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THE POWER OF EFFECTIVE GEOSPATIAL INFORMATION MANAGEMENT IN SOUTH KOREA: DEVELOPMENT AND APPLICATION

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Geospatial information technology has emerged as a major contributor to economic transformation for many countries. Established along with the E-government drive, the National Spatial Data Infrastructure (NSDI) in South Korea is especially remarkable, given the fact that South Korea was recently ranked 10th (in 2019) for its geospatial data infrastructure at the global level. Since the formulation of the open government policy in 2013, data were used from a wide range of end users, including the private and public sectors, which facilitated a significant growth in the national market, recording around USD 7 Billion of sales revenue in 2018. This note first introduces geospatial information and its technical evolution in general, then describes the NSDI development plans and strategies, economic impacts on the national market and two geospatial information applications. Finally, the note concludes with the key factors that contributed to the successful development and application of the National Spatial Data Infrastructure, Information and Innovation.

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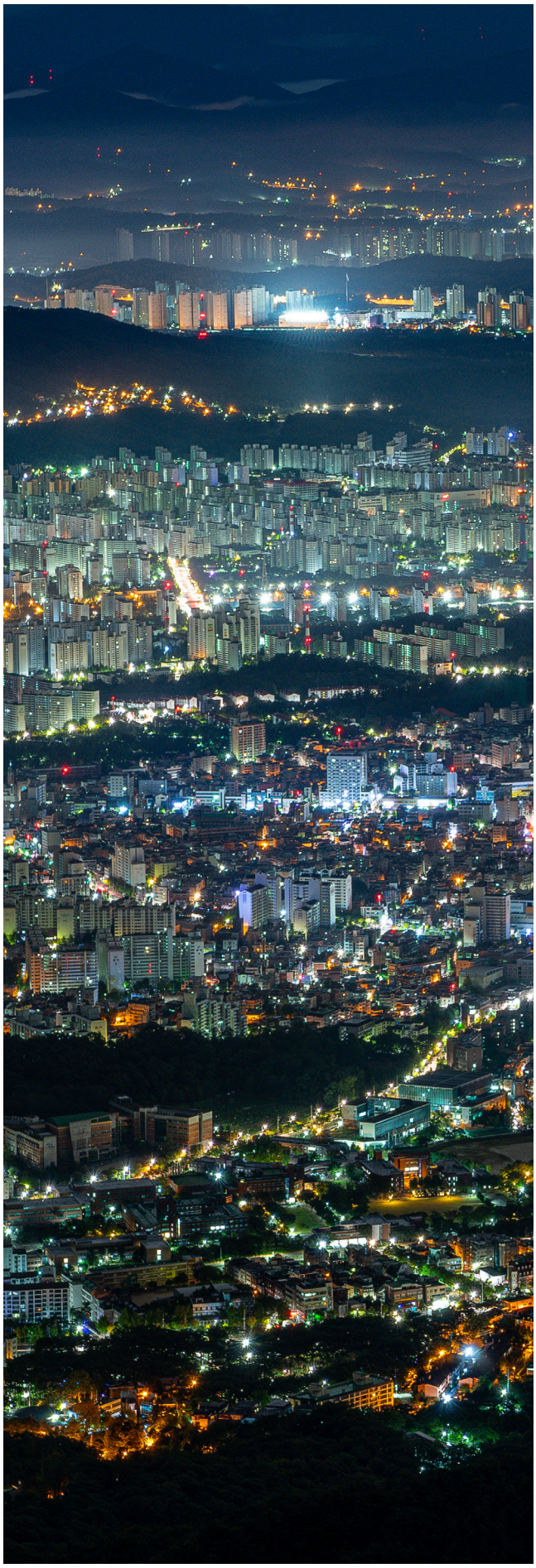


Executive summary

In less than 25 years, South Korea has become one of the world's leading countries for its geospatial information, systems, innovative technologies and applications, and one of the most influential countries for Smart City policies and implementation. The 2019 Geospatial Industry Outlook & Readiness Index Report indicates that South Korea is ranked 10th for its Geospatial Data Infrastructure at the global level.

South Korea adopted a National Open Data Policy and transitioned towards an Open Government Policy in 2013. These policy initiatives have had a profound and positive impact on economic growth. Since 2013, the use of geospatial information in the marketplace has significantly increased and energized the entire national geospatial information market; recording KRW 8.5 Trillion (around USD 7 Billion) worth of sales revenue in 2018 at the national level (MOLIT, 2019). In addition, South Korea has been benchmarked for its successful management of COVID-19 by making use of geospatial information to manage outbreaks and community services during the pandemic.

However, state-of-the-art data sharing was not always the norm. The Government overcame earlier data integration difficulties by initiating a robust NSDI Basic Plan, and a succession of five yearly plans, supported by well-established legal mandates. The NSDI Basic Plan provides specific policy guidelines and technical solutions for the integration of datasets, based on national data, technology standards and development guidance, which are supported by annually revised Action Plans.

A number of key drivers supported the successful development and application of geospatial information infrastructure and information, which also served as catalysts for activating the national geospatial information market: (i) the adoption of an Open Data Policy, which has played a key role in providing data access today; (ii) the establishment of the Spatial Information Industry Promotion Institute

(SPACE N) to promote geospatial information industries, to provide education and nurture start-ups; technical components such as (iii) the provision of integrated, technical infrastructure through the National Integrated Information System (NIIS); (iv) an extension to the range of both fundamental and thematic datasets available to users, and new procurement methods that have boosted the geospatial data market; and (v) well justified annual investment plans and Public Private Partnership (PPP) strategies have enhanced the successful maintenance and operation of the NSDI in South Korea.

The South Korean journey since 1995 of creating effective national geospatial information management has been transformational, supporting sustainable solutions for social, economic and environmental development and delivering economic prosperity. There are many lessons learned from the South Korean experiences that can be applied to most countries worldwide.

Introduction

In 1995, underground gas explosions in Daegu and Seoul sent shock waves across the country. These explosions were a catalyst for the Government to accelerate its plans for better management of map based (geospatial) information of property and assets both above and below the ground. Investigations revealed that underground maps had not been maintained, and that data inconsistencies posed major safety threats for the nation. This led to several high-profile projects to improve the management, maintenance, sharing and accessibility of geospatial information.

The recognition that geospatial data (digital data that has a location dimension to it) was a critical component of the national information infrastructure and knowledge economy was initially introduced by Prof. John McLaughlin from the University of New Brunswick, Canada in 1991. He introduced the term National Spatial Data Infrastructure (NSDI) and the vision was to use the NSDI to leverage investments in people, technology, data and procedures to create and provide the geospatial knowledge required to understand, protect, and promote national and global interests, and to improve citizen engagement in society's decision making.

A NSDI was originally defined as "the technology, policies, standards, and human resources necessary to acquire, process, store, distribute, and improve utilization of geospatial data." The NSDI became a critical vehicle for facilitating seamless data development, information sharing, and collaborative decision making across multiple sectors of the economy.

South Korea was an early adopter and implementer of a NSDI, with their first NSDI program being launched in 1995, and has become one of the most successful countries to implement a comprehensive, national solution. Through this experience, South Korea made a significant contribution to the global understanding of how to successfully achieve a NSDI. This included the expansion of the original scope of a NSDI to include new dimensions, such as innovative business models, PPPs, education and capacity development, and Open Data Policies.

DEFINITION AND EVOLUTION OF GEOSPATIAL INFORMATION TECHNOLOGY

In simplest terms, geospatial information means "information" that has a location element. It delineates the location and names of features beneath, on and/or above the earth's surface from the basic topographical information on a map to more complex 3D data.

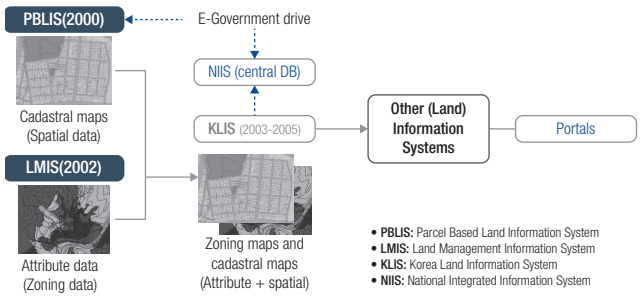
Since the first procurement of geospatial information data in 1995 to 2017, the Government invested around USD 1.34 Billion for the establishment of geospatial data infrastructure (LX, n.d.). The development of geospatial information-related technologies played a substantial role in stimulating economic growth as it advanced the geospatial data market enabling more location-based products and services to be developed, such as those developed during the COVID-19 Pandemic. In line with Industry 4.0, the geospatial information sector has experienced rapid innovation in parallel with major national agendas, such as Smart Cities and Ubiquitous Cities (Shin, D. H., 2009). As a result of these efforts, South Korea is ranked 10th for its Data Infrastructure and 13th for its industry fabric[1] (Geobuiz, 2019).

