Toward the sustainability of urban water system

持続的な都市水システムを目指して

지속가능한 도시 물 관리를 위하여

Voice of young professionals from Korea and Japan

Report of student session at 8UDM & 2RWHM conference

September 7-12 2009, Tokyo, Japan

The University of Tokyo, Seoul National University

東京大学 THE UNIVERSITY OF TOKYO

서울대학교 SEOUL NATIONAL UNIVERSITY

Preface

This booklet is a summary of a student session at the 2RWHM + 8UDM joint international conference which was held on Sep 7-12, 2009 at the University of Tokyo. Students were mainly from Seoul National University and University of Tokyo, but their nationalities were from Korea, Japan, Vietnam, India, Jamaica, Thailand, and Indonesia. Students made presentations about their discussion results, opinions, and messages at the closing session and post conference workshop on Sep 12.

The main purpose of this student session was to provide a platform to learn urban water management and to propose methods to deal with current water problems. The second objective was to build international friendship necessary for corporation when dealing with climate change.

The students discussed the increased risks in urban water management systems caused by climate change and countermeasures which are being practiced in Korea and Japan using several case studies such as rainwater harvesting, wastewater reclamation and restoration of surface water and groundwater etc.

In their discussion, the students identified water related problems, raised imperative questions, proposed solutions, and finally delivered a message. All students enthusiastically participated, suggested creative ideas and exchanged friendship in the seminars, field trip, group discussion and farewell party.

The voice of young professionals is important for older generations who are decision makers of the current water management system. This is not only because the young generation can suggest new and creative ideas, but also because we share our future world with them. Therefore, we encourage these student activities at various occasions for building friendship and deriving creative solutions.

This Student Session was one of the many activities supported by the Global Center of Excellence (GCOE) for Sustainable Urban Regeneration at the University of Tokyo and Safe and Sustainable Infrastructure Research Center (SIR) at Seoul National University.

Mooyoung Han, Professor,
Seoul National University

Hiroaki Furumai, Professor,
The University of Tokyo

Prof. Mooyoung Han

Prof. Hiroaki Furumai

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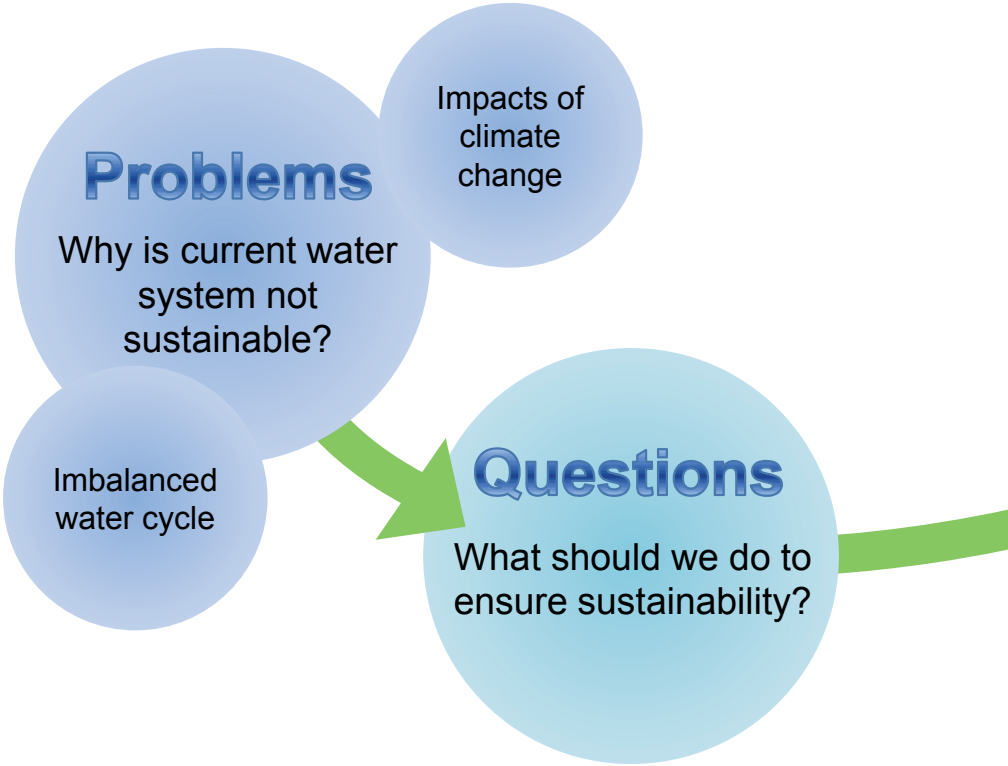
Outline

Current urban water systems; Are they sustainable?

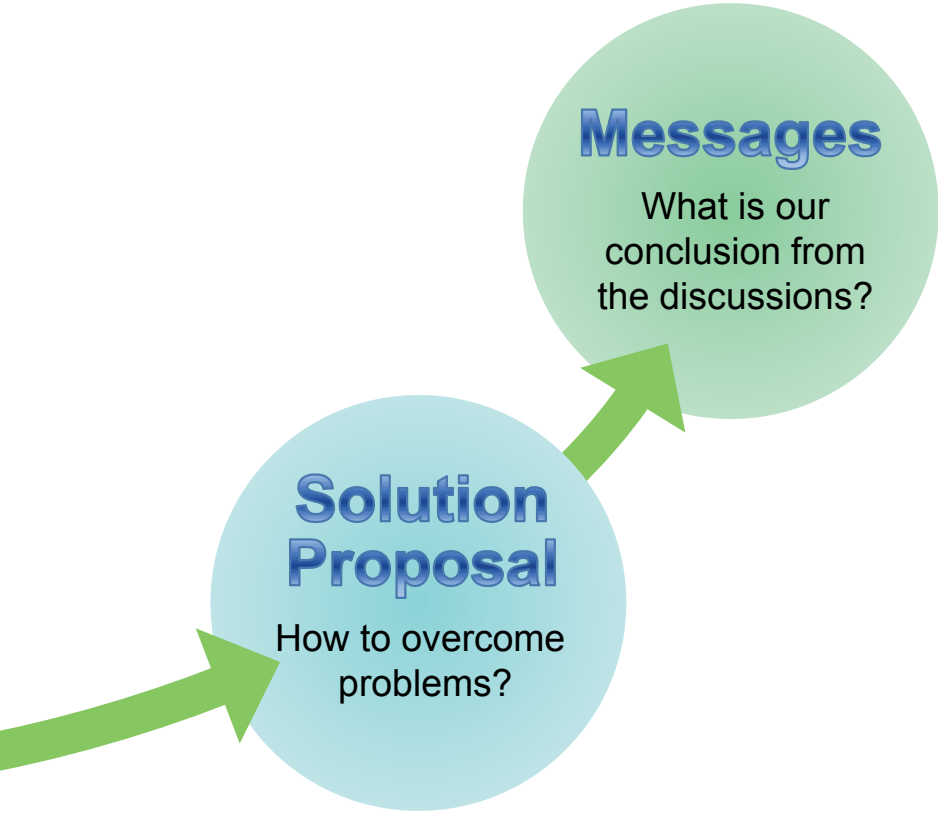
We use a large amount of water in urbanized area thanks to water systems such as water supply and sewerage systems. However, the systems have problems from a standpoint of sustainability, and these problems are expected to become serious in the future.

In this booklet, first we identify two kinds of issues in urban water systems; imbalanced water cycle and impacts of climate change. This is the starting point of student session as **Problem Identification.**



After understanding the causes of the problems, we identify key questions to achieve the sustainability of urban water systems. This is the step of **Question Setting**.

Then we propose three types of solutions which we discussed in the student session. In this process, we introduce some case studies in Korea and Japan, and suggest ideas to promote these solutions effectively. This is the step of **Solution Proposal**. Finally, we draw conclusions from our discussion and deliver an intelligible message as young professionals toward the sustainability of urban water system. This is the final target of **Message Transmission**.



Problems in urban water system

Imbalanced water cycle in urban areas

How have we changed the natural water cycle? Why is the urban water cycle imbalanced? Let us compare the natural water cycle (Fig.1) and the urban water cycle (Fig.2).

Natural water cycle

Water circulates by precipitation and evapotranspiration. From earth, 77% of water evaporates from sea surface and 23% from land surface. In the opposite, 23% water rains on the sea surface and 77% rains on the land surface[1].

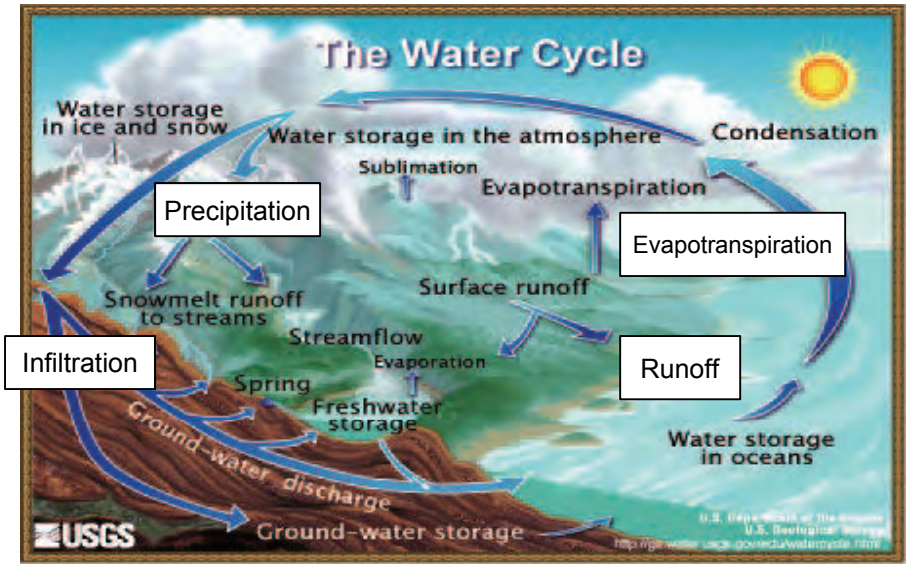


Fig.1 Natural water cycle [1]

Water for use in natural water cycle

In the natural water cycle, there are finite water sources as follows.

