Ministry of Foreign Affairs

New solutions for water resources management in South Korea

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New solutions for water resources management in South Korea

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1. Introduction

This report aims to provide an overview of new solutions of water resources management in South Korea (hereinafter 'Korea'). Korea has expertise in water management and is capable to do a lot itself. Especially, Koreans are strong at building dams and operating hydropower plants and Korea has been exporting the techniques to other countries. So, opportunities for Dutch business are most likely in innovative solutions in water resources management, focusing on certain niches.

Korea has abundant rainfall but there is a lack of water resources available. Its annual precipitation is 1.6 times higher than the world's average, but the precipitation per capita is only about 1/6 of the world's average. A large population (51,709,098) is living in a small country (100,363km^2). About 65% of the land is mountainous. Most of the rainfall is concentrated in the summer months and more than 60% of the annual precipitation flows into the sea. So the actual available water resources are not much per person.

However, Koreans use water every day without realizing the water shortage thanks to the stable and cheap water supply. The water resources are scarce, but the water intake facilities are well equipped and maintained nationwide and the cost of water is not very expensive (the average water rate was KRW 736.9/m^3 and the production cost was KRW 914.3/m^3 in 2018). So Koreans do not feel the necessity to limit their water consumption. This may affect a lot the ecosystem of rivers and streams when a large amount of water is drawn, as well as the level of the groundwater which may cause sinkholes and subsidence. When a drought occurs and gets severe for a longer period, the Korean government reduces the supply of water in the order of environment maintenance water, agricultural water, domestic water then industrial water. Even if rice paddies dry out due to the drought, and rivers become streams, the tap water still comes out well. So urban people hardly have a difficulty in accessing and using water even when the drought hits the nature hard.

Dams (56%), rivers (33%) and groundwater (11%) are Korea's main water resources. However, it becomes more difficult to find suitable places to build dams in Korea due to geographical and environmental reasons. In addition, the cost of building dams is increasing year by year. The cost per ton of dam construction increased by 30 times for Hoengseong Dam built in 1996 compared to Soyang River Dam in 1973. The Han River, the Nakdong River, the Geum River and the Yeongsan River (and Seomjin River) are the four major rivers in Korea, with a total area of 67,630km^2 and a total length of 1,763km. As the dependence on the mainstream of the four major rivers in Korea increases, so does the potential water crisis, especially when the climate change impacts on floods and droughts more and more.

Climate change is a worldwide challenge. Water will become more scarce and expensive. It also impacts on Korea and its water resources, so climate adaptation measures need to be taken for water security in Korea. For example, the dry summers with long lasting heat waves in the recent years have caused problems with daily water use. Some cities and provinces could not supply water for 24 hours due to the severe droughts. Increasing water problems will require for new and innovative solutions for water resources management. Korea has been developing and using some alternative water resources, such as wastewater reuse, seawater desalination, groundwater reservoir, riverbank filtration and rainwater harvesting to supply water in areas of islands, coasts and mountains where it is difficult to secure water resources, increase the efficiency of water use and diversify water resources in the country and will continue further development.

<table>
<tr><td colspan="4">Total water resources in Korea
[132.3 (100%) | Unit: billion m^3/year]</td></tr>
<tr><td colspan="2">Available water resources
[76 (57%)]</td><td colspan="2">Loss by evapotranspiration
[56.3 (43%)]</td></tr>
<tr><td>Spill to the sea
[38.8 (29%)]</td><td>Dam water
[20.9 (16%)]</td><td>River water
[12.2 (9%)]</td><td>Groundwater
[4.1 (3%)]</td></tr>
<tr><td></td><td colspan="3">Total Capacity
[37.2 (28%)]</td></tr>
</table>

2. New solutions for water resources management and cases

2.1) Wastewater reuse

The Korean government has enacted a law in 2010 to promote wastewater reuse so that treated wastewater could be used as water resource. With the development of technology and solutions, the use of wastewater, such as supplying high quality industrial water, has been increased. It has been used in the agricultural and industrial areas where severe droughts cause water shortage for drinking water and domestic water.

The policy to promote the wastewater reuse has contributed to increase both the amount and the rate over the period of 2008-2018. The amount of treated wastewater is used in the order of the use in wastewater treatment plants, river maintenance water, industrial water, agricultural water and other water.

The Korean government will establish a second national basic plan for water reuse in December 2020 to stimulate and expand water reuse. It will include plans, such as projects to supply treated wastewater to industrial complexes that require a large amount of water. Local governments also strive to expand water reuse. For example, Suwon City will build a wastewater reuse facility by 2025 to purify 325,000m^3 of wastewater per day and supply industrial water to companies in Suwon and nearby.

The amount and the rate of wastewater reuse in 2008-2018

Year	2011	2012	2013	2014	2015	2016	2017	2018
Wastewater (mil. ton/year)	7068.85	7174.32	7186.77	6995.3	7005.18	7165.77	7016.55	7163.72
Amount of reuse (mil. ton/year)	781.10	872.32	907.44	942.88	1027.46	1121.05	1113.23	1112.73
Rate of reuse (%)	11.0	12.2	12.6	13.5	14.7	15.6	15.9	15.5

The use of treated wastewater reuse in 2018

Use in wastewater treatment plants (cooling, washing, cleaning etc.)	521 mil. tons	46.8%
River maintenance water	480 mil. tons	43.2%
Industrial water	75 mil. tons	6.8%
Agricultural water	12 mil. tons	1.1%
Other water	24 mil. tons	2.1%

Policies to promote wastewater reuse

'Act on Promotion and Support of Water Reuse' promotes the water reuse and sustainable use by efficiently utilizing water resources. (2010)
'Article 12 of the Enforcement Decree' states that the public wastewater treatment facilities with a capacity of more than 5,000m^3 per day are obliged to reuse more than 10% of the amount that they treat.