Evolution of geospatial information technologies

Under a wider e-Government national project initiative (1995), the first Parcel-based Land Information System (PBLIS) was established under the Ministry of Home Affairs (now known as the Ministry of Interior and Safety) in 2000, and the Government started to build land ownership and underground facility geospatial datasets in collaboration with relevant public corporations.

In 2002, rapid urbanization increased the demand for sustainable land use management and the Land Management Information System (LMIS), to manage land use and regulation-related geospatial information, was procured by the Ministry of Construction and Transportation (now known as the Ministry of Land, Infrastructure and Transportation). Between 2003 and 2005, the PBLIS and LMIS systems were combined into one single system: the Korea Land Information System (KLIS).

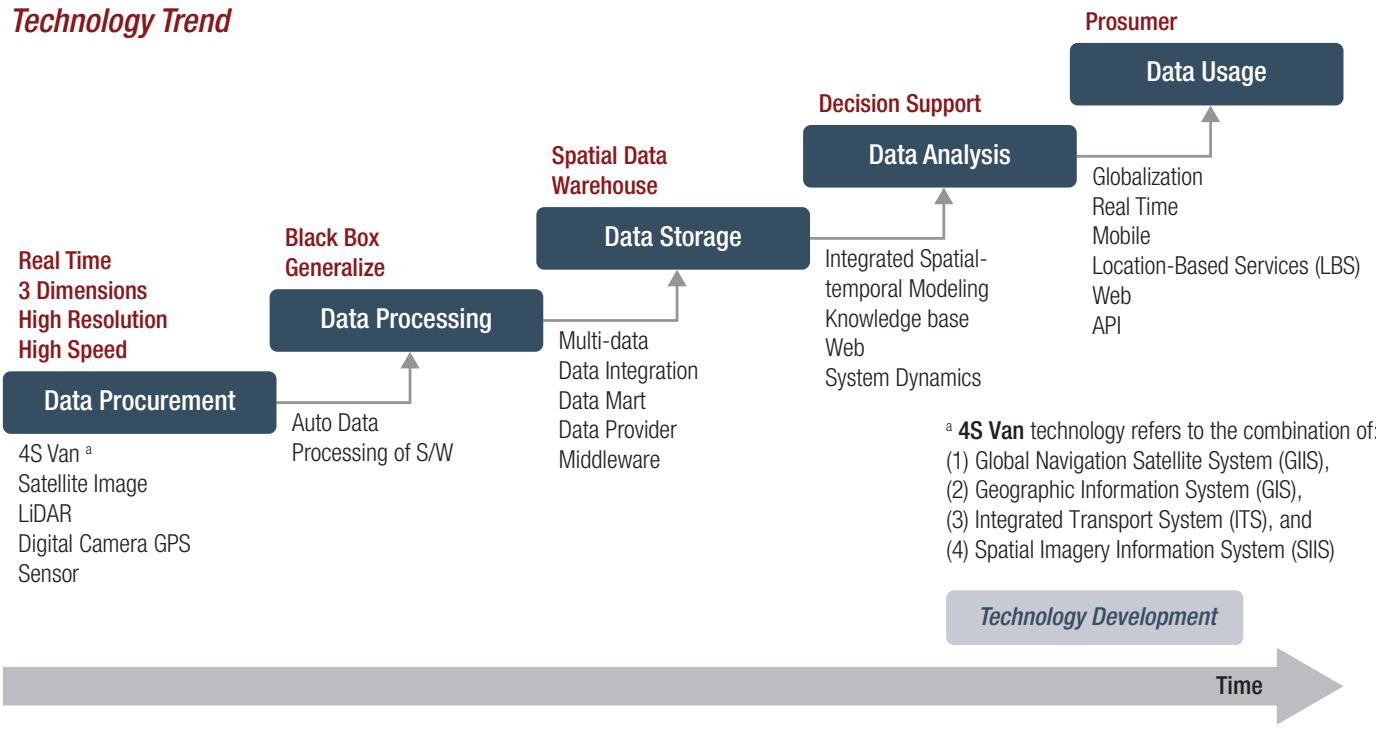
Figure1. Diagram showing the relationship between E-Government, PBLIS, LMIS and KLIS, and NIIS



In addition, the National Integrated Information System (NIIS), operated and curated by the Ministry of Land, Infrastructure and Transportation (MOLIT), was also established; its purpose was to integrate Government geospatial data, systems and

1 The industry fabric refers to the Geospatial industry's capacity to develop and deliver solutions and services to the customers, to collaborate and engage with various stakeholders through knowledge sharing and business development networks, new venture creation and technology research and commercialization support ecosystems are strong indicators to assess the geospatial industry ecosystem in countries.

Figure 2. Development of Geospatial Information and Technology Trends



Source: MOLIT

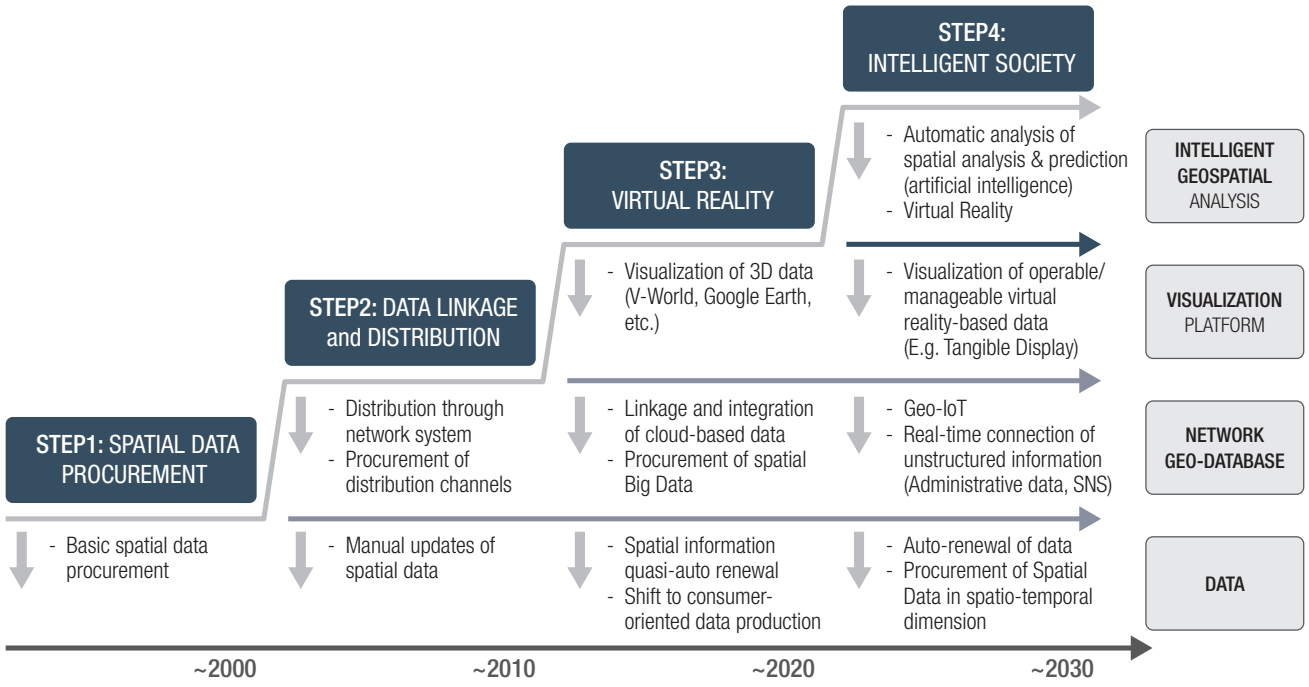
distribution channels, and provide a single interface for all Government information, including the KLIS.

Along with the procurement of the first Land Information Systems, geospatial technologies evolved rapidly as a result of procuring geospatial data (satellite images, LiDAR, GPS) between 1995 and 2000. From the mid-2000s, system integration and data / service distribution channels became the main components of the geospatial information infrastructure. Once distribution channels such as Web portals were established, geospatial information technologies for automated data processing (software and algorithms) slowly dominated the sector. This was followed by the development and improvement of database systems, data quality improvement, adoption of standards, storage and distribution (platform) technologies, such as the National Integrated Information System.

