about interregional trade of Kanto region is operated by the census of logistics in Japan. Secondly we estimate the water use by sector about 11 regions by census of manufactures. The method of calculation of regional water footprint is based on the model of interregional inducement by input output analysis. The result is that Tokyo Metropolitan area such as Tokyo Kanagawa Saitama Chiba leave water footprint towards surrounding area such as Ibaraki Tochigi Niigata Shizuoka. The result has important information that some region uses their water for other region. The result also gives useful information for regional water management.

Keywords: Compilation of Interregional input output table, Water footprint, Water inducement of regional linkages.

1. Introduction

The 10th meeting of the Conference of the Parties (COP10) to the Convention on Biological Diversity (CBD) ended in Nagoya, Aichi Prefecture, on Oct. 30.2010. Previously, The Millennium Ecosystem Assessment (MA) concluded concludes that human activity is having a significant and escalating impact on the biodiversity of world ecosystems, reducing both their resilience and biocapacity. Additionally, MA included the sub-global assessment (SGA) that is the assessment of regional, watershed, state as well as the global scale. In Japan SATOYAMA SATOMI SGA is put into practice by using SGA framework. We chose the Hokkaido Tohoku Kanto-Chubu Hokuriku Nishi-nihon cluster as the area of SATOYAMA SATOMI SGA. Above all, Kanto-Chubu cluster has four sites that is Kanagawa Tochigi Chiba Tokyo and the scope of target is Tokyo Bay, Naka River, Ise Bay, Mikawa Bay.

The author collaborates with the researcher of Kanagawa site and studies the impact of ecological system through the change of socio-economy of Kanagawa, Ishiro and Hasebe(2010).

The Objective of this paper is to clarify the relation between economic activity and structure of water usage in Kanto region, based on SATOYMA SATOMI SGA.

Especially, having regard to the fact that trade with other regions is essential to regional activity, the main purpose is to see how trading of each region within Kanto region affects the water usage of Kanto area.

There is previous study, Okadera, Fujita, Watanabe and Suzuki (2005), that has common awareness of the issues. They made Kanto interregional input output table including seven regions of Kanto area, the year 1995 and estimated the water demand of this region. On the other hand, our study made Kanto interregional input output table including 11 regions.

2. Previous study

There are many studies that analyze the CO_2 emission Land and Waste by using interregional input output tables. As for water, the studies of Niizawa(1988), Okadera, Fujita, Watanabe and Suzuki (2005), Shimoda Watanabe Yue , and Fujikawa(2009) are representative research in Japan. Or there is earlier research of input output study, Carter and Ireli(1970). Niizawa(1988) reveals the balance of water inducement between Chiba and Ibaraki by using regional input output tables. Judging from the result of this analysis he speculates the high water dependency of Tokyo to other region.

In Okadera, Fujita, Watanabe and Suzuki (2005) they target six regions including

Tokyo as Tokyo Bay Basin and estimate the structure of water demand of this area by compiling the interregional input output table of six regions. They conclude water demand of Chiba Kanagawa Ibaraki is high compared to the one of Tokyo however water inducement from consumption of Tokyo derives from other region over 50 percent. In Shimoda Watanabe Yue, and Fujikawa(2009), they analyze the embedded water trade with CO_2 energy land by using Asian international input output table made by IDE-JETRO. They concluded the maximum user of water is China, and the maximum transfer of embed water is transfer from China to Japan. Additionally Japan support oneself through domestic water about only 66%, they import largest amount of water from China. In Carter and Ireli(1970) , they calculate water transfer between Arizona and California by using two interregional input-output table between Arizona and California in 1958. They conclude in the actual trade of goods between Arizona and California export from California to Arizona is four times larger than import from Arizona to California, on the other hand in water transfer import from Arizona to California is three times larger than export from California to Arizona.

In the study, we expand the geographical area from seven regions in Okadera, Fujita, Watanabe and Suzuki (2005) to eleven regions and expand the estimation of sectoral water use from Kanagawa in Ishiro and Hasebe(2010) to other regions. In method of analysis we refer to the method of Shimoda Watanabe Yue, and Fujikawa(2009). Additionally we have same problem consciousness that in water transfer considering inter regional economic activity the region have large scale of economic activity depends on other region have water resource in earlier work of Carter and Ireli(1970).

