

Supplementary materials

Air pollution and public bike-sharing system ridership in the context of Sustainable Development Goals

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Table S1. Sustainable Development Goals (SDGs) of the United Nations and of South Korea (K-SDGs).

The 17 Goals	SDGs [1]	K-SDGs [2]
Goal 1. End poverty in all its forms everywhere	1.1 By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than \$1.25 a day	1-1 Reduce the proportion of all people whether men, women, or persons with disabilities to below the OECD average.
	1.2 By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions	1-2 Minimize the blind spot of the social welfare system and achieve substantial coverage of the poor and vulnerable.
	1.3 Implement nationally appropriate social protection systems and measures for all, including floors, and by 2030 achieve substantial coverage of the poor and the vulnerable	1-3 Strengthen the provision of social services to the poor and the vulnerable.
	1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance	1-4 Reduce the exposure and vulnerability of the poor and those in vulnerable situations to economic, social, and environmental shocks and disasters, and build their resilience as well.
	1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters	
	1.a Ensure significant mobilization of resources from a variety of sources, including through enhanced development cooperation, in order to provide adequate and predictable means for developing countries, in particular least developed countries, to implement programmes and policies to end poverty in all its dimensions	
	1.b Create sound policy frameworks at the national, regional and international levels, based on pro-poor and gender-sensitive development strategies, to support accelerated investment in poverty eradication actions	
Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture	2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round	2-1 Ensure that people in vulnerable situations have reliable access to food
	2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons	2-2 Increase the income of farmers by diversifying their income sources and broadening management protection systems.

	2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment	2-3 Build sustainable food production systems
	2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality	2-4 Maintain the genetic diversity of seeds, crops, as well as farmed and domesticated animals, and their related native and wild species. Ensure the stability of food commodity markets by reducing food price volatility.
	2.5 By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed	
	2.a Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries	
	2.b Correct and prevent trade restrictions and distortions in world agricultural markets, including through the parallel elimination of all forms of agricultural export subsidies and all export measures with equivalent effect, in accordance with the mandate of the Doha Development Round	
	2.c Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility	
	3.1 By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births	3-1 Manage risk factors of chronic diseases and expand health coverage.

Goal 3. Ensure healthy lives and promote well-being for all at all ages	3.2 By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births	3-2 Improve mental health and prevent drug abuse.
	3.3 By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases	3-3 Prevent death and injuries from accidents including traffic accidents.
	3.4 By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being	3-4 Work to prevent and manage infectious diseases.
	3.5 Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol	3-5 Protect and promote mothers' health.
	3.6 By 2020, halve the number of global deaths and injuries from road traffic accidents	3-6 Protect and promote children's health.
	3.7 By 2030, ensure universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes	3-7 Reduce death and illnesses from hazardous chemicals as well as air, water, and soil pollution and contamination.
	3.8 Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all	3-8 Tackle low birth rates and prepare for the aging population in South Korea.
	3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	3-9 Achieve universal health coverage by expanding public health services.
	3.a Strengthen the implementation of the World Health Organization Framework Convention on Tobacco Control in all countries, as appropriate	
	3.b Support the research and development of vaccines and medicines for the communicable and non-communicable diseases that primarily affect developing countries, provide access to affordable essential medicines and vaccines, in accordance with the Doha Declaration on the TRIPS Agreement and Public Health, which affirms the right of developing countries to use to the full the provisions in the Agreement on Trade-Related Aspects of Intellectual Property Rights regarding flexibilities to protect public health, and, in particular, provide access to medicines for all	
	3.c Substantially increase health financing and the recruitment, development, training and retention of the health workforce in developing countries, especially in least developed countries and small island developing States	

	3.d Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks	
Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	4.1 By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes	4-1 Ensure that all children irrespective of gender and disability complete free and quality primary and secondary education leading to appropriate and effective learning outcomes.
	4.2 By 2030, ensure that all girls and boys have access to quality early childhood development, care and pre-primary education so that they are ready for primary education	4-2 Ensure that all children have access to quality early childhood care and education services so that they are prepared for primary education.
	4.3 By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university	4-3 Ensure that all learners have equal access to affordable and quality technical, vocational, and tertiary education, including university, regardless of gender and disability.
	4.4 By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship	4-4 Substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, necessary for employment, decent jobs, and entrepreneurship.
	4.5 By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations	4-5 Eliminate gender disparities in education of education and ensure equal access to all levels of education and vocational training for the vulnerable including persons with disabilities, migrants, and children in vulnerable situations.
	4.6 By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy	4-6 Ensure that all youth and a majority of adults achieve literacy and numeracy.
	4.7 By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture	4-7 Ensure that all learners acquire the knowledge and skills needed to promote sustainable development including, among others, through education for

