IJABER, Vol. 14, No. 5, (2016): 2913-2929

COMPARATIVE ANALYSIS OF SMART CITY PROJECTS* – IMPLICATIONS FOR U-CITY –

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Abstract: *The majority of cities around the world are currently facing common socioeconomic urban problems resulting from a rapid increase in population; these problems include enlargement and concentration of urban facilities, aging population, rising crime rate, and threats to urban safety. Smart city projects are being implemented as solutions these problems in various parts of the world. This study selected a number of countries well known for their successful implementation of smart city projects: Korea, Japan, China, the United States, and several countries in Europe. This study compared and analyzed the characteristics of these projects, with particular regard to background, time, promotion system, and application area, to discover implications that should be considered when such projects are launched. The findings confirmed that the projects in East Asian countries had been enforced by the central government, whereas, in the United States, state governments, local governments, or private enterprises has been commissioned as the main actors of the program. A notable finding is that several of the European countries have built cooperative systems between the civil society, businesses, and local governments, and such an approach had led to successful consequences. Such outcomes imply that open and innovational cooperation systems should be formed for the demand side, and this can be achieved by the integration of the strong impetus of the governments, the technical skills of companies, and the support of citizens. This study posits that, although smart city projects are typically applied to develop new towns, they also should be implemented to urban regeneration projects as well.*

Keywords: *U-city, smart city projects, open cooperative system, sustainable urban regeneration projects*

I. INTRODUCTION

A. Background

Various urban problems arise as urban population rapidly increases, because urbanization is mainly generated by the population drift from rural to urban areas. The remarkable growth of urban population has triggered several problems, such

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* This work is financially supported by Korea Minister of Ministry of Land, Infrastructure and Transport (MOLIT) as 0U-City Master and Doctor Course Grant Program

as the enlargement and concentration of urban facilities, an increase in the aging population, a rise in crime rate, and threats to urban safety. Unfortunately, the urbanization trend is expected to continue according to the 'World Urbanization Project', a report published by the United Nations (UN) that was based on a census conducted in 233 countries. The main statement of the report indicates that the world population would rise from approximately 7.2 billion (in 2014) to 9.5 billion (in 2050), and the largest proportion of this increase would be concentrated in large cities. Furthermore, the proportion of the urban population is predicted to reach up to 66% by 2050, whereas that of the rural population is forecasted to decline to 33%. Therefore, several countries are now implementing smart city projects to address the potential problems.

For example, in Korea, by applying high-tech information and communication technologies, an information system has been set up and operated for the management of facilities, disaster, safety, transportation, and environment in the cities. A primary (2009–2013) and secondary (2014–2018) 'Ubiquitous City (U-city) Comprehensive Plan' have been established and performed to establish a system for overall management, promptly handle emergency situations, cut down management and operation expenses, and develop new service industries.

Korea is not alone in showing a great interest in smart city projects. Demonstrating an aggressive attitude toward constructing smart cities, China has announced that more than 50 trillion won (or 40 billion USD) will be invested in smart city projects. Moreover, the total number of smart city projects being implemented around the world has increased recently, although they are largely concentrated in only a number of countries. Nikkei BP estimated that 608 projects have been reported thus far, and 84% of which were implemented in Korea, Japan, China, the United States, and Europe.

(B) Purpose

Smart city projects established in various parts of the world are applied as effective methods of coping with socioeconomic urban problems commonly faced by countries today. Thus, by comparing and analyzing the characteristics of the projects that have been implemented in leading countries, this study intends to suggest valuable implications that should be considered when such projects are launched. In Chapter 2, a few countries are selected that are well known for their successful performance in smart city projects: Korea, Japan, China, the United States, and several countries in Europe. The background, time, promotion, system, and application area of each country's project are thoroughly investigated. In Chapter 3, implications are drawn on the basis of the research results discovered in Chapter 2.

II. PROJECT ENFORCEMENT SITUATION FOR EACH COUNTRY

(A) Korea

Smart city projects in Korea were started in 2003, when new towns were being actively constructed in the capital areas, such as Songdo in Incheon, Heungdoek in Yongin, Unjeong in Paju, and Pangyo in Seongnam. In 2006, the Ministry of Information and Communication established 'Master Plan for Constructing and Invigorating U-city', which details how the ministry intends to develop a standard model of U-city services and legalize the projects. In recognition of these efforts, the legislation for the construction of U-city was enacted in 2008, and a primary and a secondary 'U-city Comprehensive Plan' were published in 2009 and 2013, respectively.