3. The compilation of Kanto interregional input output table and water usage data

In this paper we compile the Kanto interregional input output table about 11regions. Additionally we made the sectoral water usage data in accordance with the sector of Kanto interregional input output table that we made. As for the compilation of Kanto interregional input output table we noted **appendix1**. As for the compilation of the sectoral water usage data we noted **appendix 2**. As for the area classification we noted **figure1**.As for the sector classification of input output table we noted **figure 2**. As for the tabular form of Kanto interregional input output tables we noted **figure 3**. As for the water usage data of 11 regions we noted **figure 4**.

Figure 1, Area classification of Kanto region

Figure 2, Sector classification

1	Agriculture, forestry and fishery	15	Precision instruments
2	Mining	16	Miscellaneous manufacturing products
3	Beverages and Foods	17	Construction
4	Textile products	18	Electricity, gas and heat supply water supply
5	Pulp, paper and wooden products	19	Commerce
6	Chemical products	20	Finance and insurance
7	Petroleum and coal products	21	Real estate
8	Ceramic, stone and clay products	22	Transport
9	Iron and steel	23	Information and communications
10	Non-ferrous metals	24	Education and research
11	Metal products	25	Public administration
12	General machinery	26	Business services
13	Electrical machinery	27	Personal services
14	Transportation equipment	28	Activities not elsewhere classified

Figure 3, tabular form of Kanto interregional input output tables

		intermediate demand											final demand											export	export to ROJ	production
		Tokyo	Kanagawa	Chiba	Saitama	Ibaraki	Tochigi	Gunma	Niigata	Nagano	Yamanashi	Shizuoka	Tokyo	Kanagawa	Chiba	Saitama	Ibaraki	Tochigi	Gunma	Niigata	Nagano	Yamanashi	Shizuoka			
intermediate input	Tokyo																									
	Kanagawa																									
	Chiba																									
	Saitama																									
	Ibaraki																									
	Tochigi																									
	Gunma																									
	Niigata																									
	Nagano																									
	Yamanashi																									
	Shizuoka																									
import from ROJ																										
import																										
Value added																										
production																										

Figure 4, water usage data unit; million cubic meters

		Tokyo	Kanagawa	Chiba	Saitama	Ibaraki	Tochigi	Gunma	Niigata	Nagano	Yamanashi	Shizuoka	Total
1	Agriculture, forestry and fishery	19	114	1,678	1,081	2,210	2,111	686	3,102	1,137	198	594	12,931
2	Mining	0	0	0	0	0	0	0	1	0	0	0	2
3	Beverages and Foods	38	75	51	33	46	22	43	24	37	12	61	444
4	Textile products	2	1	0	4	1	8	10	17	2	3	45	93
5	Pulp, paper and wooden products	94	4	16	73	44	21	3	63	17	6	547	888
6	Chemical products	19	121	150	16	107	3	22	205	2	2	159	809
7	Petroleum and coal products	0	37	43	0	13	0	0	4	0	0	0	97
8	Ceramic, stone and clay products	6	8	11	17	17	9	7	17	8	4	32	136
9	Iron and steel	4	55	167	7	115	19	7	9	2	0	1	385
10	Non-ferrous metals	2	6	0	0	1	2	1	2	1	2	25	42
11	Metal products	8	5	12	10	11	12	21	5	5	1	9	99
12	General machinery	4	9	2	5	9	4	6	10	7	3	10	69
13	Electrical machinery	10	18	12	20	19	10	21	22	25	12	13	181
14	Transportation equipment	5	14	1	8	2	14	10	1	3	1	22	82
15	Precision instruments	2	1	0	1	1	2	0	0	4	2	4	19
16	Miscellaneous manufacturing products	15	14	10	18	19	20	25	4	7	8	36	176
17	Construction	35	15	11	11	7	4	4	7	6	2	9	112
18	Electricity, gas and heat supply water supply	118	68	57	36	27	11	13	40	15	4	29	419
19	Commerce	27	5	3	4	2	1	1	2	1	0	3	50
20	Finance and insurance	38	4	3	3	1	1	1	1	1	1	2	57
21	Real estate	31	14	8	10	3	2	2	3	3	1	5	83
22	Transport	62	22	21	16	9	4	4	6	5	2	12	164
23	Information and communications	32	8	5	6	2	2	2	2	2	1	3	64
24	Education and research	63	61	31	36	24	13	14	8	9	5	13	275
25	Public administration	75	18	11	13	6	5	5	13	10	4	17	177
26	Business services	94	13	7	6	3	2	2	3	2	1	4	135
27	Personal services	323	89	69	61	27	24	23	24	27	10	47	725
28	Activities not elsewhere classified	2	1	0	0	0	0	0	0	0	0	0	5
	Private consumption	1,182	952	664	739	277	175	217	216	200	73	313	18,721
	Total	2,314	1,754	3,043	2,235	3,006	2,506	1,152	3,810	1,538	357	2,015	37,443

