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Integrating Spatial Planning and Environmental Planning to Reduce Fine Dust

Park Jong-soon, Nam Seong-woo

1. Background and significance

Current issue in the national environment: fine dust

There is growing anxiety among people due to fine dust[01] generated in Korea or flowing in from neighboring countries. According to the 2018 social survey of Statistics Korea, the Korean people considered crime, national security, and environmental pollution as the top three factors of anxiety, and of the environmental problems, 36% of respondents said that the domestic air environment has become worse than it was two years ago (Statistics Korea, 2018).

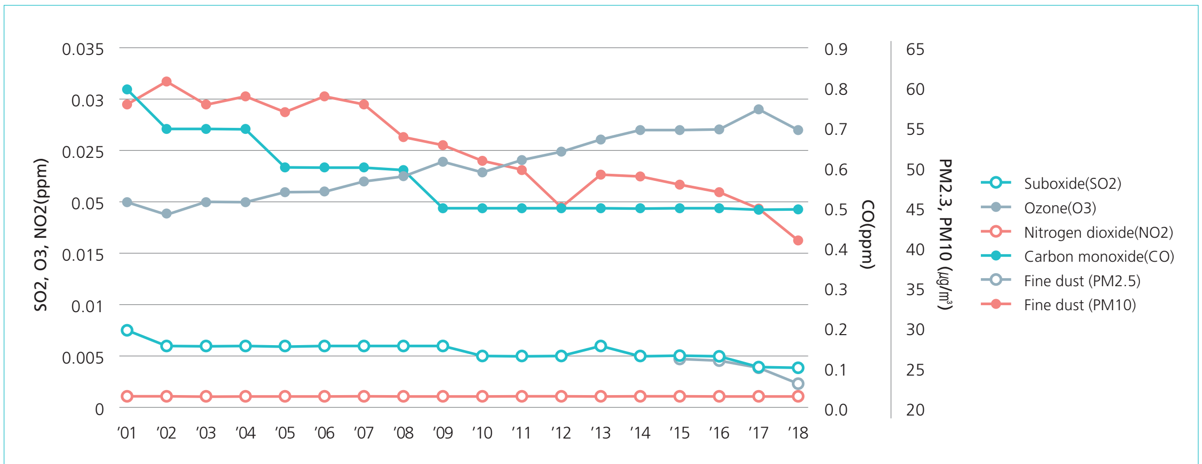
In order to reduce the fine dust problem, the government mainly implemented policies to regulate the emission sources. This includes the management of emission sources such as replacing old diesel vehicles, expanding the supply of eco-friendly vehicles, distributing road-cleaning vehicles, and implementing a dust emission control system (Joint Ministries, 2017, 2018). The government has also increased the budget by about 20% in the last four years to improve the air quality (National Assembly Budget Office, 2019). However, the correlation between the emission level and the concentration of fine dust before and after 2012 is decreasing. This means that in order to solve the fine dust problem, it is not enough to have policies that simply manage the emissions of the sources.

Need to integrate spatial plans and environmental plans to introduce wind paths

The effectiveness of fine dust policies will increase if spatial management policies such as creation of wind paths are combined. The case of Stuttgart in Germany and several domestic studies have shown empirically that landscaping plants reduce fine dust, and the layout and height of buildings affect the concentration of fine dust.

It is difficult to find cases where wind paths are practically

Figure 1. Trend of National Air Pollution Concentration



Source
Park et al. (2019, p.63).

01. "Fine dust" refers to inhalable dust from each of the following items among dusts pursuant of subparagraph 6 of Article 2 of the Air Quality Conservation Act: a. dust with a particle diameter of 10 micrometers or less (PM10, Particulate Matter), b. dust with a particle diameter of 2.5 micrometers or less (PM2.5). (Korea Ministry of Government Legislation, 2019)

applied in cities. There may be several causes, but one of them is the dualized system of spatial planning and environmental planning. Basic information about urban atmosphere is required to apply wind paths to spatial planning, and the spatial range of urban wind paths need to be set based on this information. That is, wind paths can be naturally applied if the spatial range of wind paths is set in the environmental planning and is reflected in the urban and development planning. Or, the desired purpose can be achieved by internalizing the wind paths within the national land and urban planning.

2. Characteristics of domestic fine dust

The level of fine dust in Korea is improving but is still below international standards

The PM10 concentration in Korea exceeded the annual average standard (50㎍/㎥) in the early 2000s, but the air quality gradually improved and has been satisfying the standard since 2010. However, the PM10 concentration in Korea is still about two times higher than the recommended standard of the WHO which is 20㎍/㎥.

The PM2.5 concentration has been measured by the national measurement network since 2015, and it exceeds the air quality standard. The concentrations in 2015 and 2016 were 27㎍/㎥ and 25㎍/㎥ respectively, which exceed the recently updated annual average standard (15㎍/㎥) and are close to or satisfactory with the previous annual average standard (25㎍/㎥).

Fine dust varies by season and region

From the spatial perspective of national land, the west side of the country has a higher concentration of PM2.5 than the east side. The causes include industrial and economic aspects, monsoons, and topographical factors. In Korea, several thermal power plants and industrial complexes that can be a source of fine dust are located near the coast of the West Sea. Fine dust can also flow in from neighboring countries such as China in winter and spring when the north wind, the northwest wind and the westerlies are strong. Topographically, the dispersion of fine dust can be delayed by the Taebaek Mountains. Figure 1,2

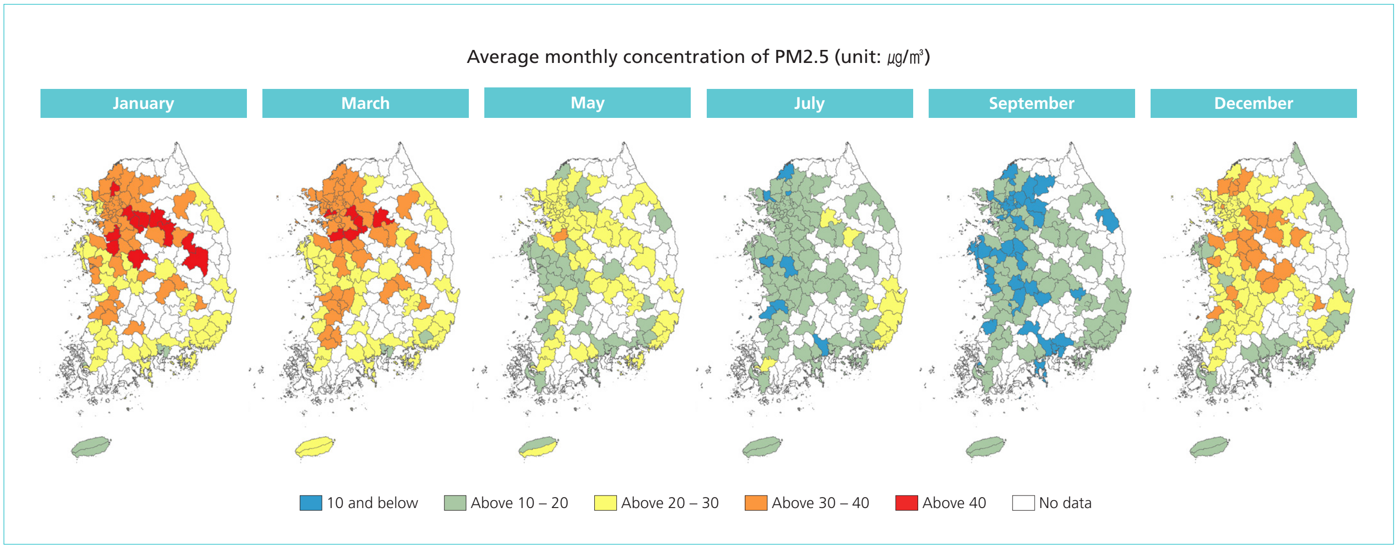
3. Problems caused by the divided system of urban and environmental planning

Division of spatial and environmental planning

The Integration of spatial and environmental planning, which started in the Netherlands in the 1970s, began to be discussed in Korea only from 2000. There have been attempts to spatialize environmental planning and to reflect spatialized environmental information in land use plans to make this linkage possible.