- Freshwater storage (e.g. rainfall, river, pond, lake)
- Groundwater discharge (e.g. spring)

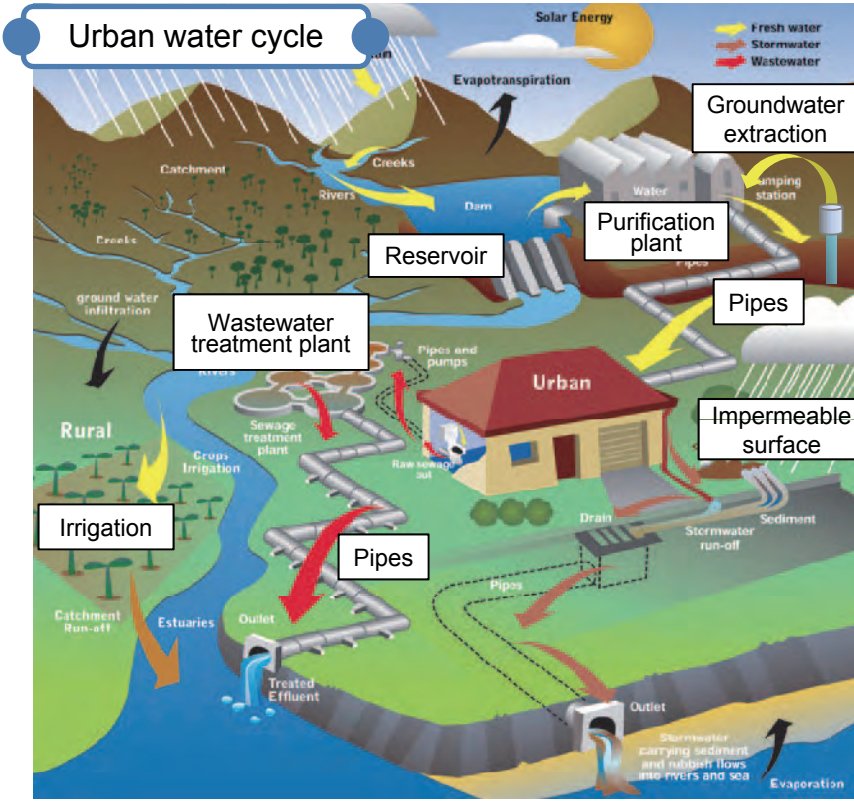


Fig.2 Urban water cycle [2]

We have altered the water cycle by the construction of centralized water management systems and by land use change such as follows:

1. Water supply system: To meet increasing water demand by urban development (e.g. population increase, industrial development), we have constructed many reservoirs (e.g. dams), water purification plants and pipe networks. Groundwater is still playing an important role, though.

2. Sewerage system: Increasing wastewater from cities have caused declining quality of urban waters. In order to treat wastewater and efficiently drain stormwater, sewerage system has been introduced.

3. Land use change: Increasing impermeable surfaces which prevent rainwater infiltration causes an increase in stormwater runoff and a decrease of groundwater recharge.

What are the problems in cities with a high dependence on centralized water management systems?

Centralized water supply systems and sewerage systems create an artificial water cycle underground, of which the volume of flow can be higher than that of a river flow. Although we enjoy the benefits of their high capacity in managing the water in urban areas, there are some problems caused by them. Here we give you some examples:

• No More Dams?

Our water resource is highly dependent on the storage in large dams. However, construction of dams sometimes damages the landscape and ecosystems upstream (Fig.3).

Fig.3 Dam made view changed (Dongbuk-dam, Korea) [3]

• Combined Sewer Overflows (CSO)

Some cities like Tokyo have combined sewer systems; which collect both wastewater and stormwater. On rainy days, stormwater flow exceeds the capacity of wasterwater treatment plant (WWTP) and untreated wastewater is discharged with stormwater. This phenomenon is called **Combined Sewer Overflow (CSO)** and causes heavy contamination in receiving water bodies (Fig.4).

Fig.4 Combined sewer overflows[4]

Water balance in Tokyo

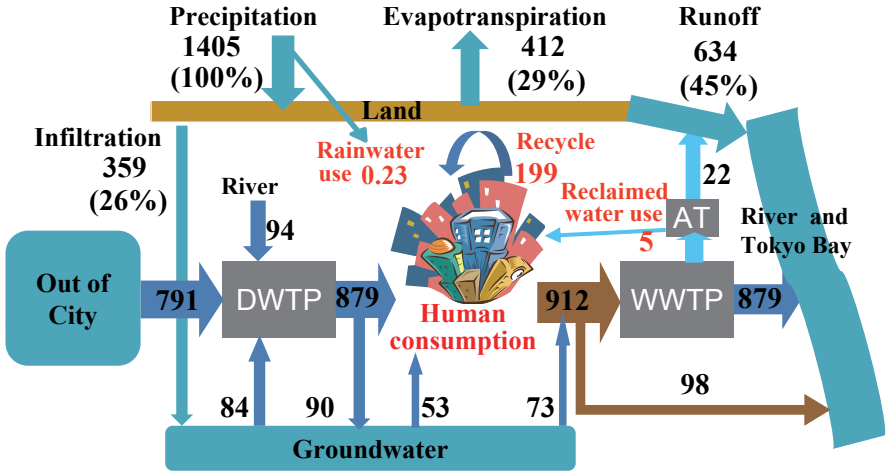


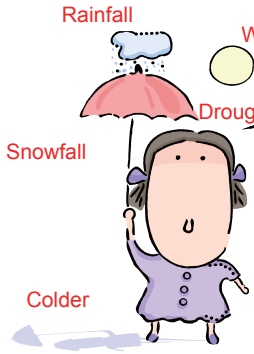
Fig.5 Water balance in Tokyo (unit : mm/year)[5]

Let us see the details of the urban water cycle in Tokyo (Fig.5). To compare with the natural water cycle (precipitation, evapotranspiration and runoff), each water flow per year is divided by the city area.

- Available water from rainfall (i.e. precipitation – evapotranspiration) is 993mm/year, which is smaller than total human consumption of more than 1,100 mm/year. 82% of the water resource in Tokyo comes from outside the city.
- Compared with the national average, stormwater runoff in Tokyo (634mm/year) is bigger due to the high presence of urbanized impervious areas[5]. On the other hand, the infiltration is limited.
- We have installed facilities for rainwater use and reclaimed water use in industries and sewer systems to save the water, but their contribution to the overall water cycle is still very low in Tokyo.

We have shown thus far the current problems in the urban water management system. In the next section, let us see what kind of problems will be caused by climate change.

Threat of Climate Change on Current Water Management



Do you sense any changes in weather patterns these days?

This phenomenon is called **climate change** which is often referred as **global warming**. It is mainly caused by increasing concentrations of greenhouse gases generated by **human activities** such as burning of fossil fuels and deforestation. Let us examine its impact on water environment (Fig.6).

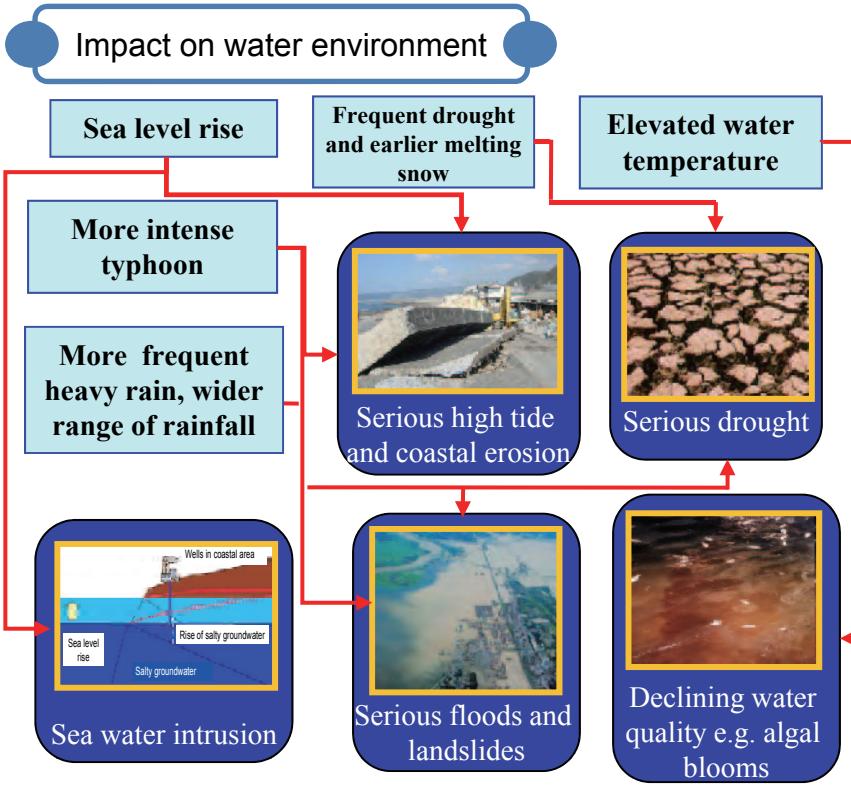


Fig.6 Impact of climate change on water environment [6]

Risk of heavy rain and water shortage

If the earth's temperature rises, surface water evapotranspiration occurs at an accelerated rate resulting in high precipitation. The observation since the beginning of the 20th century show that the frequency of extreme rainfalls has progressively increased (Fig.7). In addition, it is projected that heavy rainfall will escalate and pose risk of **flooding**, **landslide** and coastal **storm disasters**. The threats associated with floods are not only **construction-related** but also water-related **health risks** and loss of life.

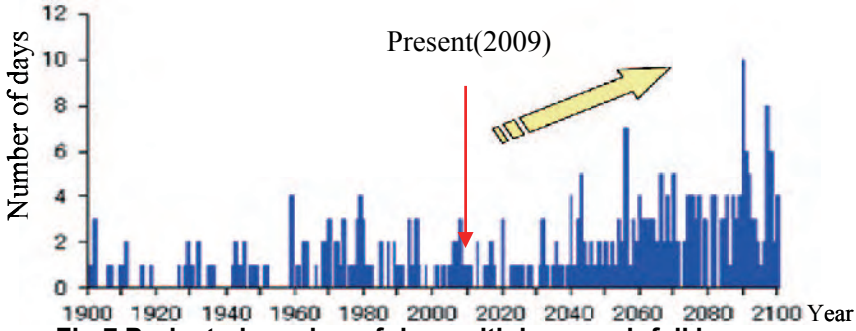


Fig.7 Projected number of days with heavy rainfall in summer (daily precipitation of more than 100mm)[6]

The timing of **melting snow** is expected to get earlier. This will cause **water shortage** for paddy agricultural use during rice planting period (Fig.8).

