Smart Decentralized Water Systems in South Korea

Sookwon Chae and Juneseok Lee

Abstract This chapter introduces selected cases of integrated water resource management practices focusing on smart decentralized water systems in South Korea, where industry/government bodies have made significant progress in smart water use. SDWM (Smart Decentralized Water Management) connects multiple alternative water resources within individual buildings and continuously balances their utilization to enhance self-efficiency and build resilience. It also supports more efficient water supply portfolio/transfer/trade within district water networks. We expect that SDWM will play an important role in augmenting the efficiency of integrated water management planning and operation through closer interactions among stakeholders and informed decision-making at all levels.

Keywords Decentralized water systems · Smart water management · South Korea

1 Introduction

In this chapter, we introduce examples of integrated water resource management practices in South Korea, focusing on smart decentralized water systems. Water resource planning and management is critical for the economic competitiveness of a country and the well-being of its inhabitants. The water industry and government agencies in South Korea have thus been devoting considerable effort to develop and implement smart water technologies, building on their strong research and development capabilities in Information and Communication Technology (ICT). We begin by describing South Korea's major waterwork infrastructure and general water management characteristics, and then move on to discuss several case studies of projects that utilize

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T. Younos et al. (eds.), *Resilient Water Management Strategies in Urban Settings*, Springer Water, https://doi.org/10.1007/978-3-030-95844-2_3

smart decentralized water systems before closing the chapter with some concluding remarks.

2 Historical Development of Major Waterworks in South Korea

The period from 1900 to 1945 represents the “initial stage” of waterworks facilities in Korea. The first water treatment plant was built in Tukdo in 1908 and had a treatment capacity of 12,500 m^3/day. Korea was annexed by Japan in 1910, and its status as a vassal state of Japan continued until the end of the Second World War. As of 1945, only 2 million South Koreans were living in areas where water was supplied and the country’s water treatment capacity was only 27,200 m^3/day (total population was about 17 million in 1945). The period between 1950 and 1990 is often referred to as the “growth stage”. The Korean War between North Korea and South Korea (1950–53), among the most devastating wars of the modern era, left the entire country in ruins and made Korea one of the poorest countries in the world. After the war ended, however, the immense redevelopment and reconstruction effort undertaken enabled South Korea to achieve rapid economic growth based on a series of successful five-year economic development plans that included the construction of a national water infrastructure system [1].

Unfortunately, this rapid economic growth also brought some negative effects, one of which was environmental pollution. Amidst the economic development, the amount of both sewage and untreated wastewater increased, causing serious environmental pollution in the country’s rivers and basins. South Korea built its first wastewater treatment plant in Cheongye in 1976, treating 150,000 m^3/day. The 24th Summer Olympic Games, which were held in Seoul in 1988, led to rapid economic growth. As many foreigners were expected to visit South Korea to watch or compete in the Games, the Korean government invested heavily in creating a clean and healthy environment to create a good impression [1].

Today, South Korea has a population of ~51 million people; the national water supply rate increased from 97.4% in 2009 to 99.2% in 2018. The number of water purification plants actually decreased over the same period, dropping from 546 in 2009 to 484 in 2018. This reduction is primarily due to the closure of old water purification plants, the integration and abolition of water purification plants between regions, and the expansion of metropolitan waterworks [1].

3 Water Supply and Demand in South Korea

South Korea’s precipitation is about 1.3 times the global average, at about 1000 to 1800 mm. However, the available water per capita is just 12% of the worldwide average. This discrepancy means Korea has abundant rainwater but lacks available water. Two-thirds of the country's rainfall is concentrated in July and August, and South Korea's terrain, which is hilly and mountainous, means that this excess precipitation tends to flow quickly downhill to the sea, leaving the country with insufficient water resources.