Among the environmental factors, the field that could be linked was the ecological environment. The ecological axis or

Figure 2. Average Monthly Concentration of PM2.5 by Region in 2018



Source Park et al. (2019, p.70).

network was jointly established in both plans and was intended to be reflected in the designation of conservation areas and establishment of land use plans. However, despite various efforts, materializing the spatial scope of the ecological axis was a difficult task due to the abstract vision of promoting biodiversity, difficulty of setting target species, and the different management directions in both plans regarding the ordinary natural or non-urban areas. For these reasons, the spatial extent of the agreed ecological axis is still absent except for the Baekdu-daegan protected area.

The wind paths of this study can link the two plans without much difficulty because they can be expressed in a clearer spatial range than the ecological axis and can contribute to solving the challenge of reducing fine dust.

Lack of basic information due to the dualization of planning

It is difficult for urban planners to obtain basic information about the atmospheric environment necessary for planning wind paths. Environmental plans should provide flow charts of cold air and potential wind paths; however, such information is rarely presented in drawings. This makes it difficult to obtain related information even if planners try to establish an urban plan reflecting the air flow. Therefore, urban planners and environmental planners should jointly investigate and share the wind environment, which is possible through the linkage of plans.

Difficulty of setting up the development and conservation axes

The divided spatial planning makes it difficult to establish conservation and development axes in consideration of the wind paths. As these axes are linked with land use, it would be desirable to set the passages or paths through which the cold air passes as preservation axes if possible, and to divide land parcels into suitable uses in the future. However, the current spatial planning lacks an institutional mechanism that can mediate the preservation and development axes even if they are set unilaterally in both plans. Therefore, to apply wind paths to spatial planning, the preservation and development axes should be set in consideration of environmental factors such as urban climate, atmospheric environment, and cold air flow chart, and this requires a linkage between plans.

Lack of consideration of urban climate and meteorological environment

A linkage between plans is also necessary to carry out development projects that take into account urban climate and meteorological environment. Installation of infrastructure or buildings inevitably affects the wind environment in the project site or the entire city. If a development project has a potential of making a significant impact, it should be revised or changed. Currently, air environment impact assessment is conducted on development projects over a certain scale or for specific purposes. However, this assessment does not cover in depth whether the

impact is limited to the project site or negatively affects the city-wide wind paths. Therefore, application of wind paths will be possible if the environmental plan is drawn up in the project unit along with the development plan and it, they move together with the air environment impact assessment system.

4. Measures to Integrating the two plans

Stage of surveying natural and human environment

In the survey stage, survey items related to fine dust, urban climate, and wind paths should be jointly set and used when establishing national land and environmental plans. In urban planning, basic data related to wind paths in the city can be collected in connection with land use, parks and green space, and the green axes and can be used when establishing plans.

In the survey stage of environmental planning, it is necessary to create an air pollution map using the air pollution measurement data, and to understand the direction and speed of main winds in the city as well as the flow of cold air. An urban climate map should be prepared to map the main wind directions, green and blue networks, and the flow of cold air at night.

Stage of plan preparation

In the stage of plan preparation, it is necessary to determine the spatial scope of the wind paths by reviewing details related to the weather and climate of the city obtained in the survey stage, and plan development and conservation axes based on this. At the regional and urban levels, the spatial range of wind paths should be made clearer, and the flow of cold air should be considered when setting the development and conservation axes. The area where cold air is generated and flowing should be designated as land for conservation purpose, such as park and green areas, as much as possible.

Specifically, we propose a method of establishing the direction and layout of buildings in consideration of the local wind paths in the district unit plan. This makes it possible to prevent the congestion of fine dust by facilitating a smooth air flow, and ultimately improve the air quality through reduction and diffusion of fine dust.

Stage of plan evaluation

An evaluation item for wind paths should be added to the environmental review in the National Land Planning Evaluation Guideline. Whether or not wind paths are secured in development projects can be evaluated under the Environmental Impact Assessment Act. In particular, when assessing the environmental impact, it is important to assess whether the wind paths are secured not only in the project site but also in adjacent parcels. At the same time, whether or not the development projects block the wind paths should be assessed at the regional and urban levels.

Stage of project implementation

There are two ways to apply wind paths in the implementation stage in terms of the possibility and reality of policy promotion. First, as a method of internalizing wind paths in urban planning, the plans for land use and wind paths can be linked when development plans and implementation plans are prepared for developing new residential areas or industrial complexes. This is a case in which the entity that prepares development and implementation plans establish its own plan for wind paths by reflecting the contents of the local environmental preservation plans, while maintaining the framework of the current legal system.

Another method is linking urban planning with environmental planning. Environmental plans are currently not established for each project unit, but these plans can be established separately in the mid-to long-term and reflect the wind path-related contents in the development and implementation plans.

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Introducing Wind Paths for Fine Dust Reduction

Yoon Eunjoo, Park Jong-soon

1. Background and significance

Definition of urban wind path

"Urban ventilation corridor" or "wind path" are derived from the German term "Ventilationbahn" which was first used by Kress (1979).[01] A wind path is a "network of green space, water, and open space" through which fresh air flows from mountains and seas to cities (Kim et al., 2007, p.130). In a narrow sense, a wind path is a physically open space, and in a broad sense, it includes all open spaces, trees and facilities that improve air pollution, and even spaces that aid ventilation. Climate maps (wind path maps) are prepared based on this concept, and wind paths can be applied from the perspective of urban planning. The urban wind path map is prepared by reflecting various factors from statistical data on urban climate to empirical judgment of various experts.

The effect of wind paths on fine dust reduction

Wind paths or ventilation corridors in a narrow sense can contribute to the reduction of fine dust through ventilation of the city. Fresh cold air generated at night in natural areas such as mountain regions can enter the city along the wind paths and improve the air quality in the city (Eom, 2010.)

Wind paths are also effective in fine dust reduction in a broad sense. Plants and soil on wind paths or ventilation corridors can contribute to the reduction of fine dust through adsorption. Plants make photosynthesis using VOCs (volatile organic compounds) which can become fine dust, and air pollutants adsorbed on the soil can be used as nutrients for microorganisms. Lee (2019) experimentally revealed the adsorption effect of major landscaping plants in Korea on reducing fine dust. After placing PM2.5 fine dust and the experimental plants in a completely enclosed chamber, the concentration of fine dust was measured at 30-minute intervals

> "The green space network created on the wind path can play an important role not only in improving the atmospheric environment but also in improving the urban environment."

01. To improve air exchange and ventilation conditions in the city center, Kress(1979) proposed considering two important factors of "functioning areas" and "compensating areas" before creating urban ventilation corridors linking two areas together to make it easier for cool fresh air to flow to the center of the city.

for 8 hours. The results showed that 82% of fine dust was reduced in the case of yew, 72% in the case of holly, and 69% in the case of ivy. The concentration of fine dust in the air is naturally lowered by gravity, but yew trees have a higher adsorption rate for foliar or root than other landscaping plants.

