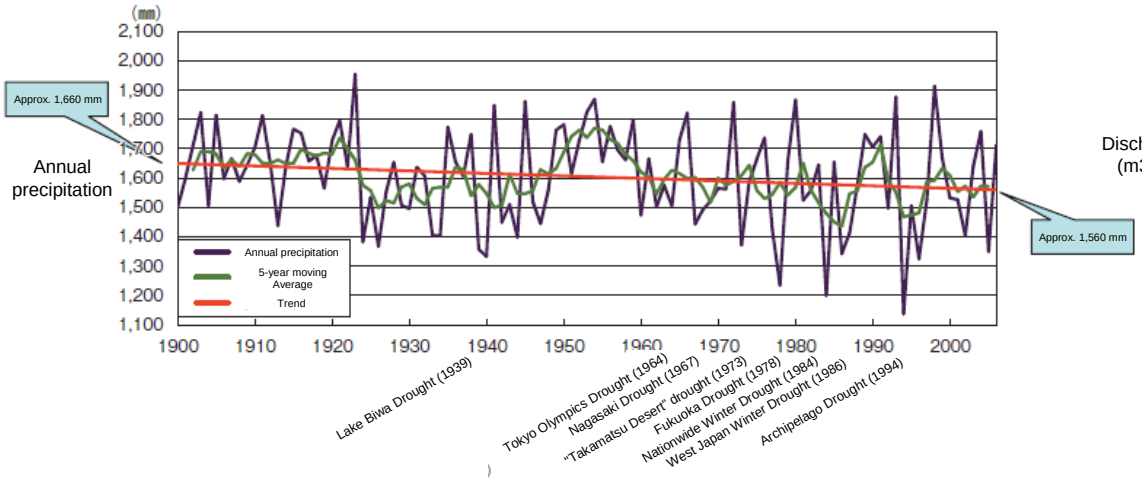
A study on ways to utilize reclaimed wastewater in order to cope with increasing drought risks due to climate change

Climate Change Adaptation Research Group
National Institute for Land and Infrastructure Management

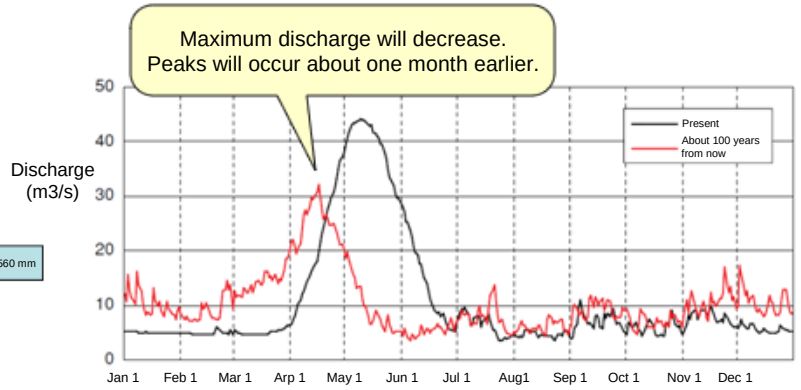
Wastewater and Sludge Management Division, Water Quality Control Department

Necessity of using water in Japan more efficiently to cope with climate change



Changes in annual mean precipitation in Japan

Source: Water Resources in Japan 2008, Water Resources Department, Ministry of Land, Infrastructure, Transport and Tourism



Source: Water Resources in Japan 2005, Water Resources Department, Ministry of Land, Infrastructure, Transport and Tourism