South Korea has two types of water supply systems: regional (large-area) waterworks and local waterworks. Regional waterworks, which provide raw or purified water to two or more local governments (Fig. 1), are managed by K-water, South Korea's public water company, and are responsible for nearly 50% of the total water supply. The remaining 50% is supplied by local waterworks. Regional water resources are sent to regional water treatment plants through regional intake facilities, while raw water is sent to local government water treatment plants. Where

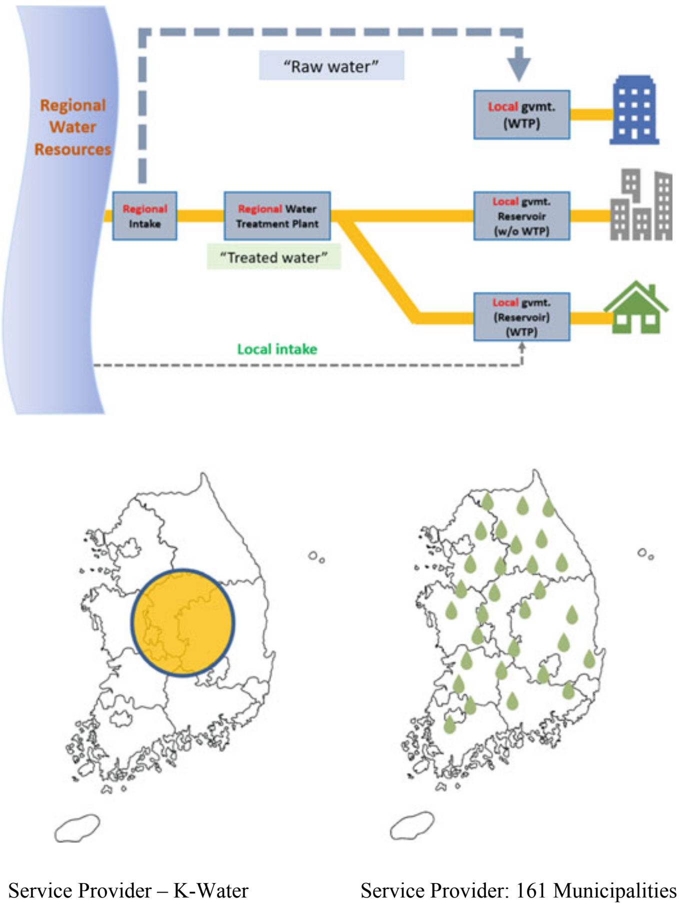

Fig. 1 **a** South Korea's water supply model: regional and local government; **b** service providers in South Korea. *Source* Author

there is no local water treatment plant, regional waterworks supply treated water directly to individual households. Where there is a local water treatment plant, the local waterworks treat water and send it to a local reservoir for water supply. Where there is a local intake facility, water from local water resources is sent directly to local water treatment plants that treat and supply water to local households. The underlying concepts that guide the design of multi-regional water supply systems in South Korea can thus be summarized as follows: first, solve regional imbalances in water resources to balance the water supply across the region; second, redistribute water from intake sources with plentiful water resources to provinces where the water resources are scarce; and third, utilize multi-purpose dams as intake sources [2].

The amount of water use has risen steadily since 2016 to a level of about 348 L per person per day in 2018. This increase is largely due to an increase in the number of single-person households. The revenue water ratio increased from 82.6% in 2009 to 84.9% in 2018, and the leak rate dropped from 11.4% in 2009 to 10.8% in 2018 as a result of a new policy that was implemented to conserve water and improve the water use rate.

4 Integrated Water Resource Management (IWRM)

Integrated Water Resource Management (IWRM) is based on a holistic approach that takes into account the quality and quantity of sustainable water, healthy ecosystems, culture, and disaster mitigation and avoidance. The principles of IWRM in the context of South Korea can be described as follows [2]:

(1) *Equity*: Stakeholders are encouraged to participate actively in the decision-making process in order to achieve societal consensus.
(2) *Environment*: Achieving ecologically sustainable water cycles is a major objective.
(3) *Economy*: Economic profitability is taken into account and IWRM implemented at the river-basin level.

South Korea has been utilizing IWRM to predict and address water shortages by promoting the coordinated development and management of water, land, and related resources to maximize economic and social welfare equitably, without compromising the sustainability of vital ecosystems. IWRM can help alleviate the peak loads in water distribution, reduce greenhouse gas emissions, prevent unnecessary leaks, and protect valuable water resources. These features combine to achieve substantial reductions in water consumption, increase public awareness, and reinforce behavioral/perception changes related to water use reduction and recycling.