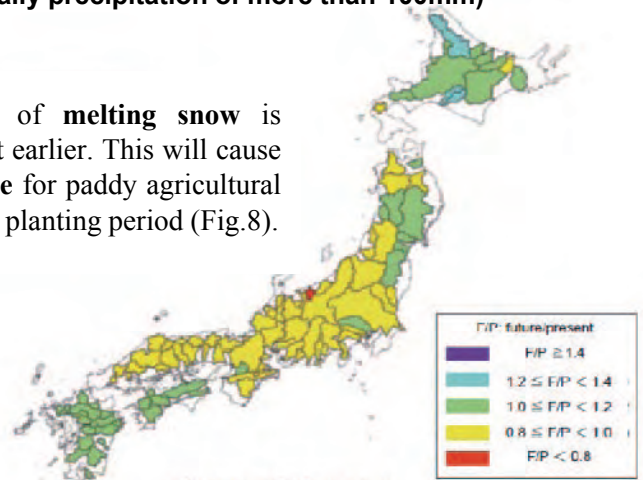


Fig.8 Reduction of river flow in rice planting period in 100 years (2080-2099 relative to 1979-1998)[6]

Population growth, urbanization, economic development and land use change cause imbalances in water cycles in urban areas. The demands on water are increasing, while the disputes over the construction of centralized water supply and sewerage system are intensifying. Then, how will we combat the stress on water systems which are expected to intensify due to the climate change? Comprehensive studies to find new sources of water, to rebalance water cycles and to mitigate impact of climate change should be emphasized in order for us to prepare for future challenges on water supply.

Questions

Q. **What new water resources can be found?**
新しい水資源は何か
새로운 수자원은 어떠한 것들이 있는가?

Solution proposal

Rainwater harvesting (Page 12)
Reclaimed water use (Page 22)

Q. **How to restore/balance water cycle?**
水の循環とバランスを維持するためには?
건전한 물 순환을 회복하는 방법은?

Solution proposal

Restoration of surface water and groundwater (Page 30)

Q. **How to mitigate water shortage and floods?**
水不足や洪水を軽減するには?
가뭄과 홍수 피해를 최소화 하기 위해서는?

Solution proposal

Rainwater harvesting (Page 12)

Discussion Summary

Rainwater harvesting

Rainwater harvesting is to gather, or to accumulate and store, rainwater.

At present, risk of flooding and water shortage in urban areas is becoming higher due to climate change. Rainwater harvesting system therefore is an important solution in maintaining water sustainability and balance in urban areas.

Rainwater harvesting and storage systems can be used to supply **alternative water resource** as well as for **flood control**.
Here are some examples:

- Water for miscellaneous use: toilet flushing, car washing etc.
- Water for emergency use: fire prevention, earthquake.
- Reduction of stormwater discharge through sewerage systems.

If rainwater harvesting and water reclamation are promoted, the quantity of runoff and water intake from rivers will be reduced. These can help solve water shortage and flooding. Some examples of rainwater harvesting are shown in the next page.

BRAIN FOR RAIN (雨) RAIN FOR GAIN

"We will use our **Brain** to create **Rain** water harvesting systems, and use **Rain** water to **Gain** sustainable water supply for future."

"It takes both **rain** and sunshine to make a Rainbow"

Case study in Japan 1

In urban areas of Japan, there are many rainwater harvesting and reclamation facilities. The data shows that the number of these facilities in Japan has been increasing each year (Fig. 9).

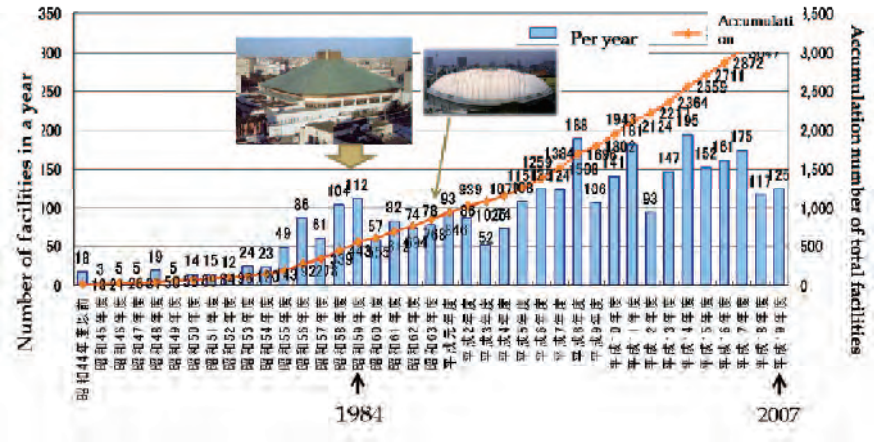


Fig.9 Change of number of rainwater harvesting and reclamation facilities in Japan[7]

One of the good examples of large-scale rainwater harvesting is that of *Ryogoku Kokugikan* (Sumo-wrestling Arena) in Tokyo (Fig. 10).

Ryogoku Kokugikan 1984

Tank Capacity of 1000m^3
(effective vol. 750m^3)

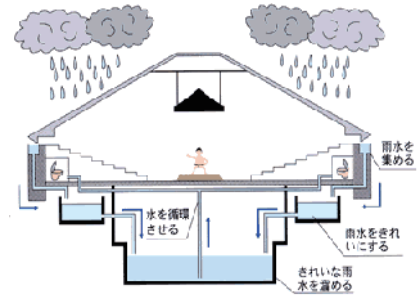
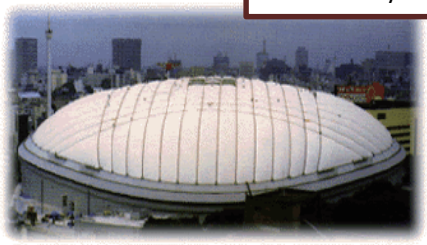


Fig.10 Rainwater tank for flood control and harvesting at Ryogoku Kokugikan[8]

Case study in Japan 2

One other symbolic example is a rainwater tank at Tokyo Dome (Fig. 11). This tank is not only for rainwater harvesting but also for flood control as well as for emergency water supply.

Tokyo Dome 1988



Tank Capacity of 3000m^3
1000m^3 for flood control
1000m^3 for miscellaneous water use
1000m^3 for emergency water supply for such as fire fighting

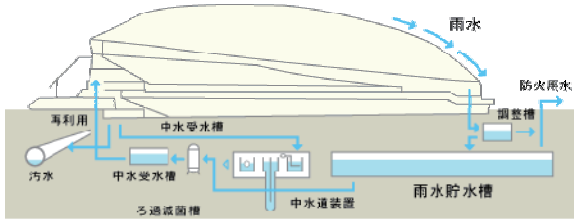


Fig.11 Rainwater tank for flood control and harvesting at Tokyo Dome[9]

Yet another example of rather smaller-scale rainwater harvesting is the one installed at the city government building of Ayase city (Fig.12).

Fig.12 Rainwater harvesting in the city hall at Ayase city

Case study in Japan 3

There is another type of rainwater harvesting system adopted at the household level, rainwater harvesting tank (Fig.13). These tanks are subsidized by local government.

Fig.13 Rainwater harvesting tank[10]

Case study in Japan 4

Water retention pavement as a countermeasure against heat island is one of the new types of rainwater use adopted in Japan. Rainwater falling on each square block flows into side ditch and is stored in an underground tank (155 m^3) (Fig. 14). Water from the tank is then supplied to paving blocks via sprinkling pipes (Fig. 15).

Water retention pavement

Fig. 14. Rainwater harvesting underground tank[9]

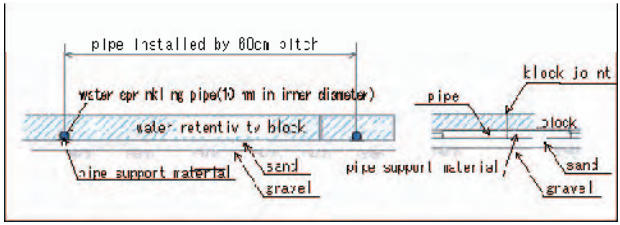


Fig. 15 Underground sprinkler[9]

Case study in Japan 5

Temperature reduction to 19 ºC was observed when stored rainwat er was supplied eight times per day, for 15 minutes at a time. This rai n-water harvesting system has already been installed at a walkway ne ar Shimbashi railway station,Tokyo.(Fig. 16)

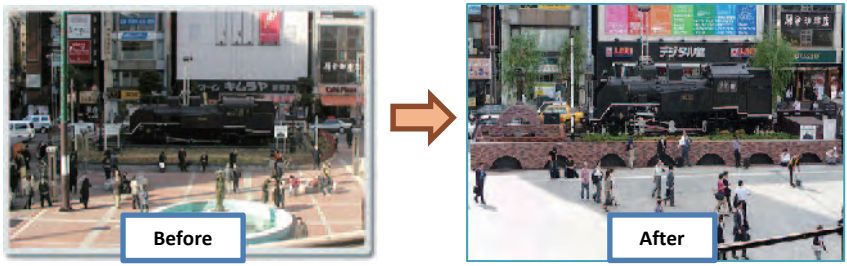


Fig.16 a pavement near Shimbashi railway station in May 2006[9]

Tokyo Sky Tree

Fig.17 Tokyo Sky Tree (rendering)[11]

The Tokyo Sky Tree (originally referred to as New Tokyo Tower) (Fig.17) is a broadcasting tower currently under construction in Sumida ward, Tokyo.

This building is one of the new buildings promoting rainwater harvesting. Rainwater stored in a tank will be treated and used in the building for miscellaneous purposes such as toilet flushing. The water will also be used for community use such as gardening.

Case study in Korea 1

In Korea, installation of rainwater harvesting systems is encouraged by central and local governments. Existing cases of systems installed for research or field scale monitoring, and recently constructed private sector application are shown below.

