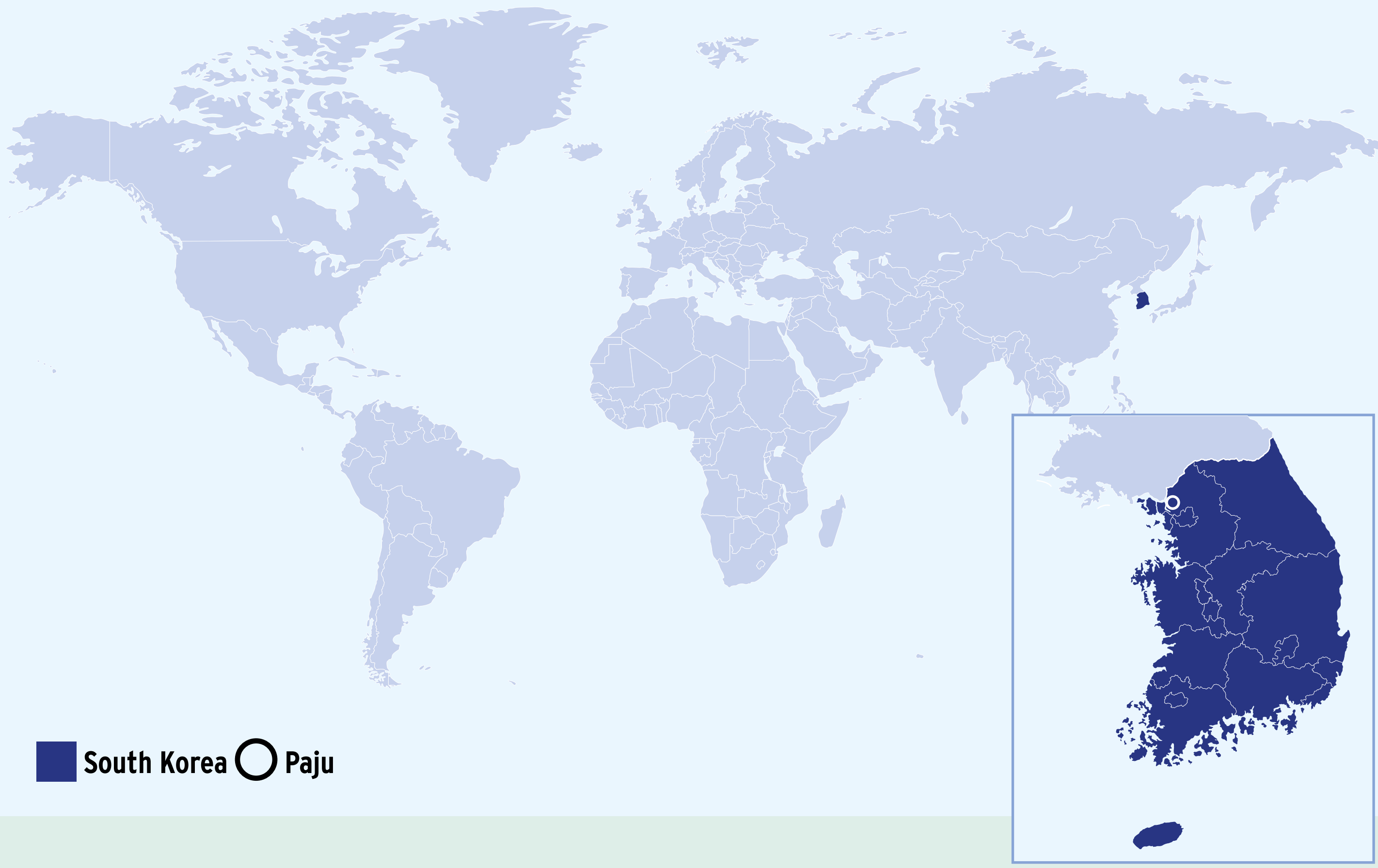
Smart Water Management Application to Paju Smart Water City

Mr. Sukuk Yi, Dr. Munhyun Ryu, Dr. Jinsuhk Suh, Dr. Shangmoon Kim, Mr. Seokkyu Seo, Mr. Seonghan Kim, K-water (Korea Water Resources Corporation)



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Summary

Despite the availability of high quality drinking water in Korea, the direct tap water drinking rate of Korea is only around 5%, which when compared with advanced countries such as the United States (56%) and Japan (52%), is extremely low. The main reason why Koreans do not drink tap water directly is distrust. More specifically, the general public has a strong distrust of tap water quality due to concerns about the aging water pipes, the smell of tap water and the taste of tap water. As a result, K-water has focused its investments on improving the water quality of existing waterworks projects and community perceptions of the water rather than on quantitative centered investments. In order to reassure people of the quality of tap water and to remove any anxieties, K-water introduced the *Smart Water City (SWC) healthy water services* with the goal to increase the direct tap water drinking rate.

A SWC integrates Information and Communication Technology (ICT) throughout the entire tap water supply process, from treatment to faucet, so that people can directly check for themselves in real-time the status of the tap water supply process and water quality. By implementing ICT into a city's water management in this way, a SWC can effectively reduce the general public's distrust in tap water thereby increasing the drinking rate of tap water.

In Paju Smart City, ICT technology including real-time sensors and on the ground staff engagement increased the tap water drinking rate substantially from 1% to 36.3% in three years. In addition to increased tap water drinking rates, community trust in water safety was also shown to increase. This shows the potential for SWCs to assist with raising community awareness of the safety of drinking water, leading to increased access to low cost safe drinking water and improved decision-making for the community interested in contributing to the efficient use of water management.

1. Introduction

1.1 Paju City Context

1.1.1 General Status

Three criteria were considered when selecting the pilot SWC project sites: 1) local governments that expressed interest in improving existing facilities and analyzing the effects of SWC; 2) areas in which advanced water treatment processes had already been or will be implemented in the near future; and 3) regions that included new cities and had relatively low densities.

Paju City was selected as the first site of the Smart Water City (SWC) pilot project. The municipality is particularly appropriate project site since K-water is already managing the local water supply system. In total, K-water operates water supply systems in 22 out of 162 municipalities in Korea through consignment agreements. Among those 22 systems, Paju City had the best conditions to carry out the SWC pilot project with advanced water treatment (activated carbon) facilities, appropriate block management; short construction period of block-building, available operation of connections between blocks with pipe networks, and optimized tap water supply facilities with dual water supply system.

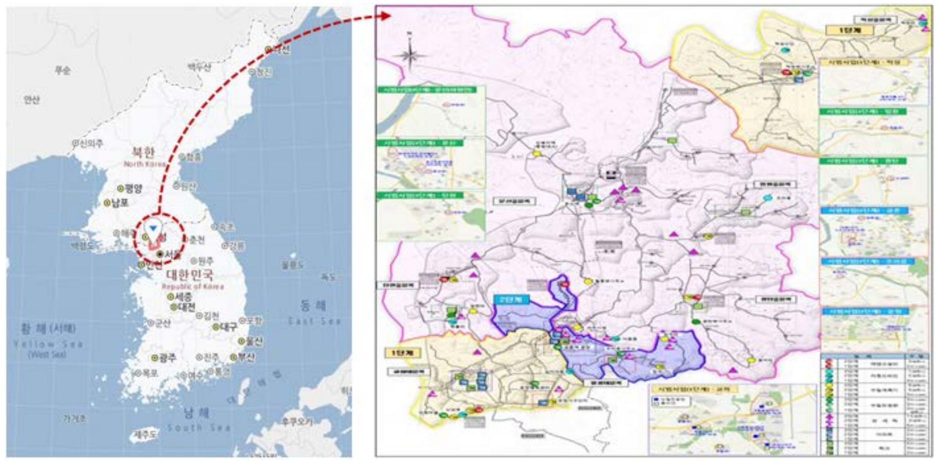


Figure 1. SWC Site (Paju City)

1.1.2 Economic Status

Gross Regional Domestic Product

Paju's Gross Regional Domestic Product (GRDP) amounted to about 9 trillion KRW (hereafter won, equivalent to 7.82 billion USD) in 2010, which accounted for 3.9% of the GRDP of 221 trillion won in Gyeonggi Province. In addition, GRDP per capita was 20.1 million (17,478 USD) won for Gyeonggi Province, while Paju City was 26.6 million won (23,130 USD).

Paju City has a great potential for regional economic growth since the growth rate of GRDP in Paju was 22.2% and GRDP per capita in 2010 was 26.6 million won (23,130 USD). The city is specialized in high-tech manufacturing and creative industries such as high-tech industrial convergence (e.g. 5G, Internet of Things, 3D printing and big data) and culture/distribution industry, these innovations will have a profound impact on industrial processes as well as create opportunities for product and service transformation, with a high possibility that it will grow into an industrial base in Northeast Asia.

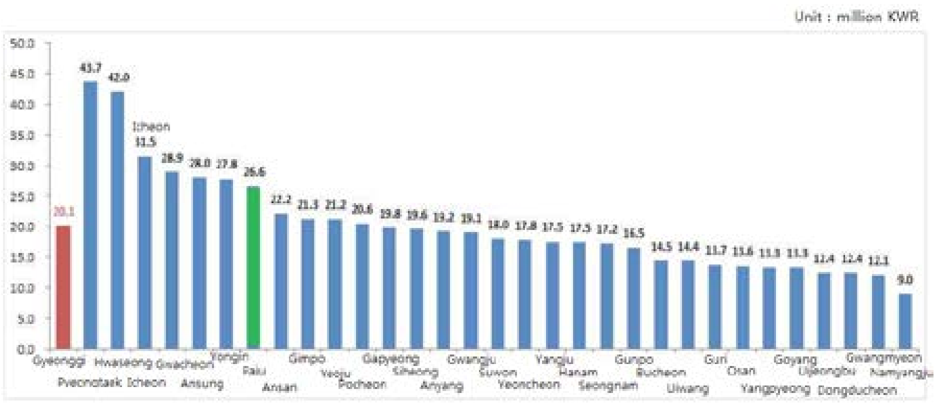


Figure 2. GRDP Increase in Paju (2010)
Source: Paju Mid-to Long-Term Development Plan, Paju City

Table 1. Gross Regional Domestic Product (GRDP) Increase in Paju (2009 to 2010)

	Paju	Gyeonggi-Province
GRDP growth rate (year-on-year ratio)	22.2%	11.6%
GRDP per capita (2010)	26,634 thousand won	20,079 thousand won

Employment Status and Conditions

The employment rate in Paju was 57.6% in 2012, which was lower than the average of 59.5% in Gyeonggi Province. However, the employment rate was 10th among the 31 cities in Gyeonggi Province. The percentage of casual workers decreased from 23.4% in 2011 to 19.9%, which was the 14th lowest among 31 cities in Gyeonggi Province. This means that the proportion of regular workers has increased and thereby the quality of jobs in the city has improved respectively.