4. The models

We use basically the same model of the one of Ishiro and Hasebe(2010). However in Ishiro and Hasebe(2010) we consider the single region model because we use the single input-output table in Kanagawa. Meanwhile in this time we apply the interregional input output about water inducement models because we use the Kanto interregional input output tables that we compile.

We indicate the model of simplified version about two endogenous regions and one exogenous region. The formula 1 denote as follows.

$$\begin{bmatrix} \mathbf{x}_1 \\ \mathbf{x}_2 \end{bmatrix} = \begin{bmatrix} \mathbf{A}_{11} & \mathbf{A}_{12} \\ \mathbf{A}_{21} & \mathbf{A}_{22} \end{bmatrix} \begin{bmatrix} \mathbf{x}_1 \\ \mathbf{x}_2 \end{bmatrix} + \begin{bmatrix} \mathbf{f}_{11} + \mathbf{f}_{12} + \mathbf{f}_{13} \\ \mathbf{f}_{21} + \mathbf{f}_{22} + \mathbf{f}_{23} \end{bmatrix} \quad (1)$$

$\mathbf{x}_i$ denotes domestic products of i regions, $\mathbf{A}_{ij}$ denotes input coefficient　if i=j it represents intermediate goods within this region,　if $i \neq j$ input coefficient of import intermediate goods from i region to j region. $\mathbf{f}_{ij}$ denotes final demand of j region about the goods of i region. $\mathbf{f}_{i3}$denotes the export to exogenous region. $\mathbf{I}$ denotes unit matrix.

If we development formula 1, we get formula 2 as follows.

$$\begin{bmatrix}\mathbf{x}_1\\ \mathbf{x}_2\end{bmatrix}=\left[1-\begin{bmatrix}\mathbf{A}_{11} & \mathbf{A}_{12}\\ \mathbf{A}_{21} & \mathbf{A}_{22}\end{bmatrix}\right]^{-1}\begin{bmatrix}\mathbf{f}_{11}+\mathbf{f}_{12}+\mathbf{f}_{13}\\ \mathbf{f}_{21}+\mathbf{f}_{22}+\mathbf{f}_{23}\end{bmatrix}=\begin{bmatrix}\mathbf{B}_{11} & \mathbf{B}_{12}\\ \mathbf{B}_{21} & \mathbf{B}_{22}\end{bmatrix}\begin{bmatrix}\mathbf{f}_{11}+\mathbf{f}_{12}+\mathbf{f}_{13}\\ \mathbf{f}_{21}+\mathbf{f}_{22}+\mathbf{f}_{23}\end{bmatrix} \tag{2}$$

If $\mathbf{w}_i$ denotes unit of water use of i region, $\mathbf{h}_i$ represents water intensity formula 3 as follows.

$$\begin{bmatrix}\mathbf{h}_1 & \mathbf{h}_2\end{bmatrix}=\begin{bmatrix}\mathbf{w}_1 & \mathbf{w}_2\end{bmatrix}\begin{bmatrix}\mathbf{B}_{11} & \mathbf{B}_{12}\\ \mathbf{B}_{21} & \mathbf{B}_{22}\end{bmatrix} \tag{3}$$

