Environment, Ecology, and Protection

Environmental Issues of Northeast Asia

The environmental setting of Northeast Asia is unique because peninsula and island nations are directly tied to environmental conditions in continental Asia. Environmental problems will transcend political boundaries and affect other nations. This is why all nations in this geographic realm need to study and monitor grave environmental effects that may cause long-term or even irreparable damage. International cooperation has become vital in mitigating regional environmental issues.

Every country in Northeast Asia faces different environmental challenges according to their natural environmental conditions and socio-economic factors. Korea and Japan share environmental problems that can generally be seen in developed countries; their advanced industrial structures have led to increases in energy consumption and the number of private vehicles. On the other hand, North Korea and Mongolia experience environmental problems that are brought about by poverty. In particular, North Korea is undergoing serious environmental damage as a consequence of forest degradation due to food and energy shortages. Mongolia and western China are affected by desertification and aridity due to their dry climate, while recent rapid industrial development in eastern China has caused serious air and water pollution.

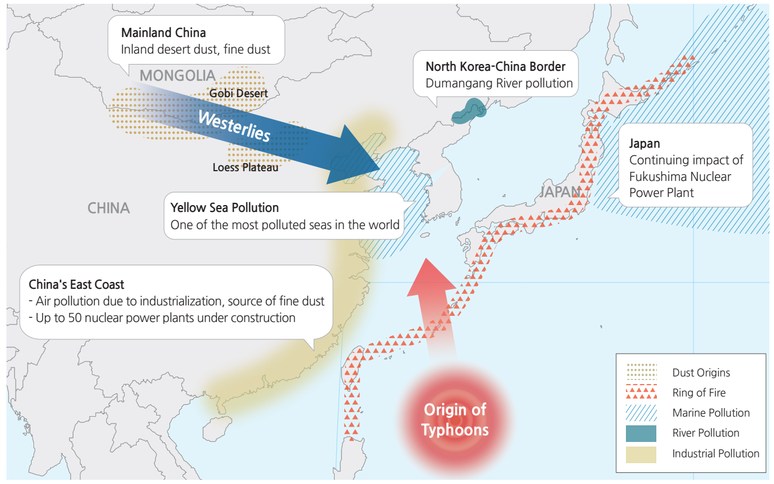
Such environmental problems in Northeast Asia are linked in diverse ways, and their consequences are influential across countries. For instance, yellow dust originating from the Gobi Desert and the Loess Plateau picks up pollutants such as fine dust and nitrogenous compounds as it crosses the rapidly industrialized east coast of China. It then rides the westerly winds and reaches Korea and Japan. The pollution of international seas and streams such as the Yellow Sea and Dumangang (river along the border between North Korea and China as well as Russia) is also being discussed as constituting some of the most important environmental issues in this region.

Not only is Northeast Asia located on the same plate boundary, it also shares the risks of various disasters, which can be carried by westerly winds, currents, and typhoons. With an increase in risk factors such as the growing number of nuclear power plants in eastern China, the future of Northeast Asia is projected to be even more vulnerable to environmental disasters.

Responding to yellow dust that originates from the Gobi Desert is an important environmental task for not only Korea, but also the entire Northeast Asian region. Korea has actively pushed for a collective response to this issue, regarding it as a major agenda in national summits such as the Environmental Cooperation Channel in Northeast Asia and the Tripartite Environment Ministers Meeting (TEMM) composed of Korea, China, and Japan. Experts from Korea, China, and Japan have conducted collaborative research in two areas in Hulunbuir, Inner Mongolia, China. The first round of research was conducted from late of July to early August 2013, with a follow up in July 2014. This research will be used as a foundation for ecological restoration efforts in areas undergoing desertification.

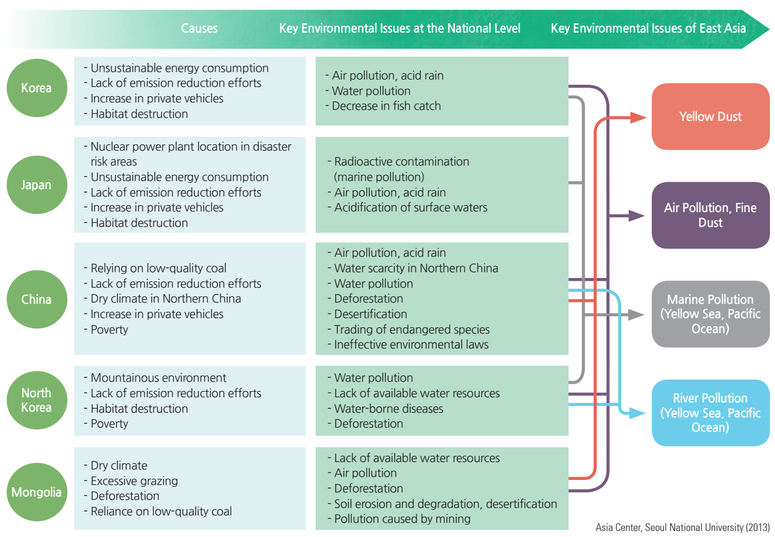
The Tripartite Environment Ministers Meeting is now an annual meeting that was first proposed by the Korean government in 1992. Its objective is to devise cooperative measures to tackle East Asian environmental issues such as yellow dust, acid rain, atmospheric pollution and hazardous waste management, and to raise a sense of environmental community among the three countries. This meeting is the only minister-level conference in the East Asian region and has served as the highest-level coordination mechanism on environmental cooperation. A total of 18 meetings had been held by May 2016.

Environmental Issues in Northeast Asia



Asia Center, Seoul National University (2015), Chosun Ilbo (2014)

Key Environmental Causes and Issues in Northeast Asia



Asia Center, Seoul National University (2013)

Brief Interpretation the Map

The Environmental Issues of Northeast Asia map clearly shows the long distance relationships between environmental conditions from interior continental Asia with countries in the Northeast Asia Realm. Environmental problems can cross international boundaries and create problems for another country. The map demonstrates why all countries in the region need to work together to mitigate and/or alleviate such environmental problems.

Air pollutants from the industrial area of an upwind country may include chemically soluble gases and dusts. What happens when too much of these pollutants are carried by wind over a sea or an ocean and pick up moisture before reaching a downwind country? What might be a possible outcome of its effects on the agriculture and the soil of the downwind countries?

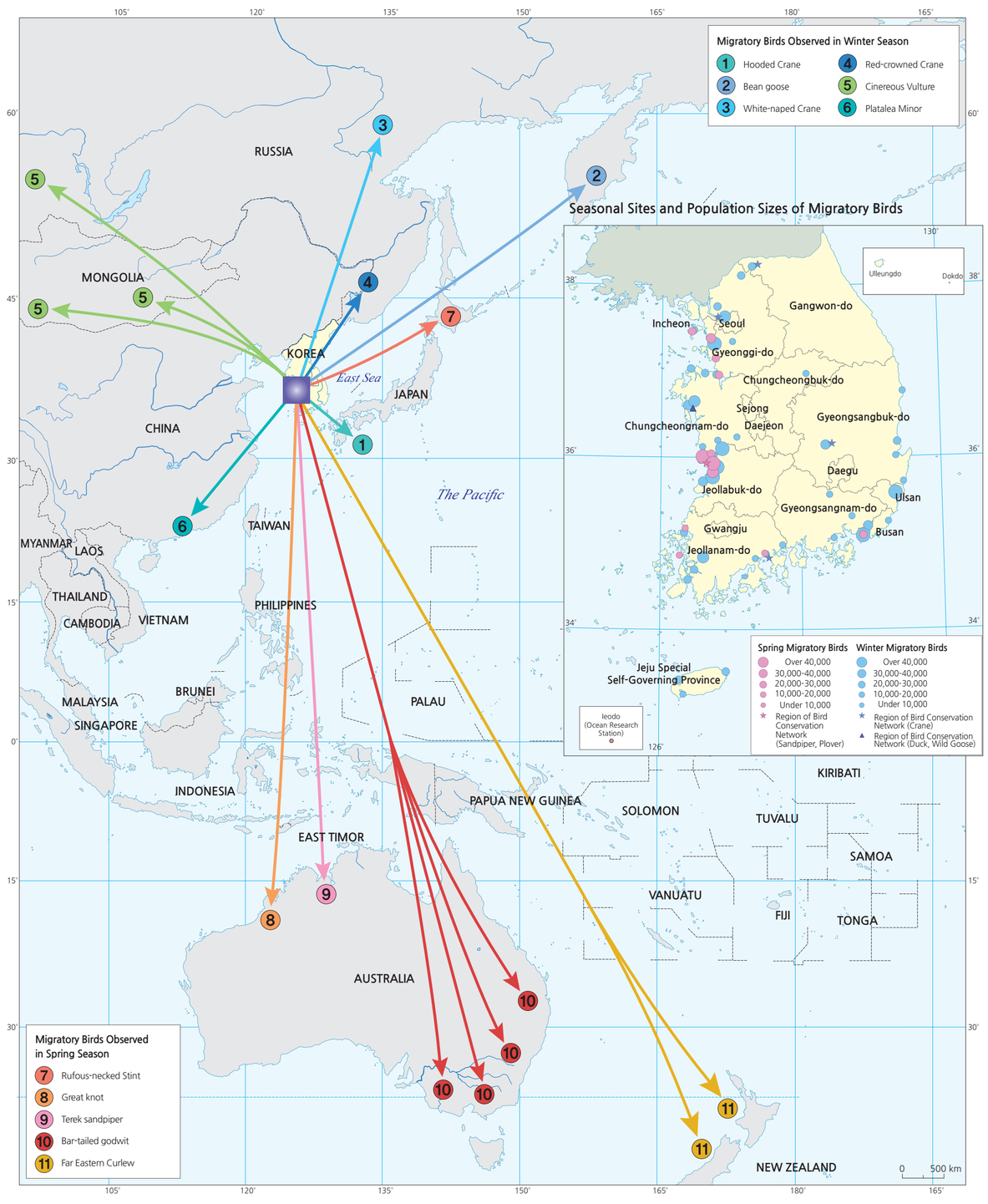
Spatial Technology and Environment

While environmental issues can transcend international boundaries, spatial technology has provided us with instruments and techniques to study positive environmental phenomena. One such phenomenon relates to winter/summer migration of birds. Birds can also transcend international boundaries and fly great distances for their own survivals. The use of Geographic Information Systems (GIS) and Global Positioning Systems (GPS) has enabled geographers and biologists to track the flight path of migratory birds, in order to understand their adaptation to adverse environmental conditions.

Many migratory birds that are internationally endangered visit and use the Korean Peninsula as over-wintering sites, breeding sites, and stop-over sites. In particular, shore birds that spend winter in Australia and New Zealand and then migrate to Siberia for breeding stop to feed in the tidal flats of the west coast of Korea during spring and autumn.

Sandpipers and plovers visiting South Korea follow the East Asia-Australia Flyway (EAAF), one of the 9 major flight paths used by migratory waterfowls in the annual bird migration for breeding and wintering. It has been reported that 35 species of globally endangered waterfowl, 13 species of near-threatened waterfowl, and 50 million birds belonging to more than 250 population units travel along the EAAF.

Flyways of Major Migratory Birds



National Institute of Biological Resources (2015)

Brief Interpretation of the Map

While it is estimated that 50,000,000 migratory birds visit nesting, breeding and feeding sites in South Korea annually, the size and location of the recorded sites are relatively small. Most of the sites are islands and near inland sites along the Yellow Sea coast. There are also some sites along the southeast coast, on islands and on the coast extending northward to Ulsan.

Study closely the locations of the migratory sites on the northwest coast south of Incheon. As noted earlier on page 47 (also later on pages 130–131) of this volume, this coastline is also the location of major sea reclamation sites for a combination of tidal power projects, and agricultural and urban development. Discuss the environmental conflicts resulting from this type of reclamation in coastal areas. Think about how planning and development decisions in the creation of these reclamation sites might alleviate some of the environmental problems. Are there any land uses that will result from reclamation in bird frequented sites that cannot be avoided?

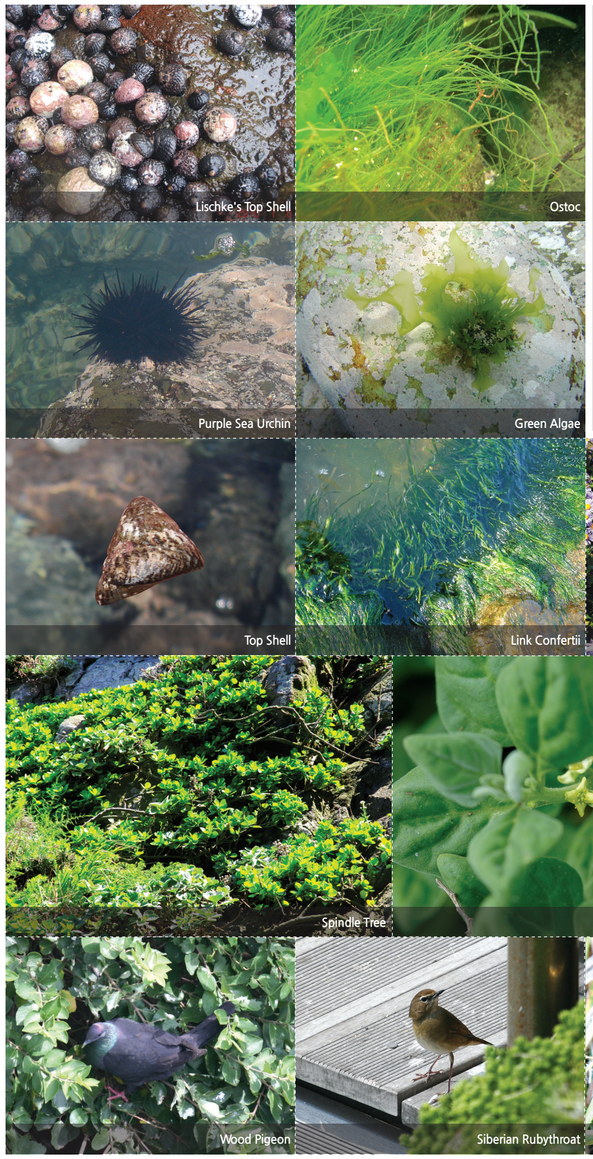
The Environment and Ecology of Korea

When we refer to the environment of a place, there is generally a complex relationship between the natural/physical processes and human uses of natural resources from the land, water, and atmosphere. In the process of extracting natural resources from the natural world, we also alter its state in ways that may be either positive or negative. This is why we need to study the environment. An adverse environment will tend to harm the human race while sustaining a viable environment will provide healthy living conditions.