Dormitory of Seoul National University

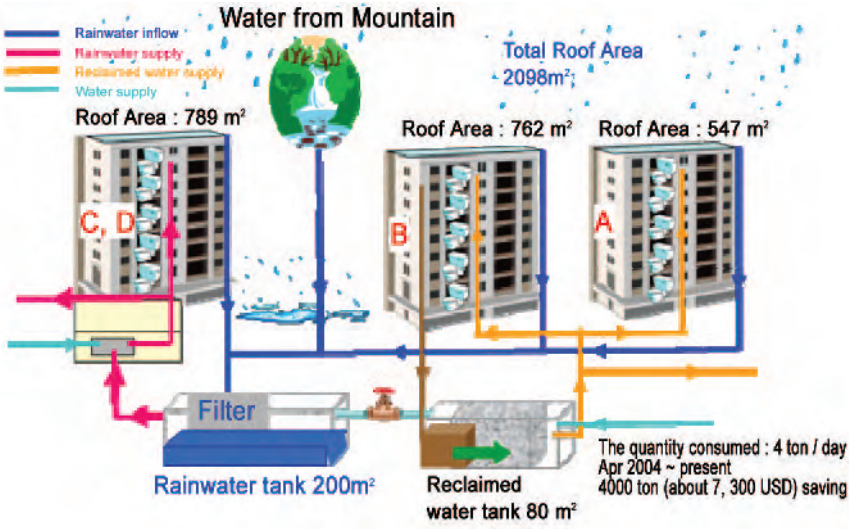


Fig.18 RWH system in Dormitory of SNU[12]

Outline of facility

- Location : Dormitory for graduate students in Seoul National University
- Completion of construction : Nov. 2003
- Storage capacity : 200 m^3 (Concrete tank)
- Tapwater replacement ratio by rainwater : 66%

Purpose of installation

- Research : long-term monitoring of rainwater harvesting system operation
- Toilet water supply for multiplex house.

Case study in Korea 2

39th Engineering building of Seoul National University

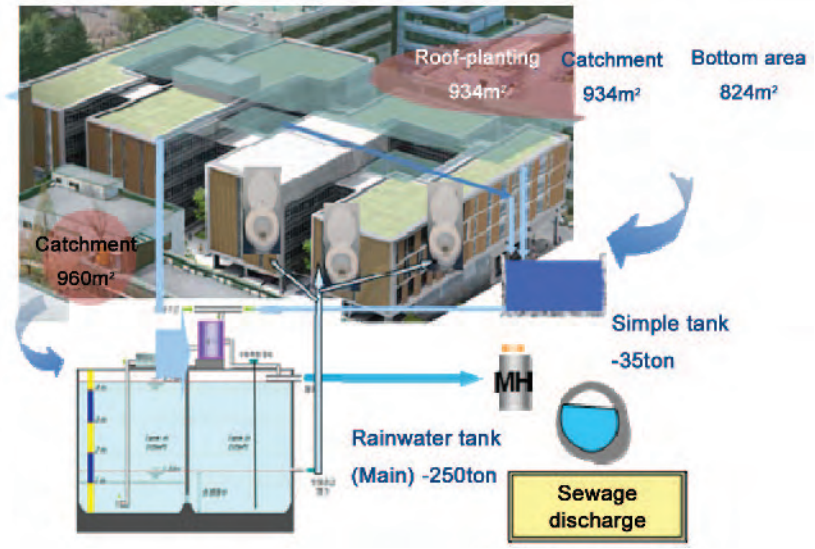


Fig.19 Rainwater harvesting system in 39th Engineering building of Seoul National University[12]

Outline of facility

- Location : 39th building of engineering college in Seoul National University
- Completion of construction : Oct. 2005
- Storage capacity : 250 m^3 (Concrete tank)
- Tapwater replacement ratio by rainwater: 62.3%
- Use of rainwater per day on average: 6.2 m^3

Purpose of installation

- Research : long-term monitoring of rainwater harvesting system operation
- Toilet water supply for education building.

Case study in Korea 3

Star-city

Star city is a residential-commercial complex located in Gwangjin-Gu, Seoul. This site is famous for its novel rainwater harvesting system, which is innovative in both engineering and social aspects. The example of rainwater system in this complex suggests a strategy to spread rainwater harvesting facilities without conflict between government and private sectors. Floor space index of 3% was additionally allowed as an incentive to install rainwater harvesting system.

Location	Seoul Metropolitan Gwangjin-Gu Jayang-Dong
Scale	Site Area : 62,505.2 ㎡ Building Area : 16,867.729 ㎡ The third basement～the ground 35/45/50/58 F, total 4 blocks
Use	Garden water, Public toilet water, Swimming pool water (prearrangement)
Tank capacity	3,000 ㎥ (1,000 ㎥ × 3 tank)

Storage tank #1

- Collect rainwater from rooftop ⇒ For Gardening and toilet-flushing water

Storage tank #2

- Collect rainwater from ground ⇒ For flood control

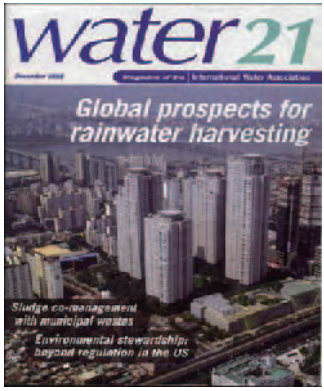
Storage tank #3

- Emergency water ⇒ For fire fighting

Case study in Korea 4

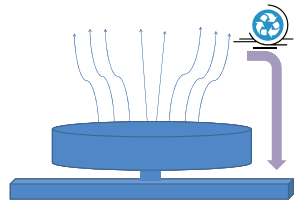
Significances of Star-city

- Example of successful water management practices satisfying all stakeholders involved (i.e. local government, resident, and construction company).
- Advanced system design in various aspects of water management (i.e. water supply, flood prevention, and water security for emergency)
- Conflict-minimizing site development model in urban area by adopting rainwater harvesting



Rainwater harvesting system in Star-city was featured in 'Water 21', a world-wide water journal, as a cover-story[25].

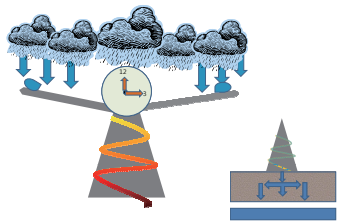
Summary

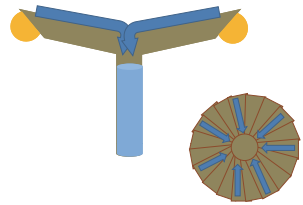


Rainwater harvesting and storage system is regarded as a promising technology for flood control and to secure supplemental water resource in urban areas, which can contribute to solution of imbalanced water cycle. Recently, Japan and Korea have promoted construction of rainwater harvesting facilities in residential buildings as well as public and commercial buildings. However, rainwater use is still limited due to insufficient public awareness, resulting in producing meaningless and wasteful runoff water. The "Mottainai" concept should be applied to this issue.

If rainwater harvesting systems get more widely adopted, problems of water shortage, runoff pollution, threats of floods can be minimized. Adoption of rainwater harvesting facilities at various all levels of society, from large-scale infrastructures to individual residence should be promoted. Government should encourage the adoption by giving subsidies or tax incentives to private companies or citizens who install the rainwater storage and harvesting facilities. In addition, application of rainwater collection and storage systems will have symbolic effects when combined with public properties such as community clock tower or street lights. A successful combination with creative design will help raise public recognition and awareness of seriousness of water issues, too.

Image of rainwater collection and storage system combined with clock tower (left) and street light (right)





Reclaimed water use

What is reclaimed water ? How is reclaimed water used? Let us examine the current situation.

Water reclamation

Unlike the conventional wastewater treatment, **water reclamation** is a process in which wastewater is cleaned using sophisticated biological, physical and chemical processes so that the water can safely be returned to the environment for various purposes.

Reclamation of wastewater has come to play a new role of sewerage systems in order to provide a new water resource inside urban cities.

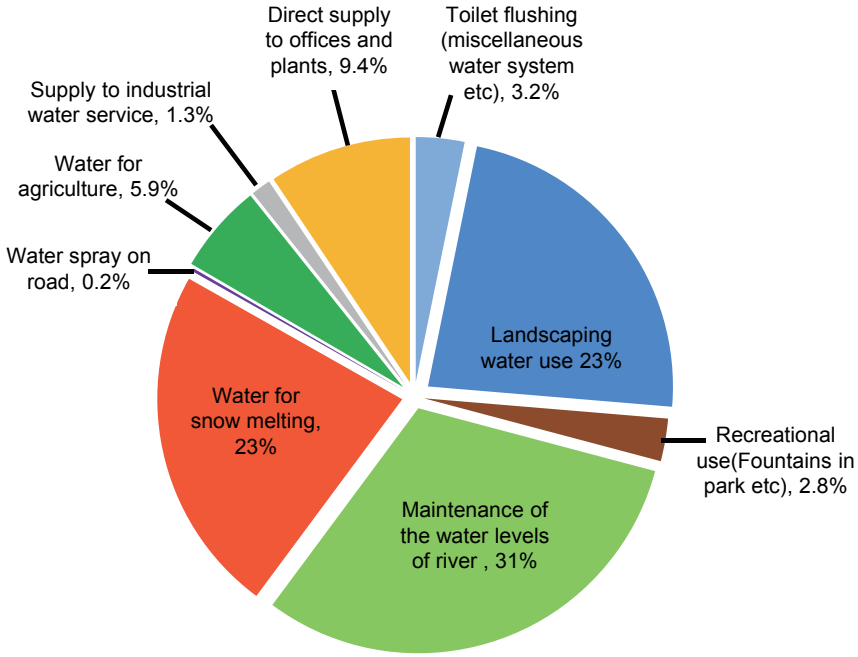


Fig.20 Percentage and Purpose of use of reclaimed water in Japan, 2004 [13]

How to Use?

Fig.20 shows breakdown of water reuse in Japan. Reclaimed water is mainly used for maintenance of water levels of rivers, landscaping and snow melting. The total amount of wastewater treated in WWTP is 14.1 billion m^3 per year. However, rate of reutilization is only **1.4% (0.19 billion m^3).** This rate is low compared to other developed countries such as U.S.A. where a large volume of reclaimed water is used for agriculture.