	of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development	sustainable development, human rights, gender equality, promotion of a culture of peace and nonviolence, global citizenship, and appreciation of cultural diversity and culture's contribution to sustainable development.
	4.a Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, non-violent, inclusive and effective learning environments for all	4-8 Build and upgrade education facilities that are child-, disability-, and gender-sensitive and provide safe, nonviolent, inclusive and effective learning environments.
	4.b By 2020, substantially expand globally the number of scholarships available to developing countries, in particular least developed countries, small island developing States and African countries, for enrolment in higher education, including vocational training and information and communications technology, technical, engineering and scientific programmes, in developed countries and other developing countries	4-9 Secure sufficient financial resources to provide inclusive and quality education at all levels.
	4.c By 2030, substantially increase the supply of qualified teachers, including through international cooperation for teacher training in developing countries, especially least developed countries and small island developing States	4-10 Secure a sufficient number of teachers to provide quality education at all levels.
Goal 5. Achieve gender equality and empower all women and girls	5.1 End all forms of discrimination against all women and girls everywhere	5-1 End all forms of discrimination against women.
	5.2 Eliminate all forms of violence against all women and girls in the public and private spheres, including trafficking and sexual and other types of exploitation	5-2 Eliminate all forms of violence against all women in public and private spheres including trafficking and sexual and other types of exploitation.
	5.3 Eliminate all harmful practices, such as child, early and forced marriage and female genital mutilation	5-3 Recognize and value unpaid care and domestic work.
	5.4 Recognize and value unpaid care and domestic work through the provision of public services, infrastructure and social protection policies and the promotion of shared responsibility within the household and the family as nationally appropriate	5-4 Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic, and public life.
	5.5 Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life	5-5 Ensure universal access to reproductive health and rights for all.

	5.6 Ensure universal access to sexual and reproductive health and reproductive rights as agreed in accordance with the Programme of Action of the International Conference on Population and Development and the Beijing Platform for Action and the outcome documents of their review conferences	5-6 Enhance access to technology, particularly in information and communications technology, to promote women empowerment.
	5.a Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws	5-7 Adopt and strengthen sound policies and legislation for gender equality promotion and women empowerment at all levels.
	5.b Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women	
	5.c Adopt and strengthen sound policies and enforceable legislation for the promotion of gender equality and the empowerment of all women and girls at all levels	
Goal 6. Ensure availability and sustainable management of water and sanitation for all	6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all	6-1 Provide safe and equitable drinking water for all.
	6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	6-2 Provide sufficient and equitable sewer service regardless of region including areas with the most vulnerable water supply.
	6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	6-3 Improve water quality and the health of water ecosystems by reducing water pollution and minimizing the release of toxic chemicals and hazardous substances.
	6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	6-4 Ensure a reliable supply of water to address concerns over water scarcity and pursue the effective use of water resources by supplying tap water without leakage.
	6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate	6-5 Implement integrated water management through the Total Pollution Load Management System.
	6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	6-6 Protect and restore water-related ecosystems including wetlands, rivers, aquifers, and lakes.

	6.a By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies	6-7 Support and strengthen the participation of local communities in sound and safe water management.
	6.b Support and strengthen the participation of local communities in improving water and sanitation management	
Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all	7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7-1 Ensure reliable and adequate access to energy services.
	7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7-2 Increase the generation of clean energy among national energy resources.
	7.3 By 2030, double the global rate of improvement in energy efficiency	7-3 Save energy and increase energy efficiency
	7.a By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology	7-4 Minimize air pollution from energy consumption in the transportation sector.
	7.b By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States and landlocked developing countries, in accordance with their respective programmes of support	
Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	8.1 Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 per cent gross domestic product growth per annum in the least developed countries	8-1 Achieve economic growth for the benefit everyone.
	8.2 Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labour-intensive sectors	8-2 Enhance policies to create decent jobs.
	8.3 Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services	8-3 Limit environmental damage caused by economic growth through the efficient use of resources.
	8.4 Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-Year Framework of Programmes on Sustainable Consumption and	8-4 Ensure that proper compensation is implemented.

