Rivers and Watersheds

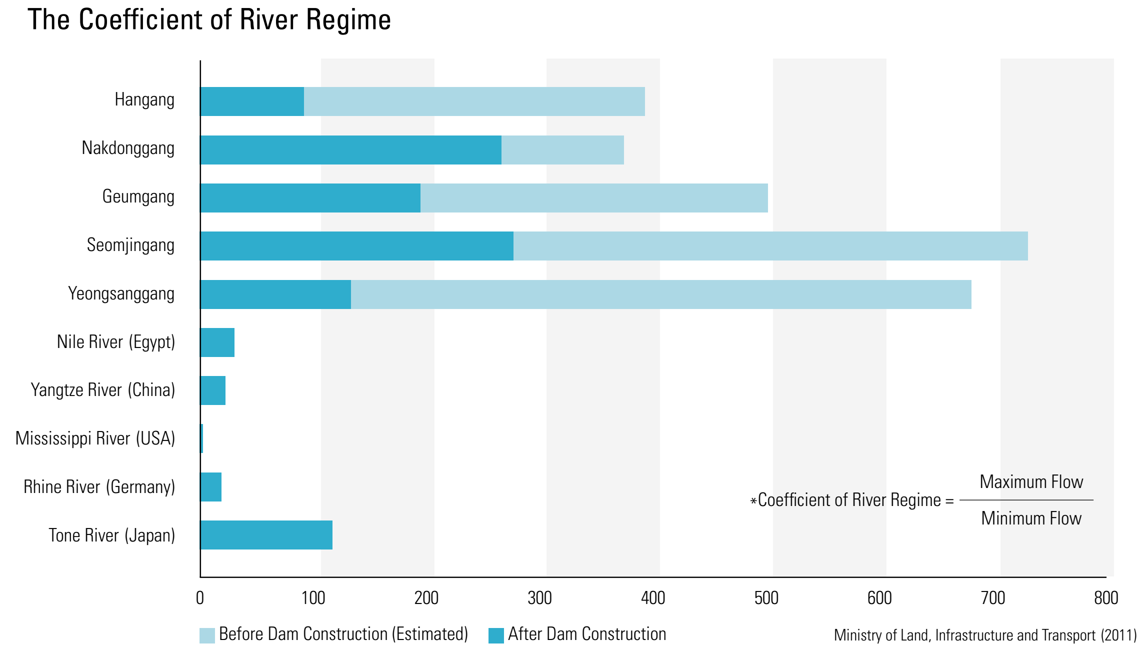
The terrain of Korea is characteristically high along the east coast and low along the west coast. Consequently, most of the rivers flow into the Yellow Sea and the South Sea. The shoreline of the east coast is monotonous and rivers flowing into the East Sea are relatively short and steep-sloped. On the other hand, the shoreline of the west coast is more complex and many rivers flowing to the western and southern coasts are relatively long; they have gentle slopes and wider basins that result in higher flows. In these areas, river sediments shape extensive alluvial plains and alluvial basins, and meandering channels are often formed as well.

In Korea, there are five large rivers: Hangang, Nakdonggang, Geumgang, Seomjingang, and Yeongsangang. Several mid to small-scale rivers are also found in the country, including Anseongchun, Sapgyochun, Mangyeonggang, Dongjingang, and Hyeongsangang. In order to systematically manage river and water resources, the rivers have been divided into 117 sub-basins. Hangang has the largest drainage area of 35,770 km^2 (including the portion in North Korea). It also has an annual runoff volume of 16 billion m^3, which constitutes 35.1% of the nation's total runoff volume. The longest river in Korea is Nakdonggang, with a length of 510 km.

From 2005 to 2014, the average annual precipitation in Korea was approximately 1,323.7 mm, which is equivalent to about 1.6 times the world average. This is enough to classify Korea as a high rainfall region, although seasonal variability is extremely high. Due to seasonal rain and typhoons, 735.8 mm of rainfall (55.6% of the annual rainfall) is concentrated during the summer and often causes floods. Furthermore, rainfall has the tendency to quickly collect in the rivers as over 70% of the land is mountainous with an average slope of about 20%. These geomorphological and climatic characteristics cause high fluctuations in the flow rate of rivers throughout the year, often causing extensive floods and severe droughts.

The coefficient of river regime indicates the ratio between the maximum and minimum flow of a river. Seomjingang currently has a coefficient of river regime of 270, which is the highest among the five large rivers of Korea, and nine times higher than the Nile River in Africa (coefficient of river regime: 30). Before the installation of dams, each of the five large rivers had coefficients of river regime that were higher than 300. In particular, Seomjingang and Yeongsangang displayed extremely high levels at around 700. Consequently, dams and reservoirs were actively constructed to ensure the reliability of water resources, reduce flood damage, and mitigate the effects of drought. Intensive plans were also implemented to conserve river banks and their surrounding areas.

The Coefficient of River Regime

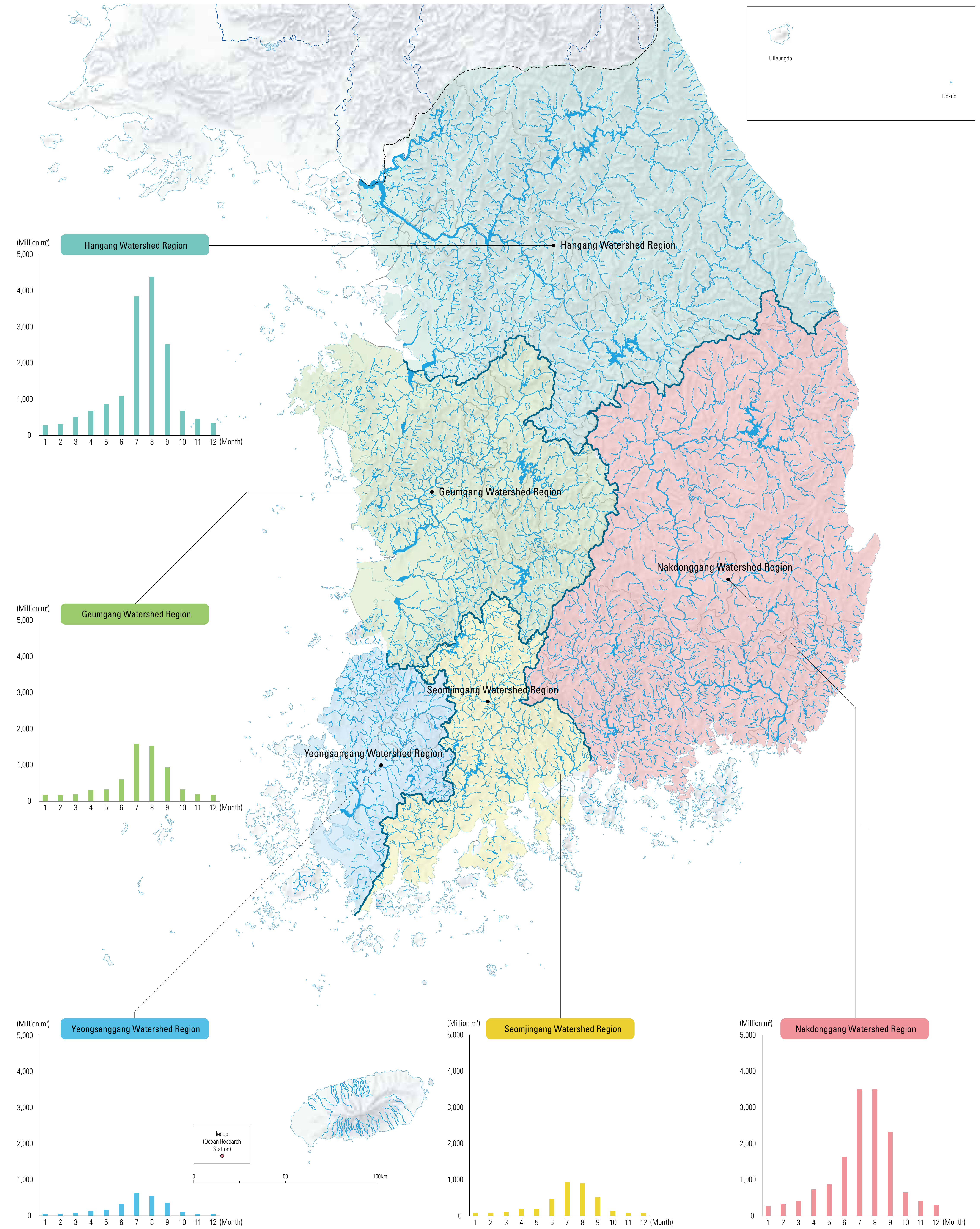


Ministry of Land, Infrastructure and Transport (2011)

ATMOSPHERE AND HYDROSPHERE

Rivers

River Networks and Monthly Discharge of Major Watershed Region



K-water (2015)

History of Hydrological Development

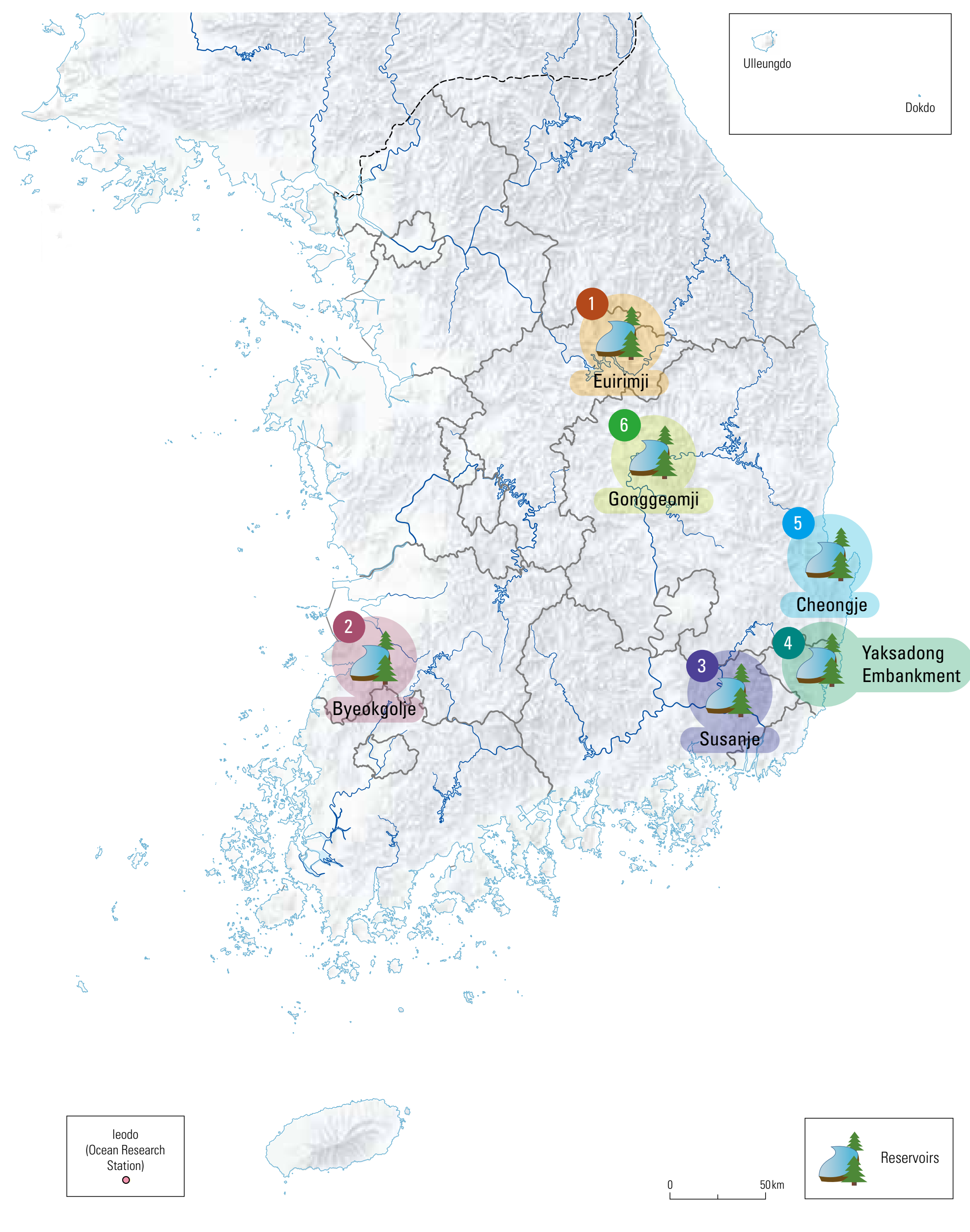
1 Euirimji in Jecheon-si

Euirimji is an ancient reservoir in Mosan-dong, Jecheon-si, Chungcheongbuk-do that is still in use to this day. Although the exact year of construction is unknown, a 2009 radiocarbon dating of sedimentary deposits estimated that it was built during the Three Han States. According to legend, Wooreuk (a renowned kayageum player) blocked off the river during the period of King Jinheung of Silla, while others argue that Mayor Park Euirim constructed the reservoir. The maximum water surface area of Euirimji is approximately 160,000 m^2 and the maximum storage capacity is about 6.6 million m^3.

Painting of the Euirimji

This painting of Euirimji reservoir in Jecheon-si is by Bangwon Lee (1761 – 1815), a landscape painter of the late Joseon Dynasty. It features pine and willow trees planted around the embankment and the reservoir. Such forest landscapes, now referred to as *Jerim*, were artificially constructed to increase the stability of traditional reservoirs.

Ancient Reservoirs



6 Gonggeomji in Sangju-si

The Gonggeomji reservoir, also known as Gonggalmot, is located in Yangjung-ri, Gonggeom-myeon, Sangju-si, Gyeongsangbuk-do. Although the reservoir is known to have been built during the Three Han States, only a few records remain on the details. According to *Sangsanji*, Choi Jeongbin (an official accountant in Sangju) repaired the embankment in the 25th year of King Myeongjong of the Goryeo Dynasty (A.D. 1195). It was about 860 steps long with a perimeter of 16,647 cheok (the Korean foot: approximately 30.3 cm). *Dongguk munheon bigo* and *Sinjeung dongguk yeoji seungram* state that the embankment was approximately 430 m long with a perimeter of 8.8 km and a depth of 5 – 6 m.

5 Cheongje in Youngcheon-si

Cheongje is an earthen dam located in Geumho-eup, Yeongcheon-si, Gyeongsangbuk-do. It is estimated to have been built before the 23rd year of King Beopheung of the Silla Dynasty (A.D. 536). Its embankment is 243.5 m long and 12.5 m high, and it has a maximum water surface area of approximately 110,000 m^2. The reservoir has a maximum reservoir storage capacity of about 590,000 m^3 and is still being used today. Historical records reveal that the construction project of Cheongje was a national irrigation project that involved approximately 7,000 people. Wooden stakes and fences were used to build the floodgates.

2 Byeokgolje in Gimje-si

Byeokgolje is a reservoir embankment extending from Pogyo to Wolseung-ri that is 3.3 km long and up to 5.6 m tall. According to *Samguk sagi,* it was built in Buryang-myeon, Gimje-si, Jeollabuk-do in the 27th year of King Biryu of Baekje (A.D. 330). Five floodgates were maintained or newly built by the 15th year of King Taejong of the Joseon Dynasty (A.D. 1415), but only two remain today. Byeokgolje is an earthen dam with an irrigation area of approximately 95 km^2.

Old Map of Byeokgolje

Byeokgolje is shown in the old map of Gimje-si, created in 1872. It appears in the form of an embankment located downstream of the Juksan (Wonpyeongcheon) tributary of Dongjingang. Unlike other ancient reservoirs that were formed by levees in valleys, Byeokgolje was shaped by dikes built on plains. This has led to an ongoing debate on whether Byeokgolje was originally built to be a reservoir or a seawall.

3 Susanje in Miryang-si

Susanje reservoir, located in Hanam-eup, Miryang-si, Gyeongsangnam-do, was built during the Three Han States. The embankment extends approximately 1 km from Susan-ri to Doyeonsan, a section of which remained until 1928. It has since been converted into rice paddies. A 181 cm high, 152 cm wide, and 25 m long floodgate with a 7 m long connecting waterway was built on natural bedrock.

4 Yaksadong Embankment in Ulsan

Yaksadong embankment—located in Yaksa-dong, Jung-gu, Ulsan-si—is an ancient irrigation reservoir constructed around the end of the Three Kingdoms period to the early Unified Silla period. It was built by connecting the levees on both sides of the Yaksacheon, and is estimated to be 155 m long and 4.5 – 8.0 m high. Typical ancient engineering techniques were used in the construction of the embankment; the foundation was formed with shells and a silt layer, and leafy twigs were utilized in a leaf mat method.

Rice was first introduced to the Korean Peninsula in the Neolithic Age and became widespread throughout the south during the Bronze Age. *Samguk sagi*—the first historic record to mention rice farming in Korea—documents that King Daru (the second king of Baekje) established rice paddies across the country in his 6th year of ruling, or A.D. 33. As rice farming grew more central during the Three Kingdoms period, nationwide projects were carried out to build structures such as embankments, waterways, and reservoirs that would facilitate the access and storage of water. *Samguk sagi* also states that King Ilseoung of Silla ordered the construction of river banks and reclamation of wastelands in his 11th year (A.D. 144). As such, the Three Kingdoms period saw the construction of some of the oldest ancient reservoirs in Korea: Byeokgolje in Gimje-si, Euirimji in Jecheon-si, and Susanje in Miryang-si. Various flood control facilities and reservoirs such as the Yaksadong river banks in Ulsan, Cheongje in Yeongcheon-si, and Gonggeomji in Sangju-si were also constructed during this period.

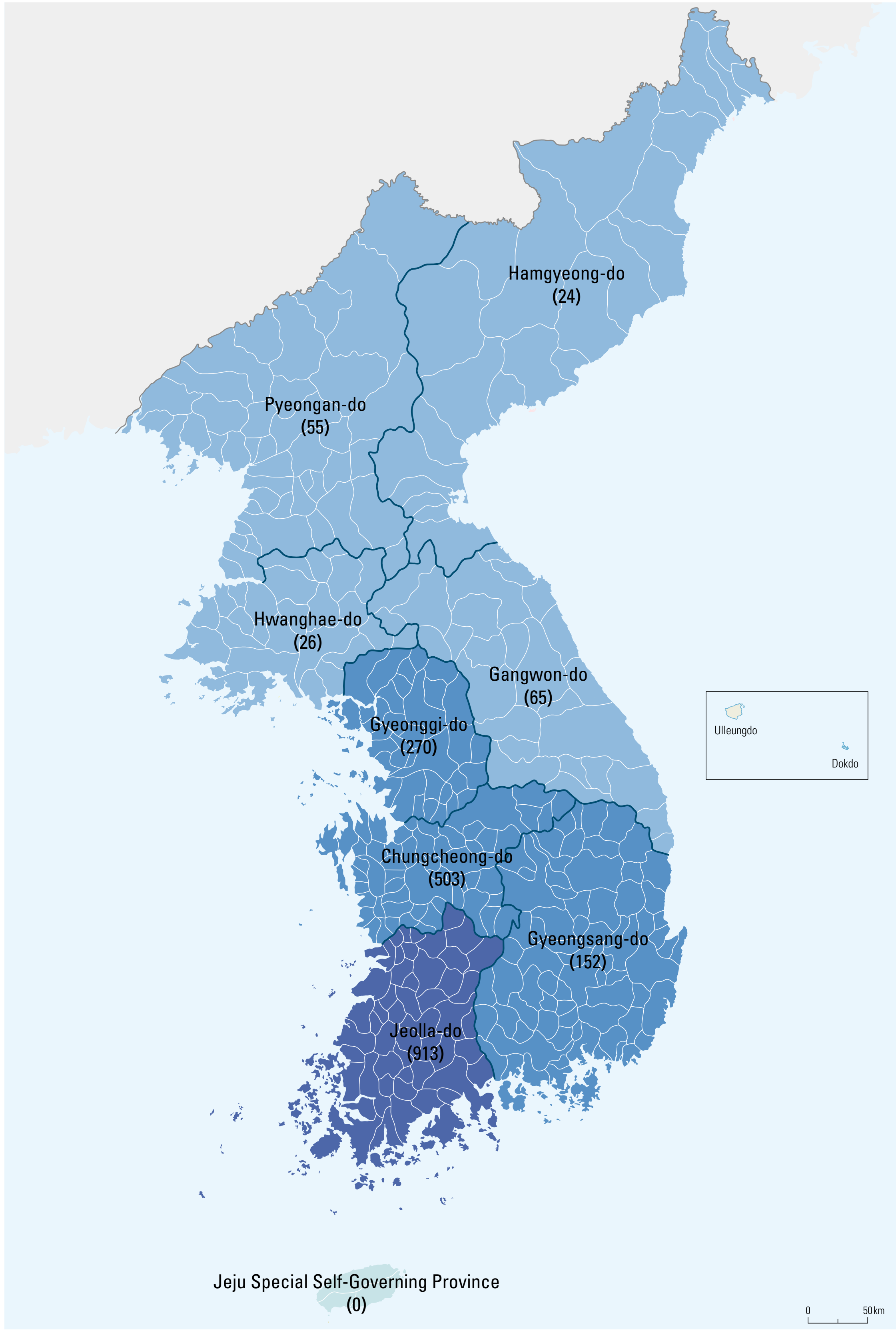
As for the Goryeo Dynasty, early records state that *Usubu*—a government bureau in charge of irrigation and waterways—was established in the 14th year of King Seongjong (A.D. 995). During this era, land reclamation was carried out on coastal regions and deserted inland fields, while islands underwent active development. Embankments, breakwaters, and reservoirs were newly constructed or built as an extension of existing structures. The largest embankment of the Goryeo Dynasty is Hwangsan-un, estimated to have been built in the early 12th century.

As the Joseon Dynasty was a predominantly agrarian society, it experienced significant improvement in flood control and irrigation management techniques. For instance, the Gwonnonggwan system was first established in the 4th year of King Taejo (A.D. 1395). It introduced government officials who promoted agricultural development and pushed for the construction of reservoirs. In A.D. 1419 (the 1st year of King Sejong), two copies of *Jeeon daejang* were completed to provide a full list of reservoirs across the country. A bureau named *Jeeonsa* was also established in order to administrate dams and other facilities. According to *Dongguk munheon bigo*, there were 3,378 dams recorded in 1782, most of which were located in the southern part of the Korean Peninsula.

During the Japanese Colonial period, the Japanese imperial government intended to utilize Korea as a strategic military base for invading the Asian continent. For this reason, Japan built dams and reservoirs all across the country. Of the 30 dams constructed in the northern part of Korea, 25 were for electricity and 5 were for irrigation. A total of 135 dams and reservoirs were built in the southern part of Korea – most were for irrigation purposes while 3 were for electricity and 7 were for domestic and industrial uses. The larger dams, mostly built after 1940, were constructed to serve local needs rather than for the comprehensive development of watersheds.