Between mid-2000 and early 2010, geospatial data started to be used more extensively to support policy development and decision-making. It also marked the "Prosumer's" (producer-consumer) phase, sometimes referred to as the dot-com era, where open data and open data portals were used by entrepreneurs to develop applications for business endeavors, and where citizens became avid users of location-based services.

By the mid-2010s, the Government started to procure 3-D geospatial data and significant volumes of data (Big Data) to improve the visualization of geospatial information on the NIIS platform and to increase the quality and accuracy of the geospatial information in general. Global Navigation Satellite Systems (GNSS) enabled new location-based services to be developed, and the increased availability of Open Application Programming Interfaces (APIs) triggered a rapid development of social and business applications. These included Intelligent Transportation Systems (ITS) and online real estate information and transaction systems that have shaped todays "Intelligent Society" and spurred economic growth. Today, innovative platform technologies such as Virtual Reality, autonomous vehicles and artificial intelligence software, etc. are now becoming mainstream capabilities (see Figure 5).

Figure 3. Evolution of Geospatial Technologies: (1) Geospatial Data Procurement, (2) Data linkage and distribution, (3) Virtual reality, and (4) Intelligent Society



Source: MOLIT

Geospatial Information: Public and private data

Geospatial datasets can be classified as public and/ or private data. Public data or government datasets are data procured by public institutions or agency under each respective Ministry. Government datasets are divided into two main categories: (1) National Framework Datasets; and (2) Specific (Thematic) Datasets. National Framework Datasets are fundamental 'base map' datasets procured by MOLIT. They are considered fundamental datasets as they underpin many applications and business operations, such as health, tourism, education, transport, disaster management and urban planning – all of which have a recurring need for this 'base map' information. The NSDI Framework Act Chapter 4, Article 19 defines Fundamental datasets as:

(i) ground (geological), (ii) coastline, (iii) administrative boundaries, (iv) road or railroad boundaries, (iv) river boundaries, (vii) land cadastral (registration), (viii) spatial data of artificial structures, including buildings, and (ix) other major spatial data prescribed by Presidential Decree as ***fundamental spatial data***, and publicly announce such data in the Official Gazette after consultation with the heads of relevant central administrative agencies.

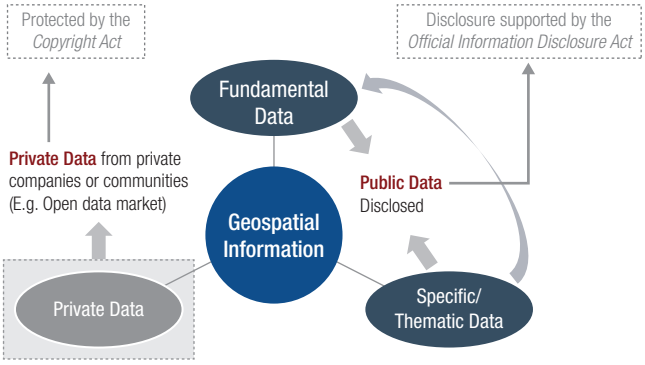
Specific datasets, often thematic in nature, are datasets that are not included in fundamental datasets since they only serve the needs of individual or a small number of Ministries for specialized business operations.

Specific (Thematic) data procured by the central (e.g. Ministry of Environment) or local government (Seoul Metropolitan Government) are datasets that are not considered fundamental. It includes land use data, zoning data, etc. However, in line with Industry 4.0, some Specific data such as 3D Spatial Data (accessible from VWorld.kr) have been incorporated as part of Fundamental Data since 2017.

Private geospatial data are data procured or processed by private individuals, communities or

companies that are protected under the "Copy Right" Law. These data can be sold or disclosed under certain conditions or rules regulated by the data producers.

Figure 4. Types of Data including disclosed public data and private data



GEOSPATIAL INFORMATION APPLICATION

Innovative Application (1): Rapid response to COVID-19

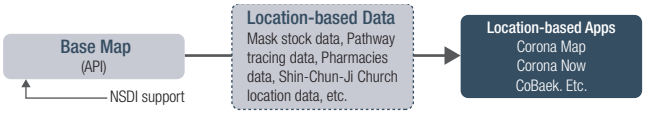
South Korea is highly regarded for its successful management of the COVID-19 pandemic. During the early stage of the pandemic, the number of COVID-19 confirmed cases increased rapidly, reaching a peak of 909 new, confirmed cases on February 29th, 2020 (ROK, 2020). Twenty days later, South Korea had successfully flattened the COVID-19 curve, by taking prompt measures that made use of the geospatial information to develop: (1) COVID-19-related Apps and an (2) epidemiological investigation support system.

Location-Based Apps

Location-based Apps are applications that make use of the location data to provide need-based services. Most of the COVID-19-related location-based Apps use the "base map", which are constructed based on the NSDI Framework.

The base map is often imported as an API (Application Programming Interface) format from Naver or Kakao[2] that provide real-time updates. Some COVID-19 supporting Apps such as pathway tracing and mask stock Apps have hence benefited from the well-established NSDI. Location-based data are procured by the government or in collaboration with private entities. For instance, COVID-19 pathway data during the mass outbreak were procured with the support from credit card and telecom companies.

Figure 5. Simplified diagram showing the use of Geospatial information for the development of COVID-19-related location-based Apps



Pathway Tracing Apps

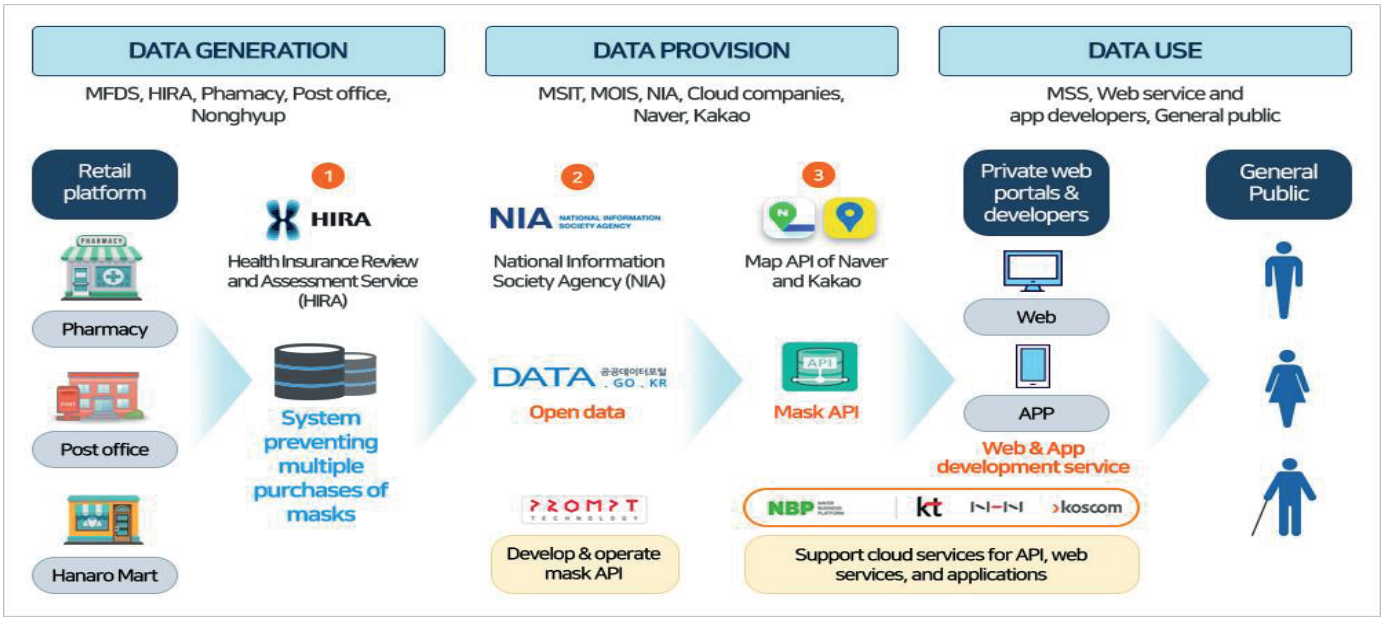
There are over 150 Apps created to respond to the rapid spread of COVID-19, developed since January 2020. The first coronavirus-related App was the "**Coranavirus Map**"[3], which was created by a university student and launched on January 30th, 2020. The App comprises a visualization service showing users the movement of COVID-19 cases based on information provided by the KCDC.

A Second App "**Now and Here**" was developed in March 2020 by a private company, Innovative Technology Lab. This App calculates a mix of risk factors based on location and estimates the percentage risk associated with commuting routes

2 Naver and Kakao are online platform operated by Naver Corp. and Kakao Corp. respectively. Naver has its own search engine and is also frequently referred to as "the Google of Korea". Kakao initiated its business with SNS services and has recently expanded its application to other sectors such as transport, banking and mapping services.