5 Smart Decentralized Water Management (SDWM)

SDWM is a system that connects alternative water resources within the same building to form a network that balances the combined flow of water within that building. A bidirectional real-time network is created that receives data from sensors, measuring devices, and controllers installed throughout the building. These sensors monitor the pressure, energy consumption, temperature, and water quality at various locations. Additionally, the system controls functions such as local pressure regulation, pumps, distribution valves, and graywater/rainwater utilization. Software and specialized apps that remotely monitor important parameters and diagnose problems can also be included. The fundamental concepts of SDWM lie in intelligently planning and operating the water system within each building, focusing on providing a self-sufficient and reliable water supply for the occupants.

There are essentially four phases involved for IWRM-SDWM: (1) mapping the water resources and weather forecasting, which requires on-site terrestrial sensing, geological information systems, Internet access, and appropriate sensor networks; (2) asset management for the water system network, which includes buried asset identification and electronic tagging, smart pipes, and real-time risk assessment and repairs; (3) setting up an early warning system, meeting the various stakeholders, and establishing procedures for rainwater harvesting, flood management, the management of aquifer recharge, smart metering, and process knowledge systems; and finally; (4) SDWM manages water intelligently by making necessary decisions in real time based on the data provided by the geographic information systems, sensor networks, and the Internet. When sensor information, control information, and asset management information are monitored and disclosed to the consumer portal through SCADA, SDWM can become the core of IWRM. The fundamental principles governing the effective implementation of SDWM-IWRM in the South Korean context are as follows [2]:

Principle 1. The timely provision of data and information is at the heart of all smart technologies.
Principle 2. System analysis provides an effective means of communication and highly reliable decision-making tools.
Principle 3. Innovation and new ideas are integrated into the smart water grid operations to enable it to adapt to changes and meet future needs.
Principle 4. Two-way management provides more effective and timely decision-making.

Over the last three decades, South Korea has devoted considerable effort to promoting IWRM by further developing SDWM. However, these efforts have been hampered by issues, such as the ministry's siloed approaches to water management, failures in coordination between sectors that has resulted in overlapping investment in water-related projects, and the formation of an unnecessarily bloated organizational tree due to work duplication. To address these problems, the government enacted two new pieces of legislation, the Framework Act on Water Management and the Act on Water Technology Industry, and revised the existing Government Organization Act in 2018 to provide the necessary legal framework for integrated water management. There are significant benefits to be gained through implementing SDWM-IWRM in intelligent, ecologically sound green building projects, which will eventually help promote the smart management of information that supports conflict prevention and resolution, improves disaster risk management, and boosts the eco-efficiency of basin operations. The next section presents several case studies that demonstrate how these principles can be applied in real world projects [2].

6 Decentralized System Cases in South Korea

6.1 Case 1. The 2nd Lotte World Tower

The 2nd Lotte World Tower is the tallest building in South Korea, at 555 m, with 123 above-ground stories (Fig. 2). The building consists of the Podium (floors 1–8), offices (floors 14–38), officetel (multi-purpose residential/commercial units, floors 42–71), a hotel (floors 76–101), premium offices (floors 108–114), and an observatory (floors 117–123). There are six intermediate machine rooms and shelters on every 20th floor. The building utilizes five alternative water resources: rainwater (1900 m^3/day, greywater (1200 m^3/day), groundwater(3,000 RT of underground heat), lake water (for emergencies such as water shortage), and river water(5⁻8

Fig. 2 The 2nd Lotte World Tower [3]. *Source* Wikipedia

m^3/month). Green power sources include a geothermal system installed under the building, a solar module installed on the glass of the high-rise exterior wall, and a small wind turbine installed on the roof. A 'wide-area water supply method' using the temperature difference between the ambient temperature within the building and that of the raw water coming into the building via the wide-area water supply pipe passing under the Songpa-main street is also utilized. Taken together, these sources provide 30% of the energy needed to cool and heat the building.

6.1.1 Rainwater Treatment Facilities

The 2nd Lotte World Tower has two rainwater treatment facilities, one with a design capacity of 500 m^3/day on the west side and another larger one than can treat 1400 m^3/day on the east side. The rainwater is passed through a sieve screen to remove larger particles and other debris and then through a fiber pore filter, after which it is stored in a rainwater treatment tank before being passed through a filtration system and sent to a rainwater storage tank for reuse. Once the storage tank is full, the filtration process stops automatically and an emergency pump discharges the excess rainwater out to the municipal storm drain system [4].

