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Smart Green Mobility

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Smart Mobility

Sung Ho Oh

The Industrial Revolution in the late 18th century, which began with the invention of steam engines, brought about major changes in mankind's economy, society, politics, and life. The positive aspects include technological development and economic expansion due to increased productivity, but the negative effects include excessive urbanization resulting in traffic congestion, increased unemployment and crime rates, and environmental pollution. Previously, measures were taken to solve the above problems through relatively simple physical and financial input. In other words, roads were expanded and constructed to solve traffic congestion, finances were allocated to reduce the unemployment rate, and more police personnel were put in place to prevent crime. However, there have been criticisms that these methods were inefficient and unsustainable.

Recently, with the development of information and communication and AI- (artificial intelligence) related technologies, there has been a movement to solve urban problems with “smart cities” using them. In particular, “smart transportation (mobility),” which can be said to be the core of smart cities, is receiving great attention. In addition, changes in the demographic structure and the advent of the new normal era after COVID-19 are bringing about a shift in the mobility paradigm. First, as the number of single-person households increases and traffic behavior diversifies, a flexible transportation system is needed. Second, the need for a sustainable ecofriendly means of transportation is emerging. Third, with the expansion of the market for the sharing economy, the sharing service of transportation is expanding. Fourth, as society becomes more complex and interest in safety increases, the need to establish an integrated transportation operation system using information and communication and artificial intelligence technology is emerging.

In response to such social needs, smart mobility provides services that allow passers-by to move ecofriendly, safely, and efficiently. Representative smart mobility technologies are cooperative intelligent transport systems (C-ITS) and autonomous driving technologies. C-ITS is a next-generation advanced transportation system that allows ITS to share traffic data between vehicles or between vehicles and infrastructure in real time to overcome the limitations of being unable to respond quickly to unexpected situations such as traffic accidents. Self-driving is a technology that enables a vehicle to operate on its own without manipulation of a driver or passenger and reduces traffic accidents caused by driver negligence. In addition, it is possible to respond to various transportation demands and provide transportation services for the transportation vulnerable in combination with public transportation systems and shared transportation services.

Meanwhile, in order to establish a sustainable transportation system, a technology that can replace internal combustion engines, a by-product of the Industrial Revolution, is needed. Hydrogen fuel cells and electric motors are representative ecofriendly car engine technologies. A hydrogen fuel cell is a type of tertiary cell[01] that generates electrical energy by using oxidation/reduction reactions of hydrogen and oxygen. Currently, hydrogen fuel cells are not widely used, but they are used in some cars, ships, and trains. On the other hand, electric motors are widely used in many electric vehicles, and demand is increasing thanks to tax benefits and high fuel efficiency.

01. A battery that can continuously generate electricity through a chemical reaction by a catalyst using fuel.

In the era of smart transportation, along with changes in vehicles, space utilization will be remarkably improved. Currently, the road where vehicles travel is a two-dimensional flat space, but in the era of smart transportation, means of flying in the sky, such as air buses and air taxis, that is, urban air mobility (UAM), is expected to be activated. As the current road space is gradually reduced and returned to a living space for citizens, the main road of the city center will be mostly used as an underground space. As space diversifies and moving space expands, traffic congestion experienced in the present era is likely to remain a relic of the past.

Smart mobility is a key technology for future transportation systems. Recently, the Korean government has proposed policy tasks such as expanding the electric and hydrogen vehicle market and commercializing fully autonomous driving technology in the shortest time, predicting that the future car market will be led by ecofriendly cars and self-driving cars in 2030. Korea has strengths in that it has a solid vehicle power technology, semiconductor technology base, geographical requirements, and communication infrastructure. However, the auto market has been stagnating recently due to the economic slowdown caused by COVID-19 and the U.S.-China trade war. Even in such a situation, companies have difficulty investing in developing smart mobility technologies such as autonomous driving. In addition, ICT-related companies are facing similar difficulties. Therefore, through steady and bold investment, technology development, and system improvement, we should overcome the difficulties at this point and have the capability to lead the smart era in the future.