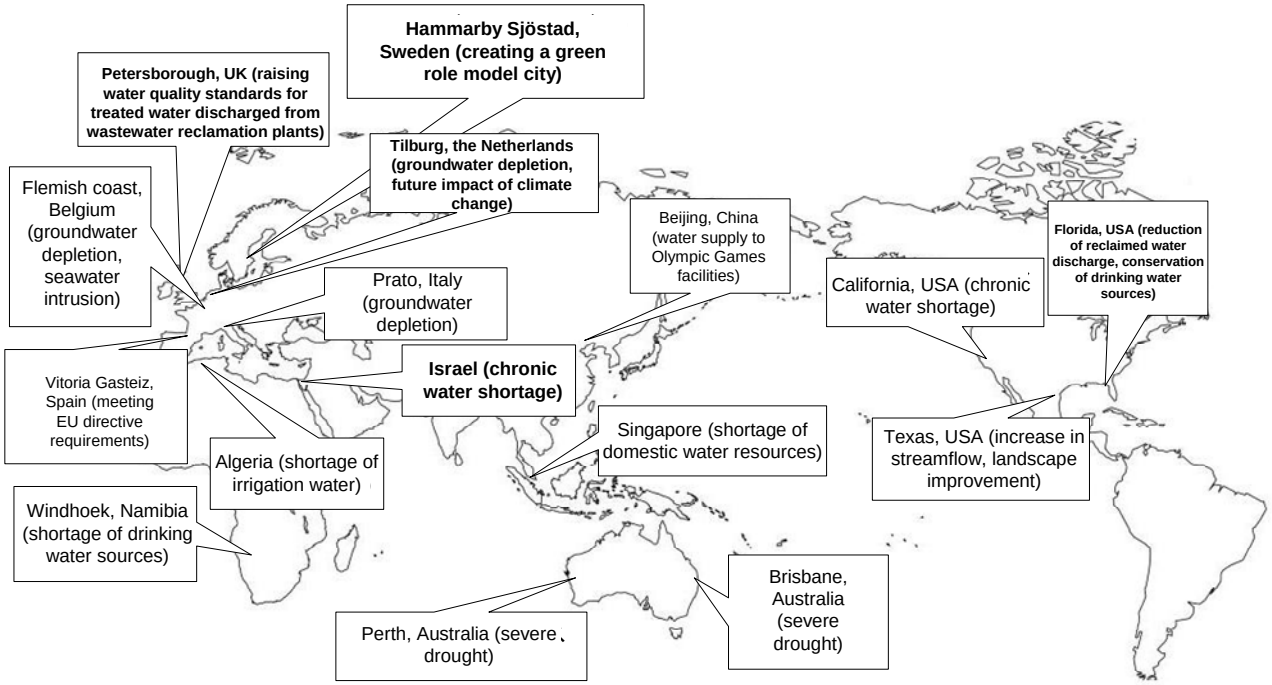
Annual fluctuation pattern of streamflow due to climate change

Decreasing trend in annual mean precipitation
Increasing frequency of drought

Early snowmelt and snow depth reduction due to temperature rise, and decrease in river runoff during the irrigation period

Necessity of efficient use of water including recycling of reclaimed water (water reuse)

