Integration of Theoretical Systems and Practice for Sustainable Urban Development

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Abstract: In this study, we extended the practice of six city theoretical systems, namely "sustainable city," "eco-city," "low-carbon city," "smart city," "resilient city," and "knowledge city" to obtain a clear understanding of, the sustainable development of contemporary cities. The study was divided into two parts: First, we executed a review of the literature on the six city theoretical systems, and second, we combined the practice of international organizations and cities corresponding to the aforementioned theories. We elucidated the definition of the theoretical systems and their practical application, representative cities, and relationship with sustainable urban development in terms of international organizations and operations. Finally, we conclude that low-carbon city is the only city theoretical system that can develop international legal initiatives and that it represents the importance and urgency of sustainability in the global urban environment. This study suggests that because different city theoretical systems are considered from the perspective of "sustainable cities". The sustainable development is dynamic and changes with time and must thus be investigated in depth.

Keywords: City theoretical systems, sustainable cities, eco-cities, low-carbon cities, smart cities, resilient cities, knowledge cities, sustainable urban development.

1. INTRODUCTION

To clarify the understanding of the urban categories proposed in the past few decades, Jong *et al*. (2015) studied the differences between the important concepts of the city categories. Although the scope of these categories is interrelated, they can be independently classified. The differences between the new and old categories overlap with the concept of varying degrees. In particular, 12 urban categories were grouped into six theoretical systems, namely "sustainable city," "eco-city," "low-carbon city," "smart city," "resilient city," and "knowledge city." Among them, "sustainable city" has the most frequent occurrence, and it is also the largest and the most interconnected node, followed by "eco-city" and "green city." "Sustainable city" is a pillar of sustainable development and is a comprehensive umbrella concept related to the ecological, economic, and social aspects of various problems.

The city theoretical systems are inherently overlapping and difficult to define clearly. Although the study by Jong *et al*. (2015) clearly discussed the city theoretical systems, it did not integrate the practice of relevant city categories. Therefore, in this study, we investigated and discussed the six city theoretical systems and combined the practice of international organizations and cities. The sustainable development of a contemporary city can be clearly explained by integrating the theoretical systems and practice.

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2. METHODOLOGY

The methodology of this study was divided into two parts: The first part involved a review of the literature on the six city theoretical systems, sustainable city, eco-city, low-carbon city, smart city, resilient city, and knowledge city; the second part entailed combining the practice of international organizations and city corresponding to the aforementioned theories. The conclusions are then presented through the combination of contemporary city theory and practice of induction and analysis, and they can be helpful in contemporary city planning development.

2.1. Review of Theoretical Literature

2.1.1. Sustainable Cities

The current use of "sustainable development" as a policy term can be credited to the Brundtland Commission. In the report "Our Common Future," sustainable development was defined as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). The term "sustainable city" is an almost automatic derivative from this definition relating to urban development. It was subsequently fleshed out in the Aalborg Charter (1994) for more than 700 cities worldwide and by the Melbourne Principles in Local Agenda 21 (UNEP, 2002). "Sustainable city" as a concept grew especially popular in the 1990s (Roy, 2009); in practice, it became strongly intertwined with and operationalized by the

E-ISSN: 2409-9821/17

conception of the "three pillars" denoting a close interrelationship between economic, social, and environmental sustainability, with a combination of indicators to measure each of them. Sustainability has been widely used in the field of resource management since the beginning of the twentieth century, and it refers to "the largest sustainable production," which means that through an appropriate resource management policy, maximum maintenance of renewable resources without loss can be ensured (Brown *et al*., 1987). In 1987, the World Commission on Environment and Development presented "Our Common Future" at the United Nations General Assembly, the 1992 international Earth Summit, and the adoption of Agenda 21 and the United Nations Millennium Declaration. The concept of sustainable development is an important global concern for actively improving the deteriorating environmental conservation problems (Lee *et al*., 2008).