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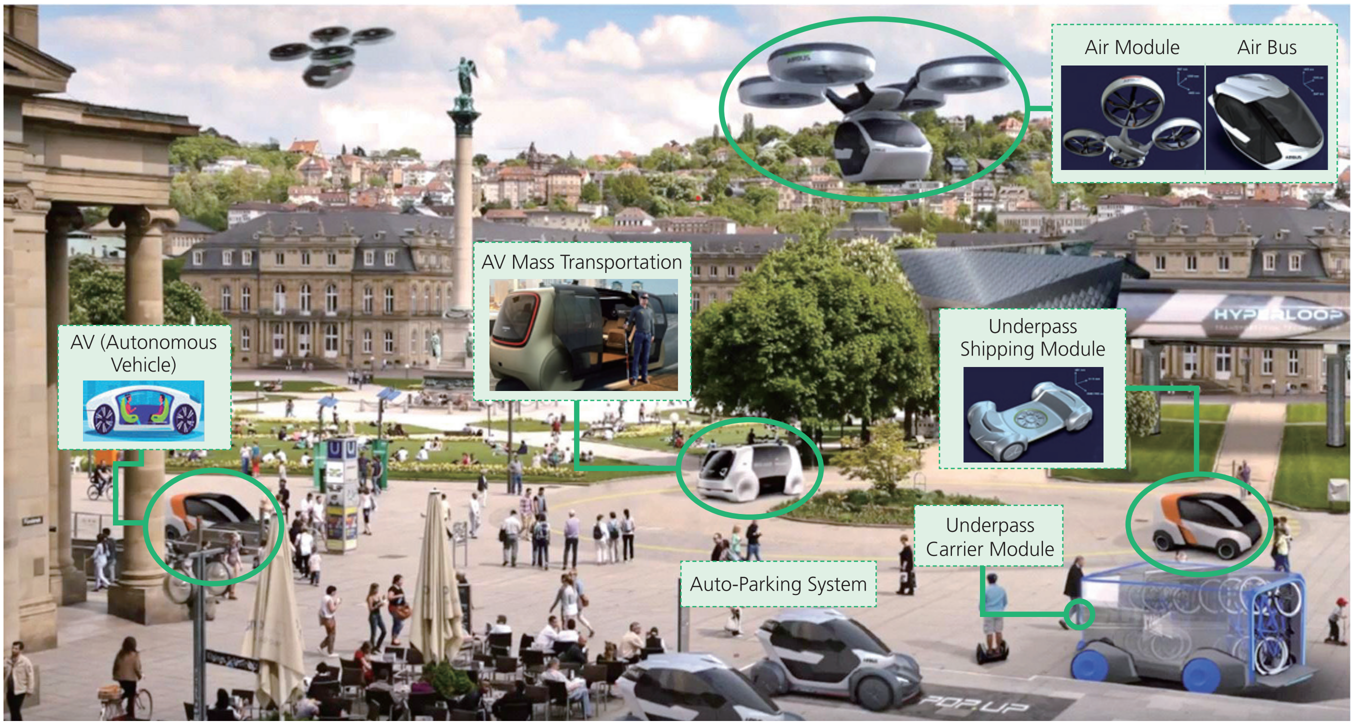
Figure 1. The future of vehicles and mobility by 2050



Source Data from public hearings for ITS Basic Plan 2030 in the field of automobile and road transportation (Nov. 2020).

Strategies to Implement Autonomous Public Transit : Focusing on Autonomous Bus Rapid Transit and Shuttle Services

Tae Kwan Yoon

1. Rapidly Growing Autonomous Vehicle Market and Public Transit

The autonomous vehicle market is growing rapidly, and experts predict that global sales of autonomous vehicles will reach nearly 600,000 units by 2025 and 21 million by 2035, respectively. The government is also working on developing plans to improve the infrastructure for fully automated vehicles by 2022. In the era of full automation, it is expected that autonomous public transit will be introduced first, instead of self-driving cars owing to the issues related to the safety and efficiency, expensive price, traffic congestion, etc. In the meantime, autonomous public transit will contribute to addressing and mitigating prolonged issues surrounding public transport, including poor safety and accessibility, and passenger congestion in transit systems. Although the implementation of autonomous public transit brings many benefits as listed above, previous research in this area was largely focused on its technological development. Therefore, the purpose of this study is to define autonomous public transit services and propose directions for the implementation by phase and order of introduction based on the trends of technological advances.

The autonomous public transit means public transport modes on the road equipped with fully autonomous driving technology. Namely, it refers to various types of buses (including metropolitan, trunk, feeder, demand responsive, and rapid transit), and car-sharing and taxis (a quasi-public transit mode) are excluded from the scope of this study.

2. What is the Autonomous Public Transit Service?

For the purpose of this study, the autonomous public transit service is fundamentally defined according to the following four types based on their specifications (size, speed, levels of vehicle autonomy, etc.) and travel conditions (distance, existence of dedicated lanes, traffic flow, and characteristics of routes):

- Circular/Shuttle bus: Designed to travel upon interrupted flow with light-duty vehicles for low-speed operation and used to provide the first/last mile service for better accessibility to the public transport
- Trunk/Bus Rapid Transit (BRT) bus: Designed to travel on the routes of closed and uninterrupted flow with middle/heavy-duty vehicles for high-speed operation and used to provide trunk service ensuring the just-in-time arrival
- Demand Responsive Transit (DRT) bus: Designed to explore dynamic routes based on demands with light-duty vehicles available for low-speed operation to be used to provide services to remote areas and improve the convenience of vulnerable road users
- Feeder bus: Designed to travel fixed routes with a short distance of open and interrupted flow with mid/heavy-duty vehicles for low-speed operation

3. Implementation of Autonomous Public Transit and Expected Outcomes

Autonomous vehicles are expected to provide many benefits to drivers and road operators. The improved safety and increasing road capacity, owing to the reduction of distance headway, are considered as the two biggest advantages of self-driving cars. This study focuses on the analysis of expected outcomes with the adoption of vehicle autonomy to mass transit. Based on the analysis of existing patterns of bus accidents, the result found that a considerable number of such accidents could be prevented. If the number of bus accidents decreases by 10%, it could help us save KRW 16 billion on average each year. The implementation of autonomous public transit will lead to the reduction of labor expenses of hiring drivers and better public transport services with the placement of more buses per the same cost. It will also bring a series of direct/indirect benefits, including efficient use of urban spaces, high capacity with a low construction cost, provision of novel transport services, reduction of environmental pollution, etc.