At present, the Ministry of Land, Infrastructure, and Transport is responsible of the general policymaking for smart cities; the Ministry of Security and Public Administration is in charge of administrative works; and the Ministry of Trade, Industry, and Energy manages the specific policymaking with regard to energy and environment. The Ministry of Information and Communication was the first to suggest the concept of U-city was first suggested by, which is the same as that of the one currently being operated by the Ministry of Land, Infrastructure, and Transport. By utilizing information and communication technologies (ICT), both ministries offer contributions to improve the quality of life in the city, encourage city competitiveness, motivate the competitiveness of domestic businesses, and export the U-city model to other countries. One advantage of Korea over other countries is that it already set exporting related techniques to other countries as a goal when the projects were launched.

Today, 73 out of 250 cities in Korea are planning or implementing smart city projects. Among those cities, nearly 65% are estimated to implement the projects when new towns are constructed. An estimated 55% of cities in the capital area and 23% of cities in rural area are projected to carry forward with smart city projects.

In addition, the Korean government is now enforcing a support project for U-services (TABLE I). The purpose of this project is to improve public services and resolve pending national issues by guaranteeing that everyone can have access to any services whenever and wherever.

Table I
Current Situation of Supporting Project for U-services

Year	*Service Details*
2008(22)	• RFID-based clearance of importing air cargo • USN-based combined monitoring of weather and sea • USN-based remote health monitoring

contd. table 1

Year	*Service Details*
	• U-Care on senior citizen who lives alone
	• USN-based crime prevention and security services in children protection zone
	• integrated control center for tunnels
	• management of water treatment facilities
	• unified management of city life wastes
2009(16)	• RFID-based government goods management
	• Demonstration project of developing waterfronts
	• Urban facility management
	• Management of carbon emissions
	• Construction of ubi-Z
	• Safety control of wooden cultural heritage
	• Services on Eco Park
	• Services on cultural space
2010(11)	• Clearance service on importing ocean freights
	• Easy life service
	• Monitoring on handicap parking
	• Services to support and sustain traditional markets
	• Fire control services
	• Library services
	• Senior community services
2011(13)	• 911 reporting services
	• Provision of integrated information on disaster relief supplies
	• Management of army recruit
	• Realization of smart working environment
	• E-book for people who live in farming and fishing villages
	• Management of food wastes
	• Prevention of damage caused by dangerous birds
2012(13)	• GPS-based information management for wastes
	• Guidance of sightseeing
	• Integrated management of steep slopes
	• Maritime casualty safety management
	• Management of integrated information on fish farms
	• Smart town service for revitalization of old towns
2013(9)	• Monitoring atmospheric environment of industrial complex
	• Control system for hazardous wild animals
	• Cultivating container for crops
	• Analysis system for managing growth and development of mushrooms
	• Electronic system for transporting livestock excretions
	• Emergent transfer system for people living on remote islands
	• School meal services linked to local food system
2014(6)	• Navigation system for emergency rescue services
	• System for appropriate treatment of livestock excretions
	• Forecast and warning system for the collapse of steep slopes or reservoirs
	• Monitoring of toxic substance spill in chemical complex
	• Police support system with wearable cameras

The government has also begun utilizing Internet of Things (IoT), and businesses have since improved since the government established a ground plan for applying IoT to U-city in August 2015. Consequently, Korea has gained the reputation of making the best use of IoT despite the stiff competition between countries.

(B) Japan

Smart cities had been barely remarked upon in Japan until 2010. However, in 2011, when Japan suffered an energy crisis because of the massive earthquake in East Japan and the Fukushima nuclear disaster, the Japanese government became primarily concerned with devising a Smart Policy to secure the energy infrastructure with the use of the Smart Grid. The government anticipated that building smart cities would be an effective means of rehabilitating cities destroyed by the earthquake in the northeast area. The government also sees smart cities as a useful way of coping with not only the energy crisis but also other social issues, such as super-aging, low birthrate, and disaster prevention.

Similar to that in other countries, smart city projects in Japan are also promoted by major government agencies. The most representative governmental efforts are the Eco-Friendly Future City plan, the Smart Community plan, and the ICT Smart Town plan.