Cases of wastewater reuse

1) Asan New Town Public Wastewater Treatment Facility and Reuse Facility

Provider	Asan Smart Water
Customers	Samsung Display and companies nearby
Operator	K-water (August 2016-August 2036)
Constructor	Samsung Engineering (1st: June 2014-August 2016, 2nd: February 2018-February 2019)
Facility	Reuse facility (27,000m^3/day) MBR → Reuse process → Waste reservoir → Ultrapure water treatment facility → Production facility
Total cost	KRW 29.7 billion (national treasury: KRW 8.9 billion, private capital: KRW 20.8 billion)
Remarks	Asan City and Asan Smart Water signed a contract in 2013.

2) Pohang Treated Wastewater Reuse Facility

Provider	P-WATERS
Customers	POSCO and companies nearby
Operators	K-water and POWELL (July 2014-July 2034)
Constructor	Lotte Engineering & Construction (February 2012-July 2014)
Facility	Wastewater reuse (100,000m^3/day) Wastewater treatment facility → Reuse facility → Treatment facility → Production facility
Total cost	KRW 125.9 billion (national treasury: KRW 75.5 billion, private capital: KRW 50.4 billion)
Remarks	When this project was decided in 2009, the Korean government aimed to promote water reuse as a green new deal and new growth engine of business and foster wastewater reuse into a new water industry, and had provided legal and institutional support.

3) Chilgok Wastewater Reuse Facility

Developers	K-water and Hanwha Engineering & Construction
Customers	Companies in the local industrial complex in Waegwan
Operator	Chilgokenv (May 2006-April 2026, Shareholders: Hanwha (51%) and K-water (49%))
Facility	Facility: Wastewater reuse (10,000m^3/day) Wastewater treatment facility → Reuse facility → Treatment facility → Production facility
Total cost	KRW 7.1 billion (amount borne by causers: KRW 3.5 billion, private capital: KRW 3.6 billion)

Zero Liquid Discharge (ZLD)

As more attention is paid to the increasing water pollution, some Korean companies have been using the zero liquid discharge (ZLD) treatment system for their own wastewater treatment. This method consumes a lot of energy and the production cost is high, but it doesn't discharge wastewater to the outside. Companies save 30-40% of industrial water through the ZLD and wastewater reuse, such as Hyundai Motor Company which started the ZLD since 1996, SK Hynix, LG Chemical etc. Doosan Heavy Industries & Construction has developed its own ZLD technology since 2012 and has been applying it to some thermal power plants in Korea, such as Yeongheung Thermal Power Plant (1,250m^3 per day). They will continue applying the technology to companies doing wastewater consignment treatment in the small and medium-sized industrial complexes.

Beyond the corporate level, the Ministry of Environment is considering to apply the ZLD treatment system to industrial complexes to protect water quality in the areas where use the Nakdong River as water source. The Nakdong River is the longest river in Korea (521km) with the river basin of 23,817km^2. It is an important water source to supply water to 13 million people (25% of the total population). More than 200 industrial complexes and three national industrial complexes are currently in operation in the Nakdong River basin. In 1991, the phenol contamination in the Nakdong River had caused people around the river to suffer from using tap water safely, since then, the water quality of the Nakdong River is very critical, especially to the cities located in the downstream of the Nakdong River where polluted more than the upstream. So companies doing business around the river are cautious when discharging wastewater. Seokpo Smelter, located on the top stream of the Nakdong River, has purified the wastewater then discharged into the river, but will start the ZLD from 2020.

2.2) Seawater desalination

Surrounded by the sea on three sides, Korea has developed technologies to utilize seawater more effectively and has been building many seawater desalination facilities to secure alternative water resources from the sea.

The Korean government has installed small scale seawater desalination facilities in the island areas where it is difficult to build local and regional waterworks and have difficulty in getting water supply. About 70% of domestic seawater desalination facilities are located in island areas, which are mainly small scale with a capacity of less than 1,000m^3 per day. The installation will continue expanding in more islands to supply water.

Seawater desalination facilities to supply water for domestic use in Korea

Number of facilities	101	83 in operation / 18 not in operation
Amount (m^3/day)	8,271	6,371 in operation / 1,900 not in operation

Seawater desalination seems the most realistic way to supply water in coastal regions and islands. K-water, as a public company for water, has been operating 36 facilities (2,390m^3/day) in 8 local governments nationwide since 2004 and will continue the consigned operation. However, some problems need to be solved, such as high production cost, operational maintenance issues and facility aging caused by salinity in the island areas.

Medium-sized seawater desalination plants have been established in Gwangyang and in Busan. A new seawater desalination plant (100,000m^3/day) is planned to be built at Daesan Industrial Complex in Seosan, one of the Korea's 3 largest petrochemical complexes with Yeosu and Ulsan Industrial Complexes.

Cases of seawater desalination facility

1) Gwangyang POSCO Steel Seawater Desalination Facility

Owner	POSCO
Operator	POSCO E&C (July 2014-June 2043)
Constructor	POSCO E&C (January 2013-July 2014)
Facility	Seawater desalination (30,000m^3/day) DAF → UF → SWRO → BWRO
Total cost	KRW 50 billion

2) Busan Gijang Seawater Desalination Facility

Developers	Busan Metropolitan City, Korea Agency for Infrastructure Technology Advancement (KAIA), Gwangju Institute of Science and Technology (GIST), Doosan Heavy Industries & Construction
Constructor	Doosan Heavy Industries & Construction (2010-2014)
Facility	Seawater desalination (45,000m^3/day) From 2 trains each, 'DAF → UF → SWRO → BWRO → Post treatment' and 'DAF → DMF → SWRO → Post treatment'
Total cost	KRW 195.4 billion (national treasury: KRW 82.3 billion, Busan municipal treasury: 42.5 billion, private capital: KRW 70.6 billion)
Remarks	In 2006, this was selected for a national R&D innovation project, 'World market leading seawater desalination system' by the Ministry of Land, Transport and Maritime Affairs.

