CGE Approach to Assess the Impacts of Water Scarcity due to Climate Change in Japan

:Focus on Agriculture Sector

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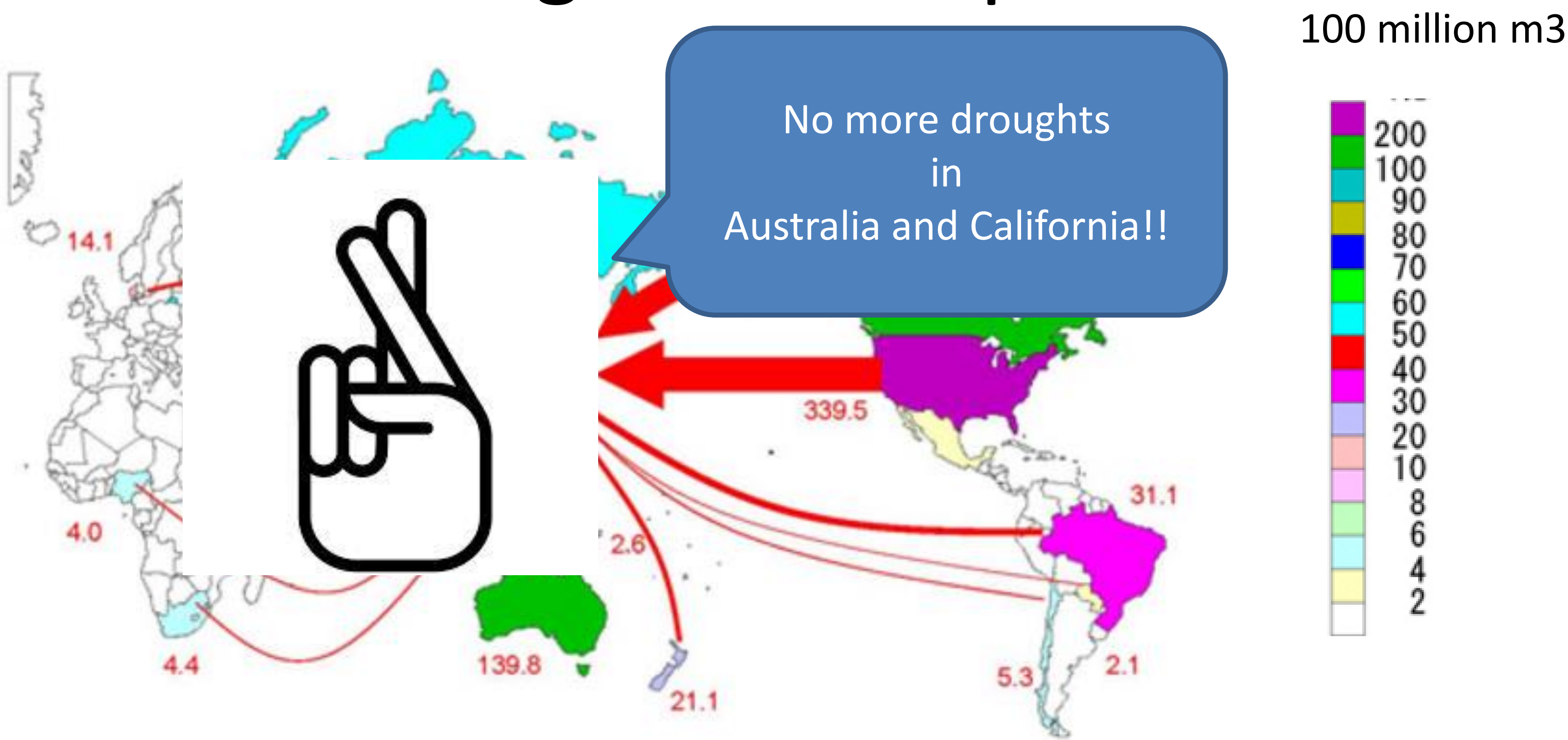
Contents

I. Introduction & Motivation

- Japan is surrounded by sea and little attention is paid to domestic water management.
- Volatile weather change, frequent drought and flood and continuous climate change, increasing temperature and increasing number of non-rain days and decreasing snowfall, bring about water scarcity impacts.
- There is no research on water scarcity effects from economic point of view.
- Partial economic model is unable to provide indirect effects of changes, but CGE (computable general equilibrium) model provide more complete welfare assessment, incorporating constraints and feedbacks between different economic sectors and agents.
- We develop CGE model which include water sector and estimate how water scarcity impact spread in Japanese economy and estimate water market benefits.

II. WATER ISSUE IN JAPAN

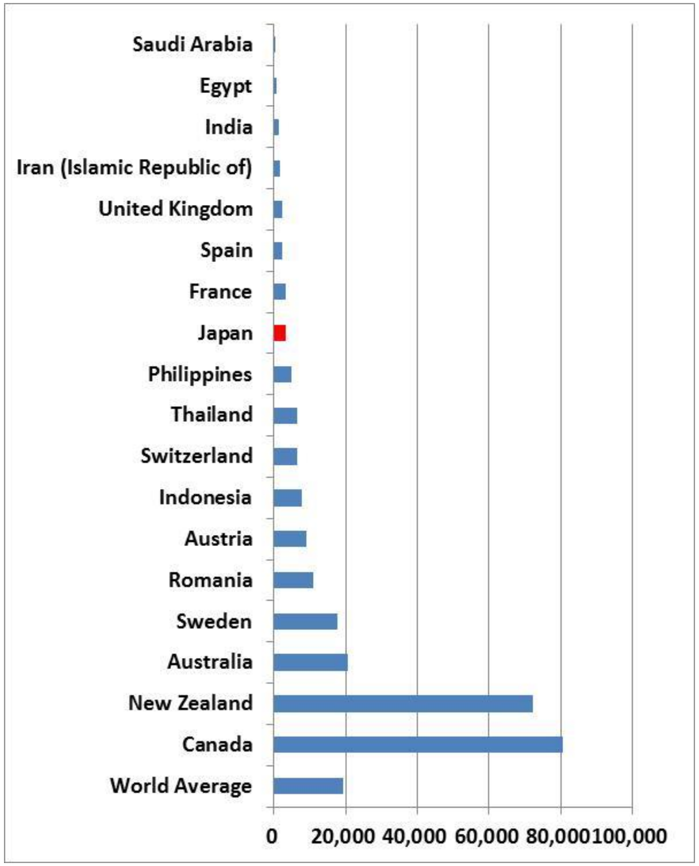
Japan Water Issue was Virtual Water through Food Imports



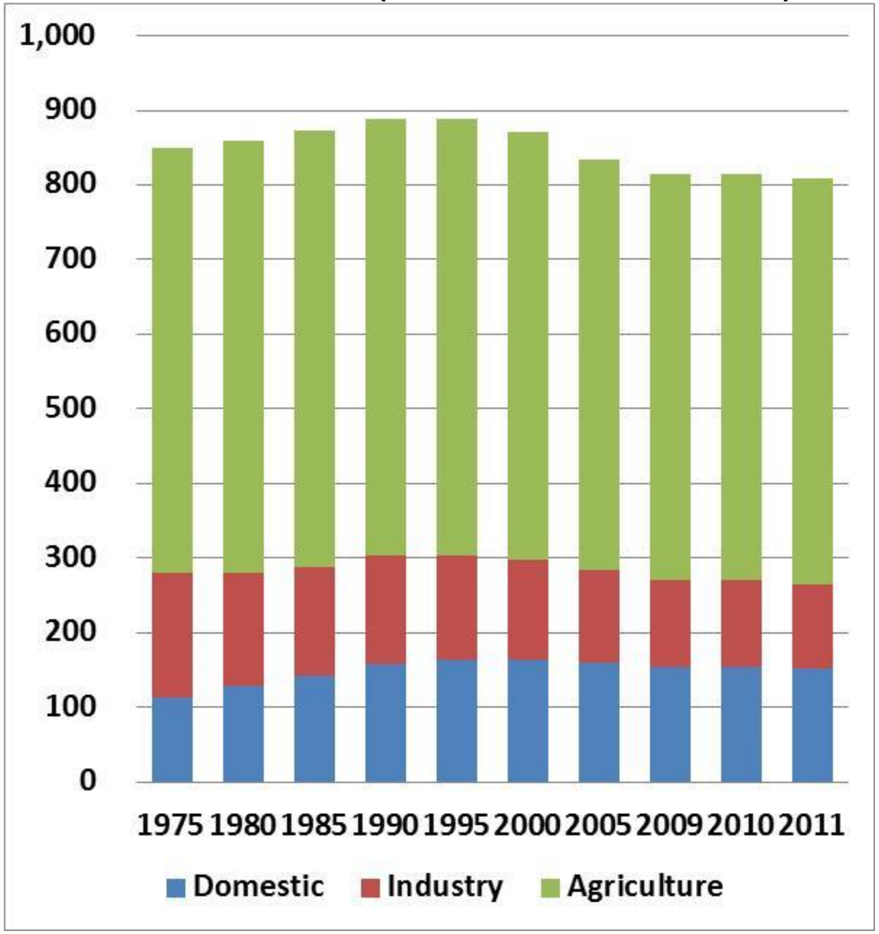
Source: MoE, https://www.env.go.jp/water/virtual_water/img/img_big.jpg