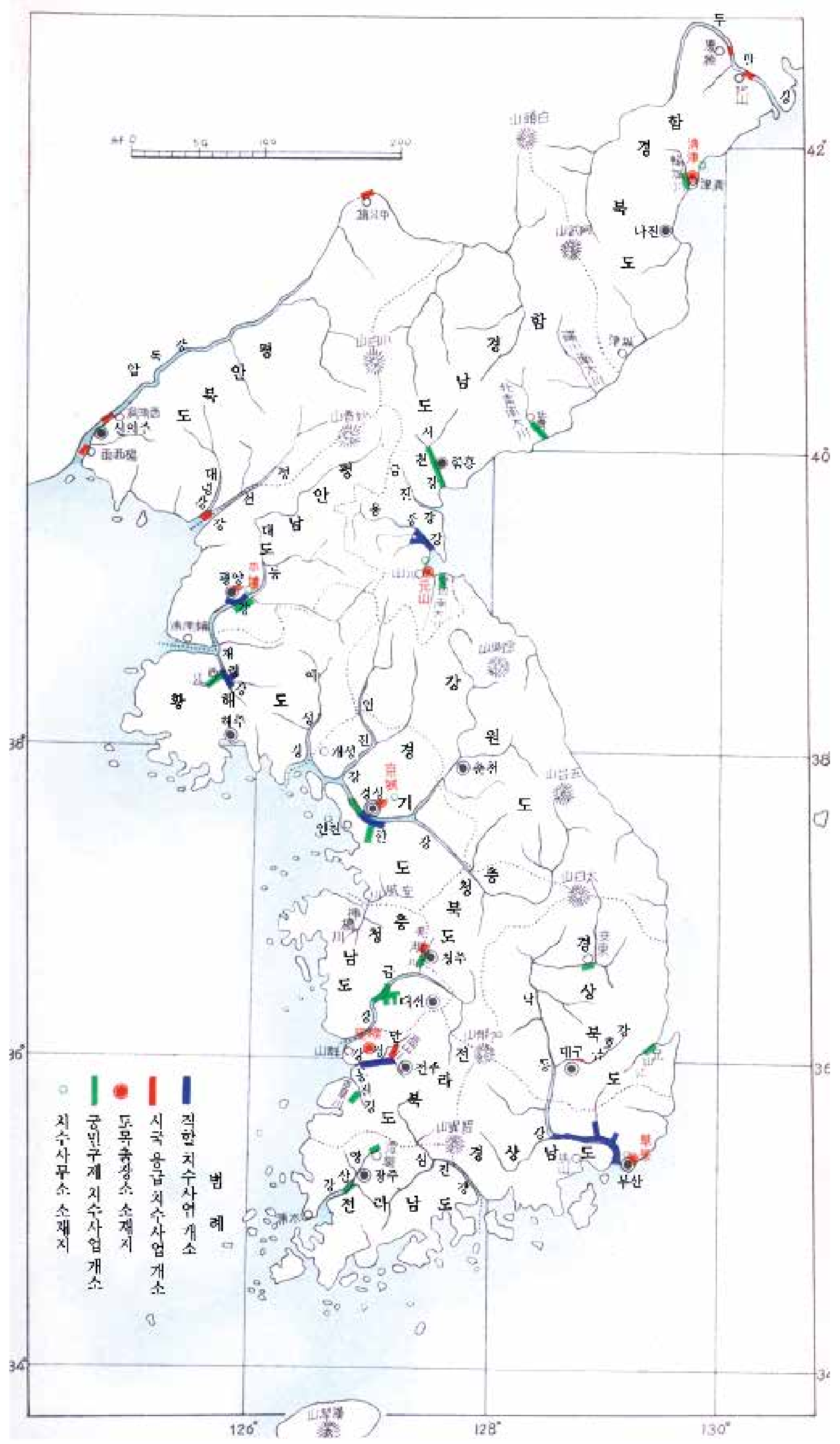
In the early 1910s, Japan launched an extensive investigation on Korean rivers in order to solve its food security problem. After conducting two cycles of research on 25 major rivers, it devised a river repair plan which later served as the basis for the *Joseon Rivers Survey* (published in 1928). According to the publication, river improvement projects began on Mangyeonggang and Jaeryeonggang in 1925, and Hangang, Nakdonggang, Daedonggang and other major rivers in 1926. These projects included the construction of dams and river banks for irrigation purposes, as well as the straightening of river channels. From 1911 to 1945, Japan also carried out three rounds of a nationwide survey on hydraulic power to supply information for the further construction of dams and reservoirs.

Number of Reservoirs in the Joseon Dynasty



K-water (2000)

River Conservation Work during the Japanese Colonial Period



Japanese Governor-General of Korea

River Improvement Projects on Nakdonggang

Bank Construction in Chojung
(Chojung-ri, Haja-myeon and Chooldoo-ri, Daejeo-myeon in Gimhae-gun)

- Total Length - 775 m
- Cost 2,000 ¥
- Initiation 1935/10/16. Completion 1935/12/4.

Floodgate Construction of Myoungji Dam
(Myeongji-myeon, Gimhae-gun)

- Width 1.85 m, Height 1.25 m, Length 24.5 m
- Cost 12,000 ¥
- Initiation 1935/11/01. Completion 1936/03/31.

Dam Establishment in South Korea during the Japanese Colonial Period

	Water	Power	Irrigation	Total
Year 1910 – 1940	4	1	31	36 (26.7%)
Year 1941 – 1945	3	2	94	99 (73.3%)
Total	7 (5.2%)	3 (2.2%)	125 (92.6%)	135 (100%)

K-water (2000)

Characteristics of Watersheds

Hangang Watershed

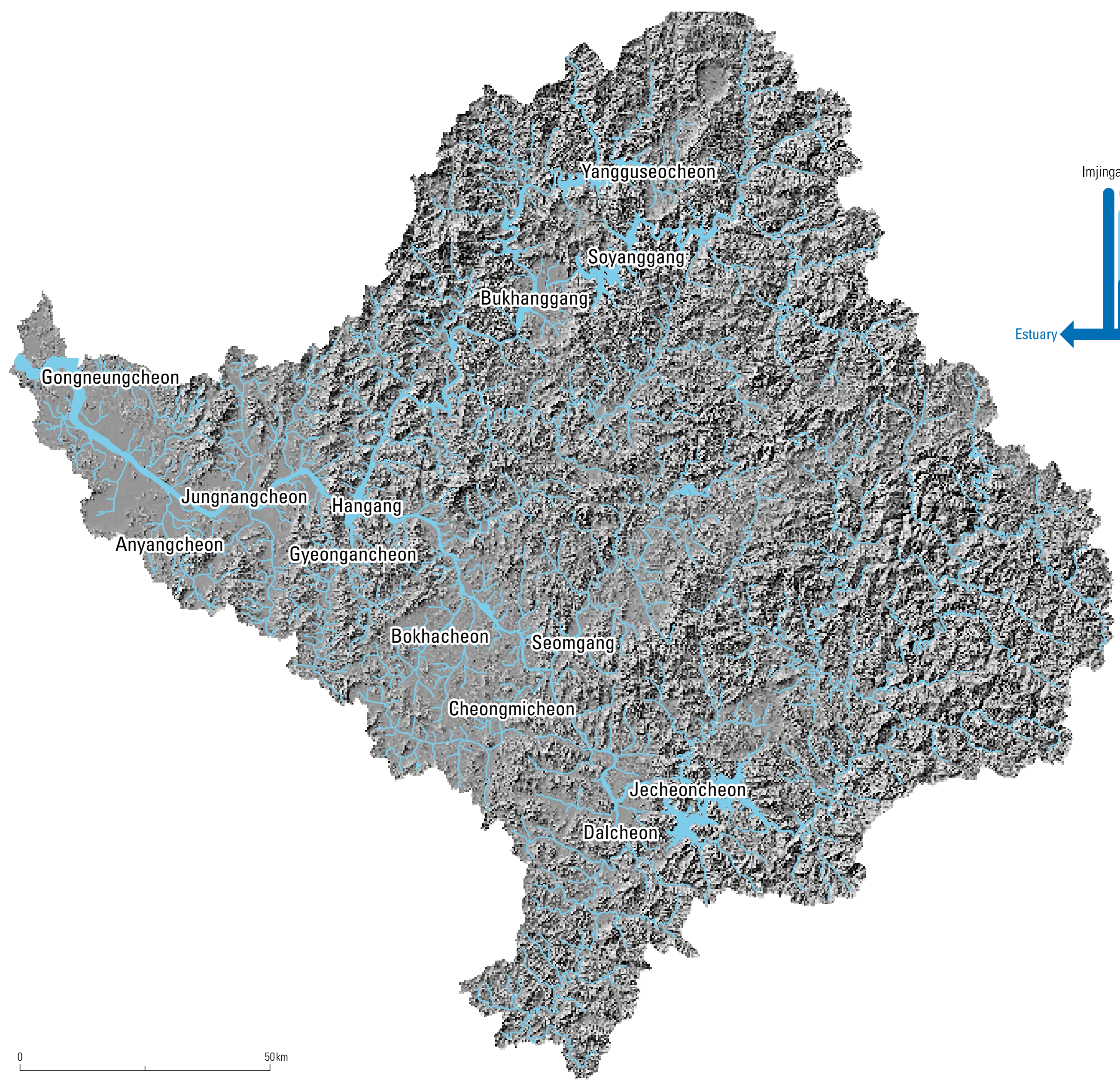
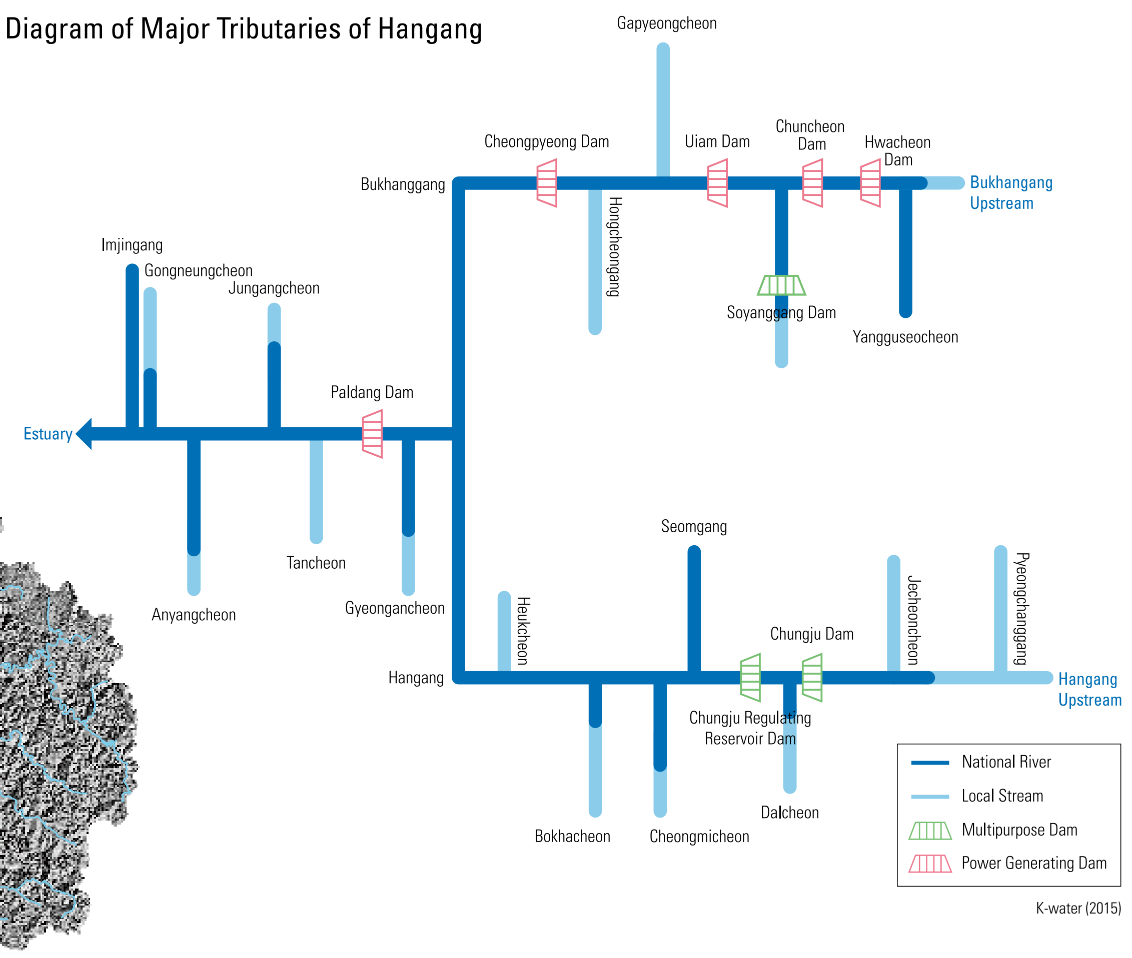
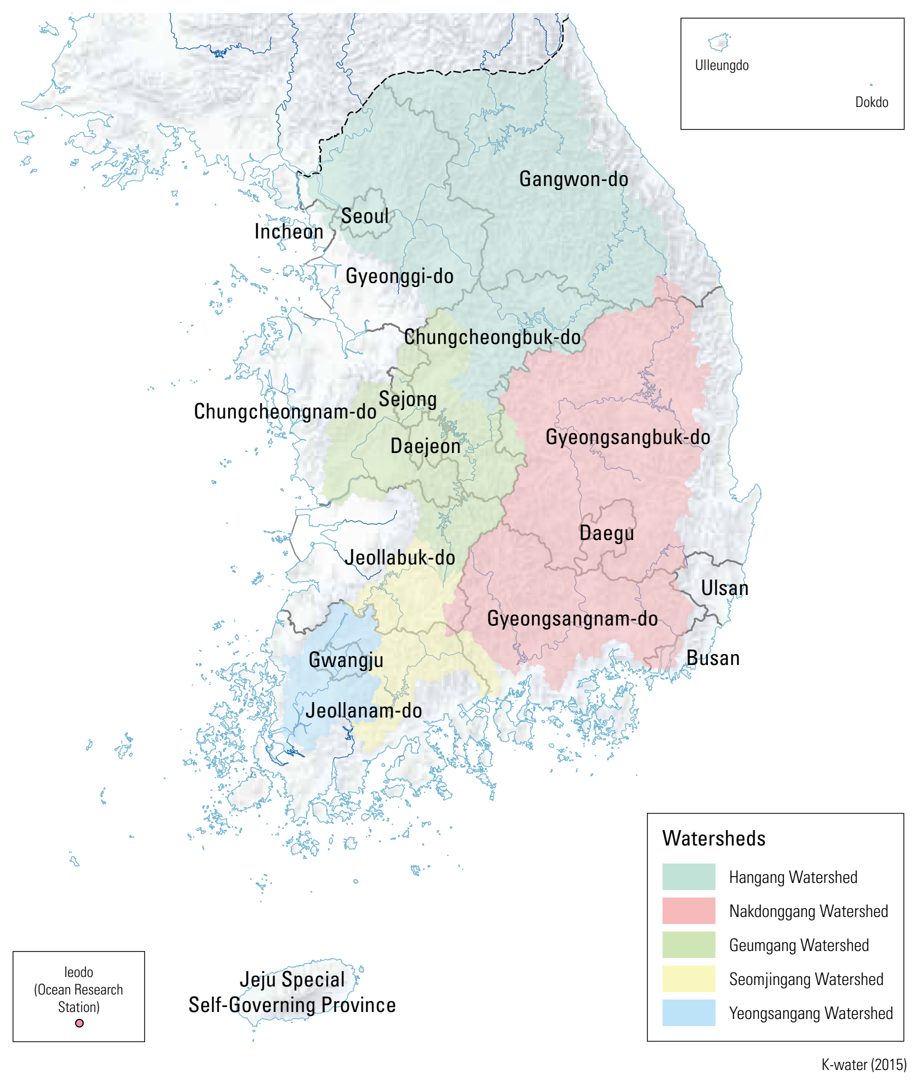


Diagram of Major Tributaries of Hangang



Watersheds of Five Major Rivers



Nakdonggang Watershed

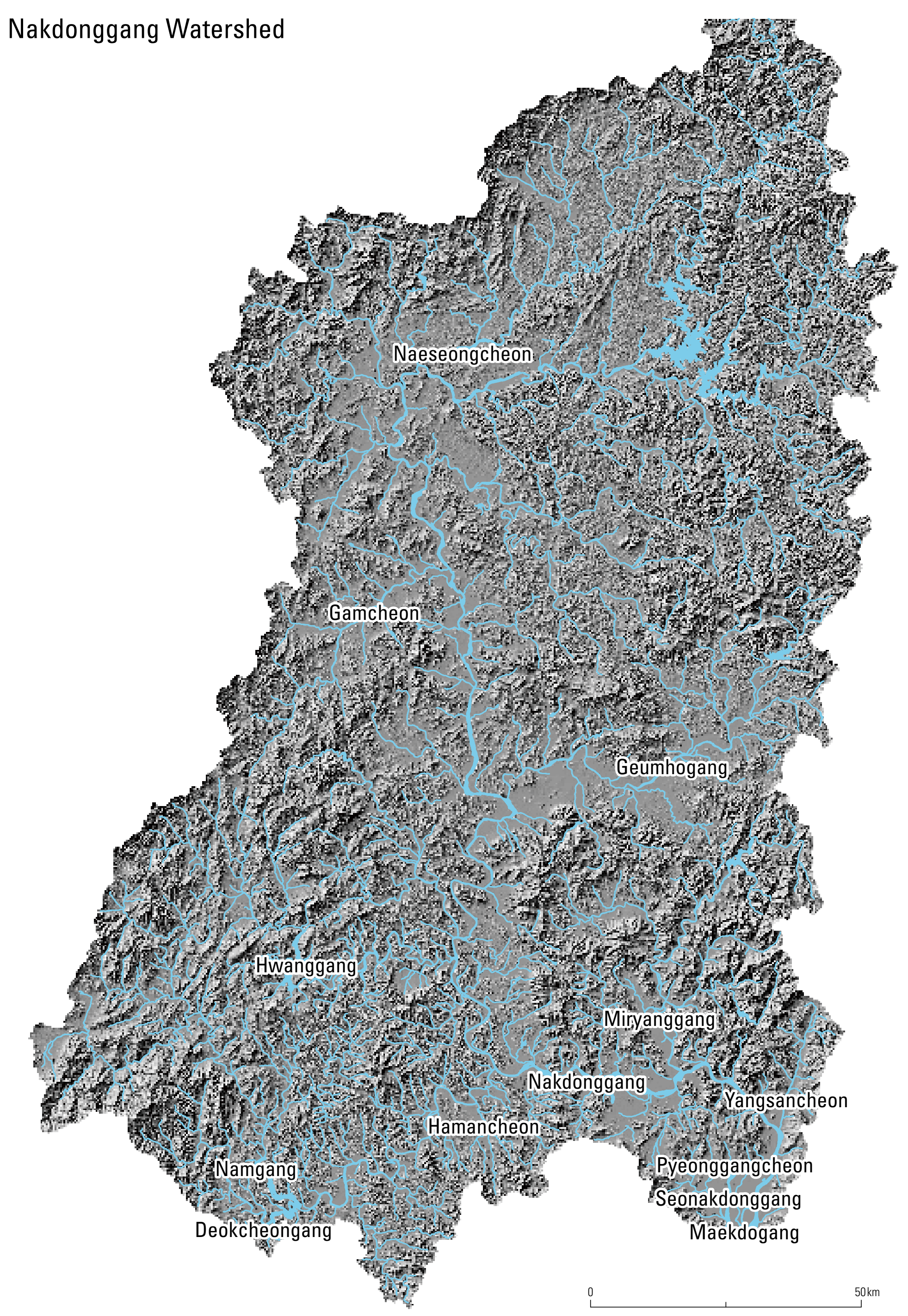
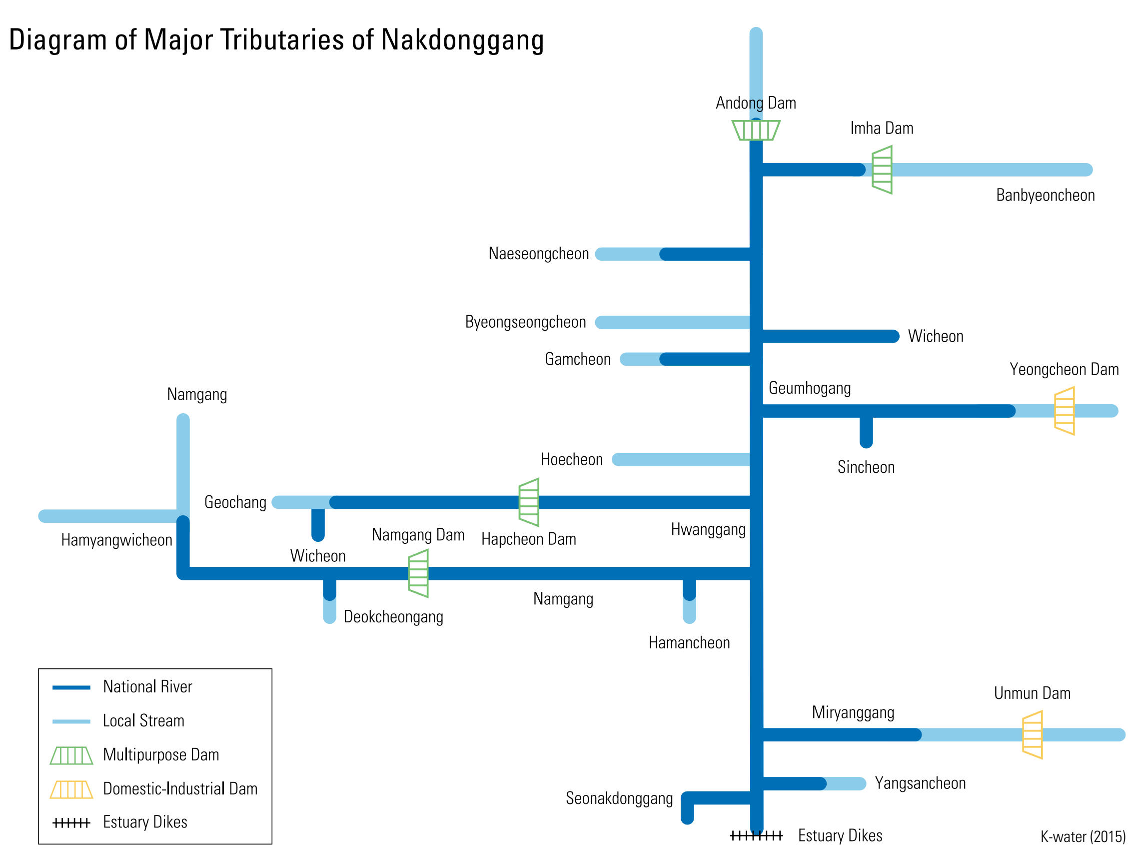
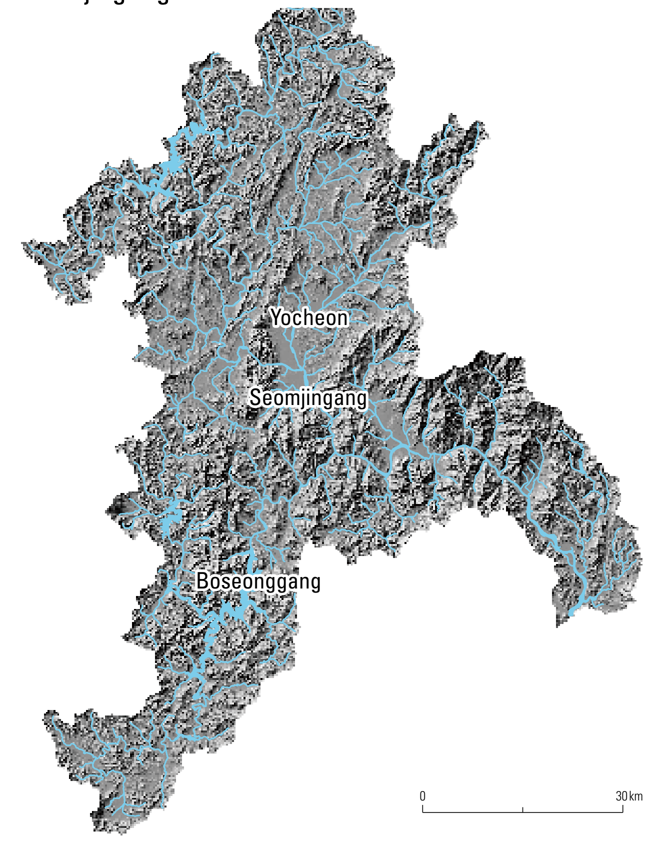