6.1.2 Graywater Treatment Facility

The drainage coming off the 2nd Lotte World Tower is recycled as graywater with the water quality complying with the legal graywater quality standards. The building has a dedicated graywater treatment facility to ensure effective water reuse. The design criteria include an inflow of 1200 m^3/day, BOD 250 mg/l, COD 200 mg/l, and SS 250 mg/l for the incoming water, and better than BOD 5 mg/l, COD 15 mg/l, SS 5 mg/l or higher than residual chlorine 2 mg/l, a chromaticity of 5 NTU, and a turbidity of 2 NTU for the treated water. The treatment process involves a combination of MBR, ozone, and activated carbon in the following order: raw water inflow, flow control tank (capacity: 586 m^3, residence time: 11.7 h), aeration tank (capacity: 236.9 m^3, residence time: 4.7 h), membrane tank (capacity: 493.02 m^3, residence time: 9.9 h), ozone contact tank (capacity: 140.76 m^3, residence time: 2.8 h), filtration tank (capacity: 162 m^3, residence time: 162 h), and discharge tank (capacity: 244.88 m^3, residence time: 24.9 h). The membrane tank maintains a dissolved oxygen concentration of 2.0 to 3.0 mg/l, and microorganisms adsorb and oxidize organic matter in the inflowing sewage, after which an immersion-type membrane with a pore size of 0.1 μm is immersed in the tank, and suction filtration is performed at low pressure using a pump. Finally, the microbes and the treated water are separated into solids and liquids to produce clean treated water [4] (Fig. 3)

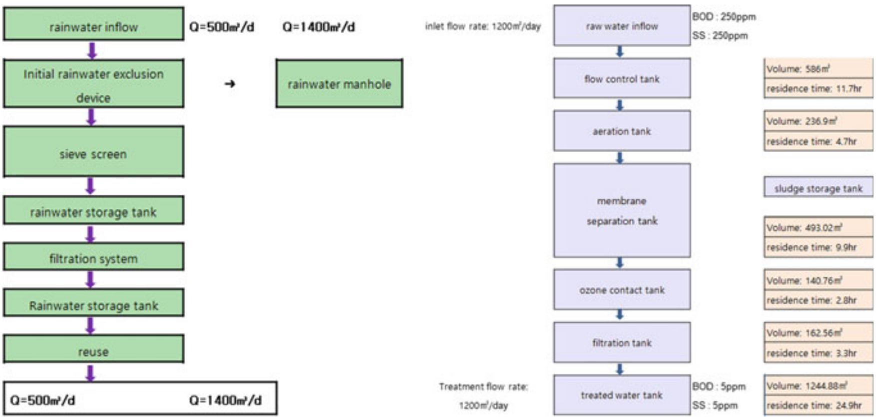

Fig. 3 **a** Rainwater treatment facilities; **b** Graywater treatment facilities. *Source* Author

6.1.3 Other Alternative Sources and Uses

Seokchon Lake, which is close to Songpa Naruto and the 2nd Lotte World Tower is an artificial lake formed as part of the Han River reclamation project. Because it is an artificial lake, the lake's water level is maintained at 5 m by injecting from 5 to 8 m^3 of Han River water every month. Currently, there are concerns about the deteriorating water quality in Seokchon Lake caused by the discharge of various pollutants, which has increased due to the rapid rise in the number of visitors to the site. There are also concerns about the deteriorating air quality, including the high levels of fine dust created by traffic congestion in the Jamsil area.

Securing and retaining multiple water resources is one of top priorities. Multiple urban water resources such as city water, stormwater, graywater, and groundwater are now being utilized to supply newly constructed skyscrapers to supplement local conventional water resources such as river and lake water as part of the city's strategy to support the goal of integrated management of the various water resources. Seoul's metropolitan water supply of 50,000 m^3/day is being boosted by the 2nd Lotte World Tower's water recycling and water-saving facilities, which include a 1200-m^3 graywater treatment facility and an 1900-m^3 rainwater storage tank. The new building's facilities can also convert about 40,000 m^3/day of domestic sewage into recycled and reused water resources, with the excess being sold/transferred to nearby buildings, thus representing a water resource that creates additional economic value as a third alternative water source.

In the area around the 2nd Lotte World Tower complex, various Low Impact Development (LID) techniques have also been implemented. These include permeable sidewalk blocks, penetration flower beds, and penetration landscaping. Various environmental sensors have already been installed in and around the new building complex. These include the area around Seokchon Lake, where the integrated water management is made intelligent by installing additional smart sensors. Water quantity and quality sensors, various building operation management sensors, and unit platforms have been installed and 23 underground water level gauges and eight ground subsidence gauges are in operation to support the safe management of the area around Seokchon Lake (esp. related to sink hole issues nearby the lake).