2. Simulation in the case area

Comparison of wind path before and after the creation of Cheotmauel in the Multifunctional Administrative City

The following numerical experiments were designed to understand changes in wind direction and speed before and after the creation of Cheotmaeul (First Village) in the Multifunctional Administrative City. As a result of numerical experiments using CFD (Computational Fluid Dynamics), the wind direction showed a flow similar to the inflow before the development of Cheotmaeul in the Multifunctional Administrative City. The flow was somewhat distorted by the influence of the terrain in the vicinity of Janggun Mountain located in the southwest of the case area, but the flow was still strong in the center of the numerical drawing. After the development Cheotmaeul, the wind direction and speed changed significantly in the vicinity of Cheotmaeul due to the influence of the buildings. In the center of the numerical drawing, a flow almost identical to the wind flow was simulated, but the wind speed was lower than the edge (see <Figure 1>). This suggests that the wind strength has been weakened due to the development of a new town. Figure 1

The flow of cold air in the Sejong (construction area)

A simulation experiment was conducted using KLAM_21[02] to understand the flow of cold air after sunset in the Multifunctional Administrative City (construction area) in Sejong. The simulation was conducted for 8 hours, initially at 15-minute intervals, and then in 30-minute increments.

Image (a) of <Figure 2> shows the flow of cold air 15 minutes after sunset, where cold fresh air is formed in the mountainous regions, and this clean air descends along the valleys and rivers and thickens its layers. The flow and height of the cold air 8 hours after sunset can be seen in (b) of <Figure 2>. Here, we can wee that the layer of cold air in mountain regions is lowering, while the layer of cold air in lowland rivers and valleys is thickening. In summary, a considerable amount of cold air is created in Seodaesan and Janggun-myeon located in the south of Sejong, and the clean air produced here moves to the lowlands such as the Geum River.

In the case of Sejong, the wind flow is expected to worsen over time as the urban development progresses rapidly. Proper wind flow management would be necessary in Sejong through the setting of wind zones and wind path planning. Figure 2

Changes in the concentration of fine dust according to the layout of buildings

<Figure 3> shows the change in the concentration of fine dust after 3 hours at a location 0.5m above the ground when buildings are newly constructed in the B1 block of the 6-3 living zone in the Multifunctional Administrative City. Assuming the current concentration at 80㎍/㎥, which is the level of "very bad" for PM2.5, the concentration of fine dust in the incoming air is set relatively clean at 5㎍/㎥.

Here, when the buildings are constructed in a plate shape (vertical direction to the wind path), fine dust was significantly dispersed at 9.8㎍/㎥ (12.2% compared to the concentration in the background) in the central green area (wind path), but the fine dust on the right side of the case area was still stagnant. When the buildings are constructed in a plate shape in the horizontal direction to the wind path, fine dust was significantly dispersed at 6.5㎍/㎥ (8.1% compared to the concentration in the background) in the central green area (wind path) and the case area was improved overall.

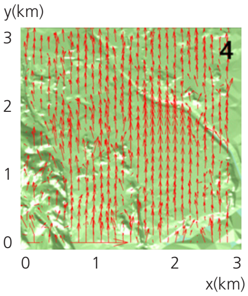
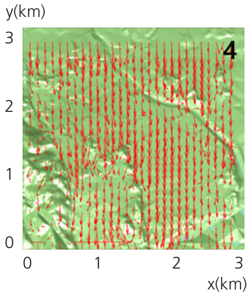
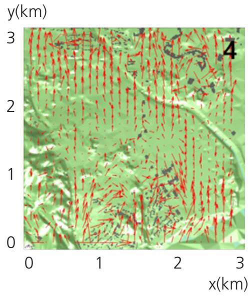
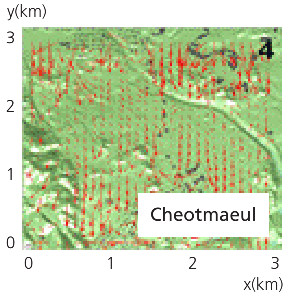
In the case of a tower shape (V shape), fine dust was significantly dispersed at 6.2/㎥ (7.7% compared to the concentration in the background) in the central green area (wind path), but the fine dust on the right side of the case area was still stagnant. In the case of a mixed shape (plate shape + tower shape), fine dust was significantly dispersed at 8.9/㎥ (11.2% compared to the concentration in the background) in the central green area (wind path), but the fine dust on the right side of the case area was still stagnant. As a result, at the height of 0.5m above the ground, the tower shape was advantageous for reducing fine dust in the case of central green area, and the plate shape "in the horizontal direction to the wind path" was advantageous for reducing fine dust in the case of the entire simulation area. Figure 3

3. Implications and future tasks

Construction of new towns and changes in urban atmosphere

Under the influence of new town construction, the surface

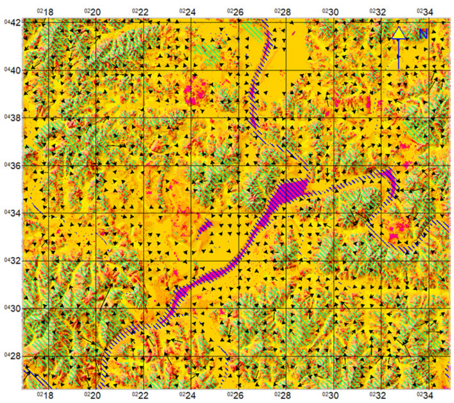
Figure 1. Comparison of the Wind Vectors of Before and After the Creation of Cheotmaeul (Living Zone 2) in the Multifunctional Administrative City

	Before the new town construction		After the new town construction	
	South wind	North wind	South wind	North wind
Wind direction				

• The figure above shows the wind direction and speed before and after the creation of Cheotmaeul in Sejong.
- Image on the left (before construction): Terrain affected wind direction and speed, but there was no significant change overall.
- Image on the right (after construction): Wind speed slowed down overall and the wind direction of Cheotmaeul especially became complicated.

Source Park et al. (2019, p.98).

Figure 2. Cold Air Flow and Height in the Multifunctional Administrative City



(a) 15 minutes after sunset

- It is a time when cold and fresh air is formed in the mountains.

Deutscher Wetterdienst Modell KLAM_21 V2.009

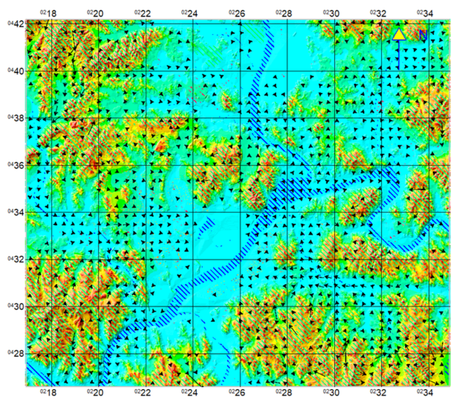
.../Sejong.in Kaltlufthoehe und Stroemungsfeld in 10.0m Hoehe

Integrationszeit = 15min

500m
1m/s
Farbskala
Unit:m

0 | 1 | 2 | 3~4 | 5~9 | 10~14 | 15~19 | 20~29 | 30~39 | 40~59 | Residential area | Forest | Water body

Weiter: <EINGABE> druecken.



(b) 8 hours after sunset

- Most of the cold and fresh air formed in the mountainous regions accumulates in valleys and rivers.

