Kindai University

Faculty of Business Administration

Understanding the Relationship between Industry Fragmentation and Wastewater Efficiency, so as to Inform Japanese Government Policy on Wide Area Cooperation and Consolidation

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Today's Topics

- Background and Motivation
  - Direction of Policy Reform
  - Research Questions
- Brief History and Industry Structure
- Case study: Hyogo Prefecture
- Summary

Background and Motivation

- Fragmented water and sewage system organised at municipal level
- Diverse vertical and horizontal structure
  - Very Large and Very Small
  - Fully Integrated, Mixed, Fully Vertically Separated
- The Industry Faces at Least Three Major Issues
  - **Potentially high investment needs** given ageing facilities and frequent natural disasters
  - **Fiscal Pressures** High Debt/GDP ratio requiring more cost effective management, and limits potential for subsidizing investment
  - **Rapid Population Decline/Ageing Population**

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Direction of the Government's Policy Reform

- ◆**Promoting regionalization** -Policy on Economic and Fiscal Management and Reform 2017, sets goals for FY2022 in order to improve economically sustainable management of water supplies and sewerage.
- ◆**Wide-Area Cooperation and Sharing of Facilities**
- ◆**Public Private Partnerships**

MLIT (Ministry of Land, Infrastructure and Transport) is sponsoring academic research related to this agenda in its Gesuido Academic Incubation to Advanced Project (GAIA Project) which supports this research.

Modelling Required to Understand Relationships Between Firm Size, Structure, Fragmentation, Outsourcing, etc. to inform policy development

What are the Project's Research Questions?

- Provide an Appropriate Model to assess the operational performance (cost efficiency) of Japanese sewerage utilities
- Better understanding of how interactions between population served **and** area served by the sewage collection network influence overall returns to scale, so we can inform Japanese policy makers on restructuring

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Water Pollution in Economic Growth Period

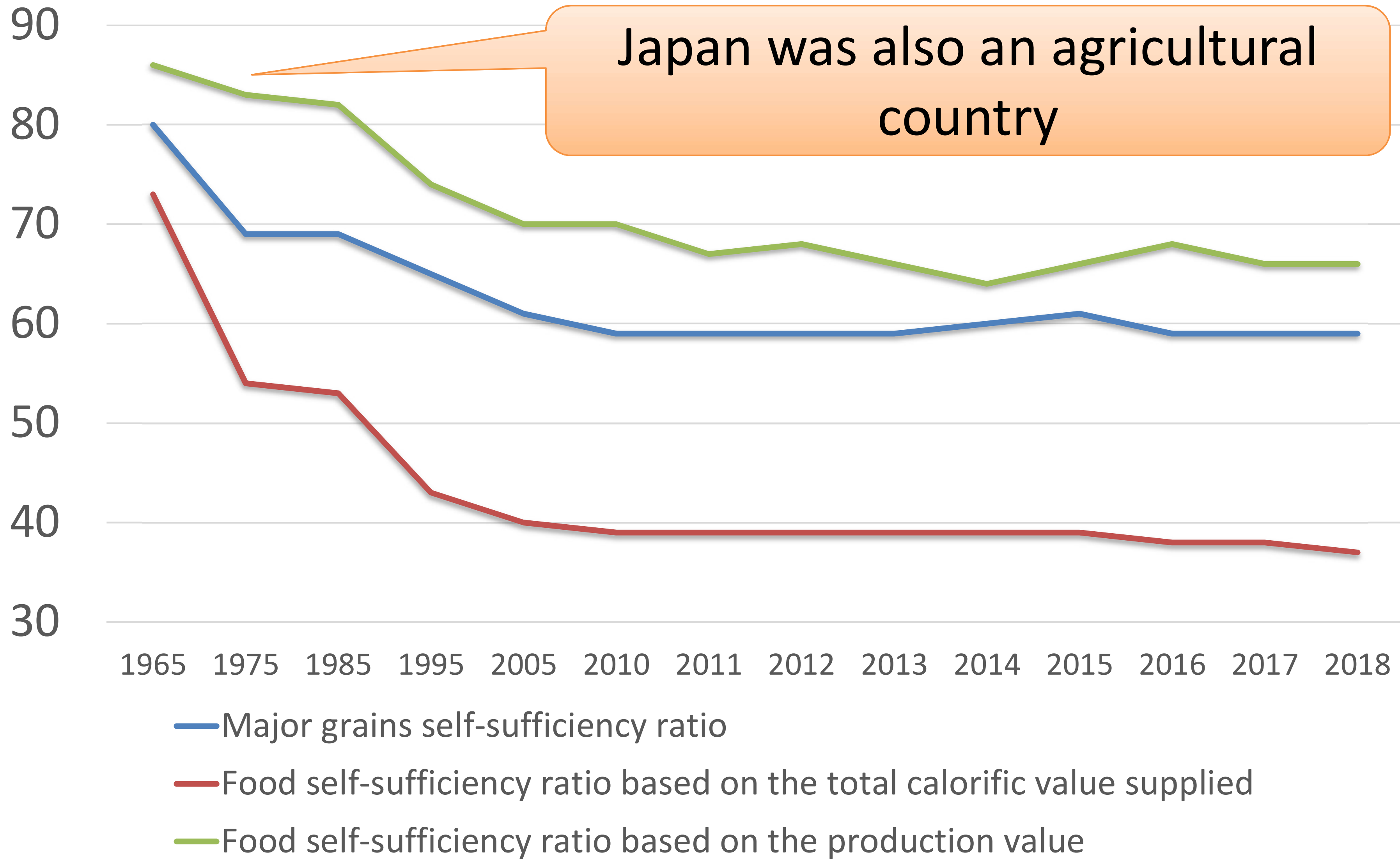
Sumida river in early 70's (Tokyo)

Dokai bay in '60s (Kitakyushu city)

Tama River in '70's (Tokyo)