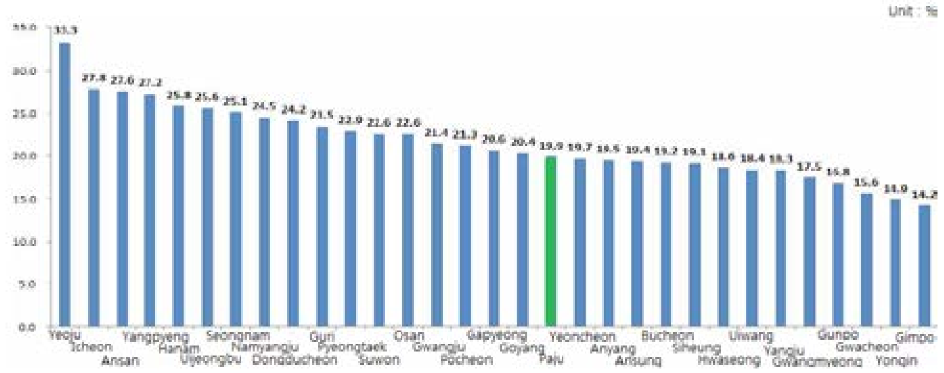


Figure 3. Percentage of Temporary Workers by City in Gyeonggi Province (2012)
Source: Employment Survey by Region, National Statistics Portal (http://kosis.kr/)
Note) Temporary and daily workers among all workers (ratio of less than one year contract period)

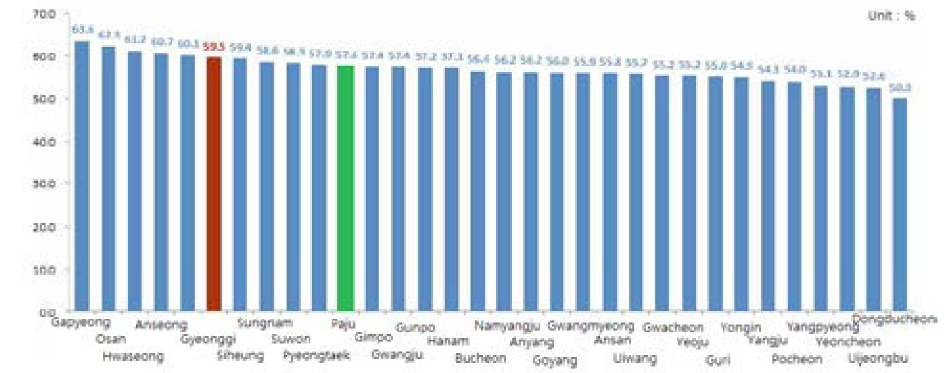


Figure 4. Gyeonggi Province Employment Rate by City (whole)
Source: National Statistics Portal (http://kosis.kr/)>
Note) Employment rate (%) = (Employment ÷ population over 15 years old) × 100

1.1.3 Population and Urbanization

Paju is experiencing rapidly changing market conditions through population growth due to the development of Unjeong (a new city), the revitalization of industrial complexes (such as LG Display), increase in foreign investment, and the Paju Development Project. As of 2015, the population of Paju City was 433,052 people in 171,753 households, having grown by 4.43% per annum for 10 years.

Figure 5. Paju Population Trend (2002-2013)
Source: Paju Mid-to Long-Term Development Plan, Paju City

1.1.4 Waterworks Facilities and Operation & Management Status

Prior to the SWC, Paju City commissioned K-water to operate its water management facilities. As of 2014, the total number of water users in Paju was 406,000, with a total water supply of 46,386,000 m3 / year and a household water supply rate of 96.6%. Paju sources its water from the Imjin River and Paldang Dam, which are situated to the west and southeast of Paju respectively. The water pipe network of Paju is 1,472 km, with 49 pumping stations and 44,033 service connections. The pipe network is in relatively good condition. Water supply (per capita, per day) is 361 litres (L), and sewer penetration rate is 79.5%.

Table 2. Paju Water Supply Use (as of 2015)

Year	Total Population	Served Population	Service Rate (%)	Facilities Capacity (m^3/day)	Per Person Per Day Water Supply(L)
2008	319,395	272,073	85.2	225,000	370
2009	331,504	302,818	91.3	225,000	350
2010	364,223	335,254	92.0	120,297	304
2011	387,273	365,390	94.3	156,000	305
2012	402,126	382,709	95.8	100,800	297
2013	410,158	393,575	96.0	225,000	373
2014	420,526	406,145	96.6	225,000	361
2015	433,052	426,123	98.4	553,500	351

Source: Paju Statistical Yearbook (2015)

Paju City has two water treatment plants; Munsan Water Treatment Plant (96,000 m^3 / day), which receives water from the Kumpa water intake plant in the Imjin River and supplies tap water (65,000 m^3 / day), and the Goyang Water Treatment Plant (210,000 m^3 / day), which receives water from the Paldang Water Intake Plant and supplies tap water (74,000 m^3 / day). Both standard water treatment processes and advanced water treatment processes are in operation in Paju City.

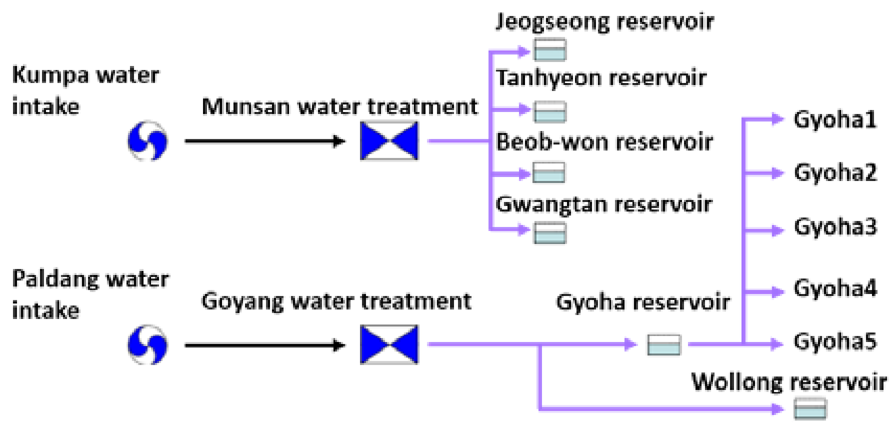


Figure 6. Paju Water Supply System

Table 3. Paju Water Supply Status (2015)

	Water Treatment Plant	Facilities Capacity (m^3 / day)	Water Supply (m^3 / day)	Reservoirs
Local Waterworks	Munsan Water Treatment Plant	96,000	65,000	Jeogseong, Tanhyeon, Beob-won, Gwangtan, Munsan
Multi-Regional Waterworks	Goyang Water Treatment Plant	210,000	74,000	Gyoha, Wollong

Box 1. Paju's Natural Environment

In Korea, 65% of the land is mountainous, the topsoil of the soil is thin, and the river slopes are steep, this results in reduced ability for watersheds to regenerate themselves and in floodwaters being discharged all at once. Paju City is located in the mid-western part of the Korean peninsula and in the northwest part of Gyeonggi Province. The area of the city is about 30km in length east-west and 36km in length north-south. Paju has a unique terrain, not found in other parts of Korea. The topography of Paju is a rectangular obsidian form, and the eastern part is composed of mountain areas connected to Mt. Gamak, Mt. Papyyeong, and Mt. Goryeong. It is also composed of flat land formed along the lava site of the Imjin River basin, where vertical cliffs formed by river erosion have created a canyon filled landscape.

1.2 Water Status in Paju City

1.2.1 Water Resources Status

The average annual precipitation in Paju is 1,223mm (Korea's annual mean precipitation is 1,227mm), and the precipitation in July and August accounts for 47.1% of the annual total. Fluctuation in runoff is consequently high, with peak flows in summer.

In addition, Paju has an abundance of water resources including four national rivers, 30 regional rivers and 76 small rivers. Among them, the main rivers of Paju are the Han River, which is facing the west, and the Imjin River, which flows into the Han River through the south. Imjin River (51%) and Han River (49%) are used as water sources, and agricultural irrigation canals are used in the Paju and Kyongha Plains, respectively. Other small streams, such as

Gwacheon, Gobyeon River, Nulchon, and Tanpongchun, along with the Imjin River, Munsan River, and Gongneung River, are continuously improving river flood prevention.