Multiple water sources are in continuous use, linked to the large-scale stormwater storage tank (31,000 m^3) at the nearby Jamsil Stadium. This supplies and distributes water intelligently for purposes such as road cleaning, fine dust reduction, heat island effect reduction, and environmental water uses such as stream maintenance water, in conjunction with water from two lakes, Seongnaecheon and Mongchon. For example, fine dust, which is a serious issue in South Korea that often causes problems in Songpa-gu, can be reduced by spraying water cannons in an appropriate direction from the 2nd Lotte World Tower. A surge in water consumption can often be predicted in advance when a major cultural event is held in the park that will be attended by a large crowd. This can be planned for and water consumption cut by producing and supplying water from alternative resources such as rainwater, graywater, and groundwater. Water for various purposes, such as hotel swimming pools, hand-washing water for restaurants, and water purifier purified water can also be provided from these sources.

Several outstanding issues have yet to be addressed, however, including (1) reducing the cost of using raw Han River water to maintain the water level in Seokchon Lake, which cost 200 million won (about US$ 170,000) for 1.23 million m^3 of water in 2014, by replacing it with rainwater, groundwater, and graywater; (2) enabling the multi-water resources produced and treated in the 2nd Lotte World Tower to be supplied and traded to other nearby buildings; and (3) reducing the consumption of water supplied to the entrance of the complex in one direction, which would generate further economic benefits by reducing water consumption as a result of using the multiple water sources secured within the 2nd Lotte World Tower Complex. It is important to note that the 2nd Lotte World Tower project is specifically designed to support direct citizen participation in decision-making for water demand issues and the supply methods to be used for various distributed water resources. Furthermore, a future hyper-connection based on digital water informatization, digital twin, cyber-physical system, and Living lab operation could become possible by building a platform where all things (i.e., multi-purpose water sources), all services (i.e., multi-purpose water supplies), and all humans (i.e., multi-purpose water consumers) can converge and communicate [5].

6.1.4 Use of Renewable Energy Sources

The 2nd Lotte World Tower is an energy-efficient building that is designed to satisfy 15% of its total energy use with renewable energy sources, including geothermal, hydrothermal, sunlight, and solar heating. The building's overall cold (air conditioning) load is 29,100 RT (Refrigeration Tons), and its heating system total design load is 90.7 m^3/h. The heat source system uses ice storage, geothermal, and shrinkable heat as its main sources, divided into low-rise and high-rise plants. The heat source supply to the lower floors utilizes a header method, while the heat source supply to the upper floors is supplied by pumping up steam or cold water and exchanging heat with air or water in each zone [5].

Ice heat storage operates the refrigerator with electricity at night and stores cold heat in the heat storage tank in the form of ice, using this as a cooling source during the day. The geothermal cooling/heating system installed in the energy center has a capacity of 3,000 RT. To construct the system, 720 150 mm diameter holes were drilled to a depth of 200 m below ground level on the site using a vertically sealed method; 696 of the holes were drilled under the building itself. The underground heat is used to heat and cool the lower floors of the building. An important feature of this wide-area water temperature differential heat-storage system is that it combines a heat pump and a heat-shrinkage system using a wide-area water supply as a heat source. At night, the heat pump is operated to store hot and cold water in a heat shrink tank that can then be used for heating/cooling during the day. Water flows within the pipeline 24 h a day, with the raw water moving back to the purification plant at night. Since this thermal energy would otherwise be unused, the system's energy efficiency is high. The circulation pump controls the heating and cooling temperature by circulating cold or hot water through the building, while the geothermal condensate circulation pump controls the heating temperature through heat exchange, circulating water that has been heated deep underground through the building's heating/cooling system before sending it back into the ground [5].