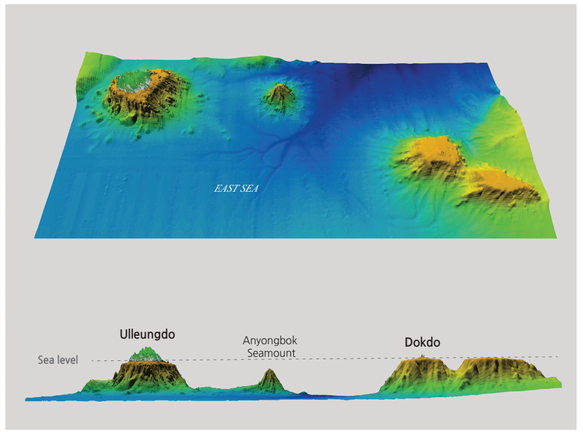
This chapter is intended to bring awareness to environmental conditions of South Korea and to reveal some of the thinking and processes it has implemented to help mitigate issues of environmental degradation due to pressures from increased population, industrial growth, demands for agricultural products, and the need for energy consumption. We begin with the physical environment of Dokdo, a place that seems to have relatively less environmental pressure than other places in Korea.

Physical Geography of Dokdo

Ecosystem of Dokdo



3D Seabed Images of Dokdo



Physical Environment of Dokdo

Dokdo is a volcanic island that was formed by lava which erupted about 2,000 meters underwater in the East Sea. It was formed between 4.6 million and about 2.5 million years ago. Ulleungdo was formed later, sometime between 2.5 million and 10,000 years ago. The geology of Dokdo is alkaline volcanic rocks: the main rock above sea level is made up of andesite, and most of the undersea rock is believed to consist of basalt. The island is actually a part of a gigantic, round volcano (the Dokdo Seamount), with a base reaching more than 2,000 meters deep. As the topographical map shows, the Simheungtaek and Isabu Tablemounts are in the eastern part of the Dokdo Seamount, while the Anyongbok Seamount is located between Ulleungdo and Dokdo.

The East Sea belongs to the group of marginal seas in the North Pacific running from the Okhotsk Sea to the South China Sea. Waters around Dokdo, located at the center of the East Sea, are where the North Korea Cold Water (NKCW) and the East Korea Warm Current (EKWC) meet. The East Sea near Dokdo is characterized by a very complex submarine topography. It consists of three topographic highlands more than 2,200 meters deep in the west; they get shallower towards the east. The strait between Dongdo and Seodo is 330 meters long, varying in width from 110 meters to 160 meters, and it is 5-10 meters deep. The depth of water surrounding Dongdo reaches hundreds of meters at certain places, depending on its distance from the coast; however, the waters near Seodo are shallower than those around Dongdo.

The warm and cold currents circulate and meet near Dokdo. Where warm and cold ocean currents meet, an area is created that is rich in plankton, an important food source for fish. Environmental conditions are also very good in the coastal waters of Dokdo in large part due to their long distance from land and their relative isolation. The sea around Dokdo is relatively undisturbed by human activities, and so it is home to a diversity of marine life.

The waters around Dokdo are abundant with squid and many different types of fish. Squid accounts for more than 60% of the total catch in areas near Dokdo. The drift catch of rays and flatfish, as well as the trap fishery of red snow crab and shrimp, account for tens of millions USD profit every year. The fishing grounds around Dokdo possess such significant economic value that they represent an important outpost for the Korean fishing industry in the East Sea. As of 2014, 495 animal species and 223 types of algae have been recorded as marine life resources along the coast of Dokdo.

A crossroads for bird migration routes, Dokdo serves as a midpoint rest stop for migratory birds. As such, it also serves as an important natural laboratory for scientific research on the origins, migration patterns, and destinations of these birds. The Dokdo Ecosystem Monitoring and Plant Gene Analysis in 2013 confirmed a total of 76 species of birds live or frequent Dokdo, including 4 endangered species. It is also home to the shearwaters, stormy petrels, and black-tailed gulls that only reproduce in Northeast Asia. In order to protect the breeding habitat, the Ulleung-gun Ulleung-eup Dodong-ri, Mountain 43, lot 34, with an area of 178,781 square meters, has been designated as the National Cultural Heritage Natural Monument No. 336 (Dokdo Seaweed Habitat), according to the Cultural Properties Protection Law of November 16, 1982. In addition, at least 60 species of plants and 129 species of insects inhabit the island. Since 2005 when monitoring of the Dokdo ecosystem was conducted, new species of life have been found every year. Eleven previously unrecorded species, including spindle trees (Euonymus hamiltonianus) and red knots (Calidris canutus), were recorded in 2013. The fact that the island is a very rich repository of natural resources motivated the government to designate the island as the Dokdo Natural Protection Zone on December 10, 1999 and increased the designated area to 187,554 square meters.

Traditional Ecology

The term “Traditional Ecology” refers to long-standing ways humans have adapted to the environment of the land and how to use surrounding physical and biological environments for human survival and livelihood. In Korea, the geographical perception of the Baekdudaegan Mountain Range represents the most important traditional ecology. The mountain range and riverine system of Baekdudaegan served as a fundamental base for understanding the people, philosophy, literature, ecology, and culture of the Korean Peninsula.

As of 2015, about 64% of South Korea was covered with forest. Most forests are connected to the Baekdudaegan mountain chain which has long been a central axis of the Korean eco-cultural space and spirit. The designation of the Baekdudaegan as a protected area supports the identity of the Korean people and their willingness to maintain mutual dependency with oceanic and continental ecosystems.

The protection area of Baekdudaegan is extremely valuable in terms of the Korean cultural and spiritual history. Each major mountain boasts temples that entwine Buddhist culture with impressive landscapes long before foreign religions arrived in Korea. The area houses both tangible and intangible cultural heritage values and assets. There are 543 state-designated cultural assets, including 31 national treasures, 273 treasures, and 49 historic sites. There are also 965 province-designated heritage assets, 523 cultural and historical documents, 53 registered cultural heritage sites, and so forth. In particular, temple in situ forests play a central role in enhancing the spiritual value of the protection area. Out of the 935 traditional temples in Korea, 173 (19%) are located in Baekdudaegan. Baekdamsa (Seoraksan), Woljeongsa, Sangwonsa (Odaesan), and Hwaeomsa (Jirisan) are the main temples well known to the public. They contain approximately 16,571 ha of temple-centered forests which accounts for 6% of the total protection area in Korea.

In additional to its cultural assets, the Baekdudaegan ecosystem is home to very diverse wildlife, including 126 families, 541 genus, and 1,248 species of flora and 23 species of mammals, 91 bird species, 11 species of amphibians, and 6 reptile species.

The industrialization and urbanization of modern society have caused various environmental problems and accelerated changes of the climate and natural ecosystems. The ecological knowledge and resource management practices handed down from traditional cultures have gained attention as an important legacy to aid in solving environmental problems as well as managing and distributing resources.

Korean traditional villages took the concept of the Baesanimsu (“with back to the mountain and face to the water”) as the basic principle to guide settlement location and land use. Also, this principle greatly benefited villagers who, as a result, lived within well-secured watersheds with access to water, protection against the wind, and accessibility to resources. The traditional villages were adapted to the local natural conditions and existed in a harmonious relationship with the surrounding natural ecosystems, resulting in their ability to maintain that spatial arrangement for a long period of time. One good example is the maeulsoop (Korean village grove).

A maeulsoop or village grove is a small forested area that helps the people adapt to the monsoon climate and helps the village to harmonize with the surrounding environment. The grove is a part of the village landscape, or is a property co-owned with and protected and managed by villagers. A village grove is a common gathering place for villagers and provides shelter for people during the hot summer. Further, it is a sacred site and holy place that the villagers protect and where they periodically perform ancestral rites.

Big trees such as pine and zelkova grow in the groves. Many species of birds, such as mandarin duck, scops owl, owl, woodpecker, great tit, and starling, which normally live deep in the mountain forests and build nests in the hollows of tree trunks and branches, inhabit the area and are frequently observed near the village.

The oldest village grove in Korea is Daegwallim which dates back to about 887–897 A.D. and is now protected as Natural Monument No. 154. By September, 2014, the Korea Forest Service had studied and organized information for the village groves in 1,335 regions. They found that the major plant species of village groves are Pinus densiflora and Zelkova serrata.

Traditional forest knowledge is defined as an integral aspect of the cultural heritage, ecological (genetic) resources, and traditional wisdom that a particular region or a group of people (tribe or ethnic group) has passed down over the generations. Based on this valuable preservation, Korea has developed the usage, production, and related technology for traditional knowledge. Recently, efforts have been made to classify traditional forest knowledge into 5 categories (humanities, forest philosophy, natural environment, production techniques, and social-economic policy) to fit the international trend towards the traditional knowledge-related International Patent Classification.

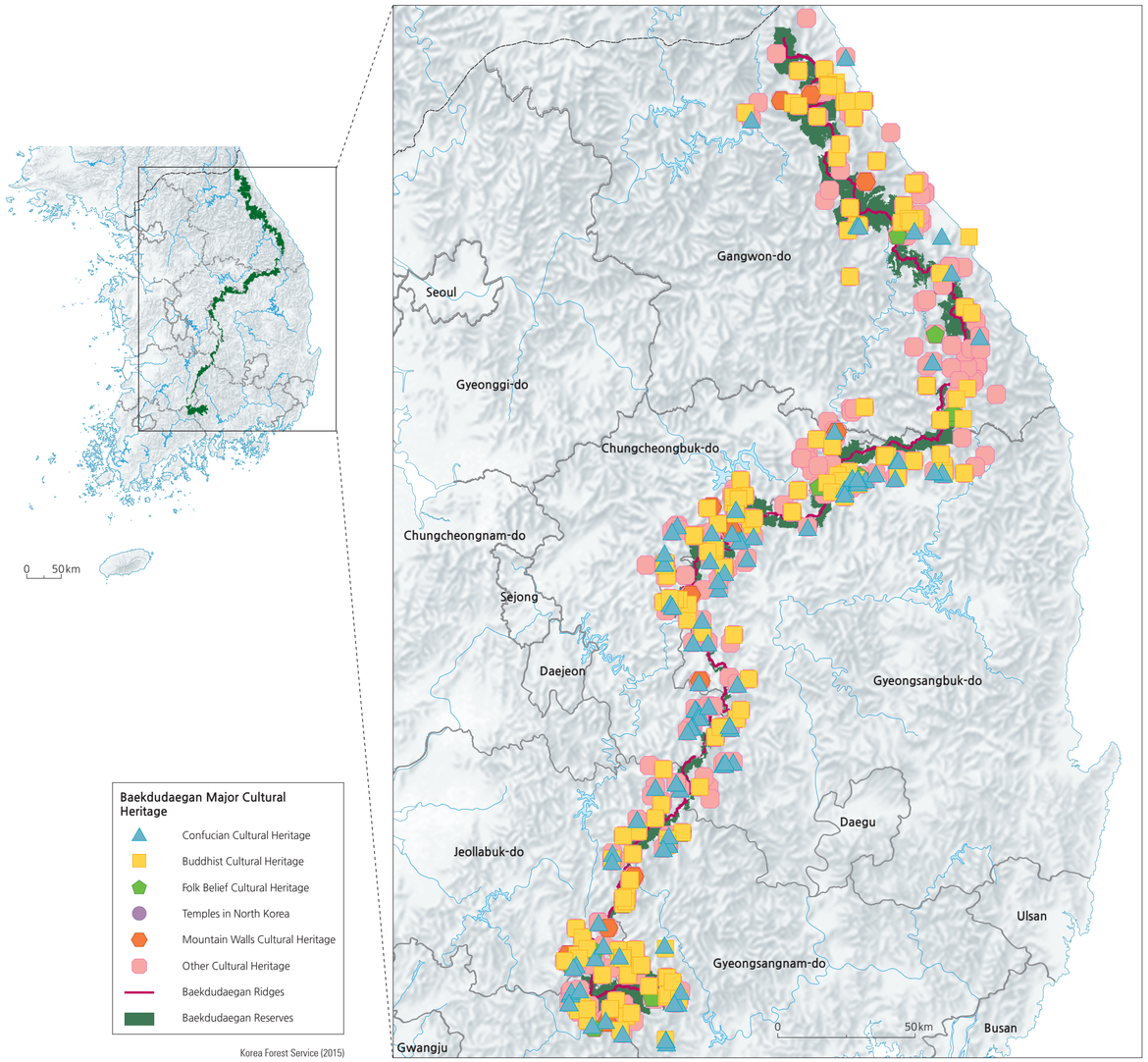
Among this wealth of traditional knowledge is one relating to the collection and processing of acorns for food. The Korean word dotori for acorn is a compound word derived from “dot” (boar) and “tol” (nut), meaning a kind of nut that wild boars like to eat. Korean people use acorns for food today. Archaeological sites on Sejuk beach in Ulsan produced evidence that people dug holes regularly to get rid of acorn tannins with sea water to make food with acorns as far back as 6,000 BC. Historical records cite King Sejong in 1424 who ordered that people “keep a good number of acorns in reserve for famine years.” He also commanded people to plant oak trees as a hardy plant when crop production was not sufficient. The Injeji of Imwon gyeongjeji (the largest practical encyclopedia of the Joseon Dynasty), explains how people could plant oak trees and take care of them. Boncho gangmok (the book of Chinese medicinal herbs) describes acorns as “neither crop nor fruit, but having merits of both, a good diet without any supplementary tonic.” Thus, sawtooth oak (Q. acutissima), which have bigger acorns and are more productive than all the other oak tree species, are generally found near villages rather than in high mountains. Sawtooth oak inhabits temperate forest regions with annual mean temperatures ranging from 5 to 14 ˚C below an elevation of 800 m.

Brief Interpretation of the Map

Buddhists have always sought places of tranquility and seclusion to build temples where monks can stay and pray in harmony with nature. Over the centuries, a large number of temples and cultural places have been built along the crest of the Baekdudaegan mountain chain where forests and wildlife are abundant. It is this spiritual setting that preserves the identity of Buddhist believers in Korea. A traditional way of life is also maintained here as opposed to the busy hustle and bustle of urban areas where everyday life is much more rushed and stressed. The mountains are a perfect place to pass on traditional forest knowledge to later generations. Although the ways modern society preserves agricultural and ecological knowledge are different, Koreans believe there is still wisdom in the traditional forest knowledge that can be tapped to solve environmental problems.