Rogers (1998) conceptualized a sustainable city as a place where a high quality of life is realized in tandem with policies that effectively reduce the demand for resources (e.g., energy and materials) drawn from the city's hinterland. Thus, "sustainable city" is a major self-sufficient economic, social, and environmental system. Because "sustainable city" advocates often adopt the triple bottom line view, they tend to frame it in broader terms than either "eco-city" or "low-carbon city" (Hajer, 1996). Although the concept of sustainable development has become a strategic reference for international governance, "sustainable development" is a concept rather than a scientific approach to the real solution of maintaining a balance between human development and environmental resources (Lee *et al*., 2008).

2.1.2. Eco-Cities

The term "eco-city" was first discussed in UNESCO's "Man and the Biosphere Species Databases" launched in 1971. The proposed five principles for urban ecological planning are as follows: 1. ecological protection strategy, 2. ecological infrastructure, 3. living standards of residents, 4. preservation of cultural history, and 5. natural integration into the city. Since then, the concept of eco-city has gradually attracted increasing attention, with people beginning to realize the seriousness of the destruction of ecosystems and the human living environment and the need for ecological symbiosis. Richard Register argued that an eco-city refers to a combination of ecology and health; the concept derives from the small towns of China and ancient Europe as well as the Indian tribes of Pueblos in the Southwestern United States. Lifestyle is a way of respect for nature and self-sufficiency (Lee *et al*., 2008). Register, in his book Ecocity Berkeley: Building Cities for a Healthy Future (1973), defines an eco-city as a city built according to the principles of living within the means of the environment. The main idea of an eco-city is that the population and artifacts produced and used remain within the ecological capacity of the city's bioregion. In his book Ecocities (2002), Register proposes the "eco-city design principles" as follows: 1. restoring degraded land, 2. adapting to local ecological conditions, 3. ensuring balanced development, 4. stopping urban sprawl, 5. optimizing energy, 6. developing economy, 7. providing health and safety, 8. encouraging sharing, 9. promoting social equity, and 10. respecting history.

Over time, the term "eco-city" has been embraced by a growing number of academic and policy specialists, with an attempt to translate the general definition into workable principles for construction, production, and consumption. White (2002) and Lehmann (2010) have emphasized eco-city planning as a combination of urban planning concepts with next-generation infrastructure and environmentally friendly buildings. Joss (2011) attempted to map a variety of eco-cities around the world and develop a typology (new-build, extension, and retrofitting) and a variety of motives adduced by policy-makers to promote and legitimize large-scale eco-city projects. However, no commonly agreed definition has emerged to date. According to the aforementioned discussion, an eco-city can be defined as a complex social–economic–natural symbiosis system established according to the ecological principles.

2.1.3. Low-Carbon Cities

The concept of "low carbon" stems from the 1997 Kyoto Protocol agreement for reducing greenhouse gas emissions. According to the protocol, between 2008 and 2012, industrialized countries must reduce their greenhouse gas emissions by at least 5% relative to 1990 emission levels. However, "low-carbon city," "zero-carbon city," and even "negative carbon city" can be seen as a direct response to the more recent climate change debates and the related role of cities. The focus here is on minimizing the human-inflicted carbon footprint by reducing or eliminating the use of nonrenewable energy resources. In 2003, the UK government issued the "UK Energy White Paper: Our Energy Future–Creating a Low Carbon Economy,"

which first proposed the low-carbon economy concept (Liu *et al*., 2009). In the white paper, a low-carbon economy is defined as one in which society creates higher standards of living and a better quality of life through improved economic output underpinned by advanced technological innovations and new business and job opportunities, while considerably reducing natural resource consumption and environmental pollution (DTI, 2003).

Since then, low-carbon economy has become a trend all over the world, signifying the attempted transformation of the mode of economic production and consumption by making these processes less energy-intensive and enhancing the share of renewables. For example, in 2008, Japan published "A Dozen Actions towards Low-Carbon Societies" proposing the application of three principles: reducing carbon emission in all departments, advocating frugality, and living in harmony with nature (GERF, 2008). Most scholars, particularly when reasoning from an economics or engineering perspective, conceptualize a low-carbon city by using the definition given by the UK government as their base reference. Chen and Zhu (2009) explained the category's impact by revealing the interrelationship between the macro level (necessity to change the economy such that energy consumption and CO_2 emissions will decrease) and micro level (reducing CO_2 by revising the entire material flow process from input to output phase).

