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WATER POLICY AND INSTITUTIONS IN THE REPUBLIC OF KOREA

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Abstract

This study reviews the water policies and institutions for water management in the Republic of Korea over a 50-year period during which the country developed from a war-torn nation into one of the 10 largest economies in the world. The Republic of Korea's water policy commenced in the form of comprehensive water resources development projects starting with basin investigations in the 1960s after the Korean War. The comprehensive development projects included large-scale dams and water control projects in major rivers in the 1970s and 1980s. The concept of eco-friendly water resources management was born in the 1990s, and the focus on water supply and/or control moved to sustainable water management including stream environment preservation in the 2000s. Since 2010, the policy has focused on coping with climate change and advancing the water management system. The paper provides lessons for developing countries that otherwise prioritize investment in roads, transportation, communication, and electricity ahead of water. The experience of the Republic Korea shows that water should also be regarded as a necessity both for the citizens' daily lives and industrial activities.

Keywords: Republic of Korea, water management, water supply systems, water pricing

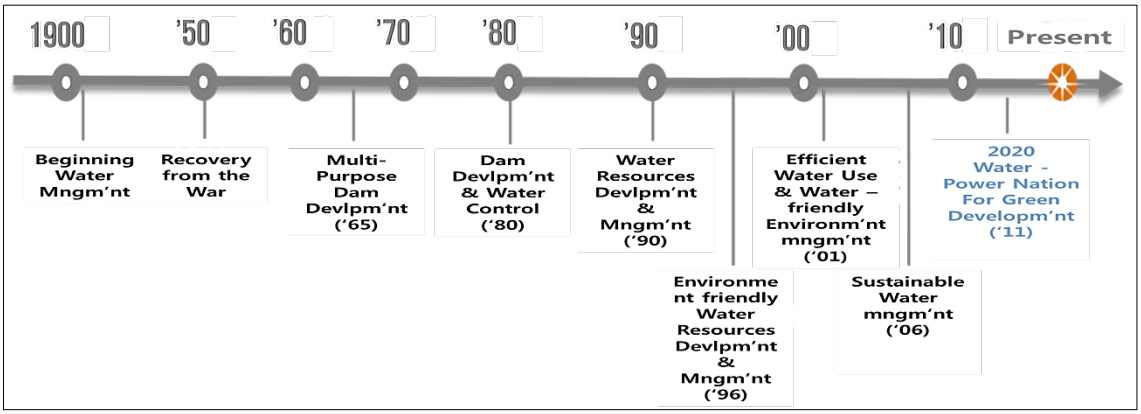
JEL Classification: L95, Q25, O13

Contents

1. INTRODUCTION

The Republic of Korea has been widely recognized for its rapid transformation from a war-devastated nation into one of the 10 largest economies in the world. The main driving forces are said to have been factors such as the comprehensive development plans laid out by the central government and strong leadership; industry development and export-centered policy; and foreign investment, high demand for education, and the diligence and solidarity of Koreans. Furthermore, investment in social overhead capital (SOC) acted as a catalyst for social and economic development. Of these, policies to address the problems of chronic flooding and drought as well as the development of water resources to meet the country's ever-increasing demand acted as the backbone for its rapid economic development. Water policy and management started in the 1960s along with the national economic development plans. Figure 1 shows the chronological water management changes in the Republic of Korea. In the 1960s, a multipurpose dam development plan was set up by the central government, and several multipurpose dams and multi-water supply systems had been built by the 1990s. Since 2000, the water policy has increasingly focused on efficiency and environment-friendliness rather than development or expansion.

Figure 1: Water Management History in the Republic of Korea



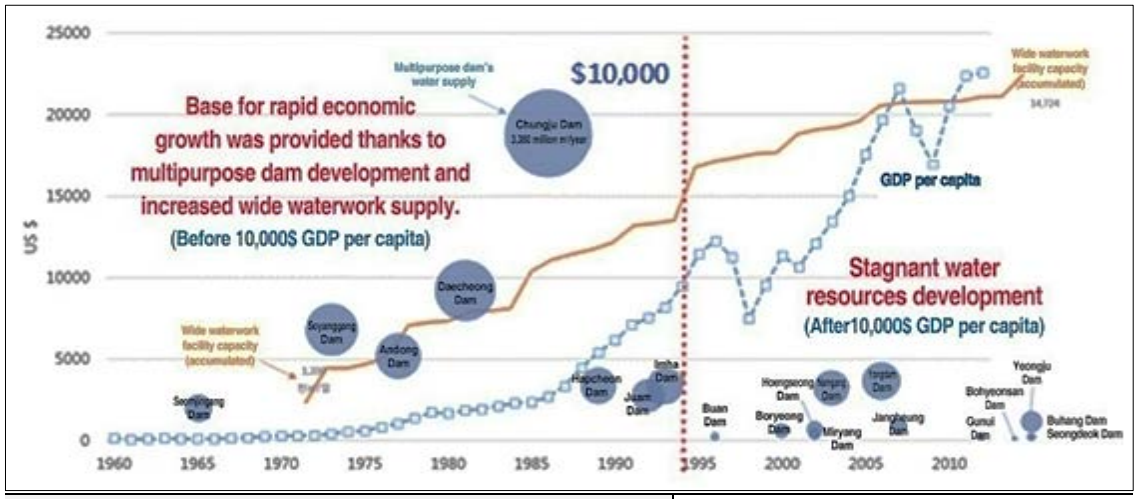
Source: Long-Term Comprehensive Water Resources Plan (2001–2020) – 3rd revision, Ministry of Land, Infrastructure and Transport, 2016.

As shown in Figure 2, the central government built multipurpose dams and water resource infrastructure as laid out in the Comprehensive National Territorial Plan and the Long-Term Comprehensive Water Resources Plan. These acted as the basis for stimulating the country's economic development and were especially effective in the early stages. One unit of water resource development increased gross domestic product (GDP) by 0.577 units in the early stages of development, whereas in the mature stages of development, GDP has increased by 0.214 (Choi et al. 2016).

Developing countries tend to prioritize investment in roads, transportation, communication, and electricity ahead of water. However, water should also be regarded as a necessity both for the citizens' daily lives and industrial activities.

Systemized laws, institutions, and leadership are regarded as key factors for the successful development and maintenance of water resources in the Republic of Korea (see Araral and Yu 2013).