About water inducement in each region, we divide the final demand of formula 2 into region 1 region 2 and region3 and if $\mathbf{W}_i$ denotes diagonal matrix of $\mathbf{w}_i$, we get formula 4 as follows.

$$\mathbf{L}=\begin{bmatrix}\mathbf{W}_1 & 0\\ 0 & \mathbf{W}_2\end{bmatrix}\begin{bmatrix}\mathbf{B}_{11} & \mathbf{B}_{12}\\ \mathbf{B}_{21} & \mathbf{B}_{22}\end{bmatrix}\begin{bmatrix}\mathbf{f}_{11} & \mathbf{f}_{12} & \mathbf{f}_{13}\\ \mathbf{f}_{21} & \mathbf{f}_{22} & \mathbf{f}_{23}\end{bmatrix} \tag{4}$$

$\mathbf{L}$ denotes two by three matrix. The column side of the matrix means the region that generates final demand. The Row side of the matrix means the region that is done by water inducement. In the analysis of this thesis there are eleven endogenous regions and two exogenous regions including rest of Japan and abroad therefore $\mathbf{L}$ denotes eleven by thirteen matrix.

5. The result of analysis

In this chapter we summarize the analysis of water footprint of Kanto region. Figure 5 shows the result of calculation based on formula (3). Grey cells shows the diagonal factor that represents water inducement of its own demand in its own region additionally the non-diagonal factor that represents top 10 score of water inducement within the Kanto region except diagonal factor. Furthermore in the row direction figure 5 shows the water inducement that occurs in the other regions based on demand in its region in the column direction water inducement that occurs in its region based on demand in other regions.

Figure 5, Kanto interregional water inducement unit; million cubic meters

	Tokyo	Kanagawa	Chiba	Saitama	Ibaraki	Tochigi	Gunma	Niigata	Nagano	Yamanashi	Shizuoka	ROJ	ROW	Total
Tokyo	690	46	31	67	17	8	9	9	9	3	10	169	62	1,132
Kanagawa	50	354	28	35	11	9	11	5	7	3	16	198	73	802
Chiba	535	150	708	117	117	38	39	24	17	7	30	472	123	2,379
Saitama	372	77	99	578	36	20	45	13	10	2	8	203	32	1,496
Ibaraki	821	173	181	135	430	78	76	13	12	4	39	679	88	2,729
Tochigi	289	134	95	260	55	387	181	49	23	7	30	780	40	2,330
Gunma	77	42	33	65	31	34	273	6	7	2	7	337	20	935
Niigata	166	122	65	210	38	44	62	1,108	169	9	18	1,485	100	3,595
Nagano	94	56	48	67	9	7	25	27	358	50	20	547	31	1,339
Yamanashi	56	12	13	31	3	1	3	1	6	62	6	75	15	284
Shizuoka	98	160	63	109	37	18	20	11	27	17	309	752	80	1,702
Total	3,248	1,327	1,365	1,674	784	643	744	1,267	646	168	493	5,697	664	

First of all we focus on Tokyo. There are seven billion cubic meter of water inducement in its region out of water demand in its region. However there are eight billion cubic meter of water inducement in Ibaraki and five billion cubic meter of water inducement in Chiba because of water demand of Tokyo. Therefore the fact shows that water demand of Tokyo caused large water inducement in other region like Ibaraki and Chiba etc. On the other hand the fact that water demand of other regions caused comparatively small water inducement in Tokyo leads to the Tokyo's dependency of water resource to other regions. Secondly in Kanagawa there is water inducement in Ibaraki Chiba and Shizuoka because of water demand of Kanagawa. On the other hand water inducement in Kanagawa for the other region is largest amount to Tokyo. In this regard Kanagawa have same characteristic as Tokyo that water demand in its region cause the large water inducement in other region. For that reason Kanagawa also have large dependency on water resources of other region same as Tokyo. In contrast Chiba have different feature as Tokyo metropolitan district. The water inducement in other region by water demand of Chiba is comparatively small. On the other hand in Chiba water inducement in its region for water demand of other region is large such as for water demand of Tokyo Kanagawa Ibaraki Saitama. For this reason Chiba assume water use of other region. This trend is especially obvious in Ibaraki. Ibaraki assume the most water use of other endogenous region in Kanto area. On one hand Saitama causes large water inducement in Tochigi Niigata by its water demand and assume the water demand in Tokyo. Additionally Niigata has a high self sufficiency of water because it has the most powerful trend that water inducement in Niigata is largely attribute to the its own water demand. As for the water inducement of its own region by the water demand of other region, water inducement in Niigata causes by water demand of rest of Japan. For that reason it would appear that geographical proximity of