Source: Ministry of Environment

Food Self-Sufficiency Ratio in Japan



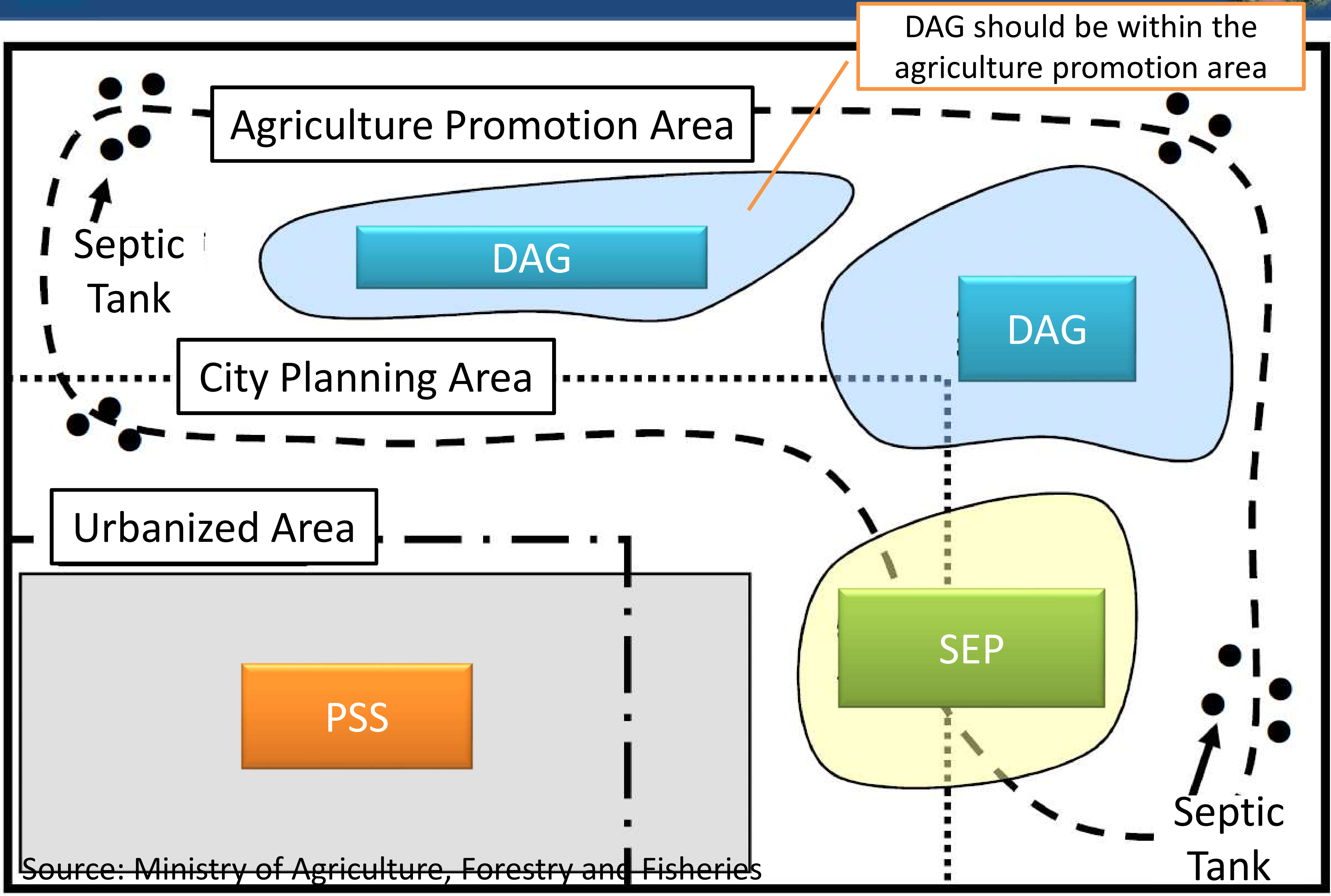
Source: Ministry of Agriculture, Forestry and Fisheries

Brief History

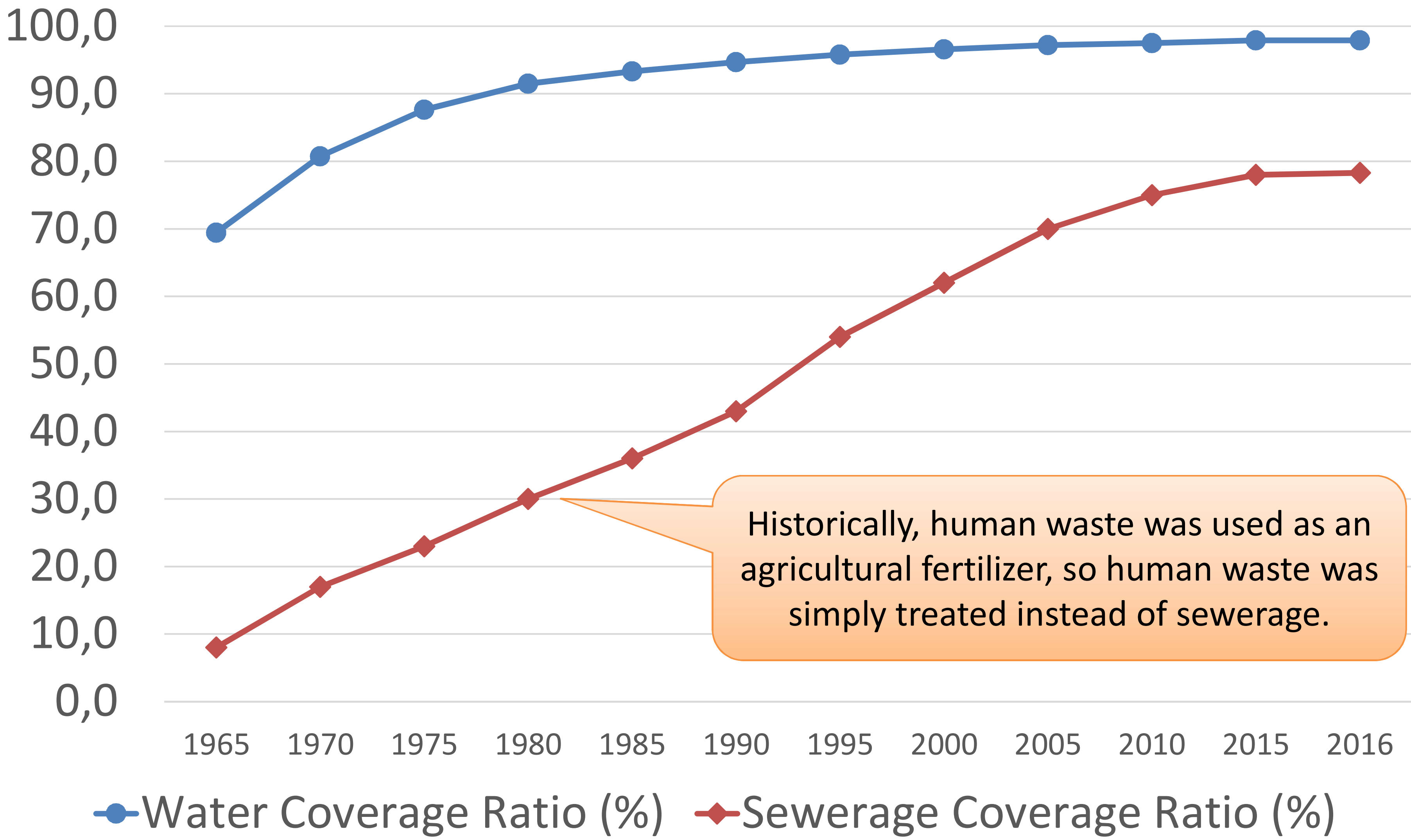
1900	The Old Sewerage Act was enacted
1922	Sewage treatment started at the first sewage treatment plant in Japan
1933	Japan's first activated sludge process started in Nagoya
1958	The Old Sewerage Act was revised due to the pollution problems in public water area Before 1970, only PSS systems responsible for sewage treatment
1970	The New Sewerage Act was enacted, Comprehensive Basin-Wide Planning of Sewerage System was implemented, and RBS was defined in law (already established in 1965)
1973	DAG was established to improve the living environment in agricultural communities
1975	SEP was established to protect the environment in rural areas and national parks
1978	DFS was established to improve the living environment in fishery communities as well as to improve the quality of local waters In1980, the current legal framework for the sewage system had been completed
2015	The Sewerage Act was revised promoting wide-area cooperation and sharing facilities between sewage systems