Figure 2: Water Resources Development and Gross Domestic Product per Capita



Comprehensive National Territorial Plan	1st (1972–1981), 2nd (1982–1991), 3rd (1992–2001), 4th (2000–2020)
Long-Term Comprehensive Water Resources Plan	1st (1966–1975), 2nd (1981–1991), 3rd (1991–2011), 4th (2001–2020)

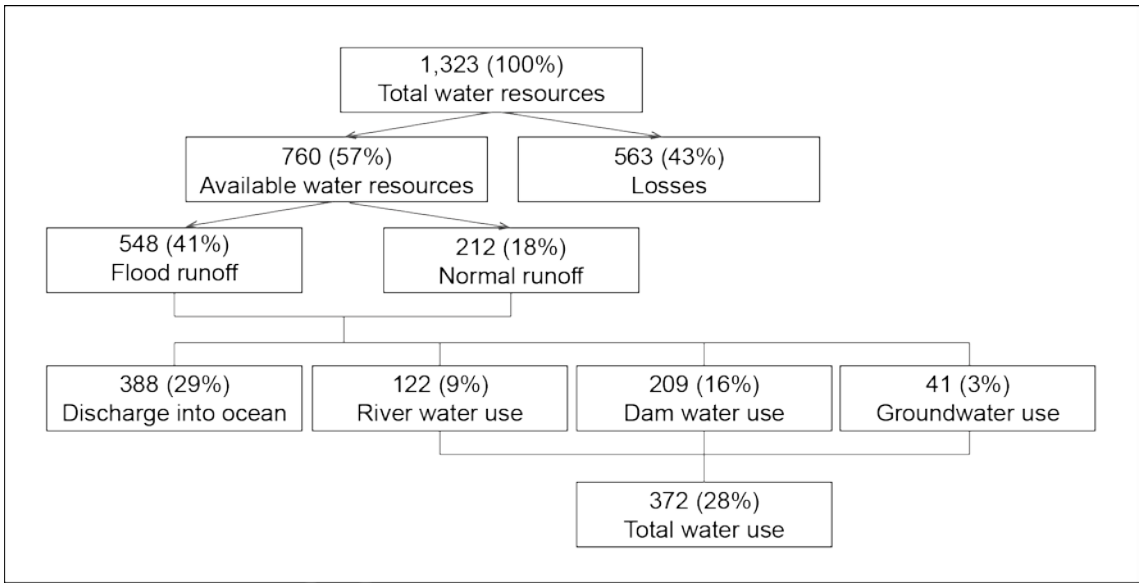
Source: Long-Term Comprehensive Water Resources Plan (2001–2020) – 3rd revision, Ministry of Land, Infrastructure and Transport, 2016.

Recently, there has been a remarkable paradigm shift in water-related policy and institutions in the country (see Araral and Yu 2013). For the integration of water resources management, which encompasses water quantity, water quality, aqua-ecosystem, and disaster prevention, among others, two main ministries related to the water management sector were combined. On 28 May 2018, the national congress determined that government organizations at the central level would be reorganized, with the Ministry of Environment managing the water sector in an inclusive way in terms of both water quantity and water quality.

2. STATUS OF WATER RESOURCES

Water resources in the Republic of Korea total 132.3 billion cubic meters (m^3), of which 76.0 billion m^3 (57%) is available as shown in Figure 3. In 2014, total water use was 37.2 billion m^3, accounting for 28% of total water resources. Since the volume of total water use exceeds the amount of normal water runoff, which is measured during the normal nonflood season, flood runoff needs to be reserved in impoundments. Among the total amount of water uses, household, industry, and agriculture use amounts to 25.1 billion m^3 per year, approximately 33% of the available water resources. The water use for households, industry, and agriculture are 7.6 billion m^3, 2.3 billion m^3, and 15.2 billion m^3, respectively.

Figure 3: Water Resources Status in the Republic of Korea
(100 million m^3 per year)



m^3 = cubic meter.

Source: Long-Term Comprehensive Water Resources Plan (2001–2020) – 3rd revision, Ministry of Land, Infrastructure and Transport, 2016.

Both seasonal and regional variations are shown in respect to water availability in the Republic of Korea. Yearly average precipitation is 1,274 millimeters (1.6 times the world average), more than half of which falls during a distinct rainy period (June to August), while winter precipitation is less than 10%. The rainy season brings frequent flash floods. In addition, the country's steep mountainous topography initiates high runoffs and reduces opportunity for soil infiltration, therefore also contributing to flooding. Regional disparities in rainfall are quite stark: the south and northeast parts (Gangwon) of the country experience over 1,400 millimeters of rainfall annually, whereas the southeast region (Gyeongsang including the so-called Central Nakdong River area) receives less than 1,100 millimeters of rainfall.

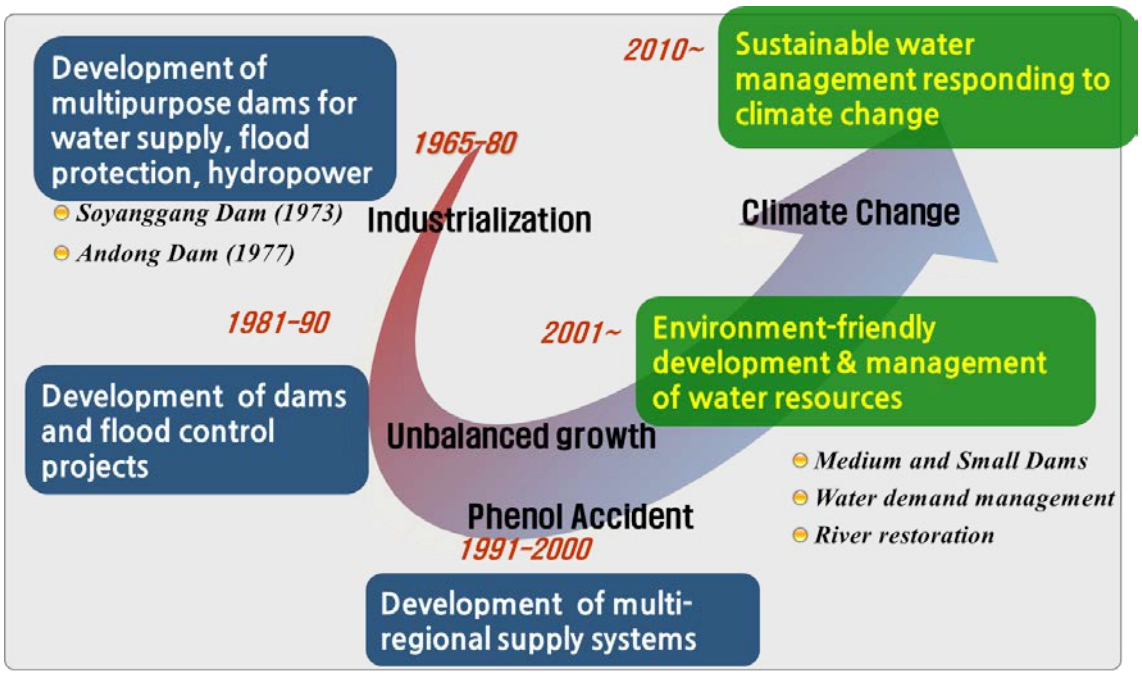
The Republic of Korea has had to adapt its water system to manage this variability and to provide even access to water supplies across the country. This effort has materialized in the form of a sophisticated and extensive network of large, medium-sized, and small dams, irrigation facilities, and multiregional water systems aimed to provide water supply for domestic, industrial, and agricultural uses; control river flows to prevent floods and droughts; and generate hydroelectricity. It was progressively developed from the 1980s to the early 2000s.