2.1.4. Smart Cities

The concept of a "smart city" involves the use of the Internet, cloud technology, and Internet of Things in daily life, from the perspective of daily user needs to homes, buildings, and communities extended to the city (NDC, 2016). In a smart city, elaborate and sophisticated information and communication technology (ICT) facilities are provided across the urban territory, allowing companies to collaborate and innovate, provide better services to citizens, and thereby empower citizens with access to information to the extent that they can debate, influence, and even make policies (Lee *et al*., 2013). An early-stage smart city can be conceptualized as one that provides combined services through the integration of information technology and construction industries (Korea Land Corporation, 2005), although it has been argued that the validity of any claim to be a smart city ought to be centered upon something more than the use of ICT alone (Hollands, 2008).

On the basis of a thorough review of the available literature on smart cities, Caragliu *et al*. (2011) conceptualized a smart city by summing up six characteristic features: (1) improving administrative and economic efficiency and enabling the development of culture and society by utilizing networked infrastructure; (2) involving an underlying emphasis on business-oriented urban development; (3) placing a strong focus on realizing the social inclusion of different types of urban residents in public services; (4) emphasizing the significant role of high-tech and creative industries in long-term growth; (5) focusing on the function of social and relational capital in city development; and (6) considering social and environmental sustainability as an important aspect of smart city development. Information technology is not considered independently and should effectively be contextualized and embedded in wider physical and social systems, thus allowing it to be at the service of people, businesses, and government (Allwinkle and Cruickshank, 2011; Leydesdorff and Deakin, 2011; Deakin and Al Waer, 2012; Jong *et al*., 2015).

2.1.5. Resilient Cities

Sustainable development of cities relies on the concept of "Resilient cities," in addition to adaptation and alleviation; the concept has been widely applied to a variety of academic fields such as ecology, economic geography, natural and man-made disaster management, terrorism, and flood control (Barnett, 2001; Polese 2010, Godschalk 2003; Davic and Welsh, 2004; Jabareen, 2013). The recent and most complete definition of resilient cities covering its application in the wide variety of academic disciplines was given by UNISDR (2010: 13) as follows: "resilience is the ability of a system, community, or society exposed to hazards to resist, absorb, accommodate to, and recover from the effects of a hazard in a timely and efficient manner, including the preservation and restoration of its essential basic structures and functions."

Although the term "resilient city" has been used in various academic disciplines, it has recently become most prominent in safety science, environmental science, and governance (Jong *et al*., 2015). The Rockefeller Foundation has proposed the selection of 100 resilient cities based on four key categories: people, place, organization, and knowledge. Toughness is developed over time, after the accumulation of processes to strengthen the results of these capabilities. Multidimensional factors contribute to the toughness and ability of cities to respond to

various shocks and pressures in order to help the city center not only cope with disasters but also deal with violence, food and water resources, and other daily-life problems (Kete, 2014).

2.1.6. Knowledge Cities

Because of information- and knowledge-intensive production without a high environmental impact, "knowledge city" is a desirable concept for urban development similar to "smart city." However, "knowledge city" lacks the emphasis on the central role of ICT in triggering this development. Moreover, it is effectively interchangeable with conceptions of "knowledge-based urban development (KBUD)" (Arbonies and Moso, 2002; Yigitcanlar and Loennqvist, 2013). KBUD is a powerful strategy for economic growth and the post-industrial development of cities to participate in the knowledge economy. KBUD includes knowledge infrastructure; technological infrastructure; connections to the global economy; and concentration of well-educated, talented, and creative people (Van Winden and Berg, 2004). Fernandez-Maldonado and Romein (2010) suggested that KBUD should balance economic quality, sociospatial quality, and organizational quality for sustainable development.

In its widest interpretation, the concept of "knowledge city" not only focuses on the knowledge economy and industrial structure, but also emphasizes enriched human capital, a vibrant and diverse sociocultural environment, conservation of the natural environment, a high-quality built environment, accessibility, tolerance and acceptance of multiculturalism, and social equity (Florida, 2005; Van Winden *et al*., 2007, Yigitcanlar *et al*., 2008b). Thus, the planning of a "knowledge city" can foster the conditions for learning networks, facilitating sustainable development at the regional level through a collective innovation process (Valkering *et al*., 2013; Jong *et al*., 2015).