Global trend toward more efficient water reuse



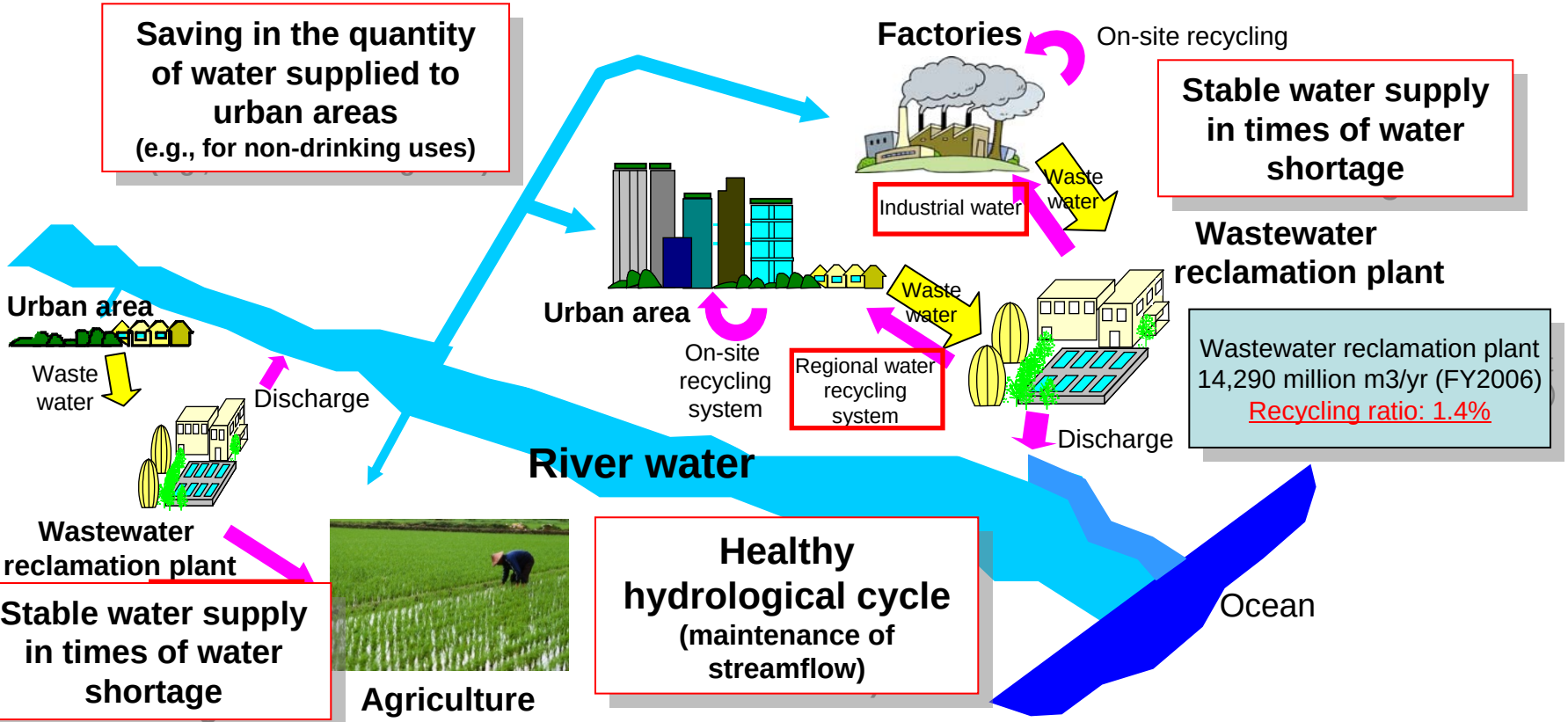
Case Studies of Water Reuse in Other Countries
(Final Report of the Confab on Reuse of Reclaimed Water, 2009)

Reverse osmosis membrane purification facilities as part of the Groundwater Replenishment System (GWR System), Orange County, California, USA (in service since 2007)

Global increase in the number of water reuse projects
Increase in reclaimed water applications
(irrigation water, water for environmental control, groundwater replenishment, indirect drinking uses, etc.)

Introducing advanced water reclamation technology
(e.g., membrane process)

Effects of water reuse on society



Effects as climate change adaptation measures, particularly measures to make more efficient use of water and cope with drought risks.

Overview of research

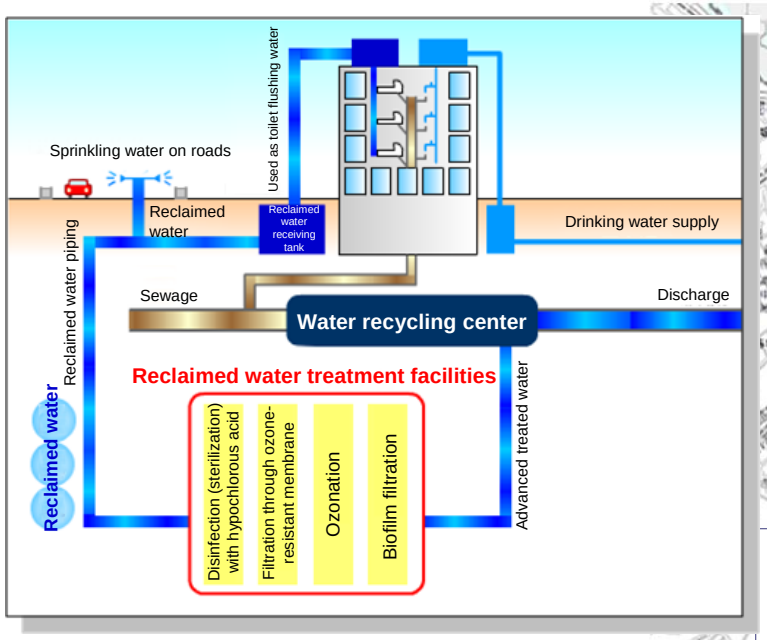
1. Research on measures to promote water reuse in order to increase the efficiency of water use over a medium to long period of time