3. HISTORY OF WATER RESOURCES MANAGEMENT POLICY

The Republic of Korea's water policy commenced in the form of comprehensive water resources development projects starting with basin investigations in the 1960s after the Korean War. The comprehensive development projects included large-scale dams and water control projects in major rivers in the 1970s and 1980s. The concept of eco-friendly water resources management was born in the 1990s, and the focus on water supply and/or control moved to sustainable water management including

stream environment preservation in the 2000s. Since 2010, the policy has focused on coping with climate change and advancing the water management system. The policy paradigm shift is shown in Figure 4.

Figure 4: Water Management Paradigm Shift



Source: K-water internal document.

3.1 The 1960s: Beginning of Comprehensive Water Resources Development

3.1.1 Establishment of Nationwide Water Resources Development and Management System

As the government accelerated land development from the 1960s onward, water resources development was promoted in full scale with the Ministry of Construction as its foundation. In 1961, the first 5-year economic and social development plan was compiled. At the same time, river improvement with an annual length of 289.3 kilometers was promoted and a 4-year water control plan was established.

The River Act, enacted for river management of water control in 1961, has played a leading role in river management and water resources development so far. Meanwhile, the 10-year Comprehensive Water Resources Development Plan (1966–1975) was established to promote irrigation and water control simultaneously. In particular, a Special Multipurpose Dam Law was enacted in 1966, which assigned the task of multipurpose dam construction to Korea Water Resources Development Corporation, the apparatus to enforce the law.

3.1.2 Introduction of Multipurpose Dams and Implementation of Basin Investigations

Construction of Seomjingang Multipurpose Dam, the first multipurpose dam in the country, was completed in 1965. The dam's main functions are flood control, hydropower generation, and water supply. In addition, a large-scale basin investigation was conducted that focused on the four major rivers (Hangang, Nakdonggang, Geumgang, and Yeongsangang).

In addition, approximately 190 agricultural reservoirs were built, and construction of hydropower generation facilities started in this period as well to utilize water and reclaimed water for self-sufficient food production, and to secure a power source for industrialization. Construction of Uiam Dam, built exclusively for power generation, was completed in 1967.

3.2 The 1970s: Settlement of Comprehensive Water Resources Development

The Four River Basin Development Plan (1971–1981) was launched and linked to the First Comprehensive National Territorial Plan. In addition, a flood control policy was adopted along the four river basins. This was followed by construction of multipurpose dams. Following the plan, consistent development policy was adopted along each river basin, such as working on river improvement and construction of estuary banks. The River Act was amended in 1971 to include the protection of the Vested Water Right. In 1973, according to the 10-Year Water Resource Development Plan, Soyang River Dam was constructed and became the largest multipurpose dam in the Eastern Region. The construction of other multipurpose dams such as Andong Dam and Daechung Dam followed. In 1979, as the first phase of developing the Seoul metropolitan area, a multiregional water supply system was constructed to ensure stable supply of both domestic and industrial water.

3.3 The 1980s: Advancement of Comprehensive Water Resources Development

According to the establishment of the Comprehensive Water Resource Development Plan (1981–2001) in 1980, multipurpose dams including Chungju Dam, Imha Dam, Hapcheon Dam, Juam Dam, and Namgang Dam were constructed. In addition, multiregional water supply systems were also promoted in Seoul, the surrounding area, and other regions. At the same time, estuaries in the four rivers were completed. During this period, water usage rapidly increased (tripled from 5.1 billion m^3 in 1965 to 15.3 billion m^3 in 1980) as a result of economic development. In addition, 249 agricultural reservoirs were constructed to secure water supply. As the necessity of water quality management became more prominent, the Korean Environment Department was established in the early 1980s. It started working on water quality management in the public water sector.

3.4 The 1990s: Application of Environment-Friendly Water Management

Since the Long-Term Comprehensive Water Resources Plan (1991–2011) was established in 1990, small and medium-scale multipurpose dams were built, such as Hoengseong Dam, Miryang Dam, Buan Dam, Boryeong Dam, Jangheung Dam, and Yongdam Dam. In addition, water demand for industrial and urban areas was met through the construction of multipurpose dams (10 dams, around 3.7 billion m^3 scale, and 600 gigawatt-hours of power generation) and the expansion of multiregional water supply systems (26 facilities, 10 million m^3 scale). However, media reports highlighted the incidents of phenol contamination and organic solvents in the Nakdong River, and water quality became a prominent social issue nationwide. In the aftermath of the incidents, the Korean Environment Department was expanded to the Ministry of Environment, and water and wastewater works belonging to the Ministry of Construction were transferred to the Ministry of Environment. In addition, disaster prevention service works were transferred to the Ministry of Government Administration and Interior Affairs (currently the Ministry of Interior and Safety). In 1999, the Basic Plan on River Maintenance was included in the River Environment Plan through the overall revision of the River Act, and environment-friendly construction methods and river maintenance flow concepts were adopted.

3.5 The 2000s: Paradigm Shift

During the shift from supply-oriented quantitative development to a diversified qualitative policy focusing on water quality, ecology, and the environment, dam development decreased and the importance of water quality and the environment was emphasized. Accordingly, alternative water resource development increased. The government strove to reach social consensus by operating water-related councils with related ministries, social societies, and private experts. In 2000, the construction of Yeongwol Dam was canceled and the construction of environment-friendly small and medium-sized dams including Pyeonlim Dam, Gunwi Dam, Buhang Dam, and Gampo Dam as well as the redevelopment of Seongdeok Dam were promoted.

3.6 The 2010s: Adapting to Climate Change

In 2011, the second revision of the Long-Term Comprehensive Water Resources Plan was conducted to secure water resource for addressing climate change and supporting the water industry. In addition, the Four River Restoration Project and the Gyeong-in Ara Waterway Project were completed. The plan for conservation and utilization of riverside spaces was established by reflecting the opinions of all stakeholders through transparent governance.

4. WATER-RELATED ORGANIZATIONS AND LAWS

The Republic of Korea's water management system can be described as centralized and diversified. In its early stages of development, organizations closely related to development and quantitative growth oversaw decision making and implementation. This was also true for water management departments. However, as the water management paradigm changed over time, its organizational structure also changed to be able to implement new policies. On 28 May 2018, the Korean Parliament approved the revision

of three water management laws, resulting in drastic changes to the water management organizational structure of the central government.

To better understand the background and direction of the 2018 restructuring, this section will focus on the organizational structure that existed beforehand.

4.1 Organizational Status before 28 May 2018

4.1.1 Central Government Level

In general, the Ministry of Land, Infrastructure and Transport was in charge of water quantity management, whereas the Ministry of Environment was in charge of water quality management. Water has been traditionally perceived as a public good in the Republic of Korea. Hence, it is generally accepted that the government takes responsibility for managing water resources. In general, the Ministry of Land, Infrastructure and Transport manages water quantity, whereas the Ministry of Environment manages water quality. More specifically, multiple ministries are engaged in water management, but no overarching control tower that oversees and coordinates functions and businesses exists. The principal roles of each ministry in relation to water management (pre-2018 restructuring) are listed in Table 1, and those of public institutes in Table 2.