Sewerage Entity Types (FY 2017)		Number of Entities				Population (10^3) (%)
Type	Definition	Prefecture	City	Town, Village	Coop	
RBS River-basin sewerage	Treatment Only	42	1	-	3	-(-)
PSS Public sewer system	Centralized sewer system in city area	4	739	430	16	96,473(75.5)
SEP Specified environmental preservation public sewer system	Rural area and natural parks	21	358	364	5	3,799(3.0)
SPS Special public sewer system	Factories and other specific area	3	7	-	-	4(0.0)
DFS Drainage facilities for fishery communities	Fishery communities	1	91	77	-	133(0.1)
DAG Drainage facilities for agricultural communities	Agricultural communities	10	461	437	-	2,524(2.0)
DFR Drainage facilities for forestry communities	Forestry communities	-	11	15	-	2(0.0)
Others	Other sewer systems	-	269	265	1	691(0.01)

Sewage Systems in Urban and Rural Area



Water and Sewerage Coverage Ratio



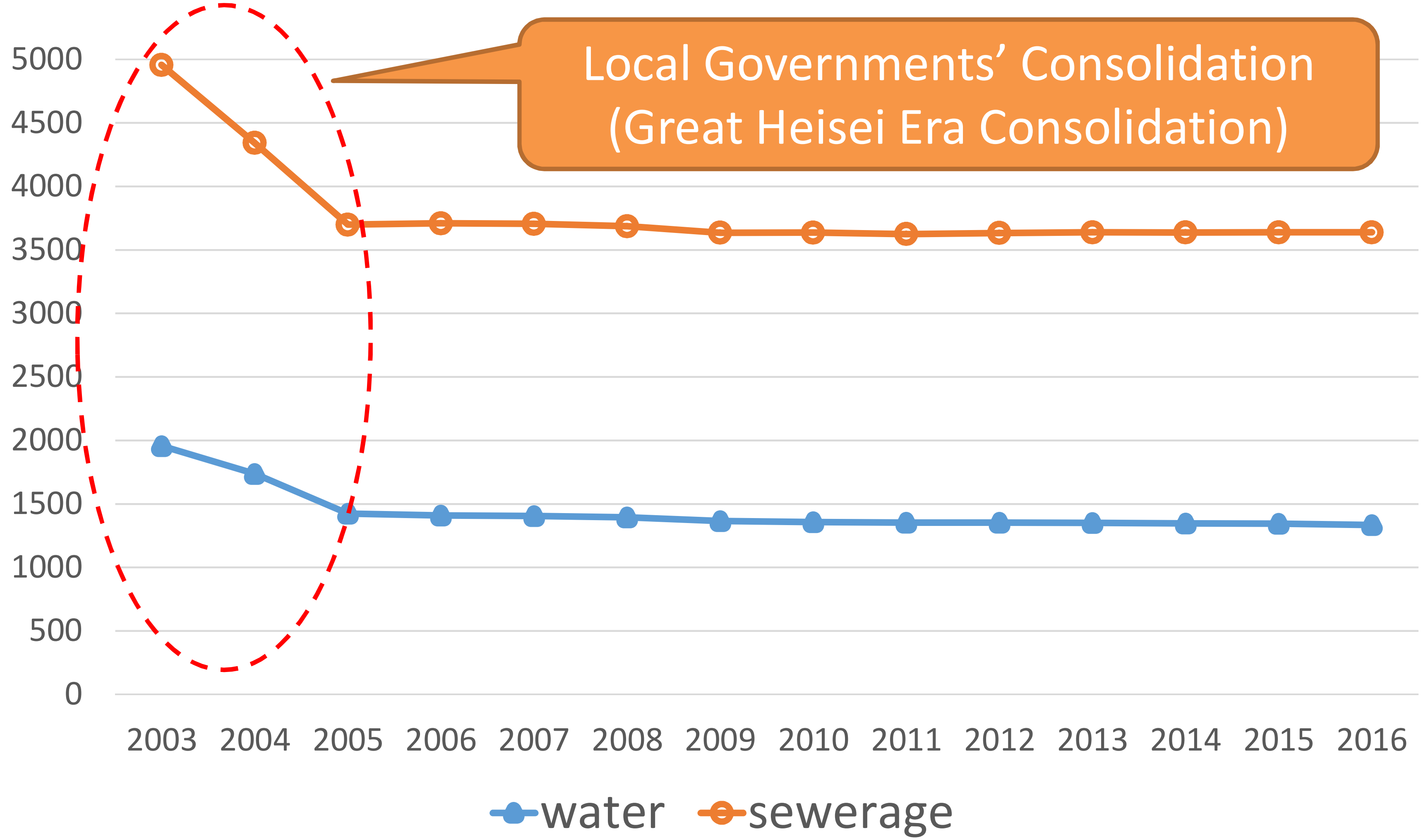
Source: JWWA, MLIT

Japanese Government System

- Central Government
  - 47 Prefectures
    - 792 Cities
    - 743 Towns
    - 189 Villages