4. Prediction of the Timing and Effective Ways of the Implementation of Autonomous Public Transit

Based on the analysis of the public awareness, safety, communications, system, and other technological advances of autonomous vehicles, the phase and order of the implementation of autonomous public transit were predicted according to the estimated period of completing the development of vehicle automation technologies in Korea. It is expected that the autonomous public transit will be introduced to the country as of 2022, starting from BRT, followed by shuttle, feeder, and DRT buses. Figure 1

To make this happen, efforts are needed to secure and develop the road and traffic infrastructure, including the management of lanes, roads, and road/traffic signs. Also, facilities to improve the driving environment and respond to emergencies should be installed and reinforced. In addition, the review of installations on bus stops, building of transport information provision infrastructure and its operation as well as strengthening the role of the control center should be carried out. Regarding the legal framework, relevant laws and regulations such as criteria for bus driver licensing, mandatory visual display of autonomous vehicles, definitions of bus stop installations for autonomous public transit, and a monitoring and data management center should be amended.

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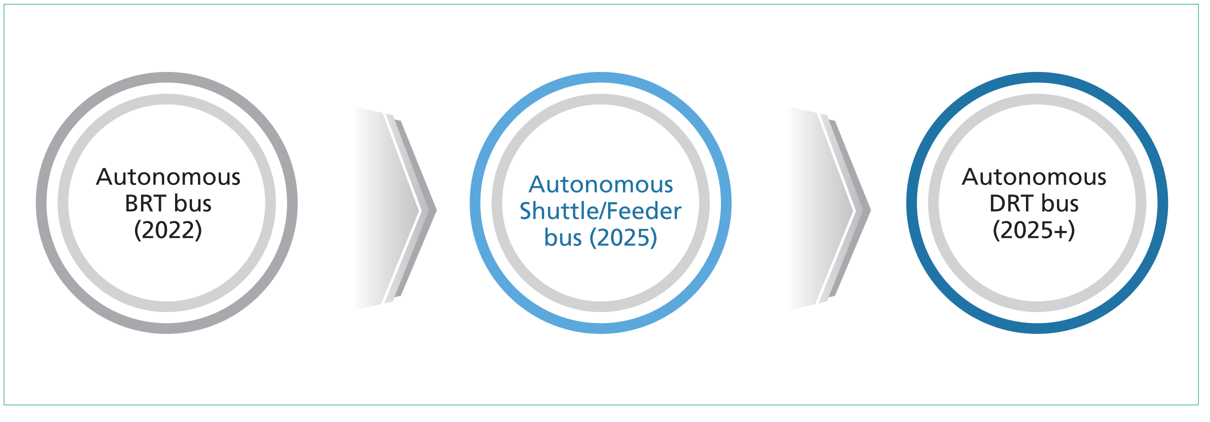
Figure 1. Introduction flow and year of autonomous public transit



Source
Yoon Taekwan et al. 2019.

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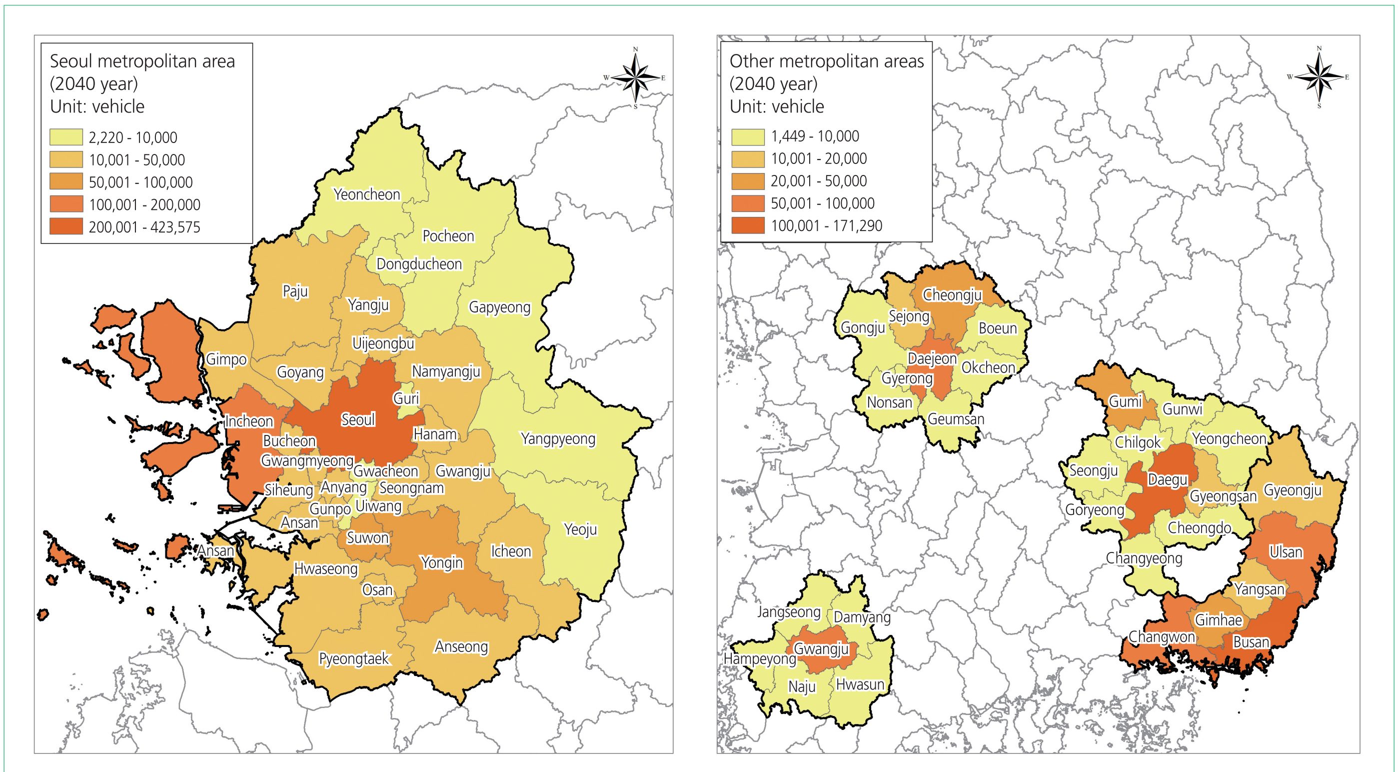
Effects of Road Environmnet Improvements in Hydrogen Economy