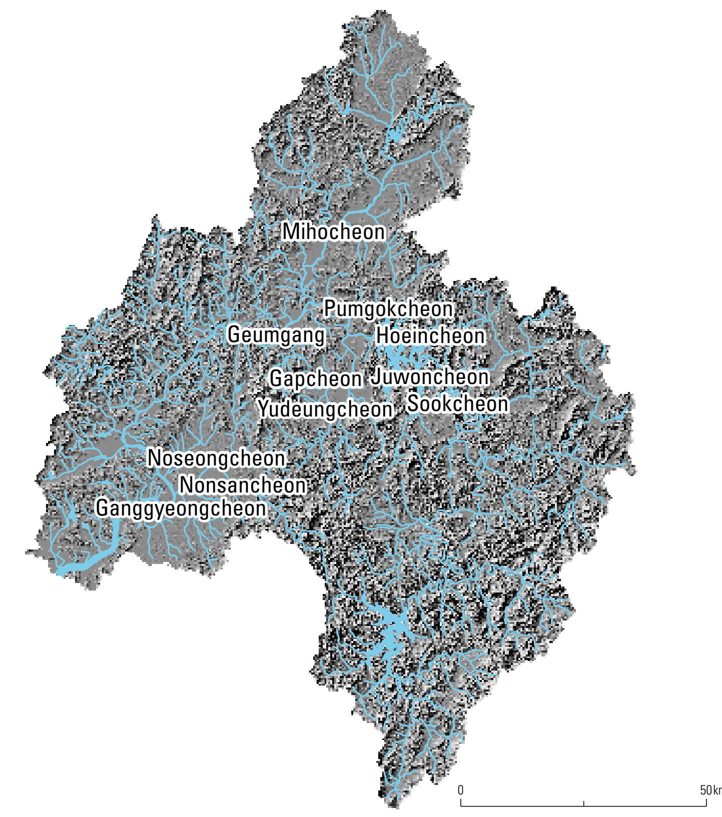
Diagram of Major Tributaries of Nakdonggang



Seomjingang Watershed



Geumgang Watershed



Yeongsangang Watershed

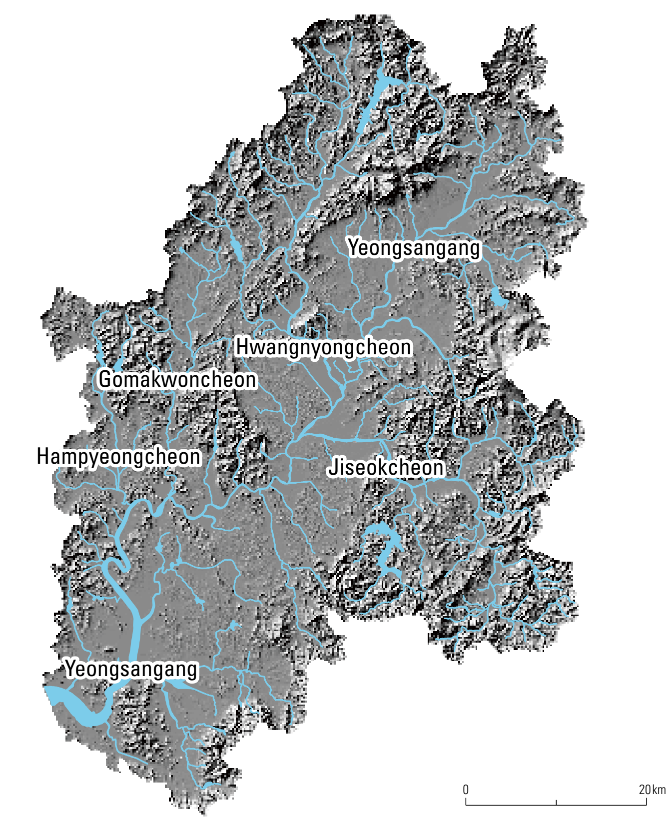


Diagram of Major Tributaries of Seomjingang

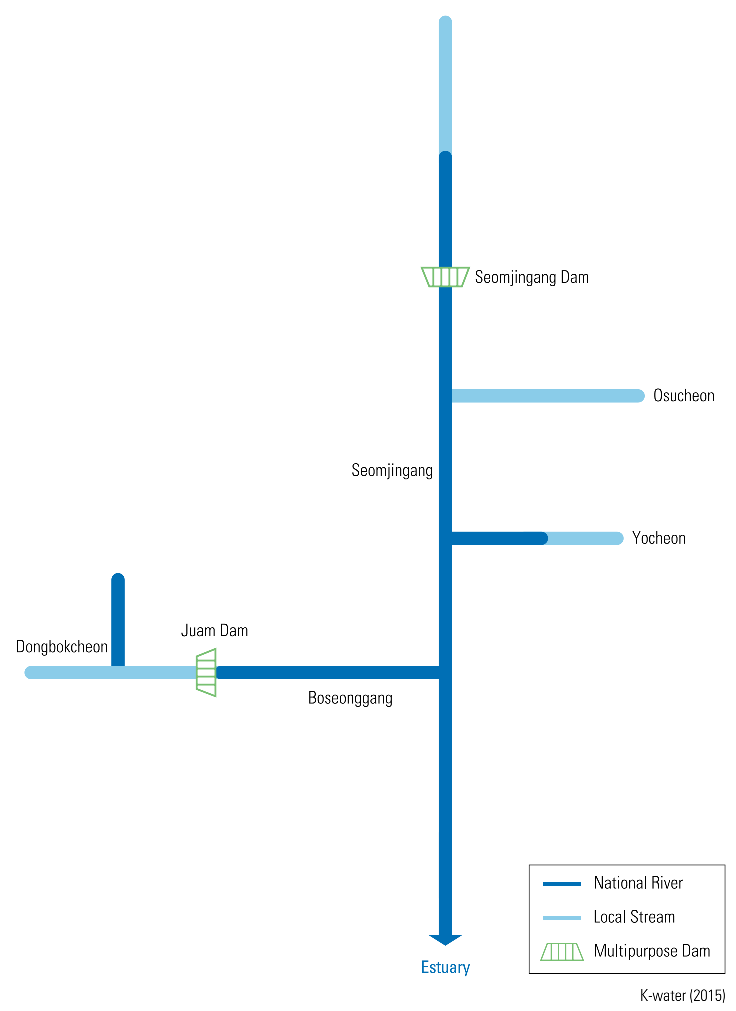
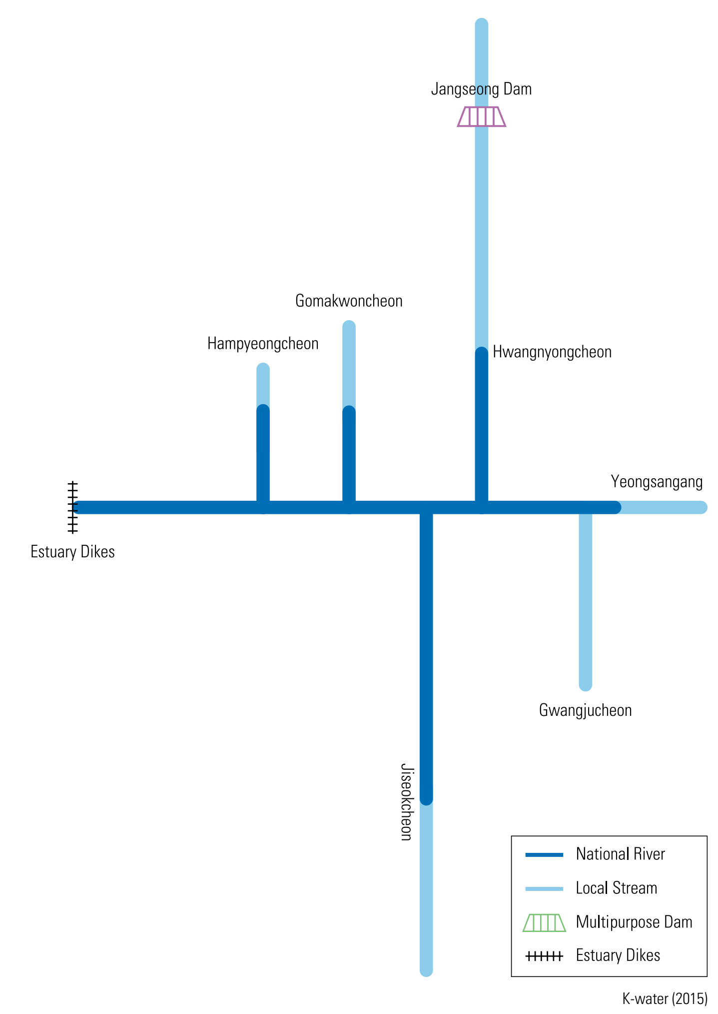


Diagram of Major Tributaries of Geumgang

Diagram of Major Tributaries of Yeongsangang



Hangang is a river that flows horizontally across the midsection of the Korean Peninsula. It is 494.4 km long and has a drainage area of 25,953 km², or 35,770 km² including the section in North Korea. Lying mainly in Gangwon-do and Gyeonggi-do, the Hangang watershed extends into Seoul, Incheon, Chungcheongnam-do, and Chungcheongbuk-do. Hangang is largely divided into Bukhangang (North Hangang) and Namhangang (South Hangang). The two rivers join at Yangsu-ri, Yangseo-myeon, Yangpyeong-gun, Gyeonggi-do, flow through Seoul, and finally drain into the Yellow Sea at Bogugot-ri, Wolgot-myoen, Gimpo-si. Namhangang, the main stream of Hangang, originates in Geomryongso of Geumdaebong (1,418 m) in Changjuk-dong, Taebaek-si, Gangwon-do. Dalcheon, Sumgang, Cheongmicheon, and Bokhacheon are some of the streams that flow into Namhangang. Bukhangang, which is the largest branch of Hangang, originates in Danbalryeong (1,241 m), Geumgang-gun, Gangwon-do and is joined by Yangguseocheon and Soyangang.

Nakdonggang, which flows south through the southeastern part of the Korean Peninsula, is 510.3 km long and has a drainage area of 23,384 km². The Nakdonggang watershed is located across Busan, Daegu, Gangwon-do, Gyeongsangnam-do, and Gyeongsangbuk-do, and also lies along the boundaries of Jeollanam-do, Jeollabuk-do, and Chungcheongbuk-do. Nakdonggang stems from Hwangji Pond on the eastern side of Hambaeksan in Taeback-si, Gangwon-do and discharges into the South Sea through an estuary dike and delta in Busan. Seonakdonggang branches off at the delta located at the river mouth of Nakdonggang.

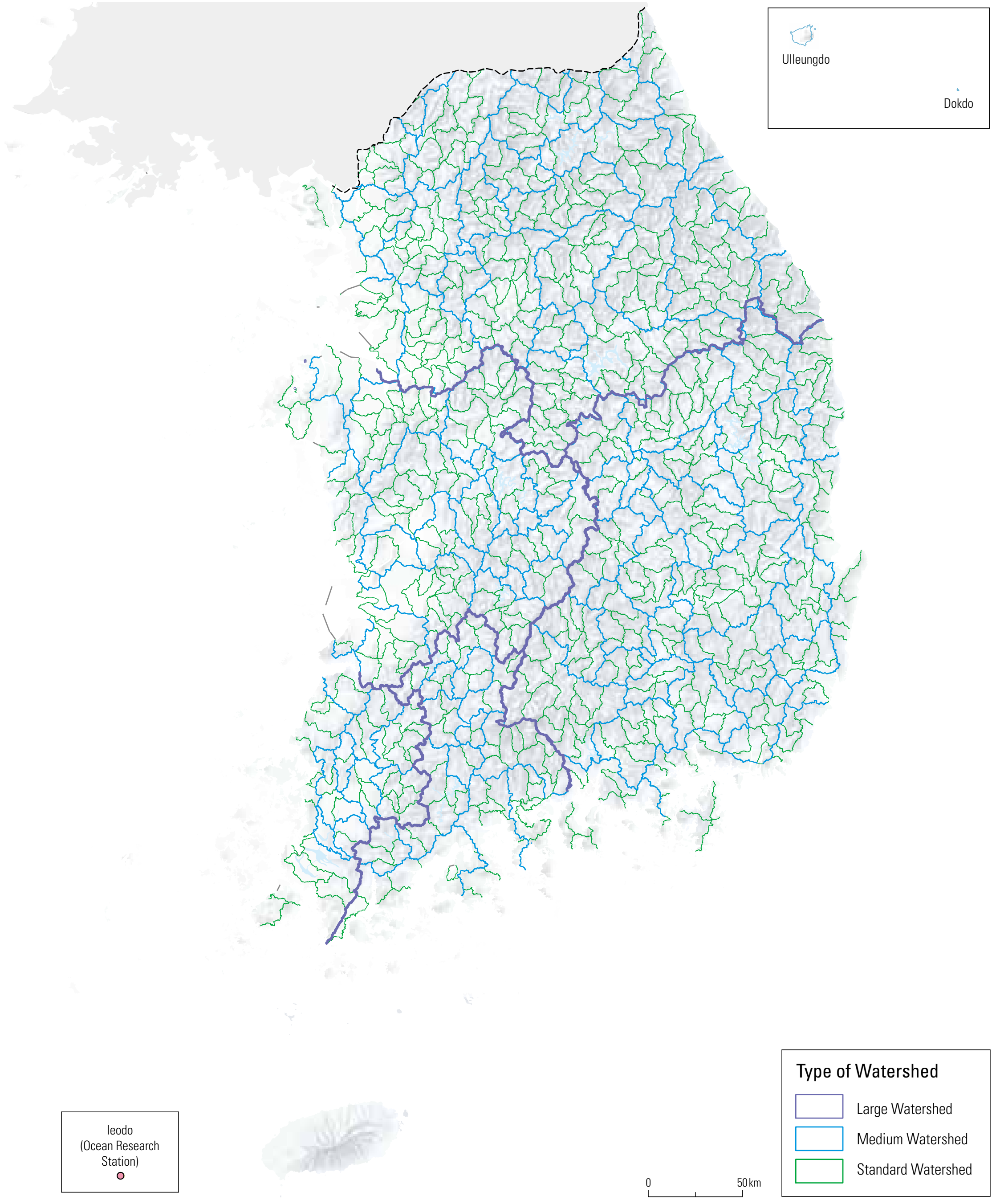
Geumgang starts in the center of the Korean Peninsula and flows northwest and southwest. It is 397.8 km long with a drainage area of 9,912 km², and its watershed lies mainly in Sejong-si, Daejeon, Chungcheongnam-do, Chungcheongbuk-do, and Jeollabuk-do. Originating in Tteunbongsaem Spring of Sinmusan (896.8 m), Subun-ri, Jangsu-eup, Jangsu-gun in Jeollabuk-do, Geumgang flows northwest through Daejeon, Daecheong reservoir, and Sejong, and then flows southwest through Gongju and Buyeo before finally discharging into the Yellow Sea. Until the completion of the Geumgang Estuary Dike in 1990, high tide seawater would flow upstream as far as Ganggyeong-eup, Nonsan-si, Chungcheongnam-do.

Seomjingang, flowing south in the southern part of the Korean Peninsula, is 223.9 km² long with a drainage area of 4,911 km². It has a watershed that is located across Jeollanam-do, Jeollabuk-do, and Gyeongsangnam-do. Starting at Demisaem Spring on Palgongsan (located at the boundary of Jinan-gun and Jangsu-gun, Jeollabuk-do), Seomjingang flows through Jeollanam-do and Gyeongsangnam-do, and discharges into the Gwangyang Bay in the South Sea.

Yeongsangang is located in the southwestern region of the Korean Peninsula. It is 129.5 km long with a drainage area of 3,467 km², and has a watershed that lies mainly in Jeollannam-do, Jeollabuk-do, and Gwangju. It originates in Yongso of Gamagol in Yongyeon-ri, Yong-myeon, Damyang-gun, Jeollanam-do, runs through the Naju Plains, and finally reaches the Yellow Sea at an estuary dike. The dike was constructed in 1981 to prevent seawater from flowing upstream at high tide. Hwangryonggang, Jiseokcheon, Gomakwoncheon, and Hampyeongcheon are some of the streams that flow into Yeongsangang.

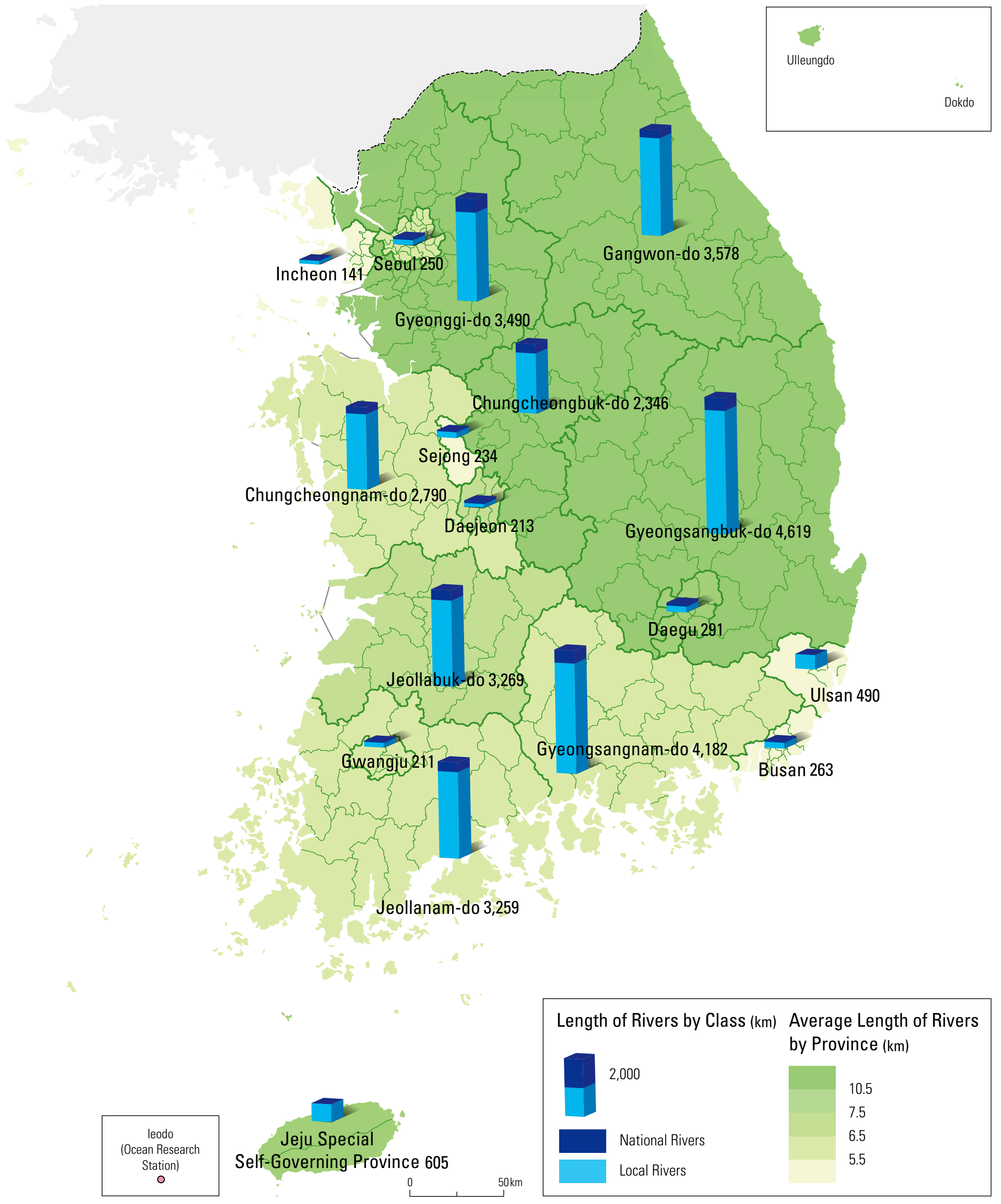
River Management

Watershed Boundary Map



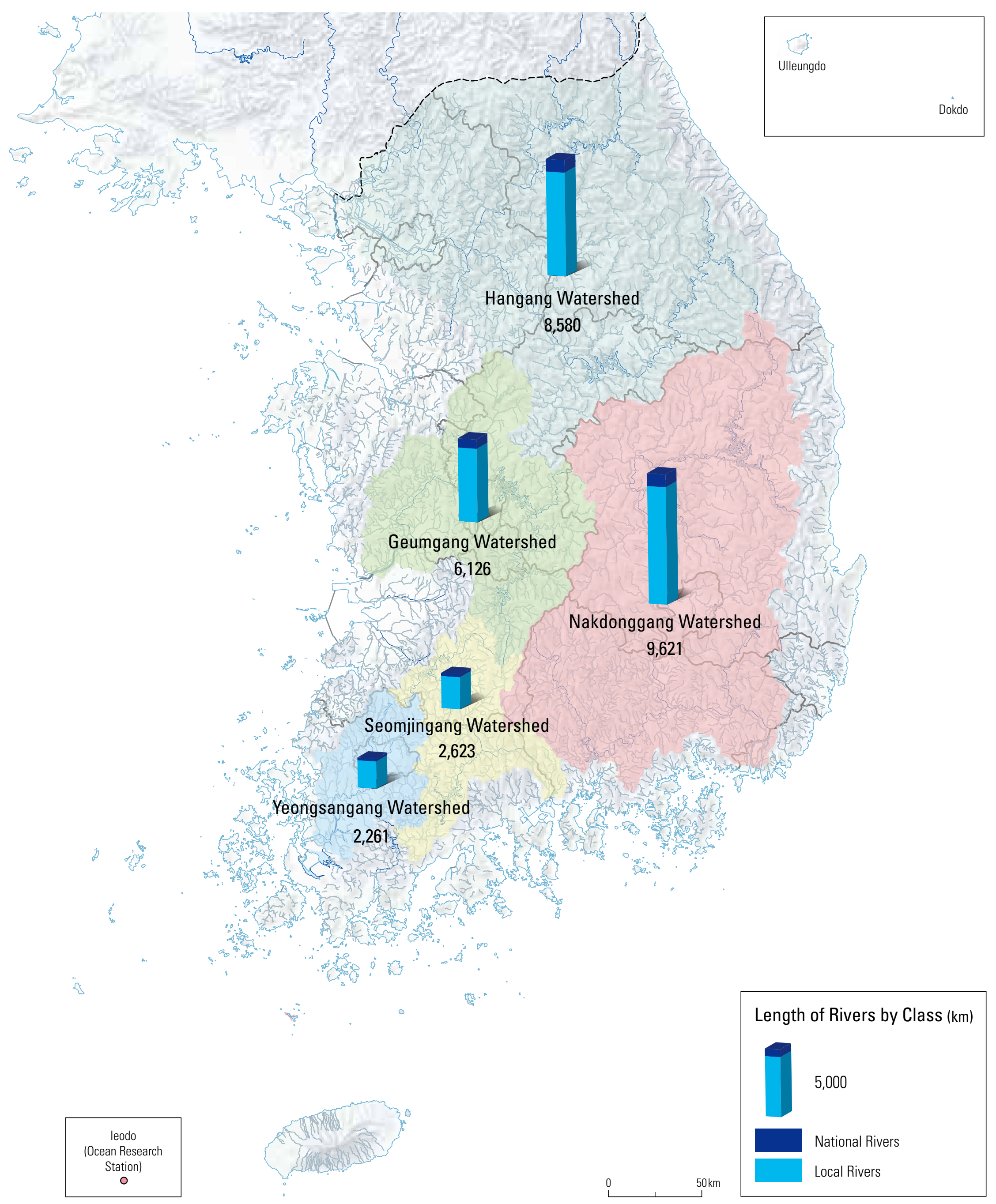
Ministry of Land, Infrastructure and Transport (2013)

Length of Rivers by Province



Ministry of Land, Infrastructure and Transport (2013)

Length of Rivers by Watershed



Ministry of Land, Infrastructure and Transport (2013)

Top 10 Longest Rivers

Name	Area of Watershed (㎢)	Length of River (㎞)	Annual Discharge (Hundred Million m³)*	Annual Precipitation (mm)*	Number of Channels
Hangang	25,953**	494	174	1,260	699
Nakdonggang	23,384	510	158	1,203	781
Geumgang	9,912	398	78	1,271	468
Seomjingang	4,911	224	44	1,457	283
Yeongsangang	3,467	130	30	1,340	169
Anseongcheon	1,656	60	12	1,215	103
Sapgyocheon	1,649	59	12	1,227	98
Mangyeonggang	1,527	77	12	1,282	70
Hyeongsangang	1,140	62	7	1,157	30
Dongjingang	1,136	51	8	1,242	87