	Production, with developed countries taking the lead	
	8.5 By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value	8-5 Increase the youth employment rate.
	8.6 By 2020, substantially reduce the proportion of youth not in employment, education or training	8-6 Protect labor rights and promote safe and healthy work environments for all workers.
	8.7 Take immediate and effective measures to eradicate forced labour, end modern slavery and human trafficking and secure the prohibition and elimination of the worst forms of child labour, including recruitment and use of child soldiers, and by 2025 end child labour in all its forms	8-7 Contribute to job creation through the development and implementation of sustainable tourism promotion policies.
	8.8 Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment	
	8.9 By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products	
	8.10 Strengthen the capacity of domestic financial institutions to encourage and expand access to banking, insurance and financial services for all	
	8.a Increase Aid for Trade support for developing countries, in particular least developed countries, including through the Enhanced Integrated Framework for Trade-related Technical Assistance to Least Developed Countries	
	8.b By 2020, develop and operationalize a global strategy for youth employment and implement the Global Jobs Pact of the International Labour Organization	
Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all	9-1 Strive to provide reliable welfare services and access to information for a majority of people.
	9.2 Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries	9-2 Secure industrial competitiveness by pursuing diversity in industries and laying the groundwork for sustainable business activities.

	9.3 Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets	9-3 Strengthen international competitiveness by building technical capacity and promoting technology commercialization
	9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities	9-4 Help boost the national economy by expanding the country's human and financial resources for research as well as planning and executing relevant research.
	9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending	9-5 Pursue industrialization with highly efficient use of resources through environmental friendly industrial activities and technological innovation.
	9.a Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and small island developing States	
	9.b Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities	
	9.c Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020	
Goal 10. Reduce inequality within and among countries	10.1 By 2030, progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average	10-1 Achieve and sustain disposable income growth of the bottom 40% of the population at a rate higher than the national average.
	10.2 By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status	10-2 Promote the social, economic, and political inclusion of everyone, irrespective of age, sex, disability, or social status.
	10.3 Ensure equal opportunity and reduce inequalities of outcome, including by eliminating discriminatory laws, policies and practices and promoting appropriate legislation, policies and action in this regard	10-3 Ensure equal opportunity by eliminating discriminatory treatment according to age, gender, and disability.

	10.4 Adopt policies, especially fiscal, wage and social protection policies, and progressively achieve greater equality	10-4 Achieve greater equality by enhancing fiscal, wage, and social protection policies.
	10.5 Improve the regulation and monitoring of global financial markets and institutions and strengthen the implementation of such regulations	10-5 Ensure the stable and orderly migration and mobility of migrants through the implementation of migration policies.
	10.6 Ensure enhanced representation and voice for developing countries in decision-making in global international economic and financial institutions in order to deliver more effective, credible, accountable and legitimate institutions	
	10.7 Facilitate orderly, safe, regular and responsible migration and mobility of people, including through the implementation of planned and well-managed migration policies	
	10.a Implement the principle of special and differential treatment for developing countries, in particular least developed countries, in accordance with World Trade Organization agreements	
	10.b Encourage official development assistance and financial flows, including foreign direct investment, to States where the need is greatest, in particular least developed countries, African countries, small island developing States and landlocked developing countries, in accordance with their national plans and programmes	
	10.c By 2030, reduce to less than 3 per cent the transaction costs of migrant remittances and eliminate remittance corridors with costs higher than 5 per cent	
Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable	11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums	11-1 Ensure access to adequate, safe, and affordable housing and basic services and improve old neighborhoods as well.
	11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons	11-2 Provide access to safe and affordable transport systems particularly by expanding public transport, with special attention to the needs of the vulnerable including women, children, persons with disabilities, and the elderly.
	11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	11-3 Raise the inclusiveness and sustainability of cities and enhance the capacity for the participatory and integrated planning and

		management of residential areas.
	11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage	11-4 Strengthen efforts to protect and preserve the world's heritage.
	11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations	11-5 Significantly reduce the number of deaths and economic losses from disasters as well as devise and implement integrated risk management solutions for urban disasters
	11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	11-6 Reduce the adverse environmental impact of cities including air quality and waste management.
	11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities	11-7 Ensure safe and easy access to public green spaces for all including women, children, seniors, and persons with disabilities.
	11.a Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning	11-8 Strengthen national and regional development planning to support economic, social, and environmental links between urban, peri-urban, and rural areas.
	11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015–2030, holistic disaster risk management at all levels	
	11.c Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials	
Goal 12. Ensure sustainable consumption and production patterns	12.1 Implement the 10-Year Framework of Programmes on Sustainable Consumption and Production Patterns, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries	12-1 Establish and implement comprehensive national policies for sustainable consumption and production.
	12.2 By 2030, achieve the sustainable management and efficient use of natural resources	12-2 Achieve sustainable management and efficient use of natural resources.