Deutscher Wetterdienst Modell KLAM_21 V2.009

.../Sejong.in Kaltlufthoehe und Stroemungsfeld in 10.0m Hoehe

Integrationszeit = 480min

500m
1m/s
Farbskala
Unit:m

0 | 1 | 2 | 3~4 | 5~9 | 10~14 | 15~19 | 20~29 | 30~39 | 40~59 | 60~99 | 100~149 | 150~199 | 200 and above | Residential area | Forest | Water body

Weiter: <EINGABE> druecken.

Source Park et al. (2019, p.101, 102).

02. KLAM_21 is a model for analyzing the flow of cold and fresh air at the urban or regional scale developed by the German Meteorological Service (Deutscher Wetterdienst) (Ryu et al., 2008).
- This model enables the analysis of the formation and flow of cold air in the process of radiation and cooling of the earth's surface at night time after sunset.
- The data needed to run the model include land cover map, terrain, and building information.

wind vector field in the case area tended to become complex or distorted and the wind speed tended to generally decrease. An impact assessment of the meteorological sector is required prior to construction as construction of large-scale apartment complexes causes changes in the wind direction and speed, which is related to the dispersion of air pollutants in the city.

In the case of Sejong, it is necessary to manage wind flow through wind path planning when building a new town because cold and fresh wind produced in the surrounding mountains moves along streams, valleys, and roads after sunset.

In the block unit, the wild field changed according to the height and layout of the buildings and had a high correlation with the concentration of fine dust. Under the given conditions, the arrangement of buildings in a plate shape in the horizontal direction to the wind path had a high effect of fine dust reduction.

Creating an eco-friendly green city starting with wind paths

The effects of wind paths accumulate over time as a city lasts for 50 or 100 years once created. In addition, wind paths can not only reduce fine dust, but also improve the overall atmospheric environment of the city. The green space network created on the wind path can play an important role not only in improving the atmospheric environment but also in improving the urban environment. In this respect, it would be desirable if various interests were paid to the creation of a truly eco-friendly green city with the theme of wind paths as the catalyst.

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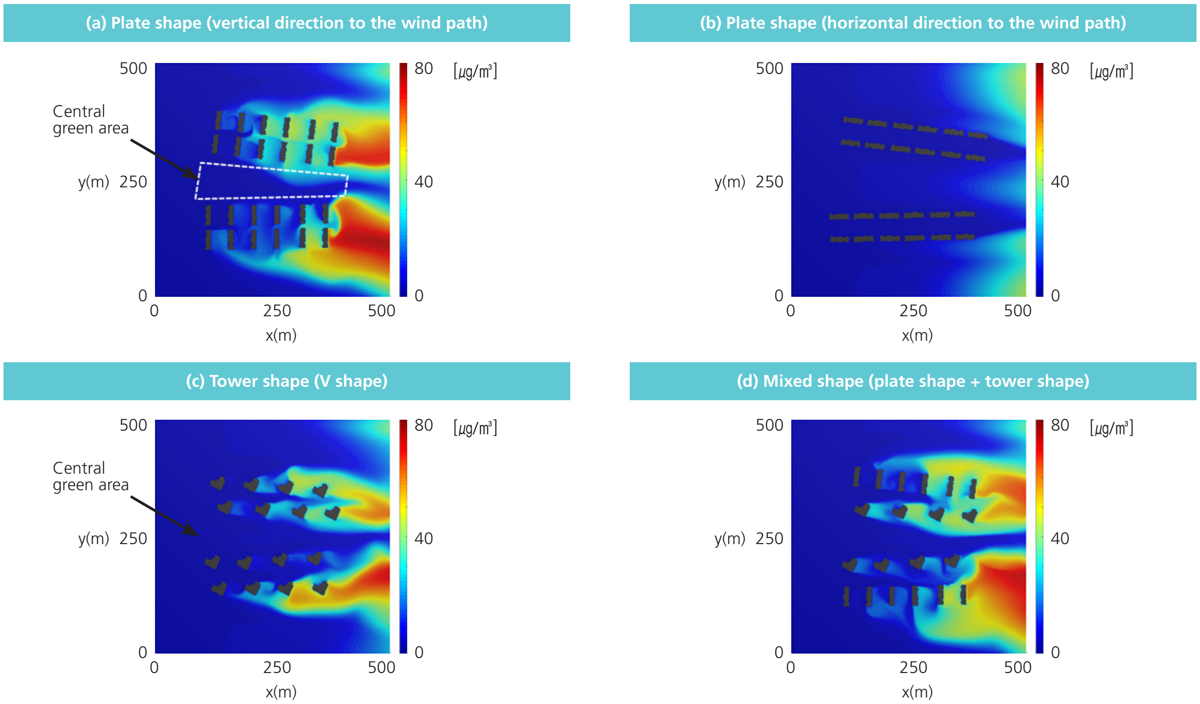
Figure 3. Analysis Result of Concentration Field in the 6-3 Living Zone (B1 Block) of the Multifunctional Administrative City (z=0.5m)



Source
Park et al. (2019, p.63).

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Analysis of Spatiotemporal Status and Influencing Factors of Fine Dust for the Policies to Mitigate Fine Dust