Busan Metropolitan City completed a seawater desalination facility in 2014 to produce 45,000 tons of tap water and supply to 50,000 households. However, after 5 years of controversial debate, the seawater desalination facility, located 11km from Gori Nuclear Power Plant, was decided to use the water completely for industrial water because of the distrust and concern of citizens, such as radioactive contamination and so on.

2.3) Groundwater reservoir

Groundwater reservoirs prevent groundwater from flowing into the sea and raise the level of groundwater storage, as well as prevent seawater intrusion from the coast to land. They have no evaporation loss and have less risk of water contamination compared to regular reservoirs and do not have to submerge any area to create a reservoir. However, it is difficult to use large amounts of water at a time and the water temperature is low to use directly for irrigation.

The developable amount of groundwater in Korea is 12.99 billion m^3 per year, and the ratio of utilization to development capacity is 31.1% on average across the country. There are 6 groundwater reservoirs in Korea with a total capacity of about 150,000 m^3 per day.

Five groundwater reservoirs for agriculture were installed to solve the extreme drought problem in the 1980s as part of a national development plan for agricultural water. In 1998, Sokcho City installed a groundwater reservoir to supply water for domestic use that produces 80% of the total demand of the city.

Groundwater reservoirs in inland area

Location	**Sangju**	**Pohang**	**Gongju**	**Jeongeup**	**Jeongeup**	**Sokcho**
Stream	Ian	Gokgang	Yugu	Yongho	Hankyo	Ssang
Basin area (km^2)	21.3	153.0	275.0	27.0	22.0	65.3
Supply (m^3/day)	24,000	23,600	27,900	25,110	16,200	33,000
Cutoff wall (m)	230	89	482	192	778	800
Establishment	1983	1986	1986	1986	1986	1998
Use	Agriculture					Domestic
Operator	Korea Rural Community Corporation					Sokcho City

Korea has a 97% of water supply rate and almost all Koreans have no problem getting water supply. However, groundwater has long been an important water resource in the mountainous areas and islands. In 2012, the Groundwater Act was revised to provide a legal basis to install groundwater reservoirs to secure stable water resources and prepare for drought. The Ministry of Environment selected eight candidate islands to supply water and prevent salt intrusion. The first two groundwater reservoirs on islands will be completed in 2020 and 2021.

Groundwater reservoirs in island area

Location	Ongjin County	Yeonggwang County
Island	Daeijak	Anma
Supply (m^3/day)	110	100
Cutoff wall (m)	65	460
Establishment	2020	2021
Budget	KRW 2 billion (90% by government, 10% by Incheon City)	KRW 10 billion (90% by government, 10% by Yeonggwang County)

2.4) Riverbank filtration

Surface water is a major source of water supply in Korea. As the water quality becomes polluted and deteriorated, the demand for clean water resources increases. Riverbank filtration uses the natural soil and aquifer to remove various pollutants from river water during the induced infiltration of river water to pumping wells. As one of the clean drinking water sources, Korea has been developed and used riverbank filtration water.

In Korea, riverbank filtration was introduced in early 2000. In the early days, vertical wells were mainly installed in riverbank filtration facilities, but recently, horizontal wells are more used. The aquifer is well developed in the estuary of the Nakdong River compared to other rivers in Korea. The downstream area of the Nakdong River is highly polluted because contaminants from the upstream are accumulated there, making it difficult to secure high quality drinking water in the surrounding areas. Local governments lead most of the riverbank filtration in Korea. In particular, Changwon City, Gimhae City and Haman County located on the banks of the Nakdong River have installed relatively large scale riverbank filtration facilities in their regions. Changwon riverbank filtration facility was planned to be the largest facility. However, due to the design errors, three out of five water intakes were shut down and two of them produce less water per day than planned.

Location	Facility		Use	Remarks
Gimhae City	Horizontal well (10)	180,000m^3/day	Water for domestic use	40~190m away from the Nakdong River
Haman County	Vertical well (18)	20,000m^3/day	Water for domestic use	90~150m away from the Nakdong River
Changwon City	Horizontal well (6) & Vertical well (43)	130,000m^3/day	Water for domestic use	70~200m away from the Nakdong River

There are riverbank filtration facilities that were built for other purposes than to supply water for domestic use. The Taehwa River in Ulsan and the Hongje Stream in Seoul use riverbank filtration water to improve water quality and maintain the water amount (40,000m^3/day and 68,000 m^3/day, respectively) in the river and stream.

In addition, the Ministry of Environment has selected 35 areas located in the four major river basins for potential locations to develop riverbank filtration water - 4 locations in the Yeongsan River (and Seomjin River) basin, 4 in the Geum River basin, 6 in the Han River basin and 21 in the Nakdong River basin.

When developing riverbank filtration water, it is important to analyze and design accurately and take measures to minimize the impact on the groundwater around the area, such as artificial groundwater recharge. Besides the problem at Changwon riverbank filtration facility, Changnyeong riverbank filtration project, which selected for a national project, has been on hold for more than 4 years because farmers have been against the project as they are afraid that the riverbank filtration facility may lower the groundwater level and cause the water shortage for agriculture. The plan was made to produce 680,000 tons of riverbank filtration water per day and use it as water source to supply tap water for citizens in Busan (620,000 tons) and in Yangsan (60,000 tons).