Jung Hwa Kim

The government is currently working on providing policy measures focusing on strengthening technological competitiveness of the domestic, new and renewable energy industry on the global stage and laying the foundation for growth in the future in an effort to foster new industries during the process of energy transition. To that end, the government announced the Third Energy Master Plan in June, 2019, to switch its policy directions from increasing the energy supply to effective demand managing. In the meantime, pan-governmental approaches to create new engines for innovative growth and end the country's current fine dust problem are being developed in collaboration with ministries and other government agencies to prepare for a fundamental shift to the 'hydrogen economy' in earnest. Based on the roadmap for the promotion of the hydrogen economy, the government aims to build an industrial ecosystem that can lead the transition to a hydrogen economy with the two pillars of 'Hydrogen Fuel Cell Vehicles' (hereinafter referred to as 'HFCV') and 'fuel cells'. The highlights of government roadmap for the promotion of hydrogen economy include producing 6.2 million units of HFCV (passenger vehicles with 2.75 million units of HFCV distributed domestically in Korea) and building 1,200 hydrogen

Figure 1. Number of HFCV supplied in study areas (based on government plan)



Source Kim Junghwa et al. 2020.

fueling stations by 2040. As detailed plans and implementation strategies are not yet provided, other than the final distribution goals, this study intends to distribute the HFCV target on the roadmap by region and calculate the air pollution emissions based on the number of vehicles by fuel type and production year and the status of land use by region. This study also reviews the potential effect of HFCV distribution by region on the cost reduction for the damage caused by air pollution by reflecting such damage cost to the estimated air pollution emissions.

1. Predictions on the Supply of HFCV by Region

This study was carried out on the assumption that the target of HFCV supply under the roadmap for the promotion of a hydrogen economy would be achieved. In order to meet the target of 2.75 million units by 2040 from the current number of registered HFCVs, the compound annual growth rate (CAGR) should be around 37.01%. If the 37.01% of annual growth rate for the supply of HFCVs continues to be maintained, it is expected that the number of HFCVs distributed for every 5 years would be approximately 23,000 units in 2025, and 560,000 units in 2035, respectively. For the purpose of this study, the figures or numbers of HFCVs supplied to each major city were calculated on the assumption that the total number of 2.75 million HFCVs (for passenger vehicles) would be distributed across the country by 2040, and that the proportion of registered vehicles by region would be the same in 2040 as the base year. Based on this assumption, the number of HFCVs in 5 major cities was calculated as follows. As the country enters into the hydrogen economy, the estimated number of HFCVs of 5 major cities and their surrounding regions in 2040, based on the share of registered vehicles by region in 2020, would be about 670,000 units in Gyeonggi-do, 420,000 units in Seoul, 180,000 units in Incheon, and 150,000 units in Daegu. As seen in Figure 1, shares of current registered vehicles were applied as it is, and it is expected that the Seoul metropolitan area with high population density will have a relatively high number of HFCVs. **Figure 1**