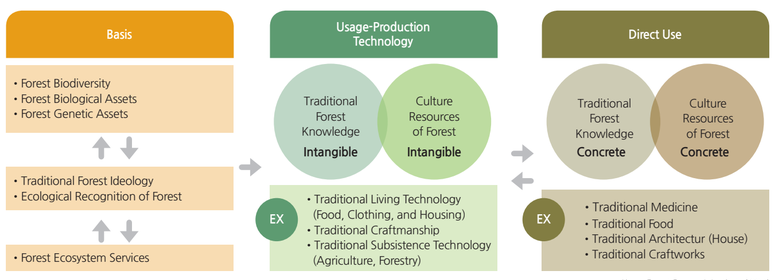
While preserving traditional forest knowledge is important to the heritage of Korea, spatial conditions change away from the mountains. The practice of Baesanimsu (“with back to the mountain and face to the water”) supplies water and protects farms from winds in mountainous areas, but such conditions are not available in the lowlands. What kind of adaptations can you imagine would be required to maintain the practice of Baesanimsu when one moves out of the mountains into the western lowlands of Korea? Are modern farming methods using machinery on larger fields more appropriate for flat lowlands? Can both methods coexist at different spatial conditions?

Baekdudaegan Conservation Areas and Distribution of Major Cultural Assets



Korea Forest Service (2015)

Developments in Traditional Forest Knowledge



Korea Forest Research Institute (2014)

Food Made with Acorns

Traditional Ecological Practices

Examples of forests in village groves

Mapping the Ecology of Korea

The Korean Peninsula is located between 33˚ and 43˚ north latitude in a temperate climate region with four seasons. Precipitation in Korea is abundant, and each season produces diverse climatic characteristics across the peninsula. In South Korea, mountain areas, which are mostly distributed around the northern and eastern regions, cover about 64% of the land. In the southern and western areas where large rivers run, various erosional or depositional landforms surround the rivers. Three sides of the Peninsula are surrounded by the sea with a ria-filled coast and many islands along the south coast; even and flat tideland resulting from a vast tidal range on the west coast; and sand dunes and lagoons alongside a smooth coastline in the East Sea.

The complexity and variety of ecosystems formed by the diverse climate and complicated topography affect the biodiversity which inhabits the Peninsula. Sub-alpine coniferous forests are common in the northern region, deciduous broadleaf forests are common in the central region, and warm, temperate evergreen forests are common in the southern and island regions. The natural conditions and variety of vegetation also create variations in ecosystem productivity, resulting in distinct micro-habitats for a wide diversity of faunal communities.

The rich and diverse ecosystems in the Korean Peninsula have attracted people for centuries. The people of Korea have been provided with abundant ecosystem services. They have developed a unique lifestyle that merges the marine culture of the Pacific with the continental culture of Eurasia. They have also established a watershed-based traditional view of nature with the Baekdudaegan Mountain Ridge as the backbone of the Peninsula, and have developed numerous unique ecological cultures such as village forest, acorn jello, Songgye (traditional social institution for sustainable forest management), and Hyangyak (local rules). Although the rapid industrialization and land development has expanded the national economy, Korea now faces significant environmental issues such as pollution of air, water, and soil, reduction of biodiversity, and ecosystem degradation.

To take action against these issues, natural environments and biota have been studied vigorously and mapped nationwide. The Ministry of Environment has been conducting a nationwide survey of the natural environment every five years. The first Natural Environment Survey started in 1986. Since 2014, the 4th survey has been carried out. The produced maps range from thematic maps such as valuable geomorphologic feature maps, vegetation maps, floral and faunal distribution maps, and comprehensive environmental evaluation maps. They are now publicized and widely consulted by various users such as environment-related governmental agencies, industries, academics, and the public.

The collected data have been comprehensively assessed and used for the formation of Ecological Naturalness Maps. Ecological Naturalness Maps visualize the ecological value of each spatial feature—mountains, rivers, inland wetlands, lakes, farmland, and urban areas—according to a specifically-derived rating system.

For the Ecological Naturalness Maps, environmental investigations are carried out to evaluate ecological naturalness through field surveys under nine categories (geographical features, vegetation, flora, benthic macro-invertebrates, insects, freshwater fish, reptiles, birds, and mammals). The results are stored in a GIS database. Based on these data, assessments of vegetation, animals and plants, geographical features, and wetlands are carried out for the comprehensive evaluation of the Ecological Naturalness Maps.

Final results are illustrated on the maps according to a 4-Grade ranking system. In Grade 1 areas, the highest grade, development activities are limited in order to preserve or restore the natural environment. In Grade 2 areas, measures are required to minimize impacts on the natural environment due to development and land use. In Grade 3 areas, systematic development and land use are permitted. National parks and cultural heritage protection sites are designated as reservation areas by laws such as the Natural Environment Conservation Act. They are classified as Special Management Areas. Grade 4 areas represent the least amount of preservation value.

Ecological Naturalness Maps are used in national and local environmental plans, as well as in the process of making and implementing development plans, environmental impact assessments, and in consultations requiring referential data.

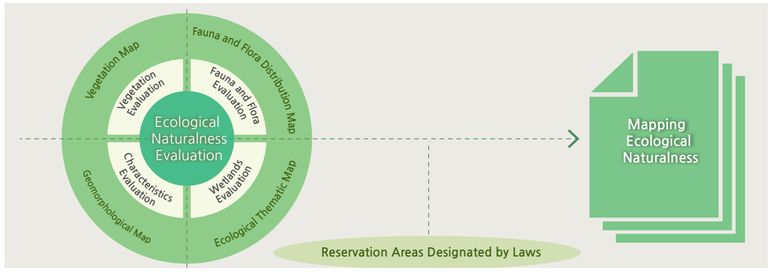
Brief Interpretation of the Map

The Ecological Naturalness Map displays areas of special concern for development sensitivity. National Parks and other special reservation areas are shown in orange and are concentrated in coastal areas and along mountain ranges in the north-central area of South Korea. Grade 1 areas with limited development tend to be also in mountainous areas and concentrated in the north adjacent to Special Management Areas. Other Grade 1 zones are small and scattered in other high terrain areas. In Grade 2 areas, development measures are required to minimize impacts on the natural environment. The Grade 2 areas comprise by far the largest category and encompass most of the rest of the country of every elevation excluding valleys, agricultural areas and urban areas.

This map shows over 80% of South Korea is covered by Grade 2 or better areas of ecological and environmental developmental concern. With this degree of sensitivity, one wonders how much more of the land area of South Korea can tolerate further development of any type or how new development needs to be tailored to protect the environment.

The Natural Environment Survey map on page 122 shows a Grade 1 (limited development activities) boundary. Part of the boundary suggests a natural boundary (roughly following a terrain elevation) and another part of straight line segments indicating a human defined administrative boundary. Does the variable nature of a composite boundary of this type require variable rules for protection steps as well? With the Grade 2 designation covering over 50% of South Korea, how effective do you think restrictions of the Grade 2 classification are in protecting the environment? Discuss if the Grade 2 classification might be too broad, given how expansive it is in areal coverage? Do you think the Grade 2 classification requires new protection rules? Should the Grade 2 category be divided into two or more classifications, to more accurately define ecological sensitivities of different areas?

Mapping Procedure for Ecological Naturalness Map



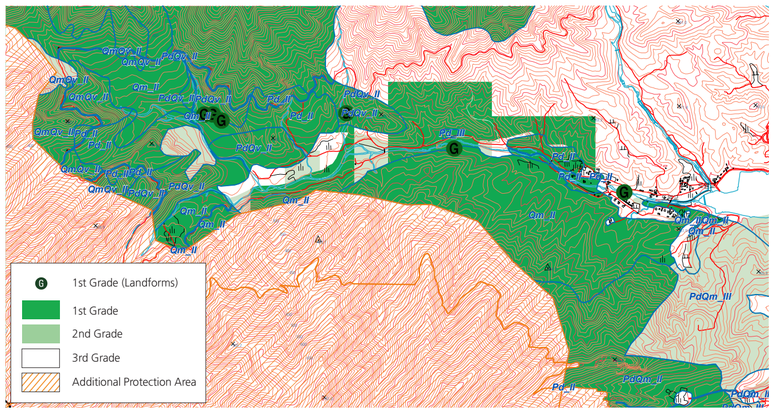
National Institute of Environmental Research (2014)

Geomorphological Feature Survey

Vegetation Survey

Fauna and Flora Survey

Example of Natural Environment Survey (Ganseong Map Sheet)



National Institute of Ecology (2015)

Ecological Naturalness Map

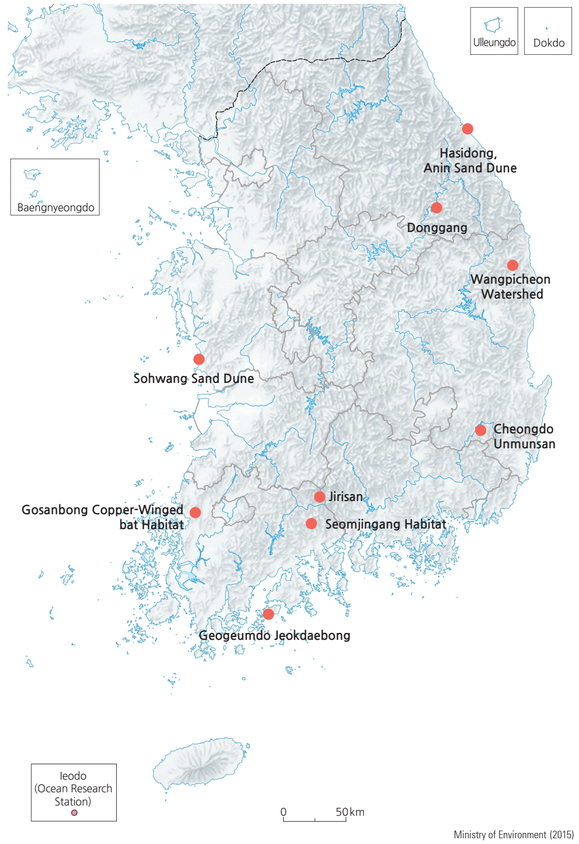
National Institute of Ecology (2015)

National Parks and Protected Areas

Korean National Parks

Korea National Park Service (2015)

Distribution of National Ecological Landscape Conservation Areas



Ministry of Environment (2015)

The modern concepts of protected areas were primarily implemented in Korea through the establishment of the Forest Act, Parks Act, and Cultural Property Protection Act in the 1960s. Hongdo and Seoraksan were designated as the first nature reserves in 1965 and Jirisan was designated as the first National Park in 1967. There are ten related Acts regarding protected areas in Korea. Three of the ten Acts, the Natural Environment Conservation Act, the Marine Environment Management Act, and the Cultural Property Protection Act deal with general matters of environmental and cultural property protection, regulating relevant provisions for these protected areas. The remaining seven Acts mainly contain provisions focusing on the designation and management of protected areas.

Since the designation of Jirisan National Park as the first national park in Korea on December 29, 1967, a total of twenty-two national parks have been designated and protected. Except for Hallasan National Park, which is managed directly by Jeju Special Self-Governing Province, the National Park Authority (established in 1987) manages all the national parks. The total area of the national parks is 6,653.924 square kilometers, of which 3,969.414 square kilometers are land and 2,684.510 square kilometers are sea. Among the twenty-two national parks, seventeen are associated with mountains, four are coastal, and one, Gyeongju National Park, is urban. Taebaeksan was the last to be designated as a national park on August 22, 2016.

Other than national parks, various regions have been selected and designated as natural parks in order to protect ecosystems and cultural landscapes. Among these natural parks, some prominent examples include provincial and county parks, as well as ecological landscape conservation areas. Provincial parks are representative areas of natural ecosystems and landscapes in metropolitan cities and provinces. By 2016, there were thirty provincial parks designated (with a total area of 1,139.1 square kilometers). County parks are representative of local districts (-si and -gun administrative levels) with a total of twenty-seven currently being operated (comprising a total area of 237.7 square kilometers). Such natural parks increase the value of the natural ecosystems and thereby provide the local community with opportunities for regional development. Lately, provincial and county parks are increasing in area as provincial municipalities are attempting to promote regional development and tourism.

National Ecological Landscape Conservation Areas are chosen and managed based on their geological-geomorphologic value, vegetative importance, ecological recognition, or necessity for conservation. These areas present significant values in conservation and scholarly research of biodiversity by maintaining the primitiveness of natural ecosystems. The regions possess distinct geological or topographical characteristics that are protected for sustainability, for research and for scenic values. The areas also represent diverse ecosystems and possess exceptional natural landscapes such as rivers, mountains, and valleys. Nine areas are currently designated and protected across the country.