Niigata to exogenous region, rest of Japan leads to strong linkage between Niigata and exogenous region. These things apply to Shizuoka. It shows from the column sum of **figure 5** that in the total water inducement by its own water demand Tokyo is 1st Saitama is 2st Chiba Kanagawa. It shows from the column sum of **figure 5** that in the total water inducement by its own water demand Tokyo is 1st Saitama is 2st Chiba Kanagawa. It shows from the row direction of **figure 5** that in total water inducement in its own region by water demand of other region Niigata is 1st Ibaraki is 2st Chiba Tochigi. The water inducement in Tochigi largely causes by water demand of Saitama however there is hardly any water inducement in Saitama by water demand of Tochigi. For that reason we find that Saitama depends on water resources of Tochigi. The largest water inducement among the Kanto endogenous region is water inducement in Ibaraki by demand of Tokyo. The second largest is inducement in Chiba by Tokyo. The third largest is in Saitama by Tokyo. Next are in Tochigi by Tokyo, Tochigi by Saitama and so on. In the water inducement by demand of rest of Japan Niigata is 1st. Next is Tochigi Shizuoka Ibaraki. In the water inducement by demand of foreign country Chiba is 1st. Next is Niigata Ibaraki Shizuoka.

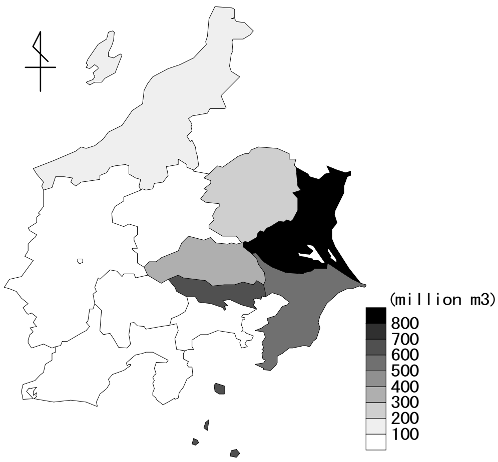
We plot the information of **figure 5** on geographical information for the sake of understandable way. We can see the water inducement in each region by the demand of the region that is noted on the map including its own region. For instance water inducement in other region by demand of Tokyo is largest in Ibaraki. Next is Chiba. This information easily figures out the contrasting density on the map.

These results of analysis by the calculation of water footprint among Kanto region considering input output linkages of each region give us important suggestion to SATOYAMA SATOMI SGA that analyze the burden of socio-economic activity toward ecological systems. In broad point of view these result give us important information about region that receives the burden of water use and gives it the burden of water use.

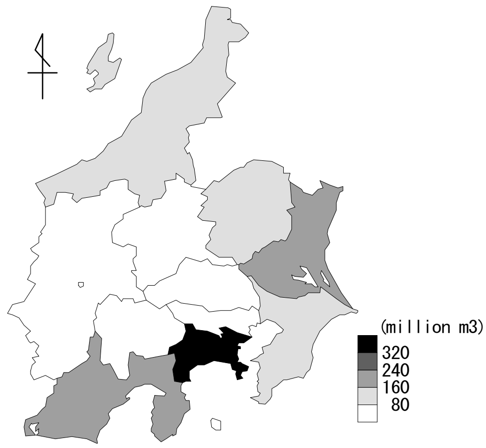
These results request that considering the whole water resources of Kanto region the region that gives other regions the burden of water use should work on conservation and maintenance of water environment in the region that receives the burden of water use.