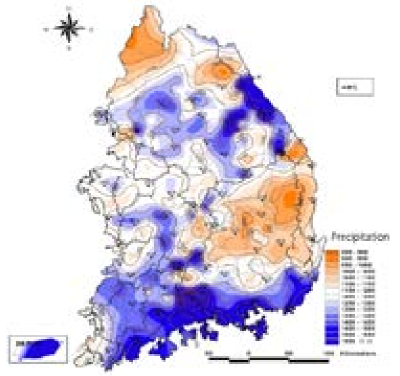


Figure 7. Annual average precipitation distribution by region (Source: Long-term comprehensive plan for water resources (2011 - 2020), Ministry of Land, Transport and Maritime Affairs)

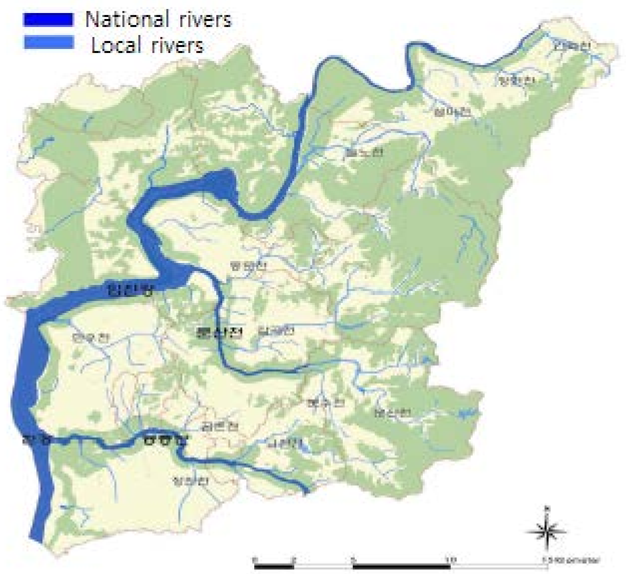


Figure 8. Paju River Status Map (Source: Paju Mid- to Long-term Development Plan, Paju City)

1.2.2 Water Quality Status

Paju lies downstream of the Han River. The Biochemical Oxygen Demand (BOD) pollution level of Paju declined over a five year period from 2008 to 2012. Since 2011, the annual average water pollution rate has decreased. The water quality targets of the central branch station of the lower stream of the Han River in 2012 were achieved with BOD 3.6mg / L and T-P 0.33mg / L. The water quality of Paju was rated grade III [1] at BOD 3.0mg /L in 2012, compared to 5.2mg / L in 2008. In addition, Chemical Oxygen Demand (COD), and Total Phosphorous (T-P) for 2012 improved compared to 2008, and the COD / BOD ratio increased to 2.3 from 1.8 in 2008.

1. The Ministry of Environment in Korea has set seven criteria (Table 4) for the river water quality based on BOD, COD, T-P, SS (Suspended Solid), etc. as provided by the Enforcement Decree of the Framework Act on Environment Policy)

Looking at the trends of water quality change from 2008 to 2012, the BOD standard is in the range of 3.0 to 5.5 mg / L ("normal to slightly better"), but the improvement trend is in the range of 6.7 to 9.1 mg / (“slightly worse" rating), but has been steadily decreasing since 2008. T-P has been increasing and decreasing in the range of 0.211 to 0.467 mg / L ("slightly worse"), however since 2009 has been decreasing.

Table 4. River Water Quality Standard

Grade	Biochemical Oxygen Demand (BOD, mg/L)	Chemical Oxygen Demand (COD, mg/L)	Total Phosphorous (T-P, mg/L)
Ia	1 ≤	2 ≤	0.02 ≤
Ib	2 ≤	4 ≤	0.04 ≤
II	3 ≤	5 ≤	0.1 ≤
III	5 ≤	7 ≤	0.2 ≤
IV	8 ≤	9 ≤	0.3 ≤
V	10 ≤	11 ≤	0.5 ≤
VI	10 >	11 >	0.5 >

Source: http://www.wamis.go.kr/WKE/wke_wqbase_1st.aspx

Table 5. Lower Part of the Han River <Middle Branch Station (Paju) Water Quality

Substances	2008	2009	2010	2011	2012
BOD(mg/L)	5.2	5.5	4.1	3.0	3.0
COD((mg/L)	9.1	8.1	6.9	6.7	6.9
T-P(mg/L)	0.361	0.467	0.298	0.326	0.211
COD/BOD ratio	1.8	1.5	1.7	2.2	2.3

Source: "Han River Submerged Land Water Environment Management Plan", Han River Basin Environment Agency

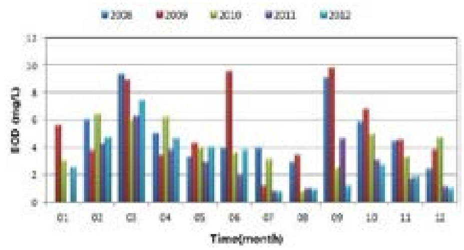


Figure 9. Changes in Monthly BOD According to the Central Branch Station Representative Year

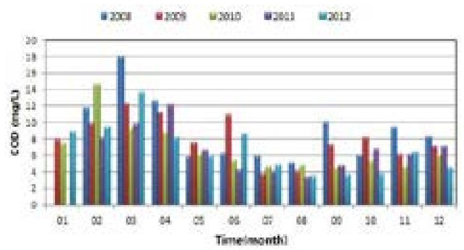


Figure 10. Change of Monthly COD According to the Middle Branch Station Representative Year

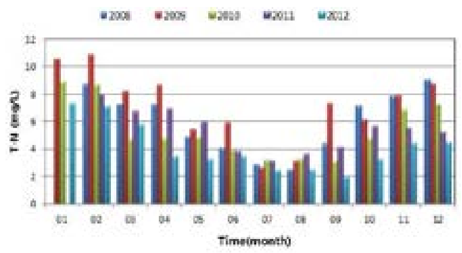


Figure 11. Change of Monthly T-N According to the Central Branch Station Representative Year

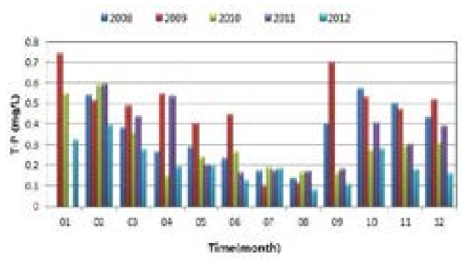


Figure 12. Change of Monthly T-P According to the Chubu Branch Station Year

Source: "Han River Submerged Land Water Environment Management Plan", Han River Basin Environment Agency

On the other hand, monthly water quality changes show that the best water quality is in summer (July-August) and lowest water quality in is winter (February to March). It is considered that this is due to both the self-purification effect that occurs with the increase of microbial activity due to the rise of the water temperature and also due to the dilution effect by the increase of the flow, which results from the summer flood.

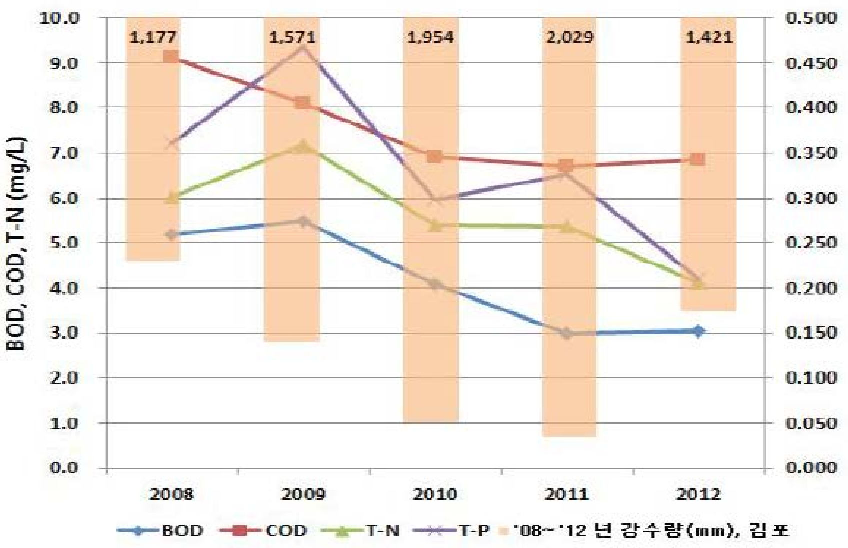


Figure 13. Annual Changes in Water Quality and Precipitation Downstream of the Han River in Paju
Source: "Han River Sub-regional Water Environment Management Plan", Han River Basin Environment Agency

In the case of the Imjin River in Paju, the BOD changes in the river according to the year between 2006 and 2011 showed that the average BOD of 2.2 mg / L in 2011 was slightly better than the river water quality gradeII and that the water quality was found to be good. In detail, the river water quality grade of Munsan Stream maintains the III grade (average) over a period of 6 years with an average BOD of 3.05mg / L, BOD (mg / L) of Gongreung Stream and Munsan Stream is slightly lowered, BOD (mg / L) remained similar to the past.

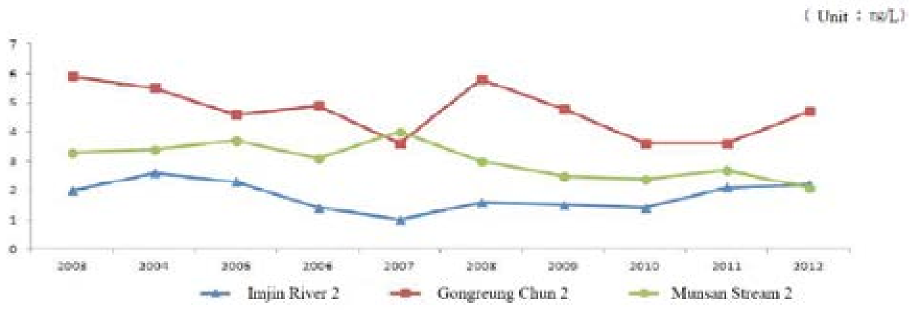


Figure 14. Change of Water Quality in the Imjin River in Paju (BOD)
Source: Water Environment Information System Homepage (http://water.nier.go.kr/)
Imjin River 2: Paju City, Gyeonggi Province
Gongreung Chun 2: Cho Ri-eup in Paju City, Gyeonggi-Province(do)
Munsan Stream 2: Bongam-ri, Paju-eup, Paju-si, Gyeonggi-Province(do)

1.3 Water Challenges in Paju City

1.3.1 Low Tap Water Drinking Rate

Despite Korea being recognized worldwide as having excellent quality tap water[2], only 5% of the community drink tap water due to a distrust in and anxiety about the tap water quality, taste and smell, and in Paju it is as little as 1%. In particular, 30.8% of respondents surveyed by K-water in 2014 were concerned about the water quality from water tanks and pipes, and 28.1% were concerned about water pollution (see Figure 15). The reasons for low tap water drinking are mainly due to the negative images and concerns about tap water. This drinking water rate is extremely low compared with advanced countries such as the US (56%) and Japan (52%).