3 https://coronamap.site/

Figure 6. Publicly Distributed Face Mask Information Service



Source: REPUBLIC OF KOREA, 2020

and the location of identified COVID-19 cases. The App also suggests that testing is available if the user was at the same place as a confirmed case at a similar time.

The "**Corona 100M (CoBaek)**"[4] is an App that was launched by the Ministry of Science and ICT on February 11th, 2020.[5] This App sends an alarm to a user when they are within 100 meters of a place that has had a confirmed case.

Mask Stock Data App

Due to the scarcity of masks, the Government launched the "Five-day rotation face mask" policy and associated distribution system on March 9th, 2020. Masks were distributed to Government-designated pharmacies, post offices and Nonghyup Hanaro convenient stores. However, in order to resolve "mask stock" shortages, the Government had to rapidly develop an information system showing the status and location of face mask stocks.

For this reason, the Government first established the system through PPPs, where the developer community and private companies participated. When the Government released the data on face masks sold at public designated retailers, the companies would develop cloud and other mapping services that provided information on mask stocks. The public data was released on March 10th, 2020, and the App service was launched the very next day (Figure 7). With the availability of Open Data and a sophisticated data infrastructure in place, it only took 13 hours to develop and deploy the entire App service.

Epidemiological Investigation Support System

The strong foundation of the NSDI and the presence of diverse geospatial data systems provided the basis for rapid development of platforms and systems for COVID-19 management. With the exponential increase of COVID-19 confirmed cases occurring as a result of the Shin-chun-ji outbreak, the need for a new platform for processing the huge amount of data was recognized.

4 https://m.onestore.co.kr/mobilepoc/apps/appsDetail.omp?prodId=0000746930
5 http://www.ilyoweekly.co.kr/news/newsview.php?ncode=1065546733012174

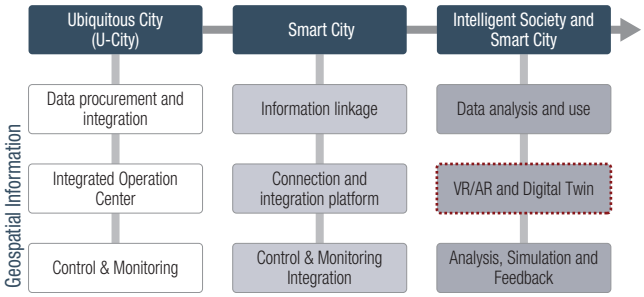
As a result, the Government decided to establish the "Epidemiological Investigation Support System" by integrating it into the pre-existing "City Data Hub", created under the National Strategic Smart City Research and Development Program. After 10 days of piloting, the system was launched expeditiously on March 26th, 2020 (ROK, 2020). MOLIT handed over the system's operation to KCDC, which cooperated with the National Policy Agency (NPA), Credit Finance Association of Korea, 3 telecommunications companies and 22 credit card companies, to process pathway-related data for COVID-19 cases collected by KCDC and individual interviews.

Innovative Application (2): Geospatial Information for Smart Cities

Smart Cities combine diverse technologies to provide holistic coverage across sectors in a city, such as transportation, environment, health and security. Developing a 'Smart City' requires a wide range of information, and geospatial information often serves as the base data and information integrator from which other data will be referenced. (Sutanta, H., et al., 2016).

Smart City was initially called "Ubiquitous City" in South Korea. Its first 5-year Master plan named as "the First 5-year Ubiquitous City Comprehensive Master plan", established in 2009. From the third Master plan, "Ubiquitous City" has been officially replaced as "Smart City".

Figure 7. Evolution of Smart Cities



One of the most remarkable technologies implemented for the realization of Smart Cities in South Korea is the Digital Twin technology. The Digital Twin is a digital replica of a non-living or living physical entity or space. It is based on the idea that a digital information construct of a physical system can be created as an entity on its own, a "twin" of the real and virtual world information. (Grieves, M., et al., 2017).

Digital Twin technology, which was highlighted in 2018 during the Korea Innovation Growth Conference, was recognized as essential for the realization of Smart Cities. Based on the Digital Twin technology, 3D maps including indoor and outdoor data are procured, serving as a basis for the expansion of innovative use and analysis across various sectors.

Figure 8. Example of 3D geospatial information use in a Smart City

Flooding Prediction through Simulation | Calculation of Sunlight Access

Real Estate Information | Virtual tourism – 3D map

Source: Daegu 3D Map (http://3d.daegu.go.kr) and Seoul Development Institute, 2018

MOLIT'S ANALYSIS ON THE ECONOMIC IMPACT OF THE GEOSPATIAL DATA MARKET

Overview of geospatial information economic impact

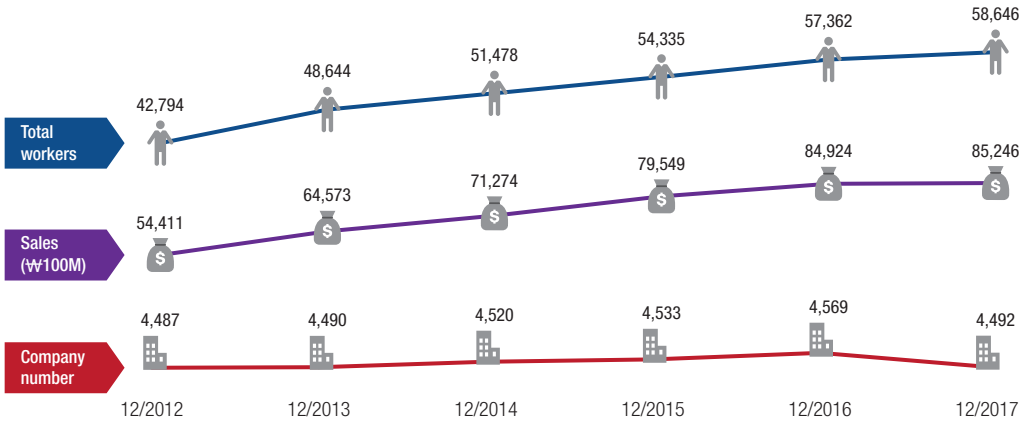
South Korea's geospatial data market has experienced remarkable growth, especially since the adoption of the Open Data Policy in 2013. Open Government was adopted with the twin aims of increasing public transparency and economic growth. In 2013, the number of available geospatial datasets reached 10,003 – doubling the 5,272 datasets previously available in 2012. This significant increase in data availability realized a rapid growth in the number of Mobile applications being developed – 267 were developed within an 8-month period in 2013 (Jeong, J., 2014).

In order to better promote geospatial information-related industries, the Government established the Spatial Information Industry Promotion Institute (SPACE N), to support geospatial information-related industries, encourage the use of Public Open Data, promote research and development, build capacity and provide consultation for start-ups and other private sector businesses. Statistics from 2011 to 2017 released by SPACE N show: a growth in sales revenues from approximately $4.5B to $7.1B; and an increase in the number of geospatial information industry-related workers from 42,792 to 58,646 (see Figure 2). That figure grew again to 63,349 in 2018 (Jang J., et al., 2019).

Geospatial information's direct and Indirect economic effects

The **direct effects** are defined by a method estimating the added value and sales contributions generated by the use of geospatial data. The estimated value is extracted from surveying enterprises utilizing geospatial data. The spatial information industry special classification is classified into 24 sub-industries in six fields, including 1) geospatial information manufacturing, 2) geospatial information wholesale industry, 3) geospatial information publication and service industry, 4) geospatial

Figure 9. Number of geospatial information-related workers, companies and sales revenue between 2012 and 2017



Source: MOLIT, 2019a

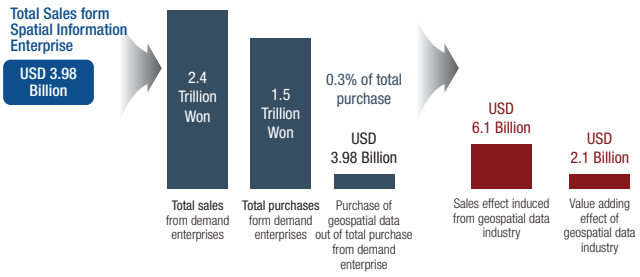
information technology service industry (Figure 12), 5) geospatial information education and 6) organization such as associations (MOLIT, 2019b).