- Promoting water reuse for municipal water supply
  (e.g., proposing methods for evaluating the environmental effects of water reuse and advantages such as stability of supply)
- Promoting water reuse for agriculture
  (e.g., proposing ways to improve water quality management including the hygienic, agricultural and environmental aspects)

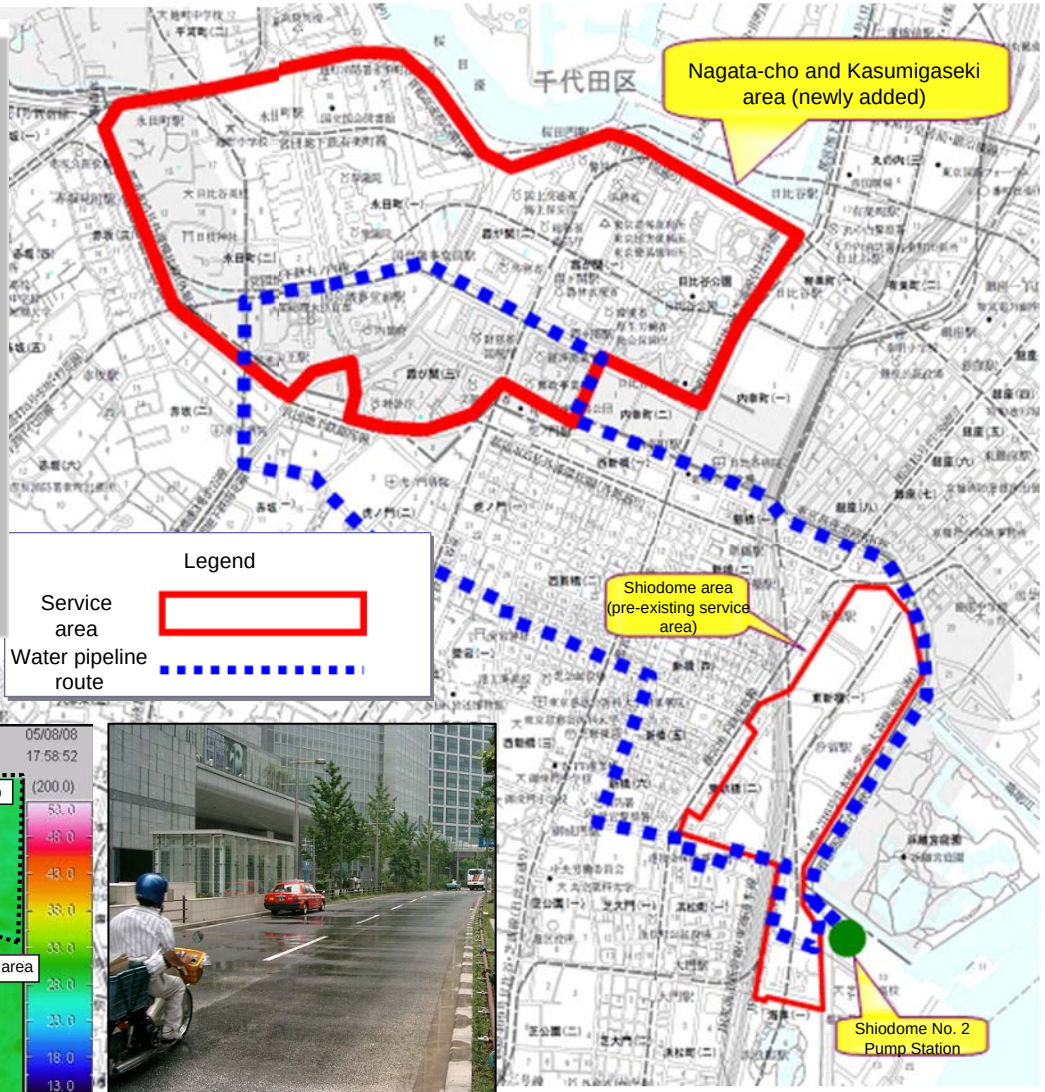
2. Research on ways to make effective water reuse as a source of water in times of water shortage