As a result of this low drinking rate, K-water is making efforts to continuously increase investment and operation to improve the quality of tap water, such as introducing advanced water treatment technology and strengthening water quality standards, thereby contributing to improving public health and living standards.

As part of these efforts, K-water required a sustainable water management plan to address the social and environmental aspects of water quality and to eliminate any anxieties about tap water. The plan also aims to maximize water use efficiency through systematic management of water quality and water quantity, and to improve the tap water drinking rate through smart water management using cutting-edge ICT (information and communicationi technology).

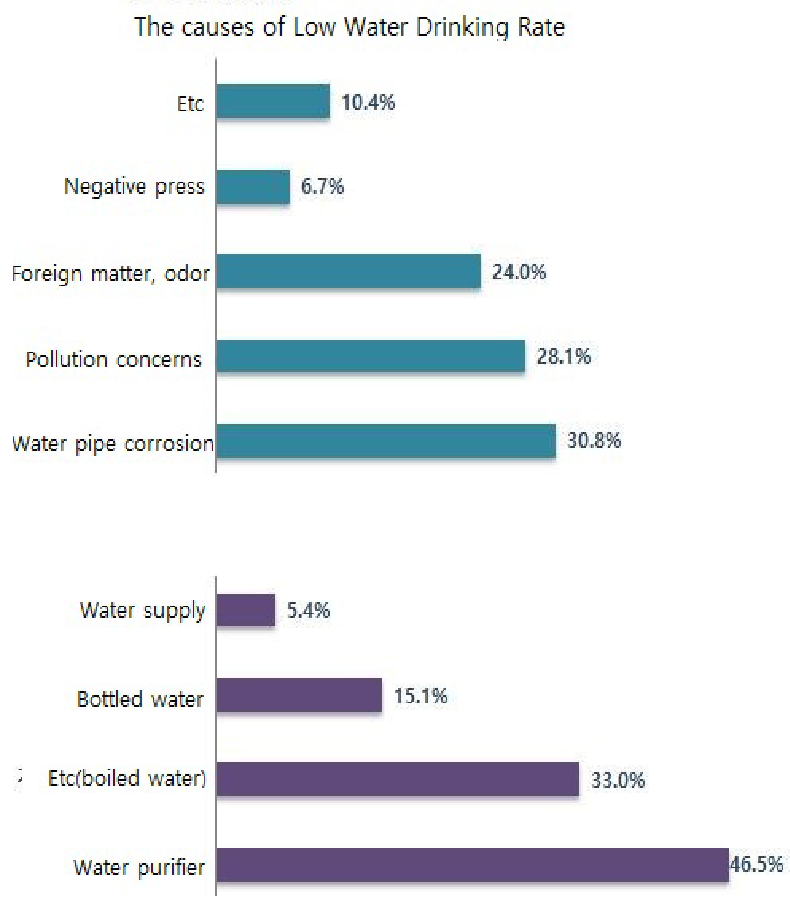


Figure 15. Drinking Water Status
Source: K-water, 2014

2. According to the UN's national water quality index, Korea ranked 8th out of 122 countries and ranked 7th at the 22nd World Water Tasting Tournament held in 2012, competing with 32 advanced countries.

As shown Figure 15, 79.5% of those surveyed said they did not drink tap water without further treatment in their homes, with 46.5% using a water purifier and 33% boiling the water to improve the taste and quality of the water, while only 5.4% of people drink tap water without any treatment.

2. Economic, Environmental, Policy and Technical Factors in Paju Smart City

2.1 SWC Investment in Paju

The budgets of the major sectors in Paju have been gradually increasing since 2014. In addition, the change in the budget scale for major sectors related to the technology business shows that it has increased year-on-year in most technology development sectors. The growth rate in the urban development sector was in the order of urban development (98.8%), public development projects (42.4%), infrastructure (29.0%) and sewerage (19.2%). The budget of the waterworks and sewerage is about 43 billion won (37.4 million USD) and 50 billion won (43.5 million USD) respectively, indicating that technology budgets are concentrated in connection with water supply and sewage systems.

Table 6. Paju City Technology-Related Budget (Unit: KRW 1,000 won)

	2014	2015	Variation	%
Public Development	778,690	1,109,127	△330,437	△42.4
Urban Development	89,484	1,110	△88,374	△98.8
Infrastructure	119,586	154,300	△34,714	△29.0
Waterworks	43,789,771	43,971,431	△181,660	△0.4
Sewers	62,843,862	50,750,799	▽12,093,063	▽19.2

Source: Paju City (www.paju.go.kr)

In addition, the size of research and development (R&D) investment for the establishment and development of smart water management (SWM) technology in Korea is steadily increasing from 5.4 billion won (4.7 million USD) in 2013, 7.5 billion won (6.5 million USD) in 2014 and 7.9 billion won (6.9 million USD) in 2016. The government is planning to increase to 10 billion won (8.7 million USD) by 2020 (MOLIT 2016).

In accordance with this trend, Paju invested 2 billion won (1.7 million USD) into the Paju Smart City project (as a pilot project for healthy tap water supply) over three years (from Phase 1 in 2014 to Phase 3 in 2016) and 5.8 billion won (5 million USD) for K-water during this time. The project was based on the agreement on improvement of the water supply network and stability of tap water supply and on water quality management and water quality information using ICT.

Table 7. Overview of the SWC Project in Paju

	Total	Phase 1	Phase 2	Phase 3
Period	’14.4 ~’16.12	’14.4 ~’15.3	’15.4 ~’16.3	’16.4 ~’16.12
Area	All Paju Areas	Gyoha·Jeogseong (Water supply population: 37,000)	Phase 1 + Wolong Area (Water supply population 223,000)	All Paju Areas (Water supply population 406,000)
Expense	7.8 billion won	2.9 billion won	1.8 billion won	3.1 billion won

Source: K-water

2.2 Environmental Factors

2.2.1 Water Quality in Paju City

As a result of examining the water quality of Munsan water treatment plant in Paju City, microorganisms such as coliform bacteria and other general bacteria[3] were found to be below the reference value or not detected, and the amount of oil and inorganic substances having harmful effects on health was measured to be significantly below the standard values. In addition, all of the aesthetic substances such as taste, odor, color, zinc and iron were much lower than the standard values. Moreover, the disinfectant and disinfection by-products were lower than the standard values. So, it is clear that the water quality in Paju City is safe overall, however to improve perceptions of the water quality within the community it was still deemed appropriate to improve the water quality to the highest possible standard.

Table 8. Results of Microorganism Testing at Paju Water Treatment Plant

	General bacteria (CFU / mL)	Total coliforms (MPN)
Standard	100	-
Measures	0	Non-detection

Source: National Waterworks Information System

Table 9. Results of Testing for Organic and Inorganic Substances that are Harmful to Health at Paju Water Treatment Plant

	Carbon tetrachloride(mg/L)	Phenol(mg/L)	Lead(mg/L)	Fluorine(mg/L)
Standard	0.002	0.005	0.01	1.5
Measures	0	0	0	0

Source: National Waterworks Information System

Table 10. Results of Aesthetic Impact Substance Testing at Paju Water Treatment Plant

	flavor	smell	Chromaticity (degrees)	Zinc (mg/L)	Iron (mg/L)	Manganese (mg/L)	Turbidity (NTU)
Standard	No flavor	Odorless	5	3	0.5	0.05	0.5
Measures	None	None	0	0.004	0	0	0.04

Source: National Waterworks Information System

2.2.2 Quality of Tap Water at Paju Water Treatment Plant

Tap water quality was assessed in September 2016 on three old water faucets in Paju. The results showed that no E. coli was detected, ammonia nitrogen was ‘0’, the pH level was adequate, and appropriate amounts of zinc and chlorine ion were detected and did not affect water quality.

2.3 Policy Factors

2.3.1 Government Water Management Policy

In 2010, the Korean national government launched research and development (R&D) into smart water management and related technologies as part of a new growth engine strategy. According to the government's SWM roadmap, the focus is on mid- to long- term technology development and budgeting, and in the short-term commercialization that supports the activation of private investment. By 2030, the government plans to promote the management of a demonstration complex with the aim of building a nation-wide SWM system and to establish a base city for each of the 7 major metropolitan areas[4]. As a result,

3. It refers to various bacteria other than pathogens in water and is generically called aerobic bacteria and anaerobic bacteria.
4. Seoul, Busan, Daegu, Incheon, Kwangju, Daejeon, and Ulsan.

efforts have been made to improve water management by ICT in the water sector. Since 1999, the government has established a detailed plan to build a comprehensive information system for national water resources management, and is constantly promoting the water management information system.

Box 2. SWM Research Trends and Cases in Korea

Korea has been interested in smart water management since 2010 and has developed various related technologies. The Ministry of Land, Infrastructure and Transport formed and supported a research group to develop and implement practical water service technologies for five years from 2012. This SWG Research Group pursued three projects; (1) Water resources and distribution management (2) Water supply and demand assessment, Integrated water management, and (3) ICT based water resources management. The goal of the first project was to develop intelligent water resources operations technology, to improve the water independence rate[1] (reducing the reliance on external water sources) by 30% and reduce energy costs used in water resources operations by 10%. The second project aimed at developing an intelligent watershed management platform for regional water shortage risk assessment, real-time water supply management, and intelligent water supply and demand integrated information management. The third project aimed to develop a two-way remote meter reading system and water information service using ICT.