Let us see the chart below (Fig.21). It shows the use of reclaimed water in Korea. Total amount of wastewater is 6.6 billion m^3 per year. Rate of use is **4.7% (0.31 billion m^3)**. In Korea, reclaimed water is mainly used to maintain water level of rivers, similar to Japan. However, the rate of reclaimed water used for agriculture is remarkably higher than that of Japan.

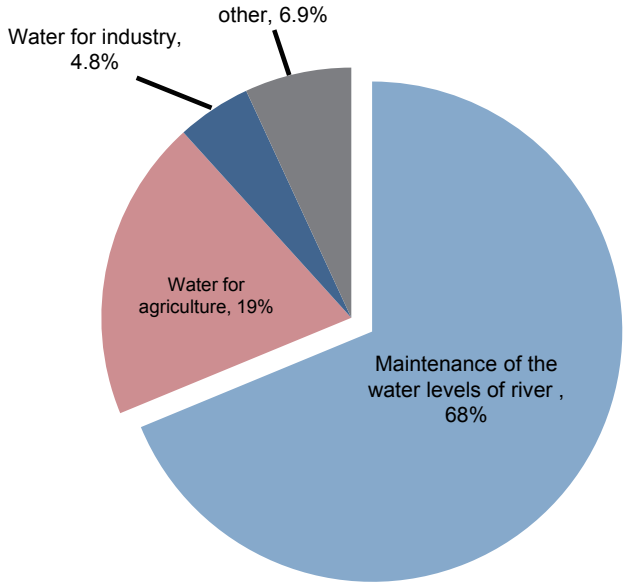


Fig.21 Percentage and purpose of use of reclaimed water in Korea, 2008 (modified from ref.14)

Case study in Japan 6

Ochiai water reclamation center (Fig.22) is located very close to the subcenter of the Shinjuku area. The center is thoroughly controlled in a environmental-friendly way as a water reclamation center surrounded by residential districts.

The treated wastewater in this reclamation center is abundant in volume and stable in quality, and can be effectively utilized for miscellaneous uses in buildings such as for **toilet flushing**.

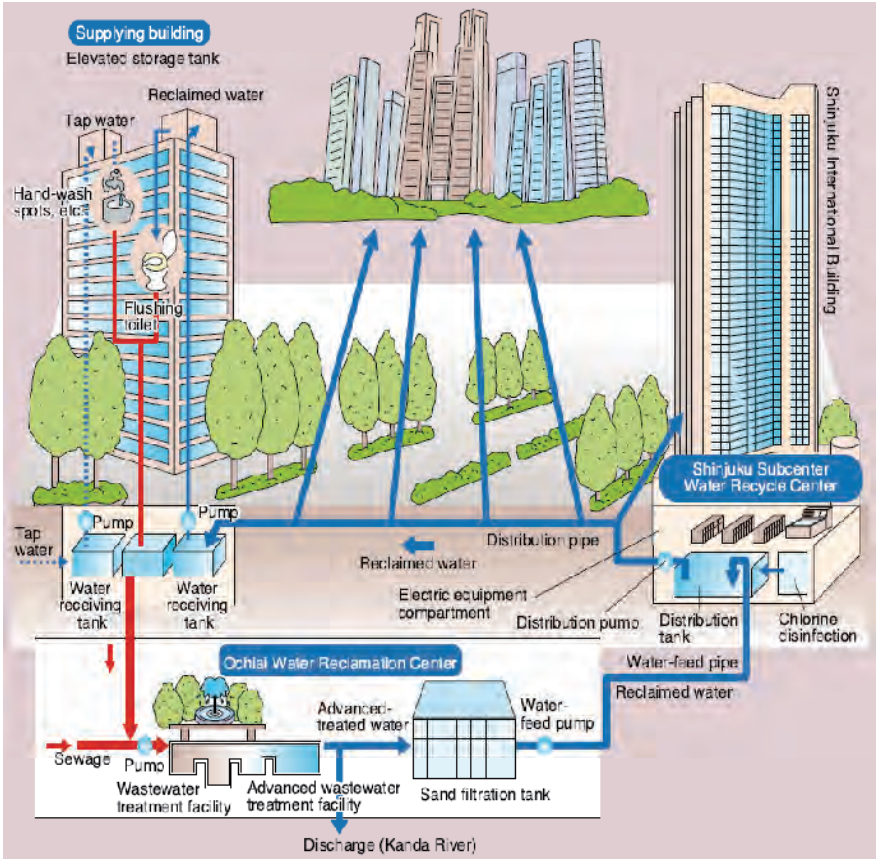


Fig.22 Schematic image of water reclamation[15]

Case study in Japan 7

In a plant in Shibaura, reclaimed water is used as a **medium to absorb the heat of air-conditioning equipment** (Fig.23). This wastewater heat utilization project contributes to the reduction of the number of cooling tower plant.

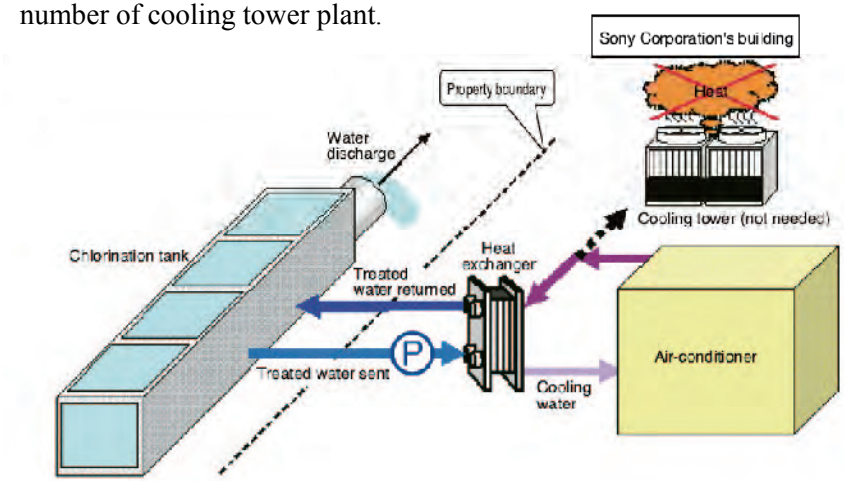


Fig.23 Wastewater heat utilizaton[16]

MBR (membrane bioreactor) is one of novel water reclamation technologies (Fig.24). Compared to CAS (conventional activated sludge) process, it has more advantages such as **small footprint, high-standard effluent or ease of operation.**

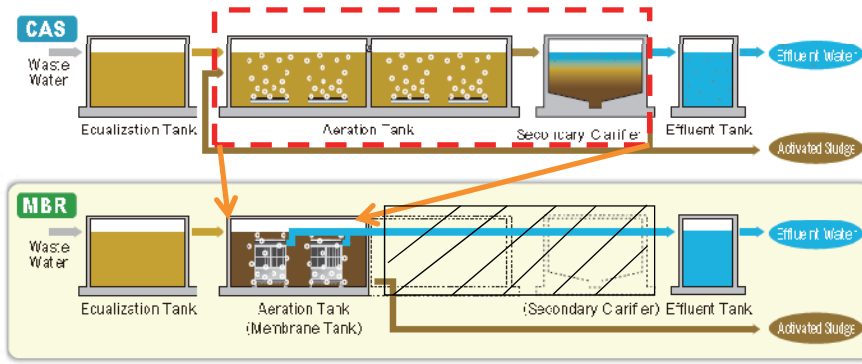


Fig.24 Comparison between CAS and MBR[17]

Case study in Korea 5

In Korea, after the successful restoration of Cheong Gye Cheon (stream) (Refer to page 33) in Seoul, interest in urban stream restoration is rapidly increasing from local governments. Many streams in cities of Korea are now being restored for the purpose of providing citizens with environment-friendly and highly accessible waterfronts. **Reclaimed water is mostly chosen as a first option to supply flowing water for these restored urban streams.**

Fig.25 Reclaimed water supply point of citizen's stream[18]

Fig.26 View of citizen's stream[18]

Citizen's stream in Bucheon-si is a 5.5 km-long artificial stream, of which water flow is maintained by reclaimed water supply. Around 25,000m^3 of reclaimed water is supplied daily after being treated by MBR (membrane bioreactor) process.

This stream is constructed not only to satisfy citizen's demands on water-friendly environment and but also to relieve people's concern about the quality of reclaimed water by demonstrating its high standard. Success of the effort will increase people's acceptance of the use of reclaimed water.

Idea for water reclamation

Let me introduce one idea related to reclaimed water use from discussion in student session.

Toilet water reuse for green-roof fertilizer

Nutrients in the wastewater can be reused to grow plants. In this way, one can reduce the use chemical fertilizer and, at the same time, reduce the discharge of nutrients into the river.

Urine and excrement are good sources of nutrients. Then, **where are they produced?** Yes, definitely in toilets. Ok, then, **where do we have toilets?** The answer should be 'in buildings'. Now, we can come up with an idea of reusing building toilet water somewhere after reclamation. Then, **where should it be?**

Recently, there are efforts to cover building roofs with plants. This is so-called green-roof, which is known to have various advantages in urban environment. We have a good source of fertilizer - **sludge from reclamation process** or **composted toilet waste**. By applying toilet waste to green roof plants, no-nutrient-discharge from building is possible and by-products of domestic water reclamation will be effectively treated.

It is useful to make the most of the benefit the green-roof deliver to urban environment. If we plant greens over roof of one building and apply toilet wastes for plants, we can close nutrient cycle within that building.

Summary

Reclaimed water is an important water resource supplement to rainwater. As data shows, use of reclaimed water is still limited in Japan and Korea. Two case studies presented suggest solutions to water control and show how reclaimed water is used.

In Japan, the government has been very active in introducing treatment facilities with superb function to realize the high standard of water quality. MBR system for wastewater treatment is a key technology to promote the use of reclaimed water with safe quality standard. The technology reassure people of safety of reclaimed water use as general service water such as for toilet flushing in buildings or landscaping. In Korea, reclaimed water, also from MBR treatment, is used to maintain water flows of artificial streams in public parks.