Table 1: Water-Related Organizations

Ministry	MOLIT	ME	MAFRA	MOIS	MOTIE
Policy	• Comprehensive water resources development	• Water conservation plan	• Agricultural water plan	• Disaster prevention plan	• Power development plan
Resource Management	• River management • Flood control • Reservoir management • Groundwater quantity management	• Drinking spring water management	• Agricultural reservoirs • Groundwater quantity and quality management in rural areas	• Hot springs • Small rivers	
Business	• Multipurpose dam construction and management • Multiregional supply system construction and management	• Local water (retail) management • Water reuse • Sewage systems	• Irrigation water (dam) • Agricultural dam construction • Groundwater development		• Hydropower • Small-scale hydropower
Evaluation/ Observation	• Hydrological data observation	• Drinking water quality • Groundwater quality			

MAFRA = Ministry of Agriculture, Food and Rural Affairs; ME = Ministry of Environment; MOIS = Ministry of the Interior and Safety; MoLIT = Ministry of Land, Infrastructure and Transport; MoSF = Ministry of Strategy and Finance; MOTIE = Ministry of Trade, Industry and Energy.

Source: Author.

Table 2: Public Institutes Associated with Water Management

Ministry	Institute	Main Responsibilities
MOLIT	Regional Construction Management Office	• Responsible for national river management as an administrative body • Five regional offices exist by province • Oversees the maintenance and management of national rivers and develops and implements the action plan • Checks construction status and manages safety of water facilities in the region
	K-water	• Responsible for construction, operation, and management of various water development facilities including multipurpose dams, Nakdong estuary bank, weirs, and canal facilities • Mitigates the effects of droughts and floods • Responsible for the construction, operation, and management of multiregional water supply systems • Constructs, operates, and manages sewage treatment facilities when they are government or local government investments • Operates local waterworks under consignment agreements with local governments • Produces and supplies renewable energies such as hydropower and tidal power
MAFRA	KRC	• Develops and supplies agricultural water • KRC supplies 524,000 ha and local government supply 254,000 ha of agricultural water for 778,000 ha of irrigated paddies nationwide
ME	Regional Environmental Management Offices	• There are four environmental management offices by river basin which are in charge of managing and conserving the environment around its river basin.
	KECO	• Responsible for technical assistance and diagnosis of operating waste management systems, installation and operation of waste recycling facilities, and operation and management of environmental pollution monitoring • Develops sewerage policies and support projects, water reuse policies, integrated operation of local waterworks and water networks improvement projects, construction and operation of automatic water quality measurement, and installation of remote water monitoring and control systems
MOTIE	KHNP	• Currently operating 10 hydropower plants (Hwacheon, Chuncheon, Anheung, EuiAm, Chungphyung, Paldang, Bosung River, Gangreung, Guisan hydroelectric, and Seomjin River) • In June 2016, the government decided to unify the operations and management of hydropower dams for efficient water management. The hydropower dams managed by KHNP will be operated in conjunction with K-water's multipurpose dams in terms of discharge quantity and dam water level.

ha = hectare; KECO = Korea Environment Corporation; KHNP = Korea Hydro and Nuclear Power Corporation; KRC = Korea Rural Community Corporation; MAFRA = Ministry of Agriculture, Food and Rural Affairs; ME = Ministry of Environment; MOIS = Ministry of the Interior and Safety; MoLIT = Ministry of Land, Infrastructure and Transport; MoSF = Ministry of Strategy and Finance; MOTIE = Ministry of Trade, Industry and Energy.

Source: Author.

4.1.2 Private Sector

Private sector participation has been encouraged since the early 1990s. Private firms have been particularly active and engaged in the field of wastewater treatment. The number of public sewage treatment plants operated by private companies was 375 out of 528 (71.0%) in 2012, compared to 46 out of 91 (50.5%) in 2001, indicating a rapid increase of 20.5 percentage points.

4.1.3 Water-Related Laws

Many water-related laws (Table 3) have been enacted and operated by the country's four major water-related ministries (Ministry of Land, Infrastructure and Transport; Ministry of Environment; Ministry of Agriculture, Food and Rural Affairs; and Ministry of the Interior and Safety) and local governments. Due to multiple actors being involved in water management, the challenge was that lack of ministerial cooperation may result in policy inconsistency and inefficiency.

Table 3: Water-Related Laws

Law	Legal Context	Ministry
Framework Act on the National Land	To contribute to the sound development of the national land and the improvement of the national welfare by providing for fundamental matters concerning the formulation and implementation of plans for and policies on the national land	MOLIT
River Act	To manage rivers properly and contribute to the promotion of public welfare by providing for the matters on designation, management, use, conservation, etc. of rivers with the objective of increasing benefits from river use, nature-friendly maintenance and preservation of rivers, and preventing damage caused by the river flow	MOLIT
Groundwater Act	To contribute to the promotion of public welfare and the growth of the national economy by prescribing the matters concerning appropriate development and utilization of groundwater and efficient preservation and management thereof, aiming for the proper development and utilization and preventing the groundwater from the pollution	MOLIT
Act on Construction of Dams and Assistance, etc. to Their Environs	To rationally develop and use water resources and promote the development of the national economy by providing for matters regarding the construction and management of dams, the revolving investment in costs for the construction of dams, environmental measures following the construction of dams, and support for residents in the areas adjacent to dams	MOLIT
National Land Planning and Utilization Act	To promote public welfare and to upgrade the quality of people's livelihoods by providing for matters necessary for the formulation, implementation, etc. of plans to utilize, develop, and preserve national land	MOLIT
Urban Development Act	To promote planned and systematic urban development, create a comfortable urban environment, and promote public welfare by prescribing matters necessary for urban development	MOLIT
Framework Act on Environmental Policy	To ensure all people have the same rights to enjoy healthy and pleasant lives by preventing environmental pollution and environmental damages and by managing and preserving the environment in a proper and sustainable manner through defining the right and duty of citizens and the obligation of the state with regard to environmental preservation, and determining the fundamental matters for environmental policies	ME
Water Supply and Waterworks Installation Act	To improve the public sanitation and thereby contribute to the improvement of living environments by means of the development of a comprehensive plan for water supply and waterworks installation and, at the same time, the appropriate and reasonable installation and management of waterworks	ME
Sewerage Act	To contribute to the sound development of local communities and the improvement of public hygiene and to preserve the quality of public waters through proper treatment of sewage and foul waste by providing for standards, etc. for the installation and management of sewerage systems	ME