1) Eco-Friendly Future City Plan

Established in 2008, the Eco-Friendly Future City plan selected 13 different cities to reduce the amount of greenhouse gas emissions to half by 2050. It was later revised to cover 11 additional pilot cities, including Kitakyushu. The specific test projects for next-generation energy and social systems promoted by the plan are organized in TABLE II. In brief, all projects set their targeted population and CO_2 emission, and they utilize smart technologies such as electric vehicles (EV), energy management systems (EMS), intelligent transport systems (ITS), photovoltaics (PV), demand reduction (DR), wind power, heat energy, biomass, and storage batteries.

Kitakyushu is the most exemplary Eco-Friendly Future City. This city aims to become both an environmentally friendly city and a people-oriented city where vulnerable members of society receive consideration. To achieve this goal, Kitakyushu implements various businesses. Specifically, Kitakyushu started a demonstration experiment of Smart Grid Dynamic Pricing in 2012 and achieved 45.9% of energy savings from the use of solar heat-based Building Energy Managements Systems (BEMS).

2) Smart Community Plan

Launched in 2009, 'The Test Project for the Next Energy System' integrates renewable energy into the former energy system for efficient energy management.

Table II
Test Projects for Next Generation Energy and Social Systems

Project	*Targeted Population*	*Technology*	*Targeted CO_2 emission*
Keihanna Eco City (Kyoto, Ohara and Nara prefectures)	102,024 people	• EMS • Power DR • EV	- 20% CO_2 emission in households by 2030 (to 2005 levels) - 40% CO_2 emission in transport 1,000 houses with PV
Kitakyushu Smart Community (Fukuoka prefecture)	225 households	• PV • Wind power • Heat energy • Hydrogen • EMS • EV • Data centre	- 50% CO_2 emission in household, residential and transport by 2030 - 10% of production = new energy Smart meters for 70 firms and 200 households
Toyota Low Carbon Society (Aichi prefecture)	227 households	• PV • Biomass • EMS • EV & ITS	- 20% CO_2 emission in households - 40% CO_2 emission in transport 3,100 EV
Yokohama Smart City (Kanagawa prefecture)	4,000 households	• PV • Storage batteries • EMS • EV	- 30% CO_2 emission by 2025 (to 2004 levels) - 27,000 kW PV – 2,000 EV

Since then, cities such as Yokohama, Toyota, and Kitakyushu were selected as test beds in 2010 (FIGURE I), and eight victim cities damaged by massive earthquakes were added to the list of pilot cities for Smart Community in 2011. Today, the government intends to apply the evaluation results of the precedent projects to the eight cities.

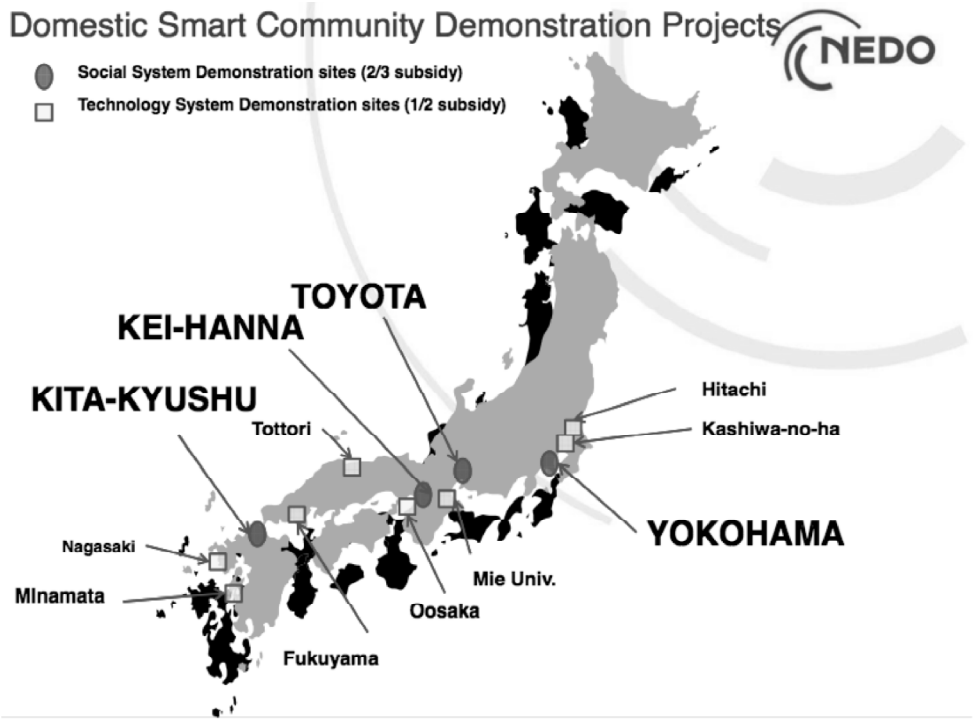

Figure 1: Smart Community Projects in Japan

With the cooperation among citizens, firms, and the city government, Yokohama successfully formed a Smart City Model. The city then constructed a social system that applies low-carbon technology to the fields of energy, building, and transportation (Subasinghe, 2015). The ultimate goal of the city is to achieve more than 60% reduction (compared with 2004 levels) of greenhouse gases emitted by people by 2050.

