2.5 Republic of Korea

1 | Country Information

Table 2.5.1 Basic indicators

Land Area (km²)		100,341 (2015)
Total Population		52 million (2019)
GDP (current USD)		1,647 billion (2019)*
GDP per capita (current USD)		31,846 (2019)
Average Precipitation (mm/year)		1283.4 (2019)
Total Renewable Water Resources (km³)		132.3 (2020)**
Total Annual Freshwater Withdrawals (billion m³)		25.1 (2020)
Annual Freshwater Withdrawals by Sector	Agriculture	61% (2020)
	Industry	9% (2020)
	Municipal (including domestic)	30% (2020)

(Source: *Korean Statistical Information Service (2020) (1,919 trillion won (seasonally adjusted, current prices)), **Sewage statistics by Korean Ministry of Environment)

Figure 2.5.1 The Han River in Seoul, the Republic of Korea

2 | State of Water Resources

Alongside exponential growth in GDP, per capita water use in the Republic of Korea has also grown. However, it has seen a marked decrease in recent years; per capita water use is currently 485 m³/year*[1], whereas availability is 1,553 m³/year (Lee et al. 2019). Seasonal variation in water availability remains a challenge for the country's water management, especially in light of water-related disasters exacerbated by climate change. About two-thirds of the annual precipitation falls in the monsoon season between June and September. There are four major river basins in Korea, namely the Han, Geum, Nakdong and Yeongsan-Seomjin.

3 | State of Ambient Water Quality

There are 1,936 sampling points for ambient water quality, which is measured against a composite water quality index divided into seven levels (Ia: Very good, Ib: Good, II: Moderately good, III: Moderate, IV: Moderately bad, V: Bad, VI: Very bad). Water quality is assessed and publicly disclosed for key sampling points as shown in Figure 2.5.2 (MOE 2020, NIER MLIT 2020).

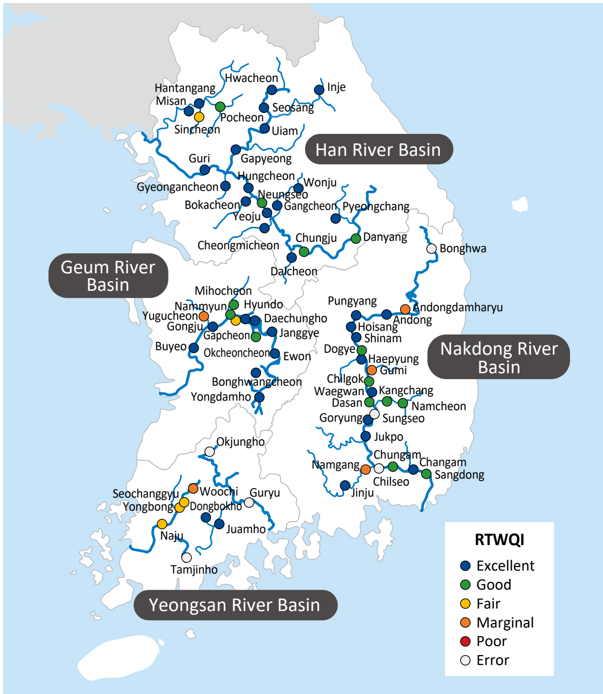

Figure 2.5.2 Water Quality Index of ambient water in the Republic of Korea (Source: Park 2020)

3.1 Rivers

All streams nationwide are classified into 115 sections and water quality targets have been established for each. Water quality in the country has steadily improved overall since the late 1990s, due to increasing public interest. Figure 2.5.3 shows the trend of water quality in selected points in four major river systems (Paldang (Han), Mulgeum (Nakdong), Daecheong (Geum), and Juam (Yeongsan-Seomjin)) in terms of BOD. During 2017–2019, average BOD values were stable at 1.2–1.3 mg/L, and average COD values have slightly improved from 4.2 to 3.9 mg/L (Figure 2.5.4).

*1 Calculated by dividing total water use (25.1 billion m³/year) by population (51.78 million) (Statistics Korea, 2020).