Sunyong Sung

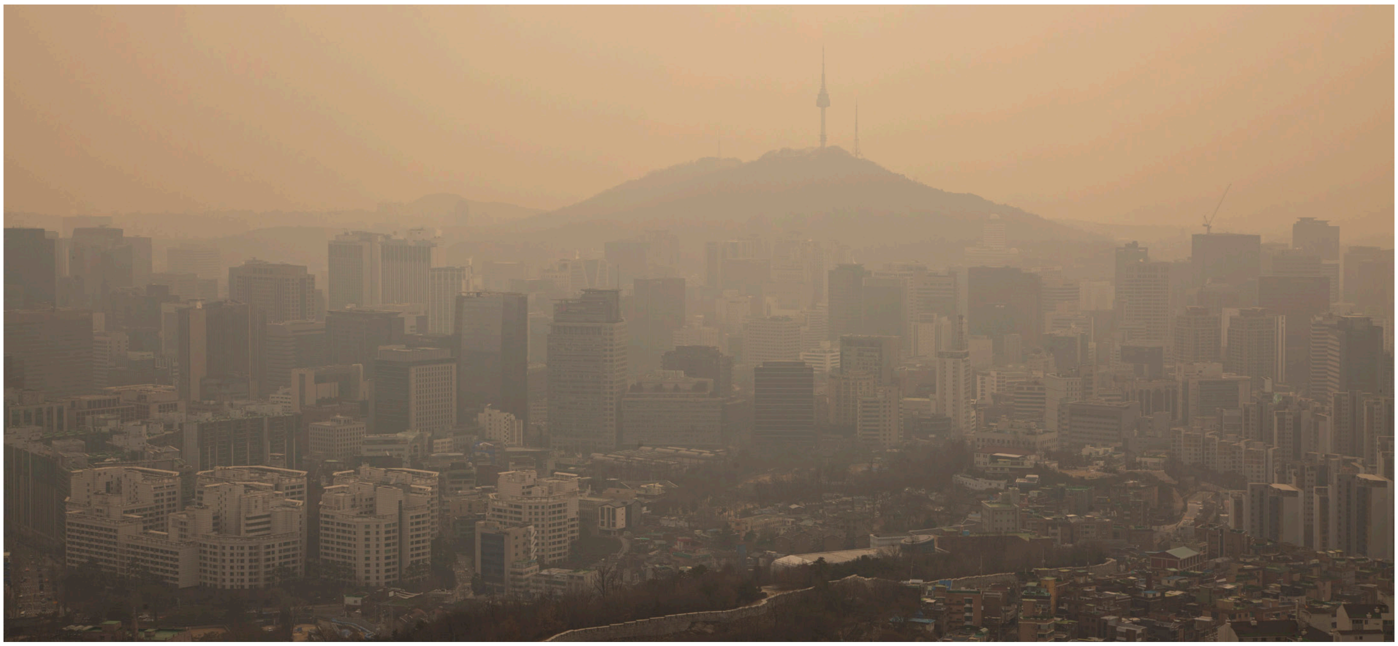
1. Background

Expansion of economic and social problems caused by fine dust

The World Health Organization (WHO) and the Organization for Economic Co-operation and Development (OECD) warn of the negative effects of increasing concentrations of PM10 and PM2.5 on health, ecosystem, and industrial sectors. In the health sector, early death is expected to increase due to lung cancer, respiratory and circulatory diseases caused by high concentration of fine dust and ozone. On the environmental side, degradation of ecosystem services is expected due to deterioration of air and water quality (OECD, 2016). In addition, negative effects are expected to be widespread such as changes in agricultural productivity following the changes in crop yields, decrease in industrial productivity caused by reduced plant operation due to emission reduction measures, and impact on tourism industry such as aviation due to deteriorated visibility.

The urgency of appropriate measures to reduce fine dust

There is growing interest in resolving the fine dust problem with the increasing inconvenience caused by higher concentration of fine dust in the daily life of people. According to a survey by Min (2019), 87.2% of the Korean people feel uncomfortable with their daily life due to the increase in fine dust concentration. In the case of Seoul, household's willingness to pay for solving the fine dust problem is 138,107 won (about 110 dollars) per year on average (Hwang et al., 2018), which shows high public demands for solving this issue. In addition, starting with the "special measures for fine dust management" in 2016, the government has announced various measures including the "comprehensive measures for fine dust management" in 2017 and the "emergency and regular



measures to strengthen fine dust management" in 2018, and is implementing various policies to reduce fine dust. Nevertheless, according to a survey conducted by Statistics Korea (2018), 36% of respondents said that the air quality has been deteriorated, which shows a higher degree of negative public experience compared to other environmental issues. While more than half (57.5%) of the people were aware of the countermeasures against fine dust, 44.6% of them were dissatisfied with the measures (Ministry of Environment, 2018), calling for fine dust measures that people can feel the effectiveness.

Necessity of analyzing the spatiotemporal status of fine dust and examining the cause

In order to effectively respond to the increase in the concentration of fine dust, it is necessary to understand the spatiotemporal status of fine dust, analyze factors affecting the change in the concentration of fine dust, and suggest countermeasures accordingly. Existing studies for fine dust reduction have been pursuing emission-oriented approaches by sector such as industry, power generation, daily life, and transportation, while fine dust measures that consider local characteristics have been insufficient. In order to establish effective fine dust measures considering local characteristics, it is important to conduct researches that study the processes and causes of fine dust known to date, and further suggest alternative measures by synthesizing factors that can affect the fine dust concentration. Therefore, this study examines the current status and causes of fine dust in Korea as well as the potential causes contributing to the spatiotemporal distribution of the fine dust concentration. This study will be able to synthesize the influencing factors of fine dust and provide a direction that can be reflected in the policies currently being pursued to mitigate fine dust.

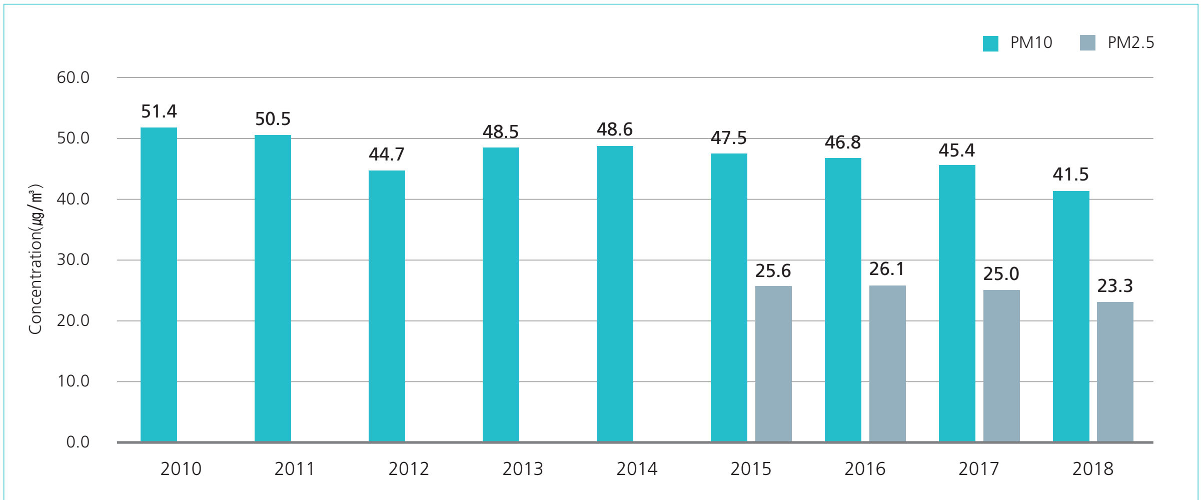
2. Status of fine dust in Korea

The average concentration of fine dust decreased steadily, but the number of days of high concentration increased

The average annual concentrations of PM10 and PM2.5 nationwide have been steadily decreasing since the beginning of observation. The average annual concentration of PM10 was 51.4㎍/㎥ in 2010, but it decreased to 41.5㎍/㎥ in 2018, and the average annual concentration of PM2.5 decreased from 25.6 ㎍/㎥ in 2015 to 23.3㎍/㎥ in 2018, which improved from bad to moderate based on the WHO standards[01]. Figure 1

The reason why people felt that the concentration of fine dust got worsened nevertheless could be due to the increase in the number of fine dust warnings and alerts[02]. In 2018, the number of PM10 and PM2.5 warnings increased about two times and 1.8 times respectively compared to 2016 and 2017, confirming the rapid increase in the number of days with high concentration of fine dust. In particular, PM2.5 alert was not

Figure 1. PM10 and PM2.5 Concentration in Korea



Source
Sung (2019)

01. The WHO standards for average annual concentration of fine dust are as follows in 2018.
- PM10 (㎍/㎥): Good (0-30), Moderate (31-50), Bad (51-100), Very bad (101 and above)
- PM2.5 (㎍/㎥): Good (0-15), Moderate (16-25), Bad (26-50), Very bad (51 and above)

issued in 2015 and 2016, but was issued once in 2017 and 2018, leading to concerns about the damage caused by the increase in the concentration of PM2.5. Table 1

Fine dust concentration varies seasonally and spatially

The analysis of the seasonal difference between PM10 and PM2.5 revealed different seasonal concentration ranking of the two types. The concentration of PM10 was the highest at 58.0㎍/㎥ in spring, while the concentration of PM2.5 was the highest at 29.4㎍/㎥ in winter. The concentrations of both PM10 and PM2.5 were the lowest in summer, and the second lowest in fall. Table 2 By season, the years with the highest concentration of PM10 were 2011 for spring, 2010 and 2013 for summer, 2010 for fall, and 2015 for winter. The years with the highest concentration of PM2.5 were 2016 for spring, 2015 for summer, 2016 for fall, and 2015 and 2017 for winter.