On the other hand, the **indirect effects** are defined by a method of estimating "indirect economic benefits" created from geospatial data-related industries, by making use of the demand-induced models using the input-output matrix table issued by the Bank of Korea (MOLIT, 2019b, p.239). According to the Spatial Information Policy annual report (MOLIT, 2019b), ***two direct effects*** are reported:

(1) Direct effects extracted from transacted data were valued at a total of **USD 3.98Billion** (Figure 9). From the economic survey, sales effects induced from the geospatial data industry had a total value of USD 6.1Billion, and a value-adding effect of **USD 2.1Billion**.

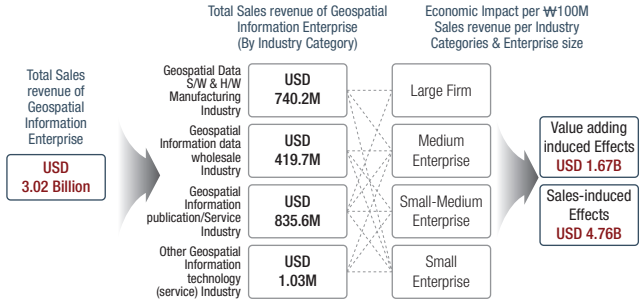
(2) Direct effects were estimated from the geospatial data industry without transacted data (Figure 10) and indicate a total of **USD 3.02Billion** revenue from direct sales of geospatial data at the national level. From the sales, a total of **USD 1.67Billion** of value-adding impacts were induced and **USD 4.76Billion** of sales revenue-inducing economic impacts have been reported for the year of 2018

Figure 10. (Direct Effect 1) 2018's geospatial industry's direct economic impacts in Korea extracted from transacted data



Source: MOLIT, 2019b

Figure 11. (Direct Effect 2) 2018's geospatial industry's direct economic impacts in Korea estimated from spatial information industry sales



Source: MOLIT, 2019b

The ***indirect economic impacts***, on the other hand, are estimated from the input-output table, issued from the Bank of Korea. Indirect economic impacts, including production effects, value-adding effects,

Table 1. (Indirect Effect) 2018's spatial Industry Indirect Economic Impacts

Unit: USD 1 ≈ KRW 1,200

Indusry Category	Geospatial Data S/W & H/W Manufacturing Industry	Geospatial Information Data Wholesale Industry	Geospatial Information Publication/Service Industry	Other Geospatial Information Technology(Service) Industry	Total
Producation Effect (Unit: USD Million)	1,372.4	1,508.9	2,925.97	5,284.6	11,091.9
Value Added Impact (Unit: USD Million)	371.5	804.3	1,849.3	3,339.9	6,365.0
Employment Impact (Unit: Person)	4,229.3	22,382.3	22,978.6	48,834.1	98,424.3
Hiring Impact (Unit: Person)	3,970.6	13,308.9	20,505.6	43,567.4	60,846.9

Source: MOLIT, 2019b

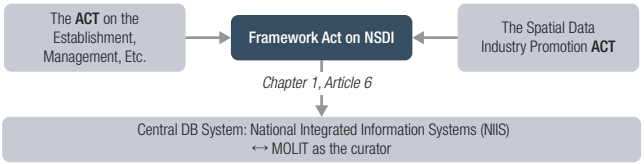
employment effects, and hiring effects, have been estimated for each geospatial data industry category, as shown in the table 1.

DEVELOPMENT PLAN: NSDI BASIC PLAN AND PROJECTS

South Korea has continually developed and revised its overarching NSDI Basic Plan since 1995, and several major NSDI projects have been completed (Table 2.). The current 6th NSDI Basic Plan (2018-2022) aims to: (i) encourage the use of geospatial information in a way that creates social and economic value; (ii) implement geospatial platforms to share information innovatively; (iii) advance the geospatial information industry to stimulate job creation, and (iv) augment geospatial information management through a public-participatory environment to enhance data quality and usability.

The Government overcame initial institutional barriers by establishing the NSDI-Committee acting as the main coordinating body amongst the various ministries. This committee is responsible for making the final approval of the NSDI Basic Plan, which is supported by three main legal pillars: (1) the Framework Act on NSDI (Act No.12736)[6], (2) the Act on the Establishment, Management etc. of Spatial Data (Act No.14936)[7] and (3) the Spatial Data Industry Promotion Act (Act No.14087)[8]. The Framework Act clearly defines the custodian of datasets and the entity responsible for managing the national central storage system (NIIS) and connecting provincial and local-level spatial data systems.

Figure 12. Relationship between NIIS and the three main pillar Acts



In addition, the NSDI Basic Plan, which is revised every 5 years, provides strategic guidance on institutional (e.g. inter-ministerial and Public-Private Partnerships), technical and educational development (capacity development) plans for the maintenance and upgrading of the NSDI. The Plan also includes local

Table2. 1st ~ 6th NSDI Project extracted from each Basic Plan; Source: NGII, 2019

1st NSDI Project (1995~2000)	2nd NSDI Project (2001~2005)	3rd NSDI Project (2006~2010)	4th NSDI Project (2011~2012)	5th NSDI Project (2013~2017)	6th NSDI Project (2018~2022)
[1] Digitization of topographic and cadastral maps [2] Establishment of thematic map (land use and underground facility maps) [3] Database / Software development	[1] Establishment of National Framework Data [2] Advance GIS utilization for land use, environment, etc. [3] 3D GIS and satellite image technology development	[1] Establishment of National Base Map [2] Advance 3D geospatial information use and establish other LIS (UPIS) [3] Improved National GIS network	[1] Establishment of geospatial data utilization system [2] Establishment of digital cadastral map [3] Establishment of 3D national data [4] Commercialization and dissemination of national GIS solution [5] Green Growth and geospatial data	[1] Establishment of fundamental data [2] Expansion of high-precision 3D and Indoor geospatial data [3] Adoption of Open Data Policy for public data [4] Improve system for data sharing from the private sector	[1] Production of geospatial information for value creation [2] Activation of geospatial data platform and enhancement of innovative sharing [3] Job creation

6 https://elaw.klri.re.kr/kor_service/lawView.do?hseq=32575&lang=ENG
7 https://elaw.klri.re.kr/kor_service/lawView.do?hseq=45866&lang=ENG
8 https://elaw.klri.re.kr/kor_service/lawView.do?hseq=38429&lang=ENG

and central-level budgets for the procurement and maintenance of fundamental and thematic datasets and proposes specific inter-ministerial project plans. For instance, the 6th NSDI Basic Plan proposes inter-ministerial projects, such as the development of a health-crisis management system (between the Ministry of Health and Welfare and MOLIT), and a natural disaster management system (between the Ministry of Environment and MOLIT).

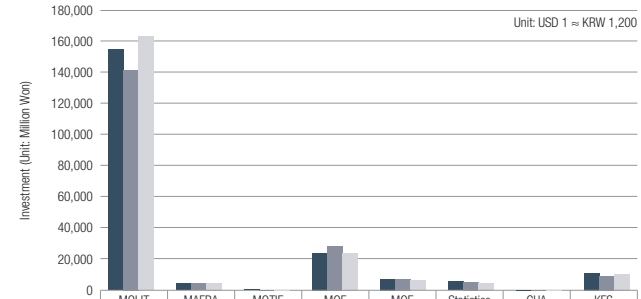
DEVELOPMENT STRATEGIES: INVESTMENT AND COLLABORATION

Investment for Public Open Data

Each year, the Government executes financial projections for geospatial information-related national projects and officially publishes the previous year's expenditure in the NSDI Annual Report. The National Framework Data is funded by central Government, while other geospatial data maintenance and procurement-related budgets are financed from local Government budgets and are dependent on the strategic priorities, vision and financial status of the regions. For example, the strategic priority of Seoul is having a 'Digital Twin' of the metropolitan region, which has led to the procurement of indoor 3D data of Seoul financed by the Seoul Metropolitan Government.

Central level investments for National Framework Data and thematic data procurements are described in Figure 12 for 2017, 2018 and 2019. The economic justification of these investments is based on the fact that technology innovations derived from the fourth industrial revolution such as IoT, Big Data and artificial intelligence stimulate value-added economic development, including the creation of new jobs (2019 NSDI Action Plan Annual Report, p.25). Specific economic impacts of the "prioritized" NSDI projects are described in this Annual Report, including an analysis of specific use cases and their associated, actual economic benefits.