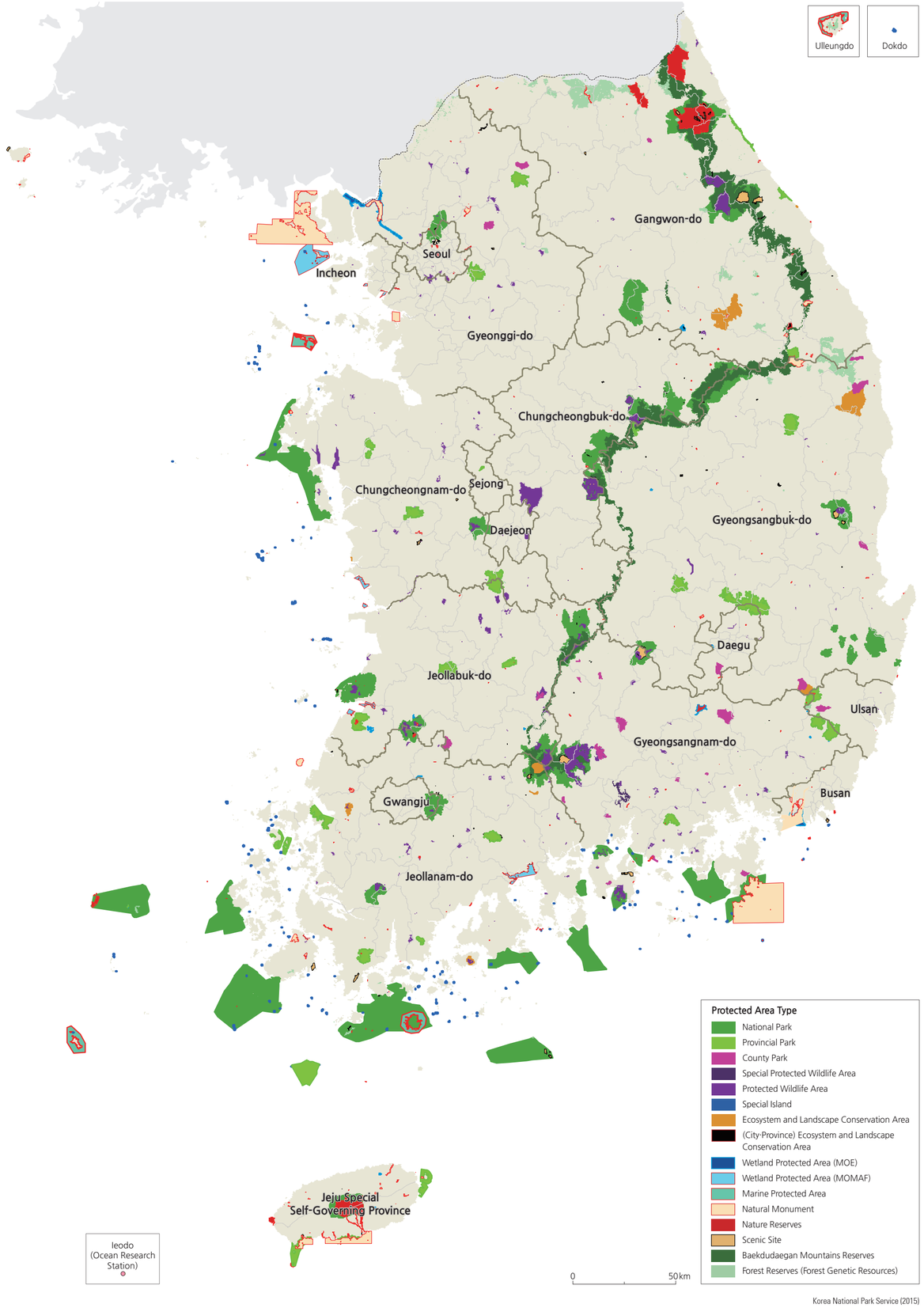
Brief Interpretation of the Maps

The Baekdudaegan Mountain Range is more than just the principle geomorphologic spine of the Korean Peninsula; it is also a philosophical core of Korean Culture. In many of the maps in this atlas it forms a central pattern of many different data distributions. It is a national treasure where many Koreans aspire to hike. Furthermore, it hosts many elements of Korean terrain, forests and cultural sites, similar to the Appalachian and Pacific Crest Trails in the United States.

The crest of the whole range is almost a continuous chain of National, Provincial, and County Parks and Reserves. The largest units of protected areas are National and Provincial Parks that are distributed around the east and south coasts. However, parks are not concentrated around major metropolitan areas. The smaller preserves are well distributed in most of the sub-districts in South Korea.

Major preserves are not evenly distributed because of the special natural characteristics that distinguish a nature preserve. Philosophically, preserves are for providing areas for rest and mental regeneration as well study and preservation. Do you see a conflict between the designations of the largest parks and reserves in more remote regions, compared to the goal of maximizing urban access to natural areas for rest, study and regeneration? What other characteristics could be useful in defining and locating different types of preserves? Preserves in South Korea tend to be large in area or very small. Can you make an argument for a variety in sizes of preserves?

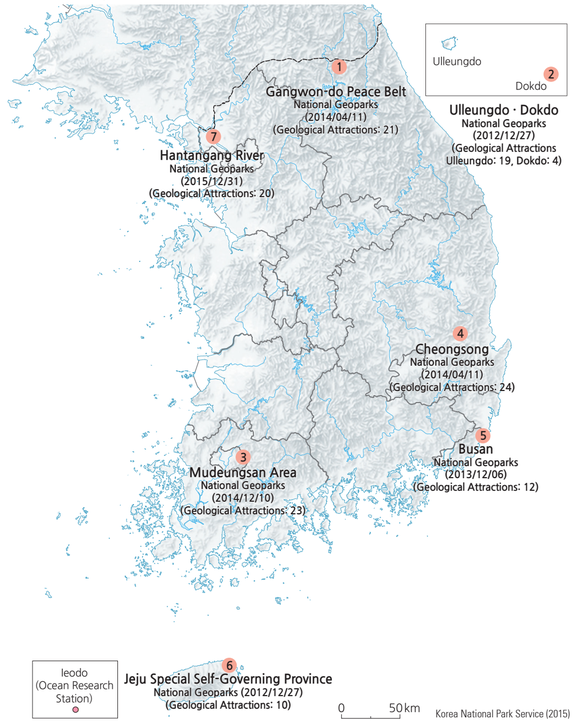
Protected Areas



Korea National Park Service (2015)

National Geoparks, Wetlands, and Uninhabited Islands

National Geopark Network



❶ Gangwon-do Peace Belt National Geopark (Geological attractions:21)

❷ Ulleungdo-Dokdo National Geopark (Geological attractions: Ulleungdo, 19; Dokdo 4)

❸ Mudeungsan Area National Geopark (Geological attractions: 23)

❹ Cheongsong National Geopark (Geological attractions: 24)

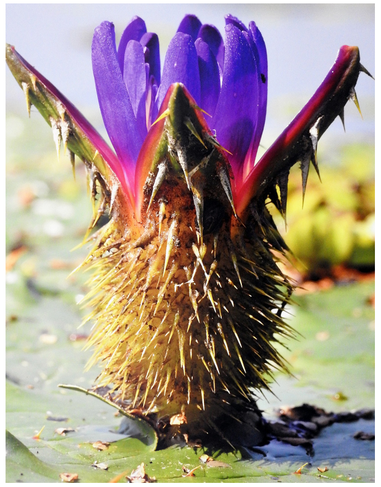
❺ Busan National Geopark (Geological attractions: 12)

❻ Jeju Special Self-Governing Province National Geopark (Geological attractions: 10)

❼ Hantan-Imjingang River National Geopark (Geological attractions: 20)

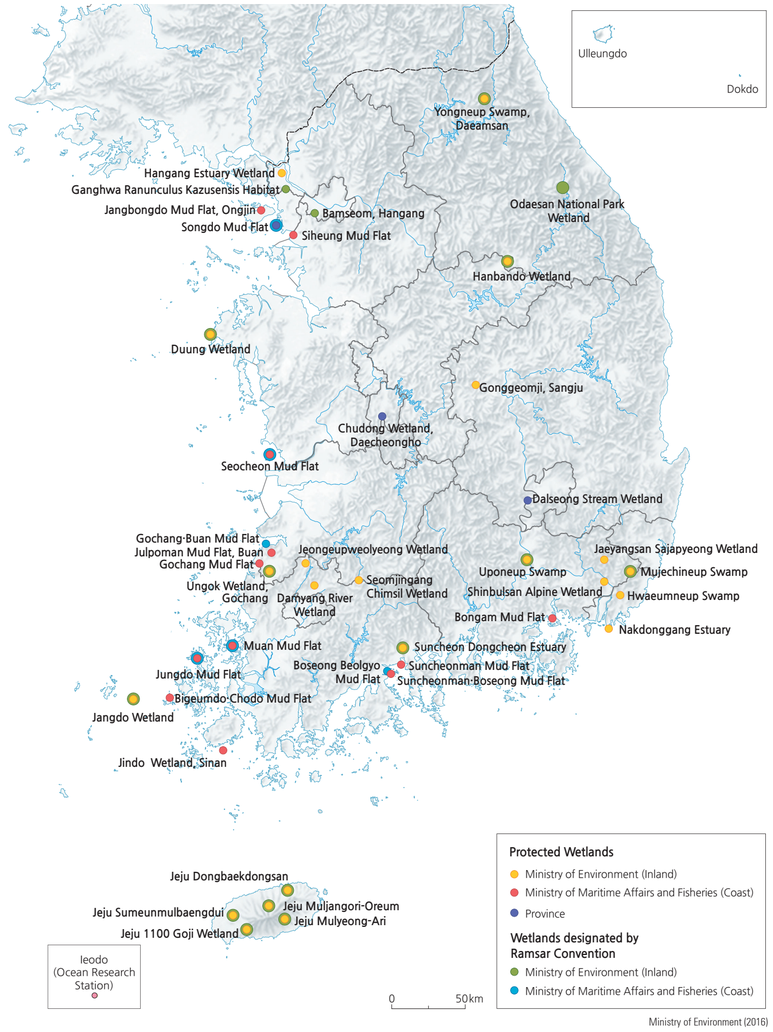
Hantangang-Imjingang Geopark includes Jaein Waterfall and Jwasang Rock of the Mesozoic Era, Jeogbyeok Columnar Joint, Dangpo Castle, Yeoncheon Jeongok-ri Prehistoric Site, Baegeui-ri Sedimentary Layer, Dongmak-ri Tuff, Pillow Lava in Auraji of Yeoncheon, Hwajeokyoun Pond, Art Valley, and Gurai Valley in Pocheon-si. It has 20 geosites and a total area of 767 square kilometers.

Changnyeong Upo Wetland (Uponeup Swamp)



Rare plants are found in the Changnyeong Upo Wetland

Wetlands



Ministry of Environment (2016)

Wetlands are a haven for biodiversity and provide an ecological buffer zone for hydrological and atmospheric processes. Korea has been conducting wetland monitoring in an effort to select certain wetlands as subjects for its conservation plans. Currently, 22 protected wetlands (with a total area of 126.28 square kilometers) have been designated by the Ministry of Environment. Additionally, twelve wetlands along the seaside (with some 225.17 square kilometers) have been named by the Ministry of Ocean and Fisheries, and seven wetlands are protected by other regions and provinces (covering 8.254 square kilometers). The Convention on Wetlands of International Importance (the Ramsar Convention) took place in Ramsar, Iran in 1971 and was enacted in 1975. It was intended to protect internationally important wetlands that function as habitats for animal and plant wildlife—waterfowl in particular. By 2015, 169 countries had joined the Convention, and Korea has been a member since 1997. There are 22 registered wetlands in Korea that are recognized by the Ramsar Convention, notably including: Gangwon-do Daeamsan Yongneup Swamp, Changnyeong Uponeup Swamp, Jangdo Wetland and Suncheonman in Jeollanam-do; Chungnam Taean Duung Wetland, Ulsan Mujechi Wetland, Muan Tidal Flat, Ganghwa Maehwamareum Habitat, Odaesan Wetland, Yeongwol Hanbando Wetland, Mulyeongari, Muljangori-Oreum, and Sumeunmulbaengdui in Jejudo.

Among the 3,167 islands of Korea, all accessible and large islands are occupied by residents while 2,675 small remote islands remain uninhabited. Uninhabited islands are important to national territory and economics, as they are pivots for defining base points for national sovereignty boundaries and exclusive economic zones. From an ecological and environmental perspective, uninhabited islands are protected from human disturbance, so their conservation status is higher than that of inhabited islands. From an academic point of view, uninhabited islands have special geologic, topographic, landscape, and ecosystem features that provide opportunities to investigate changes in climate, land surface features, sea levels and much more. Uninhabited islands are more affected by ocean currents and sea waves, thus providing easier observation of various coastal topographic features that result from erosional and depositional processes. Erosional landforms such as wave-cut platforms, sea cliffs, sea caves, sea arches, sea stacks, and notches are dominantly located where the rocky coasts of uninhabited islands meet the open sea. By contrast, islands located in inland seas often have beaches and tidal flats.

Under the Act on the Conservation and Management of Uninhabited Islands, established in 1997, conservation efforts have been carried out for uninhabited islands with particular landscape value or ecological importance. By 2014, 1,170 islands had been studied, of which 219 are registered as special islands for conservation. These special islands are mainly located in Jeollanam-do and Gyeongsangnam-do, as rias coasts (coasts with inlets) are very prominent in these regions.

Brief Interpretation of the Maps

The National Geopark Network map shows all seven geoparks are relatively evenly distributed in the country with one situated on Dokdo and one on Jejudo as island-based geoparks. Two of the remaining five are close to the DMZ and the other three are scattered to allow access from much of in the country. The locations of wetlands, as can be easily imagined, are away from the mountainous areas where the flow of water can be slowed down to accumulate on coastal lowlands and flat valleys. Generally, most of the wetlands can be found in the southern half of Korea with a few exceptions in the northeast and in areas around the capital region of Seoul. While geoparks have a high value for their geologic formations and natural wonders that attract visitors, wetlands serve a different purpose−that of conservation. Wetlands have the ability to rejuvenate battered environments, mitigate some water pollution, attract waterfowl and harbor native wildlife and rare flora. Geoparks, wetlands, and uninhabited islands are environmental assets to a nation; there is a need to protect and preserve them.

While there is no UNESCO designated geoparks in the United States listed in the Global Geoparks Network, national parks, national monuments and other designations administered by the U.S. National Park Service serve the same function as UNESCO geoparks. Describe your own experience from visits to (or your own desire to go to) national parks of your country. What can you learn from visits to national parks? Why is it important to preserve national parks and places of beauty?

Just like any country, assets of the wetlands and national geoparks of Korea need to be protected. Conservation and preservation efforts are important in helping to sustain a balance between the environment and economic developments. Korea is blessed to have large numbers of geologic structures that are of high value for researchers and tourists alike. In addition, there are also thousands of uninhabited islands. While these islands may be unoccupied, they serve a myriad of important purposes.

National Geoparks target areas with geological and geomorphologic significance to carry out conservation activities that meet the criteria globally prescribed in a particular country (in Korea, the Ministry of Environment certification). National and World Geoparks are almost identical in their assessment and certification procedures, management structures, and operating systems. As of 2016, Korea operates these seven National Geoparks: Jejudo, Ulleungdo-Dokdo, Busan, Gangwon Peace Geopark, Cheongsong-gun, Mudeungsan, and Hantangang-Imjingang. Many more candidates are waiting to be designated.

The entire island of Jejudo, with its diverse volcanic landforms and geological resources, is a National and International Geopark. As the first National Geopark of Korea, Jejudo is often referred to as a "museum of volcanoes" as it boasts a variety of unique volcanic landforms. There are 368 cinder cones, termed oreums, above the surface and about 160 lava tubes and caves that are located underground. It is a rare phenomenon to see so many oreums, caves and lava tubes on one small island.