Water Resource and Demand

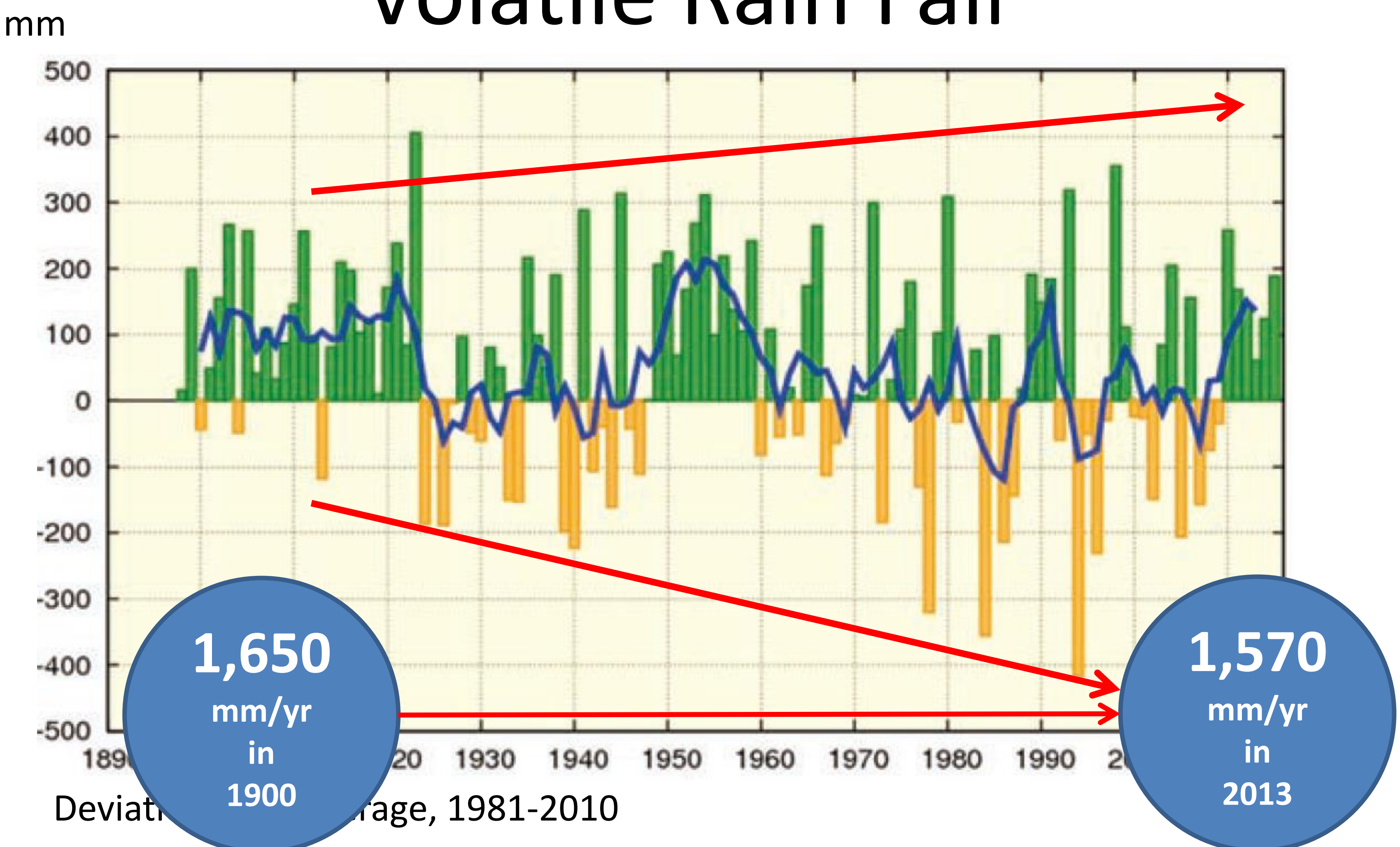
- renewable water resources per capita (m3/inhab/year)



- Water Demand (100 million m3/Year)

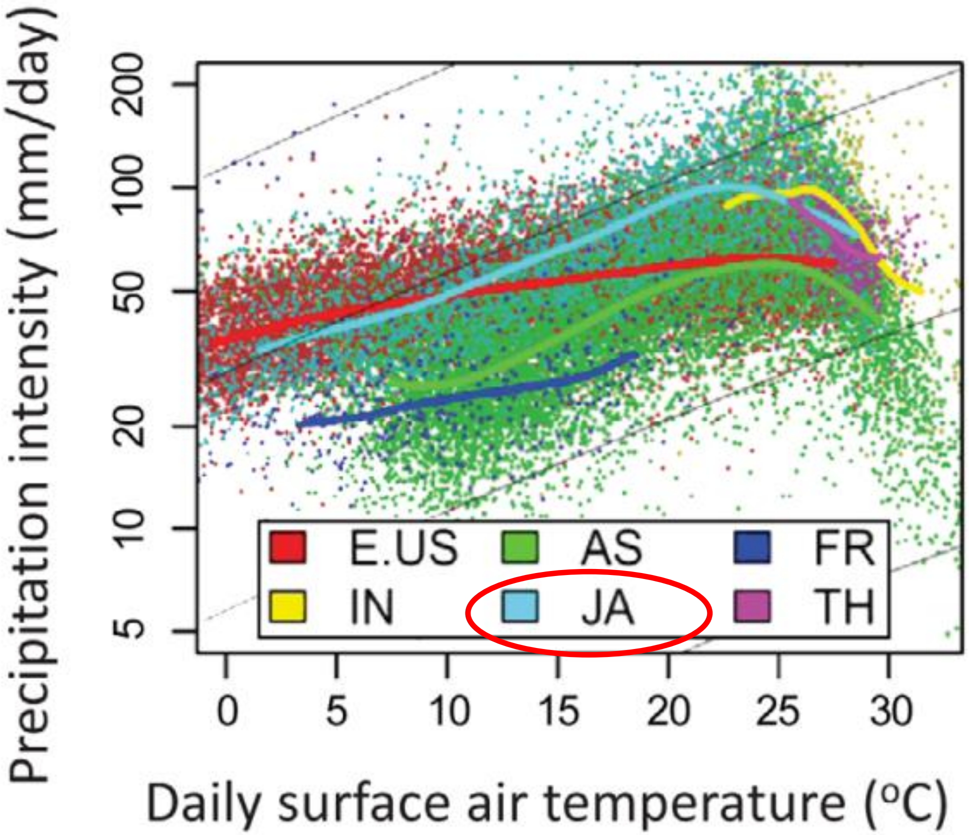


Volatile Rain Fall



Deviati... rage, 1981-2010

Increasing Precipitation Intensity



- High Temperature
- High Precipitation Intensity
- Decline of Rainfall
- Volatile Rainfall
- Decline of Snowfall

- High Frequency of Drought
- Low Water Supply

Source: Utsumi et. al., (2011)

Customary Water rights are socially accepted on the basis of custom and practice of water use for a long time by the enactment of the River Law. Those are recognized by the Law and "look upon" as water rights perm

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- Still Customary Water Rights have been Major One in Agriculture Sector.
- Water Rights are tighted to Land Ownership.

Pe…

Ra… measure amount of intake water clearly. While permitted water right holders are clearly defined with water quantity, customary water intake is sometimes defined only by the means of intake.	… the applied quantity of water intake. (2) accept 10 years of the validity newly. (3) introduce intake limit of each period in a year. (4) measure intake water daily and report annually.