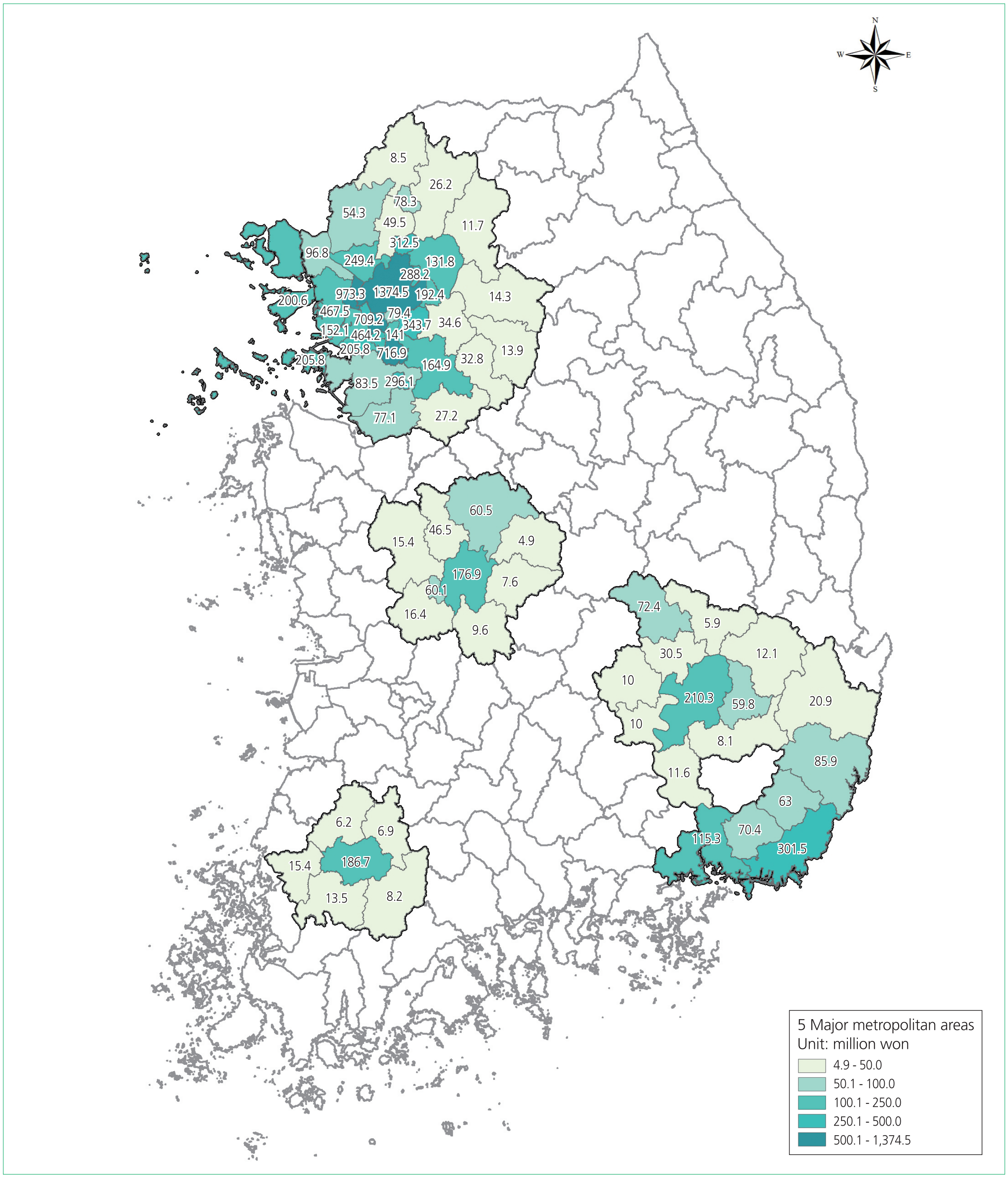
2. Estimation of the Future Air Pollution Emissions

The emissions estimation model based on the registered address of UTEAS, which allows to predict the future air pollutants of greenhouse gas emissions (GHG), was applied to conduct the analysis. The analysis targets were limited to five major air pollutants, including carbon monoxide (CO), nitrogen oxide (NOx), sulfur oxide (SOx), particulate matter (PM), and hydrocarbon (HC). Under the assumption that the HFCV distribution target of 2.75 million units would be achieved, it was found that the air pollution emissions would be reduced by 9.90 million kg for CO, 4.85 million kg for NOx, 18,000kg for SOx, 29,000kg for PM, and 2.54 million kg for HC by 2040.

3. Social Benefits of the Reduction of Air Pollution Emissions

To calculate the benefits of improved air quality, the cost of damage of each pollutant was applied to the total amount of air pollution emissions reduced in accordance with the roadmap for the promotion of a hydrogen economy. Based on this, the social benefits per HFCV were estimated. To conduct the study, the guidelines for the estimation of road and railway cost, which were used for calculating the benefits in the preliminary feasibility study of transport facilities, were adopted by applying 1.72%, which is the average consumer price index for the last 10 years (from 2010 to 2019). By doing so, the estimated benefits of reduced air pollution emissions were calculated by KRW when the target of supplying 2.75 million units of HFCVs was met in the future. Based on the monetary value of 2040 as the base year, it was found that the benefit of air pollution emission reduction was worth KRW 268.6 billion per year, which could be interpreted to create an annual social value of KRW 97,700 per HFCV. With regard to the benefit by the road area, it was found that the benefits per road area of certain cities in Gyeonggi-do were higher than those of other regions nearby major cities, followed by Seoul and major cities of Gyeonggi-do (Bucheon, Suwon, Anyang, Gwangmyeong, Gunpo, Seongnam, etc.), Busan, Incheon, and Daegu. Also, areas nearby major cities showed higher social benefits than others. **Figure 2**

Figure 2. Air pollutant emission reduction effects per unit road area



Source
Kim Junghwa et al. 2020.

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Cooperative Program of Space Planning and Transportation System for Reducing Particulate Matter Based on Big Data

Jong Hak Kim

1. A Necessity for Cooperation between Space Planning and the Transportation System to Reduce PM Emissions

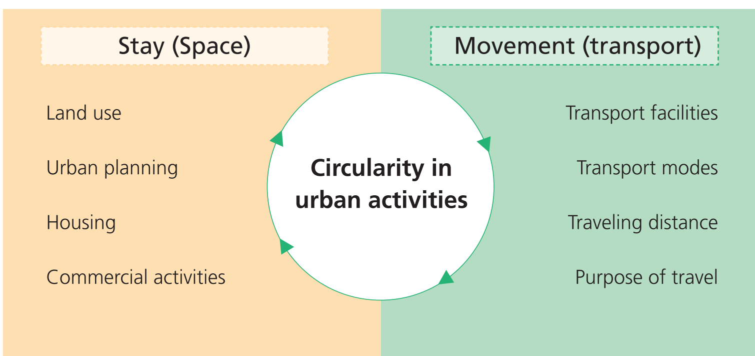
The Korean government included fine dust (particulate matter, PM) as its classification of natural disasters under the Framework Act on the Management of Disasters and Safety in March, 2019, and began to strengthen measures to reduce and manage fine dust. However, pan-governmental approaches based on cooperation among ministries are still insufficient as each ministry provides its own measures. The transport sector is considered one of the three major sources of PM generation, along with the manufacturing industry and the production process. From the perspectives of space and transport, it appears that PM is generated in certain areas (spaces) and spreads along the roads. Therefore, it can be said that cooperation between the two major activities in everyday life—stay (space) and movement (transport)—is required so that changes in daily routines lead to preemptive efforts to reduce PM emissions. Figure 1