2.2. Practice of Organization and Cities

2.2.1. Sustainable Cities

"Sustainable city" or "sustainable development" involves the implementation of the economic, social, and environmental aspects of the three areas, because "sustainable" is a holistic concept rather than a specific method. Providing an example of a representative city in practice is difficult. In the context of international organizations and operations, the International Conference on Urban Regeneration and Sustainability was established by the Wessex Institute of Technology (WIT) in England, which is a unique organization serving the international scientific community. The "International Conference on Urban Regeneration and Sustainability" has been conducted regularly since the first conference "Sustainable City 2000 – Urban Regeneration and Sustainability" was held in Rio de Janeiro, Brazil. The 12th International Conference "Sustainable City 2017" will be held in Seville, Spain (WIT, 2017).

2.2.2. Eco-Cities

The city of Berkeley is located in California, United States, north of the San Francisco Bay. In 1975, Register founded "Urban Ecology Research Association," followed by a series of eco-city construction projects. In 1980, he began to build the embryonic form of an eco-city to integrate the neighborhood projects such as the center, solar energy, and waste reduction to build an integrated urban architecture. In 1987, Register proposed Berkeley as an ecological city. In the first international eco-city conference held in 1990, Berkeley was included in the ecological city development process. Berkeley is internationally considered as a model eco-city considering its impact on the status of the United States in the development of eco-agriculture and construction of eco-cities The planned features are outlined as follows: 1. urban landscape, involving high-rise building design; 2. traffic plan, involving (1) planning the traffic system emphasizing on walking space, and integrating buildings, open space, and the natural environment, (2) establishing bike and pedestrian trail system, (3) setting a slow lane to reduce the speed, (4) using public transport in the neighborhood to replace cars, (5) planting fruit trees along streets, and (6) building a rooftop cafe or garden with a pedestrian bridge for interlocking and greening environmental measures; 3. energy plan, involving the use of solar energy facilities; 4. waste management, involving the establishment of community compost systems; and 5. nature conservation, involving the recovery and degeneration of the natural river.

In addition, in the Asian region, Singapore achieved the goal of becoming a "garden city" by 1990 by developing an eco-balanced park strategy, establishing a park corridor system, and improving the sidewalk greening and shading rate. The main purpose was ensuring a high quality of natural environment while the city underwent rapid urbanization during the development process. The construction process

focused on green and open spaces, a green corridor network, extensive use of planting techniques, and softening of the artificial lines of urban artificial products, thus improving the city's diverse ecological landscape; this thus demonstrates the ecological representativeness of the city (Lee *et al*., 2008).

In the context of international organizations and operations, The Ecocity Builders, an international organization, has been conducting a summit every 2 years since the first International Ecocity World Summit (EWS) in Berkeley in 1990. The 11th Summit will be held in Melbourne in 2017. The conference has evolved into one of the most important forums on the complex challenges of rapid urbanization.

2.2.3. Low-Carbon Cities

Freiburg in Germany is known for its extensive use of solar energy. Combined with ecology, production, and life, the city is committed to the development of green energy industry and tourism to show the charm of the city. Freiburg's forward-looking development, solar technology and biotechnology, plays a leading role in the international market, with approximately 12,000 people working in the field of environmental protection and solar energy, creating €650 million per year and increasing jobs, economic growth, and tourist potential. Freiburg has a major contribution to Germany's top rank as a low-carbon city (Chou *et al*., 2017).

In the context of international organizations and operations, The United Nations Framework Convention on Climate Change (UNFCCC) is an international convention adopted at the United Nations Headquarters in New York in May 1992. UNFCCC is also the name of the United Nations Secretariat responsible for supporting the implementation of the Convention, which is based in Haus Carstanjen, Bonn, Germany. Parties to the Convention have convened the Conferences of the Parties (COP) annually to assess progress in addressing climate change. In 1997, the Kyoto Protocol was adopted to obligate developed countries to reduce greenhouse gas emissions. In 2001, the United States refused to recognize the signed United Nations Framework Convention on Climate Change, protesting against the fact that "developing countries do not assume obligations to reduce greenhouse gas emissions" according to the Kyoto Protocol. The United States is also the only industrialized country that has not signed the Kyoto Protocol.