Lotte World Tower's Building Energy Management System (BEMS) consists of a single-platform distributed server. The BEMS and the automatic machine equipment control system are composed of a single platform with the same logic, but data are stored in separate servers so the BEMS monitors the building's energy use, analyzes it, and then transmits data to the automatic control system for the mechanical equipment. The DDC (Direct Digital Control) energy-saving algorithm then calculates the optimization point and controls the machinery. This system saves energy by preventing losses due to operation errors, administrator and user mistakes, and low-efficiency operation by taking into account vacancy time and optimizing power-saving operations, enthalpy control, and device start-up times. The building's water supply system is divided into multiple zones and an elevated water tank used to reduce the load on the pump. The objective here has been to integrate a long-life design into the structure from the outset by installed water recycling and water-saving equipment. As a result, the company earned a LEED Gold rating as it completed its construction [5].

6.2 Case 2. Star City

Completed in March 2007, Star City in Seoul contains 1310 households spread across four buildings with different heights (58 floors, 50 floors, 45 floors, and 35 floors). The complex was built on a site that habitually flooded, hence water management was a priority from the outset. The Star City complex covers an area of 62,500 m^2,

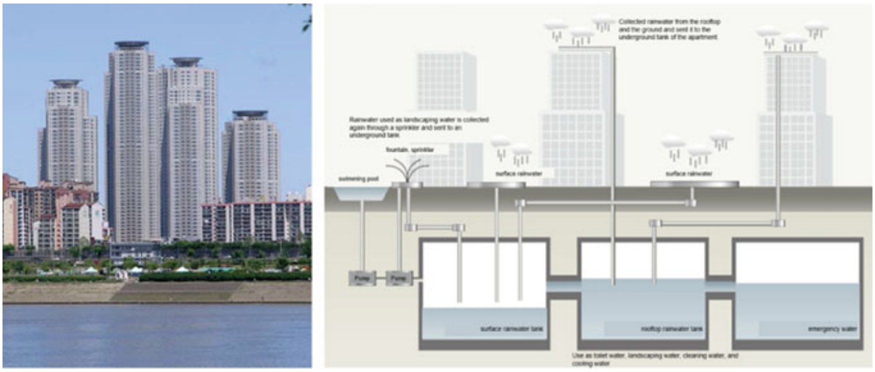

Fig. 4 Rainwater use in Star City Building [7, 8]. *Source* Building Korea and Joins.com

with rainwater being collected at ground level (45,000 m^2) and the building rooftops (6200 m^2) for a total of 51,200 m^2. Three concrete tanks holding 1,000 m^3 each were installed on the fourth basement level to store rooftop rainwater, surface rainwater, and emergency water, respectively (Fig. 4). Rainwater stored in the tanks is used for landscaping, fountains, and streams in the complex's Central Park and the public toilets on the 1st basement level and the 1st floor. The water in the second tank is used for landscaping, and the cost of water for one month is 200 won (US$ 0.2) per household, although the water is free to customers. In the event of a sudden interruption in the water supply, the emergency water collected in the third tank is sufficient to supply the entire complex for more than a week, demonstrating the benefits of a decentralized system. Under normal conditions, Star City's underground rainwater reservoir is only filled to two-thirds of its total capacity, leaving one third, i.e. 1,000 m^3, available to prevent flooding due to torrential rains in the summer months. Of the 2,000 m^3 of water regularly stored here, 1,000 m^3 are used for the public restrooms, landscaping, and cleaning, while the other half is reserved as firefighting water. Large fire trucks usually transport 10 m^3 of water, hence this water is equivalent to that carried by 100 large fire trucks is stored on site [6].

6.3 Case 3. Local Government Initiatives

6.3.1 Rainwater Policies

In Korea, more than 50 local governments, including Suwon City and Namhae County, have enacted an "Ordinance on Rain Water Management" that recognizes their status as a *Rain City*. *Rain Cities* recognize the importance and utility of rainwater, establishing and implementing systems and regulations for collecting and using rainwater. *Rain Cities* restore natural water through active water circulation improvements based on their local rainwater conditions. They aim to be sustainable and eco-friendly cities whose citizens actively participate in water conservation efforts, becoming low-carbon, green-growth cities that have reduced the energy required for their water supply by utilizing the rainwater that falls to supply their own needs [9].