2. Process of Developing a Cooperative Program of Space Planning and Transportation System for Reducing PM

After the review of factors determining each activity and their relevance to PM reduction, it was found that activities related to stay, including urban planning of wind paths, compact cities, etc., can be effective in reducing PM. It was also found that they were related to the travel distance. Thus, it can be linked with the design of eco-friendly cities as it can induce a certain degree of atmospheric circulation and passenger movement in a compact city. After the comparison of measures to reduce PM, it was confirmed that designing urban streets could be a viable option to be implemented in the short-term, reach a social consensus easily, and improve physical health of individuals. Table 1

The designing of eco-friendly streets in cities was found to be greatly related to each factor of stay and movement in the initial review, and it was later confirmed as a highly feasible plan that could be implemented for the short-term in the

Figure 1. Types of activities for stay and movement



Source
Kim Jonghak et al. 2020.

second review. In consideration of items deemed relevant for designing eco-friendly urban streets (including characteristics of passage, transport modes, and duration), utilization of walk spaces was determined as an effective method of reducing PM emissions based on the cooperation between space planning and transportation systems for the purpose of this study as passengers could travel on foot, and it could be implemented in a short period of time with a low budget. Figure 2

3. Case Analysis of Promoting Walking for PM Reduction

To conduct the study, an analysis of cases of Areum-dong and Boram-dong of Sejong was made by calculating the time required to travel from the community service center to nearby apartment complexes by different routes. Later, the most proper axis of walking was selected by comparing 12 items, including the distribution of green land, width and breadth of walking, types of crosswalks, etc. As for Areum-dong, the route B along axis C was selected as the optimum axis of walking distance as it had a crosswalk and was less interrupted by vehicles with a considerable number of shops and stores distributed to the axis C when compared to others. Regarding Boram-dong, the route B was chosen as the most desirable passage. The reason is that a relatively large number of households was scattered, had a large and fine green land and was available to reduce PM emissions as the walking distance is approximately 800 meters.

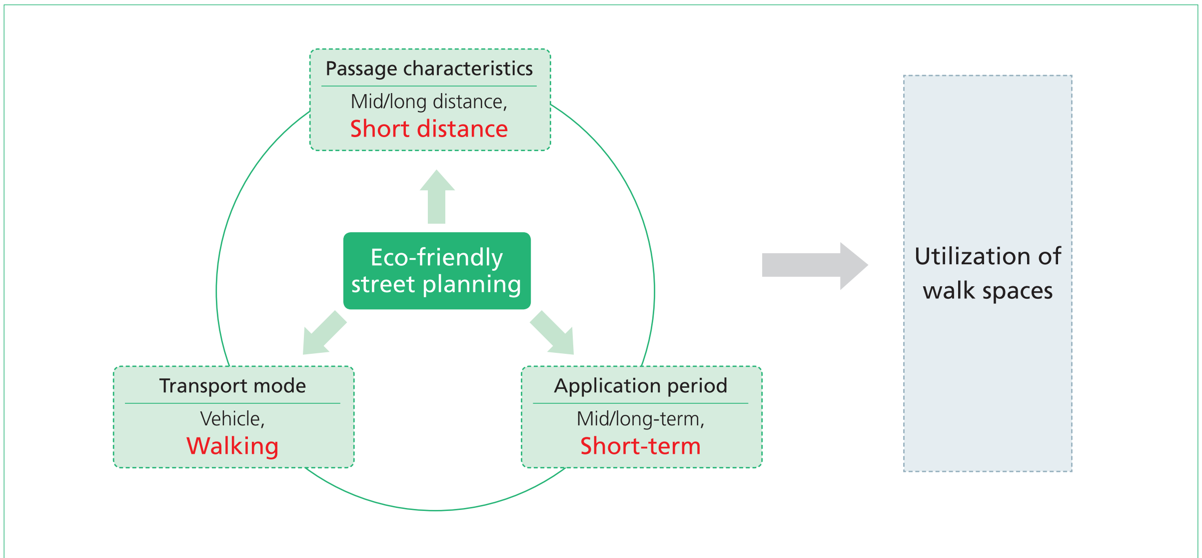
Next, subway stations not linked to other stations within the four main gates of Seoul were selected as examples of promoting walking for short distance travel in a large city. Specifically, sections within a 5-minute walking distance that

Table 1. Comparison of PM reduction measures

Classification	Designing of atmospheric circulation over urban areas	Compact city	Ultra-low emission zone (ULEZ)	Personal mobility	Designing of Eco-friendly streets
Feasibility	Mid-term	Long-term	Short-term	Short-term	Short-term
Required budget	High	High	Low	Mid	Mid
Social consensus	Mid	High	Mid	Mid	High
Improvement of urban environment	High	Unknown	High	Mid	High
Improvement of physical health	High	Unknown	High	Mid	High

Source
Compiled by the author.