Ulleungdo and Dokdo, each a part of the Ulleundo-Dokdo National Geopark, are volcanic islands that provide essential clues explaining the formation of the East Sea. They are very important in various research fields including geology, biology, oceanography, and history. Seonginbong (986.7 m)—the highest peak of Ulleungdo—is located at the center of the island. Ulleungdo also has the Nari Basin, formed by a depressed caldera, and small peaks in Albong. Some other geosites of Ulleungdo and Dokdo include Dodong and Jeodong Beaches that have well-developed sea cliffs and wave-cut platforms; Gooksu Rock with its columnar joints; and other unique sites such as Daepoonggam, Elephant Rock, Turtle Rock, Bongrae Waterfall, Songgot Peak, Seonginbong Primitive Forest, and Mongdol Beach. There are a total of 23 geosites on these two tiny islands.

Busan National Geopark has a variety of diverse landscape features such as coasts, mountains, and estuaries. Consequently, it has a rich geo-heritage and a wealth of cultural assets. Nakdong Estuary, Songdo Peninsula, Taejongdae, Oryukdo-Igidae, Changsan, and Geumjeongsan are some of the 12 geosites in Busan National Geopark.

Gangwon Peace Geopark was designated in order to transform the areas around the DMZ from a symbol of Cold War hostility to a symbol of peace. It contains a rich geological and geomorphological heritage, and spans across Cheorwon-gun, Hwacheon-gun, Yanggu-gun, Inje-gun, and Goseong-gun. There are 21 geosites, including the Cheorwon Lava Plateau, Haean Basin (Punch Bowl), Potholes of Naerincheon, and Hwajinpo Lagoon, among others in the Gangwon Peace Geopark.

Cheongsong Geopark is famous for its magnificent landscape and plenty of historical, cultural, ecological, and archaeological heritage sites. Among 24 geosites, major locations include Yongchu Waterfall, Jeolgu Waterfall, Yongyeon Waterfall, Dalgi Waterfall, Juwang Cave, and Cheongsong Ice Valley.

Mudeungsan Area Geopark is located in Gwangju, Hwasun-gun, and Damyang-gun. It has 23 geosites such as the Seosokdae Columns and the Seoyuri Dinosaur Fossil Site, and 22 cultural heritage sites such as Mujin Goseong and Unjusa Temple.

Land Use and Land Cover

Over a long period of time, Korea has experienced various changes in its patterns of land use. Urban construction took root in basins and along major rivers, and cities gradually expanded with the growth of the population. Roads and railways were constructed to connect cities, leading to the further development of new metropolitan centers in surrounding areas. Farmlands for crop production and pastures for livestock also increased throughout the years. Hills were cultivated for upland farming fields, many of which have been converted into rice paddies through modern irrigation methods. In recent years, however, there have been instances where rice paddies are converted into upland farming fields in order to grow more lucrative products such as ginseng, fruits, and highland vegetables. In coastal regions, new land was created by reclaiming land from the sea.

Although land use has shifted in order to fit human demands throughout time, such changes have the potential to cause serious environmental problems. The expansion of urban and agricultural areas inevitably led to the decrease of forest areas, which in turn triggered an increase in greenhouse gas emissions, a decrease in the absorption of carbon dioxide, and the risk of natural hazards. Forest fragmentation resulting from the construction of residential areas, roads, and railways is threatening the livelihood of plants and animals living in the forest ecosystem. Environmental problems such as odor and leachate (polluted water or liquid leaching down to the subsoil, potentially moving into drinking water aquifers, and possibly creating other problems) arise due to waste landfills in metropolitan areas. Coastal land reclamation has caused a decrease in tidal flats, leading to biodiversity loss and an increased danger of near-shore disasters.

Korea has been making efforts to minimize environmental problems and achieve sustainable land use. Land use and land cover maps have been developed to understand the status of the surface of the earth and analyze the best land use practices accordingly. Along coastal shorelines, surveys are in progress to assess and monitor the restoration of marine habitats that have been destroyed. Waste landfill sites that are located near big cities are being developed into parks in order to minimize odor and leachate. Furthermore, Korea aims to prevent badly designed development projects with the launch of the National Environmental Zoning Map and also encourage eco-friendly land use by sharing regulatory information with the public. South Korea and North Korea display a large difference in land use and land cover patterns. South Korea has an area of approximately 100,000 square kilometers, while the area of North Korea is about 120,000 square kilometers. According to a land cover map from the late 2000s (2008–2010) produced by the Ministry of Environment, the total size of all urban and developed areas of South Korea is approximately twice that of North Korea. The urban and developed areas in South Korea amount to 3,700 square kilometers, which represents 4% of the total area. The urban and developed areas of North Korea comprise 2% of the total area, at approximately 1,900 square kilometers. These areas are generally located in basins or estuaries. By contrast, the agricultural areas of North Korea are more extensive than those of South Korea. In South Korea, 20% of the total area (20,000 square kilometers) is used as agricultural land, compared to 24% in North Korea (30,000 square kilometers).

Over the Korean Peninsula, approximately 70% of the total land area is covered by forests. High mountain areas are mostly located in the eastern and northern regions while low elevations and gentle slopes primarily appear in the western region. Due to these topographical settings, agricultural areas are mainly distributed in western regions and forest areas are located towards eastern regions.

Since 1975, urbanized areas have gradually been expanding around major cities such as Seoul, Busan, Incheon, Gwangju, Daejeon, and Ulsan. Areas surrounding the transportation networks between such metropolitan regions have also become increasingly urbanized. While agricultural lands have shrunk in mountain areas due a decrease in rural population, they expanded in coastal plains and hilly areas as a result of active land reclamation. Urban and agricultural expansion has also led to deforestation, which may cause various environmental issues such as global warming and flood hazards. Significant efforts are being made in order to minimize these potential environmental problems and also heighten the value of forest areas. As such, forest resources are closely monitored and forest protection areas are designated accordingly. In 2010, forested land was recorded as the largest land cover type, followed by cropland, urbanized and developed land, and others.

Brief Interpretation of the Map

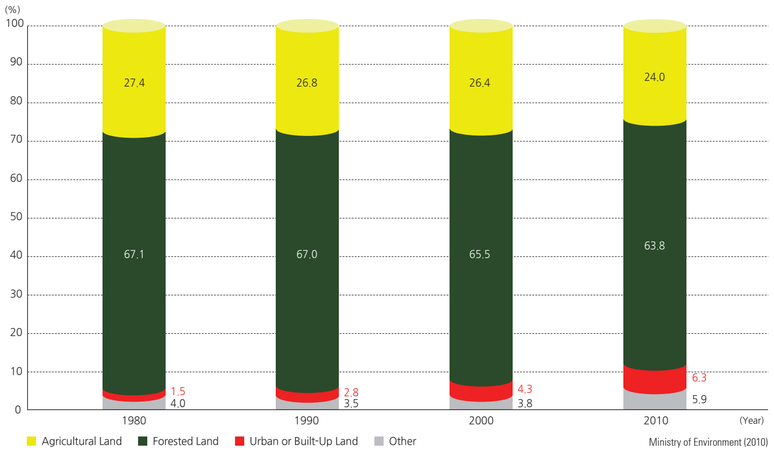
A brief look at the land-use/land-cover map gives an impression of the land as largely covered in forest, agriculture, grassland or urban -use. However, the dark green forest coloring tends to override the other categories. Also, the graph on the change of land-use over the last 40 years greatly simplifies the general pattern. The graph shows a land-cover dominated by forest and agricultural land with a relatively small decrease in forest, and a smaller decrease in agricultural land. However, these slight changes are also masked by the number of small changes within the broad categories and the composition of the changes in the large categories.

The whole texture of what processes are operating in the map may not be apparent at first glance. It is useful to take a pattern that one is familiar near their home setting and then look closely at what is happening in a similar place in Korea. Most of us are familiar with how the transitional area from urban to non-urban land appears, as one travels out past the edge of town. In most small cities, the transition from urban to agriculture is common and familiar, but the transition from urban to forest is less familiar. The scale of this map necessarily hides small transitions normally seen in the real world. However, the direction of a transition is not always the same. Urban land may move into and replace forest land on the timescales of months, years and decades, but the opposite does not happen on the same timescale. A forest does not move into and replace urban land on such short timescales.

In the transitional areas, there are often areas of environmental stress, simply because the built urban environment can change quickly and the natural one is the result of a series of slow processes. It is most useful to study this collage of patterns in small areas at a time. Tracing a narrowing valley to its head allows one to see more about the character of this collage than scanning across the terrain.

Study the Land-cover/Land-use patterns around the city of Daegu, which is in a mountainous area, and also the coastal city of Busan. Daegu is situated in a large valley. Agriculture exists on each side of the city, while forest occupies areas on the north and south sides of the city. Busan has internal forest areas and agriculture on the landward side. Place yourself 25 years in the future and project what changes you could expect to see given the patterns of the last 25 years.

Changes in the Cumulative Proportions of Land Cover



Ministry of Environment (2010)

Land Cover Map of the Korean Peninsula

Ministry of Environment (2010)

Land Reclamation

Land reclamation is a process to convert sea areas or river inlets that are adjacent to the shoreline into land areas by filling them with various kinds of earth and artificial materials, thus creating new land. Such new land can be tremendous assets for planned land use. Economic zones, residential areas, airports, industrial parks, agricultural land, transportation infrastructure, and sea ports have all been constructed on extensive reclamation systems in Korea. The most recognized of the reclaimed land is the Incheon International Airport.

Since the 1970s, Korea has been utilizing private enterprise and new technology to design and build extensive reclamation projects. The Seosan Reclamation Project, launched in 1980 and completed in 1995, was the first large-scale system to be organized by a private enterprise in Korea.

The total length of the breakwater is 7,686 meters (4.77 miles), including both districts A and B (see 2010 Land Cover Map). The reclaimed area is 15,409 hectares (38,076 acres), among which 9,626 hectares (23,786 acres) of land was reclaimed in Seosan District A, while 5,783 hectares (14,290 acres) was reclaimed in Seosan District B. The reclaimed land is mostly used as agricultural land; the rice paddies in Seosan have become the largest administrative district in Korea. This system also created the Ganwolho Reservoir (in District A) and Bunamho Reservoir (in District B). Ganwolho (see 1983 satellite image), which has been connected to the mainland, has become a tourist attraction known for its oyster production.

The Seosan Reclamation Project contributed to the development of Seosan-si and provided a habitat for winter migratory birds. Within a large scale agricultural zone, it was designed for protecting the bird habitat by reducing accessibility to human visitors. In addition, it has lots of flattened grain, making it an attractive location for birds. Typical migratory birds are the Baikal teal, bean goose, and buzzard. However, after the construction of the breakwater, species such as the longbill have decreased and there has been a decline in water quality of the reservoir. Currently, various plans are underway to improve the quality of the water.

The Saemangeum Embankment Project began in 1991 and was completed in 2006. As the longest embankment of the world, the project has a total embankment length of 33.9 km (21.1 miles). Some 28,300 hectares (69,930 acres) of land and 11,800 hectares (29,158 acres) of lake were created by the system. Saemangeum got its name by combining the first characters of Mangyeongpyeongya and Gimjepyeongya. As such, "Saemangeum" refers to the desire to establish new fertile lands that are similar to the Mangyeong and Gimje Plains.

The land use plan of the Saemangeum Project has been modified four times since 1991, with the latest plan being finalized in September 2014. According to this plan, 6 types of land uses are to be developed: industrial/research, international cooperation, tourism/leisure, agricultural, urban, and nature/ecosystem. The Saemangeum Project is expected to help the local economy by extending its land, creating rich agricultural space, securing water resources, and creating a tourism district. However, problems have risen during the development process, including damage to mud flats and water pollution. Mitigation efforts are being considered.

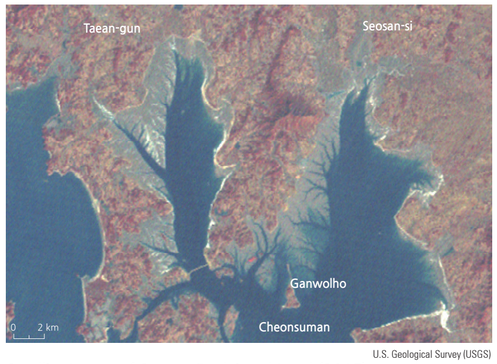
Brief Interpretation of the Map

The western coastline of South Korea is especially amenable to the development of Yellow Sea Coastal Reclamation Projects. This section highlights two especially important and very different systems. The Seosan Project, funded by private enterprise, includes the world acclaimed Incheon airport, agricultural areas, and wetlands, with provisions for wildlife sanctuaries. It must be admitted there has been some degradation of water quality within the seawalls. The Saemangeum Project, funded by the government, contains the longest seawall in the world and was designed with the primary goal of expanding prime agricultural land. However, some unidentified problems have led to a decrease in migratory birds using the area as a stopover on their routes. Local farmers have opposed the project arguing that there is not a need for more farm land because there is a drop in the agricultural sector of the economy. The environmental opposition to the project seems to come more from global groups rather than internal sources.

Another Korean project is the Shiwa Lake Reclamation Project. It boasts the largest tidal power station of the world. (See the section on Korean tides.) It was designed primarily for agriculture and energy.

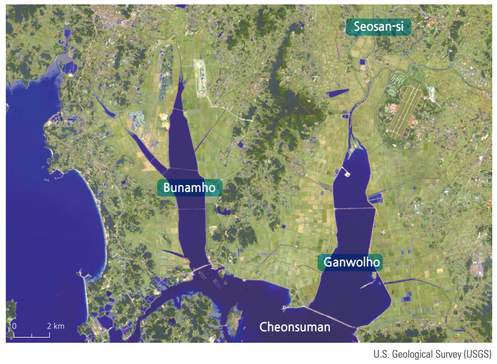
Most of the reclamation systems in South Korea were designed for uses like agriculture, wetlands and wildlife protection. Human designs rarely take the time necessary for natural processes to develop into balanced ecological environments. This problem tends to create artificial features that lack the stability inherent in natural processes. While developing large reclamation projects, efforts can be made to incorporate "natural" features such as bird feeding areas, or the creation of wetlands to protect sensitive plants and marine life. There are many steps and adjustments to make, to enhance the development of a natural feature to accommodate a species that took generations to adapt to the conditions of its natural habitat. If a human designed wetland was proposed to provide new nesting areas for a bird species, what features would be necessary in the design for a successful establishment of the species?