2.5) Rainwater harvesting

Rapid urbanization increases water consumption and impervious surface in urban areas, which lowers the groundwater level and deteriorates water quality in rivers. Efficient use and management of rainwater can reduce dependence on surface water and groundwater, secure alternative water resources and minimize the damage from flooding when floods occur in urban areas.

In Korea, rainwater harvesting facilities began to expand since 2000. Over the period of 2010-2018, the number of rainwater harvesting facilities has increased nearly eight-fold, however, the average amount used per facility has decreased to less than a quarter, from 12,584m^3 in 2010 to 3,016m^3 in 2018. This is the result of intensively installing rainwater harvesting facilities with small storage capacity. More than 95% of harvested rainwater is used for landscaping, followed by cleaning and toilet.

The number of rainwater harvesting facilities has increased significantly as the government has expanded the mandatory use of it. However, the production cost, installation cost and operation cost per 1m^3 of rainwater harvesting facilities are high, which requires for solutions to efficiently use the numerically increased facilities.

Precipitation	Year	Facilities	Consumption (year)
1,444.9mm	**2010**	334	4,203,178 m^3
1,622.6 mm	**2011**	587	7,783,612 m^3
1,479.1 mm	**2012**	630	8,295,258 m^3
1,162.9 mm	**2013**	965	9,204,372 m^3
1,173.8 mm	**2014**	1,369	7,137,180 m^3
949.0 mm	**2015**	1,560	7,018,853 m^3
1,272.5 mm	**2016**	2,043	7,402,382 m^3
967.8 mm	**2017**	2,140	8,223,338 m^3
1,386.9 mm	**2018**	2,650	7,993,872 m^3

2018 (7,993,872 m^3/year)		
Facility (2650)		Consumption
Golf courses	44	6,771,797 m^3
Business facilities	203	334,428 m^3
Other	1,089	311,993 m^3
Residential complexes	523	291,032 m^3
Large stores	85	169,875 m^3
Schools	455	32,864 m^3
Sports complexes	20	30,817 m^3
Government buildings	164	29,351 m^3

Rainwater harvesting facilities are concentrated in Seoul and Gyeonggi Province (54%) and Jeju Island uses 84% of the nation's total rainwater tank capacity and 80% of its annual consumption. Jeju Island is made of porous volcanic rocks with high permeability and 46% of rainfall penetrates underground. Groundwater is the main water source in Jeju Island for domestic water and agricultural water.

Location	Number of facilities	Rainwater tank capacity (m^3)	Annual consumption (m^3/year)
Jeju Island	45	***4,005,245***	***6,491,474***
Gyeonggi	***621***	183,310	361,141
Seoul	***806***	139,995	78,962
Total	**2,650**	**4,794,610**	**7,993,872**

Policies to promote rainwater management

Ministry of Environment

'Law on Land Planning and Use' regulates the rainwater storage and infiltration facilities when making urban plans, such as roads, parks, squares etc.

'Act on Promotion and Support of Water Reuse' regulates the installation and operation of rainwater harvesting facilities when constructing sports complexes, government buildings, large stores etc.

Seoul Metropolitan Government

'Basic Plan for Rainwater Management' promotes to install and expand the rainwater management facilities.

Jeju Island

Facilities and business using more than 1,000m^3 of water per day should install rainwater harvesting facilities. Golf courses should use more than 40% of rainwater of the total water consumption, which used to be 20%.

Suwon City, 'Smart Rain City Project'
Since 2003, this project has installed rainwater harvesting facilities throughout the city that can store 77,000 tons and increased the water self-sufficiency rate of the city by 26%.

Low Impact Development (LID)

Roads and parking lots in urban area are paved with impervious materials, such as asphalt. This creates environmental problems; rainwater does not infiltrate into the ground, cities get easily flooded and groundwater is depleted. Water pollution may occur if rainwater running on impermeable surfaces flows into rivers with the pollutants from roads or construction sites. Low Impact development is a technique that artificially infiltrates rainwater into the ground. Installing the LID facilities can decrease the amount of rainwater mixed with pollutants, reduce the concentration of water pollutants and increase the rate of groundwater recharge.

Cases of Low Impact Development (LID)

Songsan Green City Project
(Developer: K-water)
It was a project to create an environment-friendly city and preserve the ecological environment in the area of Sihwa Lake. LID technology was used in the city, such as building facilities that reduce nonpoint source pollution, converting existing facilities to LID facilities and installing decentralized rainwater catchment system that manages rainwater in situ.

Asan Tangjeong District
(Developer: LH)
It was selected as a pilot district, the Korea's first LID-based water cycle new city. Rainwater management was planned on a ‘new city scale’ (1.753 million m^2). LID technology was applied when it was designed and constructed so that the city could manage nonpoint source pollution, increase the use of rainwater and restore rainwater circulation.

‘Leading City of Water Cycle’
(Ministry of Environment)
The Korean ministry selected five cities for pilot projects (Gwangju, Daejeon, Ulsan, Andong, Gimhae). LID technology was applied to reduce nonpoint source pollution in the ‘existing cities’.

3. Conclusions

The Korean government and companies have been trying to develop new solutions for water resources management. There are many success cases that have been solving the national water problems and the technologies and knowledge that have been created and developed by Korean water experts over a long time. However, some obstacles, such as conflicts between local governments using a same river to supply water, farmers' opposition, citizens' acceptance of using reused water, seem to impede the use and expansion of alternative water resources.

