Korean ubiquitous-eco-city: a smart-sustainable urban form or a branding hoax?

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Abstract: The buzzwords of zero-carbon, low-carbon, carbon-neutral, smart-eco and ubiquitous-eco have become common brands for the sustainable eco-cities of the 21st century. This paper focuses on one of these city types 'ubiquitous-eco-city' (u-eco-city). The principal premise of a u-eco-city is to provide a high quality of life and place to residents, workers and visitors with low-to-no negative impacts on the natural environment by using state-of-the-art technologies in the planning, development and management stages. The paper aims to put this premise into a test and address whether u-eco-city is a dazzling smart and sustainable urban form that constitutes an ideal 21st century city model or just a branding hoax. This paper explores recent developments and trends in the ubiquitous technologies, infrastructures, services and management systems, and their utilisation and implications for the development of u-eco-cities. The paper places Korean u-eco-city initiatives under microscope, and critically discusses their prospects in forming a smart and sustainable urban form and become an ideal city model.

Keywords: Eco-city; ubiquitous-eco-city; ubiquitous technology; ubiquitous infrastructure; ubiquitous service; ubiquitous management system; sustainable urban development; Korea

1. Introduction

For over half a century, numerous global scale environmental, social and economic crises have significantly impacted our societies—e.g., life threatening natural disasters, loss of biodiversity, destruction of natural ecosystems, regional disparities, socio-economic inequity, digital and knowledge divide[1]. Rapid population increase and expansion of resource-consumption, combined with industrialisation, urbanisation, mobilisation, agricultural intensification and excessive consumption-driven lifestyles are seen as the principal contributors of these crises[2]. This worrying situation has provoked many scholars, practitioners and policy-makers to look for solutions to mitigate impacts of these problems by considering the development more carefully and adopting a holistic response to minimise harmful social, economic and environmental effects in order to maintain the health of ecosystems to which human beings are a part of.

Cities being branded as zero-carbon, low-carbon, carbon-neutral, smart-eco, ubiquitous-eco and so on are a consequence of searching for a remedy to the problems caused by human activities—i.e.,

unsustainable development. These branded cities are widely seen as smart and sustainable development forms with some similarities and differences in their approaches in achieving urban sustainability. A ‘smart eco-city’ is, in a broad sense, an ecologically healthy city using advanced technologies and having economically productive and ecologically efficient industries, a systematically responsible and socially harmonious culture, and a physically beautiful and functionally vivid landscape[3]. These cities contain a healthy human ecological process leading to sustainable development within the carrying capacity of local ecosystems through changes in the production mode, consumption behaviour and decision instruments based on ecological economics and systems engineering[4]. Thus, a smart eco-city can be seen as an overarching or umbrella term for various types of cities targeting a sustainable future. A ‘zero-carbon city’ is a city that entirely runs on renewable energy and hence produces no carbon footprint. Similar to zero-carbon city, but less ambitiously, a ‘low-carbon city’ is a city practicing a low-carbon economy, and seeking to establish a resource saving and environmentally-friendly society, and benignly sustainable energy ecosystem, including low-carbon production and consumption[5]. Thus, zero- and low-carbon cities are emission conscious and carbon-economy specialised smart eco-city types. A ‘ubiquitous eco-city (u-eco-city)’ is also a smart eco-city in which urban information and services are provided to residents through high-tech ubiquitous computing, with sensors and communication resources embedded in urban elements, to increase the quality of life while minimising environmental impacts[6].

The theory behind the development of u-eco-cities is not new[7], nevertheless, achieving sustainable outcomes at a city-scale is not an easy task due to the complex and complicated nature of cities and their sustainable development. The recent technology advancements along with the positive perception and behavioural change in the public on the sustainability issues now provide some optimism in realising a sustainable urban form at the city scale. There is currently no full-fledged u-eco-cities exist, a number of ambitious initiatives are currently underway, and the premises of these cities—i.e., delivering sustainability—and their outcomes for a sustainable future have not been yet been accurately evaluated. Moreover, without any concrete proof, these initiatives are imposed as solutions to the 21st century urbanisation problems due to the fact that utilisation of new smart sustainable urban development support tools—e.g., ubiquitous technologies, infrastructures, services and management systems—being perceived highly optimistically.

This paper, firstly, introduces the contemporary concepts of sustainable urban development and eco-cities. Secondly, it investigates several dimensions—i.e., technology, infrastructure, service, and management—of a new type of eco-city originated from Korea—branded as u-eco-city. For the analysis, we adopted a framework investigating the matter with a multidimensional and balanced perspective—i.e., economic, societal, spatial, and organisational perspectives. This approach is borrowed from the well-known quadruple-bottom-line sustainable urban development framework—i.e., economy, society, environment, and governance[8]. As for the methodological investigation approach, we selected technology, infrastructure, service and management dimensions as they are the main building blocks of a u-eco-city. Then, the paper focuses on investigating these key aspects of Korean u-eco-cities thoroughly. Lastly, this paper provides a discussion on whether u-eco-city is a dazzling smart and sustainable urban form that constitutes an ideal 21st century city model or just a branding hoax?—that is the research question this investigation tackles.

2. Smart and sustainable urban development

Rapid urbanisation—i.e., driving urban growth with high consumption patterns without fully considering the environmental and social needs and occupants’ behaviour and aspirations—along with the changing climate in many countries worldwide has become a major concern because of its detrimental effects on the environment and societies[9]. Sustainable urban development concept—a development seeking to respond to: integration of conservation and development; satisfaction of basic human needs; achievement of equity and social justice; provision of social self-determination and cultural diversity, and; maintenance of ecological integrity[10]—has been identified as the ultimate goal of many contemporary planning endeavours, and has become a central concept on which the urban development policies are formulated[11].

Sustainable urban development brought the sustainable urban form debate to the agenda that involves various types of urbanisation models and processes, which could provide energy efficient, and environmentally-friendly settlements and mobility patterns and social cohesion mainly focussing on divergent spatial scales from metropolitan to neighbourhood levels. The first of these scales is the metropolitan scale. At this macro-level ideal population size for self-sufficiency, limits to urban growth, macro-level effects of the urbanisation pattern on energy consumption, locations of land-uses and their mix that supports a multi-modal transport system, and protection of habitats and water resources are strategically determined[12]. The second one is the urban scale. At this mezzo-level, in addition to the strategic level tasks, a number of issues, such as, energy efficiency and transport demand with regard to clustering of urban development, finer level of land-use mix and density, provision of equal opportunities in reaching urban services, vitality and prosperity of activity centres, and protection of environmental and cultural assets are determined[13]. At the neighbourhood scale, which is the micro-level, the relationship between urban form qualities—e.g., land-use mix, density, pedestrian friendly design—and travel patterns, enhancement of local characteristics, safety and community sense by design, and urban form dependent qualities of the buildings—e.g., solar orientation, imperviousness, efficient use of materials—are determined[14].