Figure 2. Development of detailed cooperative measures for PM reduction



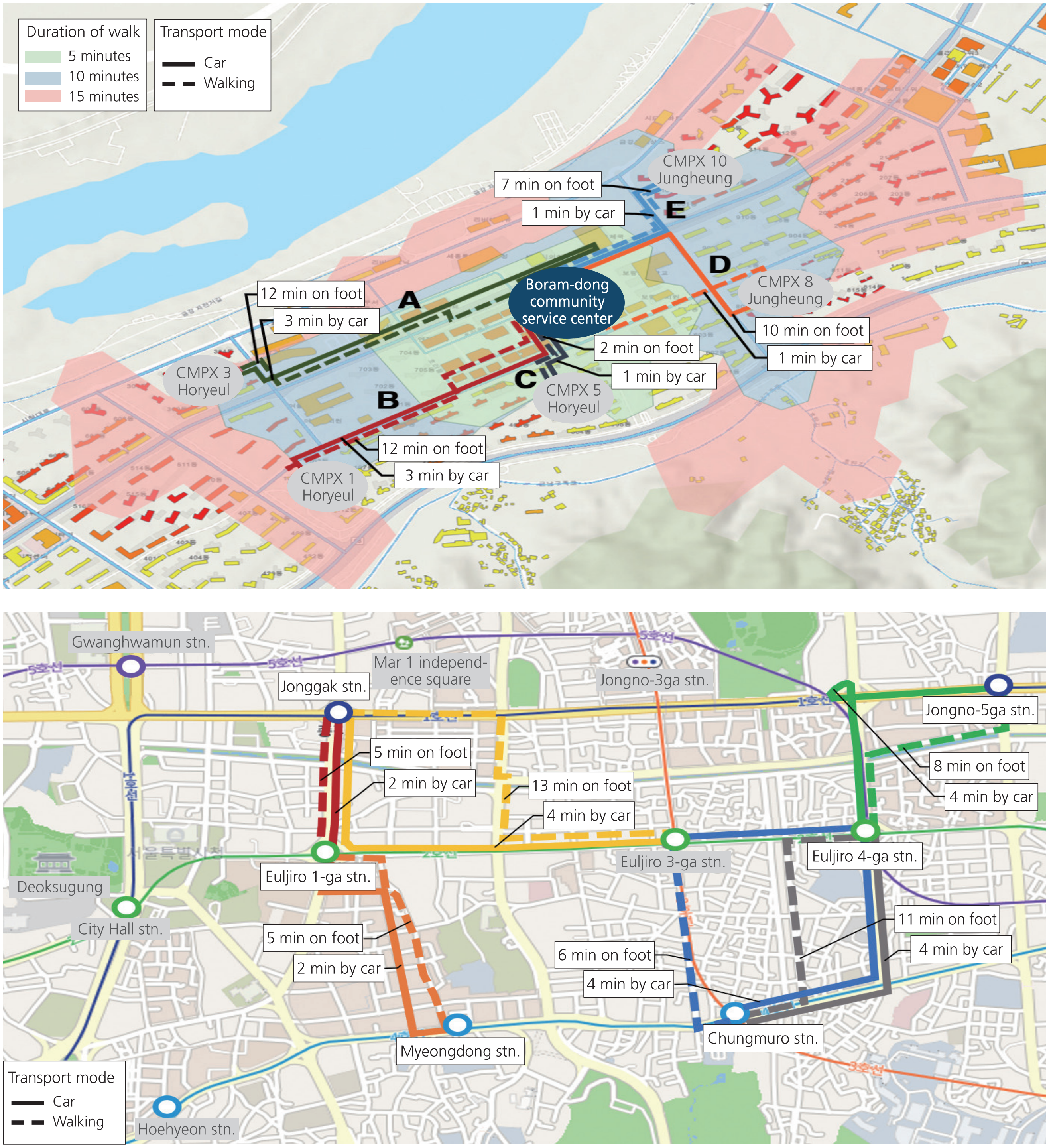
Source
Kim Jonghak et al. 2020.

overlap more than average compared to others among the routes of subway stations not connected to each other were reviewed. When the sections that overlap more than average are connected, they created an N-shaped walking network. Figure 3

4. Conclusion

In order to develop pan-governmental measures for PM reduction, efforts to eliminate fine dust based on cooperation

Figure 3. Proposed pedestrian network in Boram-dong, Sejong, and Seoul within 4 main gates (example)



Source Kim Jonghak et al. 2020.

and convergence of multiple areas are needed. For example, a policy to distribute eco-friendly vehicles in advance to industrial sites emitting a high volume of PM through cooperation between the industry and transport and promoting the installation of photovoltaic facilities to large livestock farms by linking transport and agricultural sectors. When it comes to measures to reduce PM by region, there is a need to encourage the engagement of local governments. Regarding the measure to reduce PM through walking a short distance instead of using other means of transport proposed in this document contains elements that require the involvement of local governments. Thus, it can be pursued with collaboration between the central and local governments. Specifically, measures to reduce PM emissions tailored to the characteristics of each local government can be developed from the microscopic analysis of vast data collected from mobile devices and the network. In addition, measures for improving the legal and institutional framework to promote walking followed by comprehensive strategies as pan-governmental approaches are required as well. First, there is a need to include the walking solution to the definitions of green city under the Urban Development Act as walking instead of using other transport modes can save energy and eliminate fine dust. Also, installation of walkways to promote walking should be included to the urban planning. To provide measures to reduce PM through promoting walking of passengers for a short distance, content such as the installation of walkways should be included in the development stage under relevant laws. With regard to the stages that such initiatives should be included, it should be the planning stage for housing land development, upon approval for the public housing development project, and before the notice of designation as the urban development zone.