Figure 6, Water inducement from demand of each region

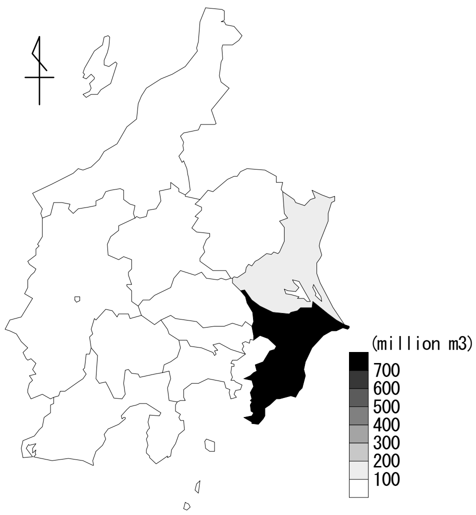
Tokyo



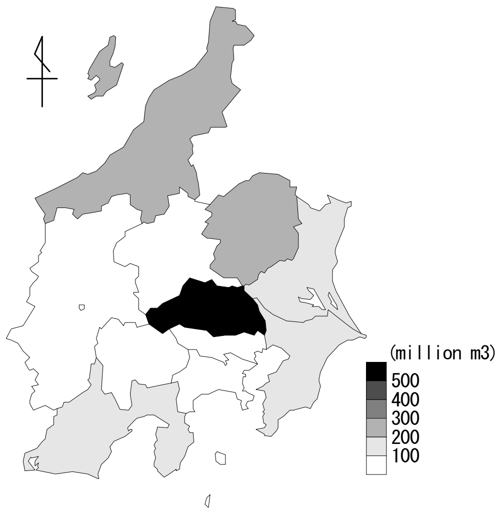
Kanagawa



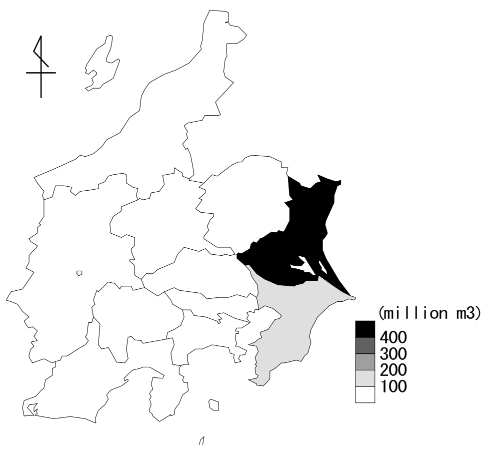
Chiba



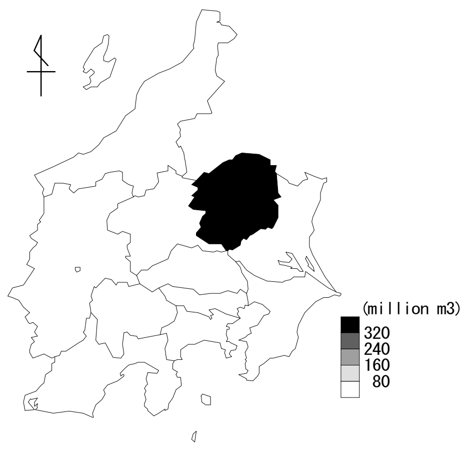
Saitama



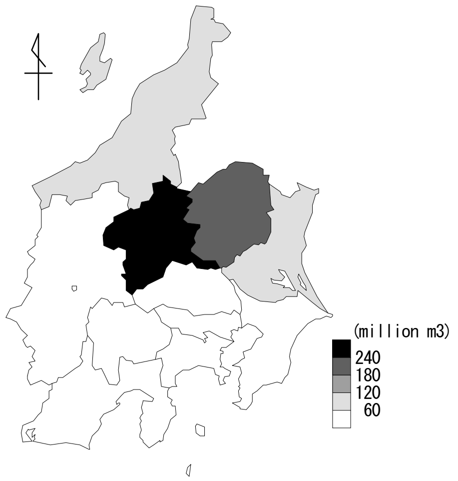
Ibaraki



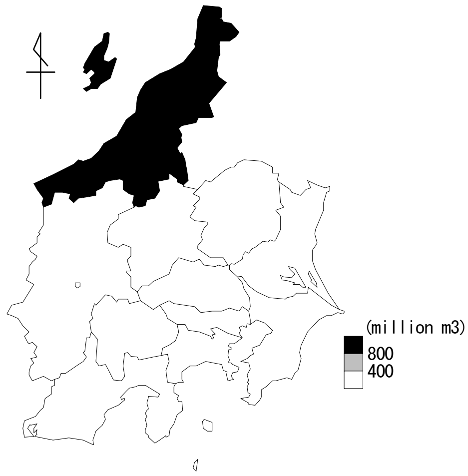
Tochigi



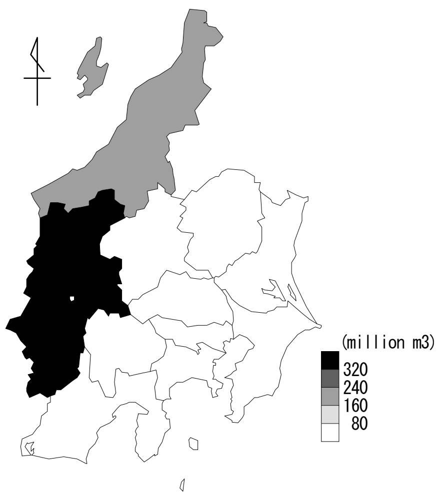
Gunma



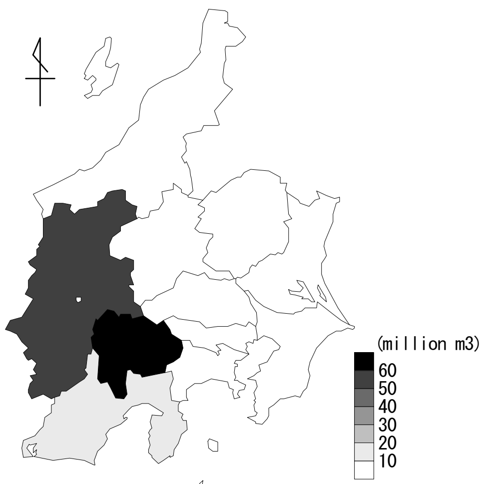
Niigata



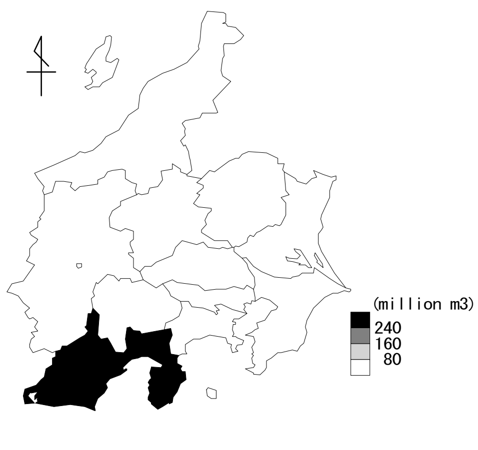
Nagano



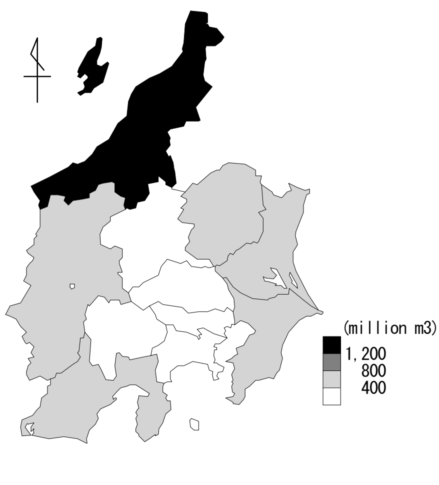
Yamanashi



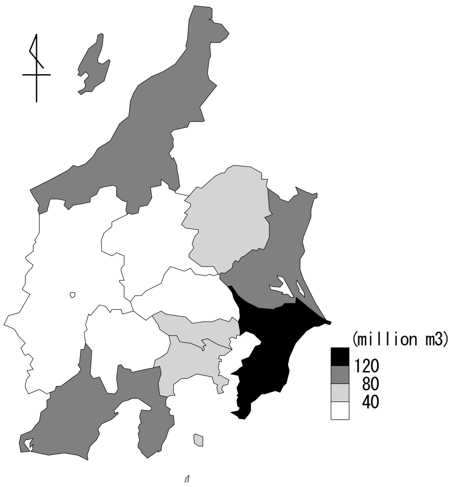
Shizuoka



Rest of Japan



Foreign country



6. Conclusion

In this study about Kanto region after we made Kanto interregional input output table including 11 regions and made the sectoral water usage data in accordance with such input output table we analyze the water inducement within Kanto region and among Kanto region and rest of Japan and foreign country. The result of this study is as follows.

First in Tokyo water inducement in its region by demand of other region is small however water inducement in other region such as Ibaraki and Chiba by demand of Tokyo is large. Kanagawa has same trend that water inducement in other region such as Ibaraki and Chiba and Shizuoka by demand of Kanagawa is large. Secondly Saitama has different trend in Tokyo metropolitan district that water inducement in other regions such as Tochigi and Niigata and Ibaraki. On the other hand water inducement in its region by demand of Tokyo is large. Thirdly in Chiba water inducement in its region by demand of Tokyo is large. On the other hand the water inducement in Ibaraki by demand of Chiba is large. Fourthly for that reason Ibaraki assume the water demand of Tokyo metropolitan district. It has large water trade surplus. In other words Tokyo metropolitan district give Ibaraki "water footprint."