This classification can also be expanded to include a fourth individual parcel or building scale—i.e., the nano-level. However, either three or four the classification does not imply that these scales are mutually exclusive and independent. In reality, macro level patterns emerge from mezzo and micro level processes and behaviours, and micro level processes and behaviours are controlled by mezzo and macro level constraints[15]. Due to complexity of the nature of sustainable urban development, it requires more than good strategic policies and behavioural change of the public for achieving a sustainable urban development in all these scales.

The concept of eco-city has been developed and promoted since 1970s as part of the sustainable urban development agenda. The original eco-city concept is introduced by Richard Register[16] featured the ecological carrying capacity of the bioregion surrounding the city as its key starting point. Especially, the recent years have seen the dramatic take up of the eco-city concept and an accelerated translation of the ideas and visions are now taking place in many practical initiatives[17]. These initiatives include—but not limited to—in India, the government selected pilot eco-city projects in 2001 aimed at retro-fitting six pilgrim cities (Kottayam, Puri, Thanjavur, Tirupati, Ujjain, and Vrindavan); this was followed in 2010 by plans for four new-build eco-cities (Changodar, Dahej, Manesar Bawal, and Shendra) along the Delhi-Mumbai Corridor, and in 2011 by the selection of 36 pilot initiatives under the national ‘solar cities’ initiatives. In Japan, in 2009, the government selected 13 cities (Chiyoda, Iida, Kitakyushu, Kyoto, Minamata, Miyakojima, Obihiro, Sakai, Shimokawa, Toyama, Toyota, Yokahama, and Yusuhura) as part of a national eco-city competition[18]. In South Korea, five eco-city projects (Gwanggyo Ekonhill, Incheon Eco-City, Magok/Seoul, Sejong, and Songdo International Business District) have been developed under the umbrella of a national urban policy program. Elsewhere, with support from the World Bank’s ‘Eco2-Cities’ Initiative, significant urban sustainability initiatives are under way in Indonesia (Balikpapan, Jakarta, Makassar, Palembang, Surabaya), Philippines and Vietnam. Masdar City in UAE is a significant eco-city initiative from the Middle East region[19]. Arguably the most ambitious eco-city program is currently taking place in China, where an estimated 100 or so eco-city projects are under development and some 259 cities have declared the intention of becoming an eco-city or low-carbon city[20].

Eco-city development in its purest form revolves around the ambition to generate households, factories, offices, infrastructure facilities, and open spaces that reduce the consumption of resources, reuse resources to the maximum extent possible, recycle waste, and valorise the remaining waste streams by recovering energy and nutrients. It implies a number of new urban characteristics, including a different use of urban space, different patterns of production and consumption relying on local resources, using primarily sustainable energy sources, eliminating current forms of individual motorized traffic, closing the water cycle and much more. In short, it requires a form of urban development that contrasts dramatically with prevailing consumer societies and with expectations of future inhabitants of increasingly prosperous cities[21].

Since the conception of the eco-city idea there have been some major shifts in its practice. The first one relates to ‘place branding’. Recent literature of eco-cities massively emphasises selling the nature of eco-city sites. Whether nature is inherited or human-produced, an eco-city’s ecology is drawn into place branding that differentiates it, as a commodity, from others. Eco-cities are thus themed and capitalised through regional differences in urban nature[22,23].

Secondly, the World Bank recently adopted an operational framework for eco-city development, focusing on four key principles to guide policy-makers towards the construction of so-called ‘Eco2-Cities’, economically and ecologically sustainable cities. These four principles consist of: (i) a city-based approach enabling local governments to lead a development process that takes into account specific circumstances, including the local ecology; (ii) an expanded platform for collaborative design and decision-making that accomplishes sustained energy by coordinating and aligning the action of key stakeholders; (iii) a one-system approach enabling cities to realize the benefits of integration by planning, designing, and managing the whole urban system, and; (iv) an investment framework that values sustainability and resiliency by incorporating and accounting for life-cycle analysis, the value of all capital assets (manufactured, natural, human, and social) and a broader scope for risk assessment in decision-making[24].

Lastly, technology is perceived as an integral part of contemporary eco-city initiatives, most typically, this takes the form of various ‘green socio-technical solutions’ aimed at reducing environmental impact and transitioning cities to a low-carbon era. Less visible but just as pervasive, various smart technological systems—such as smart grids, and ubiquitous information and communication technology operating systems—are envisaged to structure, steer, and monitor the modern eco-city, from infrastructure (energy distribution, waste collection, integrated transport systems and so on) to public life (public service provision, information management and so on)[25].

Utilisation of smart technology-driven systems for planning, development, monitoring, and management of our cities—including eco-cities—are also critical to achieve and maintain desired sustainability outcomes and performances. Although, the use of computing to support urban planning and the development of urban land-use models dates back to the late 1950s, the need for appropriate technologies to support sustainable urban development is started to be strongly emphasised in early 1970s. The term ‘intermediate technology’ is coined to signify technology of production by the masses, making use of the best of modern knowledge and experience, conducive to decentralisation, compatible with the laws of ecology, gentle in its use of scarce resources, and designed to serve the human civilization[26]. In early 1980s the geospatial technologies are started to be used as the main thrust of computing applications to enhance the urban planners’ capability to deal with complex urban environments and to plan for prosperous, liveable and sustainable communities. Fortunately, rapid and dramatic technological progress in recent years has brought unprecedented opportunities for the development of smart tools to support achieving the sustainability goals of our cities. Particularly, ubiquitous technologies, infrastructures, services and management systems provide ease in our journey to become more smart and sustainable.

2.1. Ubiquitous technologies

The word ‘ubiquitous’ can be defined as existing or being everywhere at the same time, constantly encountered, and widespread. When applying this concept to technology, the term ubiquitous implies that technology is everywhere and we use it all the time. The term ‘ubiquitous computing’ or ‘ubiquitous technology’—coined by Xerox PARC Chief Scientist Mark Weiser in 1991—refers to ubiquity of information technology and computer power, which in principle pervade all everyday objects. It suggests countless very small, wirelessly intercommunicating microprocessors, which can be more or less invisibly embedded into objects[27]. Equipped with sensors, these computers can record the environment of the object in which they are embedded and provide it with information processing and communication capabilities. Such objects have a new, additional quality—they know, for example, where they are, which other things are in the vicinity and what happened to them in the past.

Ubiquitous technology is often wireless, mobile, and networked, making its users more connected to the world around them and the people in it. Typical ubiquitous technology devices include small mobile computers—further developments of today's mobile telephones—so-called wearables like intelligent textiles or accessories as well as computerised implants. The following features characterise ubiquitous technologies: decentralisation or modularity of the systems and their comprehensive networking; embedding of the computer hardware and software in other equipment and objects of daily use; mobile support for the user through information services anywhere and anytime; context awareness and adaptation of the system to current information requirements, and; automatic recognition and autonomous processing of repetitive tasks without user intervention[28].