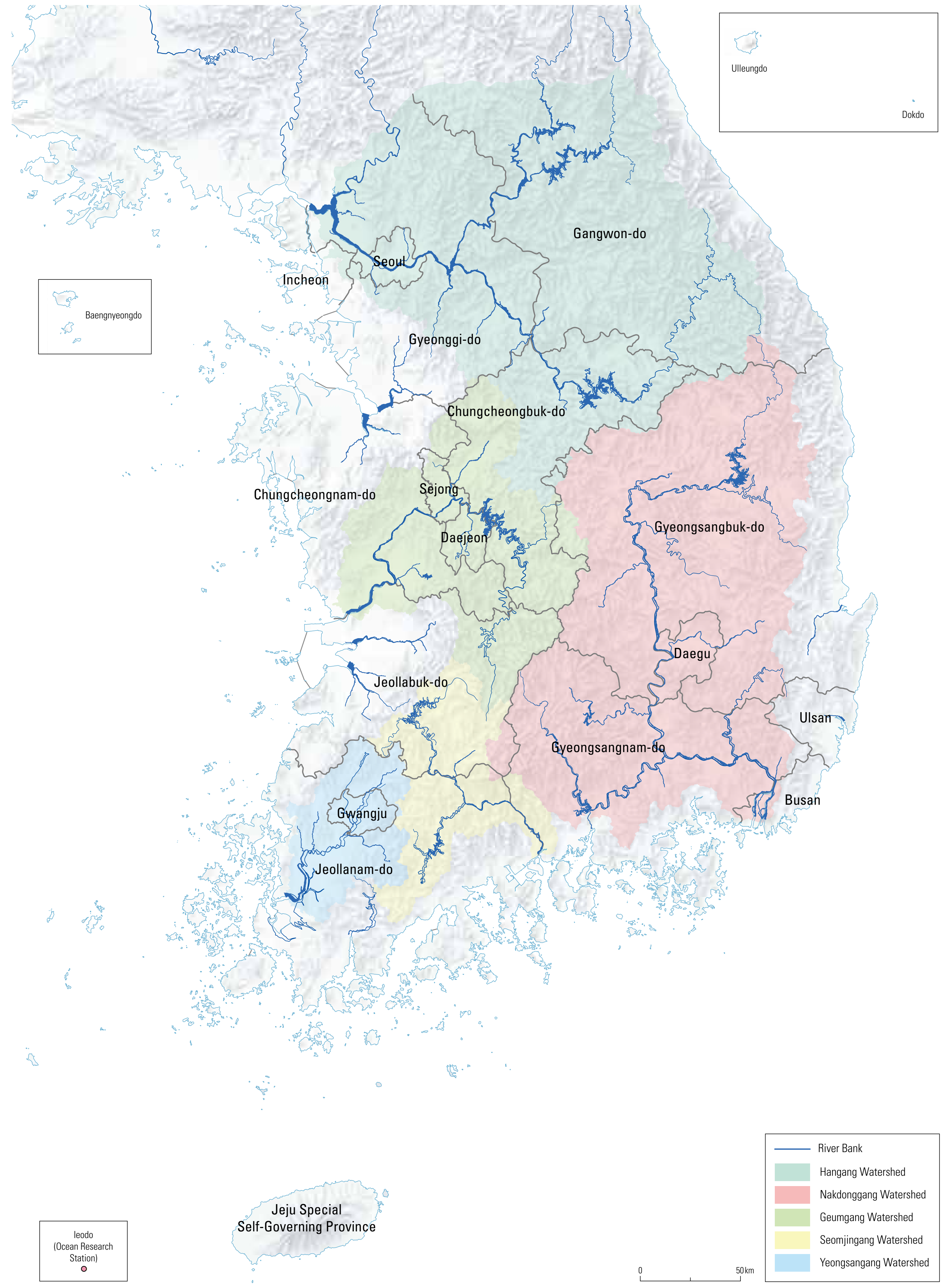
*: Annual discharge and precipitation values are based on the 30-year average from 1978 to 2007.
**: The area is 35,770 km^2 when including watershed areas in North Korea.

Ministry of Land, Infrastructure and Transport (2013)

Based on watershed area, the 10 largest rivers in South Korea are Hangang, Nakdonggang, Geumgang, Seomjingang, Yeongsangang, Anseongcheon, Sapgyocheon, Mangyeonggang, Hyeongsangang, and Dongjingang. The Hangang watershed is the largest in terms of area and volume; it has a drainage area of 25,953 km^2 and a volume of 17.4 billion m^3. Nakdonggang is the longest river, with a length of 510 km. The Seomjingang watershed has the highest average precipitation of 1,457 mm, while the Hyeongsangang watershed has the lowest annual precipitation of 1,157 mm.

Rivers in Korea are divided into two categories: legally designated rivers and small rivers. Legally designated rivers encompass both national and local rivers, while small rivers are designated by the Small River Maintenance Act. National rivers are relatively larger bodies that are important for environmental conservation and the economy of the country. Some examples include upper stream rivers affected by drainage from reservoirs, lower stream rivers located downstream from multipurpose dams, and rivers that flow through densely populated or protected areas. Local rivers are often relevant with public use and are managed by regional governments.

River Banks



Ministry of Land, Infrastructure and Transport (2013)

A River Master Plan is a comprehensive river maintenance, conservation, and utilization plan for the functional sustenance and prevention of natural disasters in river systems. Based on the analysis of weather conditions, terrain, and social and natural environment of each watershed, it is implemented and revised every 10 years in order to systematically preserve and manage rivers. As of December 2013, the River Master Plan has been established for approximately 81.6% (24,331.2 km) of all rivers in Korea: 99.1% (2,969.1 km) of national rivers and 79.6% (21,362.2 km) of local rivers.

Based on the River Master Plan, river banks are established to prevent flooding by calculating the area of cross-section depending on flood discharge standards for each river. By December 2013, 52.1% of the total length of legally designated rivers completed river bank maintenance. 23.1% of all river areas require newly established banks, among which 3.8% are for national rivers, while 48.9% are for local rivers.

River Master Plans by Class

Class	With Plan		Without Plan		Completion Rate by Length (%)
	Number of Channels	Length (km)	Number of Channels	Length (km)	
National Rivers	62	2,969.1	3	26.3	99.1
Local Rivers	3,082	21,362.2	1,664	5,460.0	79.6
Total	3,144	24,331.3	1,667	5,486.3	81.6

Ministry of Land, Infrastructure and Transport (2013)

River Maintenance by Class

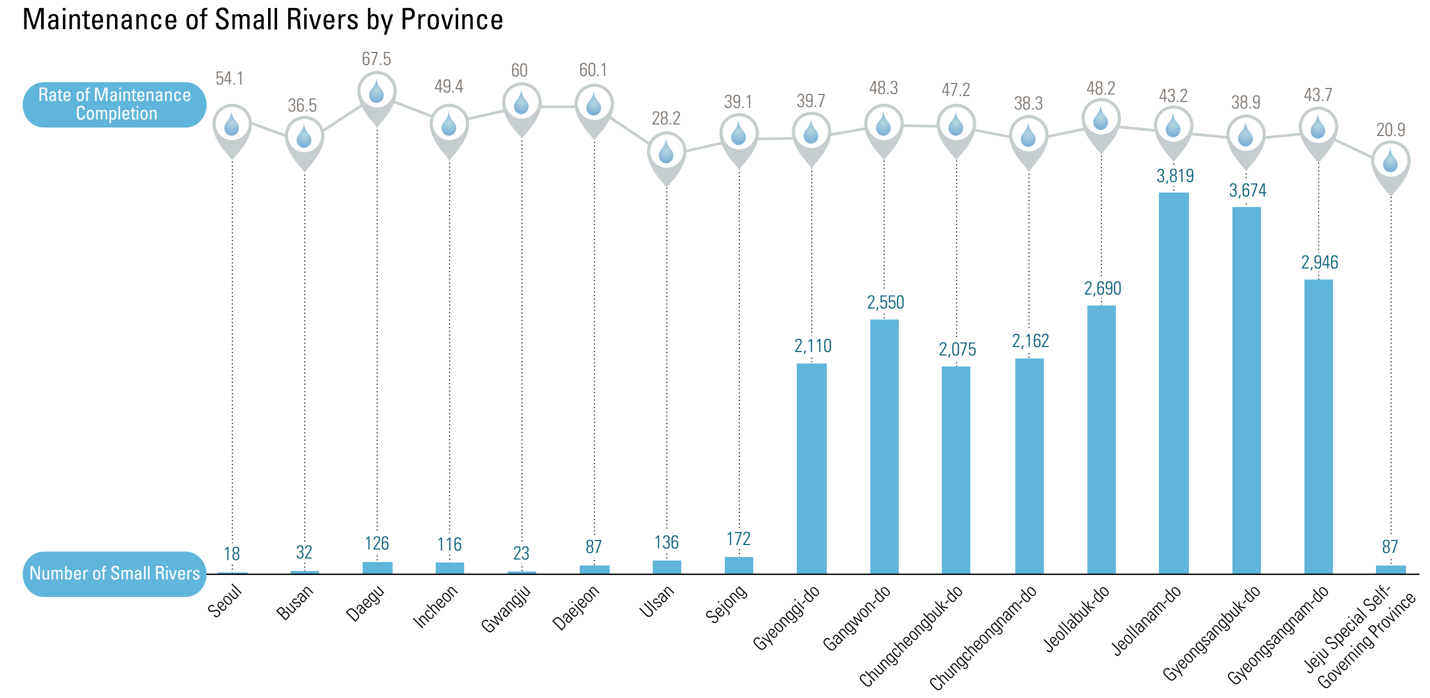
Class	Maintenance Completed		Reinforcement Needed		Infrastructure Needed		Total (km)
	(km)	(%)	(km)	(%)	(km)	(%)	
National Rivers	2,561.5	80.4	505.0	15.9	119.5	3.8	2,995.4
Local Rivers	13,992.4	48.9	7,403.7	25.9	7,223.9	25.2	26,822.2
Total	16,553.8	52.1	7,908.7	24.9	7,343.4	23.1	29,817.6

Ministry of Land, Infrastructure and Transport (2013)

Among the five major rivers, Hangang displays the highest percentage of maintenance completion at 56.9%, followed by Yeongsangang at 56.3%. Geumgang has the highest percentage of reinforcement needed (28.9%), while Yeongsangang comes last (21.6%). Seomjingang requires the most new infrastructure (31.8%), while Hangang needs the least (18.7%). By municipal district, Seoul has the highest percentage of maintenance at 95.8%, followed by Gwangju (87.1%) and Daegu (76.3%). Sejong shows the highest percentage of reinforcement needed at 34.4%, followed by Chungcheongnam-do (30.8%) and Jeollabuk-do (29.2%). Districts that need the most new infrastructure are Incheon (45.6%), Jeollanam-do (32.2%), and Jeju Special Self-Governing Province (31.5%).

In terms of small-scale rivers, records indicate that 43.1% of a total of 22,823 rivers in Korea have been maintained. Daegu had the highest rate of small-scale river maintenance at 67.5%, followed by Daejeon (60.1%), Gwangju (60.1%), and Seoul (54.1%). On the other hand, Jeju Special Self-Governing Province has a small-scale river maintenance rate of only 20.9%.

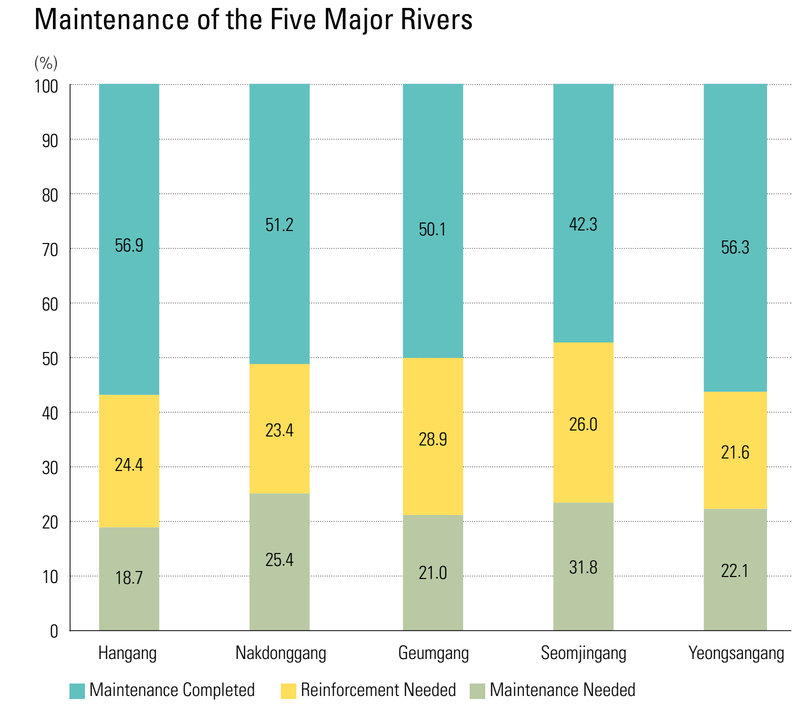
Maintenance of Small Rivers by Province



*Small rivers are not subject to the application of the River Act, and the maintenance of small rivers is aimed at preventing disasters and creating a hydrophilic environment.

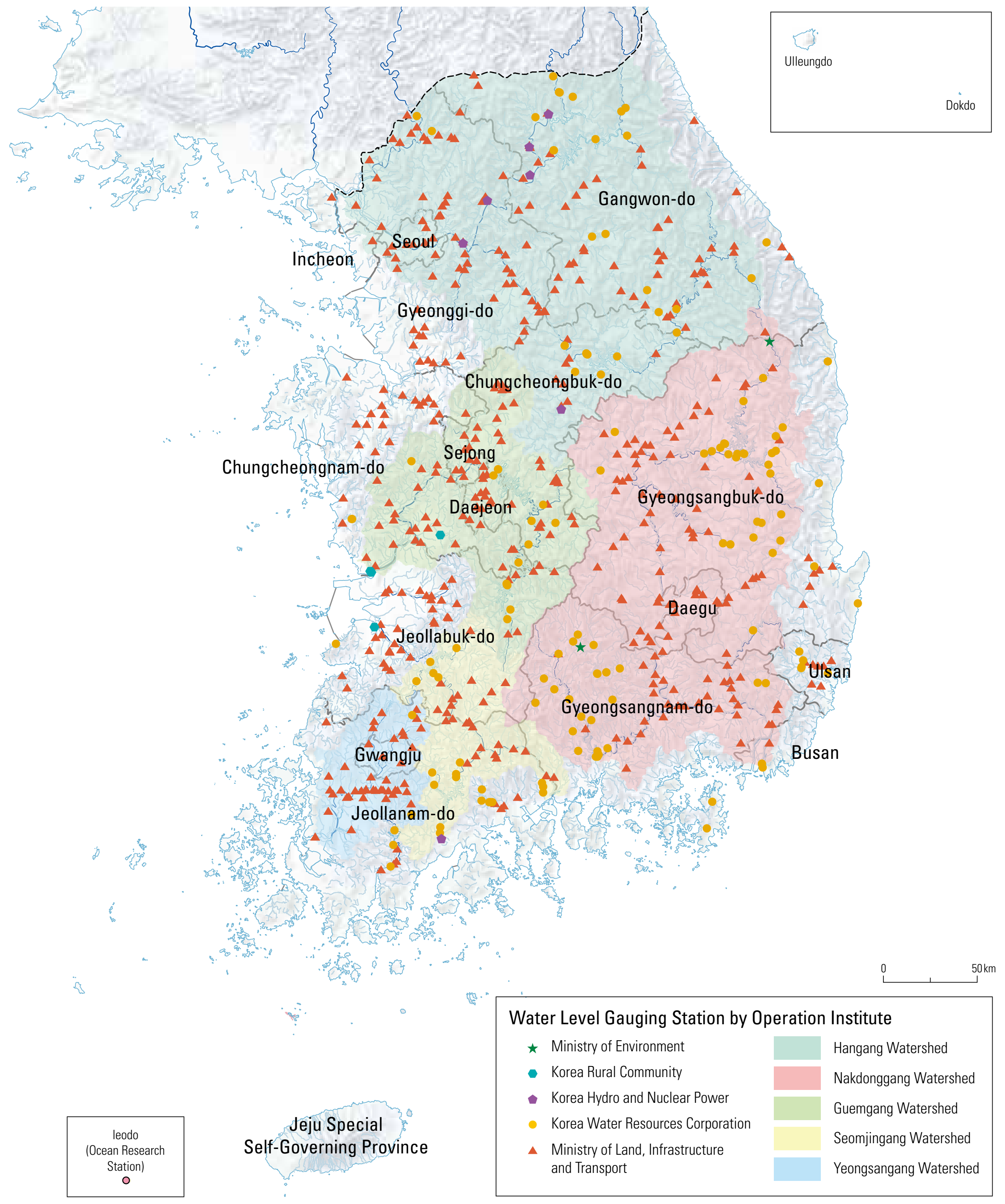
National Groundwater Information Center (2015)

Maintenance of the Five Major Rivers



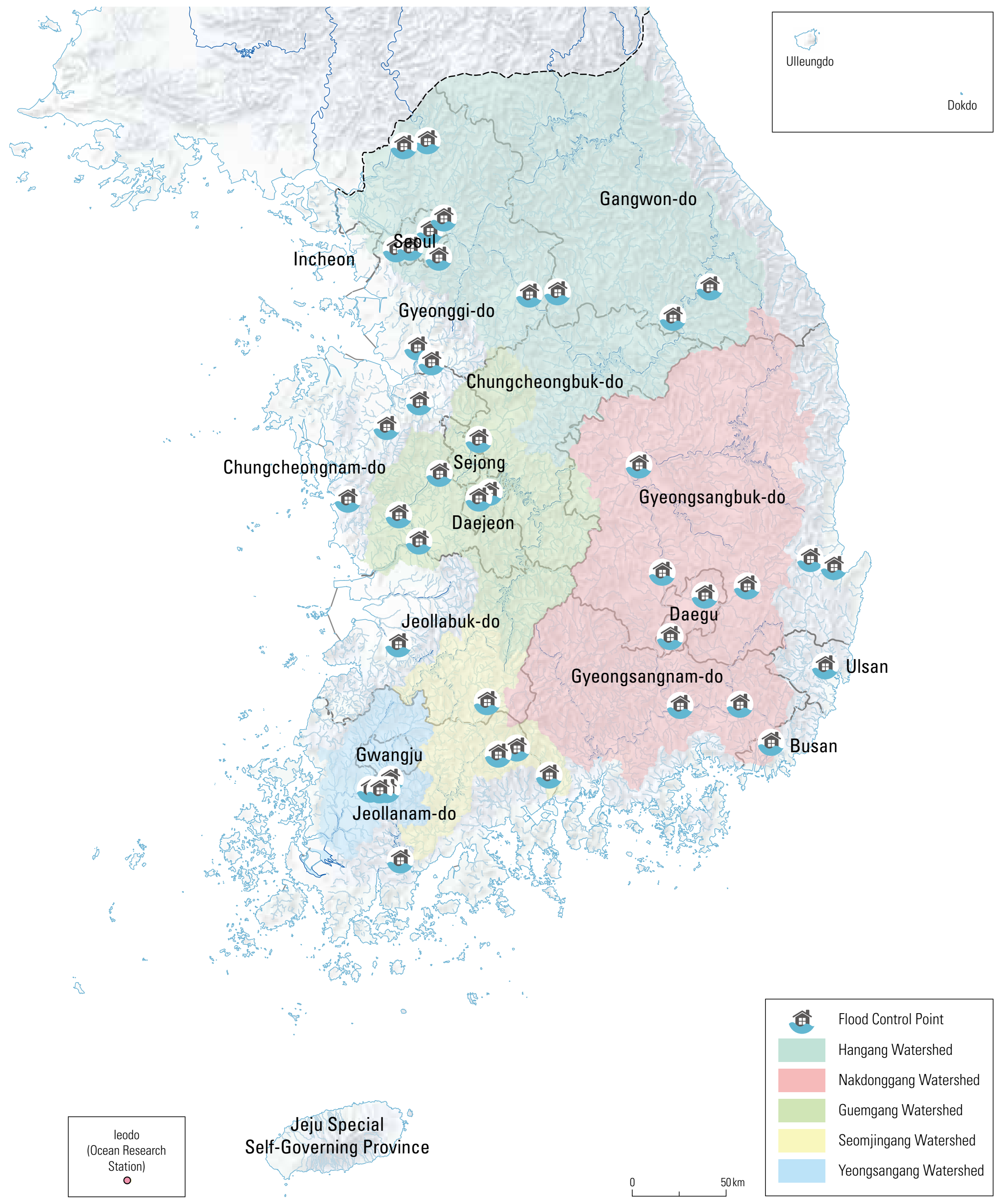
Ministry of Land, Infrastructure and Transport (2013)

Distribution of Water Level Gauging Stations



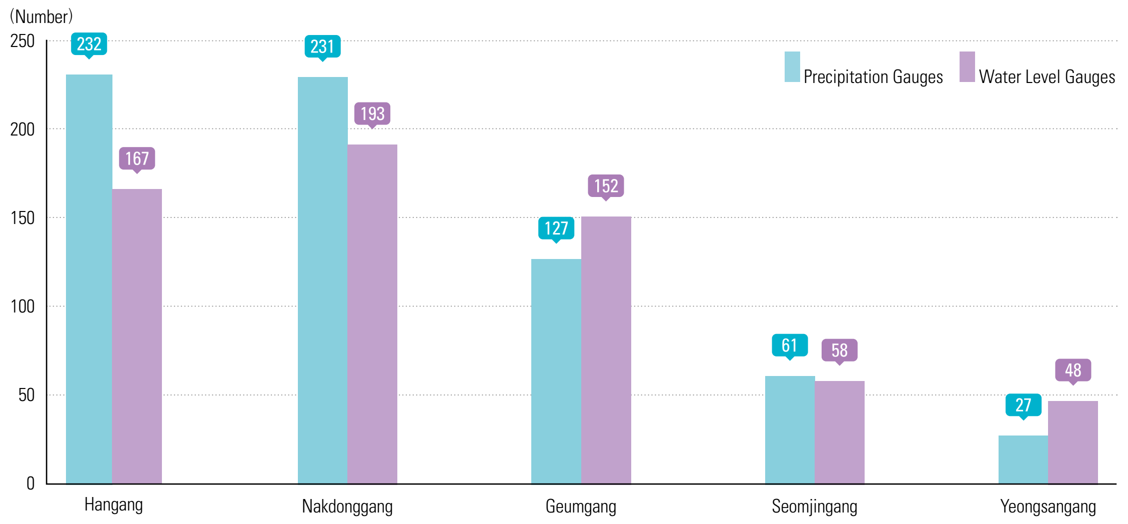
Ministry of Land, Infrastructure and Transport (2013)