3,232 in 1999 ➡ 1,724 in 2019

Number of LWS and Sewerage Entities



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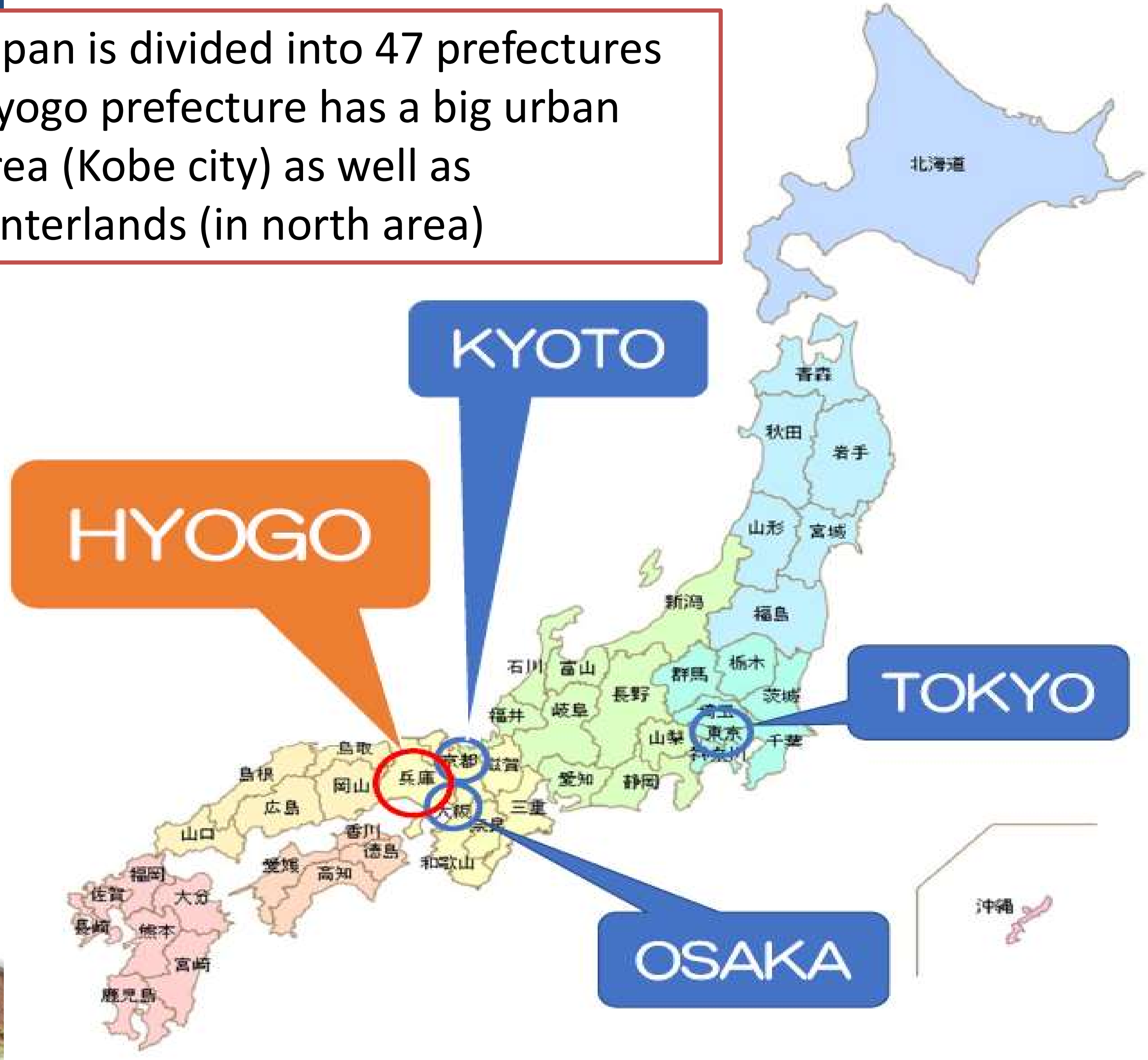
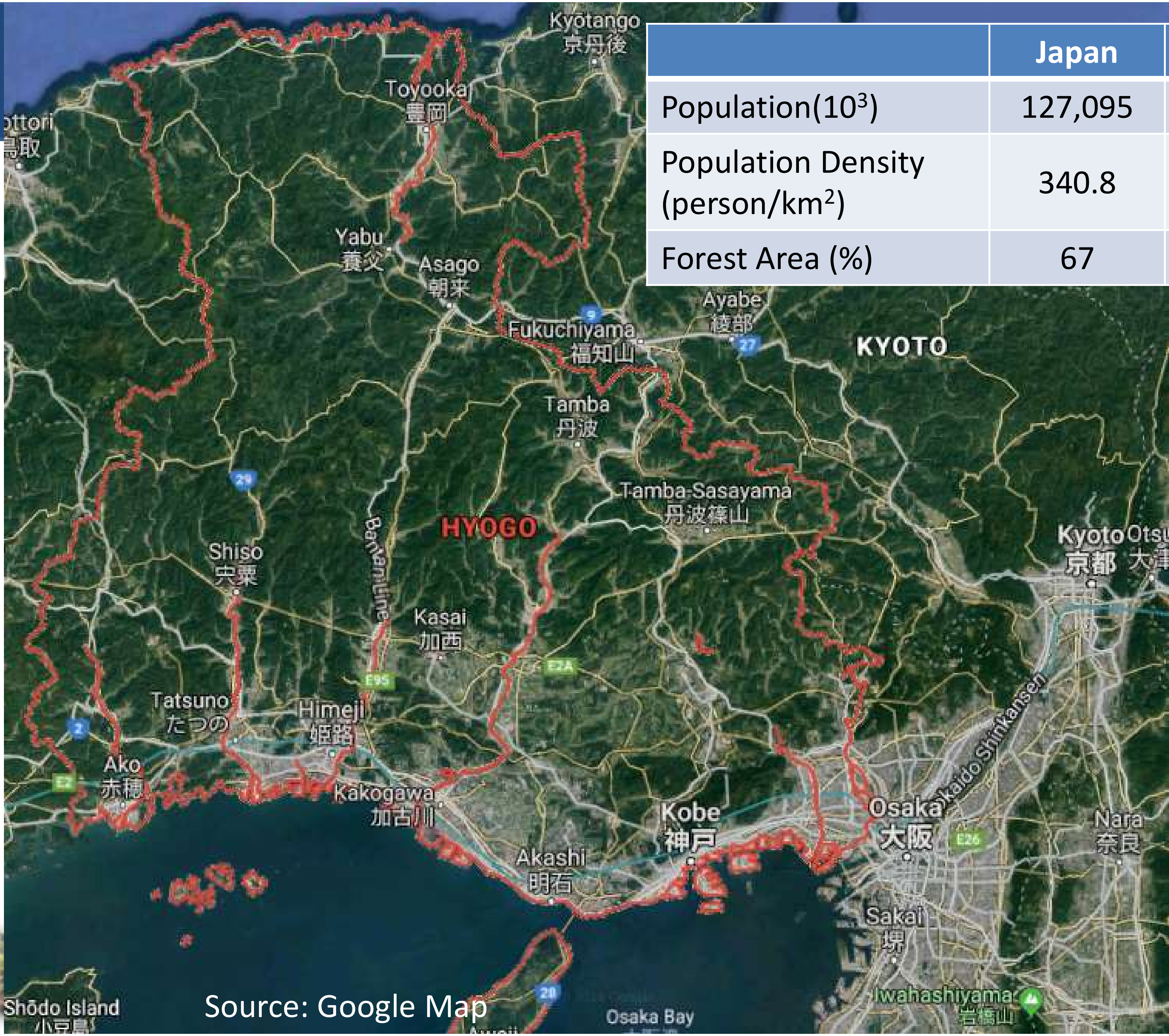
Case Study: Hyogo Prefecture