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It is necessary to implement a systematic walking network to reduce PM through the conversion of walking demand for short-distance vehicle traffic in CBD.

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KRIHS Times

SNU Environmental Planning Institute-LH-KRIHS Joint International Symposium for the 40th Anniversary of the SNU Environmental Planning Institute

Korea Research Institute for Human Settlements (KRIHS) jointly hosted the International Symposium for the 40th anniversary of the Environmental Planning Institute of Seoul National University (SNU) for 2 days from January 21st to 22nd with SNU and the Korea Land & Housing Corporation (LH). The symposium was held to introduce the latest research activities, goals and targets, and trends in Korea and overseas regarding the importance of space and environment as core media to promote human health while commemorating the 40th anniversary of the Environmental Planning Institute. Under the topic of 'Cities, Green, En-vironment and Health', presentations by experts were made followed by Q&A sessions.

Professor Catharine Ward Thomson at the University of Edinburgh delivered her keynote speech titled 'Plans for access to green space and health-inclusive outdoor space' online, and President Yong-Seung Shin of the Seoul Research Institute of Public Health and Environment gave a presentation on 'Approaches of Seoul Metropolitan Government for the management of public health, environment, and air quality in the era of COVID-19'. Also, Professor Jeffrey David Sachs at the Columbia University provided a presentation on the 'Local community and health in the era of COVID-19 pandemic'. This symposium is particularly meaningful in that it introduced the public to research that is actively being discussed in Western countries as well as China, Japan, etc.

Joint International Symposium of SNU Environmental Planning Institute-LH-KRIHS

International Seminar in Commemoration of the Launch of Geospatial Analytics & Monitoring Center

KRIHS held the 'International seminar to commemorate the launch of Geospatial Analytics & Monitoring Center' at its auditorium on April 15th. In his welcoming address, KRIHS President Hyun-Soo Kang said, "It is critical to monitor and refresh activities executed since the establishment of the 5th comprehensive national territorial plan to achieve the goals as planned. Hence, the roles and outcome of the newly installed Geospatial Analytics & Monitoring Center are all the more important". Lawmaker Seung-guk Hong (from Sejong City) delivered his welcoming remarks and said, "National territories are interdependent with each other. The Geospatial Analytics & Monitoring Center will contribute greatly to developing comprehensive plans, coming up with outcomes to eliminate regional imbalances".

International Launching Seminar of Geospatial Analytics & Monitoring Center at KRIHS

In the meantime, Professor Praveen Edara at the University of Missouri delivered his presentation titled 'Advanced cases of AI-based land monitoring', and Professor Alex Singleton of the University of Liverpool and Professor Yuki Akiyama at the University of Tokyo gave presentations on the 'Roles of the Consumer Data Research Centre (CDRC) and the Geo-graphic Data Science Lab (GDSL) of the UK and development directions for land monitoring' and 'Local innovation and cases of Japan using spatial data, and related research trends', respec-tively.

In addition, Assistant Deputy Director Jung-hwan Park of Daejeon Metropolitan City presented on 'Big data-based monitoring on local economy and examples of administrative innovation of local government', and Director Hye-joo Kim of Shinhan Bank Digital Innovation Unit explained 'Ways to embrace big private-sector data'. Lastly, Director Young-joo Lee of KRIHS Geospatial Analytics & Monitoring Center gave a presentation titled, 'Prerequisites for the innovation of databased land policies'.

KRIHS-NIE MoU Signing Ceremony

On March 3rd, 2021, KRIHS held a signing ceremony of the Memorandum of Understanding (MoU) with the National Institute of Ecology (NIE) for Research and Development (R&D) activities in the areas of sustainable land, environment, and ecology at its office. The purpose of the MoU is to contribute to the sustainable use of national territory, and conservation and restoration of the ecological environment by carrying out joint research activities in the same fields, systematically.

The President of NIE (left) and the President of KRIHS (right)

Starting from the short-term co-operation in developing basic concepts for the eco-friendly use of brownfield in Janghang, the two sides plan to implement joint studies on land and environment in the mid/long-term, including ecological services, green infrastructure, etc., and share spatial and environmental data and information for comprehensive management of plans for land territories and the environment.

KRIHS President Hyun-soo Kang said, "KRIHS has been paying attention to eco-friendly use of national territories since the installation of the Environment & Resources Research Division. We expect that the signing of MoU with NIE can provide an opportunity to implement the Green New Deal initiative in regions to achieve ecological preservation and carbon neutrality."

KRIHS-NIE MoU Signing Ceremony

NIE President Yong-mok Park said, "NIE has been leading the effort to preserve the national territories and environment by developing ecological zoning maps. We hope that the MoU, with KRIHS, can be the first step for sustainable development while striking a balance between development and conservation."

KRIHS

KRIHS (Korea Research Institute for Human Settlements) was established in 1978 in order to contribute to the balanced development of national territory and the improvement of the quality of life of people by conducting comprehensive policy-oriented research in the efficient use, development, and conservation of territorial resources.