3) ICT Smart Town Plan

The catastrophic earthquakes in 2011 triggered the Japanese government to devise the 'ICT Strategies for Revival and Regeneration of East Japan'. The same intent was continued in 2012 when the government suggested the 'Plan for ICT Smart Town', which aims to resolve urban problems, secure urban safety, accomplish economic revitalization, create jobs, and encourage national competitiveness.

(C) China

After pushing for economic reform, China faced many problems resulting from the rapid increase in urban population, because urbanization is a rather new concept. An estimated 1% of the Chinese population (approximately 12 million people) moves from rural to urban areas every year, thereby causing a shortage in the city's infrastructure.

Securing and conserving energy has become national priority goals ever since China reached the second economic scale in the world. To maintain economic growth, China cannot help but reach a degree of self-sufficiency in energy because of heavy industry-centered growth strategy. Moreover, environmental pollution, particularly smog and fine dust, has become a serious public concern. For these reasons, the Chinese government proactively imposed smart city projects and encouraged the service industry to stimulate industry transformation. Furthermore, the government urged increased personal spending, which would lead to additional investments and ultimately promote growth.

During the 12th five-year plan (2011-2015), the Chinese government was meant to construct 320 smart cities with a minimum investment of 300 billion yuan. The department responsible for all smart city policies, the Ministry of Housing and Urban-Rural Development of the People's Republic of China, announced 193 cities as test bed in 2013. The pilot cities received various forms of support from the department during the 3–5 years of the developing period and are now being screened for classification. In contrast to precedent projects, which were mostly targeted on large cities, current smart city projects are expected to be expanded to small- and medium-sized cities.

For example, Tianjin Eco City, which is gaining attention as the new model of regional economic development for China, is the first smart city ratified by the government. The venture was started when the Chinese and Singaporean prime ministers agreed to construct a city with an ecologically sustainable urban environment in the region in the vicinity of Tianjin. Tianjin Eco City follows the successful model of Special Economic Zones in Shenzhen and New Borough of Pudong in Shanghai, and is well known for introducing IoT to form Wireless Sensor Network (WSN).

(D) The United States

Policies for smart cities enforced in the United States are concentrated on Smart Grid and e-Health Care. In contrast to Asian countries where all smart city projects are mainly led by the central government, the United States federal government only manages the Smart Grid and e-Health Care, and delegates the rest of the responsibilities related to smart cities to state governments and private enterprises.

Figure II: Site of Tianjin Eco city

Figure III: Blueprint of Tianjin Eco city

The federal government is greatly interested in these two fields of smart city projects because of two reasons: the old electrical grid and the high level of medical expenses in the United States. The electrical grid in the United States was constructed such a long time ago that it has become obsolete, causing substantial power dissipation and lowering the quality of electricity. In fact, the northeastern area of the United States and part of Canada experienced a major blackout crisis in 2003. The degree of electric loss is estimated to be 7.4%, and the amount of economic loss caused by power quality degradation is calculated to be approximately 150 billion USD per year. Moreover, the United States is known as the country that has the largest ratio of medical care spending to consumption expenditure. Furthermore, the proportion of people aged over 65 is projected to reach 20% by 2030, resulting in increased household health expenditure.

Navigant Research recently published a report analyzing the competitiveness of companies specialized in smart city solutions. According to the report, IBM and Cisco Systems are well appreciated.

1) IBM's Smarter Cities™

IBM introduced the initiative named 'Smarter Cities™' in 2008 with the goal of making the world smarter. This effort was the first trial to use the concept of Smart City in the field of work. The Police Agency in New York requested IBM to construct an integrated system for analyzing crime information and invested 11 million USD to set up the 'Real Time Crime Center (RTCC)'. At present, approximately 37 thousand police officers use various databases related to crime, and crime patterns can be visualized in real time by analysis tools provided in the system. The introduction of RTCC resulted in the rising rate of solved murder cases and the decrease in the crime rate.