The Smart Water Grid Research Group was comprised of three cooperative organisations under the supervision of Incheon National University, 10 consultants, 8 consigners and 44 participating companies (Incheon National University and 54 others).

Source : Lee Sang-ho (2015), Global Competition, Smart Water Service, Journal of Water Policy and Economy, April 2015 Vol.24

Moreover, in accordance with the shift in focus from obtaining a "safe water supply" in the 1990s to moving towards a "tastier and healthier water supply," since 2000, the government and K-water are implementing the '*Healthy water for the human body' program.* This healthy water supply program goes beyond traditional methods to supply safe water by providing minerals in the tap water through the management of water quantity and water quality from source to faucet. The program includes the use of SWM, providing relevant, real-time information about tap water that can be trusted by the community at anytime and location.

As part of this SWM approach K-water is pursuing five major objectives: 1) intake source water management; 2) water treatment system optimization; 3) intelligent distribution network management; 4) customized industrial water supply and; 5) wastewater treatment operating efficiency.

Figure 16. Concept of the Healthy Water Supply Program of K-water
(Source: K-water)

Table 11. K-water's Healthy Water Supply Project

	Details
Water Quality Management of Water Resources	• Developing a prediction system that can monitor the occurrence of algae odor substances in advance to establish a preventive water quality safety management system • Establishing preemptive response measures for water quality such as algae through the operation of real-time algae odor measurement system and an on-line toxin on-line measurement system
Water Treatment System Optimisation	• Operating water safety management techniques and water treatment process diagnosis programs to strengthen healthy tap water production system that everyone trusts • Introducing of a cutting-edge water supply system including the location of water purification facilities near consumers using new concepts based on vertical water treatment technology
Intelligent Network Operation	• Collecting operational data for the entire water supply process from water source to faucet and building a remote real-time monitoring control operating system based on ICT • Analysing the collected data to realise healthy water supply through the intelligent network operation system that can manage quantity, water quality and energy, such as supply of uninterrupted water and improvement of reasonable facilities
Efficient Sewage Treatment Operation	• Constructing and operating sewerage upstream of the dam to improve the living environment, including improvement of river water quality and of public sanitation • Establishing a clean and stable water circulation system through participation in large-scale sewage projects by private investment

Within the *'Healthy Water Supply Program'* the Smart Water City (SWC) project acts as a consumer-oriented SWM system that adopts the paradigm of "healthy water supply to the human body." The purpose of the Paju SWC project is to improve the reliability of tap water by providing scientific information on water quality and ICT based water quality management, strengthening water supply stability and efficiency, and providing water quality information to the people. In addition, by integrating ICT throughout the supply process from water source to tap, water quantity and water quality is scientifically managed to create a city where consumers can trust and drink the water from the tap.

2.3.2 Water Management Policy of Paju City and Consignment and Operation Management of Water Supply Facilities

Paju is making plans in the fields of natural ecology, soil and ground water, air, water quality, water and sewage, noise and vibration, water resources, energy and waste for environmental management. In water management, it is necessary to expand water quality monitoring capabilities, enhance sewage treatment plants (increasing the treatment area, the population and improving the sewage treatment rate), manage pollution sources at the level of total pollution management and promote public participation.

Paju City is expanding the water supply and water purification systems in rural areas to meet citizens' demand for high quality of water supply and sewage treatment. In 2014, Paju City increased sewage treatment facilities in major areas and is planning additional expansion of sewage treatment facilities and sewer maintenance plans in preparation for rapid population growth.

2.4 Technical Factors

Business Overview (Innovative Smart Water Management Technology Solution Proposed)

The Paju SWC project provides a total solution for tap water operation and management including GIS and real-time measurement data, water supply, water quality crisis management and demand forecasting. Included in this SWC project is water-NET, a system developed by K-water to monitor and analyze the entire process of tap water supply using real-time ICT. The main SWM solutions provided in this project are shown below in Figure 17.

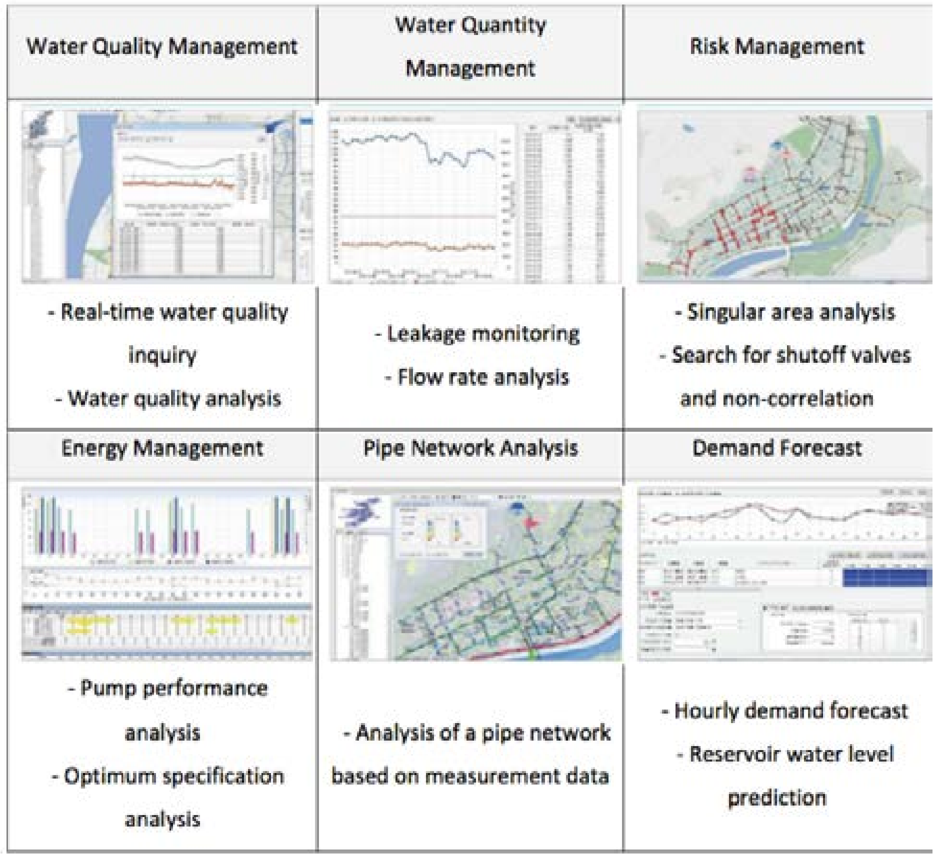


Figure 17. Main Functions of Regular Water Supply Management System Applied to the Paju Smart Water City Pilot Project
(Source: K-water)

Developed by K-water, water-NET consists mainly of two programs: Dr.Pipe and Net.Operation. Dr.Pipe is a water pipe diagnostics program, which uses performance evaluation and diagnostic software to promote technological realization of the *'Preliminary Diagnosis Post Improvement'* policy, proposed to perform maintenance and improvement of the water pipe network more efficiently and reasonably. It supports the establishment of an optimal network improvement plan based on the diagnosis and evaluation of pipeline information, repairs, water quality and facilities.

Net.Operation is a water network operation management program which is comprised of modules including real-time pipe network analysis, water quantity, water quality, crisis and energy management based on GIS and real time data, water pressure, and real-time leakage monitoring and leakage estimation.

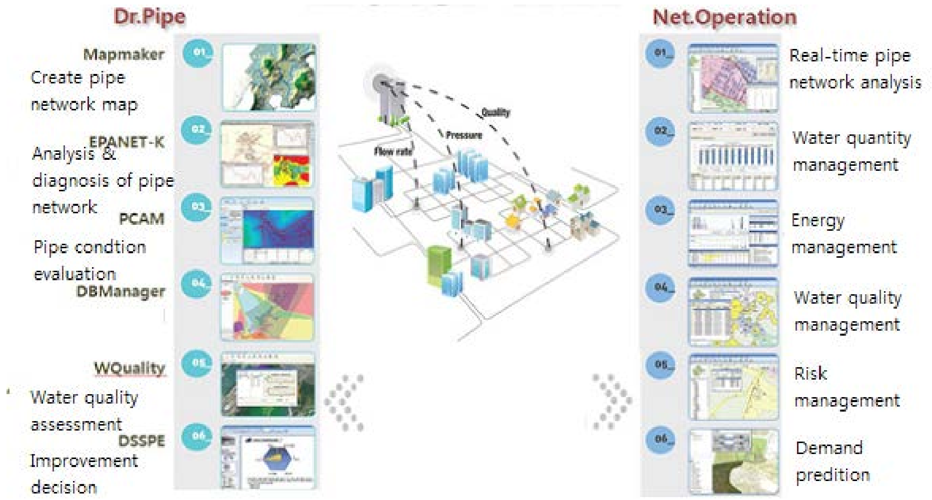
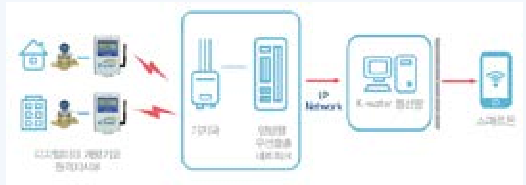


Figure 18. Water-NET system diagram applied to the Paju Smart Water City Pilot Project

Table 12. Major Technologies applied to the Paju SWC Pilot Project

Residual chlorine equalisation	Technology to improve water quality, safety and chlorine taste and smell by dispersing injection of disinfectant (chlorine) into the reservoir and pipeline to prevent propagation of pathogenic microorganisms		
Automatic drainage system	The technology to clean the pipes at all times through the automatic discharge of excess pollution and the length of time the water remains in the pipe through real-time water quality measurements of the tap water supply pipes		
Tube cleaning	The tube cleaning technique includes an air bubble injection method in which compressed air is injected into a tube to discharge foreign matter through contraction and expansion and a sponge- Injection method	 1) Air bubble injection method	 2) Sponge injection system