This is just the beginning of the use of reclaimed water. We have to further promote the use of reclaimed water, taking heavy energy consumed for advanced treatment into account. The use of reclaimed water has the distinct advantages of minimizing the impact of freshwater intake from natural water bodies and reducing the pollution load of effluent (Fig.27). Water reclamation is one of the keys to a bright and sustainable future.

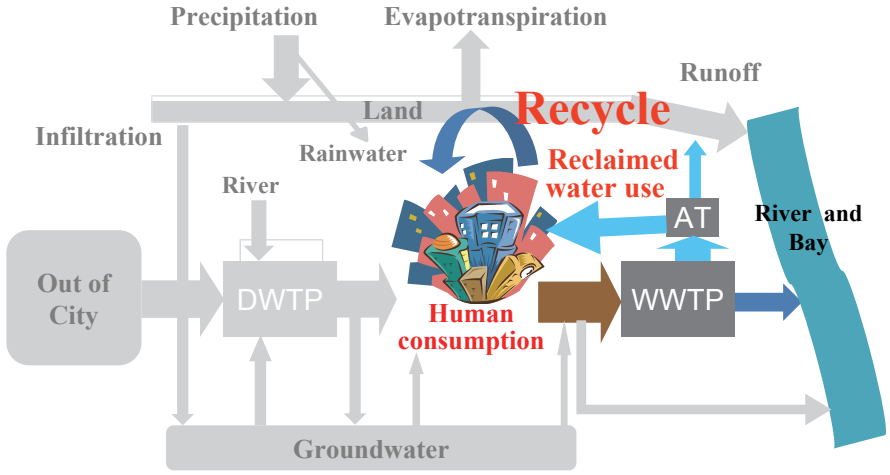


Fig.27 Future model of water balance with enhanced water reclamation

Restoration of surface water and groundwater

How can we secure urban water supply from surface water and groundwater? Why is restoring the natural water cycle important? How do we restore natural water environment?

Introduction

Restoration means representation or reconstruction something into the original form[19]. Therefore, restoring surface water and groundwater simply means returning them to their natural conditions. This will benefit security of natural water resources, ecosystem and more consistent water supply. Obvious target areas for water environmental restoration are dried-up or shallow water channels, disappearing wetlands and shrinking aquifer.

Case study in Japan 8

Surface water restoration

Examples of surface water restoration in Japan (Fig.28) includes;

- Refilling the dried streams
- Demolishing urban infrastructure such as cement bank and restoring natural water environment
- Rechanneling shallow streams and recovering wetlands

These benefit aquatic biodiversity and creation of sites for environmental education and recreation.

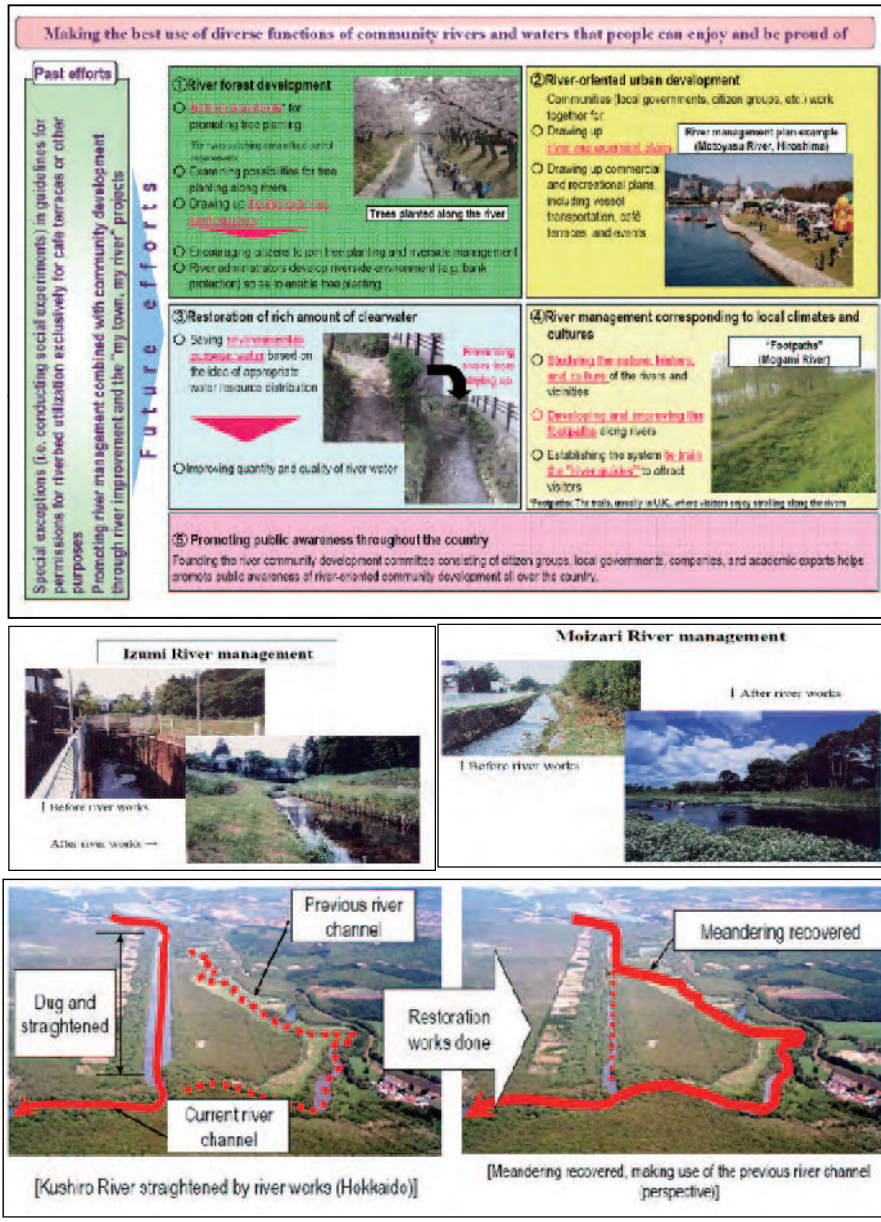


Fig.28 Surface water restoration projects[20]

Case Study in Japan 9

Groundwater recharges

Since 1980s, Tokyo Metropolitan Government has installed **Artificial Infiltration Facilities (AIF)** (Fig.29) in order to increase permeable zones in urban areas. Other benefits are controll of contaminated urban runoff, reducing combined sewer overflows, and restoring naturally purified groundwater.[21]

"Recharging groundwater is like depositing water into the water ATM. You can recharge anywhere, withdraw anywhere"

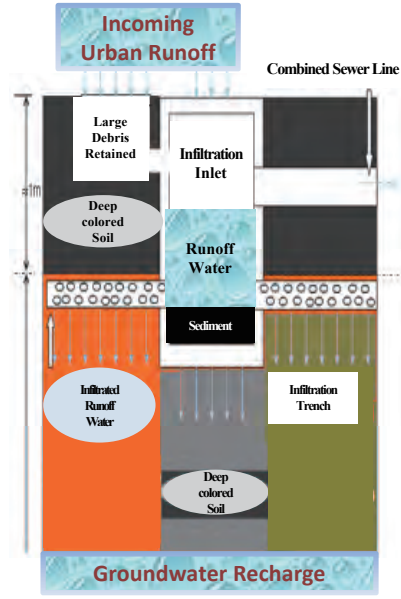


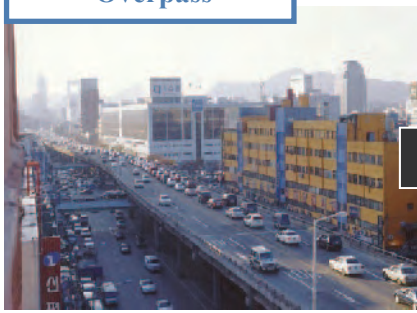
Fig. 29 Groundwater recharges facility

Case Study in Korea 6

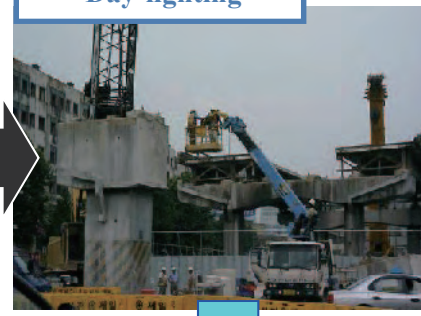
Surface water restoration – *Cheong Gye Cheon*

Cheong Gye Cheon - Day lighting of covered stream[22]

Overpass



Day-lighting



Restoration

Cheong Gye Cheon used to be a stream which was covered by pavement and an overpass was also constructed along the stream path. In July 2003, a project to remove the overpass and overlying pavement of this stream was initiated. The construction lasted for 2-years and 2-months.

After the construction was over, fresh water started to flow through the stream path of 5.84km under daylight conditions where wastewater had been flowing for last 30 years in dark. These days, restored stream provides citizens with a recreational space.

Purpose of Cheong Gye Cheon restoration

- Transfer to sustainable urban development paradigm
- Recovery of eco-friendliness
- Getting rid of risks related to the concrete covering and elevated highway
- Restoration of historical and cultural spaces
- Balanced development across areas.
- Creation of future-oriented urban environment
- Restoration of a natural environment and enhancement of the quality of life

Limitations of Cheong Gye Cheon restoration

Cheong Gye Cheon is regarded as a successful case of stream restoration in a congested urban area and provides a water-friendly space for citizens. However, the case has limitations to be regarded as environment-friendly surface water restoration practices. Water flowing through the restored stream is pumped from several kilometers away with the consumption of considerable energy for pumping. Moreover, the bottom and side of the stream is covered with impervious surface so that flowing water cannot interact with groundwater. In that regard, Cheong Gye Cheon is rather an artificial channel than a natural stream. Therefore, low energy sustainable water acquisition strategy should be made to realize eco-friendly surface water restoration.

Rainwater can give the answer to that problem. If rainwater storage tanks are put along the stream path, stored rainwater can be successfully supplied to stream. Additionally, if rainwater infiltration facilities are also installed, restored stream can act as a natural stream increasing the soundness of the urban water cycle.