2) Cisco Systems' Smart⁺ Connected Communities™

In 2009, Cisco presented the smart city initiative called 'Smart⁺ Connected Communities™', which focuses on the networking and intellectualization of urban infrastructures. The company defined it as the initiative that supports changes by the network in the community from a physically dispersed one to an efficiently integrated one. The core of the initiative is the network building mediator technology, which intelligently connects components of buildings. Cisco has expanded its application to homes, workplaces, hospitals, and schools. For example, the new Korean town in Songdo is a case for such application.

(E) Europe

In Europe, the European Commission (EC) is in charge of smart city projects promoted on the level of the European Union (EU), placing particular emphasis

on energy and transportation, whereas specific businesses are promoted individually by a country or city. According to Nikkei BP, the number of smart city projects implemented in Europe since June 2013 are as follows: 20 in Germany, 13 in the United Kingdom, 10 in France, nine in Denmark, and eight in Sweden.

The Barcelona Smart City in Spain is known as the most successful model of urban regeneration. The second-largest Spanish city in terms of size, Barcelona once flourished with the textile industry, but it slowly decayed as a new industrial complex was developed in Montjuic Hill in 1965. During 1963–1990, more than 1,300 factories were relocated to other regions, and the city became a slum. The '22@Barcelona38' plan was devised to rehabilitate Barcelona. The city government started a project of transforming the former industrial complex into a knowledge-intensive high-tech one by agglomerating knowledge-based industries to the complex. Consequently, Barcelona has grown to become the smartest city in Europe, and it is highly acclaimed for having a cooperative system among the industry, the academe, and the government, and for its efficient management of public data.

Now, Barcelona is working on building a Smart City Campus at 22@ co-working space in Poble Nou. Targeted to be completed by the summer of 2016, this project has been boosted by the investment and collaboration pledge from corporations such as Scheinder, CISCO, Agbar, and Abertis. The campus will house corporations, innovators, universities, researchers, and entrepreneurs to create an ecosystem

Figure IV: Smart City Campus at the 22@ Co-working Space

that leads in smart city solutions. With the city government leading the way in innovation, the participation of the private sector and investments would occur naturally.

Another successful example in Europe is the project promoted by Deutsche Telekom in Germany. The company conducted more than 50 test projects on six different fields of smart city, namely, transportation, education, culture, administration, medical service, and jobs. The project is now considered a great success, and the critical success factor lies in the active participation of diverse enterprises, open collaboration, and enthusiastic cooperation from the local government and the residents.

III. IMPLICATIONS FOR SMART CITY PROJECTS

On the basis of the results explained in Chapter 2, several implications for smart city projects are deducted by comparing the merits and demerits of the projects implemented by the selected countries.

(A) Open and Innovational Cooperation System between Citizens, Firms, and Governments

In Korea, the government has taken the initiative to promote smart city projects by establishing the U-city Comprehensive Plan. As the project develops to the spreading stage, the participation of firms and cooperation of citizens are highlighted. Korean projects have an interesting goal of first improving the competitiveness of domestic enterprises and then exporting the model to other countries. Therefore, its focus is on development and accumulation of the technology and the know-how related to smart city solutions.

As for Japan, various smart city policies are in operation, and most of the projects are mainly promoted by the government. The Eco-Friendly Future City plan, the Smart Community plan, and the ICT Smart Town plan exemplify the smart city projects implemented in Japan.

China shows slight peculiarity in that smart city projects had been sporadically implemented by local governments in the past. However, in 2013, the central government announced a new national smart city project and declared a plan to promote such projects through the cooperation of different departments.

Unlike other countries where the central government leads smart city initiatives, the United States federal government only concentrates on constructing Smart Grid and e-Health Care. It gives state or local governments and private companies the authority to promote businesses in other fields of smart city projects.

In Europe, the EC manages the smart city policies that affect all and some of the countries in Europe that especially focus on energy and transportation, and

specific policies and businesses for smart city are enforced by each country and city. Smart city test projects targeted in Friedrichshafen and conducted by Deutsche Telekom were particularly highly appraised for their successful results due to the active participation of various enterprises in projects, open collaboration, and enthusiastic cooperation from local government and residents.

Although the government plays a primary role in East Asian countries, smart city projects in US are mostly promoted by state or local government and private enterprises. Several countries in Europe also delegate its authority on smart city projects to localities and companies. In particular, the Friedrichshafen Smart City Project in Germany is an excellent example that demonstrates the implication to consider open and innovational cooperation system among citizens, firms, and governments.