The analysis of the spatial distribution of average PM10 concentration by season indicated that high concentration areas are formed centering on the Seoul Metropolitan Area (SMA). The concentration spread around the SMA in all seasons and some regions with high concentration were also distributed around the Jeollabuk-do region. Figure 2 The spatial distribution of PM2.5 concentration varied by season, but in general, the concentration of PM2.5 was high in the northwest region and the concentration of PM2.5 was low in the east and south coast regions. In spring and winter, which correspond to the periods of high concentration of PM10, areas of high concentration appeared in the SMA, especially inland areas. In summer, the concentration of PM2.5 was high, especially in coastal areas. Figure 2

Considering the distribution range of high-concentration fine dust and its seasonal and annual changes, it can be deduced that the concentration of fine dust that people actually experience, and the sources of fine dust may not match. That is, in order to effectively reduce the fine dust that appears in the daily living environment, the measures need to consider not only the primary sources, but also the complex factors that affect the atmospheric diffusion and the secondary generation of fine dust[03] (Boubel et al., 2003; Sung, 2019).

3. Process and causes of fine dust generation

Classification of the process of fine dust generation

The sources of fine dust can be largely divided into natural and artificial sources and can be classified into primary and secondary generation according to the generation process. Natural sources of fine dust include biological organic substances such as soil dust and pollen of plants, and artificial sources include emissions caused by fossil fuel use and scattering dust generated at construction sites (Ministry of Environment. 2016). Primary generation of fine dust is when it comes out in the solid state from sources such as forest fires, incineration of garbage, scattering dust at construction

Table 1. PM10 and PM2.5 Warning and Alerts in Korea

	PM10				PM2.5			
	Warning		Alert		Warning		Alert	
	Times	Days	Times	Days	Times	Days	Times	Days
2015	235	59	6	3	173	70	-	-
2016	187	29	23	4	90	39	-	-
2017	188	25	17	4	128	42	1	1
2018	374	39	38	6	315	70	1	1

Source
Sung (2019)

02. The Korean government standards for PM10 and PM2.5 warnings are as follows (Ministry of Government Legislation 2019).
- PM10 warning: The average hourly concentration of PM10 of the automatic air measurement station in the area lasts more than 150㎍/㎥ for 2 hours
- PM10 alert: The average hourly concentration of PM10 of the automatic air measurement station in the area lasts more than 300㎍/㎥ for 2 hours
- PM2.5 warning: The average hourly concentration of PM2.5 of the automatic air measurement station in the area lasts more than 75㎍/㎥ for 2 hours
- PM2.5 alert: The average hourly concentration of PM2.5 of the automatic air measurement station in the area lasts more than 150㎍/㎥ for 2 hours

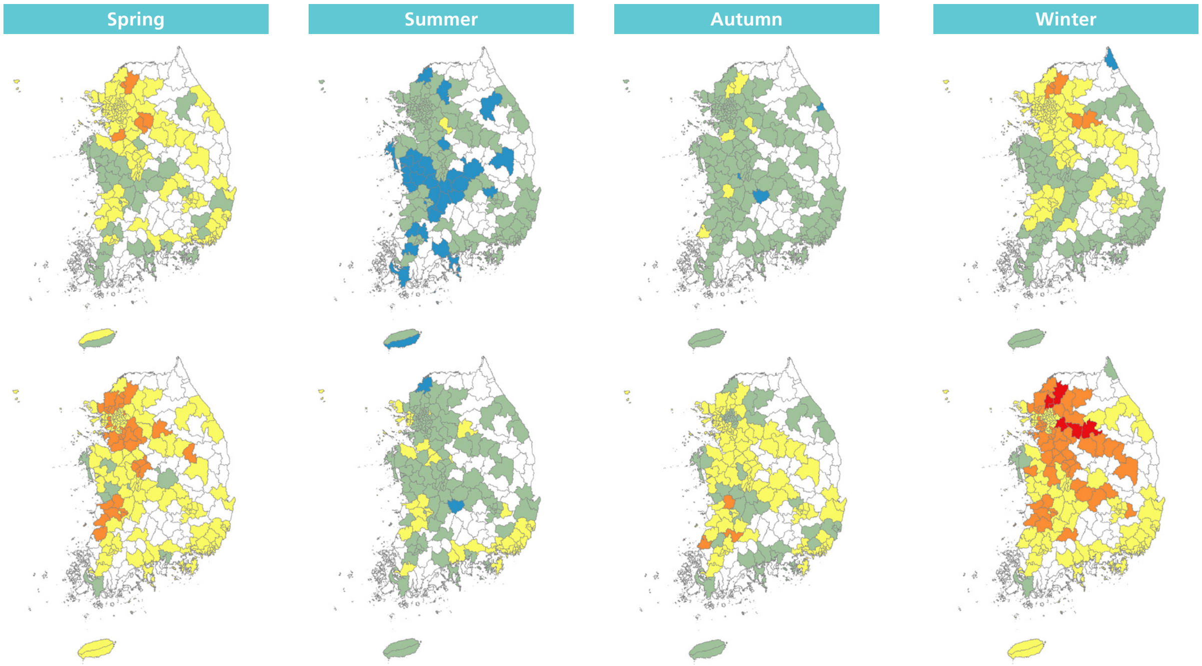
03. The sources of fine dust include natural sources and artificial sources (Ministry of Environment, 2016), and are further classified into primary generation and secondary generation according to the generation process (Kim et al., 2018a). Primary generation occurs directly in the solid state from sources such as forest fires, incineration of garbage, scattering dust at construction sites, exhaust gas from cars, and from roads. Secondary generation is caused by the chemical reaction of sulfur oxides or nitrogen oxides generated as gas as precursors (Hyun, 2018).

Table 2. Average concertation of PM10 and PM2.5 by season(unit: ㎍/㎥)

Year	PM10				PM2.5			
	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
2010	58.0	41.3	50.0	56.3	-	-	-	-
2011	66.3	38.3	41.7	55.7	-	-	-	-
2012	54.3	33.7	40.3	50.3	-	-	-	-
2013	58.7	41.3	38.3	55.7	-	-	-	-
2014	61.0	39.3	39.7	54.3	-	-	-	-
2015	55.0	38.0	38.0	59.0	26.7	23.3	22.3	30.0
2016	60.3	35.3	43.0	48.3	30.0	21.3	24.3	28.7
2017	59.3	34.3	39.3	48.7	29.3	19.0	21.7	30.0
2018	49.3	30.0	37.7	49.0	26.0	17.7	20.7	29.0
Average	**58.0**	**36.8**	**40.8**	**53.0**	**28.0**	**20.3**	**22.2**	**29.4**

Source
Sung (2019)

Figure 2. Spatial distribution of average concentration of PM10 and PM2.5 by season(unit: ㎍/㎥)



Source
Sung(2020)

PM10

Concentration of PM10 by season (unit: ㎍/㎥)

- 30 and below
- Above 30 – 50
- Above 50 – 70
- Above 70 – 100
- Above 100

PM2.5

Concentration of PM2.5 by season (unit: ㎍/㎥)

- 10 and below
- Above 10 – 20
- Above 20 – 30
- Above 30 – 40
- Above 40

Table 3. List of potential impact variables on PM concentration

Category	Factors
Climatic Variables	Temperature, Humidity, Precipitation, Wind direction, Wind speed
Emission Source	Sectoral emission, Population Density
Emission Source	Sectoral emission, Population Density
Environmental Factors	Terrain, Building Density
PM sinks	Biological Sinks (Forest, Green Infrastructure)

Source
NIER, 2007; Busan-si. 2015; Jeollabuk-do. 2017; Lim and Jo, 2017; Park and Shin, 2017

sites, exhaust gas from cars, and from roads (Hyun, 2018). Secondary generation is caused by the chemical reaction of sulfur oxides or nitrogen oxides generated as gas as precursors (Ministry of Environment, 2016). To analyze the effect on secondary generation of fine dust, it is important to understand the interaction according to the air pollution and the the surrounding environment and scale (Boubel et al., 2003). Effect of pollutants can occur at the local scale (5 km), generation of secondary pollutants can occur at the city scale (50 km), and problems with long distance transportation can occur at the regional scale (50-500 km). As for the conditions that can affect the characteristics of fine dust in cities, it is important to study the urban components, natural and climate conditions, and spatial structure, layout, and shape (Kim et al., 2018a).