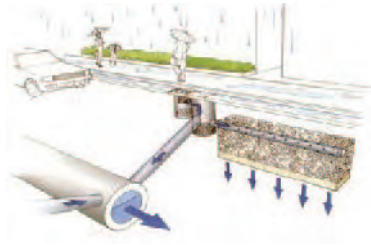
Case Study in Korea 7

Groundwater recharges

Shallow pit

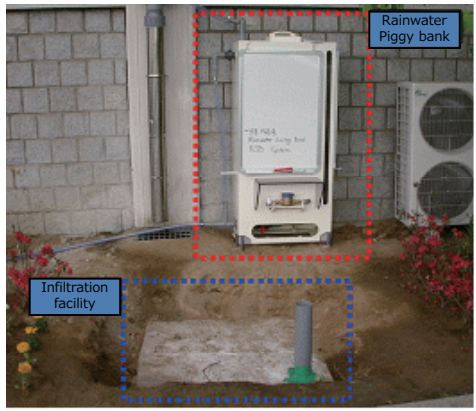
Shallow pit is an infiltration facility which is able to infiltrate runoff rainwater of a building's roof using a shallow groove. It can be installed to connected houses.

Infiltration trench[23]



Debris is filled up in an excavated drain and permeable pipe is taken to disperse the inflow equally in the middle of the drain. Infiltration trench can be installed anywhere along a roadside.

Rainwater piggy bank



Rainwater piggy bank is a small-scale rainwater tank that can be used where large-scale rainwater tank cannot be installed. When this unit is connected with infiltration facility, this unit acts as a decentralized groundwater recharging unit.

Case Study in Korea 8

Groundwater recharges

Seoul Metropolitan Government[24] developed a policy, "For all Four all", which is aimed at managing rainwater strategically at the city-level. Rainwater utilization as an alternative water supply, disaster prevention by decentralized water management, water cycle restoration through rainwater infiltration, and citizen participation in water management are included in this policy. Other local governments in Korea are also motivated to include rainwater management in their water management policy.

Summary

Restoration of the natural water cycle affected by urbanization can be done by proper management of surface water and groundwater environment. Refilling dried streams and water channels, recharging groundwater, and constructing rainwater infiltration facilities are the most common methods and are widely applied in both Japan and Korea.

Water available for restoration of water environment are those from urban water cycle, namely rainwater runoff and reclaimed wastewater. The sustainable approach of restoring natural water cycle is to supplement the missing flows that has been depleted by artificial water systems in urban areas. Therefore, rainwater harvesting and water reclamation facilities play an important role in this issue. If we can restore more of natural water streams and groundwater, we can ensure our water supply from water stock in the natural environment in the future.

Overall summary: Toward urban water sustainability

Securing urban water supply by harvesting rainwater and reclaiming treated wastewater as alternative water sources; and restoring natural water cycle to ensure continuity of natural water reservoir are recognised as current challenges. Our student session explored and discussed these issues in detail through case studies from Japan and Korea. **We also determined the needs for improvement in the current water system and also explored new ideas that can be used for future development**.

Natural water cycles are interrupted by anthropogenic activities which have created artificial urban water flows. In most cases, imbalanced water cycle is caused by intensive urban water use. In the case of Tokyo (Fig.5), an approximate water amount equivalent to rainfall of 1,100 mm/year is required for human consumption. **Most of Tokyo's water currently comes from surrounding regions, so we tried to identify water sources within the city. Use of rainwater and reclaimed water is still very limited,** although cities such as Tokyo have high precipitation (1,405 mm/year) and good quality reclaimed water. **If rainwater and reclaimed water were utilized more, the problem of imbalanced water supply could be mitigated.**

We have tried to utilize more of rainwater and reclaimed water for urban uses. Both Japan and Korea have installed several rainwater harvesting facilities such as Ryogoku kokugikan, Tokyo's Sky Tree Tower, and Seoul's new residential and commercial complex (Star-city). Still these contributions are very limited compared to the whole water demands in both cities. Therefore, **small scale rainwater harvesting facilities should be promoted to increase retaining capacity of households and other community buildings.** Government subsidies should be given to households to construct rainwater harvesting facilities for their own and community use. In addition, **more creative designs for rainwater harvesting facilities in public spaces** can encourage citizens to desire to have their own fashionable rainwater harvesting facility and initiate their concern of water scarcity.

In Japan, Tokyo Metropolitan's wastewater treatment plants changed their name to water reclamation centers. Wastewater treatment contributes to the removal of pollutants from sewage while at the same time producing new water resources, that can be used for toilet flushing, gardening, etc. In addition, **advanced treatment technology can provide a high quality of water with promising future for closed-loop water supply in the city.** In both cases, harvested rainwater and reclaimed water were used to restore natural water balance by refilling dried streams and recharging groundwater. **If the importance of restoring natural water cycle has been widely recognized, natural water environment will continue to support the sustainable urban water supply for our future.**

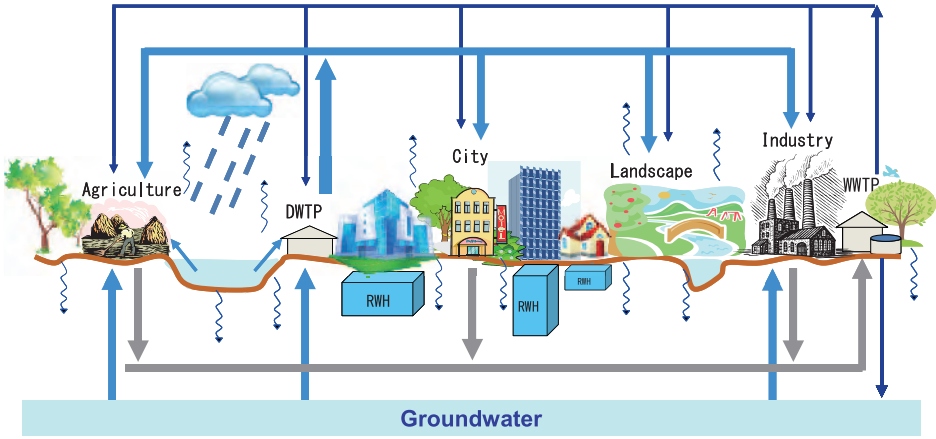


Fig.30 Water balanced city

Note

DWTP: Drinking water treatment plant

WWTP: Wastewater treatment plant

RWH: Rainwater harvesting facility

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Our special thanks for the contribution by Yuriko Hiraga for cover design, and Izumi Ikeda for emendation.

Post conference workshop on Sep 12th

After the conference, we participated in public lectures and a student-citizen workshop organized by the Japanese NPO, "People for Rainwater (PR)*". PR was established in 1994 to create an International Sky Water (=Rainwater) Center in order to help solving the water problems such as flooding, water shortage, and lack of safe drinking water in Monsoon areas.

Open lectures

In the open lectures, presenters talked about the value of rainwater harvesting and management as a countermeasure to the current water crisis. We also had an opportunity to report the results of our discussion in the student session.

- **Subject:** Raincity for Sustainable Society-How the city faces up to the water crisis accompanied by climate change?
- **Venue:** Sumida Local Enterprise Center
- **Chair:** Prof. Hiroaki Furumai, Dr. Makoto Murase

Table.1 Program of open lectures

Lecturer	Presentation title
Mr. Sungyen Hwang (Korea)	The Rain-City through the film, "Rainwater, the power, changing the world"
Jatuwat Sangsanont (Student session)	Toward the sustainability of urban water system, Voice of youngsters
Prof. Cedo Maksimovic (UK)	Lessons Learnt from Case Studies in Urban Flood Management in UK
Dr. Jiri Marsalek (Canada)	Rainwater Harvesting in the Context of Integrated Urban Water Management
Prof. Mooyong Han (Korea)	Rain City for solving water crisis in cities – case studies in Korea
Prof. Hidenobu Jinnai (Japan)	Rain City & Eco Museum in Sumida City

*"People for Rainwater": http://skywater.jp/index_e.html

Student-Citizen workshop

In the citizen-student workshop, we the members of the students session, students from Hosei University, and the members of CITYNET** visited many facilities for rainwater harvesting in the Sumida city guided by Dr. Murase and PR staff. After the field study, we had a free discussion about rainwater harvesting at the Sumida Rainwater Museum.

Table.2 Program of Student-Citizen workshop

Program (Venue)	Contents
Introduction Lecture (Rainwater Museum)	Rainwater Harvesting in Sumida City -Lecture about Rojison system
Field Study (Sumida City)	Rojison Tour
	Tokyo Sky Tree construction site
Discussion (Rainwater Museum)	Tour of the Rainwater Museum
	Discussion
Exchange Party (Rainwater Museum)	

Sumida Rainwater Museum

The Sumida Rainwater Museum designed by “People for Rainwater” in 2001 is a resource center for local citizens who are interested in installing rainwater-harvesting systems in their houses. We can learn about many kinds of rainwater utilization systems all over the world by photo-banners as well as real materials (e.g. Pumpkin-shaped rainwater tank from Sri-Lanka, collection pipes and tanks made in Germany, Bangladesh and Japan).

In addition, we also learnt the importance of rainwater through the exhibition of water shortages and flooding in the 21st Century around the world.

Fig.31 Rainwater Museum

**CITYNET is a network committed to improving the lives of its citizens and create urban sustainability across Asia-Pacific (http://www.citynet-ap.org/)

Rojison (路地尊)

"Rojison" (Fig.32) is a symbol to protect narrow alleys ("roji"). The name came from an idea to respect ("son") "Roji". Rojison pumps up the rainwater manually from underground tanks. Rainwater is collected from the roofs of houses nearby and conveyed to underground tanks with capacities of 3 to 10 tons. Residents have free access to the stored rainwater and it is usually used for gardening.

In case of fire, because response trucks cannot navigate narrow alleys, Rojison are an effective countermeasure against fire outbreaks. A total of 21 Rojisons have been set up in Sumida City so far.

Fig.32 Rojison

Tokyo Sky Tree

"Tokyo Sky Tree" currently under construction (Fig.33) is a digital broadcasting tower with a proposed height of 634m. It will be the one of the world's tallest tower and a symbol for rainwater harvesting. The construction will be completed in 2011. [3] (see also p.16)

Rainwater will be collected from the roofs of the tower's observatory and buildings around the tower, and will be stored in the rainwater tank underground. The capacity of the tank is around 2,600 tons. 200 tons of stored rainwater will be used for watering plants and toilet flushing per day. In addition, the rainwater tank will act as surface runoff control during extreme weathers.