Dutch expertise in water technology can contribute to further develop and expand new and innovative solutions for water resources management in Korea, for example, energy reduction technology and highly concentrated membranes for the zero liquid discharge treatment system, design for riverbank filtration facility.

In addition, the Korean water market is saturated and the government is actively supporting Korean companies to explore and go for overseas water market. Dutch water companies and organizations will be a good partner and can create a win-win in the international water industry.

4. Appendix

4.1) Overview of the Korean water industry

The Ministry of Environment conducts a survey of the Korean water industry every year and has released the latest statistics in April 2020. There were a total of 15,473 companies in the Korean water industry, 183,793 employees, turnover of KRW 43.25 trillion, exports of KRW 1.93 trillion, imports of KRW 298 billion and total research and development expenses of KRW 894 billion in 2018.

Construction (8,124) and manufacturing (5,358) companies accounted for 87.1% of the total water industry. More than half of the companies hired 1-9 employees and 74.7% were engaged in the water-related construction (40.3%) and manufacturing (34.4%) industries. The turnover was largest in the manufacturing industry (KRW 24.86 trillion), followed by the construction industry (KRW 11.8 trillion). The largest sales were made in the manufacturing of pumps, water pumps and similar devices for the water industry. The largest amount of turnover was generated from 'businesses between local private companies (58%)', followed by public businesses (40.3%). Exports were the largest in the manufacturing industry (87.1%), followed by the construction industry (9.2%). As for imports, the manufacturing industry accounted for 96.3%.

About 80% of Korean water companies hired less than 20 employees and only 19.2% of them conducted R&D. The export rate was 4.7%, which was only 1⁄4 of the average rate of the domestic manufacturing industry (19.9%). The Ministry of Environment will select 10 water companies each year for 10 years from 2020 and support them within a total of KRW 500 million for 5 years per company, such as development and upgrade of innovative technology, inspection and certification, on-site application and entering overseas market.

Overview of companies, employees, turnover, export, import and R&D

	Company	**Employees**	**Turnover** (KRW billion)	**Export** (KRW billion)	**Import** (KRW billion)	**R&D** (KRW billion)
	15,473	**183,793**	**43,251**	**1,931**	**298**	**894**
Manufacturing products	5,358 (34.6%)	63,144 (34.4%)	24,861 (57.5%)	1,682 (87.1%)	287 (96.3%)	568 (63.5%)
Construction	8,124 (52.5%)	74,044 (40.3%)	11,809 (27.3%)	177 (9.2%)	1 (0.4%)	178 (19.9%)
Operating facilities, cleaning and purification	901 (5.8%)	15,195 (8.3%)	3,195 (7.4%)	71 (3.7%)	9 (3.1%)	32 (3.6%)
Technology, design and engineering service	1,090 (7.0%)	31,410 (17.14%)	3,386 (7.8%)	0.19 (0.01%)	0.8 (0.3%)	116 (13.0%)

Company		**Employees**		**Turnover**	
Private companies	1,495 (9.7%)	1-4	4,134 (26.7%)	Less than KRW 1 billion	5,323 (34.4%)
Corporations	13,813 (89.2%)	5-9	4,792 (31.0%)	KRW 1 to 5 billion	6,554 (42.4%)
Non-corporate organizations	4 (0.03%)	10-19	3,295 (21.3%)	KRW 5 to 10 billion	1,677 (10.8%)
National and local governmental organizations	161 (1.0%)	20-49	2,093 (13.5%)	More than KRW 10 billion	1,919 (12.4%)
		50-99	638 (4.1%)		
		100+	521 (3.4%)		

Turnover by business source

	Public business	Between companies	Export	Other
	40.3	**58.0**	**1.2**	**0.5**
Manufacturing products	23.0	73.5	3.1	0.5
Construction	51.6	47.8	0.2	0.4
Operating facilities, cleaning and purification	34.0	63.8	0.1	2.2
Technology, design and engineering service	46.2	53.8	-	-

Turnover by business activity

	Company	Turnover	
Manufacturing products related to water industry	**5,358**	**24,861** (KRW bil.)	**57.5%**
Produce drinking water (drinking water, deep sea water etc.)	49	646	1.5%
Manufacture metal pipes and pipe fittings for water industry	331	3,272	7.6%
Manufacture non-metallic pipes and pipe fittings for water industry	326	1,181	2.7%
Manufacture tanks and panels for water industry	221	1,174	2.7%
Manufacture manholes, water grates and water permeable bricks	72	252	0.6%
Manufacture pumps, water pumps and similar devices for water industry	1,035	4,285	9.9%
Manufacture valves for water industry	1,022	3,917	9.1%
Manufacture measuring equipment for water industry	840	2,333	5.4%
Manufacture remote measurement, operation and control equipment for water management	62	301	0.7%
Manufacture water treatment equipment and devices	399	1,462	3.4%
Manufacture filters and membranes for water treatment	177	1,536	3.6%
Manufacture sterilization, disinfection and advanced equipment for water treatment	102	250	0.6%
Manufacture chemicals for water treatment, water proofing and anticorrosion	554	3,698	8.6%
Manufacture domestic water supply and sewage treatment facilities and similar products	168	554	1.3%
Construction related to water industry	**8,124**	**11,809**	**27.3%**
Comprehensive construction industry related to water industry	2,441	3,703	8.6%
Specialized construction industry related to water industry	4,616	6,249	14.4%
Water industry related facilities maintenance work	1,067	1,857	4.3%
Operating facilities, cleaning and purification related to water industry	**901**	**3,195**	**7.4%**
Operate water, sewage and wastewater treatment facilities	483	2,548	5.9%
Treat sewage and wastewater residue	160	325	0.8%
Clean and purify facilities related to water resources	258	322	0.7%
Technology, design and engineering service related to water industry	**1,090**	**3,386**	**7.8%**
Technical tests, component inspection, analysis and advisory service for water industry	448	1,816	4.2%
Facility design and engineering services for water industry	642	1,570	3.6%