Flood Control Points



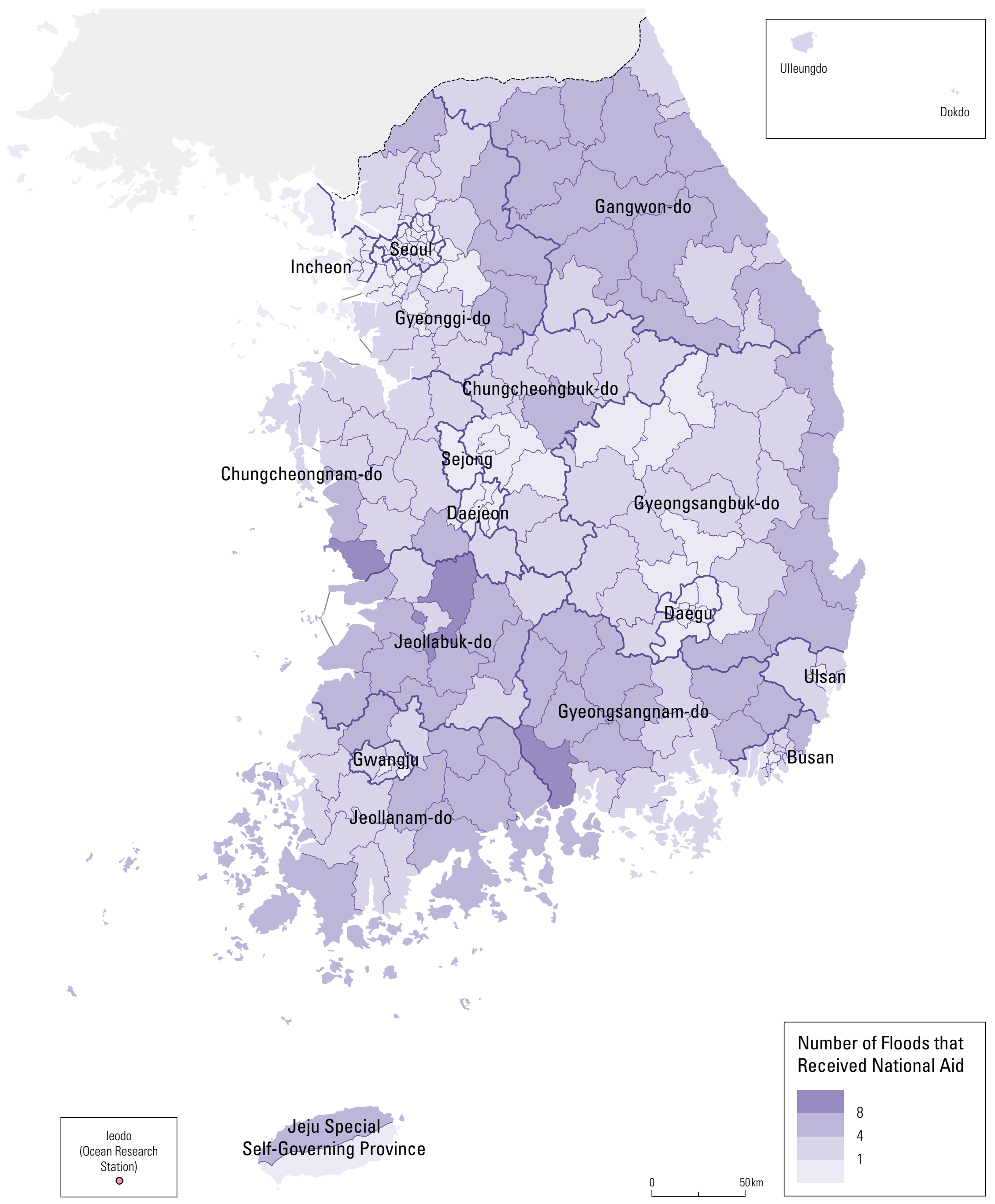
Ministry of Land, Infrastructure and Transport (2013)

Number of Precipitation and Water Level Gauges on Major Rivers



Ministry of Land, Infrastructure and Transport (2013)

Number of Floods that Received National Aid (2005 – 2014)

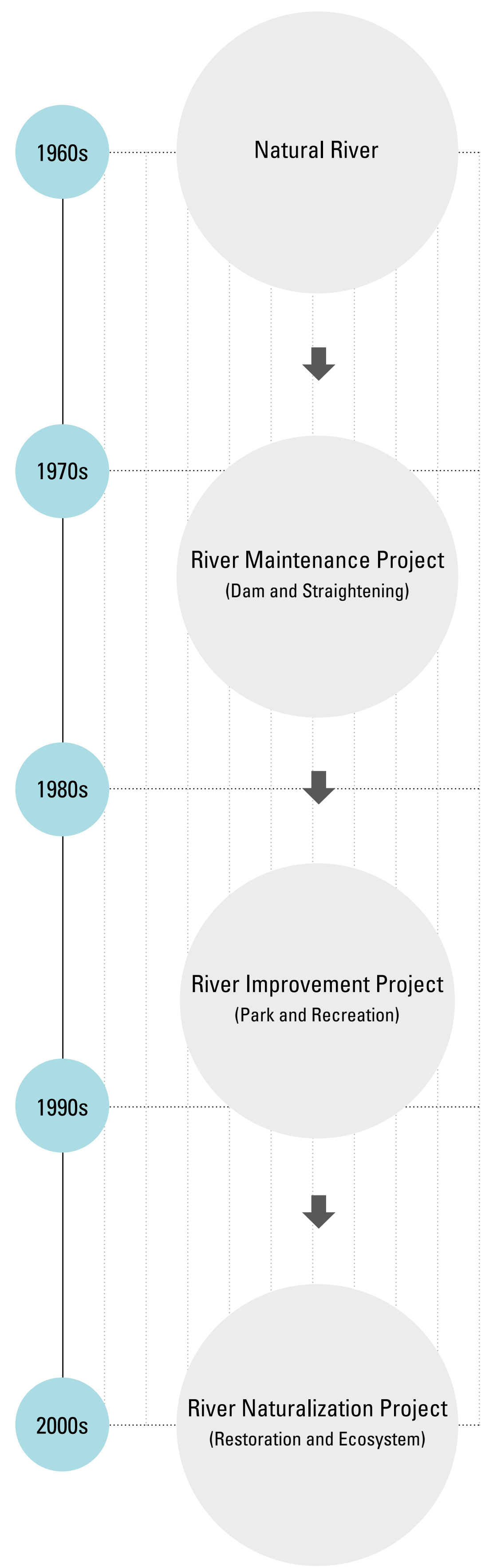


Ministry of Land, Infrastructure and Transport (2015)

River flow data is not only important for calculating the quantity of water resources, but also for developing comprehensive water resource management plans and policies. Water level gauging stations are established to consistently record water levels every 10 minutes and calculate flow rate using the stage-discharge relationship formula. A total of 684 precipitation gauges and 618 water level gauges are currently installed along watersheds all across the nation. The Nakdonggang watershed has the largest number of water level gauges at 193, followed by the Hangang watershed at 167 and the Geumgang watershed at 152. The Seomjingang and Yeongsangang watersheds have 58 and 48 water level gauges, respectively.

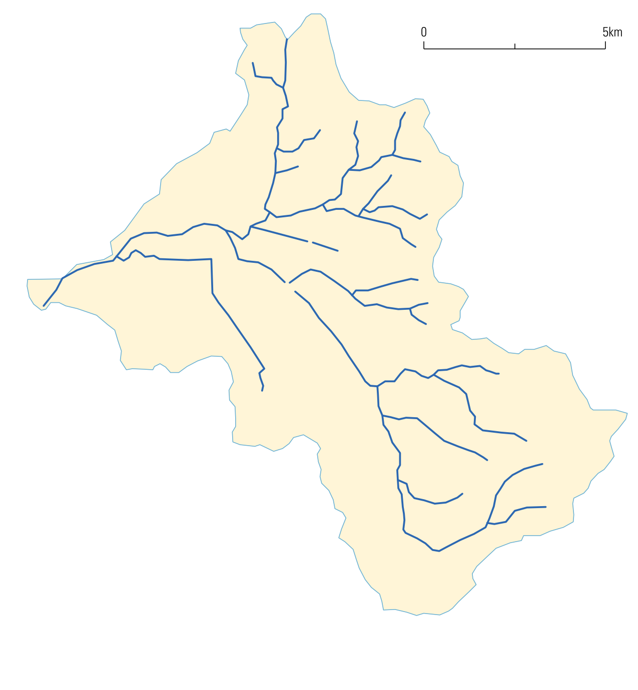
Recent changes in global climate have led to an increase in localized heavy rain, which in turn brought about a rise in consequential damage. Over the past ten years (2005 – 2014), 383 separate severe flooding events caused more loss than the national subsidy limit. As such, Korea implemented a flood control system that prevents floods in order to minimize potential casualties and property damage. Initially focused on vulnerable areas of large rivers, the system is expanding to include those of small rivers as well. As of 2015, Korea has a total of 46 flood control offices nationwide. Hangang has 13 offices, including Hangang Bridge and Jamsu Bridge, Nakdonggang has 12, such as Waegwan Railway Bridge in Waegwan-eup, Chilgok-gun, Gyeongsangbuk-do, Geumgang has 8, including Geumgang Bridge, Gongju-si, and Yeongsangang has 13 offices, including Naju Bridge in Naju-si, Jeollanam-do.

River Management Policy

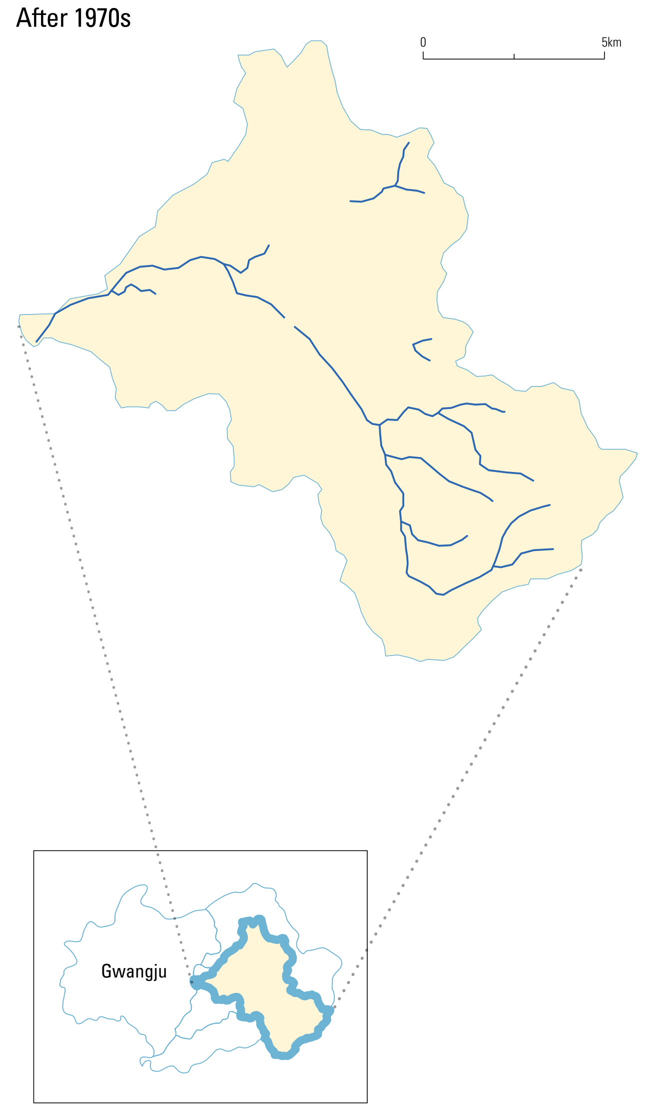


Covered Channels in Gwangjucheon

Before 1970s



After 1970s



Soyanggang Dam Construction

With the river maintenance project, various dams were constructed to access water for agriculture and generate hydroelectric power. In 1965, Korea's first multipurpose dam, Seomjingang Dam, was built. Soyanggang Dam—Korea's largest storage reservoir—was established in 1973. While these dams were beneficial for securing water and other hydroelectric resources, their construction provoked various social conflicts, including environmental issues and resident displacement.

River Maintenance Project

Initiated around the 1970s, the river maintenance project mostly focused on straightening river channels and building concrete levees for flood control. By the 2000s, 80% of the river maintenance had been completed, and many river reservations were turned into farmlands. However, such vigorous development involving artificial structures resulted in an increase in stream velocity rates and a devastation of ecological functions and self-restoration abilities.

Before the Cheonggyecheon Restoration Project

After the Cheonggyecheon Restoration Project

River Restoration Projects (Seunggicheon, Incheon)

As part of the rapid urbanization that followed the 1970s, many rivers surrounding cities were covered to make way for roads and parking lots. Beginning in the 1990s, projects were initiated to convert rivers into parks, fueling discussions to restore rivers that were previously covered. A major example is the Cheonggyecheon Restoration Project, completed in 2005.

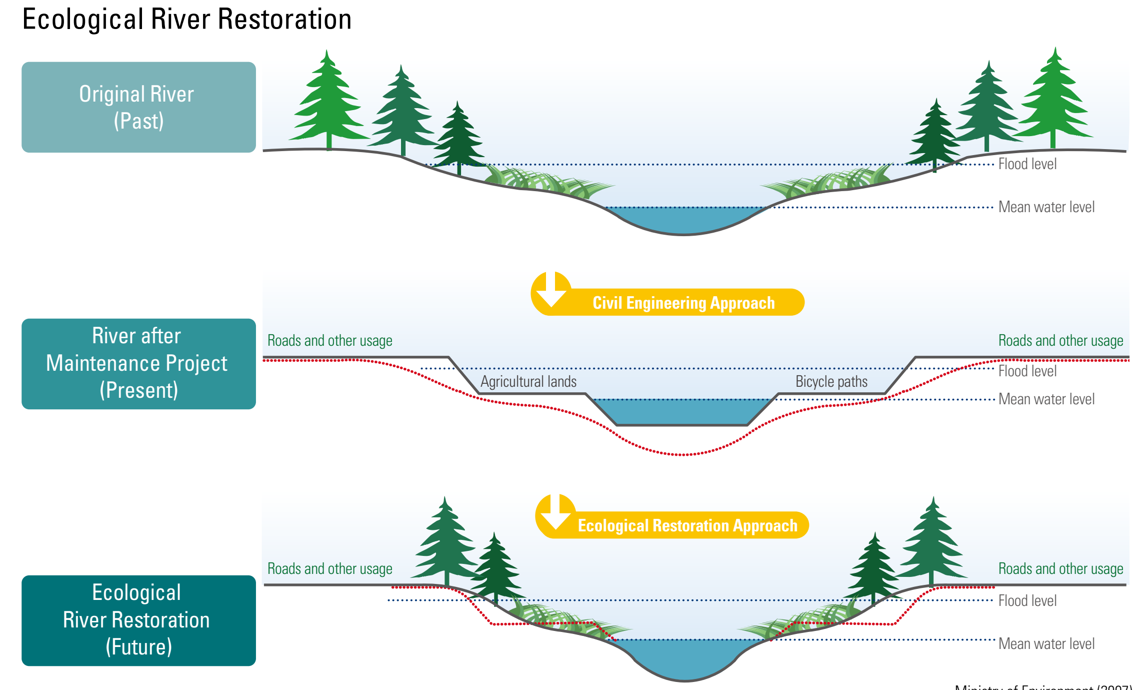
World Water Forum

The 7th World Water Forum was held in Daegu/Gyeongsangbuk-do of Korea on April 12, 2015 under the theme "Water for Our Future." 168 countries participated and 40,000 people registered, making it the largest event in the history of the forum. The main agenda of the World Water Forum is to discuss a variety of water-related topics—such as climate change, disasters, and green growth—from social, economic, and environmental perspectives. National governments, academia, research institutions, and businesses are just some of the participants that take part in the dialogue. By hosting the forum, Korea expects to heighten its international recognition and value, strengthen its global competitiveness, and increase opportunities for companies to expand overseas.

River Management Policy by Period

Year	Target	Main Activities
Before 1970s	Water resource development and establishment of river maintenance system	Enactment of River Act (1961), Establishment of Korea Water Resource Corporation (1966), 10-Year Water Resource Development Plan (1966 – 1975)
1970 – 1980	Development of integrated watershead management and construction of multipurpose dams	Establishment of 4 Major Watersheds Development Plan (1971 – 1981), multipurpose Dam; Soyanggang Dam (1973)
1981 – 2001	Basic plan for a long-term integrated development of water resources	Provides stable water supply, Increase in river improvement rate and hydroelectric power
1990 – 2000	Development of environmentally friendly rivers	Organizing integrated water management such as irrigation works, flood control, water quality conservation on hydrologic units, Riparian area maintenance.
After 2000	Intergrated water resource management policy	Dualistic management of water quantity and quality, flood control based on river system, and development of a water management policy relative to ecology and culture.

Ecological River Restoration

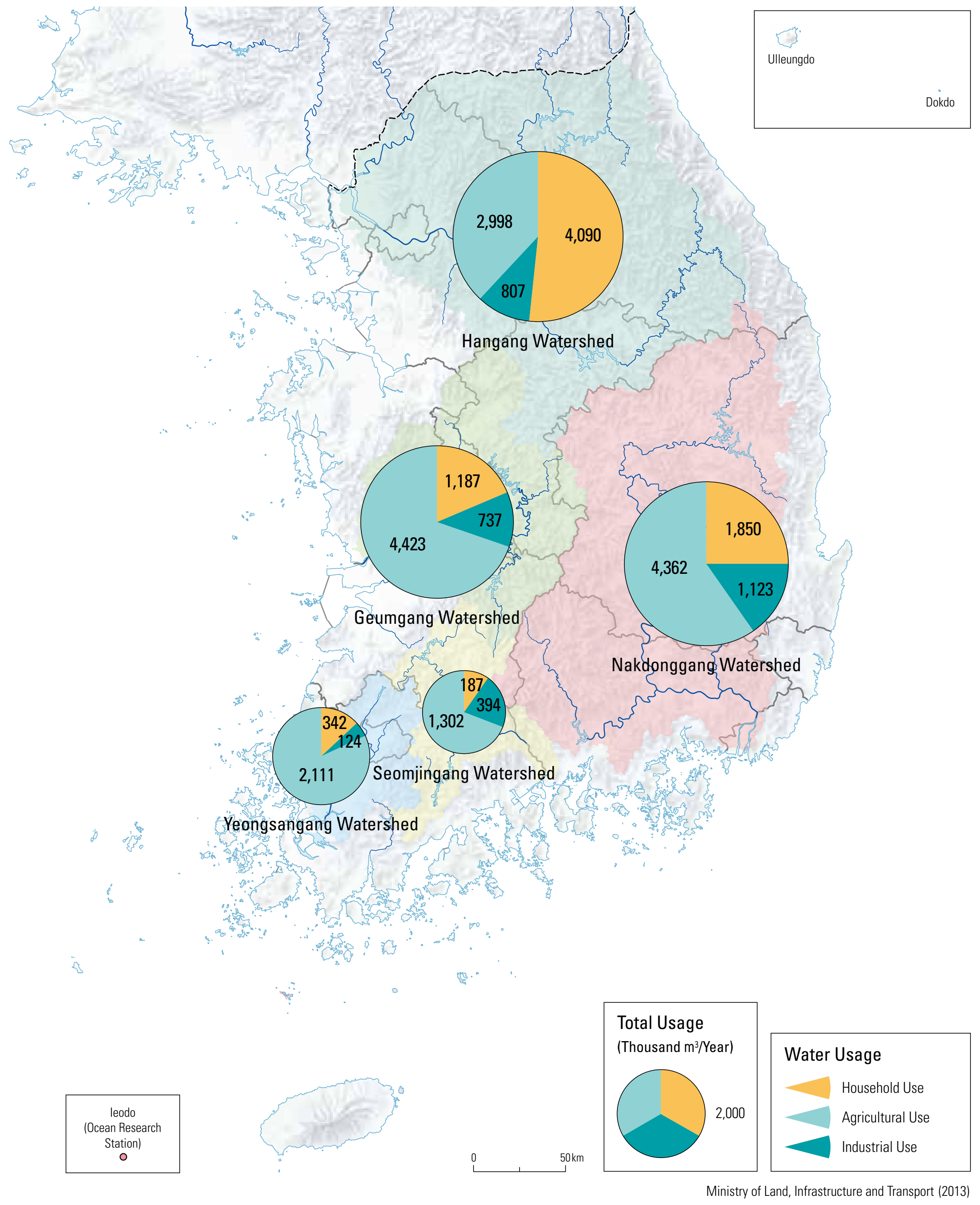


Ministry of Environment (2007)

Up until the 1950s and 1960s, most rivers in Korea were in their natural form. However, in accordance with the rapid urbanization of the 1970s, many tributaries were covered or revamped and meandering channels were straightened out in rural areas. As environmental issues gained light in the 1990s, various environmental improvement projects (such as the construction of waterfront parks and promenades) were launched in areas around rivers. In the 2000s, the concept of improvement evolved beyond the simple concept of parks to recognize the ecological and scenic conservation value of rivers for ecosystems and humans.

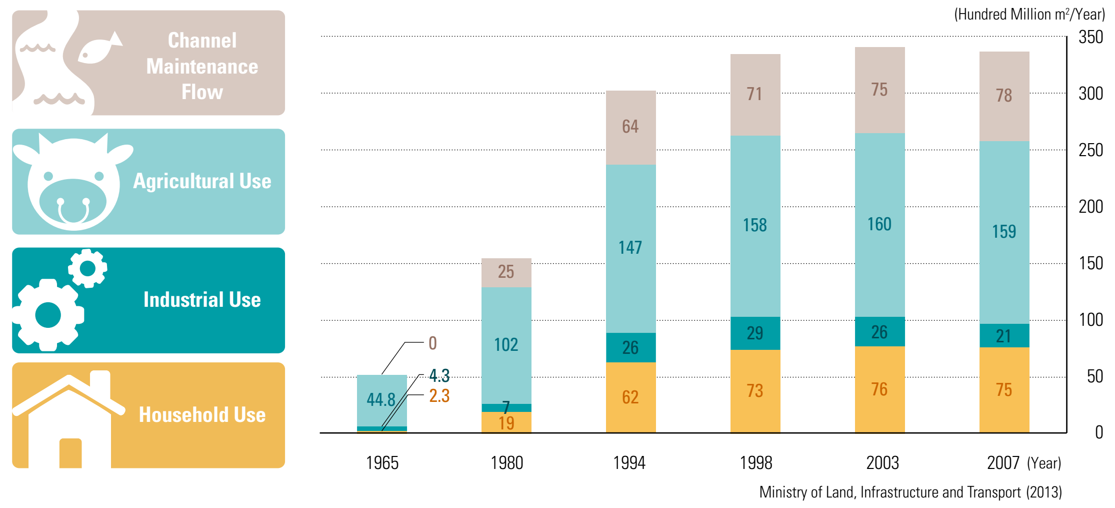
Water Distribution and Usage

Water Usage by Watershed



Ministry of Land, Infrastructure and Transport (2013)

Water Usage by Year



Ministry of Land, Infrastructure and Transport (2013)

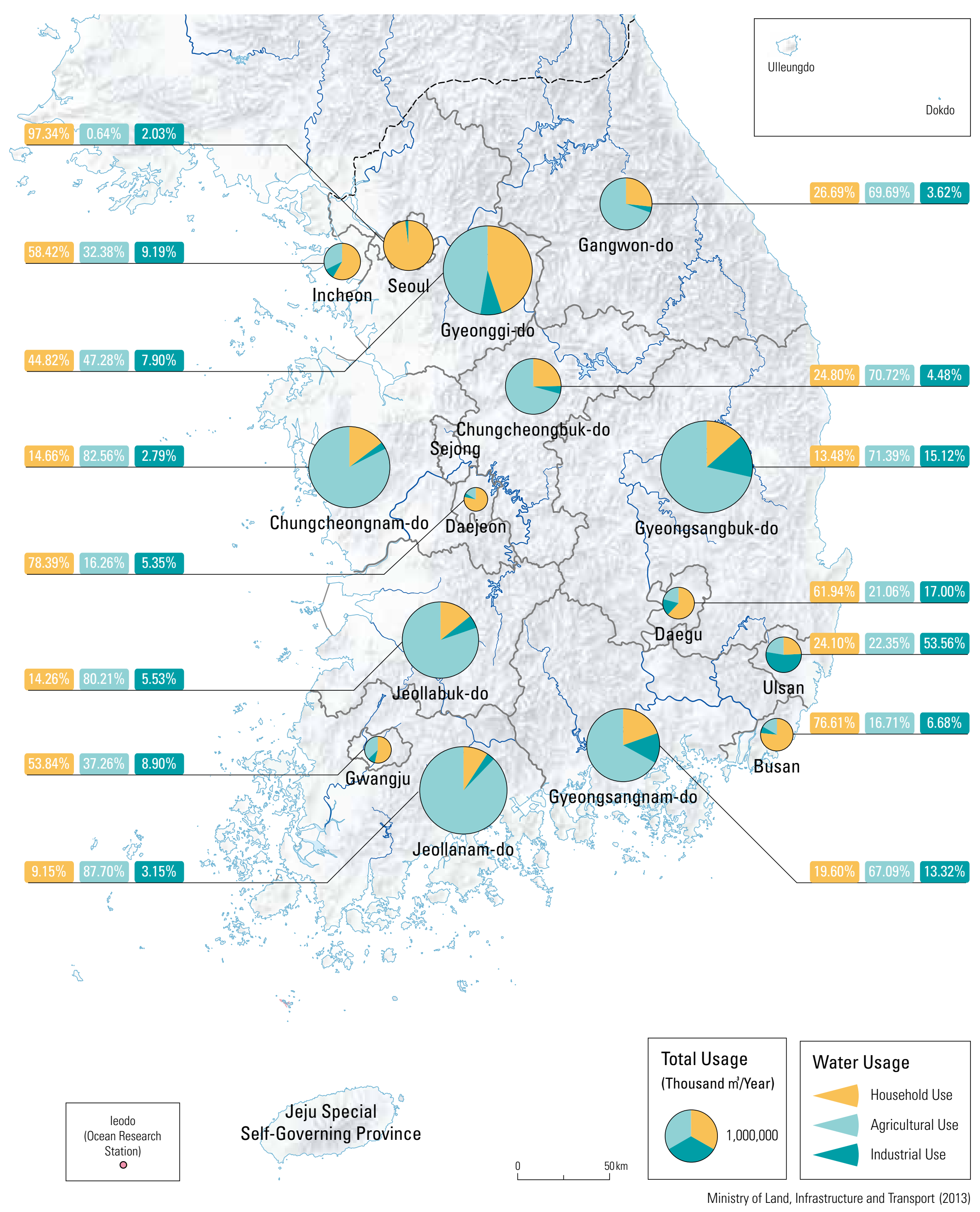
The total water use of Korea increased more than six times from 5.12 billion m³ in the 1960s to 33 billion m³ in the 1990s. This steep rise can be attributed to population growth, economic advancement, increased industrial development, and an increasing number of irrigation facilities. Accordingly, channel maintenance flow also increased to protect water quality, ecosystems, and landscapes. Since the 2000s, however, the rate of increase for water usage has been slowing down.