continued on next page

Table 3 *continued*

Law	Legal Context	Ministry
Water Quality and Aquatic Ecosystem Conservation Act	To prevent people's health and environment from being exposed to any harm and danger caused by water pollution and to properly manage and preserve water quality and aquatic ecosystems of the public waters, including rivers, lakes, and marshes, etc. in order to enable people to enjoy benefits accruing from measures, and hand down such benefits to future generations	ME
Rearrangement of Agricultural and Fishing Villages Act	To improve and develop agricultural infrastructure, living environments of rural communities, rural tourism and resort resources, and marginal farmland, etc. in an integrated and systematic manner, to raise the competitiveness of the agricultural and fisheries industries and facilitate the improvement of living environments of rural communities in order to contribute to the construction of modernized rural communities and balanced national development	MAFRA
Small River Maintenance Act	To prevent disasters and to contribute to the improvement of the living environment, by providing for matters necessary for the maintenance, utilization, management, and conservation of small rivers	MOIS
Countermeasures Against Natural Disasters Act	To prescribe necessary matters concerning natural disaster prevention or recovery and other countermeasures against natural disasters, in an effort to preserve the national land and to protect the lives, bodies, and properties of people as well as key infrastructures from disasters caused by natural phenomena, such as typhoons and floods, etc.	MOIS
Framework Act on the Management of Disasters and Safety	To establish the disaster and safety control system of the state and local governments, and to prescribe the matters necessary for the prevention of, preparation and countermeasure against, and recovery from disasters and safety controls, in order to preserve the national land against various disasters, and to protect the lives, bodies, and properties of people	MOIS

MAFRA = Ministry of Agriculture, Food and Rural Affairs; ME = Ministry of Environment; MOIS = Ministry of the Interior and Safety; MoLIT = Ministry of Land, Infrastructure and Transport; MoSF = Ministry of Strategy and Finance; MOTIE = Ministry of Trade, Industry and Energy.

Source: Author.

As climate change became more severe and the frequency and strength of floods and droughts increased, awareness of the quantitative and qualitative management of water resources increased. There has been criticism in the Republic of Korea on the subdivision of laws and administrative laws, of which there are 20 and 47, respectively, by ministry. This resulted in the overlapping of plans and created problems as regards effective use of budgets. Furthermore, the disconnection between qualitative management policies and quantitative management policies resulted in failure of comprehensive management of watershed environments and ecosystems. Without consideration of water quality, ecosystems, and demand management, sustainable supply and effective disaster management were impossible. This was especially so because optimal operations limited consideration of water quality and quantity by river sections due to the dry stream phenomenon.

4.2 Rearrangement of Water Institutions on 28 May 2018

As mentioned earlier, water management in the Republic of Korea involves the Ministry of Environment (local waterworks and wastewater treatment), the Ministry of Land, Infrastructure and Transport (dams, multiregional waterworks and rivers), and the Ministry of Agriculture, Food and Rural Affairs (agricultural water).

As a result, there are some side effects such as duplication of construction and management between government departments, waste of budget, and overlap of regulations. For a long time, there has been a need for unification of water management work and management of integrated water resources.

On 28 May 2018, the Korean National Assembly finally passed the revised bill of the Government Organization Act and established the Water Management Basic Act. The amendments to the Government Organization Act included the transfer of duties related to conservation, utilization, and development of water resources in the Ministry of Land, Infrastructure and Transport, except river management, to the Ministry of Environment. The measures to unify a large part of the water management work centered on the Ministry of Environment are expected to mitigate inefficiency and strengthen water management capacity through the integrated management of water quality and water quality.

The Basic Law of Water Management regulates basic concepts of water management and aims to sustain the water cycle system through securing water supply, conserving the water environment, and preventing water disasters such as droughts and floods, and finally to contribute to improving the quality of life of the people. In addition, it regulates the setting up of the water management committee, which will establish the basic principles of water management, such as water as a public good, water cycle, ecological environment conservation, watershed management, and integrated water resources management, and deliberate and make decisions on important matters regarding water management.

According to the act, a water management committee will be set up at the national and basin levels. Every 10 years, the Ministry of Environment should establish a basic water management plan after discussing with the heads of the relevant central governments and the chairs of the basin management committee.

The Water Management Basic Act is of great significance, because it acts as the supreme law related to water, thereby resolving conflicts and related disputes. In particular, it is expected to be able to suppress wasting budget, and to regulate the conflicts or different interests among the diverse ministries that manage respectively water quantity, water quality, agricultural water, and water-related disasters. In this context, the water management functions of the government have been transferred from the Ministry of Land, Infrastructure and Transport to the Ministry of Environment.

In order to streamline water management and resolve water-related issues such as water disasters, the National Water Management Committee and Watershed Management Committee are to be established and operated (in June 2019). The Ministry of Environment plans to integrate and manage the local water supply system on a watershed basis. In addition, it plans to eliminate droughts by developing and supplying water resources tailored to local conditions (for example, sewage reuse, leakage reduction project). It also plans to strengthen forecasts and response to water disasters such as urban flooding.

5. WATER SERVICES

Multiregional water supply systems operated by K-water and local water supply systems operated by local governments are two main water services in the Republic of Korea (Table 4). K-water supplies water abstracted from dams or national rivers, while local governments supply water abstracted from its own water sources or by a multiregional water supply system or dam.

Table 4: Water Services

Classification	Contents
Multiregional Water Supply System	The general waterworks that provide the raw or processed water to no less than two local governments
Local Waterworks	The general waterworks, excluding multiregional water supply systems and the village waterworks, which are operated by a local government to provide the raw or processed water to its own residents, its neighboring local governments, or their residents

Source: Author's translation based on the definition clause of the law.

5.1 Dam Water

K-water manages water resources development facilities such as dams and estuaries in order to supply domestic and industrial water to local governments or industries. Dam water includes not only the reserved water in a dam but also dam water that is discharged in the downstream river; this is usually supplied from a dam via a downstream river.

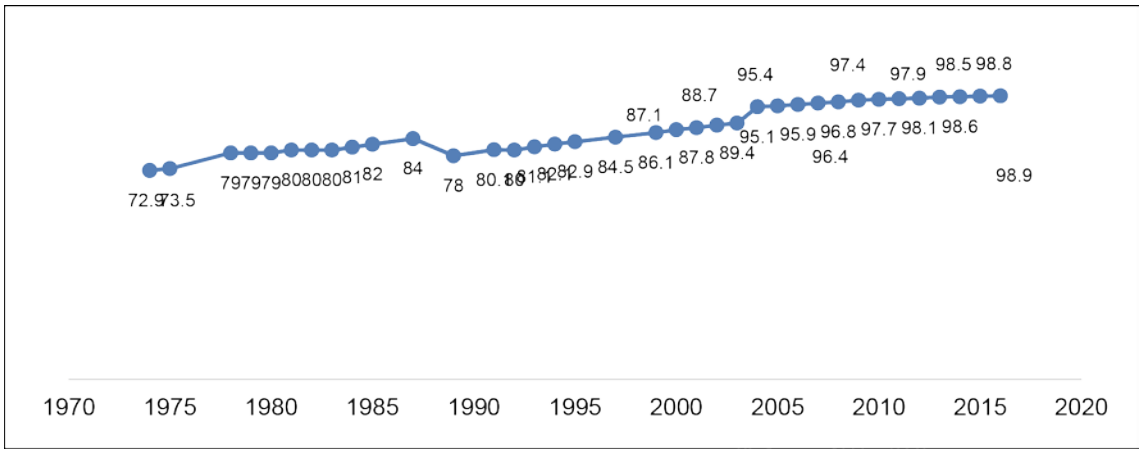
5.2 Multiregional Water Supply Systems

K-water processes water abstracted from multipurpose dams and water supply dams that it manages to meet the types of water (raw, settled, and purified water), and then supplies the water to local governments or industries. From there, local governments take the responsibility of channeling water to households. As of 2014, K-water operates 35 multiregional water supply systems. The Seoul metropolitan area utilizes 8.285 million m^3 per day, which is 60.2% of the total facility capacity (13.860 million m^3 per day). In terms of water supply, 52.9% of the total national water supply is consumed in the Seoul metropolitan area.