Satellite Image of Seosan Reclaimed Land (1983)



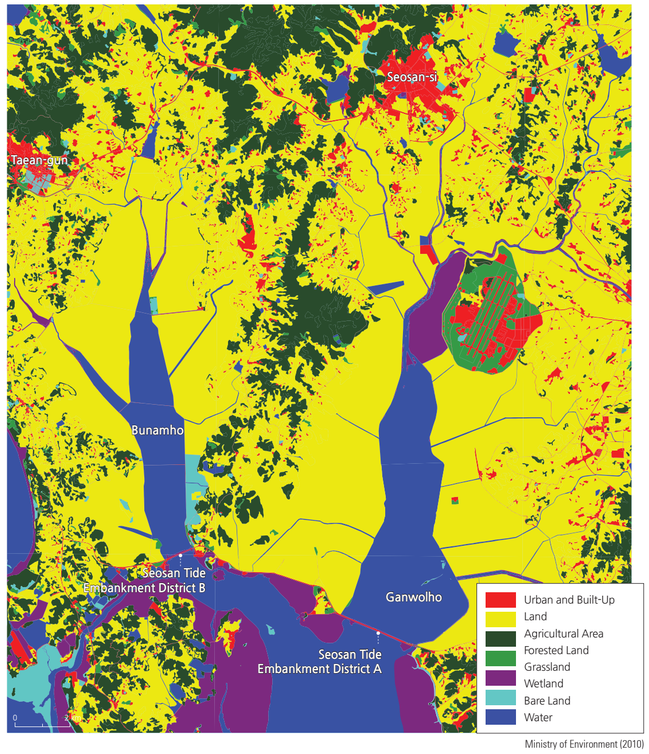
U.S. Geological Survey (USGS)

Satellite Image of Seosan Reclaimed Land (2015)

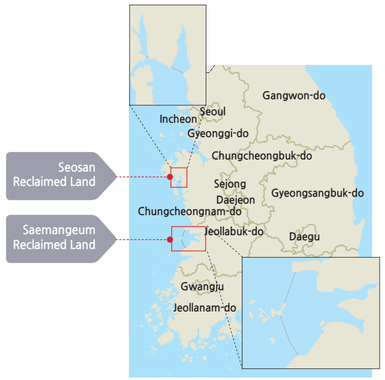


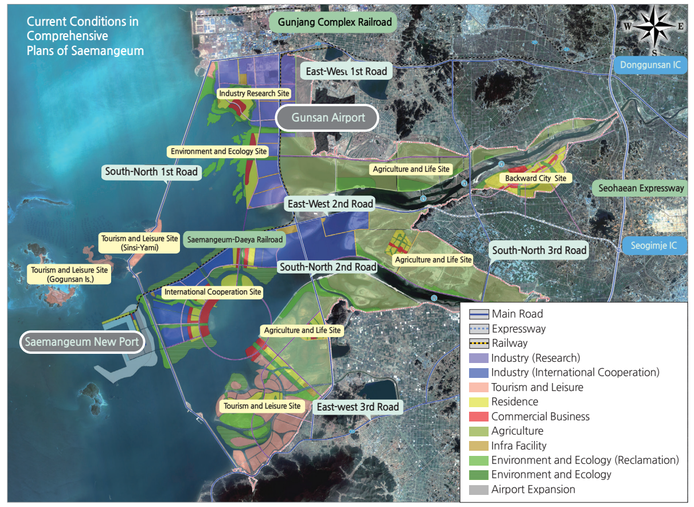
U.S. Geological Survey (USGS)

Land Cover Map of Seosan Reclaimed Land (2010)



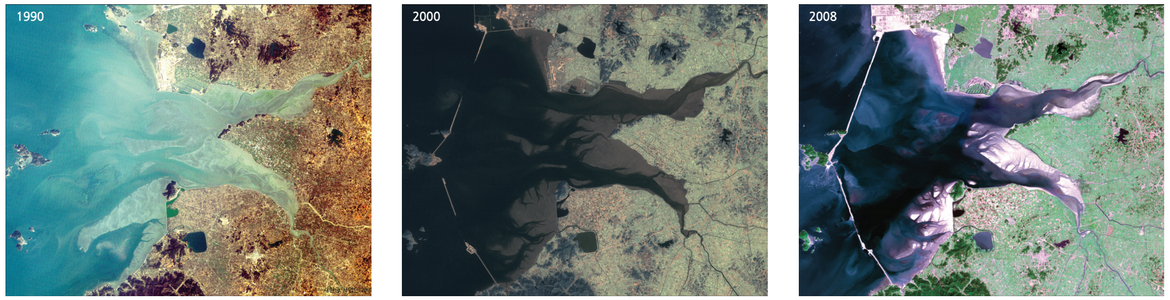
Ministry of Environment (2010)





Saemangeum Development and Investment Agency (2014)

Satellite Images of Saemangeum Reclaimed Land



U.S. Geological Survey (USGS)

Satellite Images of Saemangeum Reclaimed Land (2015)

U.S. Geological Survey (USGS)

Landfills

The completed Nanjido Landfill #1 in the process of being turned into the Haneul Park. Notice the height of the landfill by comparing to the buildings in the forefront of this photograph

Soil covering at the Metropolitan Landfill site. The poles are built to capture methane gas for use in generating electricity

Location of the Nanjido Landfill

Location of the Metropolitan Landfills

As a reality of our daily lives, garbage or waste is produced at an alarming rate. Imagine the amount of garbage that is produced on a daily basis for a city such as Seoul with its over 10 million people. Where does all this garbage go after the garbage truck collects it? Improper disposal of garbage will hurt the environment, thus every government has a vested interest to properly manage the massive amounts of garbage generated by its population. Basically, there are three management methods: recycle and reuse the waste, incinerate it, or bury it in landfills. As can be imagined, there are pros and cons for each of these three methods. While recycling and reusing are deemed the most environmentally friendly method, they also incur a high cost involved in the sorting, transporting, and processing of recyclable materials. Incineration involves the burning of garbage; this method requires expensive initial investments in incineration facilities that comply with environmental laws. Ash and some forms of gas are by-products of burning. While ash can be collected through filters, some cancer-causing dioxins and other harmful gases are likely to be released into the atmosphere. The most effective and least expensive method is to dump all the garbage into a landfill where maintenance costs seem minimal, but other problems may be created.

Large pits are dug in the ground, and lined with layers of non-porous materials before receiving any garbage. When garbage is added, bulldozers run over it to make it as compact as possible. Landfills can be several square kilometers in area and accommodate garbage as high as 100 meters. At a height that is deemed to be no longer capable of accepting additional garbage, the landfill will then be closed by covering the top with enough soil to make it stable. Because decomposing garbage will produce methane, a greenhouse gas, steps are taken before closing the landfill to install pipes and processing facilities to capture the methane, and turn it into heat energy and electricity that can power homes. This method reduces the amount of a greenhouse gas that is released into the atmosphere and energy is gained. Once the landfill is closed, it can be turned into a park; but unlike reclaimed land, no heavy buildings should be built on top of landfills as the area is not stable enough for such building weights.

The selection of landfill sites can be a challenge. During the years before it can be closed, people in surrounding areas will have to contend with its odor and the heavy traffic of garbage trucks. A site that is too far from the city will require higher travel time and costs for garbage trucks and fewer trips per day. For Seoul, there are two major areas that house landfills nearby. They are the Nanjido Landfill and the Metropolitan Landfills.

Nanjido, formerly used as a landfill site for Seoul and northern Gyeonggi-do, is currently established as an ecological park. After it was first designated as a landfill on August 3rd, 1977, the site received 110.5 million tons of waste over the next 15 years until the landfill was finally closed on March 19th, 1993. Within the 2.9 square kilometers of area reserved for the landfill, two huge waste mountains collectively spanning 1.75 square kilometers had been piled up with waste. This changed the elevation of Nanjido from 8 m to 98 m. The Seoul government built an ecological park on top of the closed site, now known as the Nanjido World Cup Park. This park features five theme parks. Currently, stabilization work is in progress and is scheduled to continue until 2022. Methane gas and other substances released from the closed landfill are used as heat energy sources for facilities at Nanjido World Cup Park and Seoul World Cup Stadium.

The Metropolitan Landfills—constructed beginning in1989 and opened in 1992—were established to complement the Nanjido Landfill. Consisting of four landfills, this system is the largest waste landfill project in the world by total area. The first, second, and third landfills are located in Geomdan-dong, Seo-gu in Incheon. The first landfill was closed in 2000, and the second landfill is currently in use. The fourth landfill will be located in Daebeok-ri, Daegot-myeon and Hakun-ri, Yangchon-eup in Gimpo-si. Although the Metropolitan Landfills were initially scheduled to be closed by 2016, measures such as the introduction of a volume-rate cost for garbage disposal system and enhanced recycling greatly reduced the volume of waste that was accumulated and processed during the 1990s and 2000s. Consequently, on June 29th, 2015, the local governments of Seoul, Incheon, and Gyeonggi-do agreed to extend the term for the Metropolitan Landfills to 2025. They also determined that additional local landfills will be prepared before the end of the term. The closed first landfill has been converted to a wildflower garden and a sports park that now serves as a leisure site for local residents.

Since the early 2000s, South Korea is making a major effort in decreasing the amount of solid waste by enforcing the separation of the different components of solid waste at its sources. A major focus on household waste has produced different types and sizes of disposal bags for homes. Waste is separated into food, combustibles, recyclables and non-combustible components at the grass root level so that waste management and recycling can be more efficient.

As a space-limited country, South Korea is also working toward other methods of solid waste management that avoid further expansion of the area required by landfills. In small villages and cities, landfills will continue to play a role in a growing population and will likely always be a cost effective method where land is available. However, other methods of waste management may be available but associated with higher investments and require larger populations to make them cost-effective. In most large urban centers programs for decreasing wasteful packaging and plastic packaging are already underway.

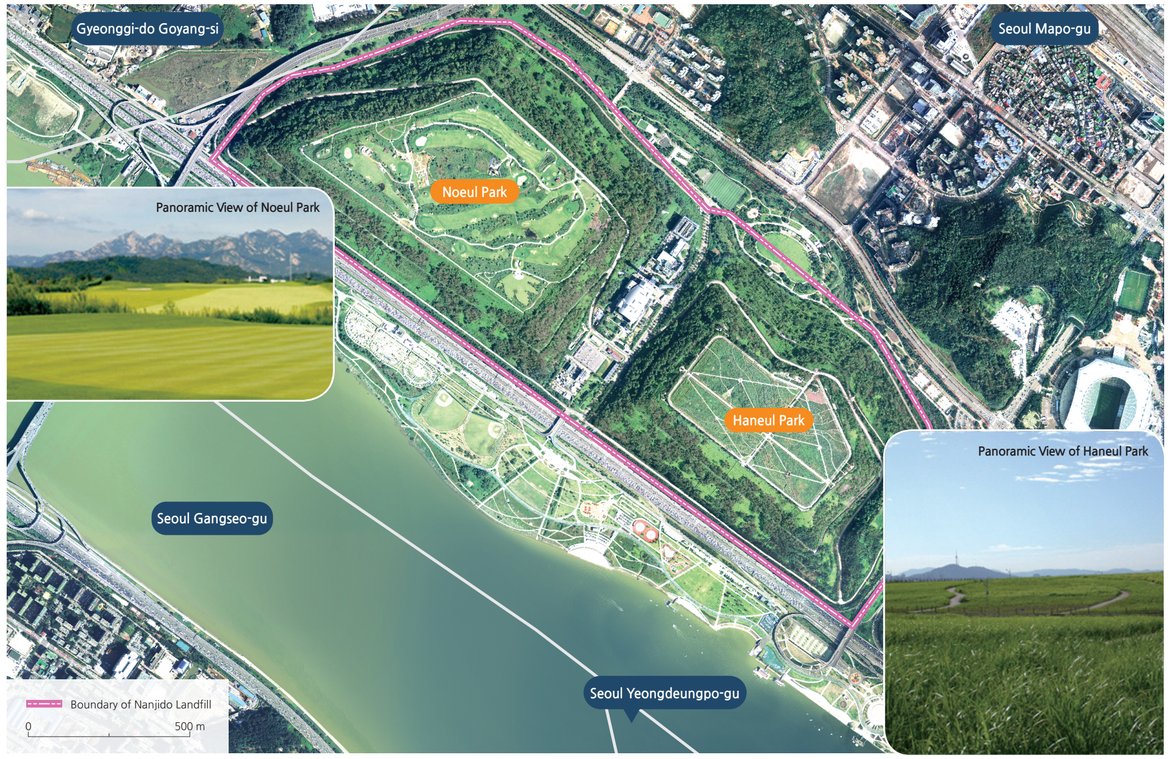
Recycling in an environmentally conscious society will play an increasing role as technological methods for sorting and reusing waste are improved. One method of decreasing organic waste is by commercial and home composting, turning scrap and wasted food into natural fertilizers while decreasing the amount of solid waste. Another method of decreasing the use of landfills is the incineration of appropriate solid waste to generate heat; this heat may be used to drive electric generators while decreasing the amount of imported fuels for electric plants. However, in South Korea only about a third of the approximately 250 combustion plants are currently being used to generate electricity, while the balance of the plants are primarily incinerating the waste to only reduce the amount of combustible materials that will be disposed of in landfills.

Brief Interpretation of the Aerial Photographs

The appearance of a landfill is hard to disguise even after its capacity has been reached and development for a different function has begun. Even though a different function can be introduced after completion such as a golf course or a nature park, the transition is primarily on the surface and masks long term effects. Because of the contents of the landfill, the natural evolution of a soils profile through biological processes is not possible, severely limiting the future of a completed site.