"Accord de Paris" was adopted in the United Nations Climate Summit in 2015 to replace the Kyoto Protocol and strengthen the United Nations Framework Convention on Climate Change for slowing down the global warming trend. On June 1, 2017, US President Donald Trump announced the withdrawal of the United States from the Paris agreement. China is likely to replace the United States in leading the world in curbing global warming and promoting environmental science and technology.

2.2.4. Smart Cities

The US "New Strategy for American Innovation," "EU Prospects 2020 Program (Horizon 2020)," Japan's "Smart Japan ICT Growth Strategy," Korea's "U-Korea," China's "The five-five plan," and other national policies, as well as Canada, Toronto, New York and Boston, Spain, Barcelona, Amsterdam, Holland, South Korea's Matsushima, and Japan's Keihan Nai area and other demonstration fields, the wisdom of the city has been promoted as a political focus and competing to promote the relevant work. At present, countries mainly focus on the application of information technology in construction, energy conservation, commercial, medical care, transportation, sightseeing, safety, and disaster prevention projects. The aforementioned project will effectively improve the energy and energy quality of the infrastructure. Purpose, let the city permanent wisdom grow. South Korea has the highest Internet coverage rate in Asia, and it has been promoting smart city construction since 2004. Moreover, it has launched several strategic plans and policies (such as U-Korea and U-City) and has promoted media in Seoul City (Digital Media City, DMC) and other demonstration fields (NDC, 2016). Despite its name, the "ubiquitous eco-city" is a characteristic and practical application of the "smart city" concept specifically within South Korea; however, it is also currently well known outside South Korea.

In the context of international organizations and operations, the World Teleport Association (WTA) headquartered in New York, USA, studies economic systems with broadband infrastructure as the mainstay to strengthen international cooperation, create job opportunities, and promote economic development. The Intelligent Community Forum (ICF) was set up by the WTA, which is designed for promoting the global wisdom of the city each year. It is divided into broadband connection, knowledge work, digital connotation, innovation, marketing, and annual theme. The first phase entails selecting Smart21 among more

than 450 cities around the world, and the second phase involves selecting Top7. Finally, the recipient of the annual award (Intelligent Community of the Year) is selected in recognition of broadband life, such as continuous planning and innovation for global development of broadband economic wisdom of a city model. The Taiwanese cities of Taipei and Taichung City won the annual Intelligent Community of the Year award in the ICF forum in 2006 and 2013, respectively.

2.2.5. Resilient Cities

The most popular resilient cities in the world are related to flood control. Hamburg is Germany's second largest city, the largest port city, and one of the world's most famous water cities. It is located on the banks of the Elbe River in the northeastern part of Bremen. "Hose symbiosis" is the concept of HafenCity, a new urban area in Hamburg, where all buildings and roads are built at a height of approximately 8 m above the horizontal level and have a flood control function. Rotterdam is the second largest city in the Netherlands, located in the southwestern part of the Netherlands; the city is the diversion area for the Rhine River. The city of Rotterdam is 6 m below the sea level, and if the sea rises, Rotterdam will be the first city on the planet to be submerged. Therefore, the Rotterdam municipal government actively supports the development of water city residents who can live in innovatively designed buildings built on a floating pavilion to realize the concept of "symbiosis with water" (PCG, 2014).

In the context of international organizations and operations, Local Government Sustainable Development (ICLEI) has conducted the "Resilient City International Forum" annually in Bonn since 2010, titled "Resilient Cities—The Annual Global Forum on Urban Resilience and Adaptation." ICLEI was founded in 1990, including 12 giant cities, 100 super cities and metropolitan areas, 450 large cities, and 450 small and medium-sized cities and towns across 86 countries for promoting sustainable development. It is also the world's largest commitment to the sustainable development of the local government network. ICLEI Secretariat in Bonn, Germany, established the ICLEI Kaohsiung Capacity Center (ICLEI KCC) in Taiwan. This is the only training center for ICLEI in East Asia, and it helps Taiwan and the East Asian (Taiwan, Korea, Japan, China, and Mongolia) cities to establish sustainable development in order to promote the effective use of local environmental resources, education, and training to overcome climate change and promote local sustainable urban development (ICLEI KCC, 2017).