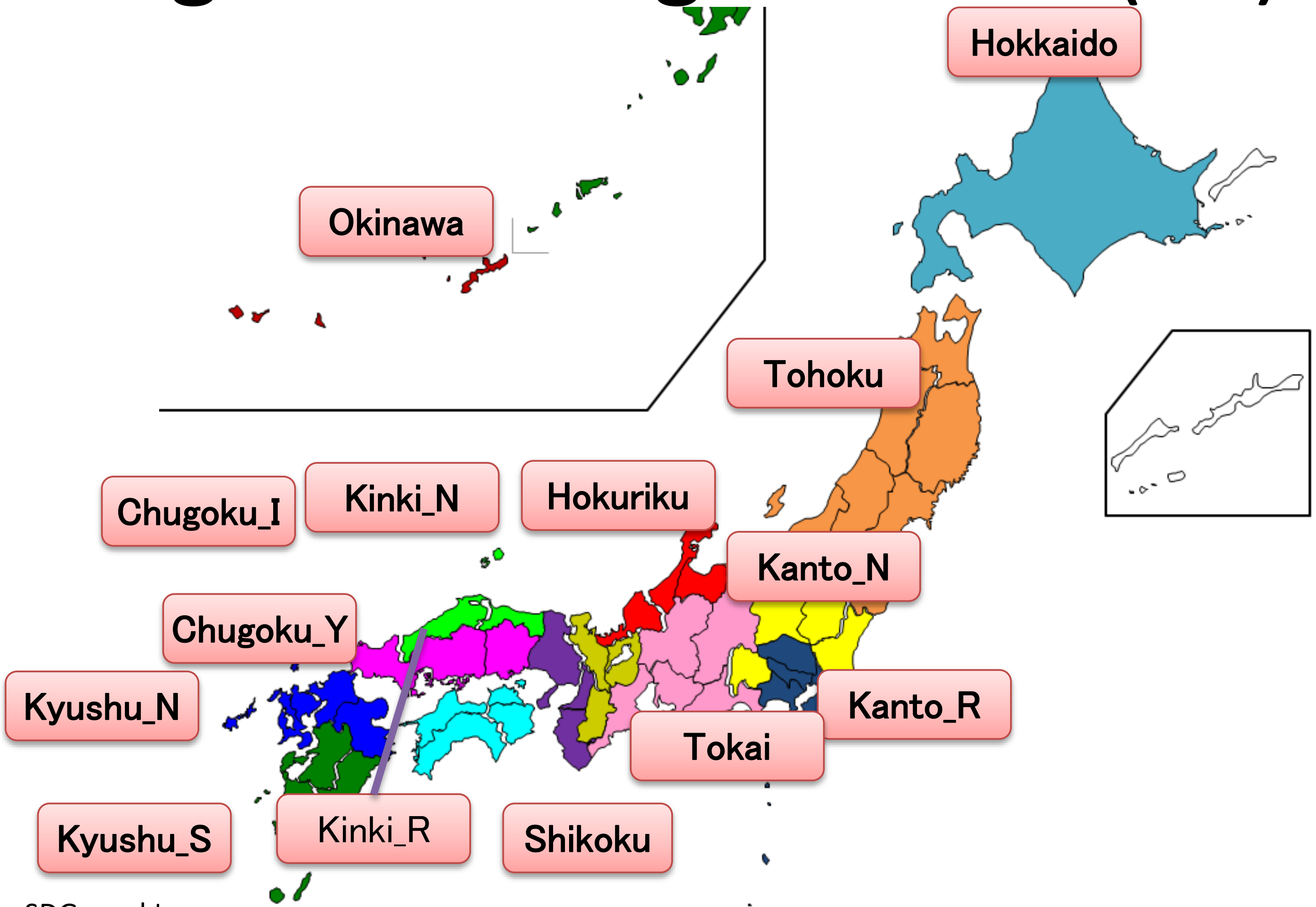
Source: MAFF

III. METHODOLOGIES

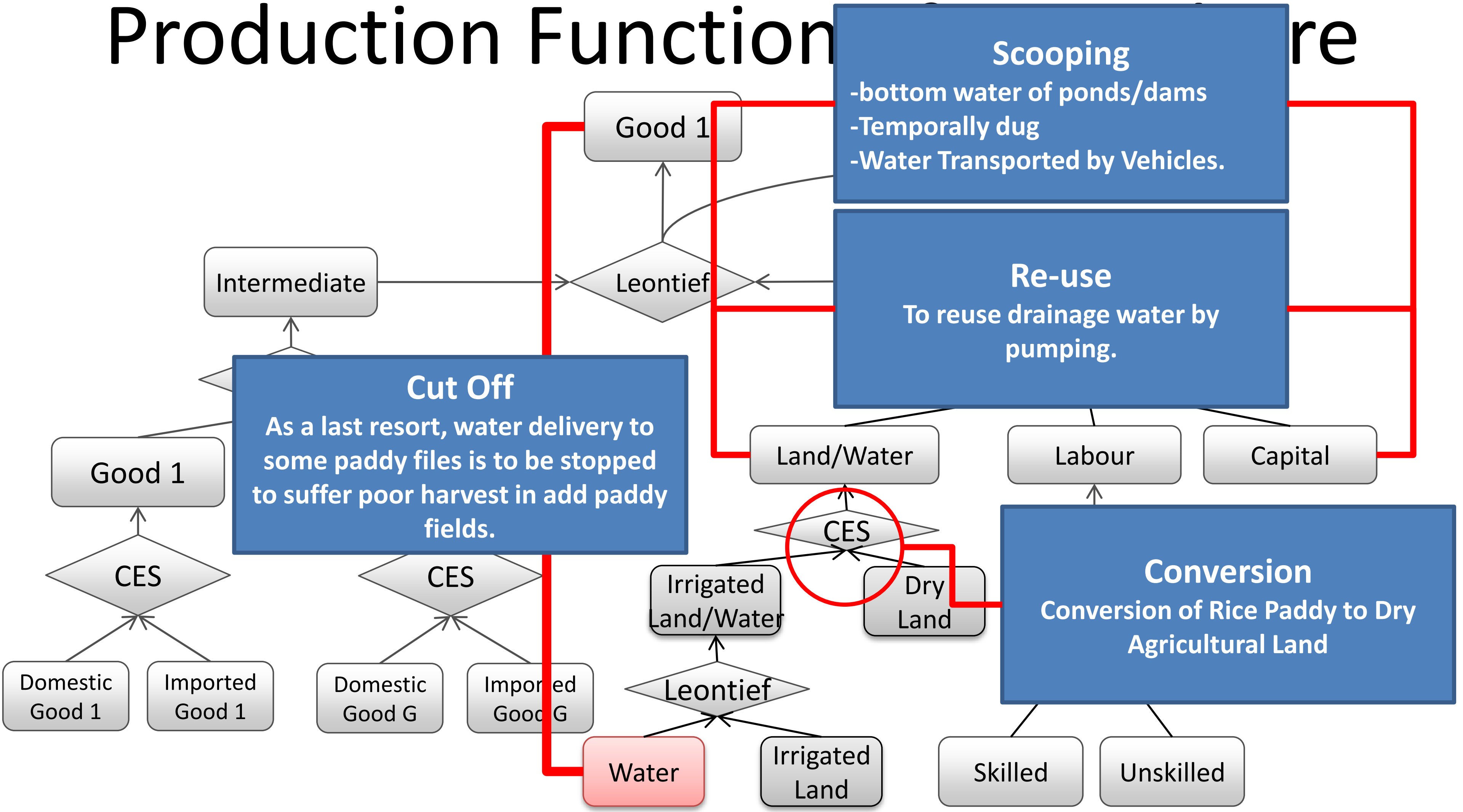
TERM_J_Water

- Partial economic model is unable to provide indirect effects of changes, but CGE (computable general equilibrium) model can provide more complete welfare assessment, incorporating constraints and feedbacks between different economic sectors and agents.
- TERM Model was originally developed by COPs (Centre of Policy Studies), Victoria University and a multi-regional Australia CGE model.
- TERM version for Japan was constructed by Yamamoto, from 104-sector and distinguishing 47 bottom-up regions
- In this research, we have incorporated water consumption module to TERM model version for Japan and aggregated regions to 14 regions to fit to water consumption statistics.

Regional Categorisation (14)



Production Function re



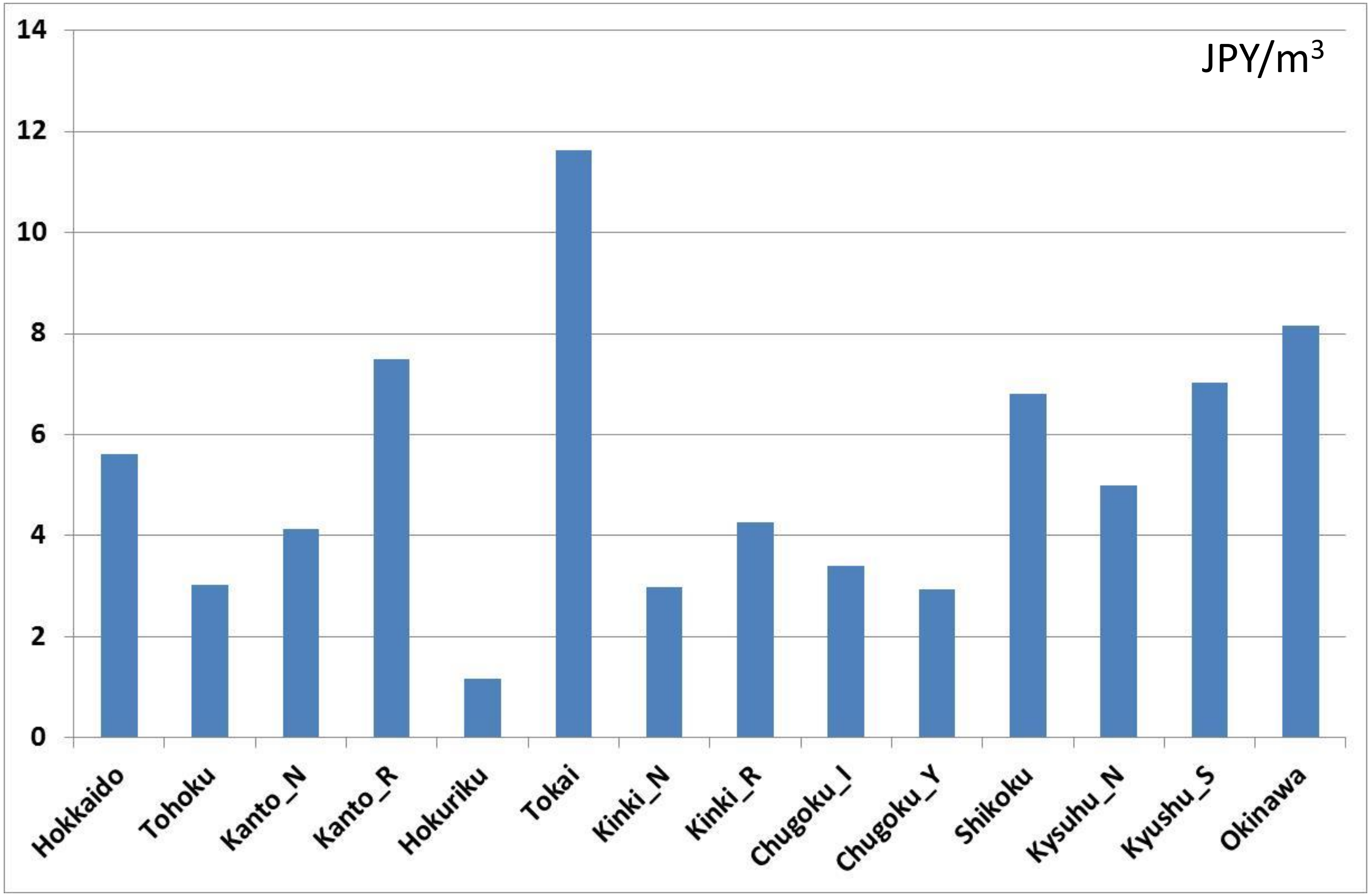
Japan Water Consumption

100 million m^3/year

	Daily Life Water	Industrial Water	Agricultural Water	TOTAL
Hokkaido	6.7	9.8	46.5	63.0
Tohoku	14.3	13.7	158.4	186.4
Kanto_N	10.2	8.8	56.1	75.1
Kanto_R	42.0	13.1	25.7	80.8
Tokai	22.6	25.1	51.5	99.2
Hokuriku	4.0	6.3	28.3	38.6
Kinki_N	7.0	3.4	19.1	29.5
Kinki_R	20.2	10.6	22.1	52.9
Chugoku_I	1.7	1.8	12.4	15.9
Chugoku_Y	7.8	14.2	31.4	53.4
Shikoku	5.5	7.4	21.9	34.8
Kyushu_N	8.9	6.0	39.4	54.3
Kyushu_S	6.0	5.6	34.4	46.0
Okinawa	1.9	0.4	2.4	4.7
TOTAL	158.8	126.2	549.6	834.6