Exploration with continued water supply	As a technology to check the internal state of the pipe without stopping the supply of tap water, long-distance unmanned aerial surveying equipment (Sahara) is able to survey D300mm or more, water pressure under 14kgf / cm2, maximum 1.8km, -15) is more than D 150mm · Water pressure is less than 7.5kgf / cm2 · It is possible to survey up to 1.8km	
Remote leak monitoring	A technology that detects leakage sounds from a buried pipe and detects frequency and amplitude to determine leakage and predict leakage points	
Smart metering	Technology that provides usage and charge information through a smartphone app by analysing usage amount, abnormal flow rate, leakage, etc. based on time data acquired through digital meters	

3. Outputs and Outcomes of the Paju SWM Pilot Project

3.1 Water Quality Improvement

The Paju SWC Pilot Project contributed to the improvement of water quality at the Paju City water treatment plant. The residual chlorine leveling operation resulted in the equalization of residual chlorine in the supply process as well as supplying healthier water based on the effects of the improvement of water quality in the Munsan and Goyang areas due to the reduction of byproducts generated during disinfection. The effect of reducing the residual chlorine concentration differed in the Munsan and Goyang areas by 29.2% and 17.2%, respectively. In the case of the Munsan water treatment plant, the amount of disinfectant (chlorine) injection required was reduced by 8.9%, and the disinfection by-products (THMs) in the entire supply period decreased by an average of 22.9% (0.0498 → 0.0384mg / L).

In the water treatment process, chlorine acts as a disinfectant, but it also causes tap water to have a distinctive odor and taste. Residual chlorine makes the taste of tap water bitter and when an excessive amount of chlorine is added to tap water, it can cause problems to the human body such as lowered immunity and increases in harmful active oxygen. In some cases, trihalomethanes (THMs) form when organics (humus) and chlorine, which is injected during the tap water chlorine disinfection process, are combined. According to the US Environmental Protection Agency (EPA) standards, trihalomethanes are classified as a carcinogen and should not exceed 0.1 mg per liter of tap water.

Therefore, in order to maintain the disinfection ability yet avoid undesirable taste and odor of tap water, residual chlorine should be kept constantly below a certain level.

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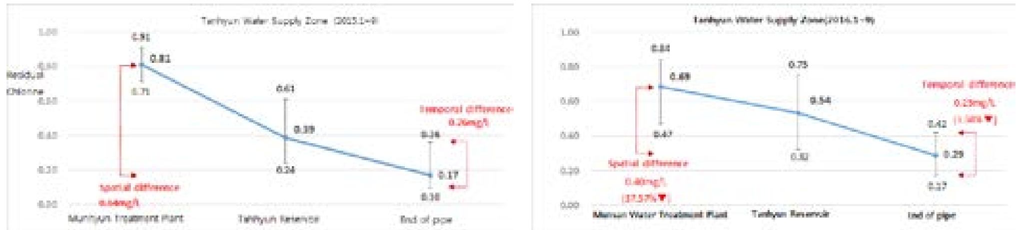
In order to solve the problem of excess residual chlorine in the potable water system, a disinfectant dispersion injection system was developed. In a conventional tap water supply system, the system injects the disinfectant once only until the tap water is delivered to the consumer. Therefore, the water company was forced to inject the disinfectant based on the average time from the water treatment plant to the faucet, which caused a difference in the concentration of the disinfectant depending on the location of the consumer. Due to differences in the concentration of the disinfectant, the taste, odor, and water quality of the tap water could not be guaranteed. Nonetheless, the concentration of disinfectant in the demonstration area can be maintained at the same level by dispersing the disinfectant in relation to the time difference between when the tap water was used in each region.

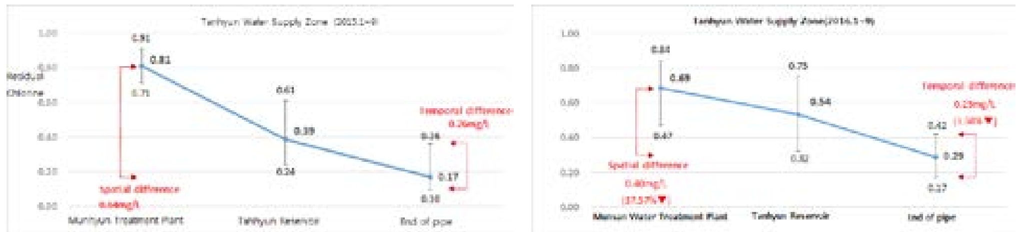
Table 13. Status of Residual Chlorine Equalisation

Water purification plant	Water supply area	Spatial distribution			Temporal distribution		
		2015 (Δmg/ℓ)	2016 (Δmg/ℓ)	% Change	2015 (Δmg/ℓ)	2016 (Δmg/ℓ)	% Change
Average change rate		-	-	↓17.24	-	-	↓29.20
Munsan	Jeogseong	0.50	0.43	↓14.00	0.42	0.13	↓69.05
	Gwangtan	0.45	0.37	↓17.78	0.34	0.31	↓8.82
	Tanhyeon	0.64	0.40	↓37.50	0.26	0.25	↓3.85
	Beob-won	0.46	0.38	↓17.39	0.20	0.15	↓25.00
	Munsan	0.39	0.37	↓5.13	0.35	0.22	↓37.14
Goyang	Gyoha	0.35	0.21	↓40.00	0.36	0.30	↓16.67
	Wollong	0.18	0.20	↑11.11	0.41	0.23	↓43.90

* (Spatial distribution) Residual chlorine concentration difference from water purification plant to tiller / (temporal distribution) Residual chlorine concentration difference



Reduction of Spatial and Temporary Residual Chlorine Concentration Difference Between Before and After Operation of Tan-Hyeun Drainage Area Re-chlorinisation Facility



Residual chlorine titration before / after disinfectant injection amount
Disinfectant injection volume reduction rate

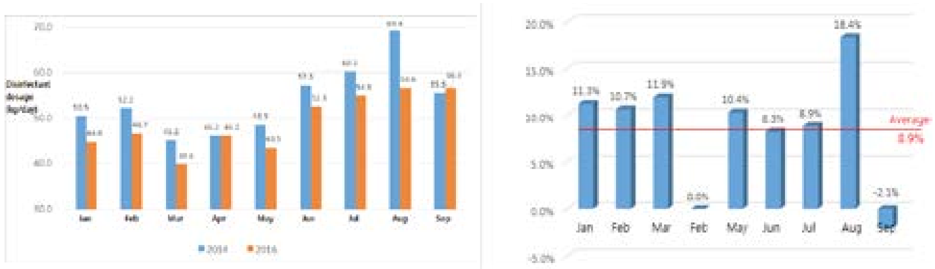
Figure 19. Monthly disinfectant injection volume change at Munsan water purification plant
(Source: K-water)

Table 14. Change in all-process disinfection by-products (THMs) reduction unit: mg/ℓ

	Average	Jeogseong		Tanhyeon		Gwangtan		Beob-won		Munsan
		Reservoir	End of pipe	Reservoir	End of pipe	Reservoir	End of pipe	Reservoir	End of pipe	end of pipe
‘15. 9	0.0498	0.048	0.050	0.047	0.053	0.045	0.053	0.048	0.050	0.054
‘16. 9	0.0384	0.038	0.040	0.034	0.038	0.036	0.041	0.036	0.042	0.041
Reduction rate(%)	22.9	20.8	20.0	27.7	28.3	20.0	22.6	25.0	16.0	24.1

Source: K-water
* Water quality standard of drinking water THMs (total trucholymethane) 0.1 mg / ℓ or less
(chart above -Munsan has no “reservoir” column- double check it is not a mistake)

In addition, the quality of the drainage pipes were improved, especially indoors and in poor quality areas. The analysis of 14 out of 15 areas of the drainage pipe resulted in a decrease of 27 - 89% in the concentration of sediments in the pipes. In addition, water quality analysis of 168 samples across 660 indoor water pipe cleaning points showed the improvement of domestic water quality (11.8% of residual chlorine standard) as well as positive effects in terms of turbidity, iron and copper.



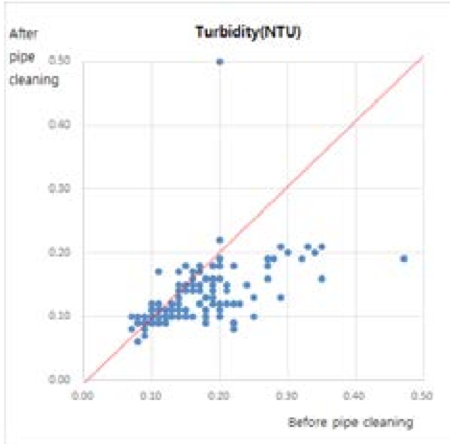
Float particle concentration before and after cleaning | Reduction rate of suspended particle concentration

Figure 20. Change in the Concentration of Suspended Particles During Pipe Cleaning
(Source: K-water)

Table 15. Water Quality Analysis Results Before and After Indoor Pipe Cleaning

	Residual chlorine(mg/L)	Turbidity (NTU)	Iron (mg/L)	Copper (mg/L)
Water quality	0.1~4.0	0.5 or less	0.3 or less	1.0 or less
Before cleaning	0.204	0.165	0.017	0.023
After Cleaning	0.228	0.127	0.006	0.016
Variation	↑0.024	↓0.038	↓0.011	↓0.007
Rate of change(%)	↑11.76	↓23.03	↓64.71	↓30.43

Source: K-water



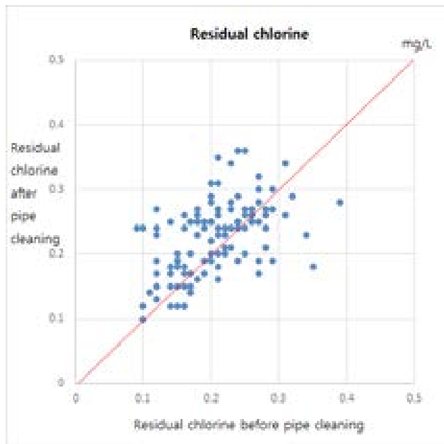


Figure 21. Turbidity before and after pipe cleaning
Figure 22. Residual chlorine before and after pipe cleaning

3.2 Social Performance

3.2.1 Establishment of a Real-Time Information Exchange System

In 2014, the first phase of the Paju SWC Pilot Project commenced to supply 37,000 people in two regions in the Paju area. By 2016 (the third phase) the total area of Paju was included, with supply provided for 444,000 people. As part of the project, each household in Paju can install leak detection sensors and automated water quality meters in their water pipes to measure leakage and water quality in real-time, with measurement results provided by way of outdoor water quality signboards and a smartphone application. In addition, an automatic drain that discharges water pollutants can prevent water quality accidents in advance. As the revenue water rate of Paju was 86.6% in 2014, which was higher than other local water management facilities, leak detection monitors were not considered a priority for the project. However, as leaks tend to occur after a certain period of time without careful management, K-water included leak detection tools to ensure the revenue water continued at a high rate in the future.