- Expanding the scope of potential water reuse as a source of water in times of water shortage from the viewpoints of the quantity and quality of water
  (e.g., proposing an emergency reclaimed water supply system using water trucks, water tanks, etc., proposing a technology to enhance the level of water reclamation in times of water shortage)

Concept of water reuse as municipal water supply (regional water recycling system)



Used to flush toilets, water planted trees, etc.



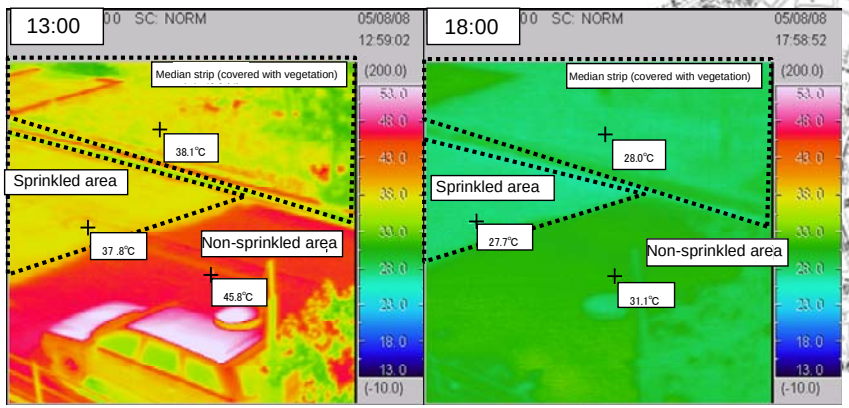


Fig. 1 Comparison of road surface temperature in sprinkled and non-sprinkled road sections (thermography results)

(Map: reproduced from the Websites of Tokyo Metropolitan Government and Tokyo Metropolitan Sewerage Service Corporation)

Municipal water
(1) Growing demand for and water reuse because of climate change

Direct and indirect impacts of climate change

Social factors

Temperature rise in cities

Covering the ground surface in cities (e.g., urban greening, water-holding pavements)

Despite the nationwide tendency toward population decline, population declines in cities are limited.

Projected rate of population growth in 2005–2035
- Nationwide: −13%
- Tokyo: +1%

(National Institute of Population and Social Security Research)

Increasing water consumption

Growing demand for water used to water trees and sprinkle on roads

If a rooftop area of 110 km2 in Tokyo's 23 wards is covered with vegetation, the total quantity of water needed for irrigation is 280,000 t/day (about 7.8% of the average quantity of water supplied) (Public Works Research Institute)

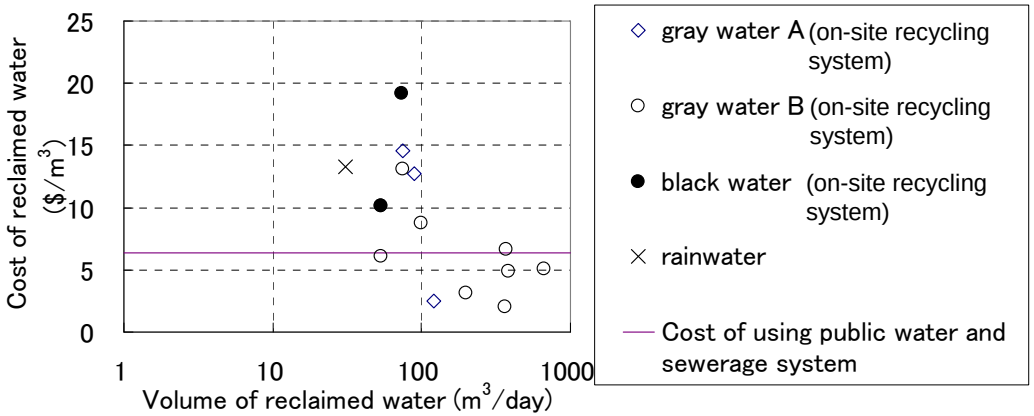
Possibility of increase in demand for non-drinking municipal water such as water for sprinkling applications