Fig.33 Sky Tree under construction

Tokyo Sky Tree, http://www.tokyo-skytree.jp/english/

Discussion

After the tour, we separated into 5 groups and had free discussion. We exchanged our impressions about rainwater utilization systems in Sumida city compared with similar systems in other countries such as Sri-Lanka, Bangladesh and UK. After discussion, each group presented their discussion summary on a handwritten poster (Fig.34).

Some groups discussed problems in promoting private rainwater harvesting systems in urban cities, while others agreed that community-based rainwater utilization systems like "Rojison" can also further promote the cooperation amongst citizens, in addition to saving water and acting as a countermeasure against fires.

Fig.34 Posters of discussion summary

Overview of student session

The student session has held during 2RWHM-8UDM joint international conference. Students studying in Korea and Japan participated in this session and had productive discussions on comprehensive subjects related to urban water management. They presented their opinions on current systems and prospects for future urban water management. General information on this session is as follows:

Goals

- To let students interested in water management figure out defects of current water management systems and discuss on countermeasures
- To build friendship and establish global human network through active interactions among participants

Affiliation of participants

- University of Tokyo , Tokyo, Japan
- Seoul National University, Seoul, Korea
- Nationalities of participants: Korea, Japan, Thailand, Vietnam, Jamaica, India

Official schedule

The session schedule officially consists of
- Three seminars for discussion and
- Report at the closing ceremony of 2RWHM-8UDM conference

Venue

- The University of Tokyo, Tokyo, Japan

Subject of discussion

In session, comprehensive urban water management issues were discussed including recognition of current challenges, water supply, wastewater treatment, and water cycle.

Toward the sustainability of urban water system	
1	Risk assessment of current water management systems under external challenges
2	Sustainable water supply management in urban area
3	Sustainable wastewater treatment in urban area
4	Water management strategies for water cycle restoration in urban area

Session schedule

Official schedule of the session consists of 3 seminars and 1 presentation at the closing ceremony of 2RWHM-8UDM conference. Topics or subjects of discussion for each seminar is as follows:

Seminar 1 (September 7, 09)

- 10-minute presentation on subject 1, 2
→ Presentation on each subject is prepared and conducted by both countries students (Korea, Japan).
- Open discussion after presentation
→ Discussion has been open not only for student session participants but for all participants of conference (2RWHM-8UDM).

Seminar 2 (September 8, 09)

- 10-minute presentation on subject 3, 4
- Open discussion after presentation
→ Specifics are in common with Seminar 1.

Seminar 3 (September 9, 09)

- Comprehensive discussion on subjects dealt with in previous seminars
- Preparation of presentation for closing ceremony of the conference

Final presentation (September 11, 09)

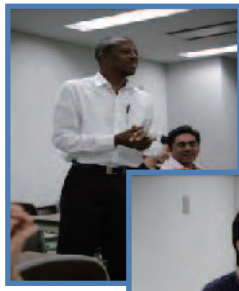
- Presentation at closing ceremony of 2RWHM-8UDM conference

Post conference workshop (September 12, 09)

-Attend the public lectures
-Visiting rainwater harvesting facilities in Sumida city
- Having a group discussion

Memories of our activities

We just met here



Let me start presentation on…

Discussion - In my opinion…

Closing ceremony

Post-conference workshop

We love rainwater, not each other..

We are friends !!

Members

From Korea

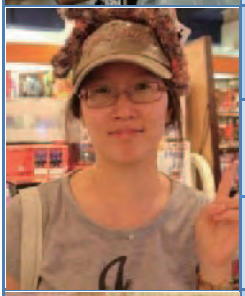
	**Name**	**Mun, Jungsoo**
	Affiliation (major)	Seoul National University (Environ. Eng.)
	Voice	This session makes student able and energetic and same to me
	**Name**	**Ki, Jaehong**
	Affiliation (major)	Seoul National University (Environ. Eng.)
	Voice	I am advancing with experiences.
	**Name**	**Dao Ahn Dzung**
	Affiliation (major)	Seoul National University (Environ. Eng.)
	Voice	I feel like I'm reading a admirable book in this session
	**Name**	**Cho, Kyungmin**
	Affiliation (major)	Semyung University (Architec. Eng.)
	Voice	I believe that this experience make me grow up.

	**Name**	**Kim, dohyung**
	Affiliation (major)	Seoul National University (Environ. Eng.)
	Voice	I could grow up with inner mind in RWHM
	**Name**	**Kwak, donggeun**
	Affiliation (major)	Seoul National University (Environ. Eng.)
	Voice	All the words through the session are pregnant with meaning for me
	**Name**	**Kim, donggeun**
	Affiliation (major)	Seoul National University (Environ. Eng.)
	Voice	I satisfied with my first international presentation
	**Name**	**Kwon, jungwon**
	Affiliation (major)	Seoul National University (Environ. Eng.)
	Voice	This was beneficial experience for preparing my future

Members

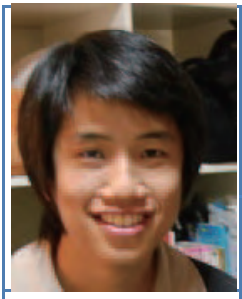
From Korea

	**Name**	**Kim, Joosoo**
	Affiliation (major)	Semyung University (Architec. Eng.)
	Voice	Special thanks to member of People for rainwater.
	**Name**	**Kim, Jeong-Yeon**
	Affiliation (major)	Seoul National University (Civil and Environ. Eng.)
	Voice	I want to hear about opinions of famous people.
	**Name**	**Choi, Sooyoun**
	Affiliation (major)	Seoul National University (Civil and Environ. Eng.)
	Voice	I had a good time to learn about importance of water resources.
	**Name**	**Kang, Dongwoon**
	Affiliation (major)	Seoul National University (Civil and Environ. Eng.)
	Voice	During staying in Japan, I learned a lot from Japan.

	**Name**	**Song, Joonhyuk**
	Affiliation (major)	Seoul National University (Civil and Environ. Eng.)
	Voice	Even now, I have excited
	**Name**	**Jo, Serim**
	Affiliation (major)	Seoul National University (Civil and Environ. Eng.)
	Voice	Next time, I would like to give them heart-warming words.
	**Name**	**Lee, Junghwa**
	Affiliation (major)	Seoul National University (Civil and Environ. Eng.)
	Voice	The things that the young and old said were very impressive
	**Name**	**Jeong, Boyoung**
	Affiliation (major)	Seoul National University (Civil and Environ. Eng.)
	Voice	I interchanged emotions with University of Tokyo

Members

From Japan

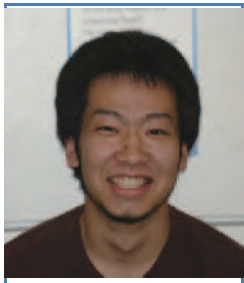


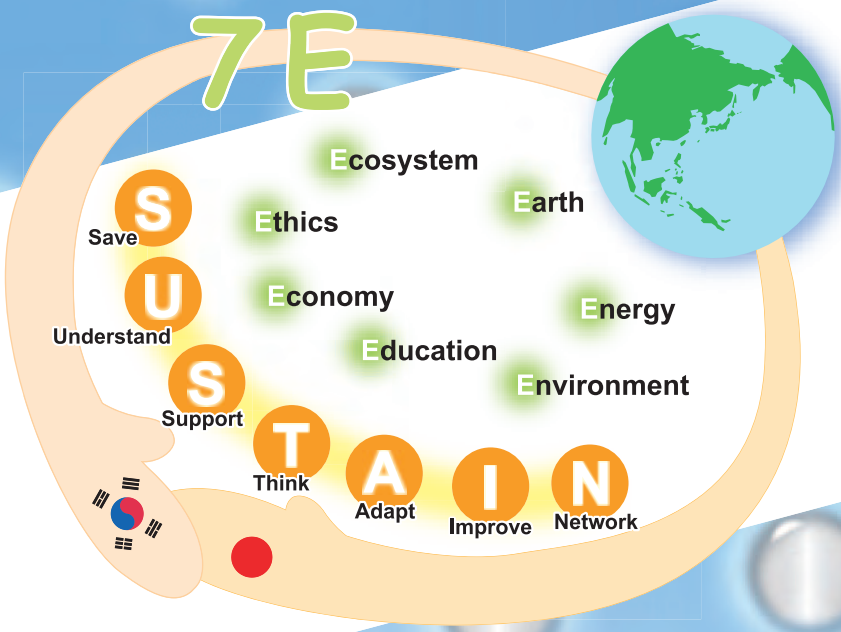
Name	Sangsanont, Jatuwat
Affiliation (major)	University of Tokyo (Urban Environ. Eng.)
Voice	There is lots of water. It depend on how we manage.

Name	Leelapanang, Pinida
Affiliation (major)	University of Tokyo (Urban Environ. Eng.)
Voice	I really enjoy the experience!

Name	Haruna, Watanabe
Affiliation (major)	University of Tokyo (Urban Environ. Eng.)
Voice	We have to work as a bridge between citizens and academics and consider all the various factors together.

Name	Thayanukul, Parinda
Affiliation (major)	University of Tokyo (Urban Environ. Eng.)
Voice	Think about risks in future, start countermeasures today.

	**Name**	**Keisuke, Shirado**
	Affiliation (major)	University of Tokyo (Urban Environ. Eng.)
	Voice	It is about time to reconsider our way of using water.
	**Name**	**Kumar, Marnish**
	Affiliation (major)	University of Tokyo (Urban Environ. Eng.)
	Voice	Water is fundamental for life, avoid its wastage and pollution.
	**Name**	**Christopher Gayle**
	Affiliation (major)	University of Tokyo (Urban Environ. Eng.)
	Voice	Ensuring future urban water sustainability, is this generation of young researcher's responsibility.
	**Name**	**Saito, Masaki**
	Affiliation (major)	Hosei University (Architec. Eng.)
	Voice	Let's think more about rain water.



Let's SUSTAIN 7E

to achieve sustainable urban water system.