By installing and operating water quality measuring instruments at major points in the supply process such as water treatment plants, pipelines, reservoirs, and apartment water tanks, real time water quality information measured during the entire tap water supply process can be directly confirmed through electric signboards and a smartphone app. Also, a variety of convenient functions are offered such as water quality and billing information, application for customized water services, and customer satisfaction reports through the smartphone application.

(1) Water quality signboard service in front of an apartment (2) Smartphone Application Service

Figure 23. Real-Time Water Quality Information Services
(Source: K-water)

In addition to the monitors and real-time updates, many drinking fountains have been installed in apartment buildings, and indoors and outdoors in elementary schools, with water quality information analyzed and disseminated in real time to manage and inform customers of water quality at all times. These drinking fountains contribute to creating a new tap water drinking culture by improving transparency and trust within the community. Real-time information provides citizens with the opportunity to get acquainted with clean and healthy tap water.

(1) Tap water station at an elementary school

(2) Tap water fountains at an apartment

Figure 24. Tap Water Fountains in Paju
(Source: K-water)

3.2.2 Customized Customer Service Implementation

In order to improve the general public's trust in tap water, residents of Paju can also request a 'Water Codi[5]' to check the water quality of each home and a 'water doctor' service is provided to check the condition of indoor water pipes and to wash the pipes when needed. As part of this service a 'Water Codi' operator, equipped with water quality measurement devices, visits and measures the water quality of the tap water, and inspects the sanitary condition by inserting endoscopic equipment in the water pipe. 'Water Codi" actions are divided into two steps. First, a test is conducted to assess five parameters including turbidity, hydrogen ion concentration (pH), residual chlorine, iron and copper. Then, in a second test, the drinking water quality inspection agency conducts a test to check the reference level. At this time, the first item is inspected again, and the bacteria, total coliform, coliform, zinc, manganese, and ammonia nitrogen are further inspected. The pilot project was conducted for the purpose of guaranteeing the quality of tap water through 'Tap water safety assurance' so as to drink tap water comfortably, and to conduct various water tap water quality inspection services.

Figure 25. 'Water Codi' Services

5. "Water Codi" is a contract worker employed by K-water specifically for the purpose of improving customer satisfaction by proactively performing customer management services such as water quality inspections and management of local waterworks and households.

Table 16. Tap Water Relief Assurance Service

Type	Services
Water pollution inspection	• Water quality inspection or water quality inspection
Self-inspection	• Conducts water quality inspections (circulation in the same area) • Daily inspections area selected for inspection only
Booth type group inspection	• Inspection of tap water from customers who visit a water quality inspection booth • Examination of large complexes such as apartments

3.3 Improvement of Revenue Water Rate

After 500 leak detecting sensors were installed in three small blocks with high non-revenue water (water which is lost to leakages) in Paju, the water network's managers were able to detect the location of the leakage points, enabling them to repair leaks quickly. The quick repair of leaking areas resulted in a reduced average leakage of 1,521m3/ day, which means that the revenue water rate improved by an average of 13.38% over the course of the project. As a result, the economic efficiency of 515 million won (447,826 USD) was achieved.

Table 17. Leakage Recovery and Non-revenue Water Rate

Location	Leak quantity (estimation) (m^3/day)	Revenue water (%)		
		Before application	After application	Improvement effect
Total (Average)	1,520.6	74.32	88.52	13.38%p↑
GH 1-3	355.7	71.91 (Jan~May, 2016)	88.08 (Jun~Oct, 2016)	16.17%p↑
BW 1-1	397.0	76.73 (Jan~Aug, 2016)	94.05 (Sep~Oct, 2016)	17.32%p↑
JS 1-1	767.9	76.77 (Jan~Sep, 2016)	83.43 (Oct, 2016)	6.66%p↑

3.4 Technical Performance

3.4.1 Homogenization rate of residual chlorine

The SWC pilot project was a challenging project that solved many of the existing tap water problems that were previously mentioned in this report. In relation to the challenges associated with too much chlorine in the water supply, the chlorine injection step was applied not only to the water purification plant process but also to the faucet. By choosing a system, which can inject the disinfectant locally, the homogenization[6] rate of residual chlorine in tap water was improved to a range of 24.3 - 36.4%. That is, the increase in the homogenization rate of the residual chlorine eventually weakens the odor of tap water, thereby reducing the discomfort of water users.

3.4.2 Reduced contamination in tap water

The indoor pipe cleaning, which was included as part of the SWC pilot, reduced pollution caused by contaminated tap water in the water treatment plant. As a result, in the SWC business district, the average number of civil complaints on tap water quality was reduced from 4.5 per month to 1.3 per month (a decrease of 71.1%).

6. Homogenization is to disperse each component of a heterogeneous mixture into particles or molecules phases to homogenize the whole.

4. Social, Environmental and Economic Impacts of the Paju SWM pilot project

4.1 Links with Sustainable Development Goals

The SWC project aimed to improve the drinking rate of tap water and increase water utilization by reducing water leakage. The reduction of water usage by minimizing water leakages can also reduce the amount of water intake from sources such as rivers and streams, thereby improving water efficiency and lowering the water stress index.

SDG 6 was created to ensure availability and sustainable management of water and sanitation for all. More specifically, target 6.4 aims to reduce water use efficiency across all sectors and ensure sustainable withdrawals and to supply water to and reduce the number of people suffering from water scarcity. This is also demonstrated in target 12.2, which looks to achieve sustainable and efficient management in water resources.

By increasing the availability of clean, affordable drinking water for communities, the Paju Project also significantly improves access to safe and affordable drinking water for the community (target 6.1). It is anticipated that as the project continues, the percentage of community members drinking tap water will continue to increase towards the rates of other developed countries.

By empowering the community with real-time information on water quality and use, they become considerably more involved in decision-making for their local water use and management. This project has also increased the trust in the community towards their water supplier, showing the potential for SWM to support water agencies in engagement and raising the awareness of communities.

By introducing SWM into Paju, job creation and training also increased (target 4.4), increasing local capacity and opportunities for the community.

Table 18. A list of the SDGs and their specific targets that relate to Paju SWM Project

Sustainable Development Goals and Targets	
SDG 4: Increase opportunities and job creation **Ensure inclusive and equitable education and promote lifelong learning opportunities for all**	
4.4	By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship
SDG 6: Clean water and sanitation **Ensure availability and sustainable management of water and sanitation for all**	
6.1	By 2030, achieve universal and equitable access to safe and affordable drinking water for all
6.4	By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
6.b	Support and strengthen the participation of local communities in improving water and sanitation management
SDG 12: Sustainable consumption **Ensure sustainable consumption and production patterns**	
12.2	By 2030, achieve the sustainable management and efficient use of natural resources

4.2 Expansion of Smart Water Management Policy

To support the aim to become a Smart Water City, Paju is actively developing water related policies such as revising the *Paju City Water Supply Ordinance* and the *Paju City Urban Planning Ordinance* to provide clean and healthy water to the residents of Paju. In addition, Paju has introduced a smart water technology (system) developed by water-related specialist organisations, such as the water-NET monitoring and analysis system for water supply in all processes to promote more efficient and sustainable water management policies.

4.3 Economic Income and Job Creation

As a result of the SWC Pilot Project, the value of water leakage reduction is estimated to be 515 million won (448 thousand USD) per year in consideration of the reduction of 1,521 m^3 / day, and the revenue water rate has improved by 13.38% on average. In relation to quantitative water balance analyses, the water leakage reduction effect is also 1,111 m^3 / day. The costs are expected to be reduced to 376 million won per year. The SWC project contributes to the regional economy as well as job creation. Since the implementation of the SWC Pilot Project, Paju City has established a 'Clean Water Environment Project Team' that includes waterworks, sewerage, environmental facilities, and cityscapes, and has deployed a total of 98 civil servants. Considering that the number of civil servants in Paju is 1,291, it can be seen that a large number of public officials have been deployed in the water related field due to this project. Paju City has selected construction companies as a local social enterprise by promoting the SWC project with K-water, which has resulted in a large number of local community jobs, including 238 jobs in water related fields for the duration of the project.