Export and import by country

	Export			Import		
	Amount (KRW billion)		**Number**	**Amount** (KRW billion)		**Number**
Asia	903	46.8%	627	117	39.1%	112
China	339	17.6%	193	60	20.1%	82
Japan	159	8.2%	104	56	18.9%	23
Southeast Asia	405	21%	330	0.3	0.1%	7
Europe	220	11.4%	105	108	36.2%	129
USA	483	25%	108	74	24.7%	70
Middle East	172	8.9%	77	-	-	-
New Zealand, Australia	29	1.5%	15	-	-	-
Other	123	6.4%	105	0.1	0.01%	7

Overview of import by HS code

HS Code		Amount (KRW million)		Number
2620	Slag, ash and residues	1,286	0.4%	2
3006	Pharmaceutical goods	29,388	9.9%	4
3214	Glaziers' putty, grafting putty, resin cements, caulking compounds and other mastics	9,148	3.1%	5
3301	Essential oils, resinoids, extracted oleoresins etc.	9,131	3.1%	3
3604	Fireworks, signaling flares, fog signals and other pyrotechnic articles	1,055	0.4%	32
4009	Tubes, pipes and hoses made of vulcanized rubber	469	0.2%	2
5911	Textile products and articles	2,070	0.7%	2
6810	Articles made of cement, of concrete or of artificial stone	13,363	4.5%	11
7325	Other cast articles made of iron or steel	28	0.01%	3
8413	Pumps for liquids, liquid elevators	28,343	9.5%	24
8414	**Air or vacuum pumps, air or other gas compressors and fans**	52,690	17.7%	31
8421	Centrifuges, filtering or purifying machinery and apparatus, for liquids or gases	2,887	1%	19
8467	Tools for working in the hand, pneumatic, hydraulic or with self-contained electric or non-electric motor	1,795	0.6%	4
8475	Machines for assembling electric or electronic lamps, tubes or valves or flashbulbs	276	0.1%	4
8479	Machines and mechanical appliances having individual functions, not specified or included elsewhere in the chapter of 8479.00	1,678	0.6%	11
8481	Taps, cocks, valves and similar appliances for pipes, boiler shells, tanks, vats or the like	10,266	3.4%	41
8536	Electrical apparatus for switching or protecting electrical circuits, or for making connections to or in electrical circuits	57	0.02%	2
9015	**Surveying, hydrographic, oceanographic, hydrological, meteorological or geophysical instruments and appliances**	30,288	10.2%	71
9019	Mechano-therapy appliances; massage apparatus	11,000	3.7%	3
9026	Instruments and apparatus for measuring or checking the flow, level, pressure or other variables of liquids or gases	22,479	7.5%	20
9032	Automatic regulating or controlling instruments and apparatus	27,014	9.1%	14
	Not identified	43,430	14.6%	9

Overview of top 10 export by HS code

HS Code		Amount (KRW million)		Number
8421	Centrifuges, filtering or purifying machinery and apparatus, for liquids or gases	167,683	8.7%	74
8311	Wire, rods, tubes, plates, electrodes and similar products, made of base metal or of metal carbides	157,111	8.1%	7
7307	Tube or pipe fittings made of iron or steel	125,342	6.5%	24
8479	Machines and mechanical appliances having individual functions, not specified or included elsewhere in the chapter of 8479.00	98,065	5.1%	90
8413	Pumps for liquids, liquid elevators	58,394	3%	80
6810	Articles made of cement, of concrete or of artificial stone	57,479	3%	42
3302	Mixtures of odoriferous substances and mixtures	53,158	2.8%	4
3825	Residual products of the chemical or allied industries, municipal waste, sewage sludge, other wastes	46,566	2.4%	16
3214	Glaziers' putty, grafting putty, resin cements, caulking compounds and other mastics	32,028	1.7%	14
8204	Hand-operated spanners and wrenches	29,460	1.5%	6

4.2) Main water organizations and responsibilities

Government ministries	
Ministry of Environment (ME)	Local waterworks management, drinking water management, sewage policy, water quality management, development of water resources, multi-regional water supply, river basin management, long-term water resource planning and water control planning for river basins.
Ministry of Land, Infrastructure and Transport (MOLIT)	River maintenance.
Ministry of Agriculture, Food and Rural Affairs (MAFRA)	Securing agricultural water development and management.
State-owned corporations	
Korea Water Resources Corporation (K-water)	Operation and management of water resources facilities, including bulk water supply to municipalities and industries through dams and multi-regional water supply systems. Under the authority of the Ministry of Environment (was under the Ministry of Land, Infrastructure and Transport till 2018).
Korea Environment Corporation (KECO)	Operation and management of local waterworks through consignment contracts with local governments, supporting policy making and implementation for water, sewage and water quality management. Under the authority of the Ministry of Environment.
Korea Rural Community Corporation (KRC)	Operating agricultural water and agricultural irrigation facilities. Under the authority of the Ministry of Agriculture, Food and Rural Affairs.
Government institutes	
National Institute of Environmental Research (NIER)	Research on total water pollution load control, water quality standards, water-environmental engineering, aquatic ecosystems and integrated water quality management and evaluation processes. Under the authority of the Ministry of Environment.
Research institutes	
Korea Environment Institute (KEI)	Science-based policy advice for government, public sector and civil society, including on water quality.
Korea Institute of Civil Engineering and Building Technology (KICT)	Advice on government policies and strategic plans regarding water resources, flood damage, drought control, waterway surveys and subterranean water mapping.
Korea Research Institute for Human Settlements (KRIHS)	Research on spatial policy, including water resources and river basin management.