Figure 13. Ministerial investment for geospatial information in Korea (2018)



	MOLIT	MAFRA	MOTIE	MOF	MOE	Statistics Korea	CHA	KFS
2017 Investment	154,880	4,349	380	24,148	7,177	5,526	340	11,065
2018 Investment	141,589	4,407	270	28,470	7,078	5,386	340	9,327
2019 Investment	163,315	4,867	258	23,815	6,284	4,813	320	10,509

Source: MOLIT Report, 2020

Data & System Procurement: Development through Public-Private Partnership

Since the mid-1990s, the Government of South Korea implemented national NSDI Projects (often called NGIS Projects), whose development frameworks and main objectives are specified in the NSDI Basic Plans (see Table 3). Since the first procurement of ICT systems to support the NSDI, including the first Integrated Land Information System (PLIS), the Government of South Korea has proactively supported and implemented PPP strategies.

While the Government finances the infrastructure and procurement of geospatial data, private companies participate in the Government's annual data capture and procurement programs through PPP procurement processes. Table 3 describes how

Table 3. Major Public-Private Partnership for (i) data procurement and (ii) establishment of data system

		1st NSDI Project (1995~2000)	2nd NSDI Project (2001~2005)	3rd NSDI Project (2006~2010)	4th NSDI Project (2011~2012)	5th NSDI Project (2013~2017)	6th NSDI Project (2018~2022)
Main objectives of partnerships		Procurement of Basic Maps 50:50 of PPP Financing for 1/5000 maps	S/W development and creation of synergies between private and public sector	GIS technology development + commercialization	Bi-directional partnerships through "Collaborative Governance"	Enhance Prosumer based system + Big data platform service	Create citizen-participatory platform + platform for autonomous and drone industry-related geospatial data
DATA	Dataset	Digitization of topographic & Cadastral map, Underground Facility Map	Maintenance and updates of existing maps + other thematic maps	Maintenance and updates of existing maps addition of thematic maps + 3D maps	Maintenance and updates of existing maps & procurement of new technology-based (sensor, RFID, etc.) data	Automatic updates of existing maps + procurement of big data	Automatic updates of existing maps + Big data + platform for new technologies (drone, autonomous cars)
	Public Corps and Private Sector	Public Corps: *LX, LH, EX, KEPCO, KoGas, KWater*	Existing public Corps. + Induce Private sector based on BOT[9], BTO[10] business models	Public Corps + Private Sector Companies	Public Corps + Private Sector Companies	Public Corps + Private Sector Companies	Public Corps + Private Sector Companies (KT, Kakao, etc.)
SYSTEM	System/ SW	PBLIS, LMIS	Korea Land Information System (KLIS)	National Integrated Information System (NIIS)	Improved system integration and Utilization systems (portal)	Improved utilization systems + Open Data portals	Improved utilization systems + Open Data portals + Shared platform
	Privates, Public Corp.	KT	[1] Samsung SDS [2] SsangYong Information & Communication [3] SK C&C	[1] Samsung SDS	Public Corps + private sector	Public Corps + private sector	Public Corps + Private Sector Companies

Source: Author formulated from 1st ~ 6th NSDI Basic Plan; Park, J. T., & Chun, J., 2014

the private sector participated in each phase of NSDI development, and the subsequent paragraphs delineates PPP strategies adopted for each NSDI project.

The first PPP implemented as part of the first NSDI Project is specified in the initial NSDI Basic Plan. It was primarily conducted to establish parcel-based geospatial information data, land use-related data (regulation, land use, etc.) and underground facility maps, in collaboration with the relevant public corporations. This was achieved through a 50:50 co-financing arrangement between the central and local Governments for 1/1000 topographic maps and another 50:50 co-financing arrangement between the central Government and the private sector for 1/5000 topographic maps.

During the second NSDI Project, the Government established a PPP model (Figure 13.) to facilitate synergies and flow-on benefits from PPP geospatial information-related developments, including capacity building of professionals and future investment in, and export of, geospatial information-related technologies. These cumulative benefits were evident during the development of the Korea Land Information System (KLIS), where the Government collaborated with Samsung SDS (Samsung Data Systems), SsangYong Information & Communication and SK C&C (SK Computer and Communication), as

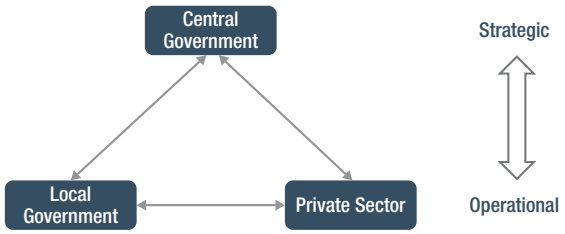
9 BOT refers to "Build-Operate-Transfer". It is a business model where the ownership is handed over to the Government, once the procurement is completed by a public or private company.

10 BTO refers to "Build-Transfer-Operate". It is a business model where the ownership is transferred to the Government after operating for a certain period of time.

well as public agencies and municipalities (**Park, J. T., & Chun, J.**, 2014).

During the third NSDI Project, the Government collaborated with Samsung SDS to establish the NIIS. In addition, a PPP based procurement program was established to develop geospatial information-related technologies, and create new datasets, such as the 3D data of Seoul, as well as the maintenance of existing core and specific, thematic datasets.

Figure 14. PPP model of the 4th NSDI Project (2010~2015)



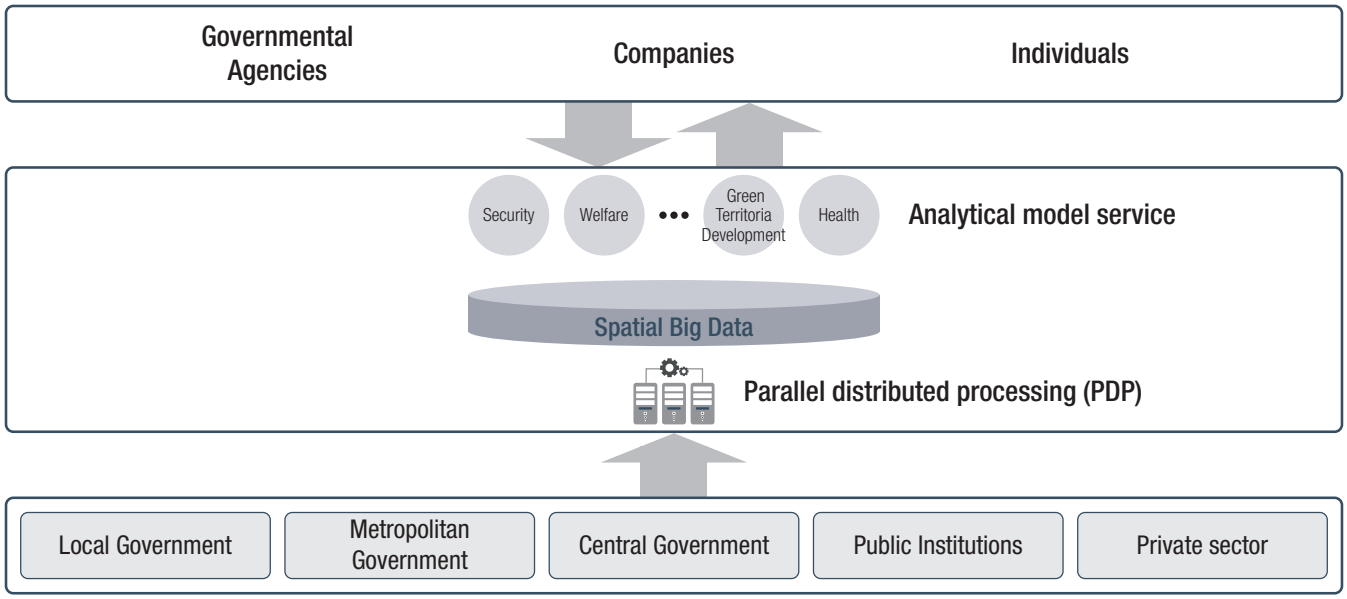
Source: MOLIT, 2010

The PPP strategies implemented during the fourth NSDI Project, introduced a new collaboration model between local Governments, central Government and the private sector. The strategy introduced "bi-directional collaborations", as a means of initiating a two-way communication (and data sharing) system. The strategy defines the central Government (i.e. MOLIT) as the custodian of the NIIS (central database system) to plan and implement development strategies, while other private sector companies and municipalities are responsible for executing pragmatic solutions for data procurement, maintenance and system operations.

The fifth NSDI Project established the 'Prosumer model' - where, central and local Government and private sector companies are considered both consumers and producers (prosumers) of geospatial data, including Big Data and users of platform services, such as Open APIs. During this period, MOLIT took on the central role for curating and managing the collection, maintenance and operations of all geospatial data, including the NIIS.