Necessity of using as-yet-unused municipal water (reclaimed water, rainwater, underground spring water)

Municipal water
(2) Cost and environmental problems related to reclaimed water

If gray water is used,
advantages of scale come into play.

In water reuse,
the rate of carbon dioxide emission
tends to be lower than in on-site recycling system.



(Yamagata, Ogoshi, Suzuki, Ozaki & Asano, 2003)

Gray water A･･･lavatory, drinking, bath, heating and cooling wastewater
Gray water B･･･kitchen wastewater
Black water･･･toilet wastewater

Figure Survey results on cost of water reuse (survey conducted by Public Works Research Institute and Housing and Urban Development Public Corporation, 2000)

Table Comparison of carbon dioxide emissions (maintenance) between regional water recycling system (water reuse) and on-site recycling system (study conducted by Sewerage and Wastewater Management Department and the National Institute for Land and Infrastructure Management, Ministry of Land, Infrastructure, Transport and Tourism, 2008)

Method	Facilities	Scale (m^3/day)	Biological treatment	Membrane treatment	Filtration	Ozone	Activated carbon	Coagulation–sedimentation process	Others	Average operation rate (%)	Recycling-induced CO2 generation rate (kg/㎥)
Regional	A	1,600				Used		Used		9	2.86
Regional	B	7,200	Used		Used	Used		Used		73	0.77
Regional	C	7,900	Used locally	Used locally	Used	Used				44	0.96
Regional	D	5,000			Used	Used				45	0.40
On-site	E	780	Used		Used					36	2.43
On-site	F	397	Used		Used				Used	58	0.40
On-site	G	120	Used		Used		Used			65	0.84
On-site	a	950			Used		Used			56	1.22
On-site	b	50	Used		Used					127	0.70
On-site	c	88		Used			Used			49	0.33
On-site	d	153	Used		Used		Used			15	2.67
On-site	e	719			Used					40	0.09
On-site	f	1,589		Used	Used				Used	18	3.75
On-site	g	2,822	Used	Used			Used			92	1.40
On-site	h	1,051			Used		Used			75	1.10

(Report of the Confab on Reuse of Reclaimed Water, 2009)

Water reuse needs to be promoted by providing users (e.g., building owners) with information on the environmental effects of water reuse and advantages such as stability of supply.

Municipal water
(3) Problems in management of quality of reclaimed water

Adoption of manuals regarding water quality standards for reuse of reclaimed water
(Sewerage and Wastewater Management Department and the National Institute for Land and Infrastructure Management, Ministry of Land, Infrastructure, Transport and Tourism, 2005)

•Deliberation by the Committee on Water Quality Standards for Reuse of Reclaimed Water (chaired by Dr. Mitsumi Kaneko, Visiting Professor of Ritsumeikan University)

•Considerations related to reclaimed water quality standards, facility standards and water reuse were presented with respect to four use categories (toilet flushing, sprinkling, landscaping and water amenity) and three viewpoints (hygienic safety, appearance and comfort, and malfunctioning prevention).

Improvement of reclaimed water recycling technology

•Progress has been made in introducing recycling technologies for water-amenity-related uses such as the ozone-resistant membrane process (Tokyo) and coagulation–sedimentation/ozone/sand filtration processes (Fukuoka City).

Need to cope with new hygienic risk factors

•Concern about viruses and chlorine-resistant pathogenic microorganisms such as Cryptosporidium
•Recycling technologies using membrane, ultraviolet light, etc., can be used (cost is a problem that needs to be addressed).

It is necessary to make reclaimed water quality management possible at low cost in order to make it more acceptable to users.