4.3) Korea Water Cluster

In 2010, the Korean government announced plans to foster the Korean water industry. One of the plans was to create a water industry cluster where domestic companies, research institutes and human resource training institutions collaborate and develop technologies, demonstrate technologies and commercialize. 'Korea Water Cluster' was built in Daegu with a size of 65,000m^2 and KRW 289 billion was invested. It started operation from September 2019 and 31 Korean water companies invested more than KRW 260 billion and about 54% of the site was sold.

Equipped with a water industry promotion facility, a demonstration facility, a business complex and Korea Institute for Water Technology Certification (the only water-related certification agency in Korea), Korea Water Cluster provides a one-stop service from developing technologies and products to demonstration, performance verification and overseas business expansion.

Korea Environment Corporation (K-ECO), under the authority of the Ministry of Environment, is responsible for the operation.

Overview of key facilities

Test beds	
Test bed plant (5,000㎥/day)	Purification: 2,000㎥/day, Sewage: 1,000㎥/day
	Wastewater: 2,000㎥/day, Reclaimed Water: 1,000㎥/day
User customized area (5,000㎥/day)	Purification: 3,000㎥/day, Sewage: 1,000㎥/day
	Wastewater: 1,000㎥/day, Reclaimed Water: 2,000㎥/day
Pipe Network Testing Area	Elevated tank, recovery reservoir, piping conduit, circulation pipe network
Promotion Facilities	
Water Convergence R&D Center	Rental research offices and laboratories, administration office
Global Business Center	Promotion exhibition hall, administration office, rental offices, dormitory
Water Campus	Library, lecture room, project lab, cafeteria

4.4) International water events in Korea

Korea International Water Week (KIWW)
Conference, World Water Cities Forum, Water Leaders Round Table, Business Forum, B2B meetings, Exhibition
Organizers: Ministry of Environment, Daegu Metropolitan City, K-water
https://www.kiww.org

Water Korea
Exhibition, seminar, B2B meetings
Organizer: Korean Water and Wastewater Association
https://www.waterkorea.kr

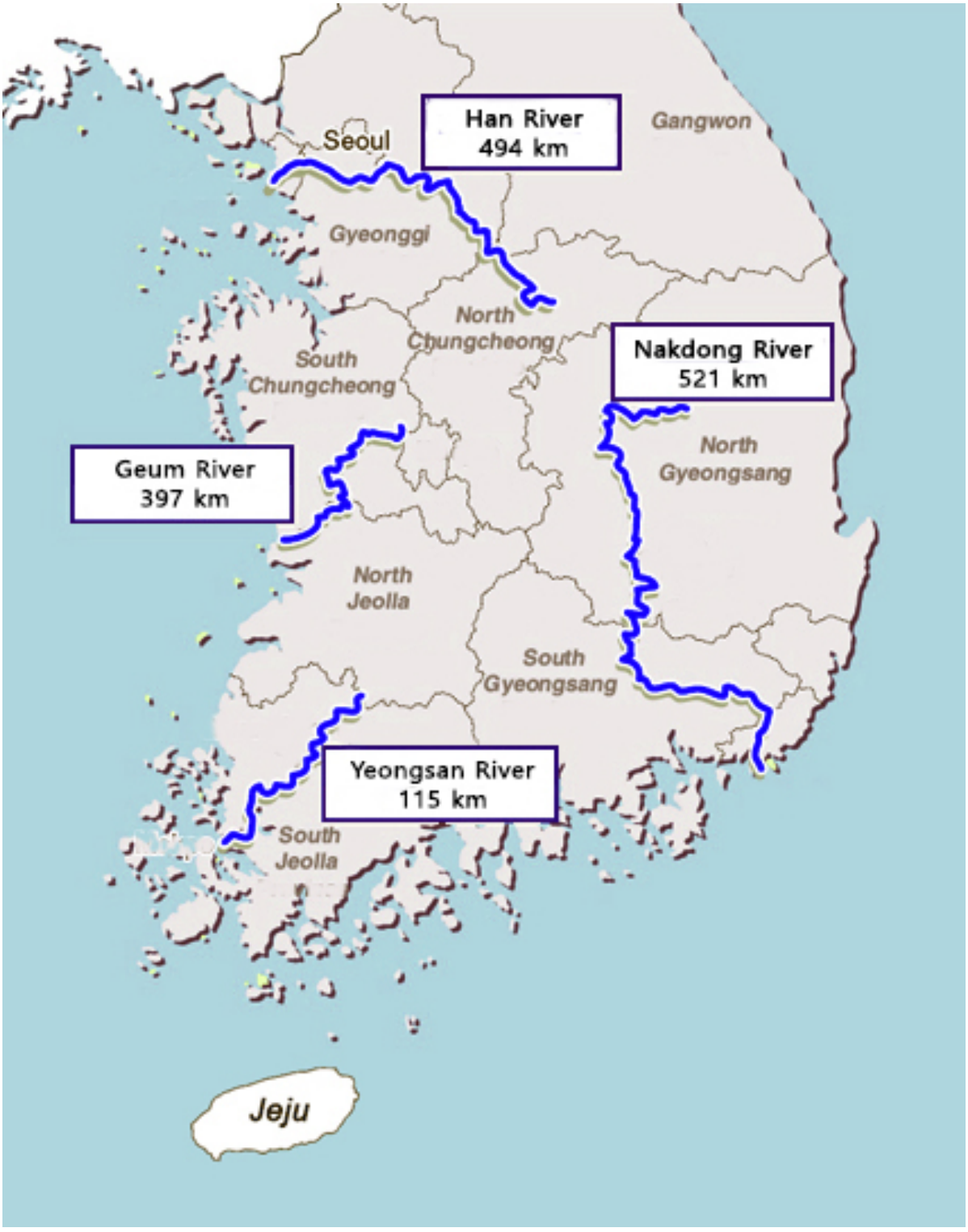
Environmental Technology & Green Energy Exhibition (ENVEX)
Exhibition, seminar, B2B meetings
Organizer: Korea Environmental Preservation Association
https://www.envex.or.kr