Ubiquitous technologies can pervade all spheres of life and are vital for the development of a ubiquitous infrastructure system that provides a range of services to the public in a u-eco-city. These technologies, for instance, increases comfort in the private home area; improves energy efficiency; makes roads safer with intelligent vehicles; raises work productivity in the office with adaptive personal assistance systems; and in the medical field, monitors the health of the user with implantable sensors and micro-computers[29]. More specifically, for example, the technology of telematics—i.e., any integrated use of information and communication technology (ICT)—allows us to send, receive and store traffic information via telecommunication devices. More commonly, telematics has been applied specifically to the use of global positioning system technology integrated with computers and mobile communications technology. Transport telematics applications are contributing to safer, cleaner and more efficient transport by helping travellers, freight distributors and transport operators avoid delays, congestion and unnecessary trips by diverting traffic from overcrowded roads to alternative modes. These functions help in controlling rail, sea and inland waterways; reducing accidents; increasing productivity; gaining extra capacity from existing infrastructure; encouraging integrated transport, thus reducing energy use; and reducing environmental pollution[30]. They could provide potential savings of time and energy for individual drivers, reduction of congestion for the city, and could impact on long-term land-use.

The followings are among the principal ubiquitous technologies that make development and operation of ubiquitous infrastructures possible: Augmented Reality (AR), Broadband Convergence Network (BcN), Context Awareness Computing Technology (CACT), Convergence Technology (CT), Geographic Information System (GIS), Global Positioning System (GPS), High Speed Downlink Packet Access (HSDPA), Wireless Broadband (WiBro), Radio Frequency Identification (RFID), Space Network System (SNS), and Ubiquitous Sensor Network (USN)—see Lee et al.[31] and Leem and Kim[32] for the classification of the most common types of ubiquitous technologies utilised in the u-eco-city development process.

2.2. Ubiquitous infrastructures and services

In the recent years, urban infrastructure has been witnessing the impetuous evolution and expansion of two types of systems. The first is the universal 'wireline network' that is now able to provide sophisticated multimedia services. The second comprehends the 'cellular or wireless network' and is able to satisfy user mobility demand, providing standard telephone services and continuously speeding data transmission[33]. As ubiquitous infrastructures and services are critical backbones for achieving the quality of life and sustainable development goals of u-eco-cities, the new generation urban infrastructures are integrating both of these wireline and wireless networks in a single and highly advanced infrastructure network. On top of this network integration, the convergence of technology revolutionises the way urban infrastructures and services are designed, developed, delivered and accessed, and contributes to the formation of the next generation urban infrastructures[34].

Ubiquitous infrastructures use sensors and networks to continually communicate with wired or wireless computer devices embedded in personal devices—e.g., mobile phones—buildings, infrastructure, and any feature or object of the urban space. This allows ubiquitous person-to-person, person-to-object and object-to-object communication where computers or devices are invisible to users. Ubiquitous infrastructure improves the effectiveness of urban infrastructure planning,

management and use. Ubiquitous infrastructures help to establish a democratic and transparent platform and encourage citizens to participate in the decision-making processes[35]. Ubiquitous infrastructures contribute to the creation of environmentally friendly, sustainable and smart u-eco-cities by assisting informed and intelligent decisions. Ubiquitous infrastructures and services have led to a significant paradigm shift in urban infrastructure planning and provision.

Ubiquitous infrastructures provide access to ranging ubiquitous services—e.g., ubiquitous life, ubiquitous business, ubiquitous government—through high-speed networks and advanced communication services. For example, *Ubiquitous-life:* Using these services, citizens can access services such as home networking which links, monitors, and controls of household appliances. They can perform remote meter readings and inspections, home banking and shopping. Citizens can check their roof-garden environment by using the Zigbee-based sustainable ecosystem, which consists of swarms of sensors for climate, environmental physical measures, soil humidity and the like. The major components of ubiquitous-life are ubiquitous healthcare, ubiquitous education and ubiquitous play that provide a range of additional services accessible from home. *Ubiquitous-business:* Using these services, firms can minimise the cost of their products especially by benefiting from ubiquitous commerce, ubiquitous office, multimedia conferencing, information management, and virtual market components. At ubiquitous office, businesspeople can confer and do business online with other global enterprises. They can exchange documents with their customers, partners or alliances through WiBro's messenger terminal. *Ubiquitous-government:* This is the next generation e-government system and has many tools for a variety of purposes. For instance, pollutants can be removed with the help of sensors that detect pollution in air, soil and water. Surveillance cameras ensure the safety of people at parks or other public areas. Ubiquitous instruments smoothly run the city's transportation system by accurately forecasting arrival and departure time of public transport systems and minimising traffic congestion. Location-based services provide protection for disable people—e.g., walking guide for blind people. Ubiquitous sensor networks located at school zones protect children[36].

Ubiquitous infrastructures and services provided by ubiquitous technologies can effectively deliver a highly integrated and networked knowledge society and are likely to have an impact on the neighbouring cities. In terms of providing quality of life and a sustainable urban future, the ubiquitous infrastructure planning focuses on the two key aspects of urban services. Firstly, ubiquitous infrastructures aim to provide an efficient infrastructure planning delivery system that complies with the planning act and regulations, and is also affordable for the users. Secondly, it aims to maximise the effectiveness of infrastructure systems and services by providing adequacy, synergy and user satisfaction.

General classification of ubiquitous infrastructures and services of a u-eco-city are based on the following major sectors: *Administration:* u-government, u-planning support, u-civil affair, u-tax; *Crime and disaster prevention:* u-emergency rescue, u-road safety, u-fire-station, u-anti-pollution, u-safety, u-security; *Culture, tourism and sports:* u-park, u-city tour, u-culture; *Education:* u-home study, u-school, u-environmental education, u-societal education; *Environment:* u-eco green, u-eco land, u-eco recycling, u-pollution management; *Facility management:* u-building, u-traffic facility, u-street furniture, u-facility; *Health, medical and welfare:* u-welfare, u-healthcare, u-hospital; *Logistics:* u-shopping, u-commerce, u-logistics, u-agriculture, u-factory; *Neighbourhood development:* u-street, u-home, u-apartment; *Transportation:* u-airport, u-traffic control, u-traffic safety, u-traffic regulation, u-tolls/fares, u-traffic information service, u-bicycle roads, u-pedestrian safety, u-telematics, u-logistics support; *Work and employment:* u-office, u-industry support, u-employment)—see Yigitcanlar[37] for a detail classification of ubiquitous infrastructures and services of a u-eco-city.