Factors affecting the generation of fine dust

Putting together previous studies, primary sources of fine dust (Park and Shin, 2017) and the amount of precursor (air pollutant) production which is the secondary source (Lim and Jo, 2017) can be considered as major factors that directly or indirectly affect the generation of fine dust. That is, primary sources of fine dust can be considered along with factors related to transport, industry and power generation, and secondary generation can be considered along with factors associated with complex chemical reactions and factors related to the spread of fine dust (Ministry of Environment, 2016). In addition to the sources previously considered, this study further extracted potential impact variables including climatic variables such as temperature, humidity, precipitation, and wind speed that affect the secondary generation and diffusion of fine dust (NIER, 2007; Jeollabuk-do, 2017), environmental factors such as terrain and urban density involved in the diffusion of fine dust in urban canyons (Kim et al., 2018a), and green spaces that absorb fine dust (Busan-si, 2015; Kim et al., 2018b). Table 3

4.Measures for the management of potential factors for fine dust reduction

Fine dust measures need to consider seasonal and regional differences

The concentration of fine dust in Korea shows different distribution patterns seasonally and spatially, so countermeasures need to be established accordingly. Although the average concentration of fine dust in all of Korea is decreasing, the phenomenon of high-concentration fine dust is frequently occurring, calling for the prioritized establishment of fine dust measures that can respond to this phenomenon. As a result of examining the temporal distribution of fine dust, the concentration of PM10 and PM2.5 was high in spring and winter while it appears to be the lower in summer. Intensive management measures, such as seasonal system for fine dust, are necessary in the periods of high concentration of fine dust (from winter to spring). As a result of examining the spatial distribution of fine dust, the concentration of PM10 was high in the SMA while that of PM2.5 was high in the whole country. As some areas have higher concentration of fine dust than others, it is important to set up fine dust management areas centering around those with high concentrations and to establish customized measures for each area.

Fine dust management considering the emission sources and environmental factors simultaneously

This study aimed to suggest the direction of mitigation measures in response to potential factors. Considering that the existing measures have been concentrated in the emission sources, discussion was made focusing on the measures that need to be considered with respect to meteorological and environmental factors, and fine dust absorption factors. Green infrastructure and wind paths can be proposed as representative measures that can be effectively applied to meteorological, environmental, and fine dust absorption factors.

Vegetation, a major component in green infrastructure, was found to have reduction effects of up to 25.6% for PM10 and up to 40.9% for PM2.5 (Korea Forest Service, 2017), and studies are being conducted to reduce fine dust using green infrastructure (Kim and Xu, 2017; Korea Forest Service, 2018; Kim et al., 2018a). In addition, there is ample room for wind paths to be used simultaneously in terms of climate change adaptation (Park et al., 2019). Ventilation corridor and green infrastructure can have a greater effect when applied in an integrated manner, and thus may act as appropriate alternatives for fine dust reduction.

In particular, studies on spatial solutions, such as expanding the possibility of fine dust reduction by restoring green space and green infrastructure and ventilation corridor that can make cold and fresh winds reach from outside the city to the inside, are all included in the recent "5th Comprehensive National Territorial Plan" (Government of the Republic of Korea, 2019) and the "5th Comprehensive National Environmental Plan" (Ministry of Environment, 2020). It will be necessary to introduce fine dust reduction measures based on quantitative analysis of the effectiveness of such alternative approaches.

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Promoting Green New Deals for Eco-friendly and Energy Transition Cities

Lee Jungchan

1. Introduction

Background

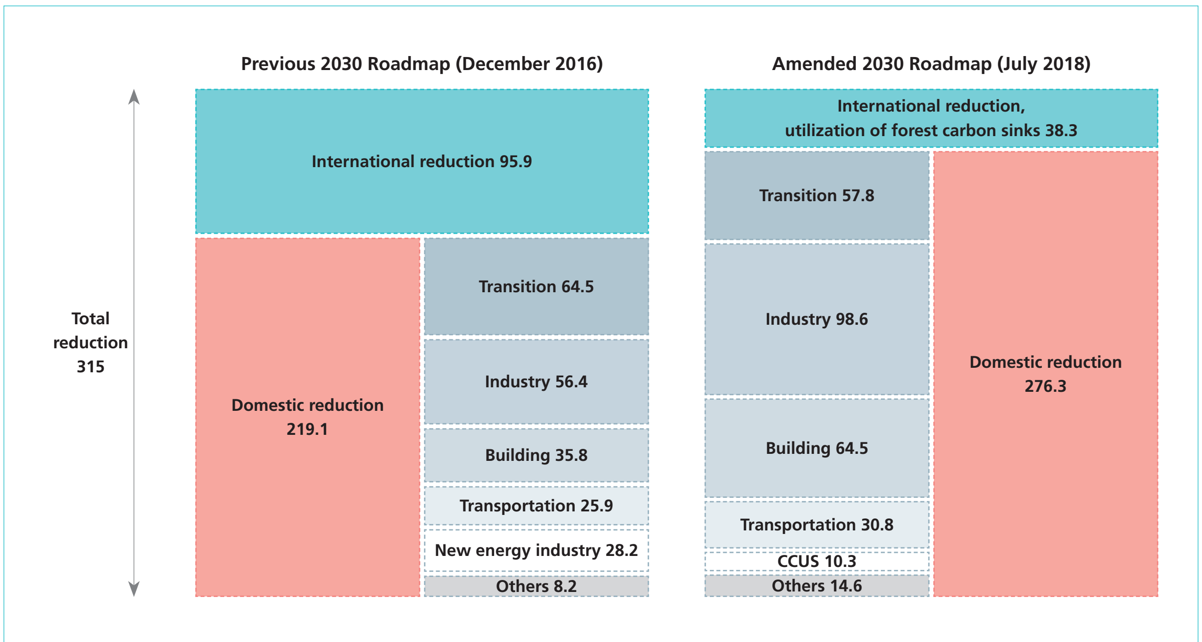
The Republic of Korea is currently facing an important situation of having to make a breakthrough in response to globally occurring economic, social and environmental trends.

First, from an environmental point of view, the global issue is the implementation of national greenhouse gas reduction obligations following the new climate system under the Paris Agreement as an inevitable pressure and social demand for eco-friendliness and energy transition. Korea has to fulfill the obligation to reduce greenhouse gas emissions by 37% compared to the BAU (Business As Usual) scenario by 2030, and to accomplish this, the government has established the 2020 National Greenhouse House Reduction Roadmap (December 2012, July 2018) twice as an original and an amendment. Figure 1

On the economic side, it is necessary to overcome the long-term economic downturn and strengthen the economic growth engine. As the world economy enters a new normal era of low growth, low prices, and low interest rates, there is a stagnation in the economy, such as poor employment due to global economic slowdown. In Korea, both general and youth unemployment rates have been on the steady rise since 2013. This issue is also overlapped with the problem of job losses due to the progress of automation and the 4th industrial revolution.