- We need to understand how sewerage systems organized by municipalities and think about potential benefit of wide-area cooperation between entities/systems.
- By selecting a specific prefecture and knowing its municipalities' population/density, the number and location of sewage treatment facilities, the cost structures, etc., so that we can obtain clues to analyze Japan as a whole

- Japan is divided into 47 prefectures
- Hyogo prefecture has a big urban area (Kobe city) as well as hinterlands (in north area)



	Japan	Hyogo
Population(10^3)	127,095	5,535
Population Density (person/km^2)	340.8	658.8
Forest Area (%)	67	67



Source: Google Map

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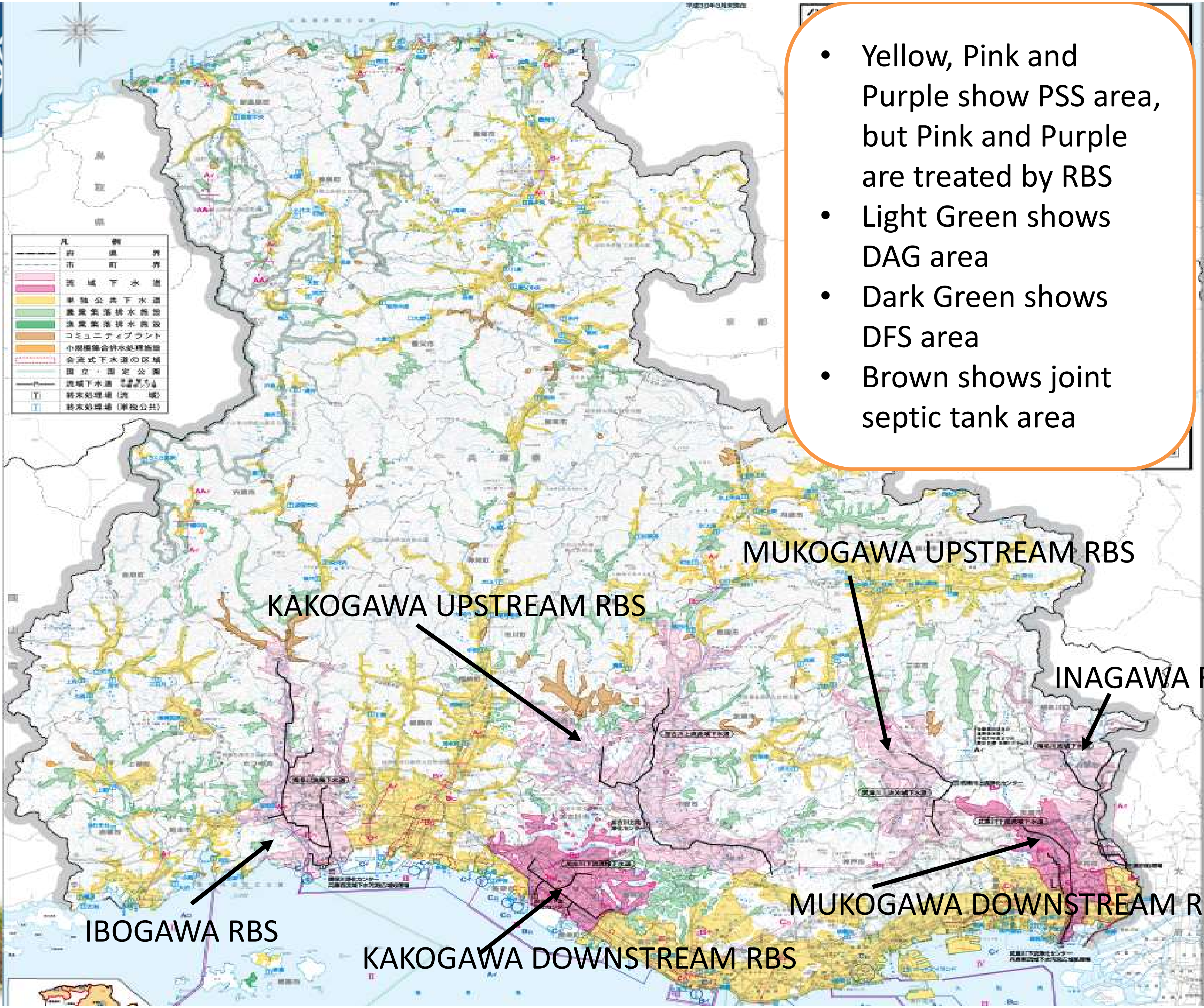
- Yellow, Pink and Purple show PSS area, but Pink and Purple are treated by RBS
- Light Green shows DAG area
- Dark Green shows DFS area
- Brown shows joint septic tank area



Population and Number of Facilities

◆Population (10^3)

Urban	stats	pop_svd	pss_po~d	SEP_po~d	DAG_po~d	OTH_po~d
Non Urban Core	sum	844.6	436.5	280.5	125.1	2.5
Urban Core	sum	4,500.3	4,405.3	54.3	38.3	2.3
Total	sum	5,344.9	4,841.8	334.8	163.4	4.9