5.3 Local Waterworks

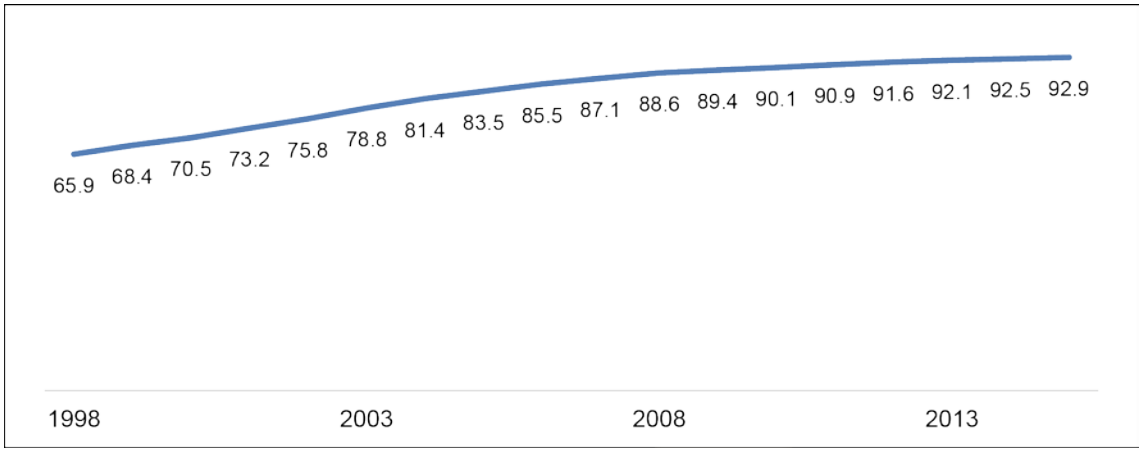
Local waterworks are managed by local governments to supply domestic and industrial water either by directly abstracting water from their own water sources such as local rivers or by receiving raw or purified water from a multiregional water supply system. As of December 2013, the Republic of Korea has 162 local waterworks operators (7 metropolitan cities, 1 metropolitan autonomous city, 1 special self-governing province, 75 cities, and 78 districts) and 1 multiregional water supply system business operator (K-water). Figure 5 shows that 98.9% of the population had access to clean water through water supply systems as of 2016, and Figure 6 shows that 92.1% had access to sewage facilities in 2013.

Figure 5: Water Supply Penetration Rates
(%)



Source: Waterworks statistics, each year, Ministry of Environment.

Figure 6: Sewerage Penetration Rates
(%)



Source: Wastewater statistics, each year, Ministry of Environment.

6. WATER PRICING

6.1 Economic Instruments

Several water tariffs and user charges exist in the Republic of Korea. Each organization imposes water tariffs or user charges under the existing laws (Table 5).

Table 5: Water-Related Revenue Sources at National Level

Organization	Revenue
MOLIT	Income from rivers (national rivers)
ME	Discharge dues, environment improvement charges (water pollution), water quality improvement charges, charges for release of pollutants in excess of the total quantity, and water use charge
Local Governments	Local water tariff, wastewater tariff, income from rivers (local rivers), groundwater utilization charge, local resource, and facility taxes
K-water	Dam water tariff, multiregional water tariff

ME = Ministry of Environment; MOLIT = Ministry of Land, Infrastructure and Transport.

Source: Author's summary.

6.2 Ministry of Land, Infrastructure and Transport

The fee for the use of river water is levied on river water users by local governments according to Article 50 of the River Act. In other words, local governments have a mandate to collect and execute the fee for the use of national river water. Other fees such as occupancy fees, licensing fees, and receipts gained from the site of a desolate river are also levied for occupying riversides and so forth (see Table 6–8 for revenue sources at different levels).

For the construction of multipurpose dams, the associated financial burden is shared pro rata according to the benefits and purpose between K-water and the government. In terms of the construction cost of multiregional water supply systems, the government's responsibility has declined to 30% since 2007 (Table 9).

Table 6: Water-Related Revenue Sources at Local Level

Category	Contents
Water and Wastewater Tariff	The biggest source of revenue is generated from local water and wastewater tariffs that are collected from end users (households), but the financial gap between required expenditure and revenue is significant.
Fees	Fees for issuing certificates and licenses, etc.
Groundwater Utilization Charge	A groundwater utilization charge is levied when local governments develop their own groundwater sources. It aims to restrain indiscreet groundwater use and pollution while promoting adequate groundwater use and conservation. The charge can be set within the maximum 50% of the water use charge according to the Enforcement Decree and ordinance. Revenue generated from goes to a local government's special account for groundwater management and is to be spent on various activities with regard to groundwater conservation and management, such as exploration, restoration and purification, and the establishment of groundwater management plans.

Source: Author's summary.

Table 7: Water-Related Revenue Sources for the Ministry of Environment

Category	Contents
Water Use Charge	Based on the polluter-pays principle, the water use charge was enacted for the purpose of preventing pollution near water sources and managing the total amount of pollution. The charge is proportionate to the amount of water used and is included in a water bill. It is determined by a river basin committee and imposed on end users that rely on the four major rivers as their source of water. The collected charges are placed into the river management fund that is to be spent on water quality improvement projects and to support residents in the upstream of a river. The River Management Committee of each river basin is responsible for managing and operating the fund. Water quality improvement projects include financial support for sewage facilities and livestock wastewater treatment facilities, purchase of land in riparian zones for waterfront green space, and support for residents, non-point pollution reduction projects, water resource conservation, and eco-friendly industries.
Discharge Dues	Based on the Water Quality and Aquatic Ecosystem Conservation Act, the discharge dues were introduced in 1983 to be levied on polluters with the objective of minimizing damages on water quality caused by water pollutants.
Water Quality Improvement Charge	Water quality improvement charges are levied on spring water manufacturers, drinking spring water import/sales business operators, and other related industries to be spent on conserving public groundwater resources and improving water quality.
Charge for Release of Pollutants in Excess of the Total Quantity	Polluters are charged for the release of pollutants in excess of the total quantity according to the Act on the Improvement of Water Quality and Support for Residents of the four major river basins.