In 2007, agricultural use accounted for the largest proportion of total water use at 48%, followed by domestic use (23%), channel maintenance flow (23%), and industrial use (6%). Domestic and industrial water usage remained about the same since 1998, while agricultural use experienced a decrease over the same time period. On the other hand, channel maintenance flow – which is used for maintaining river functions – has gradually increased.

As of 2011, the Hangang watershed was recorded as the largest area of water use at 5.23 billion m³, followed by the Nakdonggang watershed (5.1 billion m³), Geumgang watershed (2.61 billion m³), Yeongsangang watershed (1.5 billion m³), and Seomjingang watershed (0.9 billion m³).

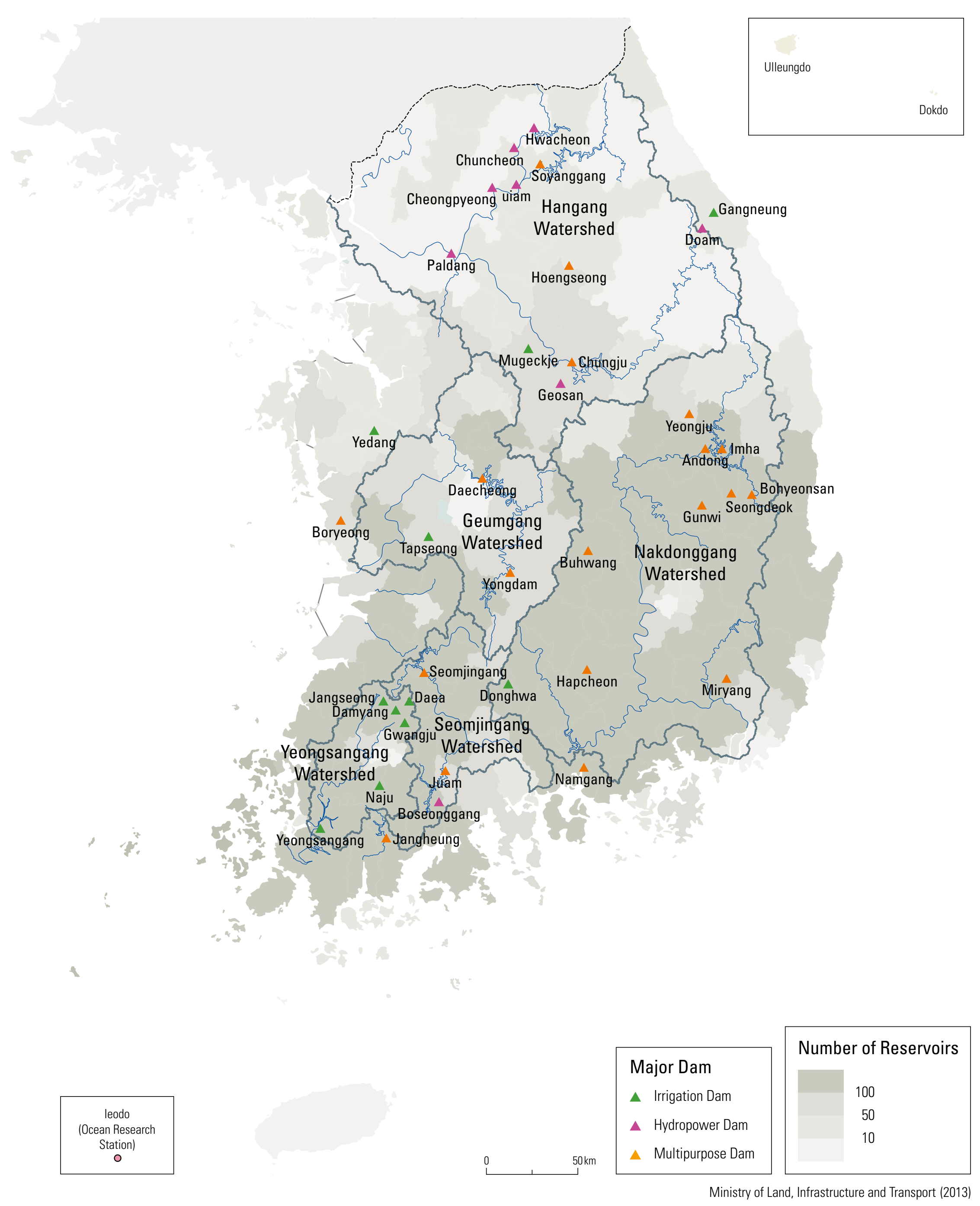
In the Hangang watershed, domestic water use took the highest proportion of water use at 54.4%, while agricultural and industrial water use accounted for 44.1% and 1.6%, respectively. For all other watersheds, agricultural water use had the highest proportion, followed by domestic and industrial water use. The rate of domestic water use is highest in the Hangang watershed due to the large population that inhabits the area. Large industrial complexes contribute to the relatively high rate of industrial water use in the Nakdonggang watershed (6.4%), while a smaller population and fewer industrial facilities are responsible for the relatively high rate of agricultural water use in the Seomjingang watershed (88.1%).

Water Usage by Province



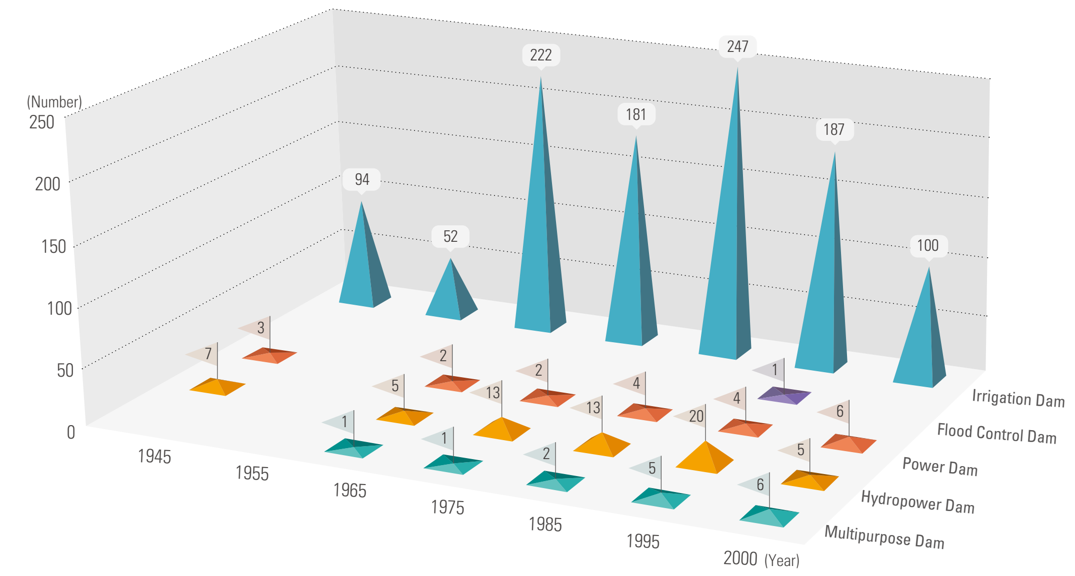
Ministry of Land, Infrastructure and Transport (2013)

Distribution of Dams and Reservoirs

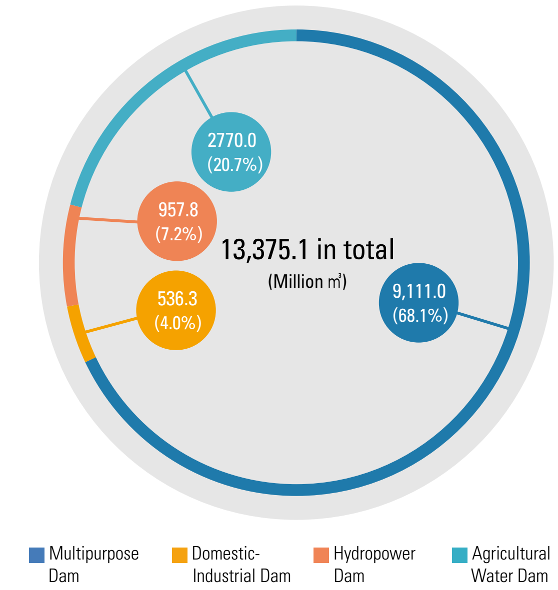


Ministry of Land, Infrastructure and Transport (2013)

Number of Dams Constructed by Year



Available Reservoir Storage

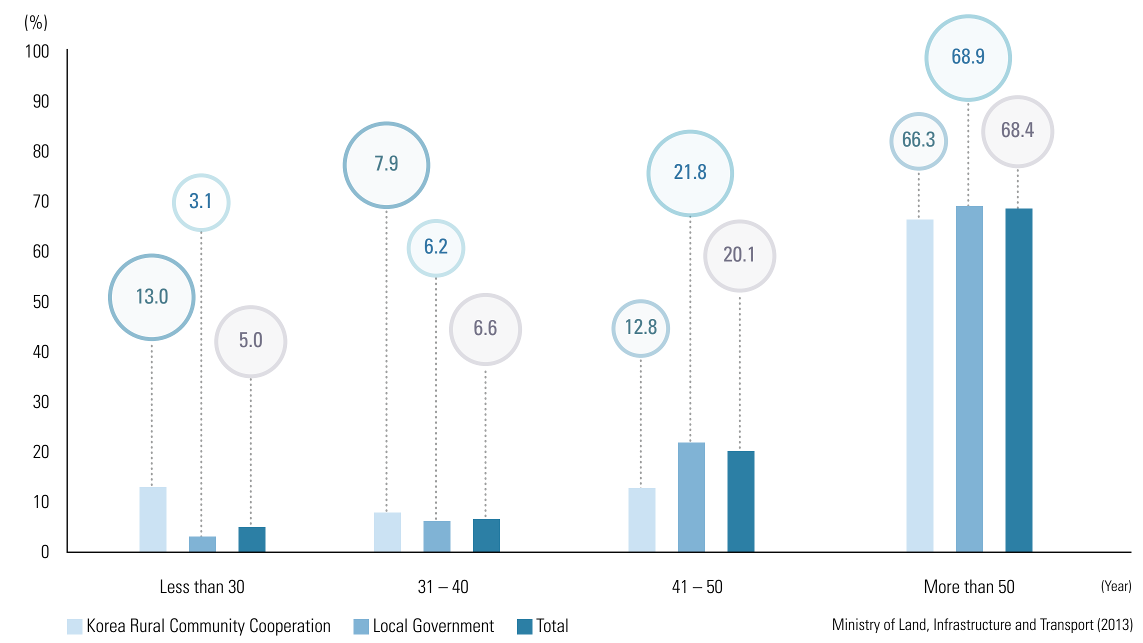


Potential Hydropower Generation by Watershed

Potential Volume (Million m³)	Theoretical Potential Volume	Geographical Potential Volume	Technical Potential Volume
Hangang	14,262	7,796	2,496
Nakdonggang	14,502	7,782	2,490
Geumgang	6,770	3,436	1,099
Seomjingang	4,034	2,074	650
Yeongsangang	2,187	1,338	428
Jeju Special Self-Governing Province	1,672	272	87
Total	**43,427**	**22,698**	**7,250**

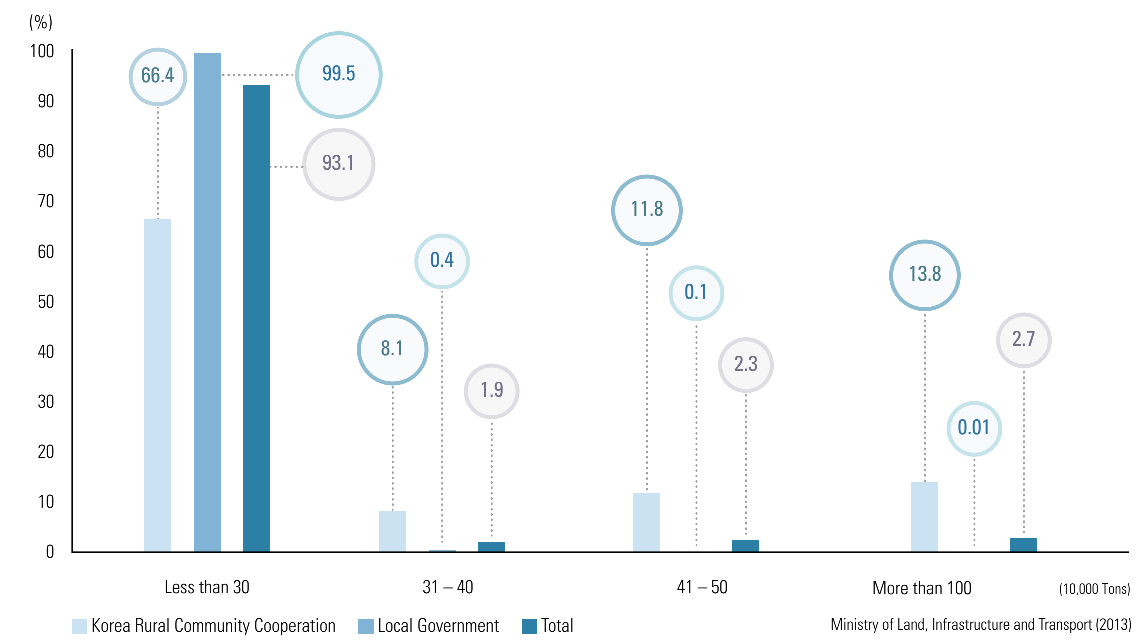
Water and Future (2015)

Age of Reservoirs (2013)



Ministry of Land, Infrastructure and Transport (2013)

Reservoir Storage Volume

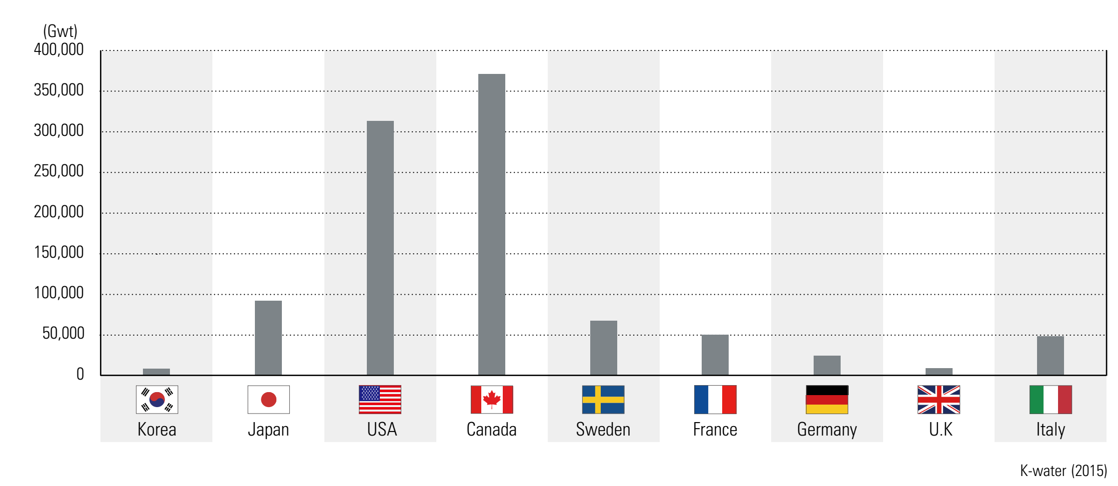


Ministry of Land, Infrastructure and Transport (2013)

Weirs and Bike Paths of the Four Rivers

River Guide (2015)

Hydropower Generation and Rate by Country



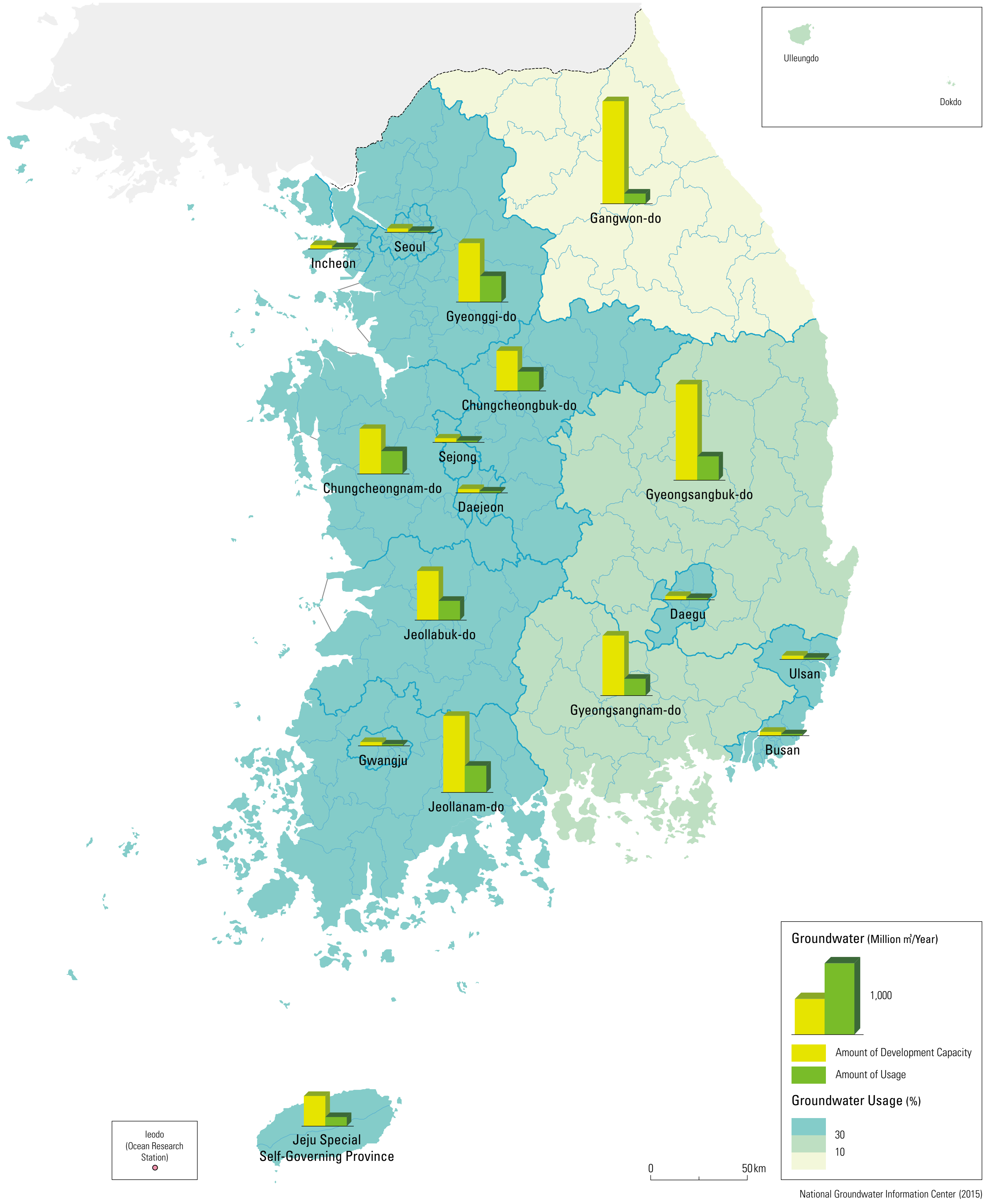
K-water (2015)

As of 2014, Korea has a total of 17,735 dams and reservoirs, including those under construction. This number includes 20 multipurpose dams, 54 domestic and industrial dams, and 12 hydroelectric dams, with the rest being small-scale agricultural dams. In terms of hydropower capacity, multipurpose dams account for 68.1% of all structures. There are also three dams for flood control: "Dam for Peace," Gunnam Flood Control Reservoir, and Hantangang Dam.

The distribution of dams by watershed indicates that 27 are located in the Nakdonggang watershed, 24 in each of the Hangang and Geumgang watersheds, and 9 in each of the Yeongsangang and Seomjingang watersheds. In the Hangang watershed, 37.5% of the dams are hydroelectric dams, while 33.3% are hydropower dams. 66.7% of dams in the Nakdonggang watershed are composed of domestic/industrial (37.0%) and multipurpose (29.6%) dams. Agricultural dams in the Geumgang and Yeongsangang watersheds take about 75.0% and 77.8%, respectively, while all types of dams are relatively evenly distributed in the Seomjingang watershed. Overall, the Nakdonggang watershed has the most multipurpose and domestic/industrial dams, the Geumgang watershed has the most agricultural dams, and the Hangang watershed has the most hydroelectric dams.

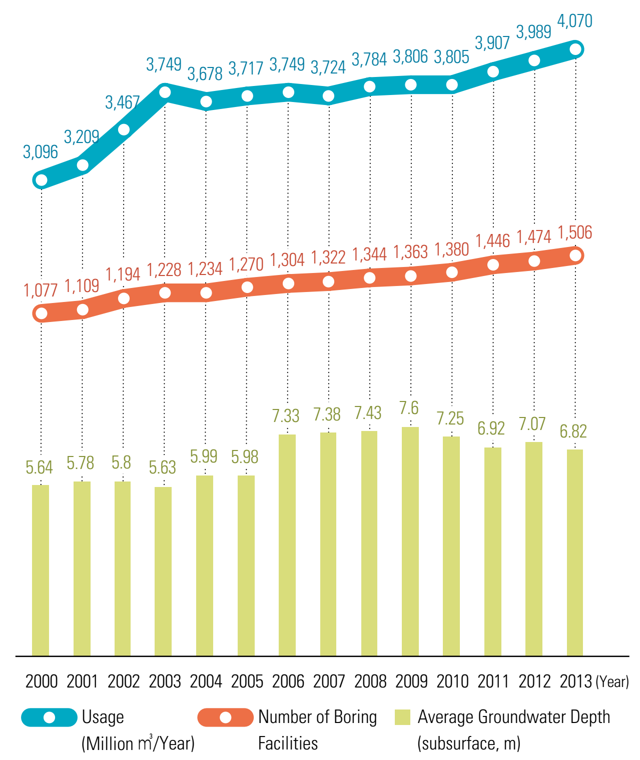
The 'Four Major Rivers Restoration Project' was launched in February 2009 with the aim to promote local development by building weirs, thus securing water resources, enhancing water quality, and developing the leisure industry. A total of 16 weirs were newly installed on the four rivers (Hangang, Nakdonggang, Geumgang, and Yeongsangang), and various leisure facilities such as riverside parks and bicycle paths were created as well. However, there are serious ongoing debates concerning water quality degradation and fewer ecological benefits of the project.