2.2.6. Knowledge Cities

The realization of knowledge cities may have a positive impact on environmental sustainability, although it is essentially only instrumental for achieving other economic-innovation-related goals. Thus, "knowledge city" does not centrally promote ecological sustainability or even regenerative development. Nevertheless, the highly praised city of Melbourne was the winner of the Knowledge

City Award in 2013, while equally priding itself in being "green" as well as the home of the Melbourne Principles for Sustainable City Development, which essentially emphasize on the community participation aspect of sustainable urban development (Jong *et al*., 2015). The following is an interview with Melbourne mayor Robert Doyle on the theme of "Knowledge Melbourne":

"Knowledge City" means the creation of high value-added products and services through research and development, technology and wisdom to promote urban development. We put forward the slogan of "knowledge of Melbourne," set up a special knowledge department to encourage knowledge cultivation, technological innovation, and scientific research, knowledge will be placed in the center of urban planning and economic development, knowledge management and intellectual capital planning. To promote knowledge dissemination and innovation, to create high value-added products and services to provide a sustainable urban environment, thereby enhancing the city's international competitiveness. We use the intellectual capital to improve Melbourne's international competitiveness and attract more students, teachers, researchers, and professionals to come to Melbourne to study, live, and work, and promote Melbourne's economic and social development, attracting more business opportunities. At the same time, knowledge city can also through knowledge cultivation, technological innovation, scientific research to enhance creativity, reduce material consumption and pollution, and maintain sustainable urban development (Don, 2013).

In the context of international organizations and operations, the World Capital Institute (WCI) is a registered nonprofit professional association headquartered in Monterrey, Mexico, with several offices across the world. The WCI is an independent international think tank whose purpose is to further the understanding and application of knowledge as the

most powerful leverage of development. The Knowledge Cities World Summit (KCWS) is an independent, global, and periodic gathering of professionals, both practitioners and researchers, related to the fields of knowledge cities and knowledge-based development. The KCWS is an initiative and a registered brand of the WCI. The First KCWS was organized in Monterrey, Mexico, in 2007. These summits have connected the various communities contributing to knowledge-based development from specialized fields (i.e., knowledge and intellectual capital management, urban studies, developmental economics, human geography, sociology, political science, and complexity studies) as well as from practitioner and application fronts (i.e., government, international agencies, professional associations, private foundations and institutes, and NGOs) (WCI, 2017).

2.3. Overall Analysis

To analysis the aforementioned six city theoretical systems, with respect to the three pillars of the sustainable urban development, we can find all city theoretical systems are involve the social category. However, these need to get consensus according to governance in economic and social pillars, which promote interdisciplinary integration. At one level, the terms sustainable development and governance are both potentially powerful bridging concepts around which interdisciplinary debates can take place. There is undoubtedly something about sustainability which complicates the search for coherence (Jordan, 2007).

On the other hand, it is noticeable about the same relationship between Low carbon cities and Smart cities, which meaning the practices of them are most easily integrated (Such as the combination of building technology on Low carbon and smart). Understanding these characteristics can contribute to the urban sustainability. All relationship between city theoretical systems with sustainable urban development are shown in Table **1**.

3. RESULTS

To summarize the six theoretical systems of the aforementioned urban sustainability practices, first, the sustainable city is considered as a comprehensive umbrella concept that is measured by various indicators in the economic, social, and environmental contexts. Self-sufficiency is the core concept. Because of its broadly defined nature, sustainable city can be considered as the common goal of contemporary urban development. Thus, compared with other theoretical systems, providing specific examples of a representative city is difficult.