	12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses	12-3 Reduce food losses arising from production, distribution, and disposal.
	12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment	12-4 Protect human health and prevent environmental pollution through the environmentally sound management of chemicals and hazardous wastes.
	12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse	12-5 Reduce waste generation through prevention, reduction, recycling, and reuse.
	12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle	12-6 Oversee companies' sustainable management activities and expand support as well.
	12.7 Promote public procurement practices that are sustainable, in accordance with national policies and priorities	12-7 Promote sustainable green consumption through the expansion of green product certification and green consumption.
	12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature	12-8 Expand opportunities for participation in environmental education to raise public awareness of sustainable development.
	12.a Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production	12-9 Increase the recycling of plastics so that they can be consumed in a virtuous cycle and to prevent them from polluting the environment through the development of eco-friendly materials.
	12.b Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products	12-10 Contribute to environmental conservation by developing measurement indicators for sustainable tourism.
	12.c Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities	12-11 Phase out fossil fuel subsidies.

Goal 13. Take urgent action to combat climate change and its impacts³	Goal 13. Take urgent action to combat climate change and its impacts³	
	13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries	13-1 Reduce the expected risk of climate change and strengthen resilience and adaptive capacity to natural disasters.
	13.2 Integrate climate change measures into national policies, strategies and planning	13-2 Work toward integrating climate change measures into national and regional policies.
	13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	13-3 Improve education, awareness-raising, and human and institutional capacity on climate change mitigation, adaptation, impact reduction, and early warning.
	13.a Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly \$100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible	13-4 Strive to keep the global temperature increase to less than 2°C and further limit warming to 1.5°C.
	13.b Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities	
Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development	14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution	14-1 Establish a management system to protect the marine environment from land and sea pollutants.
	14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans	14-2 Actively manage the marine ecological environment and habitats of fishery resources.
	14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels	14-3 Minimize the impacts of ocean acidification

		through enhanced scientific cooperation.
	14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics	14-4 Sustainably manage fishery resources and avoid excessive fishing.
	14.5 By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information	14-5 Expand the designation of marine protected areas for systematic conservation and wise use of marine ecosystems.
	14.6 By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation ⁴	14-6 Ensure economic benefits through the sustainable use of marine resources.
	14.7 By 2030, increase the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism	14-7 Enhance ocean science research capacity and expand technology transfer of marine science.
	14.a Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries	14-8 Support the stable fishing practices of small-scale fishermen.
	14.b Provide access for small-scale artisanal fishers to marine resources and markets	
	14.c Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in the United Nations Convention on the Law of the Sea, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of “The future we want”	

Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements	15-1 Actively implement conservation and restoration activities to diversify terrestrial and inland freshwater ecosystems.
	15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally	15-2 Strengthen sustainable forest management including the halting of deforestation and the restoration of degraded forests.
	15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world	15-3 Endeavor to restore degraded land affected by drought, floods, and commercial development.
	15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development	15-4 Protect threatened species to prevent the loss of biodiversity.
	15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species	15-5 Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources, as internationally agreed.
	15.6 Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed	15-6 Strive to end poaching and trafficking of protected species of flora and fauna.
	15.7 Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products	15-7 Take measures to prevent the introduction of invasive alien species and reduce their impact on land and water ecosystems.
	15.8 By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species	15-8 Exert efforts to restore the ecological axes that were destroyed by human activities, including commercial developments, and to maintain and manage ecological networks.
	15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts	
	15.a Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems	
	15.b Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance	

	such management, including for conservation and reforestation	
	15.c Enhance global support for efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities	
Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	16.1 Significantly reduce all forms of violence and related death rates everywhere	16-1 Significantly reduce all forms of violence and related death rates.
	16.2 End abuse, exploitation, trafficking and all forms of violence against and torture of children	16-2 End abuse, exploitation, trafficking, and all forms of violence and torture of children.
	16.3 Promote the rule of law at the national and international levels and ensure equal access to justice for all	16-3 Promote the rule of law at the national and international levels and ensure equal access to justice for all.
	16.4 By 2030, significantly reduce illicit financial and arms flows, strengthen the recovery and return of stolen assets and combat all forms of organized crime	16-4 Reduce illicit financial and arms flows, strengthen the recovery and return of stolen assets, and combat all forms of organized crime.
	16.5 Substantially reduce corruption and bribery in all their forms	16-5 Reduce corruption and bribery practices.
	16.6 Develop effective, accountable and transparent institutions at all levels	16-6 Develop and implement effective and accountable government policies and systems.
	16.7 Ensure responsive, inclusive, participatory and representative decision-making at all levels	16-7 Ensure responsive, inclusive, participatory, and representative decision-making at all levels and improve public access to information.
	16.8 Broaden and strengthen the participation of developing countries in the institutions of global governance	16-8 Provide legal identity for all including birth registration.
	16.9 By 2030, provide legal identity for all, including birth registration	16-9 Ensure public access to information and protect fundamental freedoms according to national legislation and international agreements.
	16.10 Ensure public access to information and protect fundamental freedoms, in accordance with national legislation and international agreements	16-10 Strengthen international cooperation for building public institutional capacity in developing countries to combat violence, terrorism, and crime.