Source: MLIT

Huge Water Price Gap



IV. SIMULATIONS

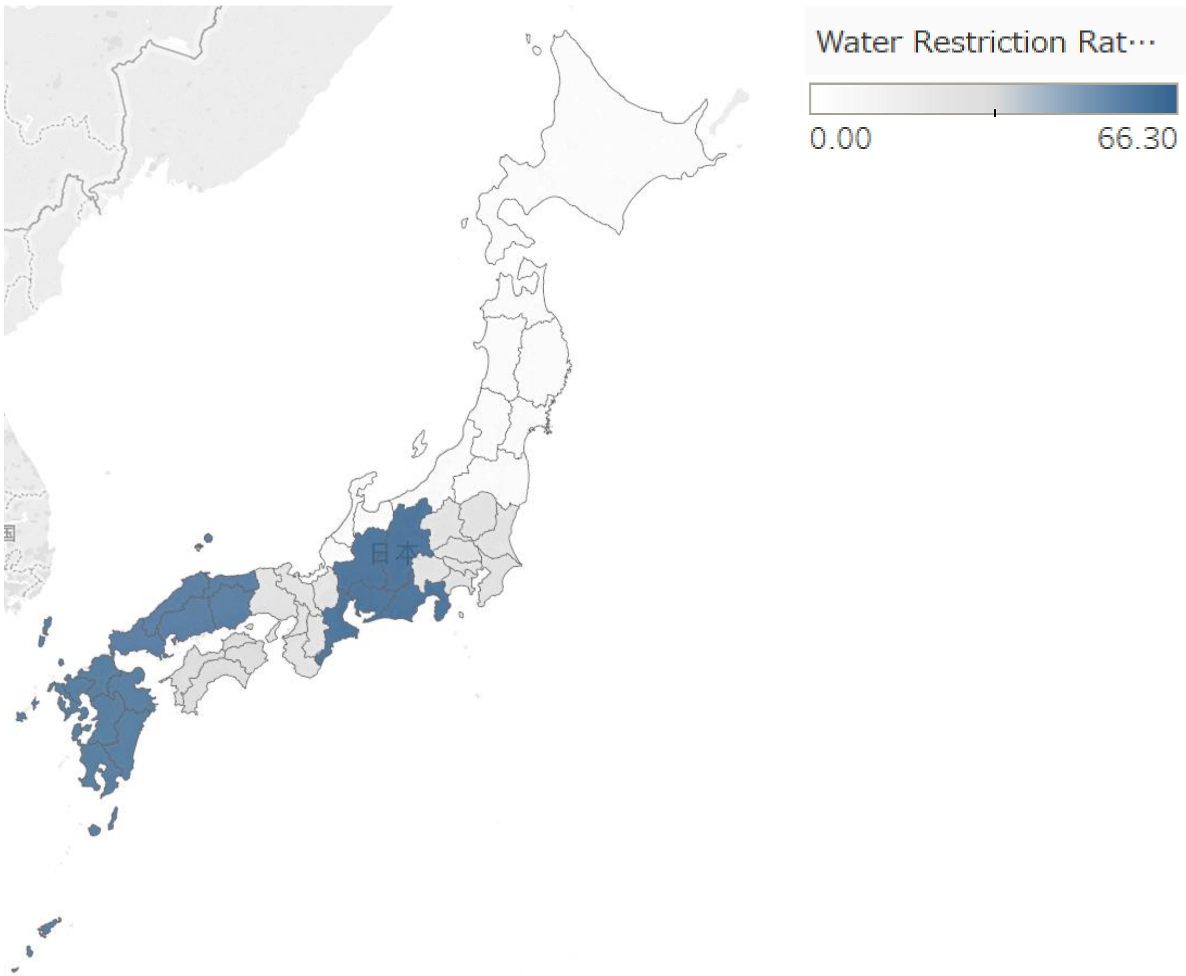
Scenario

Scenario	Water Restriction to Agricultural Sectore	Water Trade Between Regions
No-Trade	✓	
Trade	✓	✓