Second, eco-city, which involves ecological conservation principles as the core, entails maintaining the city's population, production, and consumption within its ecological carrying capacity. With time, the way of practice has shifted from a narrow ecological protection strategy to a large urban development plan for a green environment, as well as the relevant construction, production, and consumption principles. Berkeley, having a considerable status in the development of eco-cities and affecting the US eco-agricultural development and construction of industrial eco-cities, is internationally recognized as an eco-city construction model. Singapore has performed considerably well as a green city.

Third, low-carbon cities, owing to the agreement to reduce greenhouse gas emissions, integrate low-

Table 1: Relationship between City Theoretical Systems with Sustainable Urban Development

City Theoretical systems	Three pillars of sustainable urban development				
	Environmental		Social	Economic	
	Nature	Technology		Substance	Intangible
Sustainable cities	●	●	●	●	●
Eco cities	●		●	●	
Low carbon cities		●	●	●	
Smart cities		●	●	●	
Resilient cities	●	●	●		
Knowledge cities			●		●

carbon economic concepts into urban environments, reduce nonrenewable energy losses and environmental pollution, and create jobs and improve economic production. For the community to have a higher quality of life, the development of renewable energy is a crucial practice. The German city of Freiburg has the reputation of being the "Solar Valley" of Europe.

Fourth, the smart cities use ICT facilities, Internet, cloud technology, the Internet of Things, and other popularized devices for addressing user needs in daily life regarding their homes, the community, and the city at large. South Korea has the highest coverage of smart cities in Asia, and it has been promoting smart city construction since 2004. Moreover, it has launched several strategic plans and policies and has promoted digital media cities in Seoul. Taipei has won the first prize in the Global Smart City Awards in the 2006 Smart City Forum.

Fifth, the resilient city system entails improving the city operational system to ensure that it can withstand harm, ensuring that it can effectively absorb, adapt to, and recover from problematic events; therefore, resilient cities can not only deal with disasters but also respond to violence, food and water shortages, and other urban daily-life problems. Hamburg and Rotterdam are based on the concept of "water symbiosis" as a city development and governance policy.

Finally, the knowledge city and KBUD emphasize on the knowledge economy and industrial structure, human capital, a vibrant and pluralistic social and cultural environment, protection of the natural environment, high-quality building environment, sexuality, tolerance, and multicultural acceptance and social equity. Melbourne uses intellectual capital to improve its international competitiveness from a commercial and industrial center in order to develop into a livable city, cultural capital, and knowledge city.

The aforementioned six city theoretical systems, definitions, practice ways, and representative cities are shown in Table **2**, the corresponding international organizations and operations are presented in Table **3**.

4. DISCUSSION AND CONCLUSION

Wangel *et al*. (2016) showed that social capital and natural capital are not exchangeable, indicating that

Table 2: Six City Theoretical Systems, Definitions, Practical Ways, and Representative Cities

Theoretical System	Basic Definition	Way of Practice	Representative City
Sustainable cities	A comprehensive umbrella concept with a broadly defined nature and self-sufficiency as the core concept.	Evaluation in terms of economy, society, and the environment.	Common goal of contemporary city development
Eco-cities	Following the principles of ecology, the city's population, production, and consumption remain in the environment and ecological carrying capacity, and they expand to large-scale development and construction principles.	Ecological protection strategy, and green environment for urban development.	Berkeley, Singapore.
Low-carbon cities	Reducing the loss of non-renewable energy and environmental pollution, while creating employment opportunities to improve economic production for the community to develop higher standards of quality of life.	Renewable energy, and low-carbon economy.	Freiburg.
Smart cities	Application of ICT facilities, the Internet, cloud technology, the Internet of Things, and other popularized devices for addressing user needs in daily life regarding their homes, the community, and the city at large.	ICT facilities, the Internet, cloud technology, Internet of things, and other technologies.	Seoul, Taipei.
Resilient cities	Improving the city operational system to ensure that it can withstand harm, specifically ensuring that it can effectively absorb, adapt to, and recover from problematic events; therefore, resilient cities can not only deal with disasters but also respond to violence, food and water shortages, and other urban daily-life problems.	Extreme weather, earthquakes, fire, terrorist attacks, food and other environmental resources, and safety of the city management areas.	Hamburg, Rotterdam.
Knowledge cities	Emphasizing knowledge economy and industrial structure, human capital, a vibrant and pluralistic social and cultural environment, natural environmental protection, high-quality built environment, accessibility, tolerance, and multicultural acceptance and social equity.	Higher education, human capital, innovation, research and development, and learning and sharing of knowledge.	Melbourne.