Groundwater Usage by Province

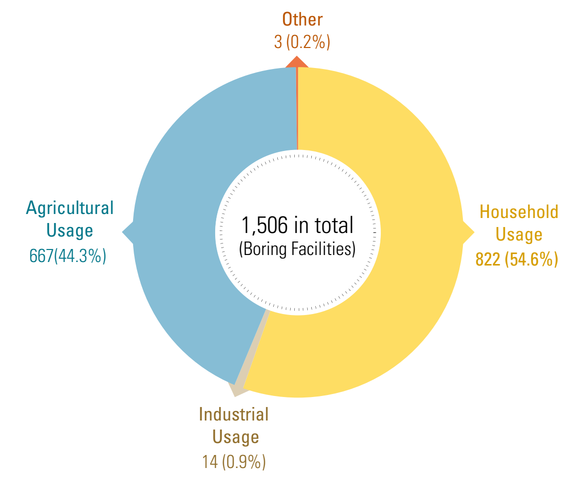


National Groundwater Information Center (2015)

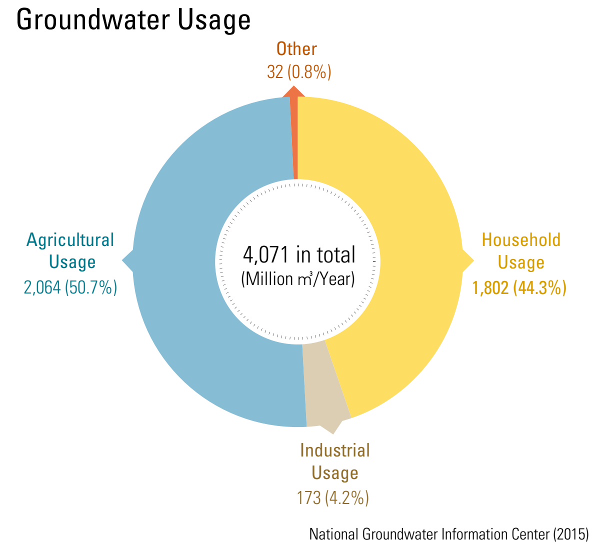
Groundwater Development and Usage



Groundwater Facility by Usage



Groundwater Usage



National Groundwater Information Center (2015)

Groundwater Level

Classification		Bedrock Groundwater Observation Well		Alluvium Groundwater Observation Well	
		Observation Point (Number)	Groundwater Level (m, El.)	Observation Point (Number)	Groundwater Level (m, El.)
Elevation (m, El.)	0 – 50	136	-8.92 – 44.98	71	-1.56 – 45.00
	50 – 100	63	34.50 – 94.55	35	46.28 – 92.62
	100 – 200	53	94.65 – 191.21	28	102.88 – 193.79
	More than 200	41	195.54 – 970.59	14	196.78 – 561.21
Total		293	-8.92 – 970.59	148	-1.56 – 561.21

* Elevation range of monitoring wells for bedrock groundwater: -8.92 – 970.59 m,
Elevation range of monitoring wells for alluvium groundwater: -1.56 – 561.21 m

National Groundwater Information Center (2015)

Groundwater Depth by Watershed

(Unit: m)

Classification		Hangang	Nakdonggang	Geumgang	Seomjingang	Yeongsangang
Bedrock Groundwater Observation Well	Mean	1.34 – 44.76	1.43 – 46.73	0.88 – 14.60	1.96 – 16.20	2.36 – 27.48
	Minimum	0.00 – 33.38	0.41 – 34.03	0.33 – 11.69	1.19 – 12.91	1.07 – 12.72
	Maximum	1.77 – 52.04	2.53 – 75.16	1.86 – 17.07	2.24 – 68.32	2.88 – 56.66
	Variability	0.68 – 19.20	1.27 – 65.90	0.70 – 9.34	0.89 – 62.77	0.94 – 45.32
Alluvium Groundwater Observation Well	Mean	1.66 – 10.86	1.48 – 13.30	1.61 – 13.51	1.94 – 13.31	2.34 – 7.46
	Minimum	0.64 – 8.86	0.20 – 9.98	0.99 – 11.75	0.31 – 6.15	0.49 – 5.99
	Maximum	2.28 – 12.58	2.36 – 18.21	1.97 – 14.93	2.20 – 19.85	2.87 – 9.31
	Variability	0.68 – 10.44	1.27 – 12.23	0.72 – 6.74	0.86 – 14.32	1.18 – 6.40

National Groundwater Information Center (2015)

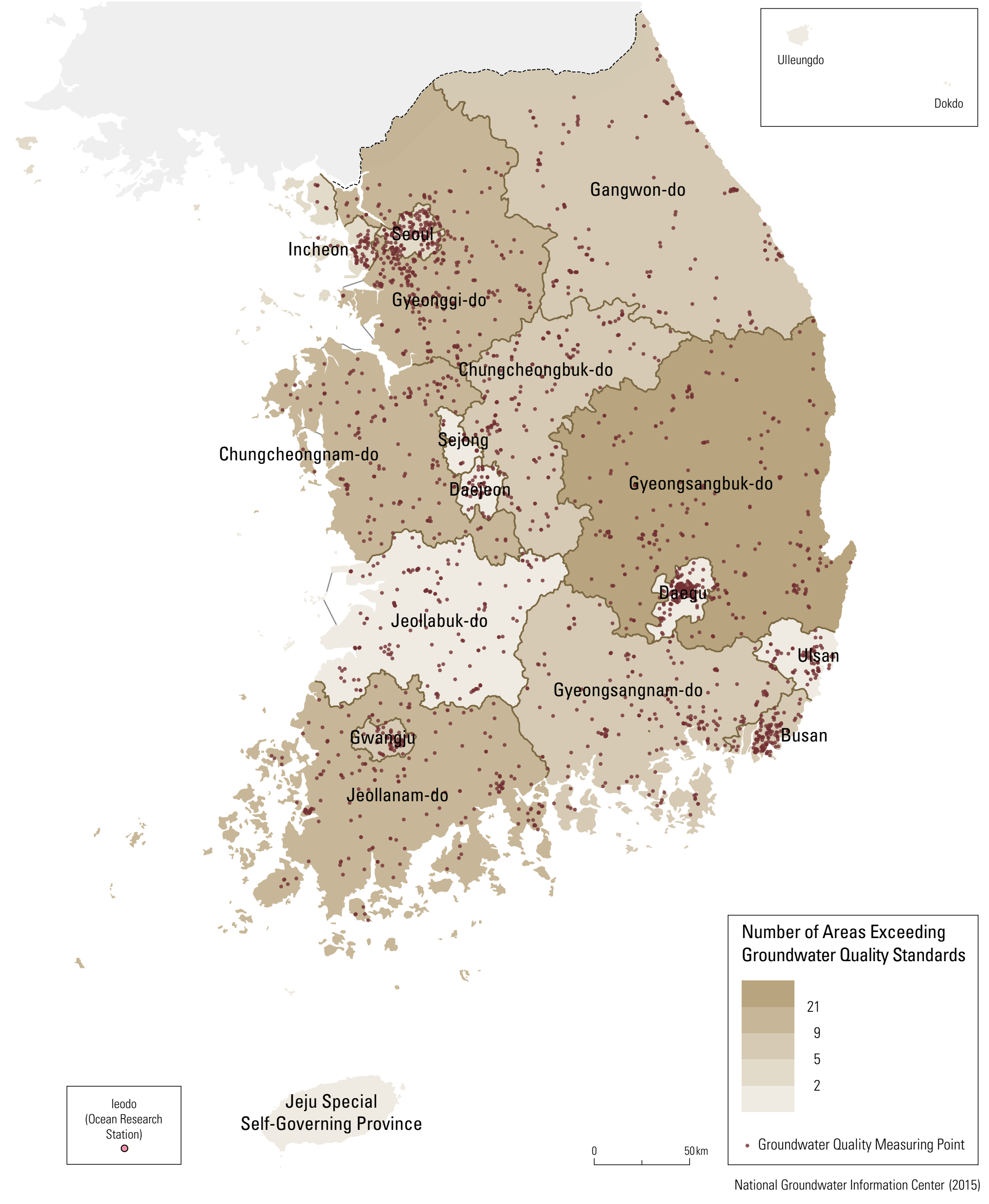
Due to rapid urbanization, Korea's groundwater development and usage is drastically increasing each year. In 2014, the country used 4 billion tons of groundwater through approximately 15.6 million tube wells across the country. Compared to 2001, this is a 45% increase in facilities and a 31% increase in usage. However, the increase in groundwater usage has inevitably led to a gradual decrease in underground water levels. The average depth of water has dropped from 5.04 m in 2001 to 6.82 m in 2013.

Alluvial aquifers are widely distributed around large rivers such as Hangang and Nakdonggang. The total area of these aquifers is 27,390 km², about 27% of South Korean territory. The depth of these aquifers is about 2 – 30 m and the production of groundwater is 30 – 800 m³/day per one bore hole. The production by region shows a pattern similar to that of Korean terrain, which is high in the east and low in the west. Due to the westward flow of most rivers, there is more recharge in the eastern region and more discharge in the western region.

The groundwater use of Korea is about 4.1 billion m³ per year (approximately 31.8% of the available amount), which is 1.4 times greater than the 2.9 billion m³ capacity of Soyanggang Dam. In Korea, about 95% of groundwater is used for agricultural and domestic purposes. Although most of the groundwater facilities are related to domestic matters, agriculture requires the highest portion of groundwater at 2 billion m³, compared to 1.8 billion m³ for domestic use. Jeollanam-do uses the most groundwater at 0.58 billion m³ annually, which accounts for 14.1% of the total groundwater use in Korea. Gyeonggi-do has an annual use of 0.56 billion m³ (13.7%), while Chungcheongnam-do uses 0.49 billion m³ (12.0%). Groundwater use in the seven largest cities in Korea stands at 0.29 billion m³, or 6.8% of total use.

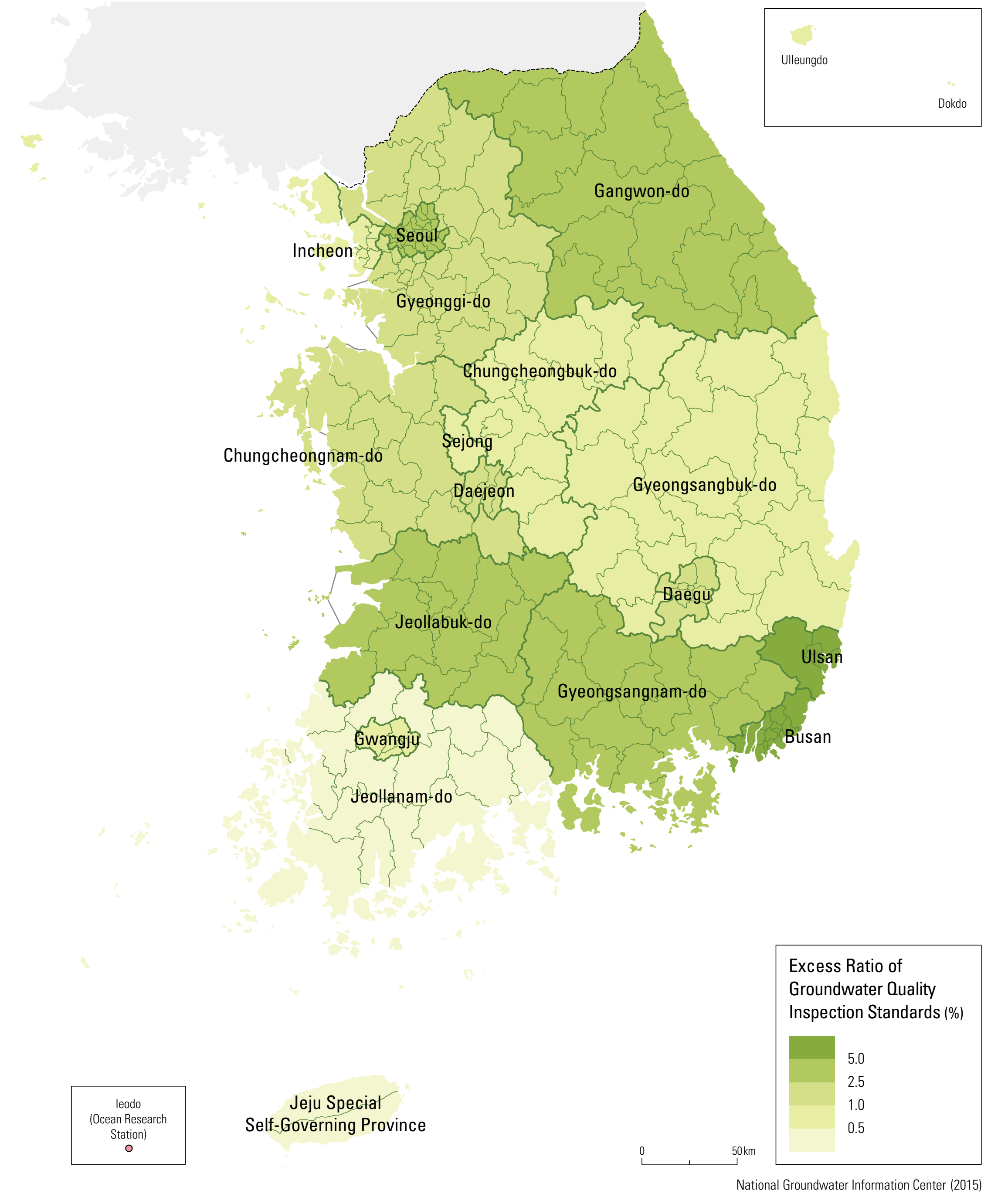
ATMOSPHERE AND HYDROSPHERE

Number of Areas (-Si/-Gun) Exceeding Groundwater Quality Standards by Province



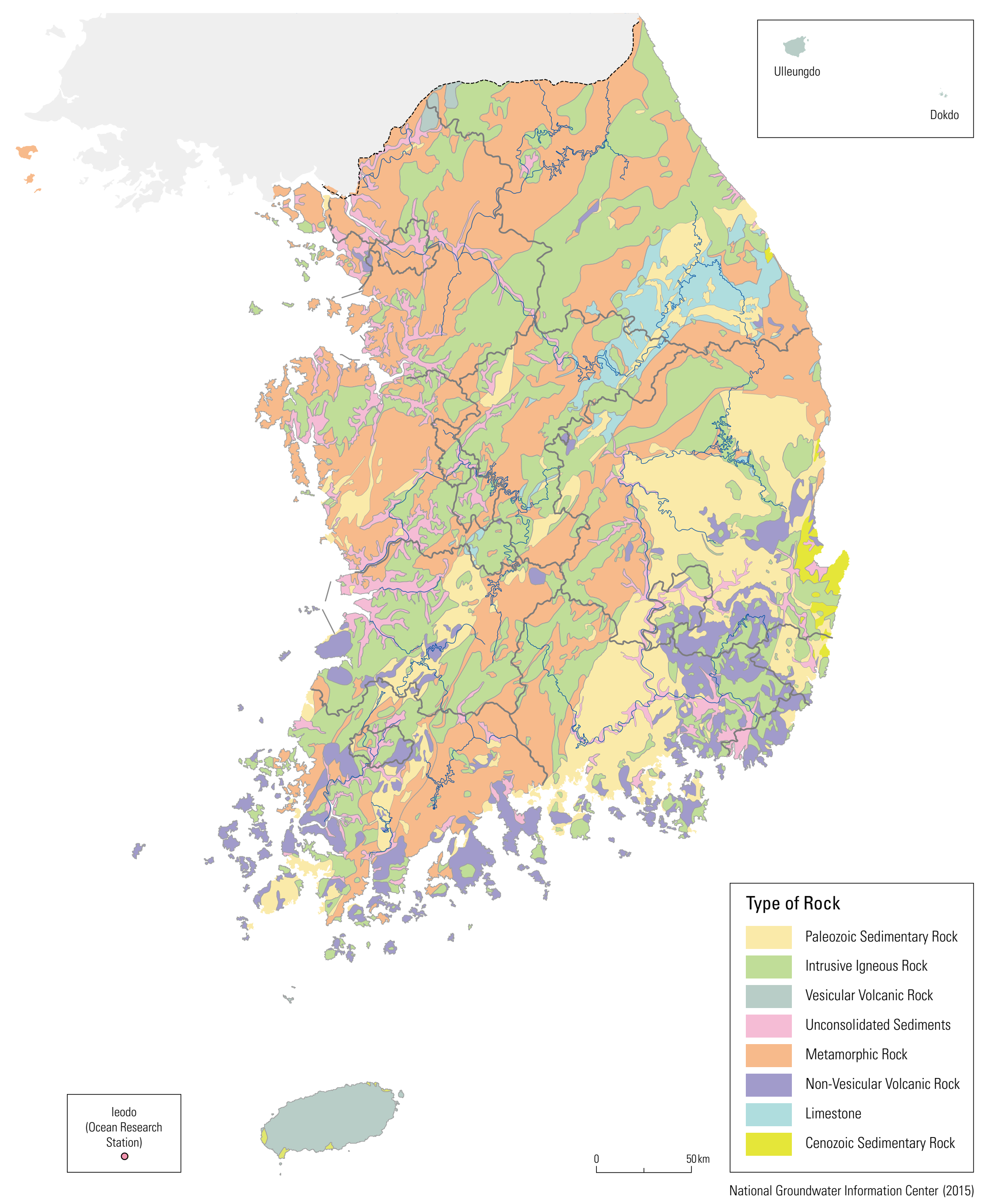
National Groundwater Information Center (2015)

Excess Ratio of Groundwater Quality Standards by Province



National Groundwater Information Center (2015)

Hydrogeological Map



National Groundwater Information Center (2015)

Number of Inspections Exceeding Groundwater Quality Standards by Province

Province	Number of Inspections	Number of Inspections Exceeding
Seoul	1,033	44
Busan	1,583	174
Daegu	678	10
Incheon	355	2
Gwangju	727	7
Daejeon	490	11
Ulsan	818	57
Sejong	394	3
Gyeonggi-do	9,434	209
Gangwon-do	3,820	121
Chungcheongbuk-do	2,662	23
Chungcheongnam-do	3,885	59
Jeollabuk-do	3,454	127
Jeollanam-do	3,469	10
Gyeongsangbuk-do	4,071	36
Gyeongsangnam-do	8,455	255
Total	45,308	1,148

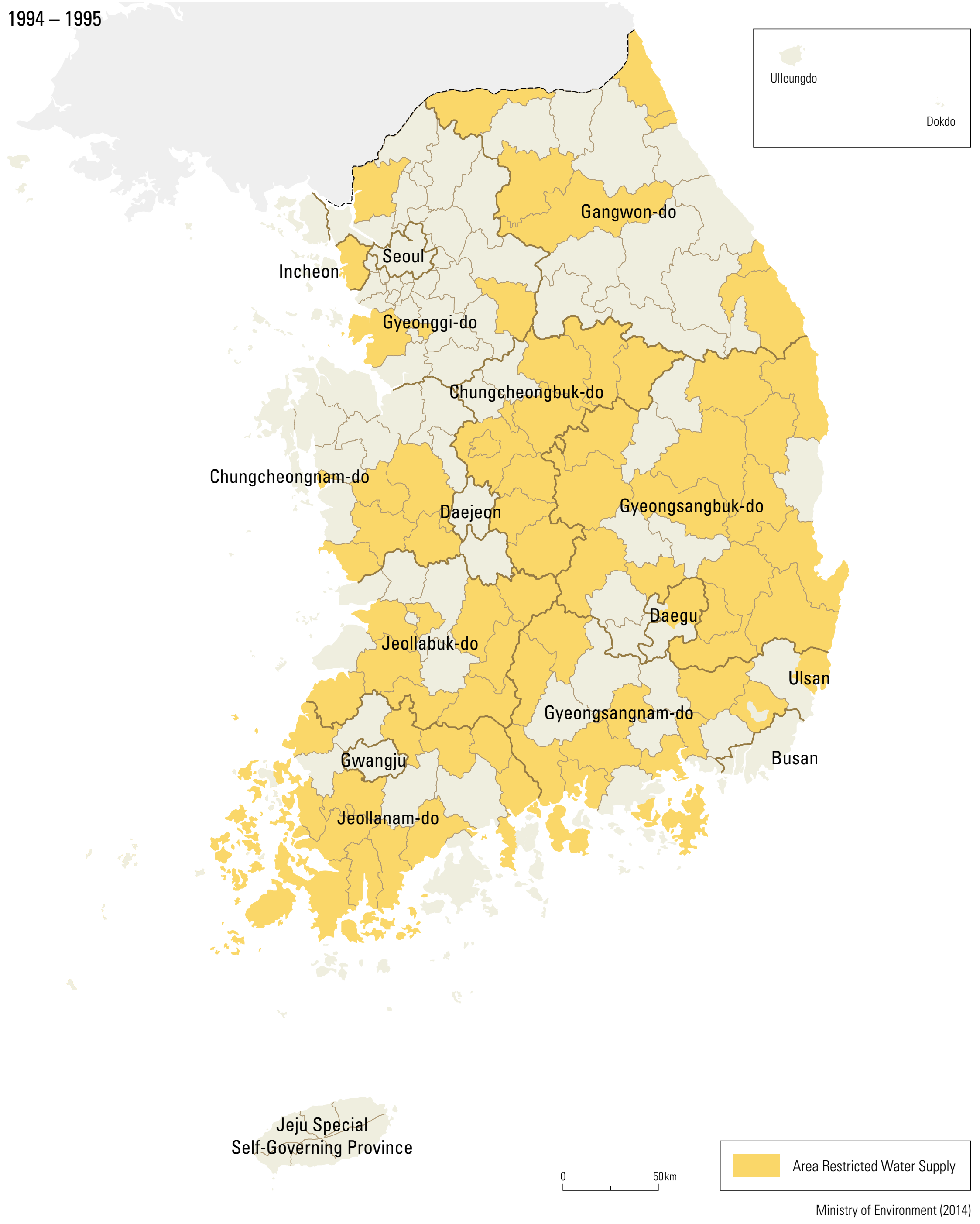
Water and Future (2015)

Korea operates a national groundwater monitoring network to ensure the efficient utilization of groundwater and maintain satisfactory water quality. As of 2015, 386 observatories are located across the nation within this network: 121 in the Hangang watershed, 106 in the Nakdonggang watershed, 88 in the Geumgang watershed, 35 in the Seomjingang watershed, 32 in the Yeongsangang watershed, and 4 in Jejudo. There is also an observation network that is established specifically for monitoring groundwater quality status and following changing trends in water conditions. 141 groundwater quality centers and 52 pollution surveillance centers are in operation nationwide.

The hydrogeological map is a reclassification that divides alluvial and bedrock aquifers in Korea into 8 hydrogeological units by rock configuration (such as type, rock sheet, pore shape, and topography). The quality of groundwater is largely determined by the geological characteristics of each region. Gyeonggi-do, Chungcheong-do, and Gyeongsangnam-do, which have a wide distribution of crystalline rocks, have relatively abundant groundwater yields in the lower weathering zone of Jurassic granites. Groundwater yield is also in good condition in upstream Namhangang and in the limestone areas in the eastern part of Korea. Jejudo, composed of porous basalt from volcanic activity, has water resources that consist entirely of groundwater. As such, it also shows good recharge and production rates.