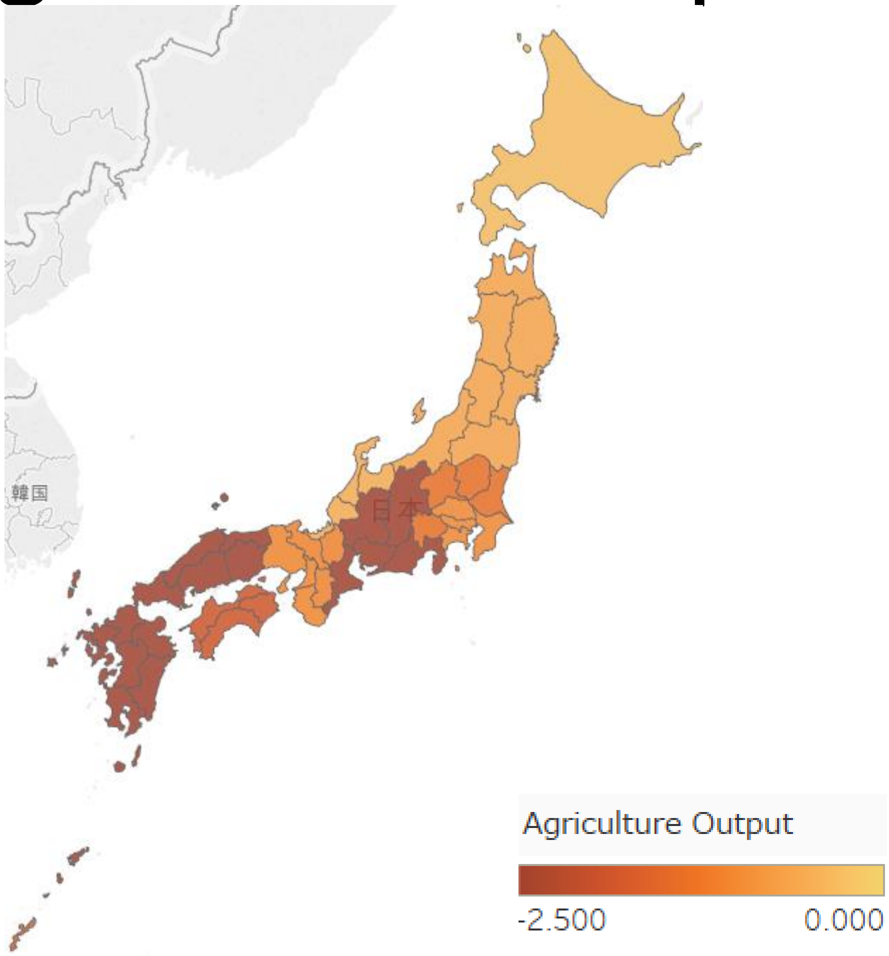
No-Trade

IV-I. DROUGHT IMPACTS ON ECONOMY

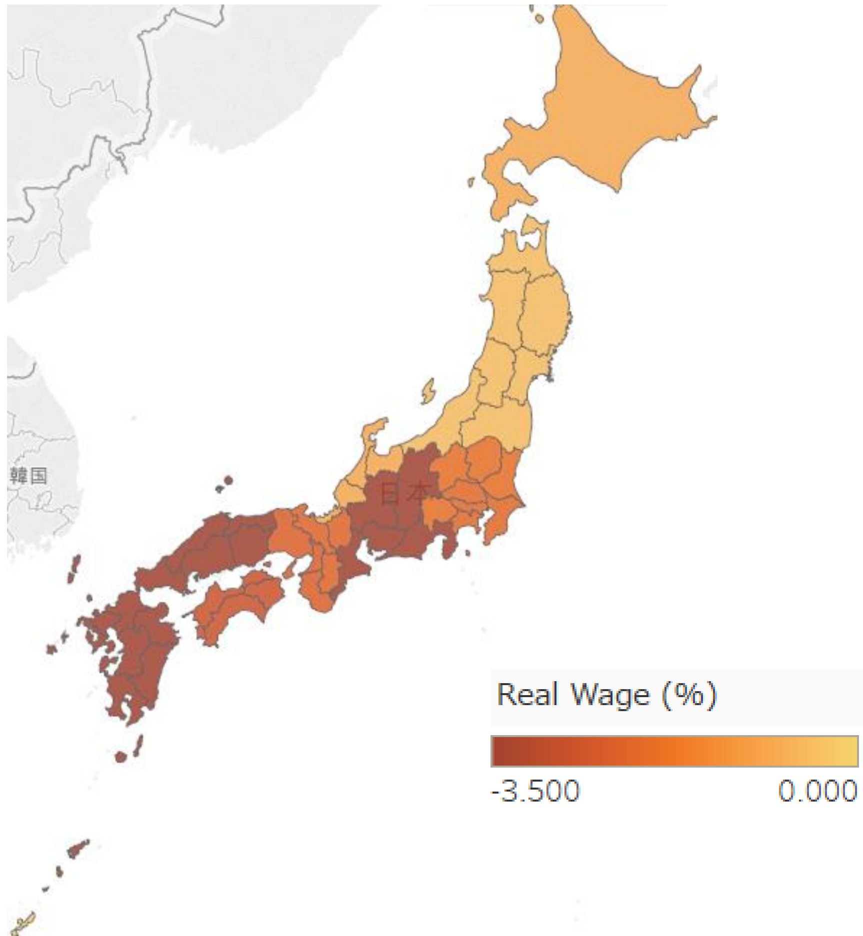
Water Restrictions due to 1994 Drought



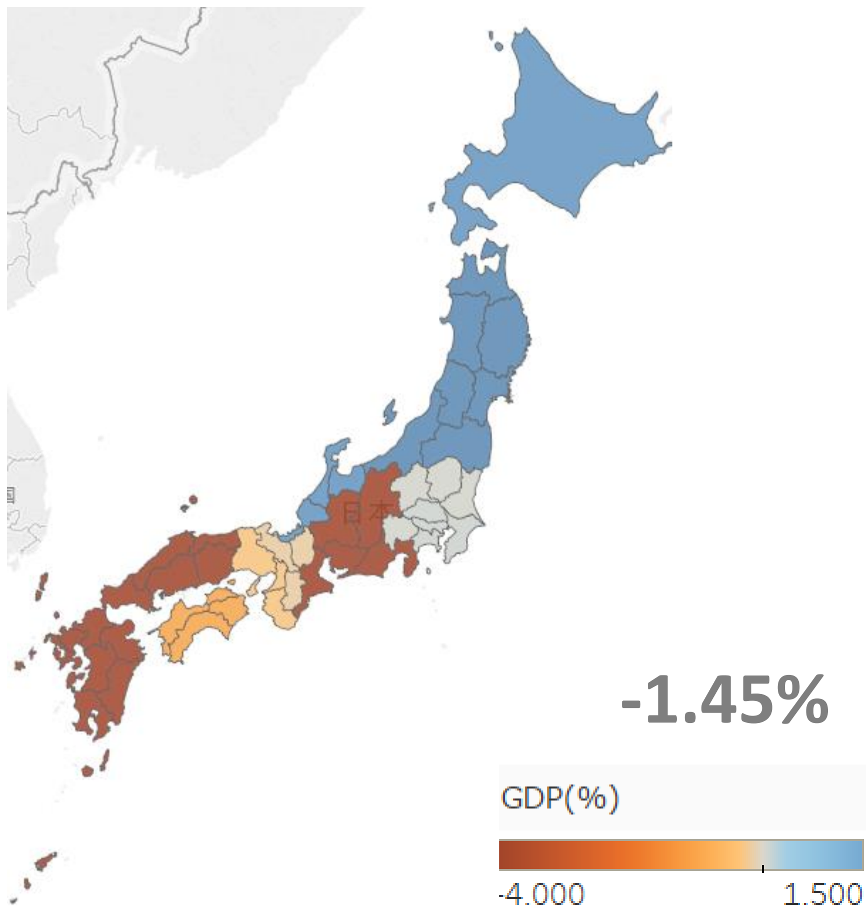
Agricultural Output



Real Wage



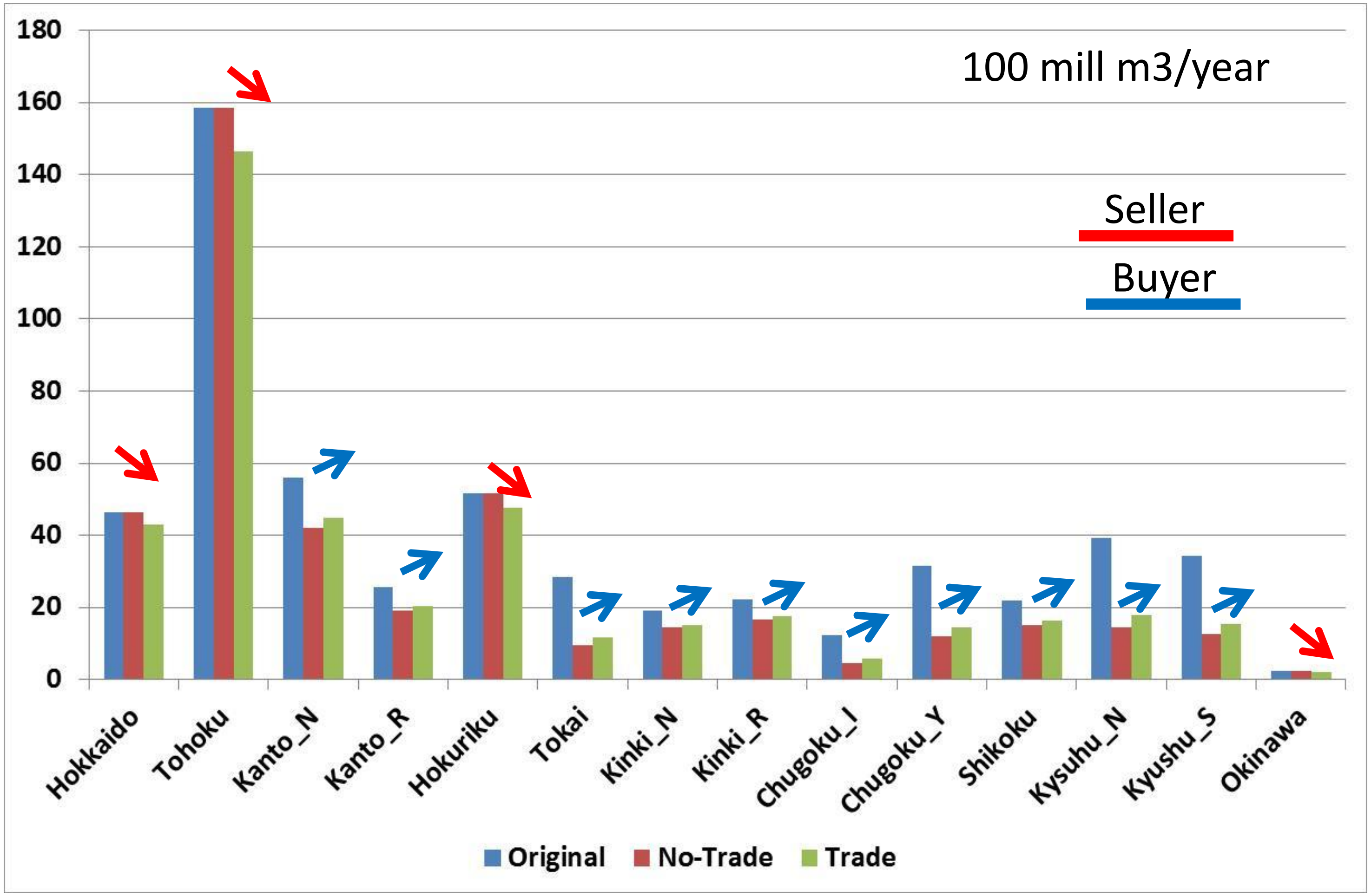
GDP Impacts



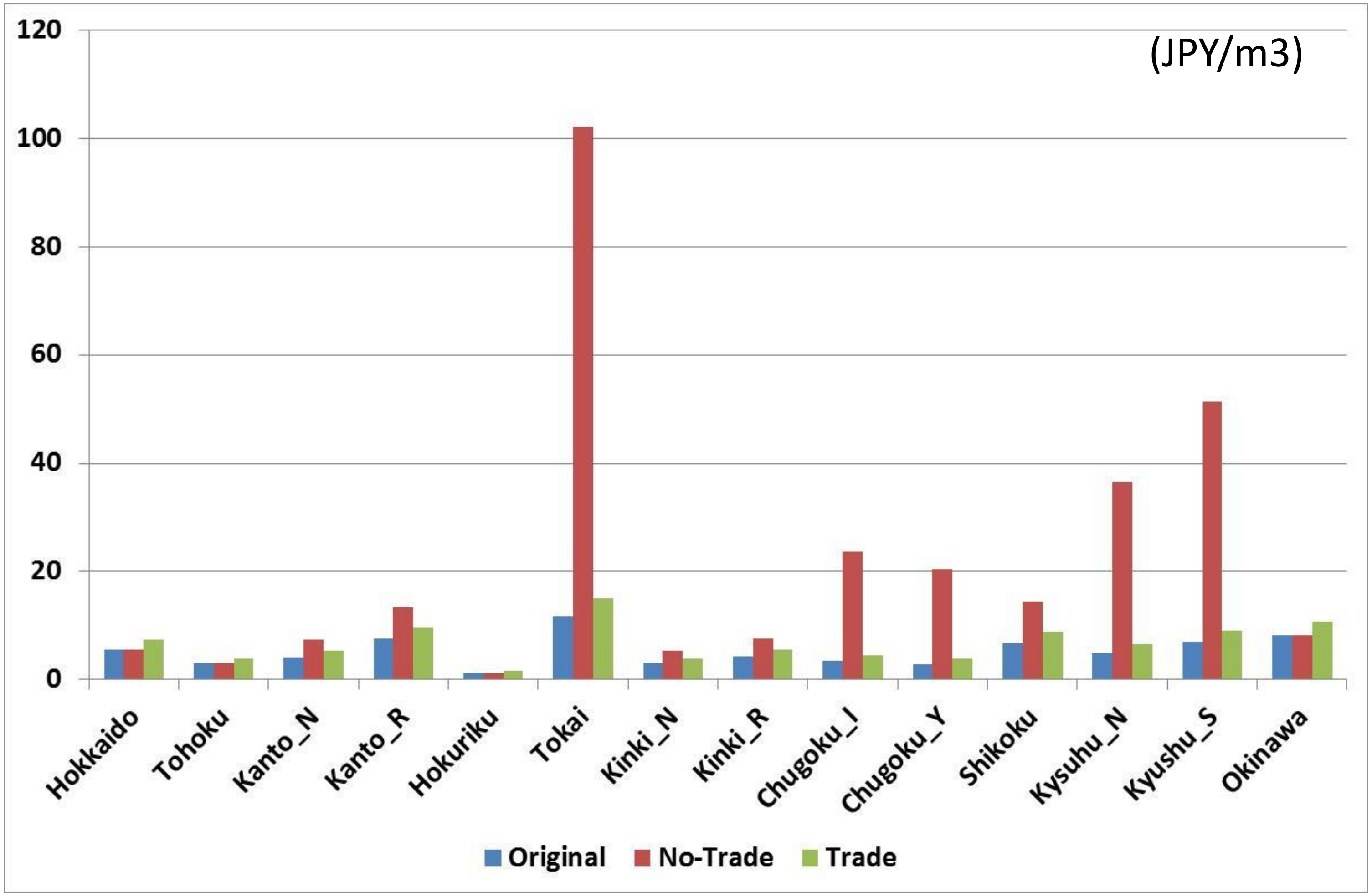
Comparison Between No-Trade and Trade

IV-2. BENEFITS OF WATER TRADING MARKET