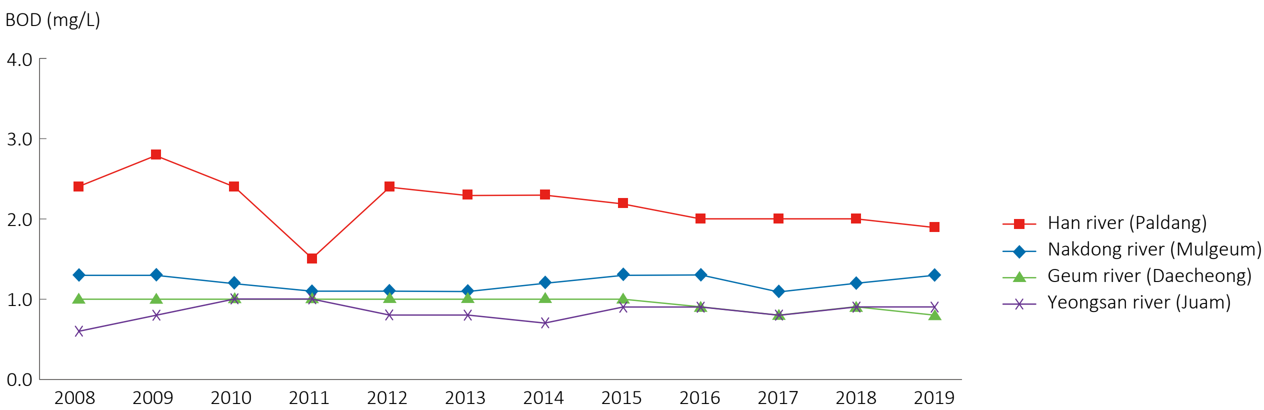

Figure 2.5.3 Changes in BOD values in four major rivers (2008–2019) (Source: MOE 2020)

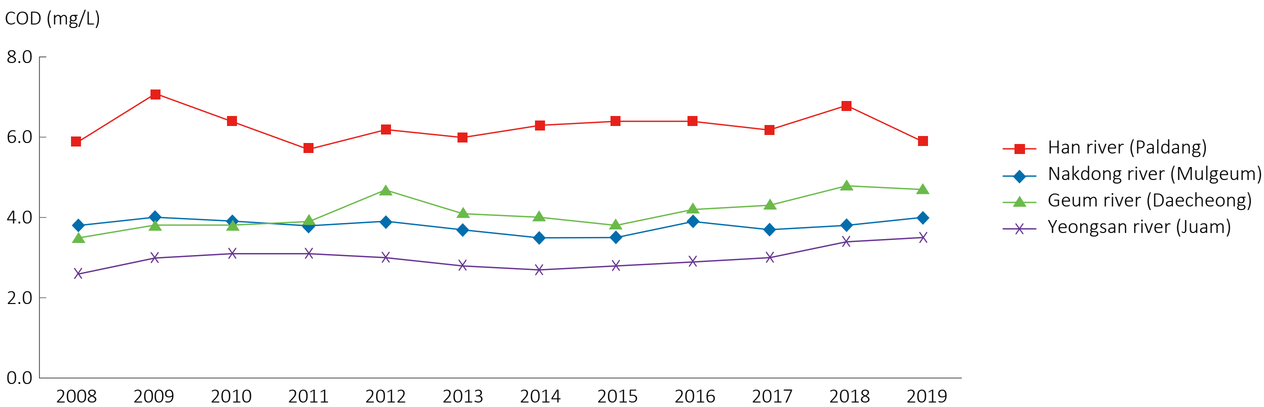

Figure 2.5.4 Changes in COD values in four major rivers (2008–2019) (Source: MOE 2020)

3.2 Lakes and Reservoirs

As with river water quality, that of lakes and reservoirs also shows a trend of improvement and stabilization in recent years. Table 2.5.2 shows recent water quality trends in selected reservoirs.

Table 2.5.2 Recent annual average water quality values for Lake Paldang, Andong, Daechong, and Juam

Year	BOD (mg/L)	COD (mg/L)	NO_3-N (mg/L)	PO_4-P (mg/L)	E.coli (CFU/100mL)
2017	1.2	3.0	1.083	0.005	36
2018	1.3	3.1	1.041	0.007	17
2019	1.1	3.1	1.072	0.006	19

(Source: MOE 2020)

3.3 Coastal Water

The Korean marine environment monitoring network is composed of port, coastal/offshore, environmental management waters, and estuaries, and monitoring is carried out seasonally (February, May, August, and November) at 417 monitoring stations. Additionally, automatic continuous monitoring is conducted in Sihwa Lake, Masan Port, Ulsan Port, Yeosu New Harbor, and the coastal areas of Busan (MLIT 2020). Coastal water quality standards were introduced in 2018 (Ministry of Oceans and Fisheries, No.10/2018), and the Water Quality Index (WQI), comprising five levels, is calculated as described in Tables 2.5.3a to c.