◆Number of treatment facilities

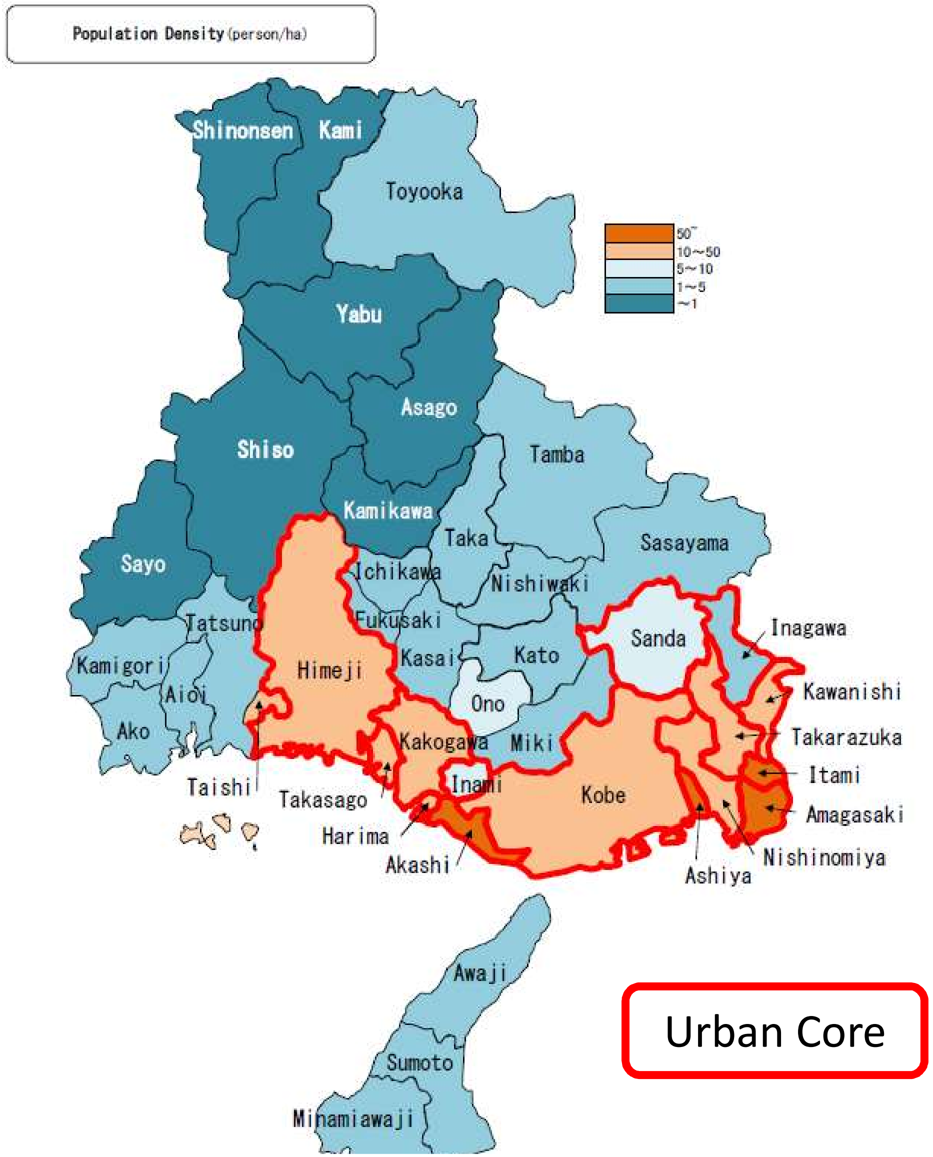
Urban	stats	num_fa~y	pss_nu~y	SEP_nu~y	DAG_nu~y	OTH_nu~y
Non Urban Core	sum	380	23	97	249	11
Urban Core	sum	94	23	3	67	1
Total	sum	474	46	100	316	12

- Most people lives in PSS area in urban core, but in rural area people lives more in SEP and DAG area than in urban area
- Treatment facilities are required more in SEP and DAG area because the areas are all geographically isolated. (PSSs are actually centralized and can connect to RBS in urban core)