On the social side, there is an increasing demand for resolution of inequality and inclusion worldwide. The United Nations has established the basic principle of "The Agenda 2030 for Sustainable Development" as "Leaving No One Behind," and has set addressing wealth inequality as the key to solving the problems through alleviating inequality and promoting fairness and justice.

Figure 1. 2020 National Greenhouse Gas Reduction Target (2030 Roadmap)



Source
The 2nd Basic Plan for Climate Change Response (October 2019). p.18.

Table 1. Composition of OneNYC 2050, the Green New Deal Initiative of New York City

Vision	Strong and Fair City	
Value	Sustainability, Resiliency, Growth, Equity, Diversity, Inclusion	
Strategy	Goals	Initiatives
	A VIBRANT DEMOCRACY	1. Empower all New Yorkers to participate in our democracy
		2. Welcome new New Yorkers from around the world and involve them fully in civic life
		3. Promote justice and equal rights, and build trust between New Yorkers and government
		4. Promote democracy and civic innovation on the global stage
	AN INCLUSIVE ECONOMY	5. Grow the economy with good-paying jobs and prepare New Yorkers to fill them
		6. Provide economic security for all through fair wages and expanded benefits
		7. Expand the voice, ownership, and decision-making power of workers and communities
		8. Strengthen the City's fiscal health to meet current and future needs
	THRIVING NEIGHBORHOODS	9. Ensure all New Yorkers have access to safe, secure, and affordable housing
		10. Ensure all New Yorkers have access to neighborhood open spaces and cultural resources
		11. Advance shared responsibility for community safety and promote neighborhood policing
		12. Promote place-based community planning and strategies
	HEALTHY LIVES	13. Guarantee high-quality, affordable, and accessible health care for all New Yorkers
		14. Advance equity by addressing the health and mental health needs of all communities
		15. Make healthy lifestyles easier in all neighborhoods
		16. Design a physical environment that creates the conditions for health and well-being
	EQUITY AND EXCELLENCE IN EDUCATION	17. Make New York City a leading national model for early childhood education
		18. Advance equity in K-12 opportunity and achievement
		19. Increase integration, diversity, and inclusion in New York City schools
	A LIVABLE CLIMATE	20. Achieve carbon neutrality and 100 percent clean electricity
		21. Strengthen communities, buildings, infrastructure, and the waterfront to be more resilient
		22. Create economic opportunities for all New Yorkers through climate action
		23. Fight for climate accountability and justice
	EFFICIENT MOBILITY	24. Modernize New York City's mass transit networks
		25. Ensure New York City's streets are safe and accessible
		26. Reduce congestion and emissions
		27. Strengthen connections to the region and the world
	MODERN INFRASTRUCTURE	28. Make forward-thinking investments in core physical infrastructure and hazard mitigation
		29. Improve digital infrastructure to meet the needs of the 21st century
		30. Implement best practices for asset maintenance and capital project delivery

Source
Content of OneNYC 2050 reorganized by the author.

Rise of Green New Deals for cities

The Green New Deal is emerging as the most powerful policy tool to address the climate change and energy problems, job creation and economic stimulus, and inequality problems listed above. Green New Deal used to be promoted at the national level in the past and is being re-examined as of 2019. The difference from the past is that Green New Deal policies are being pursued voluntarily at the metropolitan city level rather than at the national level. This so-called "Urban Green New Deal" is being promoted in New York City and Los Angeles in the United States. As cities have a large influence in Korea with an urbanization rate of above 90%, this study derives measures of promoting Urban Green New Deal in Korean cities through international case analysis.

2. Cases of Urban Green New Deal promotion

OneNYC 2050 of New York City

New York City is promoting the long-term plan "OneNYC 2050" related to the Green New Deal policies established in April 2019 and is promoting the Green New Deal in full swing with the enactment of the Climate Mobilization Act, which is a legal framework for implementing the Green New Deal.

OneNYC 2050 is a long-term strategic plan which aims to resolve the chronic problems of New York City (climate crisis, inequality, jobs, etc.) by 2050 through the Green New Deal. It consists of eight strategic objectives and thirty initiatives to build New York City into a "Strong and Fair city" by 2050 through the Green New Deal. Table 1

The Climate Mobilization Act is a type of regulation established to reduce greenhouse gas emissions from large and medium-sized buildings in New York City by 80% by 2050. Buildings are a major emissions sector, accounting for about 70% of New York City's greenhouse gas emissions. Of these, large and medium-sized buildings with a total area of more than 25,000ft^2 account for about one third of New York City's greenhouse gas emissions. The idea is to focus the regulations on these large and medium-sized buildings and reduce greenhouse gas emissions from these buildings by 40% by 2030 and 80% by 2050.

Sustainable City pLAn (2019) of Los Angeles

Los Angeles also announced a Green New Deal policy called "L.A's Green New Deal – Sustainable City pLAn 2019" in April 2019. This is a long-term strategic plan aimed at net zero greenhouse gas (carbon neutral), green job creation (400,000 jobs), and inequality resolution (establishment of fairness) by 2050.

The Green New Deal policy of Los Angeles is divided into initiatives in thirteen sectors based on eight core values under the vision of "Inclusive Green Economy." As in New York, each of the eight core values converges to greenhouse gas reduction, resolving of inequality and job creation in response to the climate crisis. Table 2

Table 2. Composition of Sustainable City pLAn 2019, the Green New Deal Initiative of Los Angeles

Vision	Inclusive Green Economy	
Value	(Related to greenhouse gas reduction)	Climate mitigation, resiliency
	(Related to resolving of inequality)	Access & equity, health & wellbeing, increased affordability
	(Related to job creation)	Quality jobs, workforce development
Strategy	▲Environmental justice, ▲Renewable energy, ▲Local water, ▲Clean & healthy buildings, ▲Housing & development, ▲Mobility & public transit, ▲Zero emission vehicles, ▲Industrial emissions & air quality monitoring, ▲Waste & resource recovery, ▲Food systems, ▲Urban ecosystems & resilience, ▲Prosperity & green jobs, ▲Lead by example.	

Source
Content of Sustainable City pLAn 2019. reorganized by the author.

3. Measures to promote Urban Green New Deal

As a result of putting international cases together, the following strategic measures are needed to promote Urban Green New Deal.

First, the common normative values should be established and targeted when promoting Green New Deal. The Green New Deal policies of New York City and Los Angeles both set "greenhouse gas reduction", "job creation", and "resolving of inequality" as the common norms that should be pursued and achieved. These three values can be set as the "three major norms of Green New Deal" and can be used to draw the direction of the Green New Deal policy in Korea.

Second, it is necessary to link the three Green New Deal norms with the top-level plans and strategies so that all policies can be converged and synergized around Green New Deal. In the case of New York City and Los Angeles, the city governments set the Green New Deal as the top-level administrative strategy and applied the normative perspectives of "greenhouse gas reduction", "job creation", and "resolving of inequality" in all sectors of the city such as housing, transportation, energy, and crime prevention. As a result, all policies in the city were converged and synergized in the mid- to long-term through the Green New Deal to enhance the possibility of realizing the vision.

Third, it is important not only to make a declaration, but also to establish a legal mechanism to strengthen practical implementation. In the case of New York City, the government established a strong law for restricting and regulating greenhouse gas emission targeting buildings, through local statutes. In addition, support measures on green finance such as tax support for deploying renewable energy were enacted to secure sustainability through provision of a financing system.

Through the above three strategies, Korea should also pursue the transformation into an environmentally, economically and socially sustainable system in response to the climate, job, and inequality crises by promoting Green New Deals centering on megacities first.

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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.

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