Table 2.5.3a WQI calculation method for coastal water quality

Category	Water Quality Index*
I (very good)	≤ 23
II (good)	24 – 33
III (moderate)	34 – 46
IV (bad)	47 – 59
V (very bad)	≥ 60

(Source: Ministry of Oceans and Fisheries 2021)

$$* \ WQI=10\times[DO]+6\times\left([Chl.a]+\frac{[SD]}{2}\right)+4\times\left([DIN]+\frac{[DIP]}{2}\right)$$

Figures in square brackets [ ] represent scores based on Table 2.5.3b. DO: Dissolved Oxygen, Chl.a: Chloropyll a, SD: transparency (secchi disc), DIN: dissolved inorganic nitrogen, DIP: dissolved inorganic phosphorus.

WQI trends of each sampling area are publicly disclosed on the NIER website. The example shown in Figure 2.5.5 is of Incheon Port.

Table 2.5.3b WQI calculation method for coastal water quality

Score	Parameter	
	Chl.a, DIN, DIP (µg/L)	DO (%), SD (m)
1	< reference value	> reference value
2	< 110% of reference value	> 90% of reference value
3	< 125% of reference value	> 75% of reference value
4	< 150% of reference value	> 50% of reference value
5	≥ 150% of reference value	≤ 50% of reference value

(Source: Ministry of Oceans and Fisheries 2021)

Reference values vary according to sea area, as shown in Table 2.5.3c.

Table 2.5.3c WQI calculation method for coastal water quality

Ecological zone	Parameter				
	Chl.a (µg/L)	DO (%)	DIN (µg/L)	DIP (µg/L)	SD (m)
East Sea	2.1	90	140	20	8.5
Korea Strait	6.3		220	35	2.5
Southwest sea	3.7		230	25	0.5
Central West Sea	2.2		425	30	1.0
Jeju	1.6		165	15	8.0

(Source: Ministry of Oceans and Fisheries 2021)

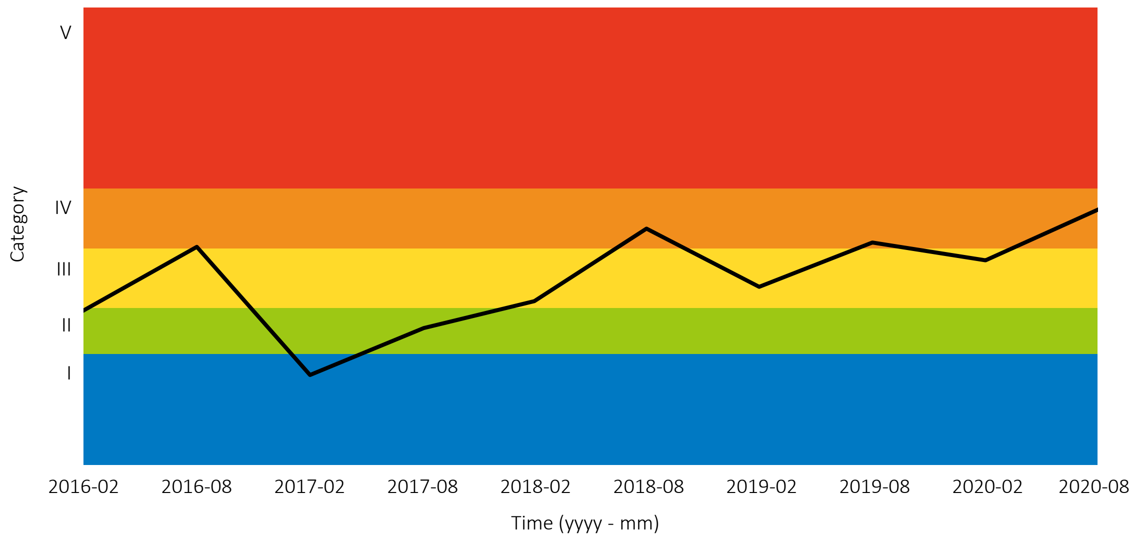

Figure 2.5.5 Trend of WQI in Incheon Port (2016–2020) (Source: NIER MLIT 2020)

3.4 Groundwater

Prior to 2018, groundwater had been managed by various acts under the control of different ministries, namely, Ministry of Environment (MOE), Ministry of Land, Infrastructure and Transport (MLIT), Ministry of Agriculture, Food and Rural Affairs (MAFRA), Ministry of the Interior and Safety (MOIS), and Ministry of National Defense (MND) (Kang et al. 2020). In 2018, the government passed the landmark Framework Act on Water Management (No.15653/2018), which transferred all groundwater-related responsibilities to MOE. According to Korea Environment Corporation (2021), 1,140 monitoring sites have been set up as of 2020, and a total of 3,725 sites are planned to be established by 2030. Kang et al. (2020) observe that strategic scaling up of groundwater use is essential in climate change adaptation, especially in light of the increasing frequency and intensification of droughts.