Source: Author's summary.

Table 8: Water-Related Revenue Sources for K-water

Category	Contents
Dam Water Tariff	According to Article 16 of the Korea Water Resources Corporation Act, K-water imposes and collects dam water tariffs for supplying domestic and industrial water through multipurpose dams and estuary banks. Considering the costs for construction as well as operation and maintenance of the dams, tariffs are levied in proportion to the amount of water consumed by users.
Multiregional Water Tariff	According to Article 16 of the Korea Water Resources Corporation Act, K-water imposes and collects multiregional water tariffs for supplying water through multiregional water supply systems. Considering the costs for construction as well as operation and maintenance of the supply system, tariffs are levied in proportion to the amount of water consumed by users.

Source: Author's summary.

Table 9: Financial Portion for Water Facility Construction

			–1993	1994–	1996–	1998–	2003–	2006	2007–	2011–
Multiregional Water Supply Service	All Facilities Except Purification Plants	Government	100%		70%	100%		50%	30%	Government 30% K-water 70%
		K-water	–		30%	–		50%	70%	
	Purification Plants	Government	100%		–			–		
		Local government	–		100%			–		
		K-water	–		–			100%		
Multipurpose Dam	Construction Cost	Government				100%				Pro rata according to benefits
		K-water				–				
	Compensation Cost	Government		100%		K-water in charge with partial support from Govt.				
		K-water		–						

Source: K-water document.

6.3 Pricing Procedure of Dam Water and Multiregional Water Tariffs

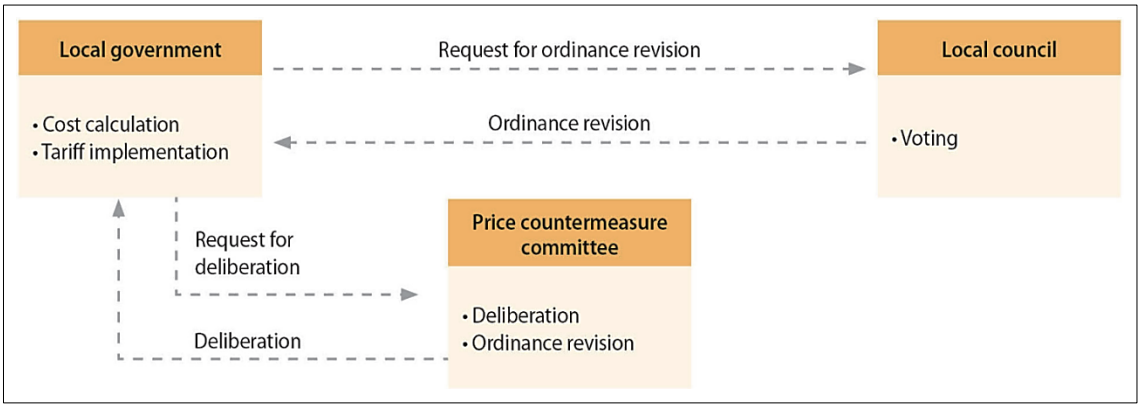
K-water must submit a request to the central government for approval of any tariff changes. Once received, the request moves to deliberation by the Water Tariff Committee. Before the final approval, the Ministry of Land, Infrastructure and Transport should consult with the Ministry of Strategy and Finance, which oversees inflation on the national level in accordance with the Price Stabilization Act.

6.4 Pricing Procedure of Local Water and Wastewater Tariffs

Local governments decide on water tariffs (retail price) according to the ordinances on water supply and waterworks. Local governors draft a tariff change plan and request for deliberation to the local price committee. If approved, the plan is then put to a vote for approval from the local council and comes into effect accordingly. While dam water and multiregional water tariffs are applied uniformly across the country, local water tariffs vary in 161 local governments.

Likewise, any adjustments to the wastewater tariff follow the same procedure. Figure 7 shows the process for setting local water and wastewater tariffs.

Figure 7: The Process for Setting Local Water and Wastewater Tariffs



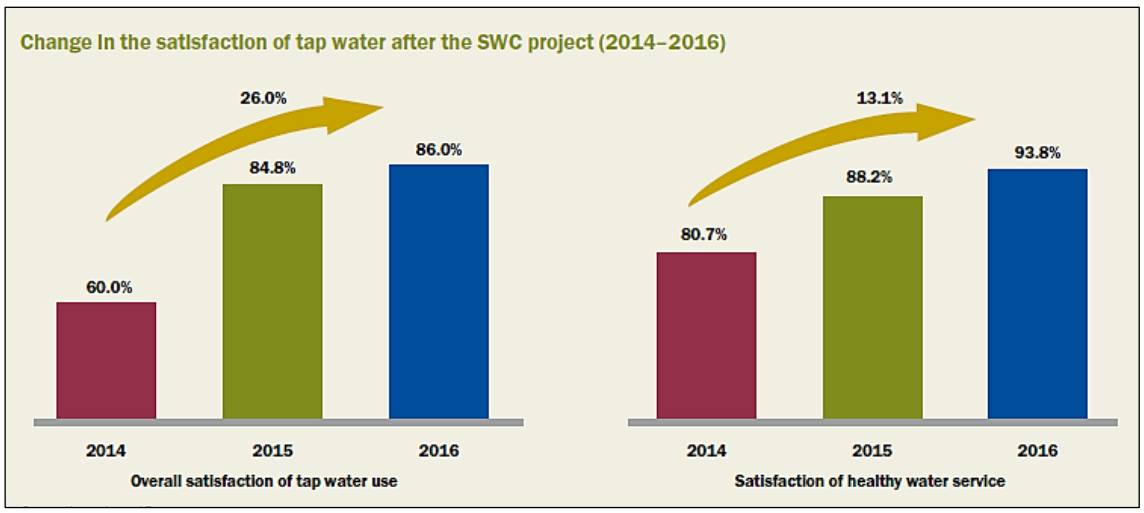
Source: K-water document.

7. CASE STUDY: SMART WATER MANAGEMENT

7.1 Paju Smart Water City

A Smart Water City (SWC) project was conducted in Paju City, a municipality where 390,000 out of a total population of 410,000 are connected to the water supply. Here, K-water in 2014 built a smart water management system that supplies safe water from the source to the customer by improving the stability and efficiency of the supply based on scientific management, using information and communication technology (ICT). The project has enabled the citizens of Paju to check the water quality in their neighborhood and homes in real time using a water quality signboard and a smartphone app. The provision includes a water coordinator service whereby staff directly check the water quality from the tap, and a water doctor service whereby staff directly check the condition of indoor water pipes and clean them. As a result, civil complaints have decreased from 4.5 to 1.3 cases per month, and the average tap-water drinking rate has increased from 1% (before the SWC project commenced) to 41.5% after implementation. Consumer dissatisfaction of tap-water quality has been allayed, and the overall satisfaction of water services was greatly improved (Figure 8).