Water Demand

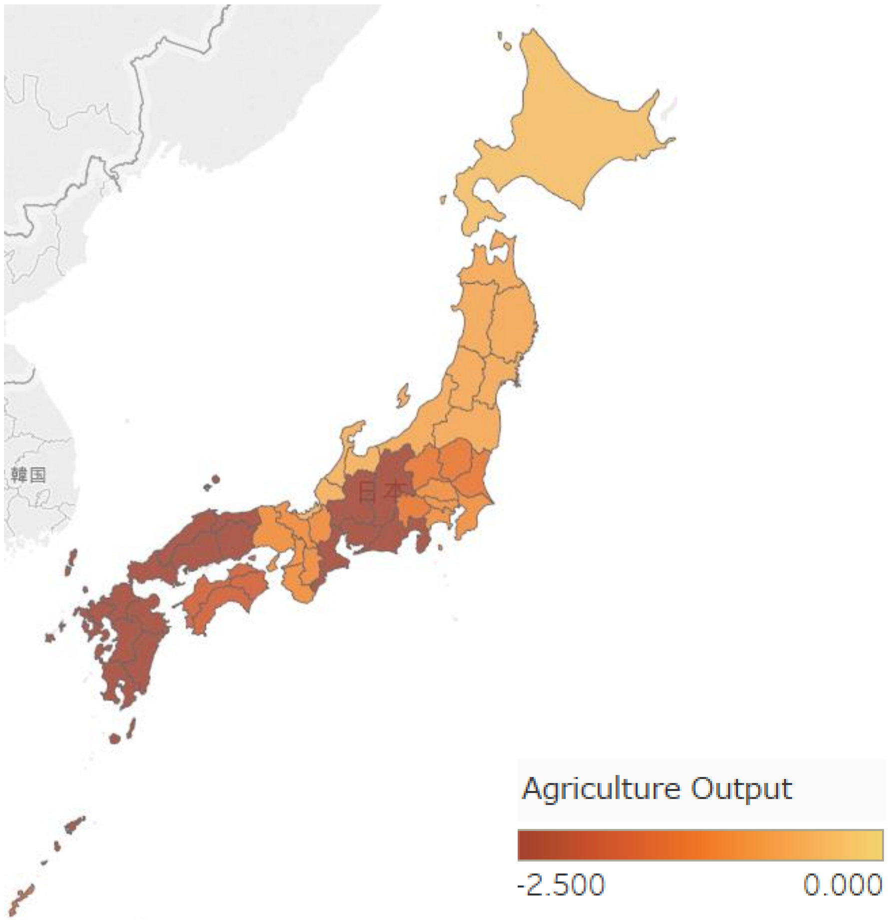


Water Price

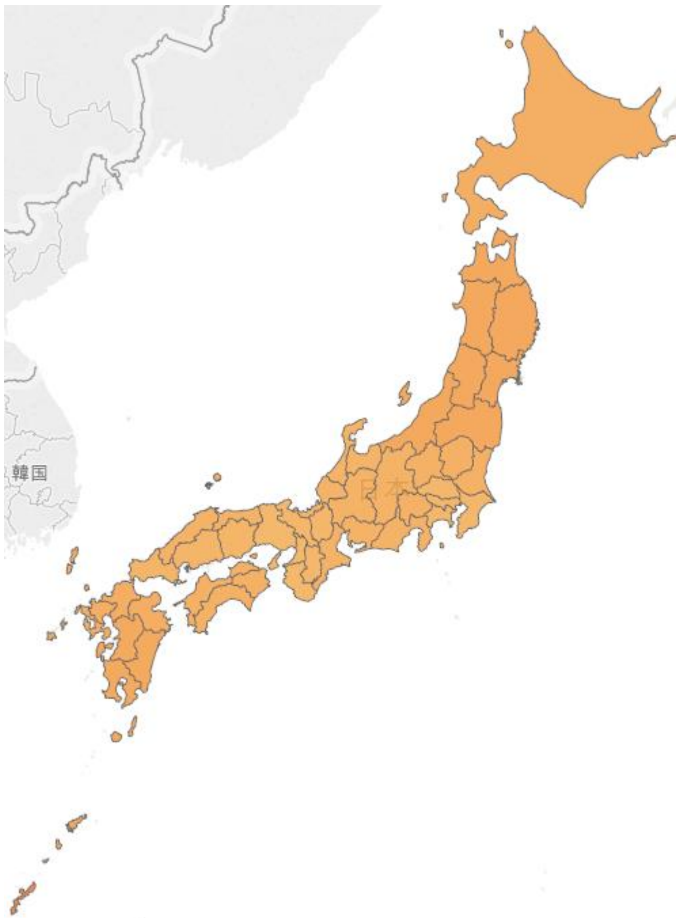

(JPY/m3)
120
100
80
60
40
20
0
Hokkaido
Tohoku
Kanto_N
Kanto_R
Hokuriku
Tokai
Kinki_N
Kinki_R
Chugoku_I
Chugoku_Y
Shikoku
Kysuhu_N
Kyushu_S
Okinawa
Original
No-Trade
Trade

Agricultural Output

Without Water Market (No-Trade)

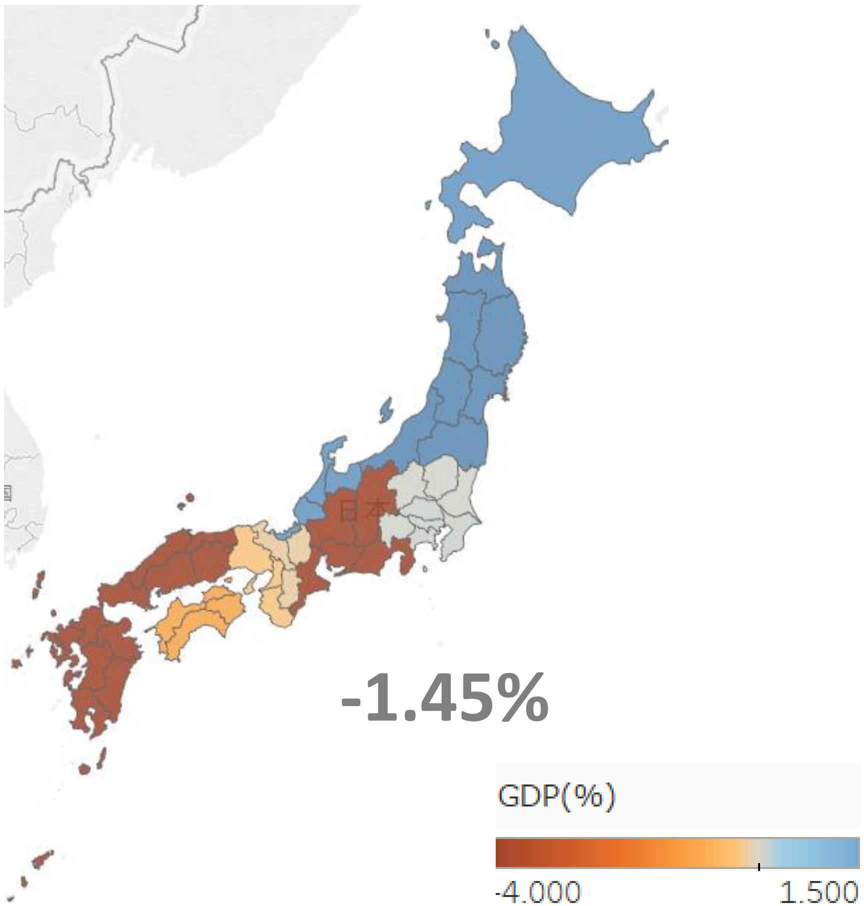


With Water Market (Trade)