2.3. Ubiquitous management systems

The traditional idea of urban management consists of the good management and planning of a city, entrusted to the institutional actors[38]. Increasing awareness of the complexity of the modern urban settings has led to the questioning of management approaches founded on institutional, administrative and geographical compartmentalisation[39]. The concept of urban management is extensive and there

are six main challenges to managing an urban community: providing an economic base; building efficient urban infrastructure; improving the quality of life and place; ensuring social integration; conserving natural environmental qualities, and; guaranteeing good governance[40]. The quality of the management depends not only on how well each of these challenges is met, but also on their integration to create coherence in the city. The changing economic, social and environmental contexts place new pressures on all the professionals engaged in managing urban development and the built and natural environments. Today, planners and managers of urban development face the complex demands of social, economic and environmental changes[41].

Around the globe increasing awareness of the complexity of the modern urban settings and abovementioned demands have led to the questioning of management approaches founded on traditional institutional, administrative and geographical compartmentalisation. Urban environments act as crucibles, where a multitude of interactions not only take place, but also make place for large numbers of individuals[42] and therefore managing such places plays a critical role in establishing sustainable cities. It has been proved that traditional urban management practices lack of comprehensively tackling urban, economic, social and environmental problems[43].

Since late 1970s, it is widely recognised that in local governments automated and intelligent information and knowledge management systems significantly contribute to the decision quality of policy and management teams by providing accurate information, knowledge and decision directions[44]. In recent years, the growing need for an effective urban management approach led into the development of the notion of ‘intelligent urban management’. This new urban management approach rises from improving communication within and between agencies and the public about the highly connected and emergent nature of problems by benefiting from advanced digital technologies—e.g., ubiquitous technologies. The most recent view of intelligent urban management is shaped by the fundamental principles—i.e., convenient, effective, efficient, integrated, real-time, reliable, responsible, sustainable, transparent—that are seen as panacea to the emerging issues of sustainable development of the urban environment[45].

In u-eco-cities an intelligent urban management system—referred as a ‘ubiquitous management system’—is a support system that employs the state-of-the-art technologies for planning, decision-making, monitoring and managing. These advanced technologies include ICTs, decision support systems, digital information systems, strategic choice tools, and ubiquitous service technologies—e.g., u-commerce, u-government, u-education. In recent years with such technologies many online decision support and management system platforms have become accessible to technicians, policy-makers and the public for collaborative planning, development and management practices[46].

Urban management is highly complex by nature, particularly at a city context, and a range of factors need to be taken into consideration, which include different agencies to develop awareness on the aspects of the complicated urban phenomena—e.g., environmental quality. The complexity of an urban management system can be simplified by using a set of variables or indicators and this simplification gives urban stakeholders a model of city development[47]. The indicators are used as a common base of comparison between the territorial entities and these indicators have three strategic purposes in urban management: monitoring, controlling, benchmarking[48].

So far there are a number of intelligent urban management systems are developed in dealing with various urban issues[49]. The most common application areas of these management systems are urban environmental, transportation and health areas. A typical intelligent urban environmental management system provides a systematic process to comprehensively address environmental issues. Tasks of this system include activity tracking—e.g., tracking waste— emission monitoring, task scheduling, permit coordination, material safety management, cost-benefit analysis, environmentally friendly material use, environmental negative impact calculation, sustainable practice planning and environmental awareness campaigns[50]. A typical intelligent urban transportation management system provides a systematic process to comprehensively address transportation related issues. Tasks of such system include real-time traffic surveillance and management, incident management, traveller information, natural and human hazard evacuation, transport infrastructure coordination, demand management, urban mobility culture support, public transport system timetabling, reliability and comfort

management, and sustainable practices management[51]. A typical intelligent urban health management system provides a systematic process to comprehensively address public health issues. Tasks of this system include monitoring and intervening the health and wellbeing of patients in hospitals or at home through a system that consists of low-power on-body wireless sensors attached to mobile users that interact with a ubiquitous computing environment—e.g., monitoring physiological parameters as well as behavioural parameters, monitoring of conditions with episodic manifestations, managing of chronic conditions, intervening with control devices[52].

In response to the evolution of urban context, during the last decade we have witnessed radical changes in management and communication[53]. The new urban management techniques are highly dynamic and derived from economic management principles and information technologies. In the light of current changes the key challenges for the management of u-eco-cities can be grouped under several groups. Firstly, as urban management is becoming more flexible, based on the integration of a strategic global scheme and local management dynamics, the management of highly complex u-eco-cities is expected to respond both local and global concerns[54]. Urban management generally addresses a number of urban projects or spatial or territorial planning, which are flexible tools for management and communication established at the urban level. The rising sustainability concerns and more and more transparency for public participation are making the management process of u-eco-cities even more complicated than they already are. Secondly, urban management deals more with powerful databases and information systems. To face the considerable volume of data, tools are needed to establish overviews of the goals and provide an appropriate level of synthesis. In a u-eco-city actors must be able to access to all relevant data neither getting lost in the details, nor swamped with information that does not provide a clear picture and is not directly useful for informed decision-making. Lastly, the evolution of management approaches requires new smart instruments and tools for strategic development, for information update and transmission, and for monitoring the development, and managing the whole planning and delivery process. At this point, new generation intelligent urban management systems or ubiquitous management systems are needed to be able to cope with the complexities of u-eco-cities. However, there are not many comprehensive ubiquitous management systems available at the moment. Thus, the big challenge faced in recent years is to develop and make such systems work in ambitious u-eco-city projects[55].

3. Korean u-eco-cities

Thus far, many cities and their districts around the world adopted ubiquitous technologies, infrastructures and services with an aim to become a ubiquitous city (u-city) or society and maintain a scientific-technological position of excellence via ensuring and expanding economic competitiveness to transforming and modernising their societies and cities—e.g., San Francisco, Philadelphia, Tokyo, Seoul, Hong Kong, Singapore, Taipei, Kuala Lumpur[56]. Although environmental sustainability idea is embedded in the objectives of u-cities, the main focus of such development is to utilise high-tech to improve the quality of the life of residents, employees and visitors and develop the city as a smart one—i.e., upgrade the city via technology. In other words, a comprehensive emphasis on the ecological dimension of city making is not strongly present in this type of city form—i.e., lack of comprehensive sustainable development perspective. This missing point is recently acknowledged and remedies are tried to be prepared to addressed the sustainability issue, particularly in the South East Asian context, by coining a new city type so-called u-eco-city—i.e., smart and at the same time sustainable city. At present, there are no existing fully-fledged u-eco-cities as a large number of them are currently being developed. Korea leads the field with its ambitious and nation-wide initiatives[57].

The concept of u-eco-city was originally driven from the concept of u-city in Korea. U-eco-city is an ICTs and eco-technologies (EcoTs) embedded smart and sustainable city, where people can access both digital and eco-services based on the technology convergence between ICTs and EcoTs[58]. At the initial conceptualisation of u-eco-city, u-city and eco-city were combined with the conventional city to form such a new city model (Figure 1). An eco-city bases its foundations on the concept of environmentally sound and sustainable development (ESSD), and since the beginning of the 21st century, eco-city concept has become increasingly global and mainstream phenomenon. An eco-city

is a type of city that aims the environmental sustainability of cities, adaptation of low-carbon economy, and establishment of new knowledge-based creative green industries focused on energy technologies including renewable energy to ease and mitigate the impacts of global climate change, global energy crisis and greenhouse gas emissions[59]. Since Mark Weiser's ubiquitous computing concept[60], u-city initiatives focused on the integration of ICTs and the physical city to aim at a convergence of the virtual and real space. U-city is comprised of multiple layers including u-city services, technologies, infrastructure, and management systems. In a u-city, any citizen can access any u-service anywhere and anytime through any digital network and devices. This concept is evolved from the earlier informational and ICT-driven digital city concepts. A u-city is also a high-tech city with an increased quality of life and strengthened urban competitiveness[61].