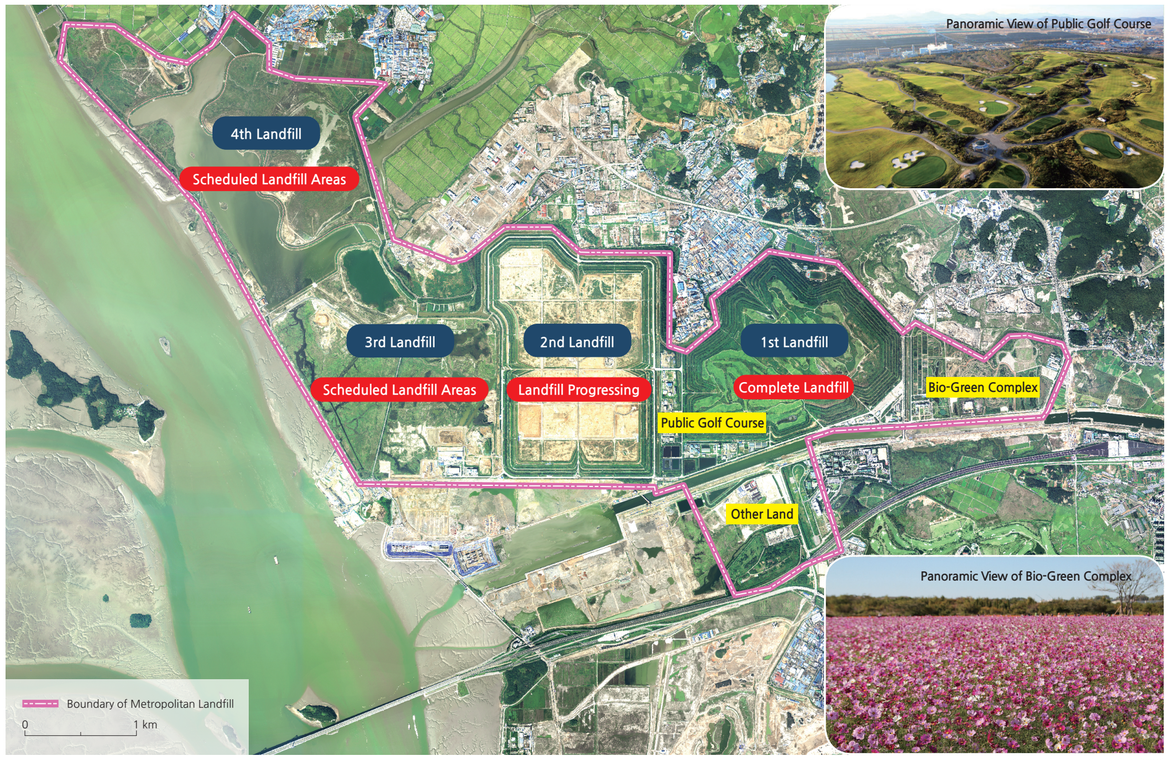
The use of landfills for disposing solid waste has a number of constraints. Discuss several of the stringent limits to the location and use of landfills near urban centers. Are these limits the same in rural communities?

Aerial Photograph of Nanjido (2012)



National Geographic Information Institute (2012)

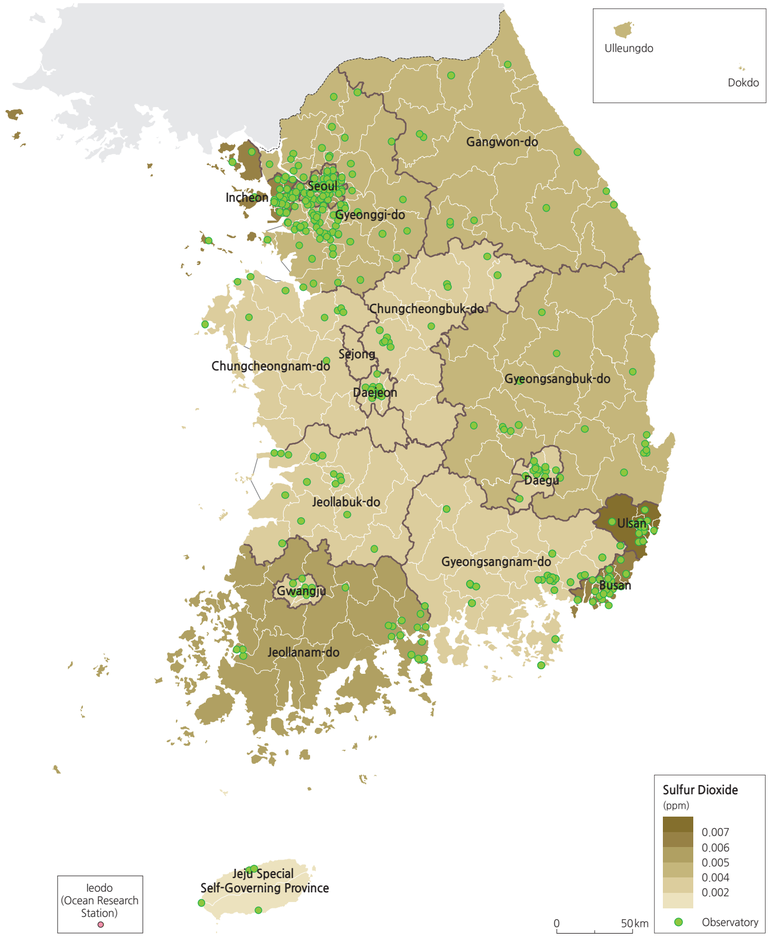
Aerial Photograph of Metropolitan Landfills (2012)



National Geographic Information Institute (2012)

Air Quality Monitoring

Air Pollution Measurement Network



Ministry of Environment (2014)

At the end of May 2015, an effort to coordinate and merge various air quality monitoring networks resulted in the National Air Pollution Monitoring Network. This new network with 514 stations was implemented throughout the country to investigate the status and trends of ambient air pollution and to determine whether air quality standards are being achieved. It is composed of an urban air monitoring network (259 stations), a roadside air monitoring network (38 stations), a national background monitoring network (3 stations), a suburban air monitoring network (19 stations), an acid deposition monitoring network (40 stations), an atmospheric heavy metal monitoring network (54 stations), a hazardous air pollutants monitoring network (32 stations), a photochemical air pollutant monitoring network (27 stations), a global atmosphere monitoring network (1 station), a fine particulate matter of 2.5 micrometers (PM2.5) monitoring network (35 stations), and an intensive monitoring network (6 stations). Data collected by the National Air Pollution Monitoring Network are stored in the National Ambient Air Monitoring System (NAMIS). Data on air pollution are disseminated in real time through "Air Korea" (www.airkorea.or.kr), an informational webpage first launched in December 2005 before the 2015 merger.

As part of the merger and in response to increased public concern regarding urban air pollution, the Ministry of Environment (MOE) installed a monitoring network to measure air pollutants such as fine dust and ozone. Approximately 300 monitoring networks —including urban air, roadside air, national background, and suburban air monitoring networks— measure a coarse particulate matter of 10 micrometers (PM10) and publicly provide real-time data on air quality. In addition, there are 6 intensive monitoring stations that prevent damage caused by air pollution by providing a more in-depth analysis on air quality.

To reduce air pollutants that are toxic or hazardous to humans, the MOE launched a PM10 forecasting program for metropolitan areas in August, 2013 and expanded it throughout the country. In 2014, forecasts were extended to include PM2.5 and ozone. The forecast level is classified into 5 stages to indicate the level of the ambient air quality associated with health risks of air pollution.

To fulfill the PM2.5 environmental standards newly implemented in 2015, the MOE expanded the PM2.5 monitoring network and established guidelines for its management of automatic data measurements. Currently, there are 164 automatic monitoring stations that measure PM2.5 concentrations (36 operated by the national government, 128 operated by local governments) and 36 standard monitoring networks.

The Korean government has also implemented an air pollution warning system for ozone levels. Used for directly announcing ambient levels of air pollutants under high concentrations of ozone and particulate matter, the system prevents and reduces damage by providing specific instructions for each alert level. It effectively notifies respiratory disease patients, the elderly, and children that are prone to harmful levels of ozone concentration, and also strives to encourage the voluntary cooperation of citizens. While the system was first initiated in 1995 in Seoul, all local governments of Korea now utilize it to verify ozone concentrations and issue warnings accordingly.

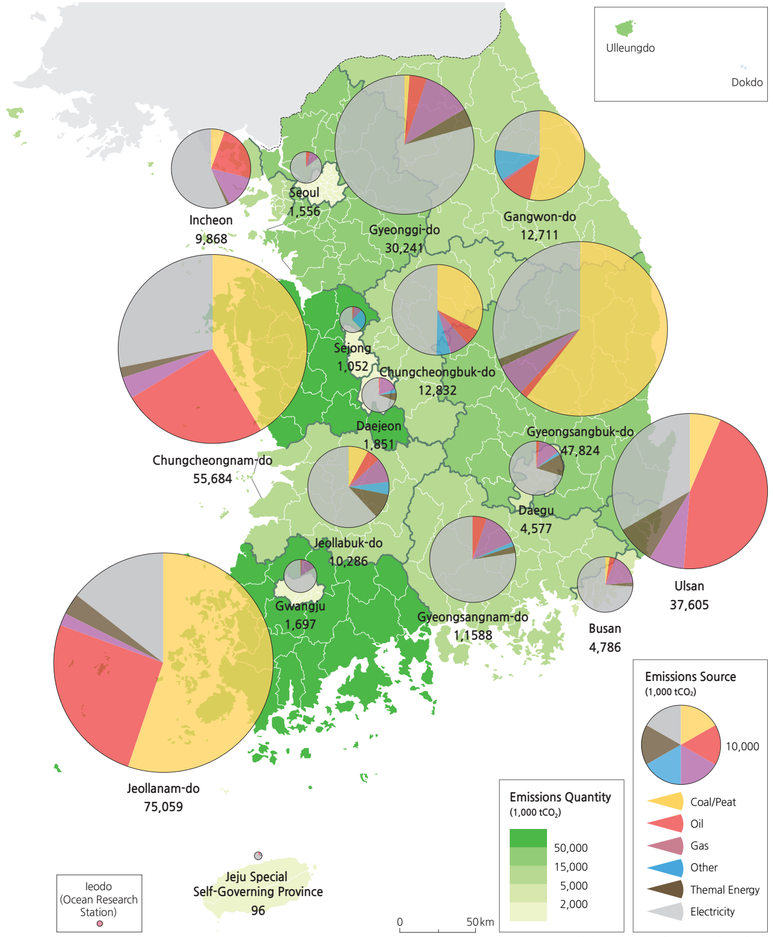
Brief Interpretation of the Map

The Air Pollution Measurement Network map shows the locations of air pollution monitoring stations. As can be expected, there is a heavy concentration of these stations in major metropolitan area where traffic congestion and vehicle exhaust, among other air pollutants, would be highest. Outside metropolitan areas, the density of these stations is sparser. The map also classifies concentrations of sulfur dioxide by province and metropolitan boundaries in units of parts per million (ppm). Interpretation of the pattern of sulfur dioxide from this map can be tricky because of the variable densities of data-collection stations between urban and rural settings. The higher number of stations in urban areas suggests that data is relatively more accurate than for rural areas. The sparsity of stations in rural areas that collect data for composing this map suggests that data are collected in just a few stations but are purported to represent the entire stretch of the province. This creates a disparity between the number of data points, comparing rural and urban areas. In turn, there may also be a significant difference in the reliability of rural and urban results. For example, the map shows high concentrations of sulfur dioxide in urban areas such Seoul, Incheon, Busan, and Ulsan but not in other urban areas such as Daegu, Daejeon, and Gwangju. What is spatially interesting is that there is a high concentration of sulfur dioxide in Jeollanam-do Province where the rural distribution of stations is uneven and clustered; three stations are clustered on the west coast of the province and over a dozen are clustered at its eastern tip, with no measuring station in between. Yet, the entire province is mapped as having a uniform color that represents 0.006-0.007 ppm. Analyzing this uniformity of data against the much clustered data collection stations strongly suggests that there must be a vast and variable spatial pattern of sulfur dioxide distribution within the province. In other words, these two clustered locations should not be taken as truly representative of sulfur dioxide concentration for the entire province.

Would the concentration of over a dozen monitoring stations in a small area create questions as to what kind of human activities are taking place there? Use an Internet world map to zoom into this area with a satellite or aerial photograph view to find out what kind of human activities are taking place at that location. (Hint: translation software available online can help identify what kind of business or industry is concentrated in this area.) What are some other environmental issues that may be of concern there? Discuss the rationale why the particular industries are located there.

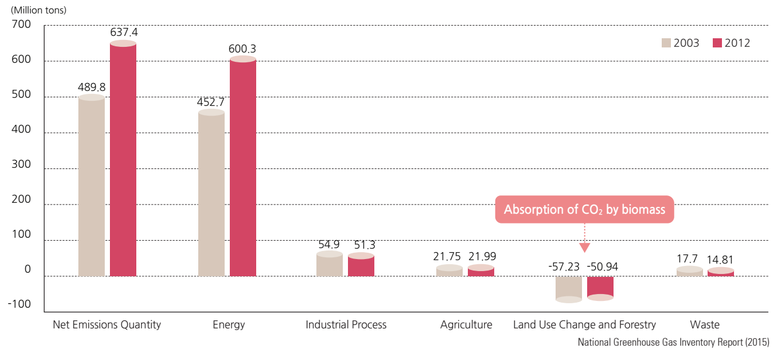
Greenhouse Gases

Greenhouse Gas Emissions by Province



National Greenhouse Gas Inventory Report (2015)

National Greenhouse Gas Emissions (CO_2 Equivalent) by Year



National Greenhouse Gas Inventory Report (2015)

While greenhouse gases may not necessarily be considered as air pollution, Korea has a vested interest in monitoring the amounts of emissions because of the direct effects of these gases on global warming. The 1996 and 2006 Intergovernmental Panel on Climate Change (IPCC) guidelines for national greenhouse gas inventories provided international standards for national greenhouse gas (GHG) emissions estimations. The current national GHG inventory of Korea has been formulated according to the 1996 IPCC guidelines. The government established the Greenhouse Gas Inventory and Research Center of Korea (GIR), which conducts monitoring and research on GHG emissions and reduction strategies.

The total GHG emissions in 2013 were recorded at 694.5 million tons of carbon dioxide (CO_2) equivalent. This represents an increase of 137.6% compared with 292.3 million tons CO_2 equivalent in 1990, and 1.5% compared with 684.3 million tons CO_2 equivalent in 2012. Net emissions were recorded at 651.7 million tons CO_2 equivalent as of 2013, representing an increase of 152.5% compared with 258.1 million tons CO_2 equivalent in 1990, and 1.9% compared with 639.5 million tons CO_2 equivalent in 2012. The energy sector accounted for the largest portion in 2013 at 606.2 million tons CO_2 equivalent (87.3% of total GHG emissions), followed by the industrial processes sector at 52.6 million tons CO_2 equivalent (7.6%), the agricultural sector at 20.7 million tons CO_2 equivalent (3.0%), and the waste sector at 15.0 million tons CO_2 equivalent (2.2%).