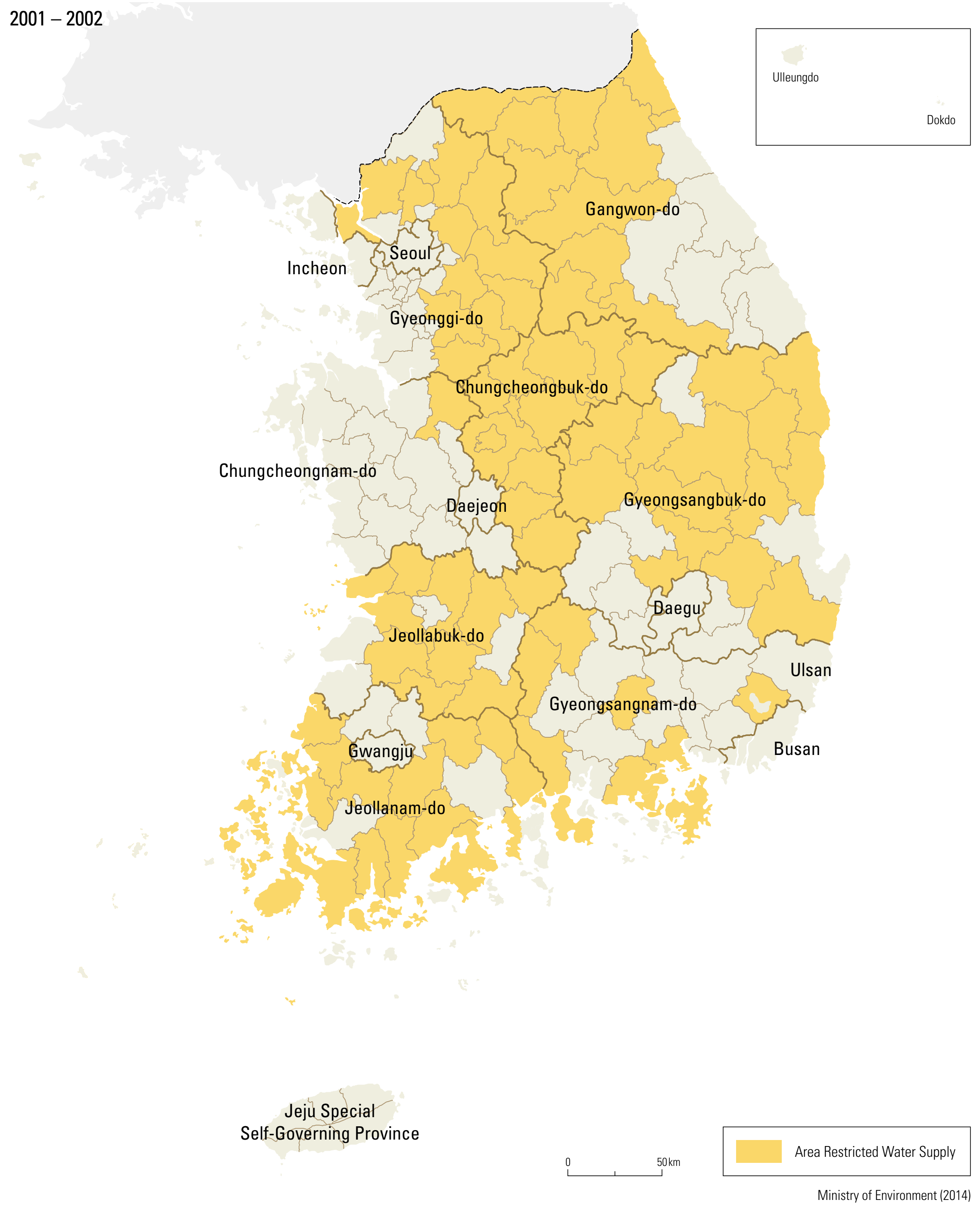
Restricted Water Supply Areas

1994 – 1995



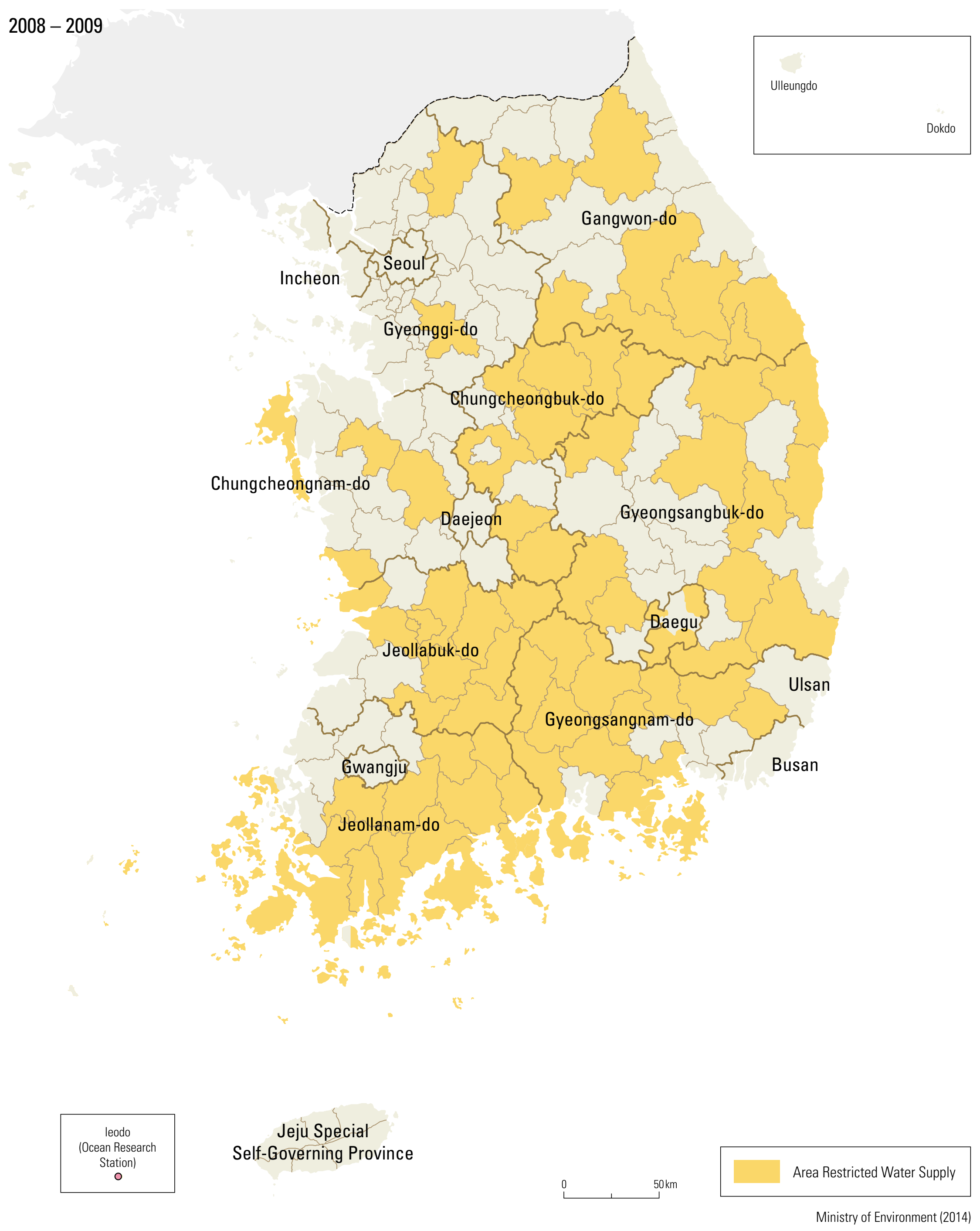
Ministry of Environment (2014)

2001 – 2002



Ministry of Environment (2014)

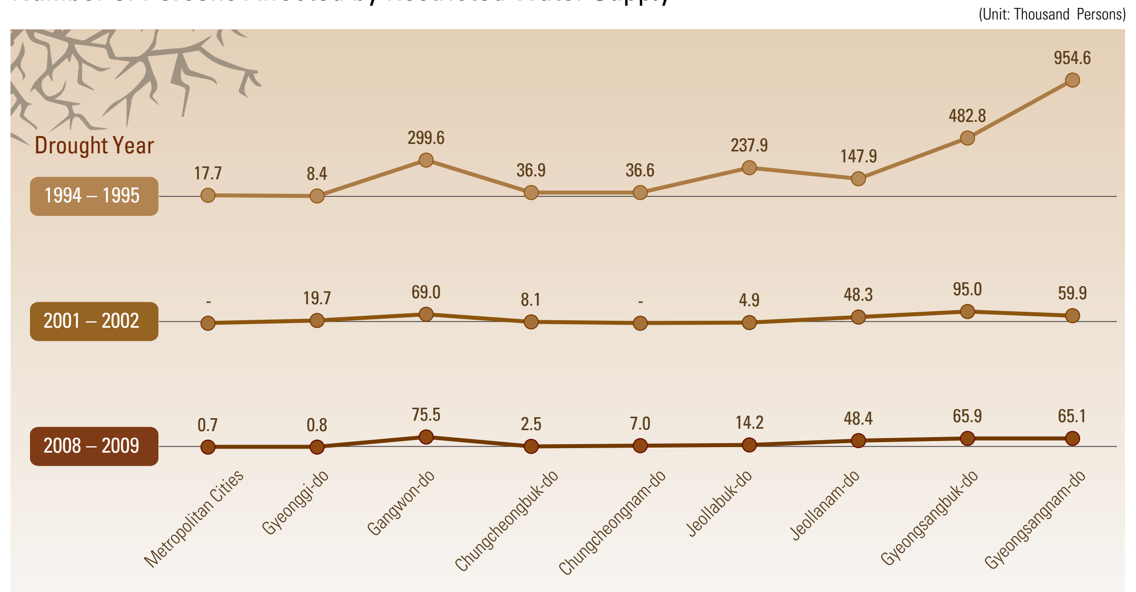
2008 – 2009



Ministry of Environment (2014)

Number of Persons Affected by Restricted Water Supply

(Unit: Thousand Persons)



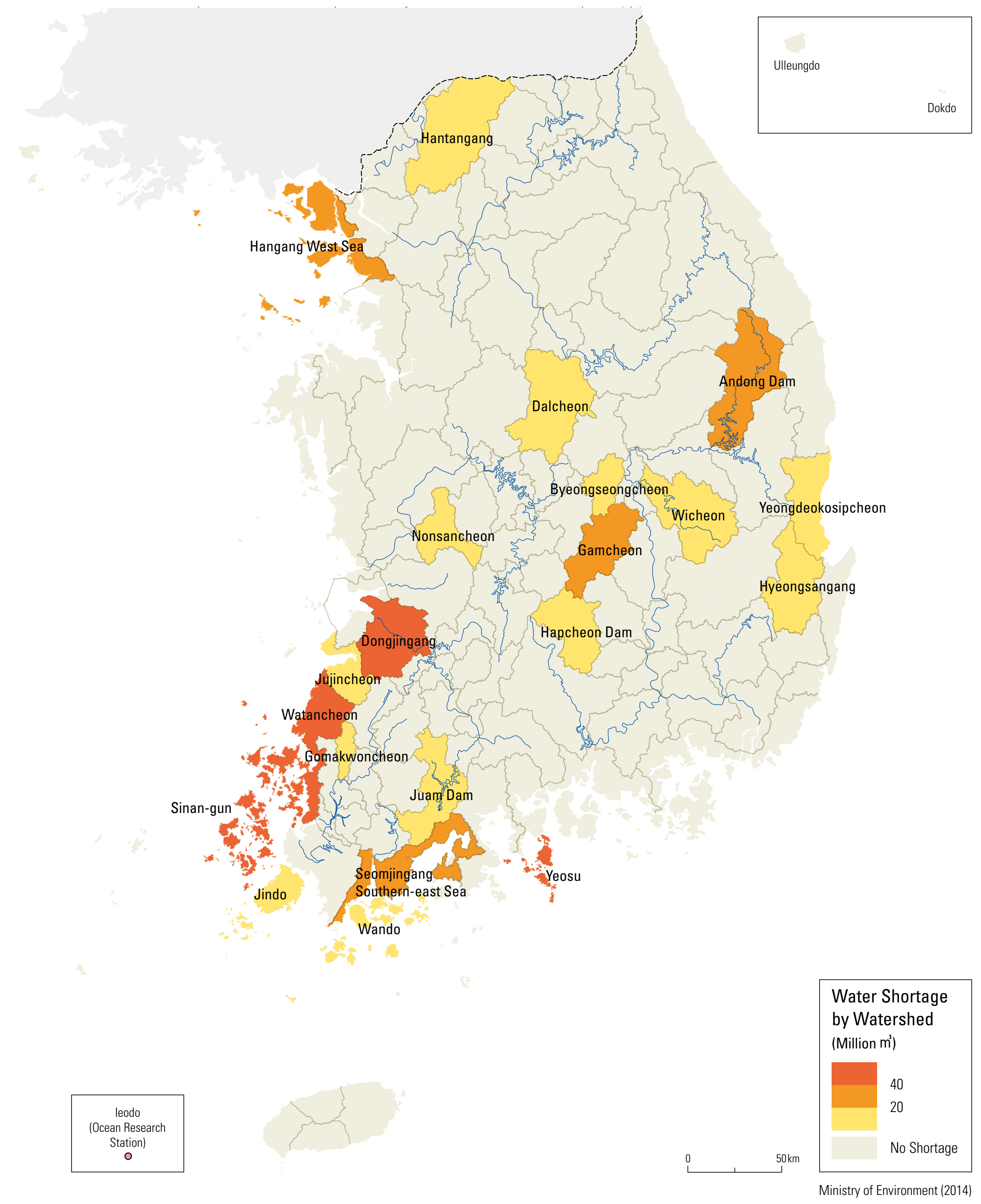
Ministry of Environment (2014)

The total volume of water resources in South Korea is recorded to be 129.7 billion m^3. 75.3 billion m^3 (58%) of this sum is available water, excluding 54.4 billion m^3 (42%) that is lost naturally due to evapotranspiration and interception. Water is recharged unevenly throughout the year, with 74% (56 million m^3) of the available water collecting over the rainy season from June to September. As agricultural water use is generally concentrated between April and September, this seasonal incompatibility causes a lack of security for consistent water use.

Of the total available water, 56% (42 billion m^3) is lost to the sea. The other 44% (33.3 billion m^3) remains in rivers, dams, reservoirs, and groundwater, among which 25.5 billion m^3 are used for domestic, industrial, and agricultural purposes, while 7.8 billion m^3 are used for maintaining rivers. During droughts, however, available water drops to as low as 14.9 billion m^3, which is a mere 45% of the annual average.

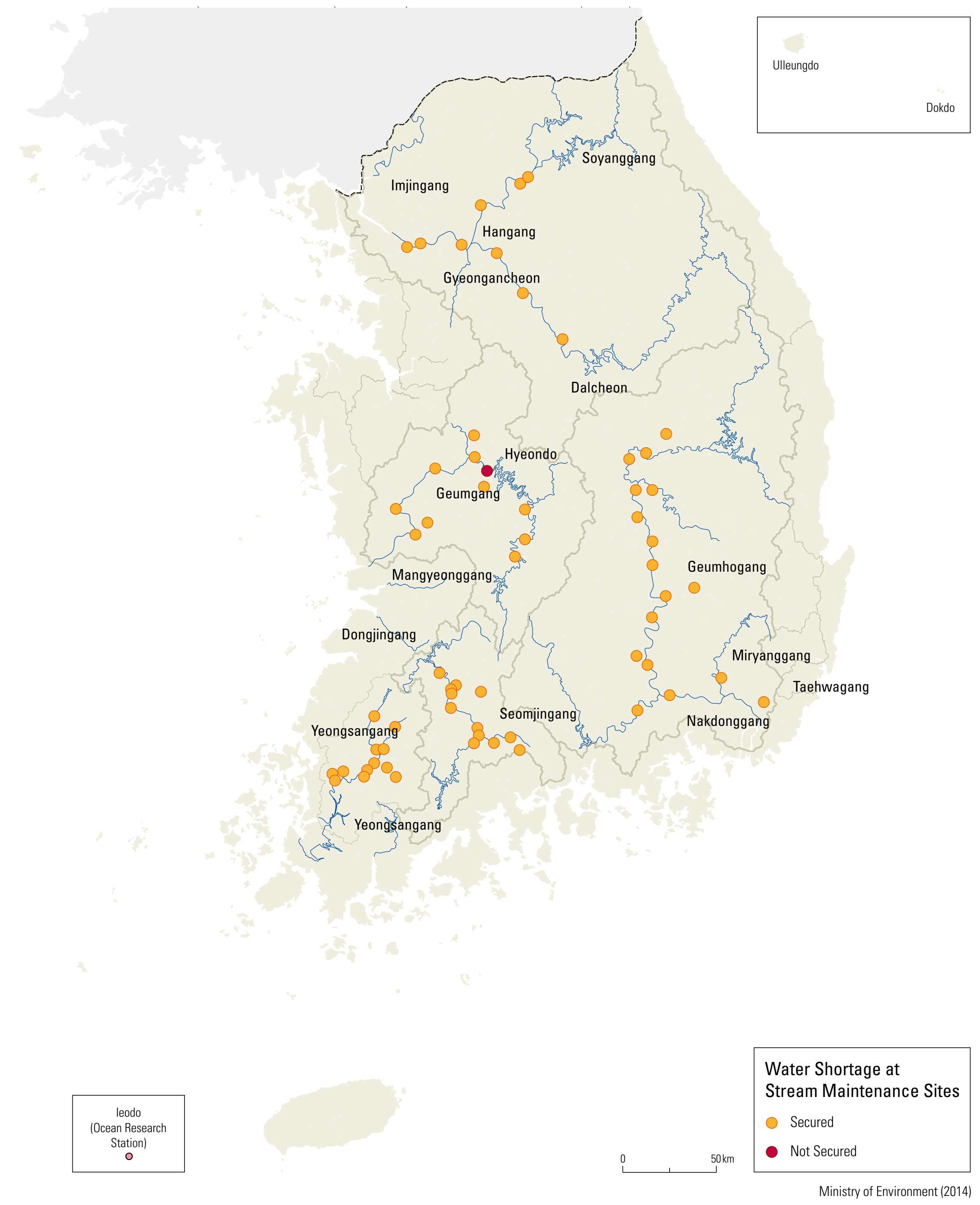
Since the 1900s, Korea has been experiencing severe water shortages every five to ten years. This can be attributed to a variety of geomorphological characteristics, such as steep river gradients, low soil moisture due to a thin soil layer, and large differences in regional and seasonal rainfall (annual minimum of 754 mm, maximum of 1,756 mm). In addition, major and minor droughts occur every two to three years, while extreme droughts are observed every seven years. In recent history, the most severe droughts occurred in 1994 – 1995, 2001 – 2002, and 2008 – 2009.

Water Shortage by Watershed



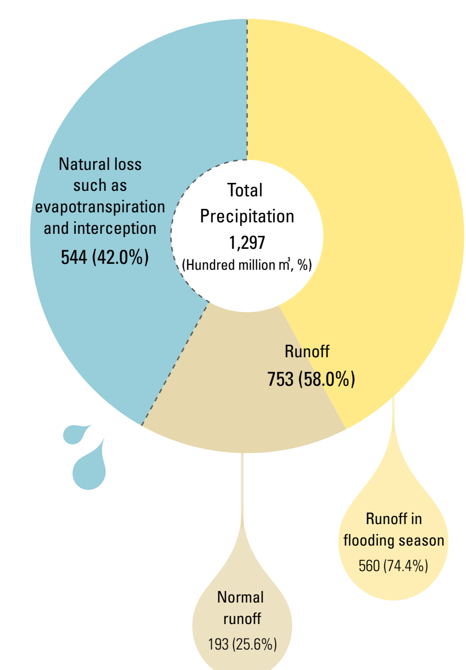
Ministry of Environment (2014)

Water Shortage at Stream Maintenance Sites of the Water System



Ministry of Environment (2014)

Total Water Resources



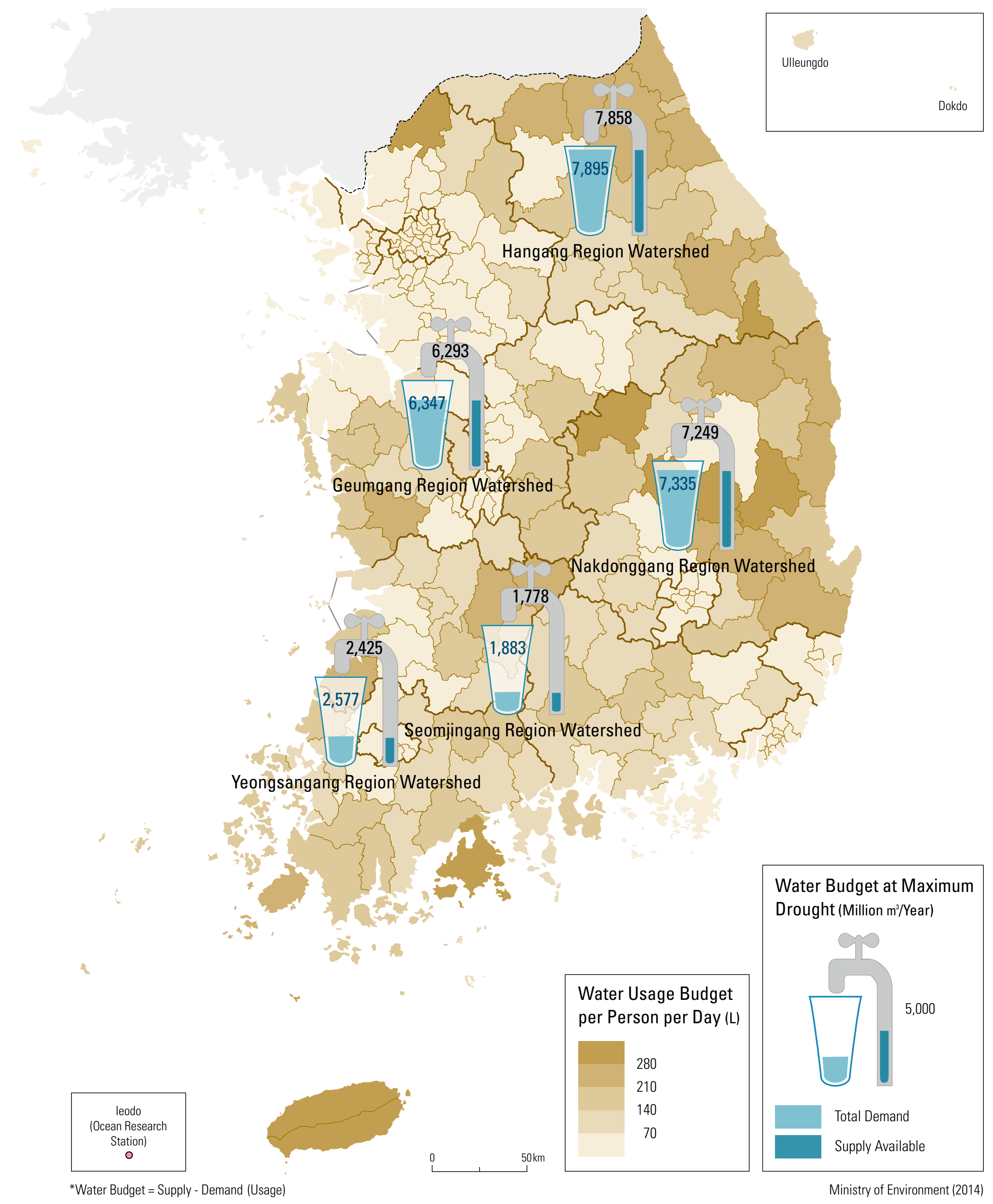
Flooding Season: June – September
Runoff in Nonflooding Season: October – May (the following year)

Available Water Resources by Watershed

(Unit: Million m³)

Region	Average Available Water Resource (1979 – 2007)	Available for Usage during Maximum Drought
Nationwide	75,300	33,676
Hangang	23,100	14,400
Nakdonggang	16,500	8,733
Geumgang	11,000	5,577
Seomjingang	4,400	2,808
Yeongsangang	3,000	2,158

Water Budget by Watershed and City



*Water Budget = Supply - Demand (Usage)

Ministry of Environment (2014)

According to the Long-term Water Master Plan (2011 – 2020), Korea is projected to have 0.43 million m^3 of water shortage if severe drought occurs in 2020. The prediction states that the Yeongsangang watershed will have the largest shortage of 0.15 billion m^3, followed by the Seomjingang watershed (0.1 billion m^3), the Nakdonggang watershed (0.09 billion m^3), the Geumgang watershed (0.05 billion m^3), and the Hangang watershed (0.04 billion m^3). Coastal regions, islands, and mountain areas will most likely experience the greatest lack of available water due to a deterioration of water resources or supply systems.

Various plans are required in order to secure the 0.43 billion m^3 shortage of water across the nation; an integrated supply system for waterworks must be established, existing facilities should be maintained to uphold effective operation, and small reservoirs should be constructed to obtain new water sources. Global climate change may further intensify the water shortage by 1.8 – 3.5 times by extending droughts and increasing demand for water. As such, it is also necessary to facilitate the capability to cope with such potential extreme water shortages.