Busan Global Water Forum
Forum
Organizer: Busan Metropolitan City
http://www.bwf.kr

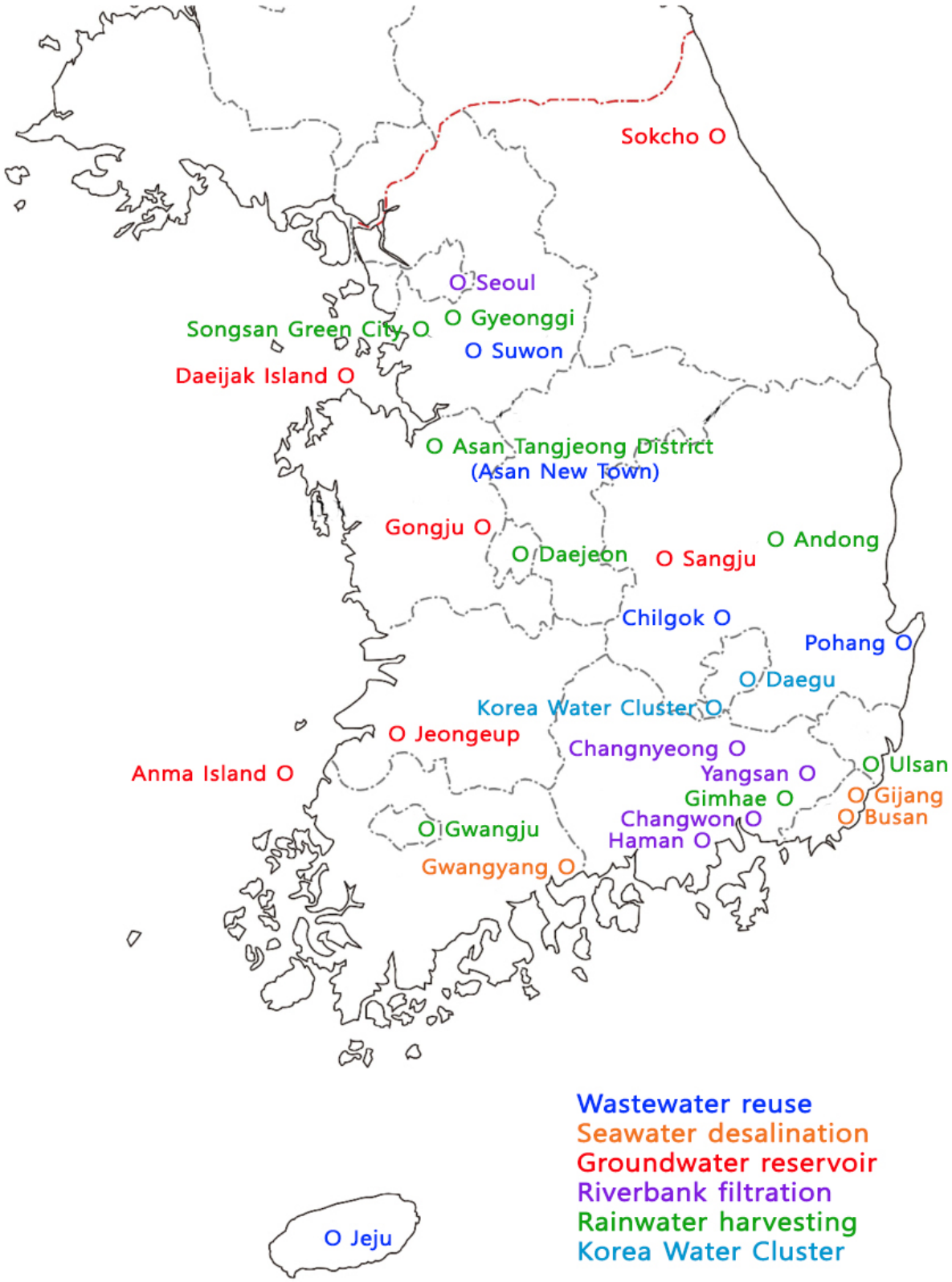
The information and statistics in this report are based on information published by relevant governments, news, sector reports, water magazines and so on. Main sources are as follows.

Ministry of Environment	http://www.me.go.kr
Ministry of Land, Infrastructure and Transport	http://www.molit.go.kr
Korea Water Resources Corporation (K-water)	https://www.kwater.or.kr
Korea Rural Community Corporation	https://www.ekr.or.kr
Korea Trade-Investment Promotion Agency (KOTRA)	https://www.kotra.or.kr
Organization for European Economy Cooperation (OECD)	https://www.oecd.org
Water Journal	http://www.waterjournal.co.kr

4.5) Maps



[Four major rivers in Korea]



[Locations mentioned in the report]

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