6.3.2 Recycling and Reusing Water in Paju Unjeong, New Town

In order to build an ecological city with water recycling, the Paju Unjeong new cities created a stream and an artificial lake using graywater from chemically treated sewage and rainwater in the city. Before planning and implementing an environmentally friendly city, three preconditions must be observed. First, in addition to the traditional civil engineering aspects of developing a new town, expert ecological environmental engineers must be involved from the outset. Second, if a problem is encountered when creating a new city, it must be solved using an "improvement design" approach. Third, once the eco-friendly new town has been successfully built, experts and citizens should remain involved, actively monitoring progress and protecting the city's eco-credentials. To develop Paju Unjeong New Town in an environmentally friendly way, the following four models were implemented [9]:

1. Of the 62,000 m^3/day of sewage effluent generated, 28,000 m^3/day are tertiarily treated and the water used to feed four 8.5 km long brooklets, one small river and a lake.
2. Recycled water must be treated to a level where it is safe enough for swimming and scientifically proven to be safe for inhabitants.
3. The stream that circulates through the new city will improve the health of the residents and foster an attitude of respect for the environment.
4. Above all, it is vital to ensure that sufficient water resources are available to achieve these objectives prior to construction commencing.

6.3.3 Utilization of Distributed Water Resources in Suwon City

In August 2019, Samsung Electronics expanded its graywater facilities to supply environmental (and sprinkler) water to Suwon City. In addition, environmental water was provided free of charge to Suwon City. Samsung Electronics expanded the graywater supply facility at their business site, which was initially 400 m^3/day, to 1680 m^3/day, and Yeongtong-gu, Suwon-si gave the company access to city-owned land where Samsung Electronics' graywater facility and supply piping could be connected to the city's environmental water distribution network. As a result, Yeongtong-gu is now able to secure sufficient environmental water (e.g., restoration of natural water bodies or open channels) to meet their needs from Samsung Electronics' graywater supply. In the future, when fine dust, yellow dust, heat waves, droughts and other similar events occur, the environmental water supplied by Samsung Electronics will be sprayed onto road surfaces to reduce dust and lower the road temperature. It will

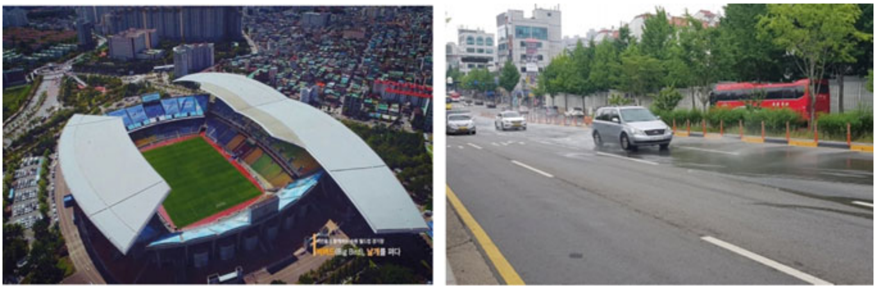

Fig. 5 **a** Installation of rainwater reuse facility underground—Suwon World Cup Stadium. **b** To reduce the heat island phenomenon, rainwater from the rainwater storage tank is sprayed onto the road [10, 11]. *Source* South Korean Newspaper

also be used for landscape water. Using this extra 10,000 m^3 of graywater each year will reduce the greenhouse gases the city generates by 3,000 kg per year [9].

Suwon City is working towards becoming a "water cycle city" by steadily building its own rainwater recycling system. By August 2020, 317 public and private rainwater storage facilities had been installed in the city, with a total storage capacity of 103,983.48 m^3 of rainwater. These rainwater storage tanks are spread across eight locations, including the Suwon World Cup Stadium, Suwon Sports Complex, and Gwanggyo Middle School, which has 47,090 m^3 capacity (Fig. 4). For the 'Rain City Suwon Season 2 Project', the city of Suwon conducted a pilot project for the 'Green Rainwater Infrastructure Creation Project' with the Ministry of Environment in 2014, building the first 'Green Rainwater Infrastructure' in the country on the grounds of their Jangan-gu Office [9] (Fig. 5)

For this project, porous block pavers, a rainwater infiltration gutter, a rainwater storage tank capable of storing 300 m^3, and an underground infiltration channel were installed in the land surrounding the office building. On the sidewalk around the city hall intersection, rainwater utilization facilities such as bicycle paths with permeable pavements, rainwater blocking fences that prevented the generation of nonpoint pollution sources, and porous blocks were installed using a 'low impact development (LID) technique.' The water collected and stored in the rainwater storage tank is available for use in the 'automatic surface road sprinkling system.' When a fine dust and/or heatwave warning is issued, the collected rainwater is sprayed on the road to mitigate the hazards [9].