4 | State of Wastewater Treatment

In 2017, 2.16 million m^3/day of domestic wastewater and 4.01 million m^3/day of industrial wastewater was generated, and the treatment rate of both was 100%; 93.6% of domestic wastewater was treated centrally and 6.4% with decentralized treatment (MOE 2018). The domestic wastewater tariff is staggered according to discharge volume; for example, in Incheon in 2016 the wastewater tariff was 0.31 USD/m^3, 0.48 USD/m^3, 0.83 USD/m^3 respectively for 15 m^3, 50 m^3, and 100 m^3 (IBNet 2020).

Public awareness regarding wastewater treatment is high. In 2017, a decision was made to construct Seung-Gi Wastewater Treatment Plant of Incheon City underground to protect the breeding site of the black-faced spoonbill (*Platalea minor*). Although numbers are gradually increasing (Sung et al. 2017), the black-faced spoonbill is on the endangered list, with 3,941 birds observed as of January 2017 (BirdLife International 2021).

The number of industries is still climbing in the country; however, the volume of industrial effluent discharged is stable, as a result of water reuse and conservation efforts by industries and governments.

5 | Frameworks for Water Environmental Management

5.1 Legislation

The basic law for the environmental management policy of the country is the Framework Act on Environmental Policy, under which environment quality standards are established. The Framework Act on Water Management was newly established in 2018 to encompass the concept of integrated water resources management. This novel initiative streamlined the previously fragmented water-related matters using a more holistic approach, and various amendments to other legislations were made accompanying this change.

The previous Water Quality and Ecosystem Conservation Act was expanded in 2018 to encompass the entire water environment, and was developed into the Water Environment Conservation Act. Figure 2.5.6 shows the legislative framework related to water environmental management in the country.

Basic policy direction of water environmental management

The Ministry of Environment has established five core strategies for the period of 2016–2025 under the framework of water environmental management, as below:

1. Establishing a harmonious water cycle
2. Securing clean water through integrated basin management
3. Improving the index for aquatic ecosystems
4. Establishing framework for safe water environment
5. Creating economic and cultural value related water environment

The water quality monitoring framework was first established in 1967, with standards first set up in 1978.

5.2 Institutional Arrangement

In line with the approach to manage water from an integrated perspective, responsibilities which were previously spread across different ministries (for

Framework Act on Environmental Policy (No. 10893/2011)

Framework Act on Water Management (No.15653/2018)

- Water Environment Conservation Act (No.15832/2018)
- Public Waters Management and Reclamation Act (No.16501/2019)

Conservation of Water Quality in Inland Water

- Act on the Investigation, Planning, and Management of Water Resources (No.16608/2019)

Rivers

- River Act (No.14722/2017)
- Act on the Improvement of Water Quality and support for Residents of the Han River Basin (No.15104/2017)
- Act on Water Management and Residents support in the Nakdong River Basin (No.15095/2017)
- Act on Water Management and Resident Support in the Geum River Basin (No.15094/2017)
- Act on Water Management and Resident Support in the Yeongsan and Seomjin River Basins (No.15099/2017)
- Small River Maintenance Act (No.16772/2019)

Conservation of Water Quality in Coastal Water

- Marine Environment Management Act (No.16520/2019)
- Coast Management Act (No.16285/2019)

Conservation of Water Quality in Groundwater

- Groundwater Act (No.15624/2018)

Other Laws Related to Water Environment

- Environmental Impact Assessment Act (No.15662/2018)
- Environmental Testing and Inspection Act (No.15200/2017)
- Water Supply and Waterworks Installation Act (No.16082/2018)
- Act on Promotion and Support of Water Reuse (No.16080/2019)
- Ballast Water Management Act (No.16160/2019)
- Special Act on the Utilization of Waterfronts (No.15624/2018)
- Water-related Leisure Activities Safety Act (No.16567/2019)
- Korea Water Resources Corporation Act (No.15624/2018)
- Development and Management of Deep Sea Water Act (No.16518/2019)

Figure 2.5.6 Legislative chart for water quality management

(Source: created by IGES based on KLRI 2020, MOE 2020) example, large rivers/streams were under MLIT, small streams/creeks were under the Ministry of Interior and Safety, lakes were under Ministry of Agriculture, Food and Rural Affairs, and sewerage was under the Ministry of Environment) were all restructured for management under the MOE.

The National Institute for Environmental Research (NIER) conducts monitoring of environmental water quality.