Previous study using input output analysis about water indicate the same feature that because the region has the large economic scale has also large scale of consuming region and in the generality rarely has enough water resources, it depends on water resources of other regions. Even as the result of this study basically shows same feature we find that a central focus on Tokyo gives surrounding area the burden of water inducement. On that basis for the situation of footprint we indicate the stuff that the region that give other region burden of water inducement should positively act for the reform of water environment.

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Appendix 1

In this study for the analysis of water footprint in Kanto region we made Kanto interregional input output table. The target year for input output table is in 2000. As Kanto region we choose the 11 regions about Tokyo Kanagawa Chiba Saitama Ibaraki Tochigi Gunma Niigata Nagano Yamanashi Shizuoka. First we aggregate each regional input output table about 11 regions into 28 sectors within the common sector code. As for the estimation of trade within Kanto region, we do as follows. From 1 Agriculture, forestry and fishery to16 Miscellaneous manufacturing products we divide the export to rest of Japan in each region according to the ratio compiling from census of logistics in 2000. From 17 Construction to 28 Activities not elsewhere classified we distribute the export to rest of Japan based on the assumption that export to each Kanto region is proportional to regional demand in each region. Finally we adjust the balance of column and row of the table we made. We complete the Kanto interregional input output table.

Appendix 2

In this research we made sectoral water usage data in accordance with Kanto interregional input output table based on the method of Ishiro and Hasebe(2010) which made sectoral water usage data of single region, Kanagawa.

As for the water usage data of agriculture from the data of irrigation water for paddy field and irrigation water for dry field in Japan and the data of cultivated acreage of paddy fields or dry fields we calculate the unit water usage data per hectare of each field in Japan. Then multiplying the unit water usage in Japan by the data of cultivated acreage of paddy fields or dry fields in each region gives the water usage data by each region. As for the water usage data of manufactures from the industrial water of each region in census of manufactures we can acquire the data of new water usage per day by removing the recovered from the fresh water. Afterward multiplying the data of new water usage per day by the number of operating day, 250 days that we assume that every sectors has same operating day same as Ishiro and Hasebe(2010), gives the data of new industrial water usage per year. As for other sector by using the data of unit water use by sector in Tsurumaki and Noike(1997) multiplying the unit water use by sector by the volume of production in each sector of each region gives the water usage data by sector.