Agricultural water
(1) Needs for reclaimed water as a drought-resistant water source

Direct and indirect impacts of climate change

Social factors

Growing drought risk

Needs for local water resources

Future trend (self-sufficiency ratio) in food policies

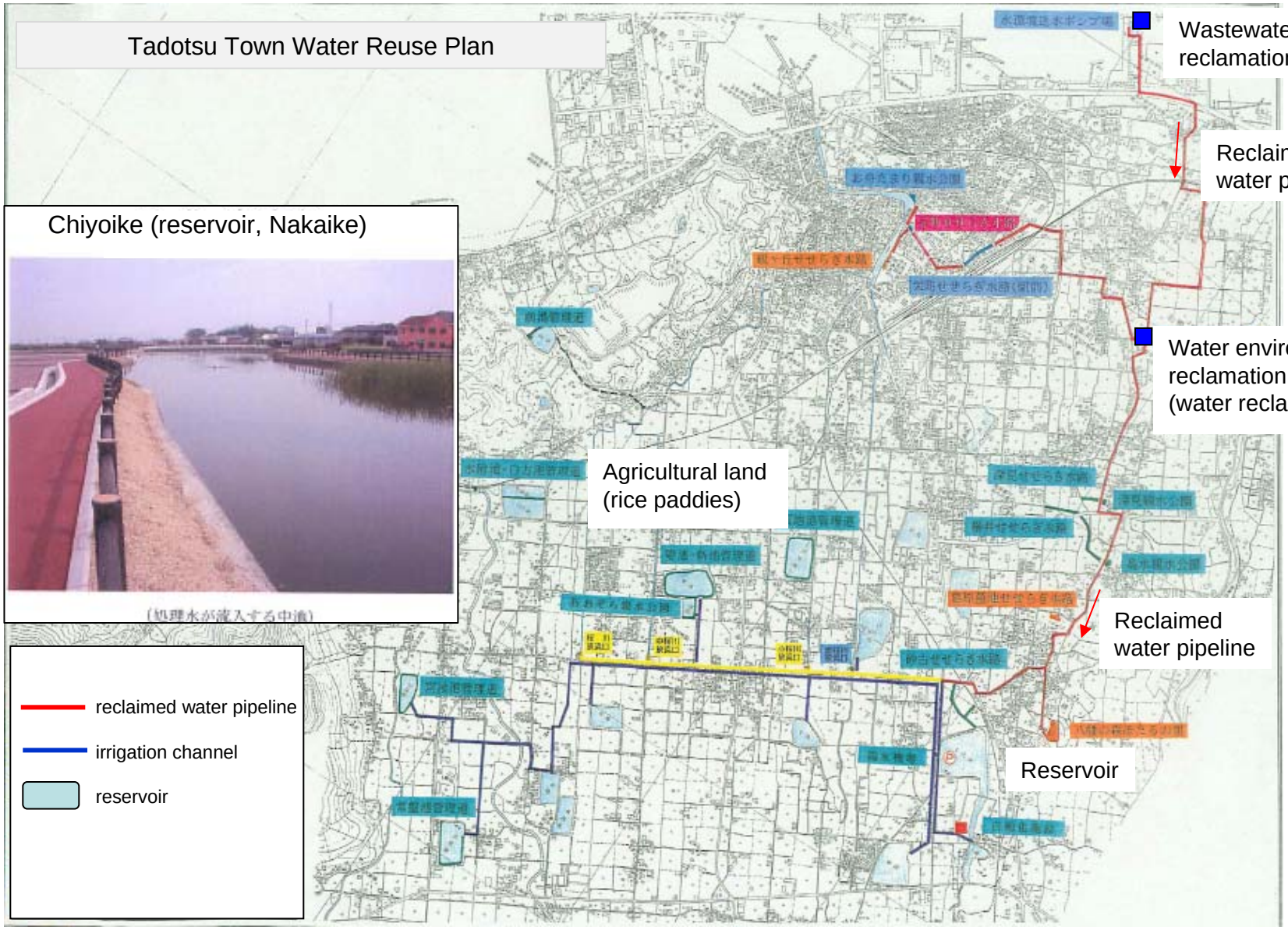
Needs for direct water reuse as irrigation water might grow.