77 municipalities in 2005

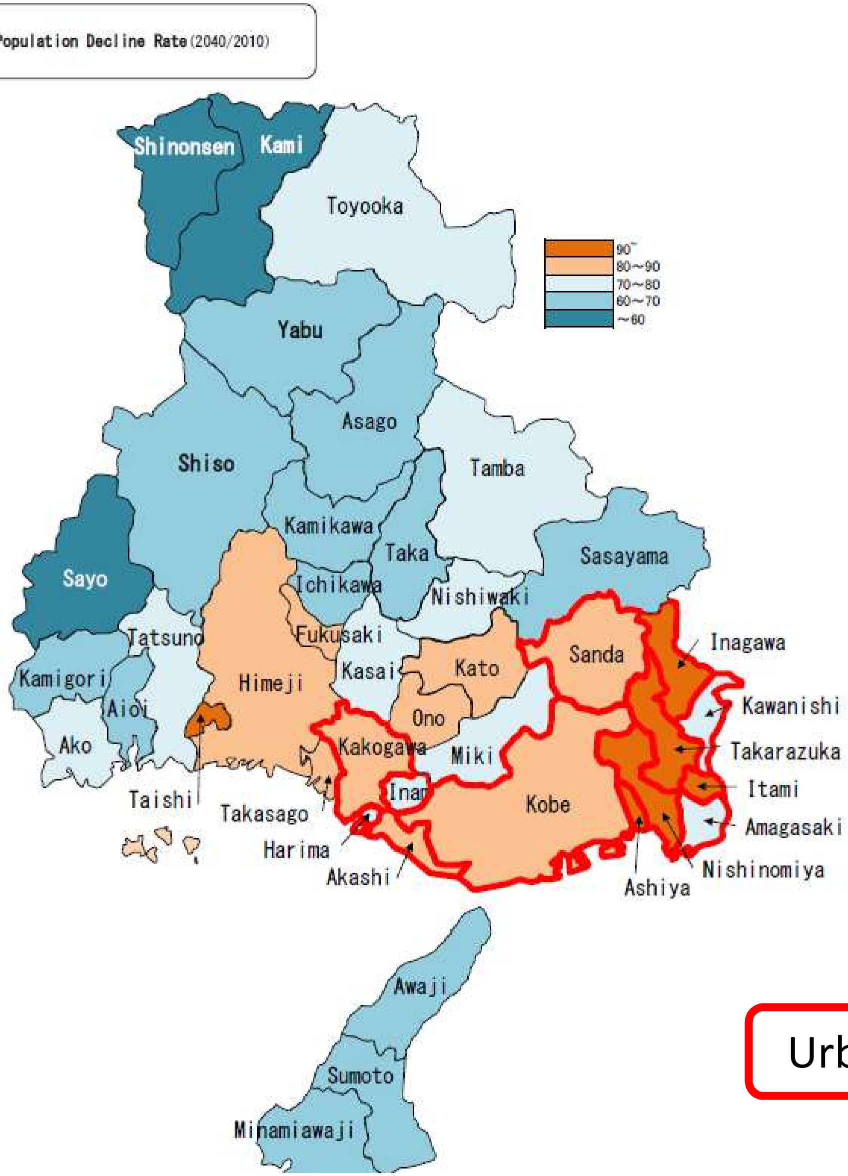
41 municipalities in 2019

10 sub-regions in Hyogo Prefecture

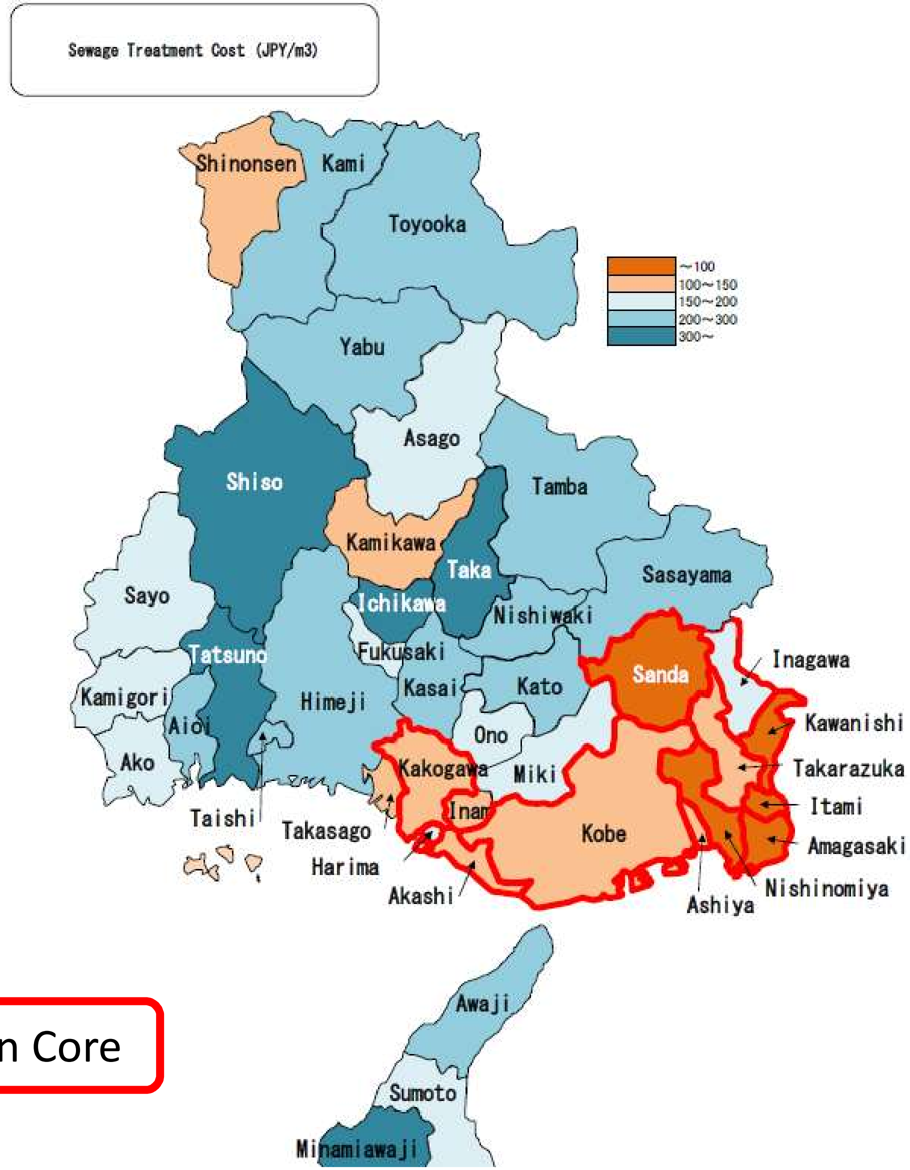


Population Density

Population Decline Rate and Cost



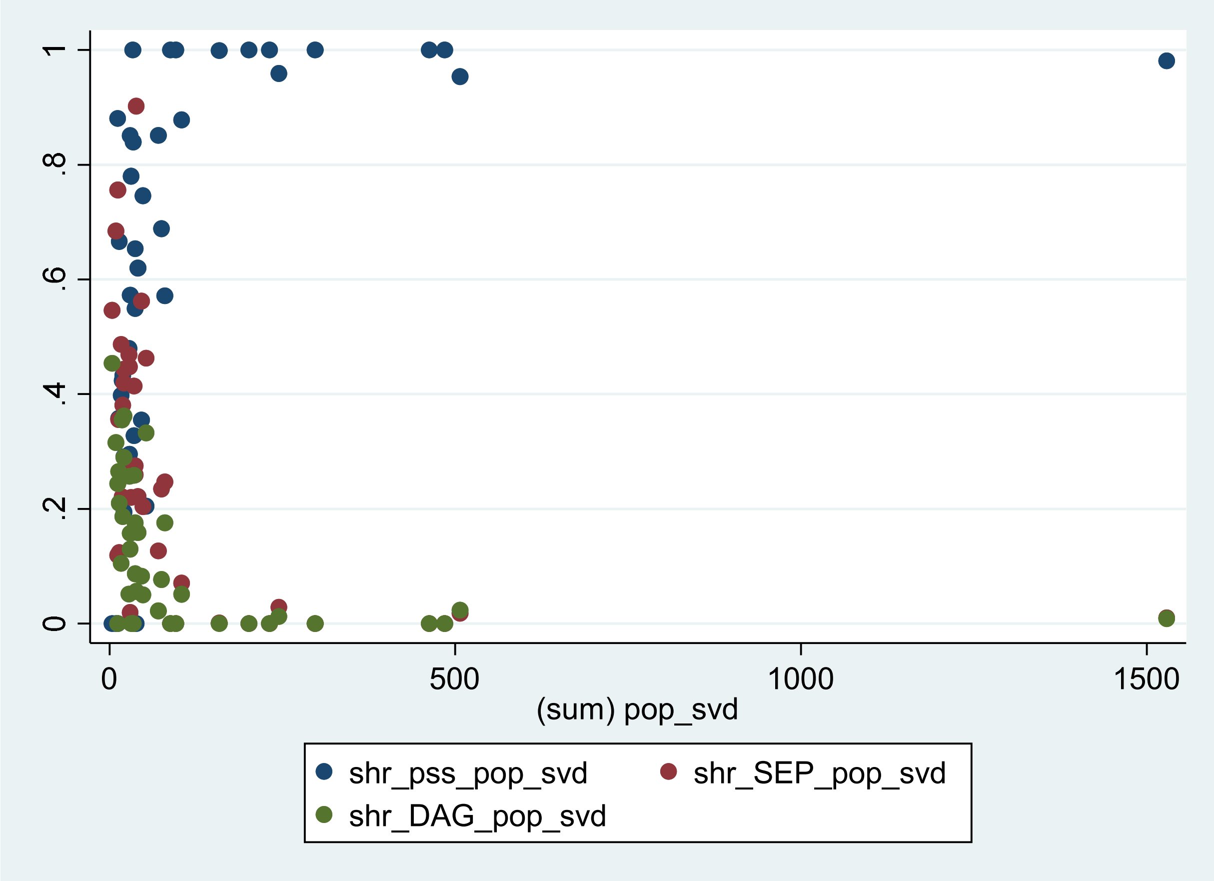
Population Decline Rate



Sewage Treatment Cost

Urban Core

Share of Pop Served for Each Types



- PSS dominates in population served for relatively large entities
- However, especially in rural area, PSS does not dominate, and DAG/SEP plays important roles in sewage treatment there.
- Therefore, we cannot ignore DAG and SEP in our analysis of wide-area cooperation.