6.3.4 Water Recycling in Guri City

In April 2021, Guri City installed a new graywater facility (65 m^3/day) that purifies and reuses sewage such as the pool water used in the multi-sports center and rainwater, allowing it to be reused for flushing toilets, cleaning and landscaping, among others. This water will be treated at a level that satisfies a water quality standard that is stricter than that normally required for sewage discharge water. Reusing 65 m^3 of water that would otherwise be wasted every day will save more than 100 million won (about US$ 85, 241) a year, while at the same time creating a heated shelter through a vertical garden installation using recycled water in the multi-sports center, and installing a reusable water supply so that the sprinklers can use the water recycled on the premises [9].

6.3.5 Using Distributed Water Resources in Pangyo New Town

For the creation of natural rivers in the Unjung and Geumto streams in Seongnam Pangyo New Town, a plan for securing distributed water resources for effective water environment management was reviewed and established as follows: (1) setting target flow to maintain the function of the river, (2) researching and distributing the natural water resources that can be secured, (3) examining various ways to secure the shortage, and (4) minimizing the impact on the river ecosystem. The optimal supply method according to the water securing strategy/scope is shown in Fig. 6 [11]. All flow units are in m^3/day. The overall treated water ratio is about 45% and the BOD ranges from 0.3–1.7 mg/L [12].

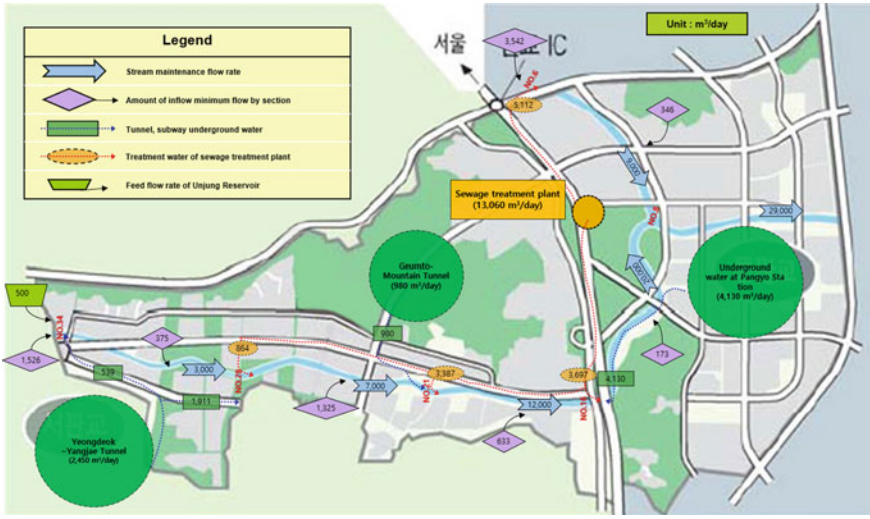

Fig. 6 River maintenance water using distributed water resources in Pangyo New Town [11]

7 Concluding Remarks

In this chapter, we presented some interesting examples of the use of SDWM practices in South Korea in the context of IWRM. South Korea is actively developing/embracing SDWM with a wide range of new ICT technologies. Alternative decentralized water resources such as groundwater, surface water, rainwater, and graywater can be utilized to elevate the self-sufficiency level of each building, flowing into the network to supplement the demand from other locations. SDWM can thus be used to address the ever-increasing demand for water while at the same time preserving our existing energy and water resources, preventing missing and illegal connections, preserving the environment and monitoring and improving water quality in real-time.

Adopting SDWM-IWRM can make multi-water source management more effective, enabling facility managers to respond to the increasing complexity of building water use and district unit management, including at the boundaries between district units. District-level smart information systems such as the ones described here are based on a type of governance that supports conflict prevention and resolution, and provides better decision-making tools. A smart information management system for water-related efforts can provide prediction capacities and rational decision support at various levels to produce three types of benefits: societal, economic, and environmental. We confidently expect that SDWM-IWRM will play an important role in augmenting the efficiency of integrated water management planning and operation through more effective interactions between stakeholders and informed decision-making at all levels.

Acknowledgements This work was supported by Korea Environment Industry & Technology Institute (KEITI) through Smart Water City Research Program funded by Korea Ministry of Environment (MOE) (2019002950004).

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