[INSERT FIGURE 1 HERE]
Figure 1. Relation between u-city and eco-city in the context of u-eco-city

In recent years the Korean u-city concept has been combined with an eco-city perspective forming a new city type—u-eco-city. This new city type adopts a blended approach of integrating different technologies, policy areas, concepts and visions to promote the ICTs and EcoTs innovation, integrated sustainable urban planning, and civic empowerment and involvement. Moreover, u-eco-city lays emphasis on the connection between technological innovation, behavioural change, and education driven by local community involvement—e.g., in the areas of waste management (waste-to-energy), public transport use, and water management and so on. Through the processes of socio-technological innovation and political and socio-economic governance, u-eco-city is developed and evolved to provide citizens with higher level of sustainable living and democratic governance.

3.1. Ubiquitous technology, infrastructure, service and management strategies

During the last two decades, Korea has continuously developed national strategies for sustainable urban development through different ICT-based strategies—i.e., cyber-Korea, e-Korea, u-Korea. The majority of people in Korea now own and make use of personal computers and mobile phones as a result of the late 1990s cyber-Korea strategy. As a result of this strategy in early 2000s rapid ICT development led to the development of the e-Korea strategy, which made internet use extensive and as consequence e-government and e-commerce services became widespread. As a consequence of the success of this strategy, Korea continued to develop national u-Korea strategies for a smart and sustainable urban development. This strategy has a philosophy based on six-visions—i.e., safety, convenience, efficiency, high-quality amenities, cultural values, participatory nature of development—and six-principles—i.e., behavioural change, equity, market-orientation, co-existence with nature, building the future. The u-Korea strategy in mid 2000s, for the first time, turned the focus on urban development to the integration of ICTs and the physical places in cities with an aim of making the virtual and actual cities converge[62]. In the initial phase, the u-Korea strategy built an extensive wireless urban infrastructure network in most of the metropolitan and large urban areas and focused on bringing together ICTs, knowledge and urban spaces to provide urban amenities to the public. At the second stage, in 2007, a law on the construction of u-cities is enacted to build u-cities by integrating ubiquitous infrastructures and services. The u-city development project has become an integral part of the national strategy—u-Korea. At the third stage of the strategy implementation, u-city agenda is transformed into u-eco-city agenda and by integrating ubiquitous infrastructure and sustainability principles a new development perspective is introduced—i.e., u-eco-city.

In Korea, even though all u-cities are now rebranded as u-eco-cities, ICT-based urban development nature of these projects has not changed a bit. *Ubiquitous technology strategies* were developed based on multiple layers such as services, technologies, infrastructure, and management, and evolved from computerisation, informatisation on the way to u-eco-cities—with no significant difference than u-city perspective. Meanwhile, technology strategies have gone through an evolutionary path from wired to wireless, from life-size to Nano, from static to dynamic, from stable to mobile/wearable, and from stand-alone to converged/integrated. *Ubiquitous services strategies* are initially evolved from online-

administration—i.e., e-government—into online-administration with GIS—i.e., e-government and map convergence—then into online-administration with USN/SNS—i.e., e-government, map, and intelligent space convergence. Lastly, single services are linked and evolved into spatially oriented complex services[63]. Likewise, technology strategies are evolved, first, from networking technologies for conveying data into sensing technologies for producing data, afterwards, interfacing technologies for presenting data, then, processing technologies for analysing data, and finally, security technologies for managing infrastructure and privacy. *Ubiquitous infrastructures strategies* are involved in providing; firstly, wired networks including high-speed internet network with asymmetric digital subscriber lines (ADSL), thereafter, BcN for conveying text, voice and video data. Subsequently, mobile ubiquitous computing infrastructures such as ICTs-embedded cars, robots, mobile phones, as well as built-in ubiquitous computing infrastructures such as wireless networks, USN connected infrastructures and places are supplied. *Ubiquitous management strategies* are focused on transparency and collaborative intelligence and developed in order to meet the management requirements of u-eco-cities, ubiquitous information operating—i.e., management or governance service—centres and platforms are planned. This way all sorts of data from ubiquitous infrastructures are incorporated to provide the high quality of ubiquitous services through collecting, monitoring, inter-correlating, analysing and distributing real-time relevant urban and environmental information. Furthermore, Korean government, in 2008, enacted the law for supporting u-eco-city construction, which included financial support for preparing ubiquitous master plans, developing model cities, and an investment of 120 billion dollars R&D fund to be spent between 2008 and 2013. Table 1 illustrates the strategy mapping and (r)evolution of u-eco-cities, where the highlights indicate the current state of ubiquitous services, technologies, infrastructures and management systems.

[INSERT TABLE 1 HERE]
Table 1. Korean u-eco-city (r)evolution

3.2. Ubiquitous service experience

Ubiquitous technologies have already been significantly affecting the society and environment by reshaping economic and socio-cultural activities and the space in Korea. The evolution of u-eco-city has a significant impact on not only human behaviours, but also urban form[64]. As a result of u-eco-city strategies, internet users in Korea have increased from 19.1 million citizens in 2000 to 37.1 million in 2010—an increase from 44.7 to 77.8 percent. More than half (59.3%) of them, aged between 12 and 59, have used ubiquitous services such as digital multimedia broadcasting (DMB), smart work or intelligent transportation services. Moreover, as of 2011, 80 percent of the economically active population owned and used these services from a smart phone[65].

Korea Research Institute for Human Settlements (KRIHS) survey series reveals that the value of the ubiquitous technologies has significantly altered citizen behaviours and lifestyles—first conducted in 2002 and repeated in 2010[66]. Survey results show that ubiquitous service usage is rapidly increasing, while 46.7 percent of respondents used ubiquitous services about a decade ago, today 93.8 percent of them are using these services, which is a significant (46.1%) increase. Today in Korea online banking subscriber ratio reaches up to 95.8 percent with a 32 percent increase from 2002. Consequently, this diminishes the banking trips as much as 78 percent[67]. Almost all (97.7%) of the respondents of the KRIHS survey are currently making use of an e-commerce service—now also evolving as a ‘social commerce service’ on Facebook and Twitter—which is resulting in replacing some of the neighbourhood stores and shopping centres. Social media users, especially young people, are easily lured into the convenient means of e-/social commerce, where in Korea, this market is estimated at about 6 billion dollar, and continues to grow on the back of the booming social media.