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Treatment Cost per Volume Charged

(JPY/m^3)

Urban	stats	cost_s~e	pss_ag~e	SEP_ag~e	DAG_ag~e	OTH_ag~e
Non Urban Core	mean	249.79	221.83	270.79	315.80	398.85
	N	26.00	22.00	26.00	24.00	4.00
Urban Core	mean	119.93	117.56	243.79	316.31	182.52
	N	15.00	15.00	7.00	5.00	1.00
Total	mean	202.28	179.56	265.06	315.89	355.58
	N	41.00	37.00	33.00	29.00	5.00

- The cost measure here is a total treatment cost per wastewater volume charged. This is used by MLIT for their discussions of policy making.
- The cost is higher for non urban core but there are not much differences for SEP and DAG.
- The most striking difference is between PSS in urban and non urban area

Density : Pop Served per Adm/Served Area

(person/ha; 1ha=0.01km^2)

Urban	stats	admind~y	served~y	den_ PSS	den_ SEP	den DAG	den_ Other
Non Urban Core	min	0.05	1.50	1.61	1.19	0.67	2.47
	mean	0.26	2.51	2.81	2.01	2.77	3.20
	max	1.52	3.70	4.50	3.76	4.20	4.09
	N	26.00	26.00	22.00	26.00	24.00	4.00
	sd	0.29	0.59	0.78	0.63	0.84	0.68
Urban Core	min	0.35	3.12	3.28	0.60	2.79	3.72
	mean	3.50	7.34	7.63	3.64	4.45	3.72
	max	9.12	11.41	11.41	11.28	8.49	3.72
	N	15.00	15.00	15.00	7.00	5.00	1.00
	sd	2.68	2.58	2.28	3.70	2.34	.
Total	min	0.05	1.50	1.61	0.60	0.67	2.47
	mean	1.44	4.28	4.76	2.35	3.06	3.31
	max	9.12	11.41	11.41	11.28	8.49	4.09
	N	41.00	41.00	37.00	33.00	29.00	5.00
	sd	2.25	2.85	2.86	1.83	1.33	0.63

- Municipal level served density is markedly different than admin area based density.
- PSS density is generally above the other density figures
- PSS density is markedly different with min urban core above the average for non urban
- All system types have higher average density in urban areas
- There are not so much difference among systems in non urban areas (opposite in urban)

Another Differences between Urban and Non Urban

	pop_svd (10^3)	shr_pop_svd	shr_area_svd	shr_pss_pop_svd	avg_pipe_per_pop_svd (km/ 10^3 pop)	plant_per_pop_svd (plants/ 10^3 pop)	cost_sewbase (JPY/m^3)
Non Urban Core							
min	3.78	0.26	0.01	0	6.59	0	114.43
mean	32.49	0.82	0.09	0.45	11.67	0.61	249.79
max	80.05	1	0.47	0.88	17.45	1.85	762.66
N	26	26	26	26	26	26	26
Urban Core							
min	30.03	0.91	0.08	0.57	2.07	0	73.85
mean	300.02	0.98	0.42	0.94	4	0.03	119.93
max	1528.89	1	0.81	1	9.82	0.27	203.02
N	15	15	15	15	15	15	15
All Municipalities							
min	3.78	0.26	0.01	0	2.07	0	73.85
mean	130.36	0.88	0.21	0.63	8.86	0.4	202.28
max	1528.89	1	0.81	1	17.45	1.85	762.66
N	41	41	41	41	41	41	41

- Even in urban core, not all people are served because there is a mountain in that
- Share of served area shows how little area is covered, so non urban is less covered than urban
- Share of served population for PSS shows marked differences between urban and non urban
- Average pipe length per population shows sewerage systems in rural area require more pipe due to widely dispersed population, indicating that network costs in rural area are generally larger and which is clear from that the max pipe per pop in the urban core is below the mean in the non urban core
- The number of treatment facilities required in urban area is less than that of non urban, indicating PSSs in urban area have better access to RBSs. Moreover, served settlement sizes are much smaller in non urban area so that required treatment facilities are more in non urban area
- As a results, disadvantages in rural areas are largely related to their costs

Correlation

	admind~y	served~y	shr_ps..	avg_pi~d	plant_~d	cost_s~e	cost_s~d
admindensity	1.0000						
serveddens~y	0.8914	1.0000					
shr_pss_po~d	0.6155	0.7281	1.0000				
avg_pipe_p~d	-0.7336	-0.8544	-0.9009	1.0000			
plant_per_~d	-0.4971	-0.5459	-0.8263	0.8006	1.0000		
cost_sewbase	-0.4404	-0.4838	-0.5445	0.6212	0.5909	1.0000	
cost_sewba~d	-0.5071	-0.5973	-0.5129	0.6387	0.4961	0.8936	1.0000

- This table shows the correlations between administrative area density (population/administrative area), served area density(population/served area), share of PSS population served, average pipe length per population, number of treatment plants required per population served, treatment cost, and treatment cost per population served.
- The strongest correlation with the standard cost measure is not with density or the share of PSS but with the average pipe per pop served and plant per pop served data

Summary

- This research (GAIA Project) is supported by MLIT, and Takuya URAKAMI is a research representative of this project. And Urakami is now serving as a member of some councils organized by MLIT.
- MLIT expects us to provide evidences of wide-area consolidation/cooperation, PPP, etc.
- We are now conducting empirical analyses, and in addition we will conduct questionnaire survey on all PSSs in January 2020 to clarify the impacts of wide-area consolidation/cooperation, PPP, etc. quantitatively and qualitatively.
- From our case study of Hyogo prefecture and other empirical analyses, we think we will be able to provide useful information for policy maker (MLIT) to restructure the sewerage industry.

Previous studies

1. Mizutani, F., and T. Urakami (2001) “Identifying network density and scale economies for Japanese water supply organizations,” *Papers in Regional Science*, Vol.80, No.2, pp.211-230, 2001.
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4. Urakami, T. (2019) " Recent Policy Changes in the Japanese Water Supply Industries," Porcher, S. and S. Saussier (eds) *Facing the Challenges of Water Governance*, Ch.13: 347-366, Palgrave Macmillan, Cham, Switzerland.
5. Nakamura E., T. Urakami and K. Kakamu (2019), " A Bayesian Stochastic Frontier Model with Endogenous Regressors: An Application to the Effect of Division of Labor in Japanese Water Supply Organizations ," *Advances in Econometrics*, Vol. 40B, pp.29-46.
6. Arocena, P., D. Saal, T. Urakami and M. Zschille (2019), "Measuring and Decomposing Productivity Change in the Presence of Mergers," *European Journal of Operational Research*, In Press.
7. Urakami, T. (2019), " Japanese Sewerage Industry," Working Paper Series of the Faculty of Business Administration, Kindai University, No. 2019-03.
8. Urakami, T., T. Tanaka, T. Nakaoka and T. Kitamura (2019), " Wide area consolidation and vertical integration of the Japanese sewerage industry: an initial analysis," Working Paper Series of the Faculty of Business Administration, Kindai University, No. 2019-04.

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Thank you!