(B) Service System for Demand Side

If a project is promoted by the government, the project would proceed much more quickly. However, such an arrangement does not sufficiently reflect the ideas of citizens in the project. The structure in most countries is that the government is in charge of smart city projects, increasing the possibility of disregarding the demand side. In fact, smart city projects in Korea faced problems of lacking services required by citizens in real life, as majority of the services were designed by the government without considering the needs of the citizens. The common cause of such problems in Korean smart city projects is that the government and firms hastily applied the latest technology and commodity available at that time to urban infrastructure rather than exerting an effort to understand the basic information about the current issues encountered by the city and what services were the citizens really asking for.

Thus, smart city projects should make use of a service system that is based on the demand side, as demonstrated by the case of Barcelona. That case shows that the realization of a smart city can be achieved not only when the newest and highest technology is utilized but when it meets the actual needs of the citizens. When a project fully satisfies the citizens' needs, whether the technology costs a great deal or not and whether it is special or typical are irrelevant. In other words, the key to developing sustainable smart cities is to foster a good relationship among governments, firms, and citizens.

(C) Sustainable Smart City Paradigm

The Korean legislation for U-city specifies that services should include administration, transportation, logistics, education, environment, facility management, health/medical/welfare, prevention of crime and disasters, employment, and culture/tourist/sports. By contrast, other countries, such as

Japan, China, the United States, and Europe, define a smart city arbitrarily as an eco-friendly and sustainable city that utilizes ICT techniques. This suggests that Korea should expand its services to include the concept of 'smartening the energy' so that it can effectively respond to the amalgamation movement between the fields of energy and the environment.

(D) Utilization of Smart City on Urban Regeneration

The majority of smart city projects performed in Korea are greenfield projects, which construct new town on the place where no city previously existed. Therefore, a great gap is observable between new towns and old towns, and this gap hinders the balanced city development in the country. This problem is partially caused by the imposed limit by the law on the size of the land that smart city projects can be processed to a certain scale. The case is different in several countries in Europe, such as the Netherlands and Spain, where smart city projects are promoted as brownfield projects by retaining the former urban infrastructure.

IV. CONCLUSION

The rapid increase in urban population has caused a wide range of socioeconomic problems, such as aging and excessive enlargement and concentration of urban facilities. As a solution to these problems, smart city projects are widely promoted worldwide. Discovering this trend, this study found a necessity to investigate the background, start time, enforcement method, and application area of smart city projects implemented in several countries. On the basis of the analysis results, valuable implications to be considered when smart city projects are launched were drawn out as follows.

First, an open and innovational cooperation system is needed for the successful construction of service systems that effectively reflect the needs of citizens. This can be achieved when the governments' strong impetus, the technical skills of companies, and the support of citizens are unified closely. In fact, the reason why the Friedrichshafen Smart City has produced a good outcome is because it encouraged an active participation of various actors in business, the government, and the civil society. Korean smart city projects are still led only by governments, and such weakness should be made the same as the case in other countries, which have already considered localities, firms, citizens as project movers.

Second, Korea should take an integrating viewpoint when promoting smart city projects. To accomplish that, other fields that also have potential application in smart cities should be included. The countries examined thoroughly in Chapter 2 roughly define a smart city as an eco-friendly and sustainable city that utilizes ICT technologies. By contrast, Korea restricts the range of smart city's application

only to several fields, suggesting that Korea may fail to effectively cope with the blending movement among different fields.

Lastly, Korea should utilize the concept of smart cities not only for developing new cities but also for urban regeneration. The currently popular notion is that smart city projects are only applicable to the construction of new cities. However, smart city projects are also available when regenerating old towns, and this approach is a much better way of maintaining the balance between cities. In fact, Korea has promoted smart city projects along with development of new towns. By doing so, Korea has faced the problem of imbalance in developmental level between new and old cities. Given that the law restricts smart city projects to be only applicable when the size of the developed land is over a certain scale, greenfield projects that usually satisfy the condition are enforced and only new cities become equipped with the latest ICT technology. Moreover, considering that the successful projects performed in Europe promote smart city projects as brownfield projects, the utilization of smart cities is necessary for urban regeneration.

This study suggested compelling explanation for each of the leading countries' smart city project and invaluable implications. However, further study is needed because the data are still insufficient. After more ample data are collected and analyzed, more concrete directions can be proposed for smart city projects.

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