	16.a Strengthen relevant national institutions, including through international cooperation, for building capacity at all levels, in particular in developing countries, to prevent violence and combat terrorism and crime	16-11 Establish and enforce nondiscriminatory laws and policies.
	16.b Promote and enforce non-discriminatory laws and policies for sustainable development	16-12 Strengthen the protection of everyone's digital rights.
		16-13 Promote inter-Korean cooperation for peace and prosperity.
Goal 17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development	17.1 Strengthen domestic resource mobilization, including through international support to developing countries, to improve domestic capacity for tax and other revenue collection	17-1 Expand the resources needed to support the implementation of SDGs in developing countries
	17.2 Developed countries to implement fully their official development assistance commitments, including the commitment by many developed countries to achieve the target of 0.7 per cent of gross national income for official development assistance (ODA/GNI) to developing countries and 0.15 to 0.20 per cent of ODA/GNI to least developed countries; ODA providers are encouraged to consider setting a target to provide at least 0.20 per cent of ODA/GNI to least developed countries	17-2 Promote a multilateral trading system, and support trade and increased investment in developing countries.
	17.3 Mobilize additional financial resources for developing countries from multiple sources	17-3 Support the strengthening of science and technology innovation systems in developing countries.
	17.4 Assist developing countries in attaining long-term debt sustainability through coordinated policies aimed at fostering debt financing, debt relief and debt restructuring, as appropriate, and address the external debt of highly indebted poor countries to reduce debt distress	17-4 Strengthen the national planning capacity to implement SDGs in developing countries, and provide enhanced international support.
	17.5 Adopt and implement investment promotion regimes for least developed countries	17-5 Increase policy coherence for sustainable development.
	17.6 Enhance North-South, South-South and triangular regional and international cooperation on and access to science, technology and innovation and enhance knowledge-sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism	17-6 Enhance various global partnerships for sustainable development in developing countries.
	17.7 Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favourable terms, including on concessional and preferential terms, as mutually agreed	17-7 Encourage and promote effective public, public-private, and civil society partnerships.

	17.8 Fully operationalize the technology bank and science, technology and innovation capacity-building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology	
	17.9 Enhance international support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the Sustainable Development Goals, including through North-South, South-South and triangular cooperation	
	17.10 Promote a universal, rules-based, open, non-discriminatory and equitable multilateral trading system under the World Trade Organization, including through the conclusion of negotiations under its Doha Development Agenda	
	17.11 Significantly increase the exports of developing countries, in particular with a view to doubling the least developed countries' share of global exports by 2020	
	17.12 Realize timely implementation of duty-free and quota-free market access on a lasting basis for all least developed countries, consistent with World Trade Organization decisions, including by ensuring that preferential rules of origin applicable to imports from least developed countries are transparent and simple, and contribute to facilitating market access	
	<i>Policy and institutional coherence</i>	
	17.13 Enhance global macroeconomic stability, including through policy coordination and policy coherence	
	17.14 Enhance policy coherence for sustainable development	
	17.15 Respect each country's policy space and leadership to establish and implement policies for poverty eradication and sustainable development	
	<i>Multi-stakeholder partnerships</i>	
	17.16 Enhance the Global Partnership for Sustainable Development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the Sustainable Development Goals in all countries, in particular developing countries	
	17.17 Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships	

	17.18 By 2020, enhance capacity-building support to developing countries, including for least developed countries and small island developing States, to increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts	
	17.19 By 2030, build on existing initiatives to develop measurements of progress on sustainable development that complement gross domestic product, and support statistical capacity-building in developing countries	

Table S2. Air pollutant emission inventory by road vehicles in South Korea (2019) [3]

(Unit: ton)

Pollutant	Road vehicles		Total
Total suspended particulate (TSP)	6,719,140	(1.39 %)	484,526,753
PM ₁₀	6,181,609	(7.06 %)	87,618,262
PM _{2.5}	6,719,140	(3.23 %)	207,865,746
Sulfur dioxide (SO _x)	308,163	(0.11 %)	272,858,617
Nitrogen oxides (NO _x)	371,850,599	(34.21 %)	1,086,861,873
Volatile organic compounds (VOCs)	36,662,804	(3.59 %)	1,020,215,773
Ammonia (NH ₃)	2,615,384	(0.83 %)	316,299,324
Carbon monoxide (CO)	180,489,028	(23.82 %)	757,847,653
Black carbon (BC)	3,800,586	(26.74 %)	14,210,715
Total	615,346,455	(14.48 %)	4,248,304,715