The following local environmental agencies conduct monitoring and legal enforcement:

- Han River Basin Environmental Agency
- Geum River Basin Environmental Agency
- Nakdong River Basin Environmental Agency
- Yeongsan River Basin Environmental Agency
- Daegu Regional Environmental Agency
- Wonju Regional Environmental Agency
- Jeonju Regional Environmental Agency

These regional environmental agencies, together with the Water Environment Research Center, Research Institute of Public Health and Environment, K-Water, and the Korean Rural Community Corporation form a multi-stakeholder consortium that implements the water quality monitoring framework.

5.3 Ambient Water Quality Standards

There are two water quality standards for surface water. The first cover the protection of human health and apply to both rivers and lakes, for which there are currently 20 parameters, such as Cd, As, and PCB, with plans to increase parameters to 30 by 2025. The second, split into two cover the living environment (residential environment criteria) and rivers and lakes/marshes, respectively. Standards for the living environment for rivers include pH, BOD, TOC, SS, DO, TP, total coliform, and fecal coliform; standards for lakes/marshes include pH, TOC, SS, DO, TP, TN, Chl.a, total coliform, and fecal coliform.

For groundwater, different standards are applied according to water usage purpose. Drinking water standards established under the Drinking Water Management Act are applied for drinking water use with 51 parameters. For other purposes such as domestic, farming and fisheries and industrial uses, groundwater standards are used to evaluate groundwater quality, with 14 to 19 parameters, based on usage.

Special metropolitan cities, provinces or "Do" can establish more stringent or expanded environmental standards than the national standards where necessary in consideration of local environmental conditions (Article 10 (3) Framework Act on Environmental Policy).

Monitoring of water quality in public water bodies and groundwater

Water quality is monitored through a nationwide monitoring network in accordance with category: 26 items for rivers, 30 for lakes and marshes, and 20 for groundwater. In particular, there are 70 automatic operating monitoring stations for surface waters. Water quality is monitored by measuring five common items such as DO, TOC, pH and 17 optional items, including VOC. To raise inspection efficiency, monitoring spots are classified according to usage: river water, lake water, groundwater, coastal water, drinking water, irrigation water, industrial water and river water flowing through cities.

5.4 Effluent Standards

As of 2019, 58 water pollutants have been identified under the legal framework, of which seven parameters (BOD, COD/TOC, SS, TN, TP, total coliform, ecotoxicity) are used for effluent standards, and 32 parameters are monitored as hazardous pollutants under the permissible discharge limits.

Industrial facilities are categorized into the following five levels according to discharge volumes.

- Level I: $\geq$2,000 t/day
- Level II: 700 $\leq$ discharge < 2,000
- Level III: 200 $\leq$ discharge < 700
- Level IV: 50 $\leq$ discharge < 200
- Level V: others

In 2007, ecotoxicity was first included as a parameter under the permissible discharge limits under the Water Quality and Ecosystem Conservation Act, and in 2019, the ecotoxicity management system was expanded to cover 82 types of industrial facilities. Ecotoxicity is analyzed with water fleas (*Daphnia magna*).

Since 2020, TOC has been used as a parameter to monitor organic substances in addition to COD_{Mn}, due to the difficulty of monitoring non-degradable organic substances, which gives higher values for TOC than COD.

Effluent monitoring

The annual calendar of monitoring, together with demarcations, is as follows:

- By May: Industrial facilities analyze samples, and submit data with justifications
- By July: Regional Environmental Agencies review and verify reports, and take/analyze samples
- By December: National Institute of Environmental Research confirms the data and conducts metadata analysis
- By following March: Ministry of Environment discloses data to the public

6 | Recent Developments in Water Environmental Management

Inclusion of the concept of integrated water resource management as part of the governance of water management has had a large impact throughout all aspects of water management in the country. While it has allotted more responsibilities to MOE, it has also resulted in a devolution of responsibilities for water environment management from central to local governments. Regarding the SDGs, achievement of indicator 6.3.2., “water bodies having good ambient water quality” is reported at 93% as of 2020.

7 | Challenges and Future Plans

The inclusion of integrated water resource management together with devolution of responsibilities regarding water environmental management from central to local governments has added another dimension to the challenge of restructuring, which requires a viable strategy and detailed plan to be rapidly laid out in order bring about institutional cooperation.

As a result of the restructure, responsibilities and activities of the Ministry of Environment have expanded rapidly, which makes it more difficult to prioritize projects regarding water environment management.

Other technical challenges currently faced include distortion of the water cycle (due to climate change and other environmental causes), increased non-degradable organic matter in effluent, difficulty of managing non-point pollution sources, and the need to add ecotoxicity standards based on other aquatic organisms. To combat these various challenges, a holistic and comprehensive review of projects is being carried out.