In almost a decade, the ratio of ubiquitous service users in the ‘smart work’ domain has increased sharply from 7.2 to 93.3 percent. In Korea tele/video-conferencing mostly substituted face-to-face contacts in business as such technology connects enterprises and organisations in a synchronous working environment. The survey shows that on average businessmen work from their ‘small offices

or home offices' (SOHO) with smart work systems up to two-and-half days a week. The survey reveals that 82.7 percent of business trips are decreased due to smart work and tele/video-conferencing arrangements. The survey indicates that increasing ratio of ubiquitousness was at its lowest in the area of socialising online (22.7%); followed by ubiquitous healthcare services (55.3%), and; the highest in smart learning area (63%). Even though Facebook, Twitter and other social network services are expected to alter social and cultural exchanges, 74.1 percent of respondents provided a view on majority of face-to-face contacts not to be replaced with digital communication forms anytime soon (Table 2). In terms of technology uptake, young citizens and the residents of central business district and inner city areas have used ubiquitous infrastructure and services more than middle age and senior citizens and the residents of the outer city areas.

[INSERT TABLE 2 HERE]

Table 2. Korean ubiquitous service experience

Owing to the ubiquitous service quality in Korea, in terms of accessibility, time and energy has become more important than distance. Lee[68] argued that as a result of the behavioural change due to ubiquitous services, spatial structure of u-eco-cities is expected to move towards a more decentralised and concentrated urban structure with polycentric, digital networked, globalised and high-dense urban form. He also indicated that short distance trips to nearby areas are likely to increase, while long distance trips are to decrease. The total travel distance is predicted to decrease between 18.4 and 21.8 percent. Decreased travel distances along with the use of EcoTs will help in saving energy and reducing pollution in u-eco-cities. In theory, Korean u-eco-cities could form an opportunity to modify citizen behaviours positively and contribute to the formation of sustainable urban futures.

3.3. Progress against the u-eco-city agenda

Korean u-eco-city agenda has recently evolved from the national u-city agenda. Although there are no fully-fledged u-eco-cities developed so far, there are increasing numbers of u-eco-city initiatives currently underway. Most of these projects are initiated as a result of a national policy and their development is coordinated by the Ministry of Land, Transport and Maritime Affairs (MLTM) and Ministry of Public Administration and Security (MOPAS) and supported by the large technology companies—i.e., Korean Telecom, LG, Samsung—and local governments. Firstly initiated with the Hwaseong Dongtan pilot project in 2008, Korean u-eco-city projects is expanded to 64 projects throughout the country as of 2013. Among these initiatives constructions of 21 are partially completed, 12 are under construction, and 31 others are at the design stage (Figure 2). Following the Hwaseong Dongtan pilot project's promising progress, the focus of the projects are concentrated on the new town developments such as Yongin Heungduck (2009), Paju Unjung (2010), and Seongnam Pangyo (2011), and then extended to 56 other project including districts of existing cities. Korean Government (MLTM and MOPAS) provided the administrative, financial, and technological supports to these projects along with the support from the local governments such as Incheon (2009), Busan (2009), Seoul (2009), Yeosu (2010), Gangneung (2010), Namyangju (2011), Assan (2011), Naju (2011), Jeonju (2012), Yeongju (2012), Yangsan (2013), and Bucheon (2013). This large number of initiatives from all across the country indicates that in the medium to long-term u-eco-city development will most likely to become a model city and norm in Korea. Seoul, Busan, Suwon, Namyangju, Osan and many others prepared u-city plans with eco-city master planning tools, which are now eventuating to official u-eco-city master plans. Below we present and discuss the progress of these initiatives against the sustainable urban development agenda.

[INSERT FIGURE 2 HERE]

Figure 2. Korean u-eco-city initiatives

Korean u-eco-city agenda aims for the convergence of ubiquitous technologies and city planning megatrends—e.g., global urban competitiveness, quality of life and place, climate change, sustainable

urban development. In order to provide megatrend solutions ICTs are utilised in the urban development process—this process is also refereed as '(r)evolution' (see Table 1). For this (r)evolution to happen, firstly, u-eco-city agenda puts its emphasis on providing quality of life and place through increased public participation opportunities. In Seoul, u-public participation services including citizen-made-safety-maps are already in use. For example, in this project unwanted incidents such as traffic accidents, crime and environmental hazards usually happen at the high-risk areas, and citizens as public sensors can determine where these high-risk or dangerous areas are by sharing this information on an online map portal through smart phones—so as to inform authorities and warn other citizens. After authority groundtruthing and authentication of the information, it can be used for the preparation of security/hazard maps or new environmental management strategies/actions, shared with public and used for collaborative policy development purposes. For instance, in Seoul u-eco-city's 'Chunman Sangsang Oasis' project—an imagination oasis for over 10 million people—such public participatory mechanism is currently in use. In this project, the ubiquitous management centre evaluates and acts upon citizen entries received through an app named 'Wolf'. This collective intelligence via public participation and utilisation of user-friendly apps contribute to the formation of safer and healthier built and natural environments.

Secondly, Smart work centres with cloud computing and mobile work systems located near the residential areas can make citizens minimise their commuting time and distance, and thus, limit the negative impacts of transport on the environment. Hence, technically, providing smart technologies and alternative living/working arrangements, do not only improve the quality of life and place in u-eco-cities—e.g., make it convenient, accessible and safer—but also contribute to the preservation and enhancement of the natural environment. For instance, as smart work systems are much popular in Korea compare to the USA, Japan and EU, leading Korean firms, including KT, Samsung and Amore Pacific, have built smart work centres to boost flexibility and productivity particularly in the major u-eco-cities—i.e., Seoul, Incheon, Busan, and Jeju. This system has a reasonable level take-up rate by the medium to large size companies as they see the benefit in efficiency, flexibility, productivity, management cost saving, and also contributing to smart and sustainable development by reducing carbon emissions.

Thirdly, Korean u-eco-city agenda aims for the convergence of ubiquitous technologies and ecological city planning principles in urban spaces to give birth to a new sustainable urban form. Citizens can access real-time environmental information without any time lag through ubiquitous technologies, which makes real-time environmental data update possible. ICTs and EcoTs with embedded eco-intelligence provide citizen with quality environmental resources—e.g., clean water and fresh air through automatic water/air pollution watch systems. In u-eco-cities eco-intelligence can also reduce energy consumption and greenhouse gas emissions with the use of eco-mileage card system, which checks electricity, water, gas consumption, as well as public transportation and bicycle use. Eco-mileage card provides incentives such as cyber money to those who reduce utility consumption and make use of sustainable transport systems. For example, Korean Ministry of Environment encourages people to use so-called 'green credit cards' for buying eco-friendly products or living a sustainable lifestyle in ways such as using public transportation. The credits earned from the scheme can be redeemed for cash or be used towards utility bills. Seoul u-eco-city has just launched an eco-mileage credit card—after this initial pilot, it is to be expanded to the other u-eco-cities. Now, both Samsung Electronics and Hyundai Motor taking part in the project, this credit card also allow people to get discount for the purchase of hybrid cars and eco-friendly appliances in return for conserving the environment. Moreover, Sejong and Yeosu cities showcase good u-eco service practices. Sejong is, the new national administration city, planned and designed with a carbon emission monitoring system (CEMS), and with this system in place the city is aiming to become the most eco-friendly city in the country. CEMS is operated by the citizen participation with the help of GIS maps and graphic interfaces, and plays a great role in diminishing the energy consumption of households in Sejong. Yeosu u-eco-city provides citizens with u-bike services. The 'bike and ride' u-service, with ICTs embedded bicycles increase the green transport usage in the city, also eliminates the bike theft problem.