Table S3. WHO Global air quality guidelines(Unit: $\mu\text{g} / \text{m}^3$)

		WHO guidelines 2005 [4]	WHO guidelines 2021 [5]
PM ₁₀	Annual	10	5
	Daily (24-hour)	25	15
PM _{2.5}	Annual	20	15
	Daily (24-hour)	50	45

Table S4. Annual statistics of particulate matter early-warning system during the study period in Seoul, South Korea.

	Year	Advisory		Alert	
		Times ¹	Days ²	Times ¹	Days ²
PM ₁₀ ³	2017	6	10	0	0
	2018	5	5	1	1
	2019	8	14	0	0
PM _{2.5} ⁴	2017	5	10	0	0
	2018	8	18	0	0
	2019	15	25	2	4

¹ Number of times of issuance

² Number of days of issuance

³ **Advisory:** when the hourly mean concentration is 150 $\mu\text{g}/\text{m}^3$ or above and it lasts for 2 hours or longer; **Alert:** when the hourly mean concentration is 300 $\mu\text{g}/\text{m}^3$ or above and it lasts for 2 hours or longer

⁴ **Advisory:** when the hourly mean concentration is 75 $\mu\text{g}/\text{m}^3$ or above and it lasts for 2 hours or longer; **Alert:** when the hourly mean concentration is 150 $\mu\text{g}/\text{m}^3$ or above and it lasts for 2 hours or longer



Figure S1. Stations and bicycle roads of bike-sharing system in Seoul, South Korea.