Examples of direct water reuse for agricultural purposes

- **Kumamoto City, Kumamoto Prefecture**
- **Tadotsu Town, Kagawa Prefecture**
- **Shimajiri area, Okinawa Prefecture (under study)**

In other countries, there are many examples (e.g., California) of water reuse for agriculture.

Water reuse as agricultural water: Example in Tadotsu Town



Agricultural water
(2) Problems related to reclaimed water quality management including the hygienic, agricultural and environmental aspects

Japan has no water quality standard for reclaimed water for irrigation.

- There are various examples of wastewater reclamation levels such as secondary treatment (biological treatment), filtration and membrane treatment.
- Thorough hygienic management is necessary, and residual chlorine might have adverse effects on crops.
- Nitrogen and phosphorus contained in reclaimed water have positive effects on crop growth (fertilizing effect).
- Indirect use, which refers to the use of water after it is released into rivers, is also common.

Accumulation of knowledge about water reuse for agriculture in Japan

- Accumulation of case study data (e.g., Okinawa, Tadotsu, Kumamoto) on the implementation of and research on agricultural water reuse.

Research on water quality management methods used in connection with agricultural water reuse in other countries

- In California, various water quality standards have been set, ranging from secondary treatment without disinfection to tertiary treatment with disinfection, depending on the type of crops (e.g., whether to be eaten raw or not).
- Depending on the type of crops, the management of salinity, etc., is also important.
- It is also important to take into consideration nitrogen pollution of groundwater.

It is necessary to establish a methodology for water quality management including the hygienic, agricultural and environmental aspects.

Water reuse as an alternative water source in times of drought
(1) Present state

There are cases where reclaimed water that is released into public waters in normal times is supplied to various users from treatment facilities in times of drought.

Example: Water reuse as an alternative water source in times of drought
(reproduced from the Website of Kagawa River and National Highway Office, MLIT)

Name of government	Description of reuse of reclaimed water
Takamatsu City	**・Under a sewerage project water reuse, a water reclamation plant was constructed in the East Area Wastewater Reclamation Plant. Currently (as of April 1, 2005), reclaimed water is supplied to 44 facilities in the city. At the wastewater reclamation plant, diversion facilities were constructed to enable water reuse (sand-filtered water) for tree watering, etc.**
Mure Town	**・Water taps were installed at the Mure Water Purification Facility and Mure Central Community Center so that treated water can be transported. Loudspeaker cars and public safety radio communication systems were used to encourage the local residents water reuse for sprinkling, etc.**
Tadotsu Town	**・Reclaimed wastewater is used for water amenity parks, river maintenance flows, etc.**
Kagawa Prefecture	**・Every year, at four water treatment facilities of the local sewer systems, sand-filtered water is made available for such domestic uses as tree watering. Information on this is also disseminated so that many people can water reuse.**

Filtered water outlet at the East Area Wastewater Reclamation Plant in Takamatsu City
Reclaimed water is used for such purposes as toilet flushing, sprinkling and firefighting in times of drought or emergency.
(Source: Takamatsu City Water Cycle Restoration Plan, 2003)

Water reuse as an alternative water source in times of drought
(2) Problems

	Water quantity	Water quality
Problems	When reclaimed water is used only in times of drought, water supply capacity is limited by the number of water trucks, etc.	Because the required level of water quality varies depending on the intended water reuse, it might not be possible to supply water in times of drought depending on the level of treatment that can be done at the wastewater reclamation facility.
Proposed corrective measures	•Establishing an emergency water supply system using water trucks, water tanks, etc. •Increasing the number of water supply sites in times of drought by, for example, laying additional piping by which to deliver reclaimed waters to public facilities	•Using advanced treatment facilities as reclaimed water supply sites in times of drought on a priority basis •Introducing technologies to enhance the level of treatment only in times of drought (e.g., movable membrane treatment equipment)

It is necessary to evaluate the usability of reclaimed water as a water source available in times of drought in terms of both quantity and quality and position water reuse as a drought response measure in community disaster prevention plans, etc.