Figure 8: Performance of Smart Water City



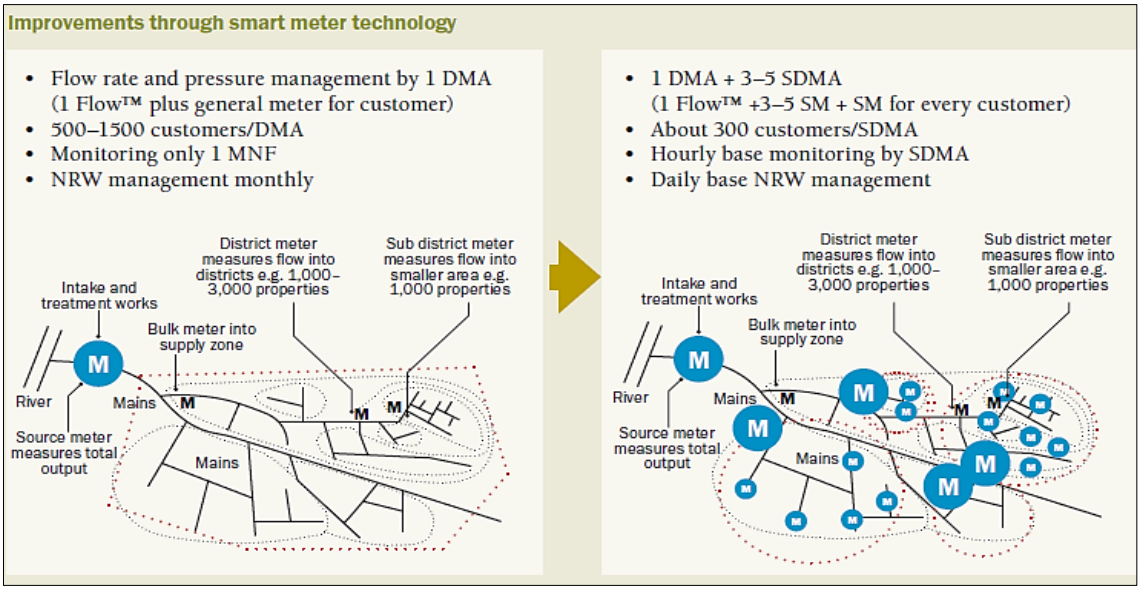
Source: K-water document.

At a time when it is necessary to respond to water crises caused by both rapid economic development and climate change, the Republic of Korea is responding by integrating ICT into water management. Smart water management creates a new paradigm of innovative water management such that it can improve water security and welfare by addressing global water issues and the imperative of sustainable water usage. With those goals in mind, and in partnership with the Asian Development Bank, K-water is providing technical assistance in the application of smart water management to countries such as Bangladesh, India, and Sri Lanka.

7.2 Seosan Smart Water Management

One of the most important tasks for Korean water supply services at present is to minimize the amount of leakage and to supply consistently safe water to users. Smart water management (SWM) technology is therefore essential as it allows operators to use real-time information to cope with such challenges. SWM combines various technologies such as information and communication technology (ICT) systems, Supervisory Control and Data Acquisition (SCADA) systems, smart meters, and other devices to ensure stability and efficiency throughout the network. SWM specifies technologies and creates standards for the overall water circulation system. Examples of applications include Smart Water Grid (SWG), Smart Water City (SWC), Integrated Water Quality Forecasting System (SUIRAN), and Integrated Water Management System (K-HIT).

Figure 9: District and Subdistrict Metered Areas



Source: K-water document.

A smart meter enables the transmission of information concerning consumer tap-water usage measured by time. The use of digital meters and Internet of Things (IoT) technology as an alternative to traditional analog meters allows operators to read meters remotely as well as manage the water usage rate in real time. The smart meter monitoring program developed by K-water analyzes usage, abnormal flow, and indoor leakage from the metering information, and provides usage and tariff information to customers through the internet and a mobile app. Previously, flow and water pressure were managed in one district metered area (DMA), but with the application of smart meters, a DMA is divided into 3–5 subdistrict metered areas (SDMAs). Figure 9 shows how a DMA was divided into smaller districts.

The management of the daily water flow rate enables quicker responses than before. Smart metering makes it possible to quickly identify leakage locations—immediate detection can reduce leakage from burst pipes and reduce non-revenue water (NRW)—to quickly correct inaccurate or damaged meters, to reduce supply costs, to improve asset management efficiency, and ultimately to enhance customer satisfaction.

In the case of Seosan City, Boryeong Dam supplies 80,700 m^3 of water per day, sufficient for a population of 157,000. The water penetration rate is 91% and the NRW rate is 16.6%. One specific area in the city, Cha-ri, was operated by two DMAs, and it was difficult to identify and cope with water loss due to the relatively wide supply area. Efforts to reduce loss were nevertheless essential because of drought.

In general, Seosan City has a relatively low NRW rate, whereas the rate of Cha-ri was the city's highest at 32% in 2015 (Table 10). Improvements were made by installing smart meters, and nine SDMA systems were built within the existing two DMAs. In addition, NRW analysis was converted to a daily system, which was previously monthly. Finally, water flow monitoring was expanded from three branches to 12.

After the installation of smart meters, intensive leak detection was carried out on vulnerable sections, reducing flow meter errors. Comparing the DMA flow rate and the total flow rate of the water supply area in Cha-ri resulted in a difference of 430 m^3 per day; inflow meter failures were detected and flow meters were substituted. After analyzing the patterns of both seasonal and hourly customer usage through smart metering, water pressure management is now conducted hourly. Automatic control of the decompression valve through SCADA systems are adjusted according to usage, depending on the season and holidays.

Table 10: Non-revenue Water Comparison, 2015 and 2016, Cha-ri Water Supply Area, Seosan

NRW (%)	**March**	**April**	**May**	**June**	**July**	**August**	**September**
2015	40.8%	36.5%	37.8%	28.8%	34.4%	26.2%	28.5%
2016	37.5%	26.6%	30.6%	26.8%	29.6%	11.6%	9.8%
Variation Rate	↓3.3%	↓9.9%	↓7.2%	↓1.9%	↓4.8%	↓14.6%	↓18.7%

NRW = non-revenue water.

Source: K-water document.

There is now greater flexibility in managing the response times required to address complaints of failure. As a result of installing the first smart metering system in June 2016, an NRW rate of 10% was achieved. As indoor leak detection has improved, so has the NRW rate and customer satisfaction. The control system allows for the analysis of customers' usage patterns according to the time of day. It also provides a "leak suspicion" alarm enabling inspectors to quickly visit a site and take recovery action if a leak is detected. This has resulted in a reduction of approximately 55% of customers' water usage and a consequent reduction in cost to the customer of 70%. Based on the results of operation monitoring over a 2-month period, the net financial benefit is expected to be about 610 million won over the next 8 years (B/C = 2.1) with a 20% improvement in the NRW rate and a 190,000 m^3 per year leak reduction.

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