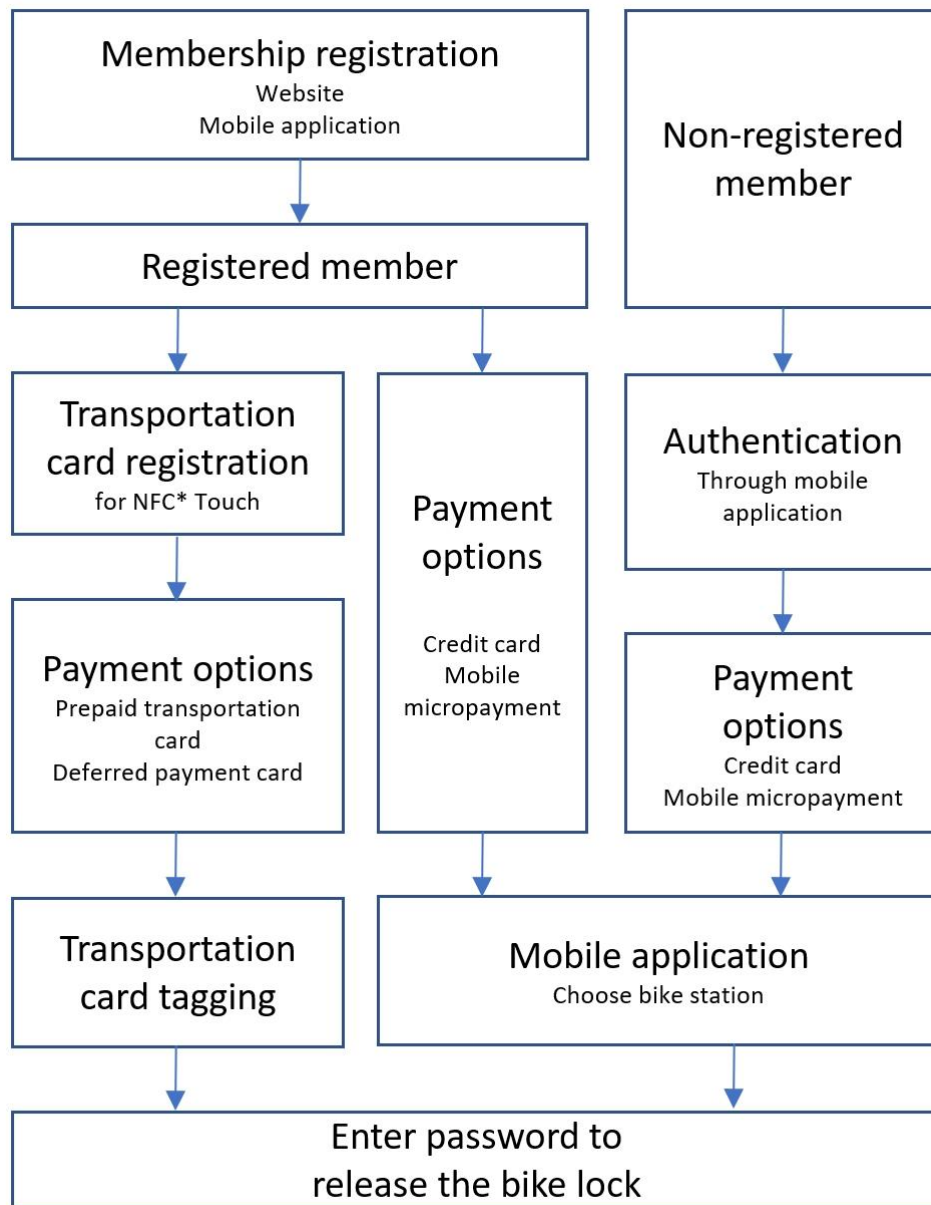


Figure S2. Rental process of the bike-sharing system.

Bicycles can be unlocked by touching the card reader with a credit card or smartphone. The bicycle can be returned to any bike station.

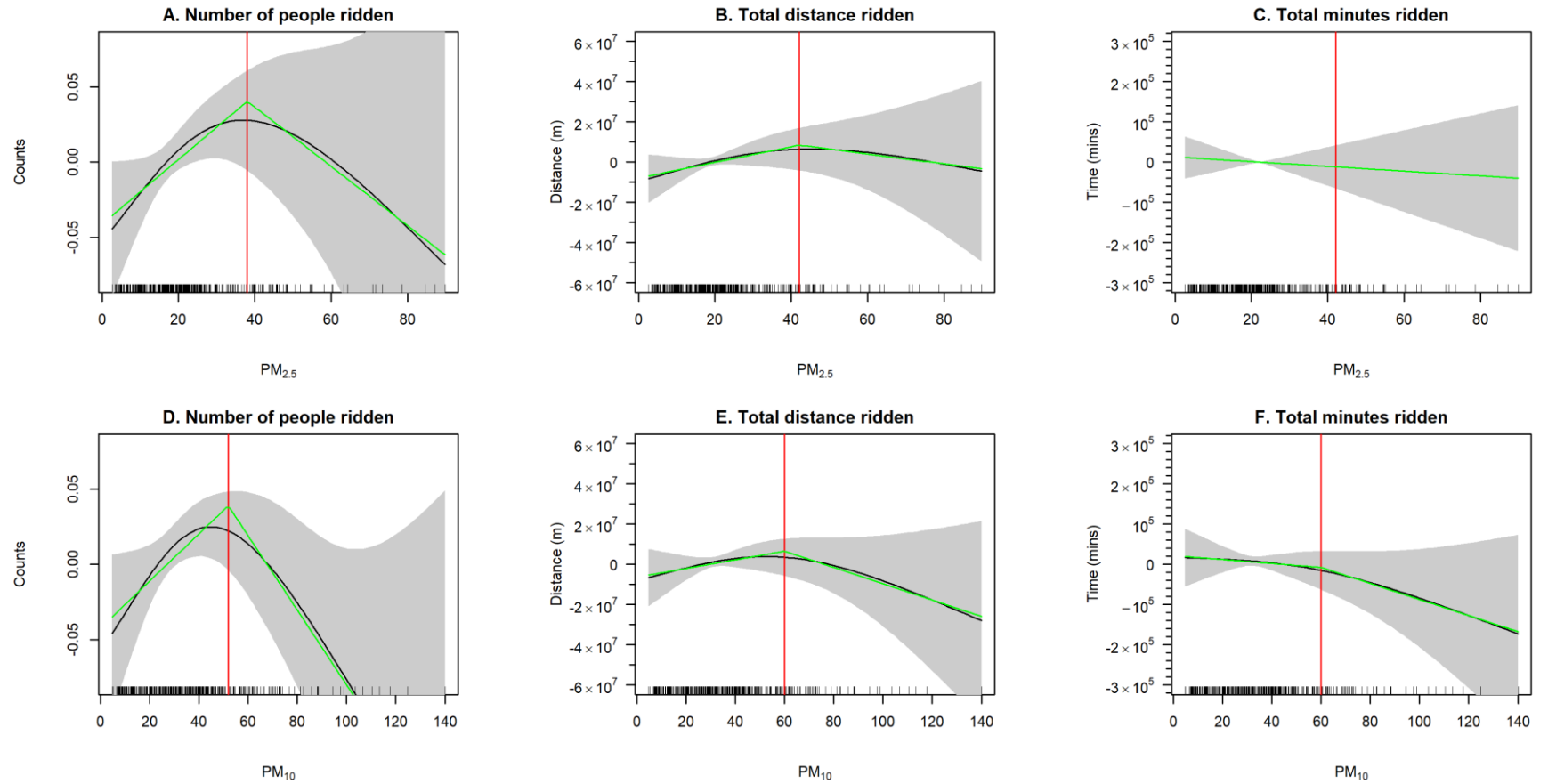


Figure S3. Exposure–response relationship with piecewise linear regression analysis to estimate the threshold of PM level using a grid search method with the minimum Akaike information criterion.