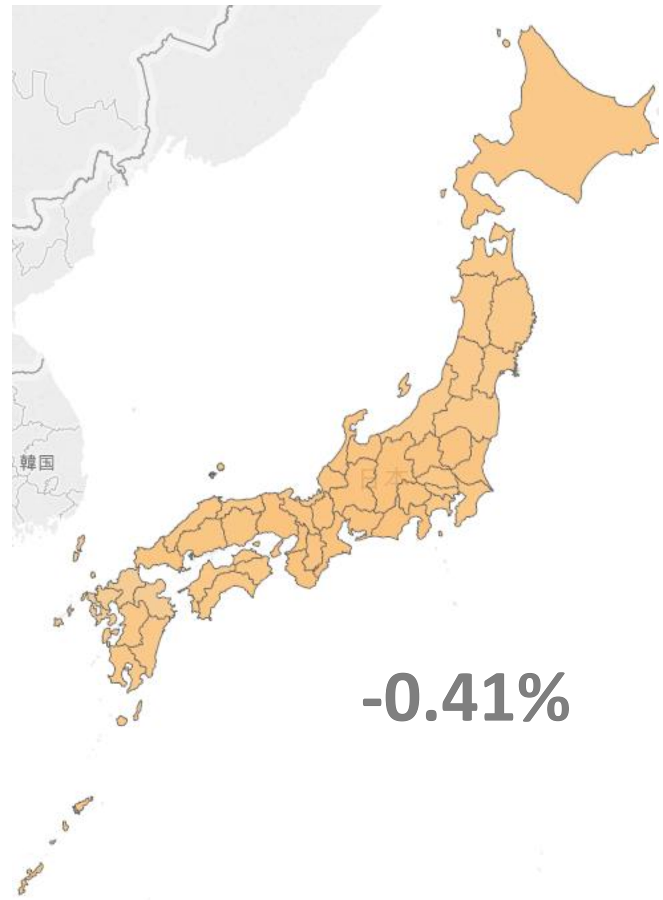


GDP Impacts

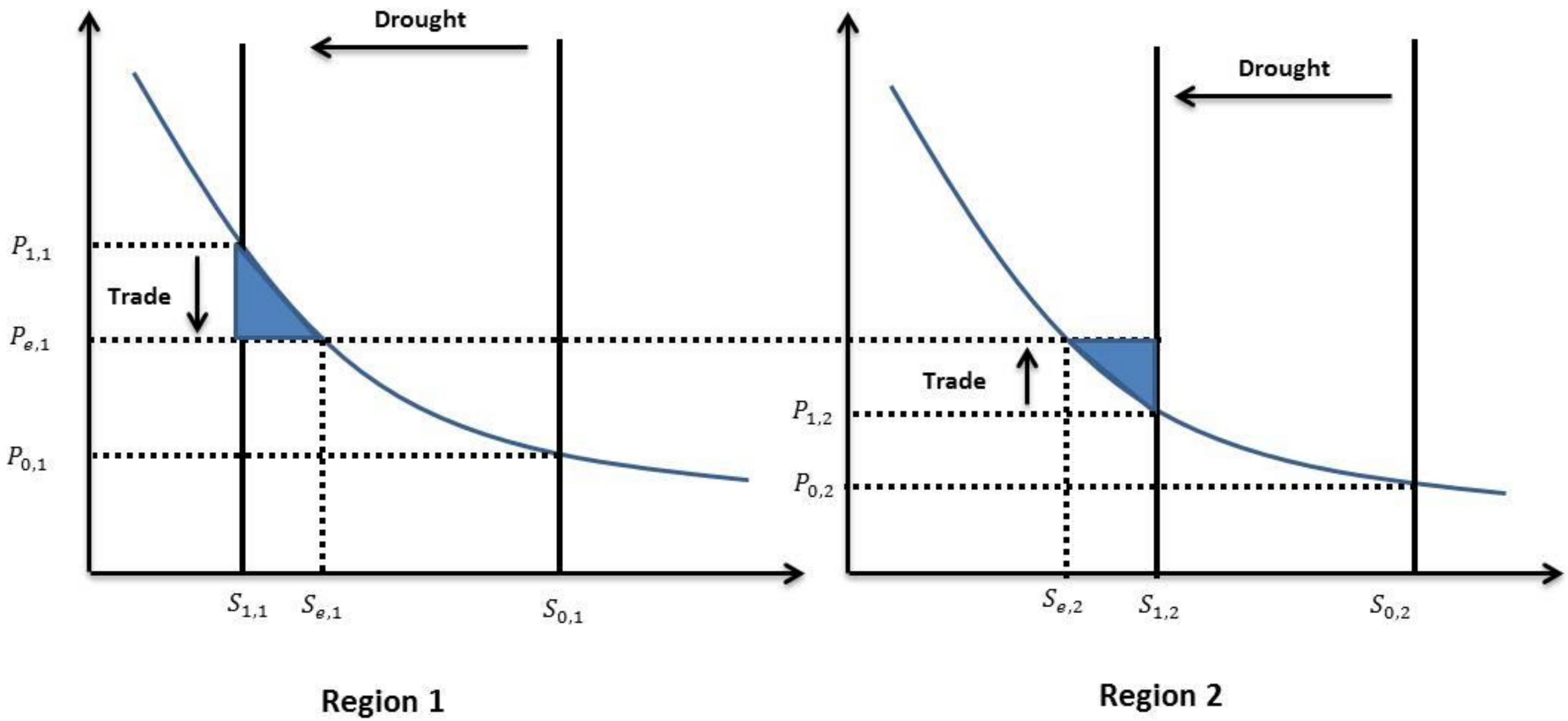
Without Water Market (No-Trade)



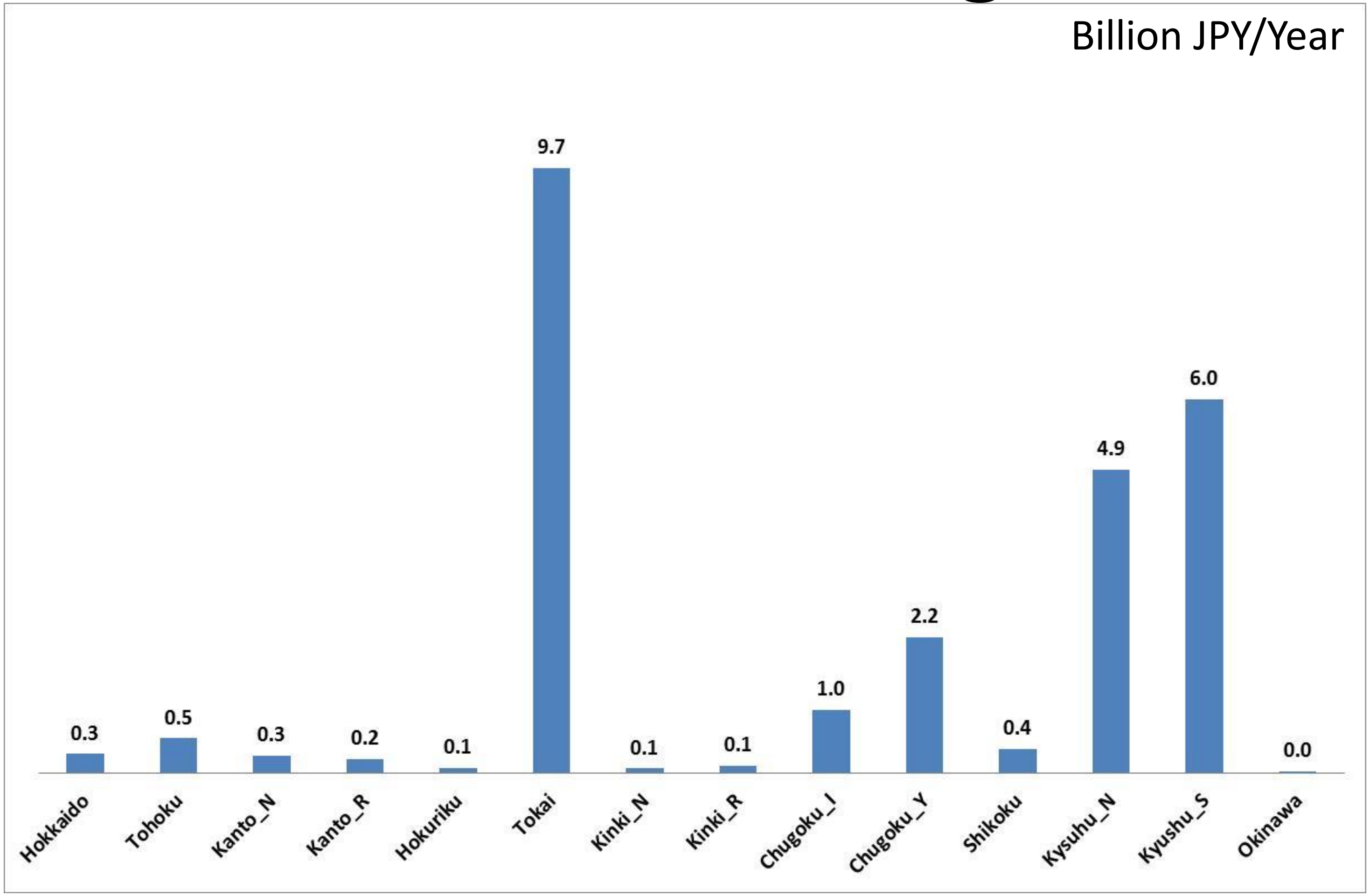
With Water Market (Trade)



Welfare Gains due to Water Market



Welfare Change



V. Concluding Remarks

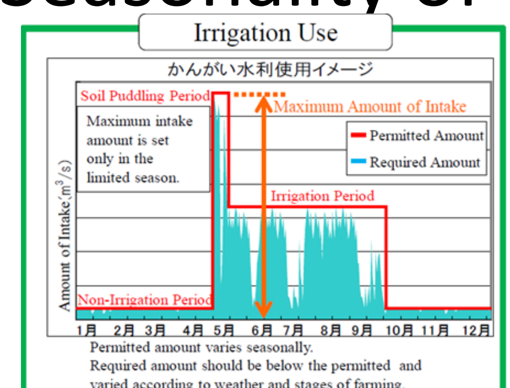
- Under current no water market situations, agricultural production decrease substantially.
- To create water market will have a potential to minimise the impacts of FY1994 level drought on agricultural sector and welfare is expected to increase in all regions.