The sixth NSDI Project (2018~2022) under the sixth NSDI Basic Plan (still valid) utilized the PPP model developed in the fourth NSDI Project, to improve the quality of existing geospatial datasets and create new geospatial information platforms for innovative technologies, such as drone and autonomous cars (MOLIT, 2018). The PPP was also extended to include citizen participation, such as crowdsourcing and citizen science projects.

Figure 15. PPP model of the 5th NSDI Project (2013~2017)



Source: MOLIT, 2013

SUCCESS FACTORS FOR A ROBUST GEOSPATIAL INFORMATION INFRASTRUCTURE

There are a number of factors that have contributed to the success of the geospatial data market in South Korea. Fundamentally, the NSDI has played a key role in providing the integrated development framework for land information systems, as well as other policy, technical, legal, capacity and institutional factors, such as the (i) Open Data Policy, (ii) National Integrated Information System, (iii) extension of fundamental and thematic datasets, and (iv) the presence of strong institutional networks, including SPACE N. Combined, these factors have contributed substantially to the very successful development of the national geospatial data market.

Policy: Open Data Policy

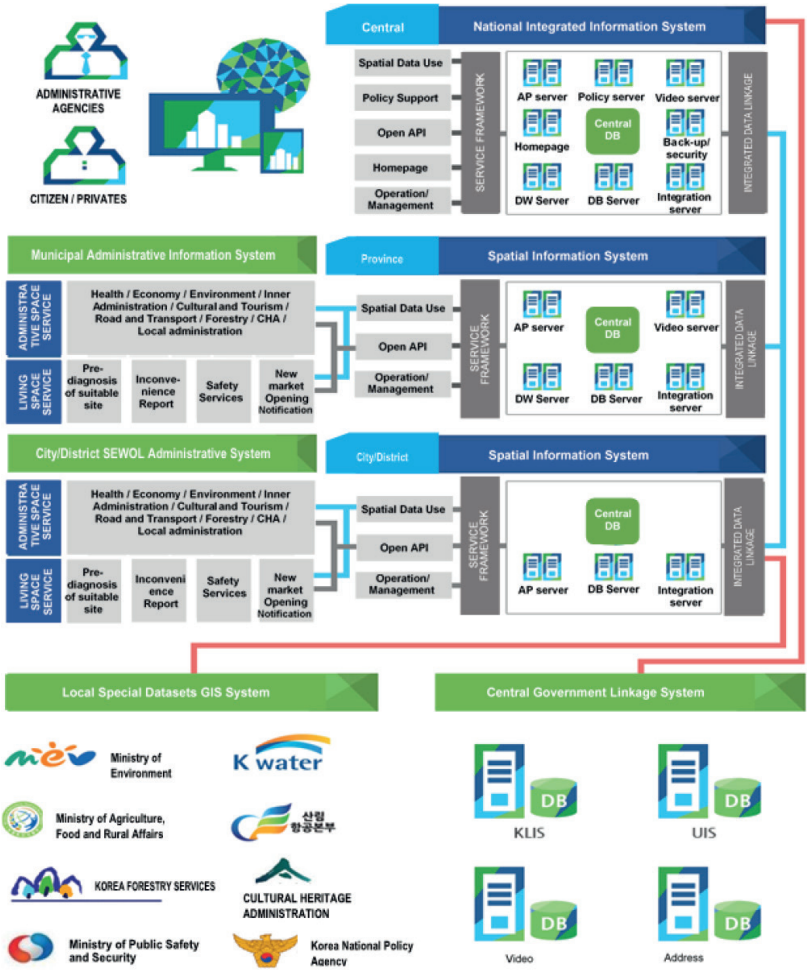
"Open data" are data provided by public institutions, which are regulated by the "**Official Information Disclosure Act**" (Act. No. 14839)[11], its Decree (Presidential Decree No.28211)[12] and enforcement rules. South Korea's Open Data Policy adopted in 2013 is supported by the "**Act on Promotion of the Provision and Use of Public Data**" (Act No. 14839), revised along with the adoption of the "Open Government". The Act provides basic principles and defines the scope of public data that can be released (Chapter 3, Article 17). The Act also mandates that all data, including geospatial information data, procured by public institutions and related agencies are free and open to guarantee citizen access rights to public data, thereby contributing to improving their quality of life and to developing the national economy through the utilization of such public data in the private sector.

Open data are accessible via "data.go.kr" portal, curated by NIA (National Information Society Agency) under the Ministry of Science and ICT. People can download data from the website or request a "data" disclosure to the relevant agency/department. Similarly, fundamental geospatial dataset, which are curated by the Ministry of Land, Infrastructure and Transportation (MOLIT) are accessible via different portals, such as the NSDI and VWorld portals, depending on the data types (fundamental data, 3D map data, etc.)

The "**Spatial Information Industry Promotion Act**" Decree, adopted in 2009, stipulates that MOLIT is to conduct market research and publicly release statistics on the geospatial information-related industry (Article 3 & 4). In line with Government annual reporting requirements, MOLIT publishes geospatial information industry-related survey results, including direct and indirect economic outcomes stimulated by geospatial information industries. These surveys show that the release of data under the Government's Open Data Policy has played a crucial role in (i) fostering economic growth through the development of innovative Apps and mapping platforms; (ii) managing crisis situations, such as natural disasters and pandemics; (iii) providing basic datasets for academic research and development; and (iii) advancing national agenda's aligned with Industry 4.0, such as Smart Cities and e-Government.

11 https://elaw.klri.re.kr/kor_service/lawView.do?hseq=47127&lang=ENG
12 https://elaw.klri.re.kr/kor_service/lawView.do?hseq=47128&lang=ENG

Figure 16. Schematic design of the National Integrated Information System



Source: NSDI, 2020

System: National Integrated Information System

The NIIS (see figure 16) was established to integrate and inter-connect central, regional and local governments' Geographic Information Systems (GIS), eliminate data duplication and resolve system interoperability issues. The NIIS, curated by MOLIT under the "Framework Act on NSDI", integrates 78 different systems operated by 27 Ministries and 17 systems operated by cities and provinces, and other 229 local systems and portals[13].

Economic growth generated through the geospatial data market would not have been possible without the NIIS providing distribution channels and a storage system for sharing, accessing and using geospatial information. The NIIS system, not only provides an integrated information network between ministerial and local governments, but also provides the collection and distribution systems for data procured by the private sector, and also creates the foundation for information portal services to the public. As a result, the NIIS has enabled pragmatic solutions for data integration, system linkages and distribution channels, which are essential for the development of a successful geospatial data market.

13 http://www.nsdi.go.kr/lxportal/?menuno=2682

Data: Fundamental and Specific Datasets

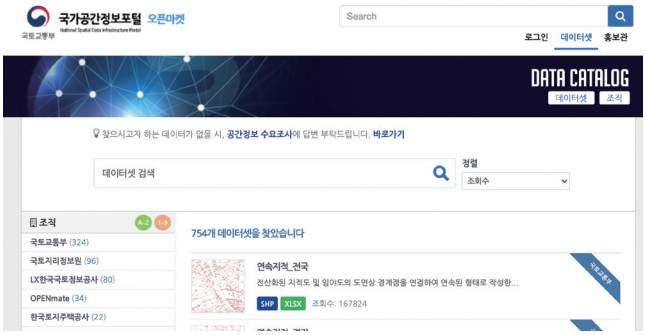
Fundamental datasets are provided through the "NSDI Portal" and "V-World Portal"[14] (comprising 3D spatial data), launched and operated by MOLIT. The list of fundamental datasets is based on the South Korean "National Framework Data". These framework datasets have typically varied from country to country. However, in 2017 a set of "Fundamental Global Geospatial Data Themes" was endorsed by Member States at the Seventh Session of UN-GGIM to facilitate integration of regional geospatial data at the global level.

These themes represent the internationally agreed fundamental geospatial data themes and their descriptions, which Member States may now reference when developing their geospatial data frameworks. The list of fundamental data themes was established with consideration for the implementation and monitoring of the 2030 Agenda for Sustainable Development: a transformative global agenda with seventeen universally agreed Sustainable Development Goals (SDGs). In order to align with the UN-GGIM endorsed fundamental themes, MOLIT is progressively converting existing specific datasets to match Fundamental Global Geospatial Data Themes. This includes datasets such as 3-dimensional models that are now in high demand by both the public and private sectors due to a surge in Industry 4.0 and Smart Cities' initiatives.

Fundamental datasets are provided to users in various formats including shapefiles, Global Navigation Satellite Systems (GNSS) data and Location Based Services (LBS), real-time data, open APIs, and all distributed via the NIIS data portals. A range of data formats are provided so that companies and individuals have greater options when extending their solutions to enter the geospatial data market. The range of formats has enabled new business start-ups to efficiently create Apps, website services and data processing services, etc.