Red vertical lines represent thresholds, marks on the x-axis are observed data points, y-axis represents the partial effect of each variable, and shaded areas indicate 95% confidence intervals.

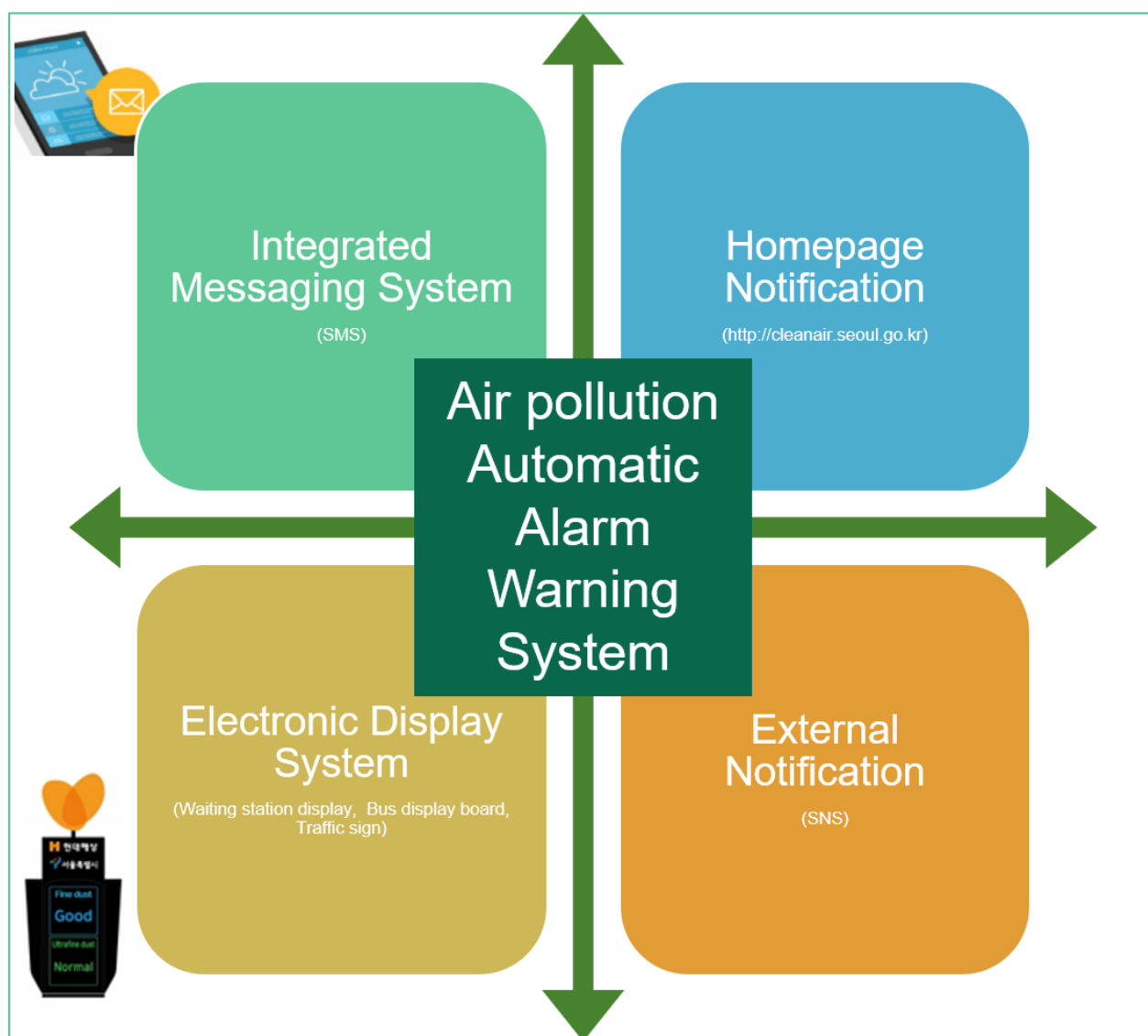


Figure S4. Air pollution warning system in Seoul, South Korea.

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