Table 3: Six City Theoretical Systems, International Organizations, and Operations

Theoretical System	International Organizations	Operations
Sustainable cities	Wessex Institute of Technology (WIT).	International Conference of The Sustainable City.
Eco-cities	Ecocity Builder.	International Ecocity World Summit (EWS).
Low-carbon cities	United Nations Framework Convention on Climate Change (UNFCCC).	Kyoto Protocol. Accord de Paris.
Smart cities	World Teleport Association (WTA).	Intelligent Community Forum (ICF). Annual award (Smart 21, Top 7, Intelligent Community of the Year, Intelligent Community Visionary of the Year and Founders Award).
Resilient cities	Local Government Sustainable Development (ICLEI).	Resilient Cities - The Annual Global Forum on Urban Resilience and Adaptation.
Knowledge cities	World Capital Institute (WCI).	Knowledge Cities World Summit (KCWS).

losses in one type of capital cannot be replaced by gains in another type of capital. The Brundtland report recognized that sustainable development depends on how society is organized and which technologies are used to pursue "needs." Currently, sustainability is often considered and used as a relative concept. To achieve sustainable development, resource use and pollution should be reduced in absolute terms (Rockström *et al*., 2009; Steffen *et al*., 2015). Thus, consideration of only internal living environments is insufficient. Instead, a relational understanding of space is necessary, including the impact of a city on its globally distributed hinterland (Zhou *et al*., 2011; Rees and Wackernagel, 1996). Therefore, we must more clearly understand the characteristics of various city theoretical systems and the strategies of their practice.

With the evolution of time, the core of eco-cities has changed from ecological conservation to a complex social–economic–natural symbiosis system, which is closer to the vision of sustainable cities. Although eco-cities and low-carbon cities are very similar in practice, the core concept of the low-carbon cities lies in the discussion of carbon reduction and energy issues, and its contribution to the urban environment can be clearly quantified. Resilient cities can be considered as a type of city theoretical system that is derived from the urgency of urban sustainable development. Similar to low-carbon cities, resilient cities must contribute to urban sustainability from a clear quantitative approach. Smart cities have been adopted by large enterprises because of the opportunity to provide innovation and investment in the urban environment, and the development is gradually moving away from the concept of sustainable cities and becoming a new city theory system (Jong *et al*., 2015). Smart cities and knowledge cities are highly biased toward economic development; however, in the distinction of practice, smart cities are based on the innovation of physical innovation. Knowledge cities are biased toward investments in human and intellectual capital to drive social and economic dynamism. However, there both need to apply the concept of ubiquitous knowledge to promote sustainable development through the concept of governance.

In the practice of city theoretical systems, almost all city theoretical systems are regularly taking place to international seminars to promote the exchange of global urban learning. Among them, smart cities can represent a more awarding concept to stimulate city competition, which also implies the debate between commercial and sustainable development in the urban environment. The low-carbon city is the only city theoretical system that can be used to develop international legal initiatives such as the Kyoto Protocol and Accord de Paris. This phenomenon also represents the benefit of clearly quantifying and determining the urgency of reducing carbon emissions in the global urban environment.

Finally, WCED (1987) proposed that sustainable development should be viewed as "not a fixed state of harmony but rather a process of change." According to this study, a variety of city theoretical systems are all considered from different perspectives of the vision of "sustainable cities." Thus, we must thoroughly study the association between various city theoretical systems and sustainable development, which is dynamic and changes with time.

ACKNOWLEDGEMENTS

The authors thank Jong *et al*. (2015) for establishing the theoretical framework and discussing the city categories in this study, which was extended to the practice for integration in this paper and contributed to the research of contemporary sustainable urban development.

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Received on 18-11-2017 Accepted on 27-12-2017 Published on 29-12-2017

DOI: http://dx.doi.org/10.15377/2409-9821.2017.04.6