The Data Catalog is one of South Korea's windows into the geospatial data market. In 2013, the Ministry of Science and ICT, in collaboration with Electronics and Telecommunications Research Institute (ETRI) and the Korea Data Agency (K-Data), launched the "Data store", renamed the "Open Data Market" in 2018 (see Figure 17). This website provides a "Prosumer-interface", where citizens can engage in purchasing both raw and processed datasets from the geospatial data market and enter the market by uploading their own data.

Figure 17. Open data portal (Open market)



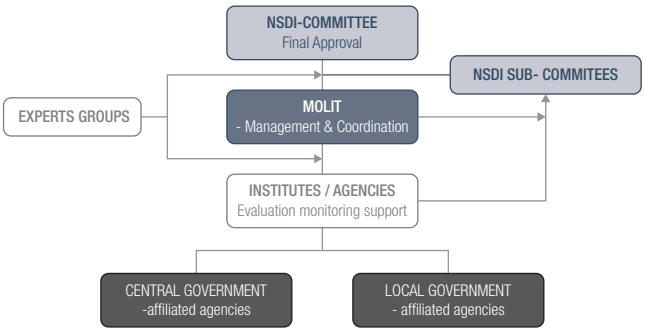
Governance and Institution

A robust NSDI governance model, underpinned by a central coordinating body and supportive institutional network, has been the most influential factor in establishing a thriving geospatial data market.

The NSDI governance is structured around MOLIT and the NSDI Committee/Sub-Committee. While MOLIT is in charge of curating the Fundamental data, the NSDI Committee and Sub-Committees, established in 1995, are in charge of directing and coordinating the development of the NSDI strategy and NSDI Basic Plan.

14 http://map.vworld.kr/map/maps.do

Figure 18. Institutional Structure for NSDI development



Source: MOLIT 2020 Annual report

In addition, in 2013, SPACE N was established by MOLIT, with the purpose of supporting business start-ups and capacity buildings through education programs provided to current and future geospatial information-related professionals. (Table 4.). SPACE N also conducts research on the NSDI Action Plan and on the promotion of geospatial information use and industries. The institute is also supported by the "Spatial Data Industry Promotion Act", which provides the mandates stipulated in the "Framework Act on NSDI" and communicates the main goals included in the NSDI Basic Plan.

Table 4. Geospatial sector-related capacity building/education programs

Main Objective	Implemented Education Programs
Strengthen industry-based education	1. Fostering Spatial Information sector based specialized high school 2. Training professionals in the field of geospatial integrated sectors 3. Operation of Spatial information-related Academy for Job seekers 4. Operation of Spatial information-related Academy for employers
Cultivate creative future professionals	1. Support of spatial information-related elementary, middle and high-schools' extra-curricular clubs 2. VWorld platform-based Digital education for elementary-middle-high schools
Smart-education environment	1. Expanding and reforming online-based education portals 2. Establishment of certification system for spatial information educations

Source: Space N, 2020[15]

CONCLUSION

Although challenges still persist in the sector of geospatial information, such as setting standards and agreeing on business models, South Korea has become a benchmark country for its geospatial datasets, technologies and platforms, and capacity development, and has emerged as one of the leading countries for Smart Cities in the Asian Continent. In addition, with the successful management of COVID-19, the South Korean data management system is now being exported to other countries.

The success of the geospatial data market, development of NSDI and the efficient use of geospatial data systems resulted from having the following components:

- Open Data Policy: the policy provided a foundation for a successful development of the geospatial data market and sector-integrated platforms. The policy also underpinned the successful management of the COVID-19 pandemic during its initial outbreak, by releasing COVID-19-related data, especially geospatial, to the public.

- Technical support: Government has successfully managed a variety of geospatial datasets and has continually improved data management systems by establishing the National Integrated Information System (NIIS), which connects geospatial data systems and platforms at the national level, including the city / district systems, metropolitan systems, and central Government systems.

- Institutional support: Spatial Information Industries Promotion Institute (SPACE N) is the main institute promoting and supporting geospatial information industry-related business and innovation start-ups. The institute also delivers consulting programs / capacity development for future and present practitioners.

15 https://www.spacein.kr/company/bizIntroCommon.do

- **Long-term investment**: Coordinated by the NSDI Committee, the Government established the first NSDI Framework in 1995, with the purpose of initiating the procurement of underground facility geospatial data and digital, national topographic maps. Since the initial 5-years NSDI Basic Plan in 1995, the government steadily invested in the procurement of NSDI, which slowly evolved around the needs that quickly emerged throughout the implementation of NSDI projects.
- **Public Private Partnership**: PPPs provided pragmatic solutions for technical implementations, such as systems, platforms and database procurement. From the first NSDI Basic Plan through to the 6th NSDI Basic Plan revision, the Government has planned PPP strategies with specific target goals. For instance, one of the main partnership objectives of the first NSDI Basic Plan was the procurement of basic geospatial data (underground facilities, national topographic maps, land use and cadastral maps) through a 50:50 co-financing mechanism.

In sum, the South Korean NSDI development experience is considered unique in the sense that it vigorously integrates both policy and technical components, especially policy and legal, governance and institutions, partnerships, capacity and education and data / systems. Also, the early establishment of the NSDI provided the foundation for data standards, regulations, distribution/storage system operations and data processing. Depending on each country's circumstances, the Korean experience can serve as useful lessons learned to be adapted to specific country needs, especially South Korea's approach to coordination and partnerships across the public and private sectors, academia and civil society.

References

Geobuiz (2019). Geospatial Industry and Readiness Index. Geospatial Media and Communications.

Grieves, M., & Vickers, J. (2017). Digital twin: Mitigating unpredictable, undesirable emergent behavior in complex systems. In *Transdisciplinary perspectives on complex systems* (pp. 85-113). Springer, Cham.

Kim, K., Chang, S. W., & Park, K. M. (2020). Integrating Geospatial Information: How the Republic of Korea Overcame Institutional Obstacles to Improve Data Management, 1998–2016.

Jeong, J. (2014). The 7th Report on the Development Strategies of Public Open Data. The Ministry of Interior and Safety (MOIS).

Jang J., et al. (2019). 2019 Spatial Data Industry Survey. Ministry of Land, Infrastructure and Transportation Report.

Park, J. T., & Chun, J. (2014). The establishment of Korea land information system (KLIS). *Knowledge Sharing Program: KSP Modularization.*

NGII. (2019). NSDI of the Korea and NGII. (Presentation material)

NSDI. (2016). Spatial information Industry Survey Report. http://www.nsdi.go.kr/lxportal/?menuno=4022

NSDI. (2020). National Integrated Information System. http://www.nsdi.go.kr/lxportal/?menuno=2682

MOLIT. (1995). The 1st NSDI Basic Plan. https://www.molit.go.kr/USR/policyData/m_34681/dtl?id=567

MOLIT. (2000). The 2nd NSDI Basic Plan. https://www.molit.go.kr/USR/policyData/m_34681/dtl?id=567

MOLIT. (2010). The 4th NSDI Basic Plan. https://www.molit.go.kr/USR/policyData/m_34681/dtl?id=567

MOLIT. (2013). The 5th NSDI Basic Plan. http://www.korea.kr/archive/expDocView.do?docId=35649

MOLIT. (2018). The 6th NSDI Basic Plan. https://www.gov.kr/portal/ntnadmNews/1550019

MOLIT. (2019a). 2019 Spatial Information Policy Annual Report. https://www.gov.kr/portal/ntnadmNews/1985912

MOLIT. (2019b). 2019 Spatial Information Industry Survey Report. http://www.spacen.or.kr/vworld_mgm/industry_trend_info.do?txtNTCE_TP_BOARD_SEQ_N=490&txtPage=&cbxSearch_Type=SBJT&txtSearch_Word=&txtMenu=11

LX. (n.d.). What is Geospatial Information? Retrieved from: https://lxsiri.re.kr/frt/ko/space/siriIntroduce/screen.do

Republic of Korea (ROK). (2020) Flattening the Curve on COVID-19: How Korea responded to a pandemic using ICT.

Seoul Development Institute. (2018). Policy Report on Seoul's Geospatial Information Improvement Plan. *Seoul Development Institute.*

Shin, D. H. (2009). Ubiquitous city: Urban technologies, urban infrastructure and urban informatics. Journal of Information Science, 35(5), 515-526.

Sutanta, H., Aditya, T., & Astrini, R. (2016). Smart City and Geospatial Information Availability, Current Status in Indonesian Cities. *Procedia-Social and Behavioral Sciences*, 227, 265-269.

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