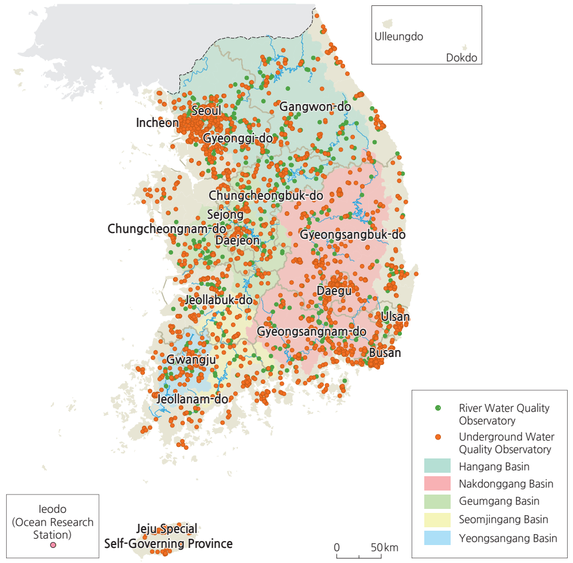
Brief Interpretation of the Map

The Greenhouse Gas Emissions by Province map shows two sets of spatial data: 1) emissions quantity and 2) emissions source by energy sectors. Both of these datasets are in units of thousands of tons of carbon dioxide. Although the title of the map specifically addresses "greenhouse gas" emissions, the only greenhouse gas that is mapped here is carbon dioxide; all other greenhouse gases (water vapor, carbon monoxide, methane, and ozone) have not been included on this map. The title also specifies "by province" which should really be "by administrative units" as metropolitan cities are also used as data collection base units (e.g. Incheon, Seoul, Ulsan, and Busan). The map shows Jeollanam-do Province as the largest emitter, followed by Chungcheongnam-do, then by Gyeongsangbuk-do, and by Ulsan as the four largest emitters. The energy sectors map legend information shows that the highest use of coal-peat and oil are, by far, the highest contributors of carbon dioxide emissions. These administrative units also coincide with petroleum, chemical, and energy industries.

All metropolitan cities, other than Ulsan, appear to produce little contribution to carbon dioxide emissions. Can you suggest a reason why this is the case? Do you expect to find large heavy industries or chemical industrial plants or petroleum processing plants located in urban centers? Provide the rationale for your answers.

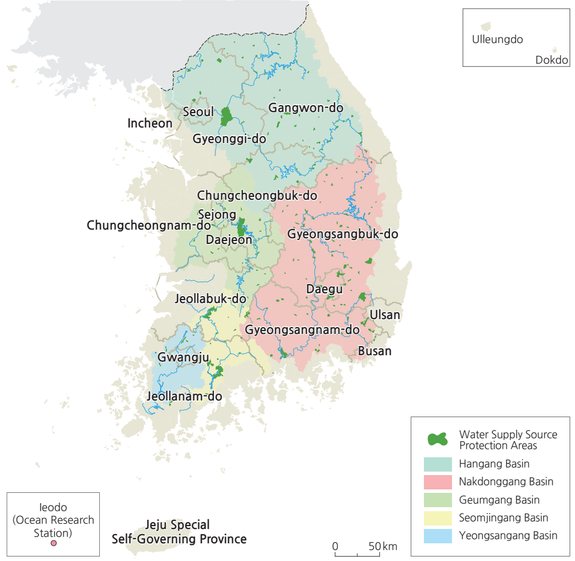
Water Quality Monitoring

Distribution of Water Quality Observatories



National Water Resources Management Information (2015)

Water Supply Source Protection Areas



National Water Resources Management Information (2015)

Water pollution may be caused by many human activities such as industrial wastes, agricultural fertilizer runoff, illegal dumping of materials into water bodies, and leaching of chemicals into the soil and underground aquifers. Scientifically, there are two ways that water pollution can occur: chemicals that dissolve in water and physical suspension or settling of materials in water.

In order to understand the status of the water quality of a nation, numerous monitoring stations that are spatially distributed over the country are needed. Water samples must be taken and analyzed in order to understand the quality of the supply of drinking water and all the water assets for both fresh water and sea water along coastal areas. Understanding the existing water quality is the first step to protecting these water resources.

In Korea, several ministries and even corporations are involved in monitoring water quality in order to prevent water pollution. The water quality monitoring network is operated to understand the status of water quality and aquatic ecosystems in public water bodies such as rivers and lakes. Water quality monitoring sites are selected based on the following criteria: sites for which water quality conditions must be addressed; sites to preserve good water quality; sites to identify changes in water quality status and pollution trends; sites to analyze contaminant inflow into rivers and their effects on the rivers; and sites to investigate pollution loads due to freshwater and seawater mixing. Currently, water quality monitoring is carried out at a total of 2,188 sites. Data on water pollution is disseminated through the "Water Resources Management Information System (www.wamis. go.kr)."

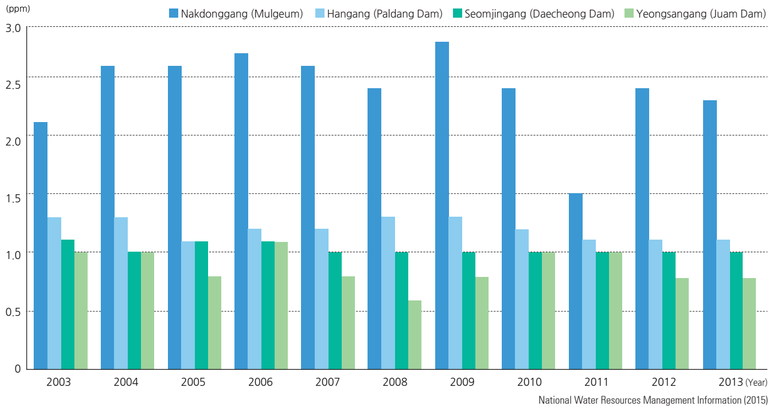
While inert (chemically inactive) materials (such as glass and ceramics) in the water do not cause as much damage, chemically active materials may change chemical composition of the water. One of the greatest concerns in surface water habitats is the depletion of oxygen, which suffocates fish and other organisms. When too much organic material is suspended in water, decomposers (such as algae) rapidly proliferate and use oxygen to decompose the organic matter, robbing oxygen from fish.

A typical example is the growth of algae. Excessive growth of green algae turns the water green. Green tides occur when suspended algae proliferate in slow-flowing rivers or eutrophic (rich in minerals and nutrients) lakes that contain high concentrations of carbon, nitrogen, and phosphorus. (Nitrogen and phosphorous are major components of agricultural fertilizers and become nutrients in surface waters for decomposers.) Although the green algae discharge oxygen by photosynthesizing during daytime, they also consume oxygen in the evening. This creates anaerobic conditions in the water that kill off aquatic organisms.

When green tides occur, green algal blooms can cover the water surface and shut out sunlight. Existing shallow water plants in affected areas have difficulty in absorbing enough sunlight to maintain photosynthesis, so they may begin to die off. This adds to the amount of organic matter available to the decomposers. All of these factors accelerate the water quality degradation. Natural surface water habitats maintain an equilibrium between species compositions, with normal input of nutrients and organic matter. When excessive nutrients are released to such waters, the system becomes imbalanced.

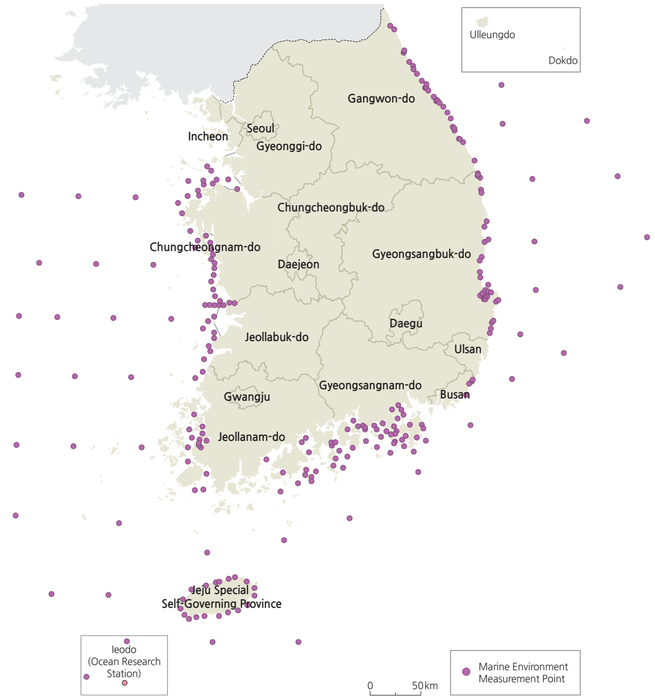
Although green tides are found in oceans all across the world, they are generally small and confined to coastal areas. Since 2000, green tides have been forming in the Yellow Sea and the East China Sea every year, usually appearing in coastal areas such as Qingdao and the Yangtze River estuary. Small patches of green algae have also been found in the open sea. In Korea, green algae mainly appear in rivers; those that form in the sea are usually not harmful to the Korean coast. Biological oxygen demand (BOD) and chemical oxygen demand (COD) are carefully monitored. BOD refers to the amount of dissolved oxygen in the water that is consumed by decomposing organic materials such as tree leaves, branches and dead algae. COD refers to both organic and inorganic materials that consume dissolved oxygen, such as the rusting of ferrous materials (iron).

Biological Oxygen Demand (BOD) by Year

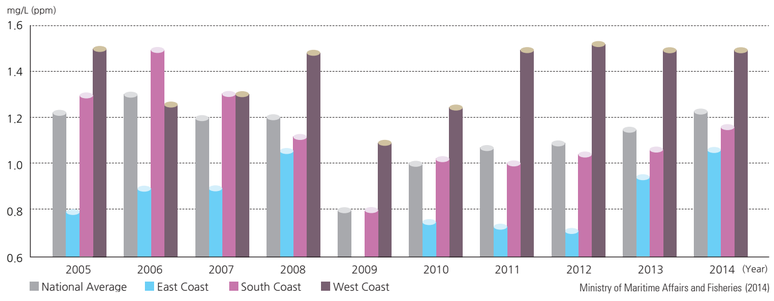


National Water Resources Management Information (2015)

Distribution of Marine Environment Observatories



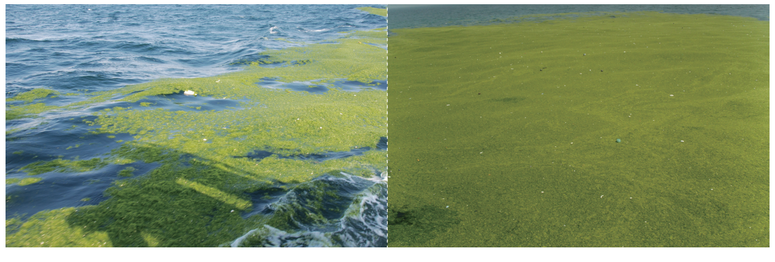
Chemical Oxygen Demand (COD) of National Coasts by Year



Ministry of Maritime Affairs and Fisheries (2014)

Occurrence of Red Tide

Occurrence of Green Tide



Brief Interpretation of the Maps and Graph

The Water Pollution Monitoring map classifies the monitoring observatories of stations into river water observatories and underground water observatories. Their locations are also classified based on the five major river systems basins. It is very clear that many stations are distributed throughout the whole country, but less clear that their densities are lower in high mountain areas (refer to the physical map of Korea on page 42). Despite the title, data for the Effluent Quality Standards for Pollutants by Province map is actually by sub-districts (-si/-gun/-gu) divisions. These standards are classified into four categories: Clean Zone, Clean A-Level Zone, A-B Level Zone, and B-Level Zone. However, the map does not specify the criteria for these classifications; because of this, the map can only be used in a subjective interpretation. The lowest B-Level Zone areas correlate with sub-district units in the heart of Busan, Ulsan, Daegu, the entire capital region of Seoul and other units to its south and northwest. In other words, the most concentrated urban areas are deemed to have the lowest water quality. There is also a large area in western South Korea that is classified in the A-B Level Zone; this area highly correlates with the agricultural belt of South Korea where fertilizers high in nitrogen and phosphorous contents are used in farming practices.

Why do you think that there are fewer water quality observatories or stations near mountain ridgelines and higher slopes? Why do you think that green tides and algal blooms occur in coastal regions, eutrophic lakes, and backwaters instead of main channels of rivers? Why is it a general practice to install an air pump in home and in commercial aquariums?

Monitoring the Marine Environment

Korea regularly monitors its coastal waters. The marine environment monitoring network aims to comprehensively understand the marine environment, and the collected information is used to establish national management and conservation policies. This monitoring network is composed of four different network types: port, coastal and offshore, environmental management waters, and estuaries. The monitoring is carried out in February, May, August, and November of every year at a total of 417 stations. In addition, the automatic seawater quality monitoring network collects data from Sihwaho, Masanman, Ulsanman, Yeosu New Harbor, and the coastal areas of Busan in order to measure the water quality of estuaries, pollution hot spots, and coastal pollution. The information from these monitoring networks is provided through the "Marine Environment Information System (www.meis.go.kr)."

Red tides refer to the situation when seawater is discolored red due to a mass bloom of phytoplankton—mainly cyanobacteria, diatoms, and dinoflagellates—in the ocean. Depending on the species of plankton, the color of the water can show tinges of yellowish brown, yellow, or grass green. Red tides can cause great damage to marine ecosystems as they may initiate mass kills of coastal fish species all across the globe.

While diatoms were widely responsible for red tides along the Korean southern coast in the early 1990s, Cochlodinium polykrikoides (a species of dinoflagellates) has primarily been the cause since 1995. Red tides from Cochlodinium polykrikoides blooms often occur in the waters between Narodo and Namhaedo and spread throughout the South Sea of Korea. In some years, they spread to the west coast and the East Sea as well. Rising sea surface temperature is one of the causes of a more frequent occurrence of red tides.

Brief Interpretation of the Maps and Graph

The Distribution of Marine Environmental Observatories map is a basic locational map that shows the spatial network of these observatories. The entire coastline of South Korea is dotted with these stations; in addition, a lattice of stations is placed far off the west, south, and east coasts to collect information about marine water quality in the Yellow Sea, South Sea, and East Sea. The graph on Chemical Oxygen Demand (COD) of National Coasts by Year clearly shows a much higher rate of COD along the west consistently through the years while the lowest rates are found along the east coast.

Compare the COD graph with the Environmental Issues of Northeast Asia map on page 116, and suggest a reason why COD is highest along the west coast of Korea. Which sector(s) of the Korean economy could most likely be affected by red tide or marine pollution? Also compare the COD graph with the currents and tides maps on pages 56–57 and offer some reasons why east coast waters consistently have much lower COD rates.