Fourthly, u-eco-city agenda concentrates on the global urban competitiveness issues. In the era of globalisation, most of the world cities are in competition and global businesses are growing rapidly. Today, for example, business transactions between Sydney and London are much more than between Sydney and Perth. No doubt tele/video-conferencing technology—e.g., Skype, FaceTime—plays a critical role in the global businesses, which gives opportunity to businessmen to communicate with their peers in other countries more conveniently—avoiding many expensive business trips, which minimises the transportation costs and carbon footprint. Besides, ubiquitous technologies help international tourists otherwise have difficulties in finding their ways, shopping and communicating with locals. For example, the smart eye of QR code—quick response code—and smart guide services from airport to hotels, from streets to shops and railway stations are located in many corners of Korean u-eco-cities like Seoul, Incheon and Busan—a critical service especially for Seoul that is a major global tourist hub. Another example is Tesco's Korean network of shops, Homeplus, which developed the idea of bringing the store to the customer—the concept of virtual store. In 2008, Homeplus started so-called the 'Wrapping Advertising' in Jamsil subway station in Seoul to advertise the new store opening in Seoul. The pillars and walls of the subway station were wrapped up with full of Homeplus products just like what customers would see at actual shop aisles. Besides convince, this smart guide service minimises the physical space use and unnecessary freight and shopping trips. Another example worth mentioning is the TOPIS project in Seoul—integrated transport information and service system—launched in 2005 to support government officials in shaping sophisticated transport policy through the collection and analysis of real-time data. Active in the major Korean u-eco-cities, TOPIS-data based information service has been assisting passengers to better plan their journeys and select the best modes of transportation by flagging congestion areas, giving estimated travel times, and providing bus arrival and waiting times—services also include remote enforcement for illegal parking and bus management.

Fifthly, Korean u-eco-city agenda is highly concerned of the costing of the investment and its returns. In u-eco-city projects, ecological information is collected via a ubiquitous sensor network in real-time, and this information is provided to citizens ubiquitously. However, further investment is needed for developing suitable interface-devices—e.g., smart phones and wall signs—and ubiquitous building sensor networks—e.g., BcN, Wifi and System—this is to say, building a u-eco-city requires additional investment than a conventional city. For example, Ansan City launched u-crime prevention service by installing CCTV systems throughout the city to address the public safety and security issue in 2009. An integrated CCTV control system was built and 560 CCTVs were installed—through this u-service, 267 violent crimes were cracked down between 2010 and 2011. For the investment not to cause a financial burden on the city, the funding issue was solved through a novel BTL approach (Built by private sector and then Transferred to public sector, where private sector collects investment via Lease from user). Another example is the Incheon u-eco-city experience that reveals the critical importance of having an efficient investment management system. Incheon created a viable business model through establishing an ICT solution with stakeholder policy committee. The model for Incheon is calculated that LEED-certified eco-buildings decrease operating costs by 8 percent to 9 percent, increase building value by 7.5 percent, improve return on investment by 6.6 percent, increase the occupancy ratio by 3.5 percent, and increase the rent ratio by 3 percent. And compared with other buildings, LEED-certified facilities stand out with 26 percent less energy consumption, 13 percent lower maintenance costs, 27 percent higher occupant satisfaction, and 33 percent less greenhouse gas emissions[69]. Additionally, according to input-output table by Bank of Korea, between 2000 and 2010, the production of u-eco-city related industries was increased steadily. The Bank's input-output analysis revealed that u-eco-industries had a positive effect on the service and construction industries through u-eco services and intelligent buildings (input-output multiplier 0.019), and a great impact on the manufacturing industries (input-output multiplier 0.32)[70].

Lastly, u-eco-city agenda is aligned with the smart growth principles including urban sustainability, mixed land-use, compact city, urban safety, renewable energy and so on. U-eco-city suggests solutions to these problems through its intelligent infrastructures. Bridges and high-rise buildings with vibration sensors provide citizens and government with a safe environment and lower management costs. U-eco-cities extend smart grid for electricity and water distribution designed for the energy saving and recycled water supply. Intelligent parking lot systems inform users where and how many

free parking lots are available. For instance, Jeju u-eco-city is expected to complete its ‘smart grid’ pilot community on Jeju Island in 2013. Jeju’s system is designed with an infrastructure to allow the use of electric cars, a network to harness clean power sources, and electric services and grids that can improve energy conservation. In Incheon Airport, parking lots that are equipped with the advanced wireless technology—i.e., Zigbee—offer automated parking leads and simple payment systems to make the use of airport parking lot more conveniently. Incheon Bridge has a construction health monitoring system with embedded tilt-meters, cable tension meters, laser displacement meters, strain gauges, thermometers and bearing shoe displacement meters. Another solution is embedding ICTs and EcoTs in smart spaces to form new programmable spaces—e.g., wall of a building can be converted into a digital advertising wall or an open digital cultural place—that produce u-eco-scapes and contributes to the compact/mixed/dense development and efficient use of the land. For instance, during the night u-street in Seoul Square at Gangnam and LED-street in central Daejeon turn into giant electronic canvases exhibiting art, education and environmental programs.

4. Dazzling urban form or branding hoax?

In order to investigate and address the research question—whether u-eco-city is a dazzling smart and sustainable urban form that constitutes an ideal 21st century city model or just a branding hoax—we adopt a multidimensional and balanced perspective analysis framework—borrowing this approach from the well-known quadruple-bottom-line sustainable urban development framework[8]. The framework basically focuses on the differing but at the same time complementing perspectives that provide a more clear and comprehensive big picture view to the analysis. The four development domains of sustainable urban development—i.e., economic, societal, spatial, and organisational development—are accommodated in the analysis framework to form a multidimensional and balanced perspective.