Table 19. Estimation of Leakage by Block and Cost Saving Effects

	Leak recovery location	Leak quantity (m^3/day)	Saved Cost (million won/year)
Total		1520.6	515
GH 1-3	3 places	355.7	120
BW 1-1	3 places	397.0	134
JS 1-1	C9	767.9	260

Note: Applied the total cost of water supply in Paju in 2014 (927.03 won / m^3)
Source: K-water internal document

Table 20. Quantitative Water Balance Analysis and Cost Saving Effects Unit : m^3/day

		GH 1-3	BW 1-1	JS 1-1
• Before leak repair				
Supply quantity(a)		2,601	2,741	2,500
Effective quantity	Revenue quantity(b)	1,870	2,103	1,919
	Uncounted quantity by meter(c)	78	82	75
Leak quantity(d=a-b-c)		653	556	506
• After leak repair				
Supply quantity(a’)		2,439	2,511	2,293
Effective quantity	Revenue quantity(b’)	2,148	2,361	1,913
	Uncounted quantity by meter(c’)	73	75	69
Leak quantity(d’=a’-b’-c’)		218	75	311
Leak reduction quantity(d-d’)		435	481	195
Cost Reduction		147 million won/year	163 million won/year	66 million won/year

Source: K-water internal document

4.4 Improving Water Environments

Based on the results of the semi-permanent antimicrobial effect maintenance (an anti-microbial injection which suppresses bacterial propagation per tube, in a pipe by itself), the reduction of disinfection by-products (THMs), and the decrease in the average turbidity by 27.2%, the SWC project is expected to have had a positive impact on water environment and ecosystem health.

The major water quality influences of the water pollutant clusters in the SWC business area (throughout the 1st - 3rd stage) were mainly caused by the drainage of sediments inside the pipes such as the reverse osmosis system and fine rust particles. It is expected that the sediments affecting the water quality will be removed and the decontamination system with weak adhesive force, which will affect the water quality, will be removed at the same time, thereby contributing to the elimination of water quality complaints due to long-term sediment discharge. As a result, from the viewpoint of water quality, turbid particles are removed from the pipe surface (27.0 - 88.7%) by pipe cleaning, and the turbidity inducing component in water is greatly reduced, resulting in a reduction of turbidity of 6.7% - 92.3%

4.5 Increasing Social Satisfaction

The major accomplishments of the Paju SWC Pilot Project include relieving distrust of tap water and improving the reliability of tap water through smart water management services and customized customer services. Although the direct drinking rate of tap water in Paju City was only 1% before the project was implemented, it was confirmed that the rate of direct drinking water rose to 36.3% after applying the SWC project. When you consider that the average drinking tap water rate of the people in Korea is only about 5%, this results show that the perception of tap water by Paju citizens has been significantly improved through the SWC pilot.

In addition to improved drinking tap water rates, after applying the Paju SWC Pilot Project, overall satisfaction of tap water improved from 60.0% in 2014 to 86.0% in 2016, and the satisfaction rate of healthy water service also improved from 80.7% in 2014 to 93.8% in 2016. Through this project, the more than 400,000 people in Paju will be able to drink tap water with confidence, and household economic and social costs related to the purchasing of bottled water and water purifiers will be significantly reduced.

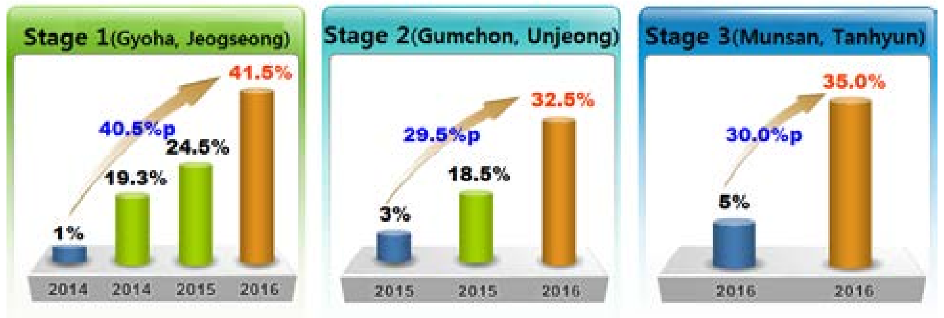


Figure 25. Paju city's direct drinking water rate change

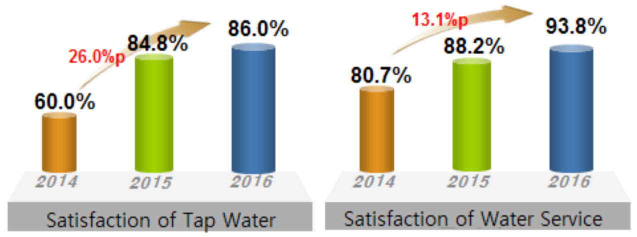


Figure 26. Change of satisfaction of tap water and water service in Paju.

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SMART WATER MANAGEMENT APPLICATION TO PAJU SMART WATER CITY

5. Enablers, Barriers and Lessons Learned

5.1 Enablers

5.1.1 Government investment

While the United States and Europe rely on the private sector the development and distribution of smart water management technologies, Korea was able to carry out projects led by the state or public entities to benefit from the initial investments that required relatively large capital. As a result of this the financial cost of disseminating SWM is also an important matter as investment in SWM was mainly covered by public funding, which may not be possible if replicating the project elsewhere.

5.1.2 High technological capacity and industry already present in Korea

Another enabler that supported the project is the information and communication technology and infrastructure construction status in Korea, which is currently the highest in the world. This was certainly an advantageous environment for developing and introducing water management technology based on ICT.

5.2 Barriers

5.2.1 Challenges in scaling up and replicating the successful pilot project

Relatively low water management technologies and water rates below cost (see Table 21) are obstacles to overcome. Compared with information and communication technology, Korea's water management and water technologies have not yet reached the highest level in the world. While there is a strong interest in Korea to both scale up and replicate the technologies used as part of the Paju Smart City pilot, K-water recognizes that low water rates and lack of related budgets may make it difficult to apply newly developed technologies to the field. Tariffs for tap water barely cover operation and maintenance (O&M) costs and only a small portion of the capital charges. Therefore, policy support and related technologies should be continuously developed to overcome these problems.

Table 21. Cost recovery ratio of tap water in Korea

	2012	2013	2014	2015
Multi-regional water supply	82.6%	84.5%	84.8%	83.8%
Local water supply	79.7%	77.8%	76.1%	77.5%

Source : K-water (2017), Local Waterworks Total Management Performance Evaluation Report

5.3 Lessons Learned

1) At the beginning of the project, investments by national or public institutions are essential.

Public investments such as state and local governments and public institutions essential at the beginning stages of the project. While there was an initial financial deficit in the first stage of the project, the public sector, governments and public entities were willing to invest in SWM due to the public benefits it achieves, such as improved quality of life, as shown in Paju City. The government realized that it was more important to have indirect benefits such as a reduction in the cost of water purifiers and bottled water and an increase in citizen satisfaction (shown through improved direct drinking rate) than to have short-term direct benefits such as the reduction of production costs through leakage reduction. The cost of the initial investments will be recovered financially through direct benefits from the SWM such as reduced costs and increased efficiency in the mid- to long-term; however, in the short-term it may be necessary to recover some costs through a gradual increase in water prices. Despite this, the overall benefits for the community will far outweigh any future cost recovery.

2) It is important to generate confidence in water quality improvement by providing visible information to consumers and diverse services
Community engagement and information sharing played a major role in increasing the tap water drinking rates in Paju. The three key factors which enabled us to increase the tap water drinking rates were: 1) involving the community in the public activities of the project, 2) the community's belief in the visible results shown during the project, such as the visiting service of Water Cordi, and 3) the open access to real-time updates on the tap water quality with the electric signboard. Likewise, through gaining community confidence in tap water quality, Paju has created a situation where safe tap water is more highly consumed.

3) Stakeholder participation and coordination mechanisms are key to the success of the project.
Community-based organization involvement is necessary in order to reflect various needs at the local level. Such involvement is particularly important to develop the appropriate strategy for a smart urban water scheme, which varies depending on the local context, as there is no "one size fits all" solution. This project could be successfully carried out in other cities by working with a local and diverse stakeholder engagement group to ensure appropriate solutions are developed with local circumstances in mind.

6. Conclusion and Next Steps

6.1 Conclusion
This study shows how SWM systems can be implemented to improve water services and by doing so can increase the trust of drinking tap water rate. Through this study, we have investigated how SWM was applied in the field of water management in Paju City and how the project manifested in the performance and effect through the Paju SWC project. Even though the SWC project has been applied to Paju for a period of only three years, the results and effects on Paju City residents are significant. These results have included 1) improved awareness of tap water, 2) improved quality of tap water through the cleaning of household pipes, 3) positive changes in the rate of direct drinking of tap water and 4) increased trust in tap water. In addition, this study highlights that government support (through policy and investment) and research and development within the technology fields are needed to support the global agenda setting of SWM. In particular, in the technical field, as mentioned above, we can say that a systematic concept integrating unit technologies plays a major role in the improvement of both water quality and quantity, along with improved community trust. Through these policies and technologies, real economic, environmental, and social performance and effects can be manifested. These effects can result in efforts and results to implement SDGs aimed at sustainable development.

6.2 Next Steps
At present, K-water is pushing for the expansion of SWC to local waterworks. As of 2018, K-water is in the process of introducing Smart Water City to six municipalities (Yangju, Dongducheon, Jeongeup, Goryeong, Naju) including Sejong City, the new administrative capital. In addition, K-water aims to introduce SWC to four municipalities in 2018, five municipalities in 2019, and five municipalities in 2020. The Korean government will invest 12 billion KRW (10.4 million USD) from 2017 to 2020 in the Sejong SWC project. This project will aim to improve the tap water supply system and to enhance water quality and water quantity management with the overall project goal set to improve the direct drinking water rate in Korea to 20%.

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K-water (the Korean Water Resources Corporation)
is the governmental agency for comprehensive water resource development in the Republic of Korea, with a large pool of practical engineering expertise regarding water resources that has been championing Smart Water Management for the past decade.

IWRA (the International Water Resources Association)
are a non-profit, non-governmental, educational organisation established in 1971, providing a global knowledge based forum for bridging disciplines and geographies by connecting professionals, students, individuals, corporations and institutions concerned with the sustainable use of the world's water resources.

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