VI. Further Challenges

- Include Water Trade Infrastructure Cost

Water Pipeline For Agricultural Water
http://www.jpe-corp.jp/products/water_01.html

- Seasonality of Water Demand and Rainfall



Water Demand Pattern in Agriculture

FUJITSU

shaping tomorrow with you

Water Trading Market

$$c\_QWTR\_AGR(d) = -\left(\frac{0.01}{WATER\_ELAS(d)}\right) \times QW0\_AGR(d) \times (p\_PWT\_AGR(d) - p\_PW0\_AGR)$$

$c\_QWTR\_AGR(d)$ **: Absolute Change of Water Demand in Region d**

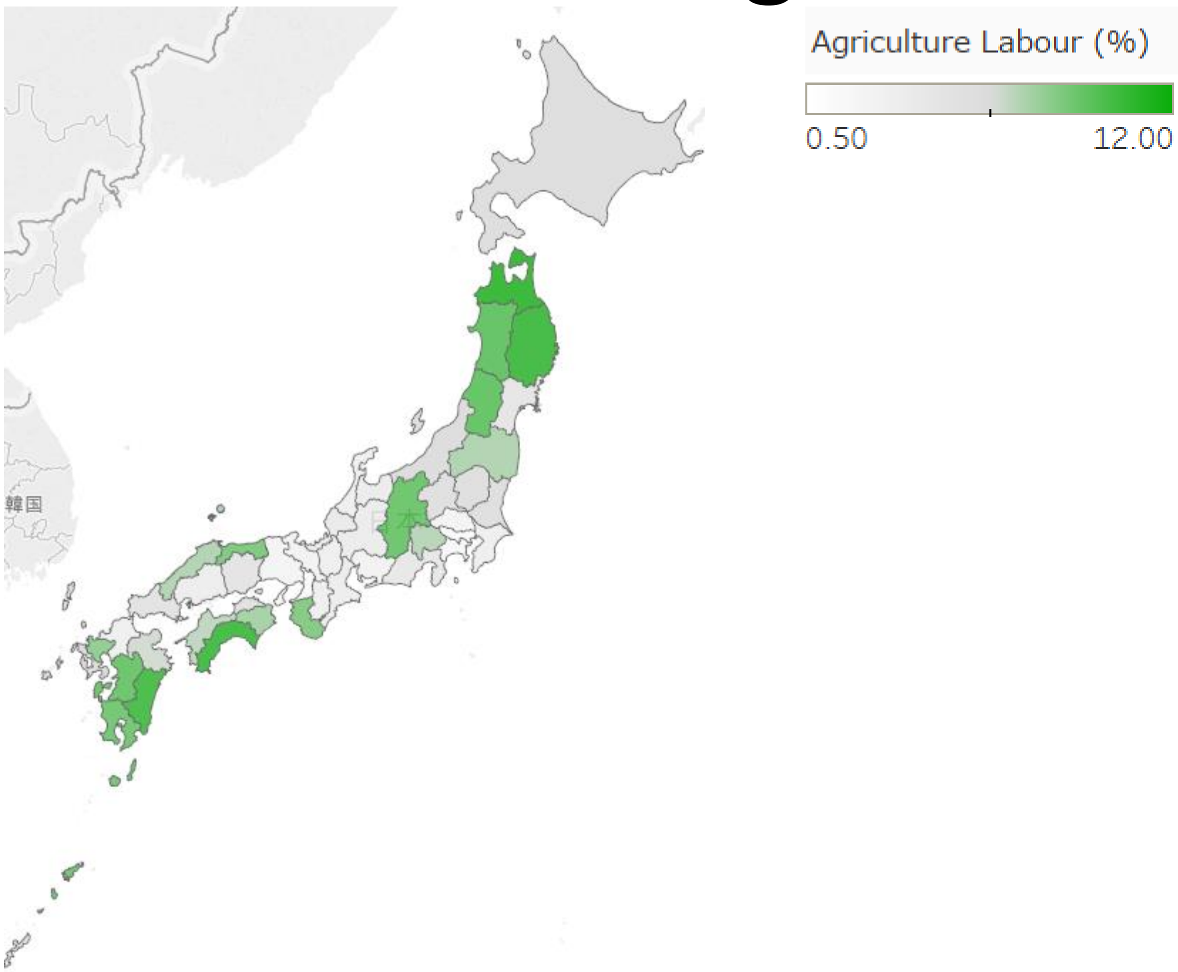
$WATER\_ELAS(d)$ **: Water Price Elasticity of Demand in Region d**

$QW0\_AGR(d)$ **: Water Supply in Region before Trade in Region d**

$p\_PWT\_AGR(d)$ **: percentage change in water price due to trade in Region d**

p_PW0_AGR **: percentage change in water price after the initial shock and before trading.**

Labour Share of Agriculture

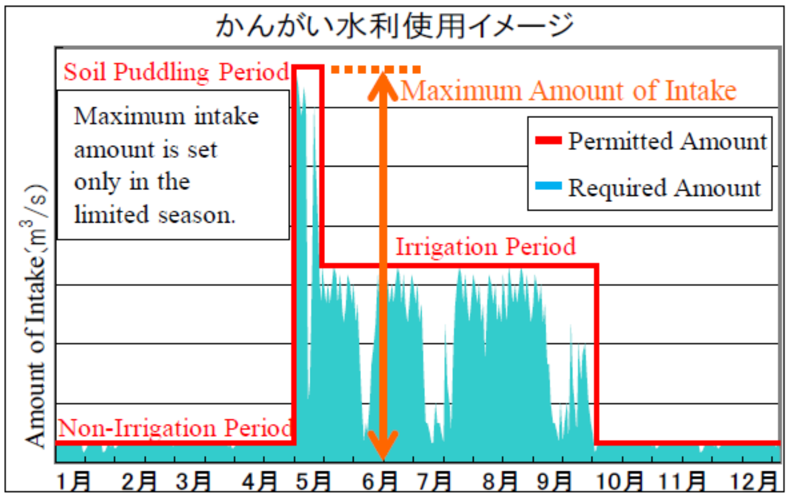


Regions	Watershed	Facility	Restriction Duration (Days)	Water Ristriction (%)		
				Clean Water	Industrial Water	Agricultural Water
Kanto	Nakagawa River		10	10	10	10
	Tonegawa River	Upper Stream 8 Dams	38	30	30	30
	Arakawa River	Futase Dam	5	90		
Chubu	Kiso River	Iwaya Dam	161	35	65	65
		Makio Dam	169	35	65	65
		Agigawa Dam	129	35	65	65
		Yokoyama Dam	65			70
	Toyo River	Uregawa Dam	133	35	60	60
	Yahagi River	Yahagi Dam	114	33	65	65
	Oi River	Ooi Dam	83	20	38	38
	Tenryu River	Sakuma Dam	72	10	30	30
	Kushida River	Hachisu dam	4	10	20	20
	Kumozu River	Kimigano Dam	4	10	20	20
Kinki	Yodo River	Miwa Dam	35	20	20	20
		Murou Dam	74	58		13
		Kizugawa	8	10		10
		Hitokura Dam	90	30		40
	Kako River	Kakogawaoozeki Dam	63	30	30	30
	Ibo River	Hikihara Dam	58		90	50
	Kino River	Saruya Dam	20	15	15	30
Chugoku	Takanashi River	Shinnaruhagawa Dam	103	50	70	80
	Asahi River	Asahikawa Dam	145	20	30	50
	Ota River	Chiden	85	27	60	60
	Gono River	Haji dam	85	27	60	60
	Ashida River	Mikawa dam	143	30	68	90
	Saba River	Shimajigawa Dam	87	20	20	20
Shikoku	Yoshino River	Sameura Dam	121	48.5	48.5	48.5
		Yanase dam	87	5	57	22.4
	Shigenobu River	Ishitegawa dam	156	42		67
	Niyodo River	Oodo Dam	19			56
	Naka River	Kominono Dam	10		20	5
	Monobe River	Nagase Dam	15			25.8
Kyushu	Chikugo River	Egawa Dam	121	63	63	63

Source: Kawashima and Takahashi (1995)

Water Usage Pattern

Irrigation Use

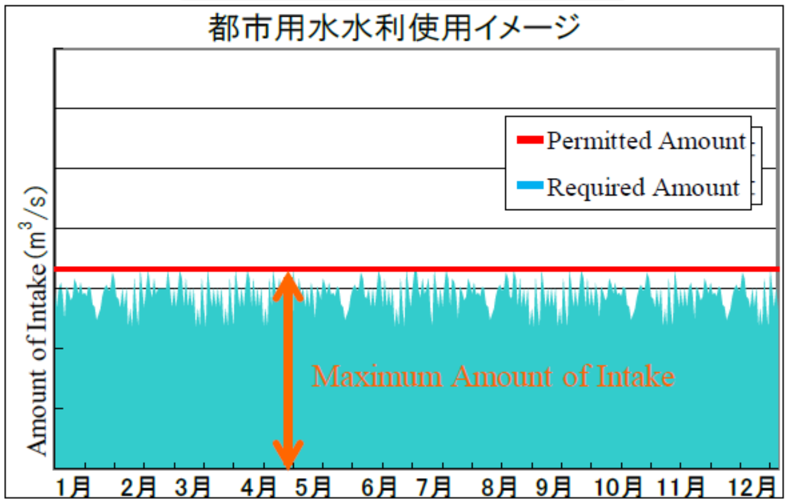


Permitted amount varies seasonally.
Required amount should be below the permitted and varied according to weather and stages of farming.

Required amount is calculated to satisfy the maximum demand of 10 years return period, which indicates, practically, water use would be below the permitted in the average year.

Bad climate condition such as low or high temperature, lack of sunlight, etc. changes the required water amount.

Municipal Use



Permitted amount is steady through the year.
Required amount is almost the same level as permitted.

Besides agricultural use, there are domestic use, industrial use and hydro power use . An inland fishery right holder is also one of concerned river users.

Generally, the most amount of intake water is used by hydro power, then irrigation, domestic and industrial to the least. Water used by hydro power is not consumed and shall return to river .

MAFF (2013)