4.1. Economic perspective

Korean u-eco-city projects are seen as economic growth engines that are jointly driven by the technology and construction industries supported by the national and local governments. U-city concept was introduced in Korea after the 1997 Asian financial crisis, u-eco-city after the 2008 global financial crisis, and both innovative city models are seen as not only solution to urbanisation problems, but also to the national economic development[71].U-eco-city projects basically are considered as flagship projects for the Korean national government to combine ecological and economic development. However, the observed economic development approach in the Korean context is rather based on increased technology consumerism than production. Meaning the technology developed for u-eco-cities is used for public consumption rather than providing citizens with an employment opportunity to contribute to the knowledge generation/local economic activities. This brings the question of in economic terms who is benefitting from the u-eco-city formation most? According to Anttiroiko[72] the Korean cases show that construction companies and UbiTech firms reap the most financial benefit, while public sector carries the major risks through their support schemes and public investment, and people are made to adjust to a new technologically mediated mode of urban life without much room for choices of their own. Furthermore, in these u-eco-city projects a national development is prioritised over local or regional developments, even though local municipalities are stakeholders of these projects.

4.2. Societal perspective

U-eco-city movement has particular challenges for the societies; hence, it is imperative that the societal compatibility of ubiquitous technologies, infrastructures and services should be carefully planned. Especially, autonomy, privacy, trust, affordability, access to and participation in the advantages of these technologies, infrastructures and services are as important in this context as issues of their management—e.g., integration, system dependency, possibility to avoid loss of control,

monitoring and normalisation of behaviour[73]. According to Rotondo [74] u-eco-city projects should be a driver of change in urban planning participation processes, which provides opportunity for establishing a true e-democracy. However, the current practice at least in the Korean context does not provide avenues for e-democracy, besides some limited user-generated content applications. Moreover, these ubiquitous systems are mainly infrastructure-based innovations and require high initial financial investments. Thus, not only governments, but also taxpayers have to be convinced of the feasibility and socio-economic and environmental benefits of these large-scale and highly costly projects—i.e., carefully weighing up the triple-bottom-line costs and benefits. Furthermore, the techo-economic polarisation that these cities produce leads to a duality in the city—i.e., dual city phenomenon. This raises another important question: Is a u-eco-city in its fragmented mode a new way of building functionally sophisticated sustainable enclaves into society, mainly serving to high income groups? Keeping in mind that there is currently no major change in public policy in Korea since the introduction of u-cities, these cities will most likely to increase social polarisation and urban segregation.

4.3. Spatial perspective

We investigate the spatial dimension of u-eco-cities by focusing on both natural and built environments. In terms of natural environments, Korean u-eco-city practice has shown a rather dynamic nature especially in the marketing the development. For instance, changing the city brand almost overnight—i.e., from u-city to u-eco-city—without significantly improving the approach and technicalities of these cities to incorporate ecological sustainability providing systems and procedures will surely not result in the formation of eco-cities. Undoubtedly so far only developing limited—e.g., ubiquitous water supply and maintenance—of the many promised ubiquitous environmental management services would not qualify newly developing Korean cities as a true u-eco-city. Especially, while considered the short history of u-eco-city development is actually built on inherent contradictions, we cannot stop thinking whether the ‘eco’ term in the title of these cities are just used as a misleading brand. For example, Incheon and Songdo u-eco-cities are built on the destruction of precious wetlands, home to some of the most rare species on the planet[75]. The placed limited measures in providing sustainable development such as efficient energy use and recycling up to three-quarter of the waste, unfortunately will not reverse the damage done to the environment. In order to archive sustainable futures, comprehensive sustainable urban development and ecological planning perspectives should be incorporated in all stages of development of these cities—especially in the construction stage. In terms of built environments, the quality of life and place has been the main motto of u-eco-cities. Perhaps this is the area that these cities are most successful of—providing world-class built environment and physical infrastructures for an increased quality of life and place. For example, Incheon, Songdo and Seoul u-eco-cities have provided pedestrian safety services through a smart curb to maximize the reduction rate of traffic accidents involving pedestrians. A recent survey result states that public awareness and satisfaction of these u-eco-city projects have been raised by 25 percent[76] However, the critical question here is that whether these cities can actually provide a true quality of life and place by mainly focusing on the built environment and mostly neglecting the natural environment.

4.3. Governance perspective

The literature on technology, infrastructure, service and management systems that support smart and sustainable urban development indicates that advancements in technology and knowledge provide sufficient confidence and foundation for us to pursue the development of u-eco-cities[77]. On the other, the literature also reveals that the term u-eco-city is not the only internationally recognised brand for smart and sustainable cities—e.g., smart eco-city, green IT smart city, sustainable smart city—nor the most popular. The term is mostly used in Korean urban development context. Furthermore, the concept of u-city seems to be patched with the label of ‘eco’ during the last several years perhaps to gain more recognition internationally. When we looked at the many so-called u-eco-city projects from Korea most of them are still referred as u-city at their promotion materials

including official websites. That surely brings to our mind the possibility of a misleading branding exercise and poor administration of the governance of these cities. Besides, the u-eco-city process needs to be a more open, transparent, participatory and collaborative one. This is critical for the planning of the development and also management of amenities, activities and the city as a whole. The current ubiquitous management tools do not provide much opportunity for including citizens' voices. Most importantly, mega projects like u-eco-city projects require political stability and continuousness of major strategies. Particularly, in the developing country context these projects are not immune from the political influence and at times even subjected to corruption. This brings to mind the question of how changing political climates impact these cities and transform their forms and functions. Beyond this, establishing a balance between the three development domains—i.e., economy, society, environment—as an enabler is the key task of governance. In current practice this is a major challenge, and thus, how to create a balanced development and democratise the very process of making of u-eco-cities is another critical question to be addressed.

4.4. Discussion and reflections

Either branded as u-eco-cities or u-cities, in practice so far the challenges and barriers—e.g., massive investment burden, societal acceptance—in developing such cities have limited the size and number of initiatives in the Eastern countries—mostly South-East Asian. As for the Western countries, they have been always suspicious about such top-down processed megaprojects. The ambitious initiatives from Korea seem to show all of the required technological components for an optimistic development of a future ubiquitous knowledge society. However, in the project development process many challenges and obstacles are still ahead of us. Even though, the success of u-eco-cities requires a national capability of designing forward-looking institutions to enable better cooperation among stakeholders, the establishment of a supportive legal framework and promotion of technology standardisation, beyond this a more comprehensive balanced and multidimensional perspective should be aimed considering the following remarks.

First of all, these cities—due to the top-down development strategy—are typically prone to problems related to the lack of social infrastructure, market restrictions, political quagmires and vested financial interests. Such cities have been built from the perspective of technical computing with an emphasis on supply-side technology, which has put in place advance technologies with impressive budgets. However, through such a computing-driven approach, social and cultural aspects have been neglected and absent from discussions of the design of u-eco-cities, which have emphasised physical aspects and industry portfolios and veered off from the idea of a knowledge culture.

Secondly, as technology only becomes cheaper when become widespread, this in the case of u-eco-cities creates a chicken and egg paradox. Korean u-eco-city examples are largely based on 'supply-push' instead of 'demand-driven'. These government initiated projects supply technology in the space it is embedded—i.e., cities—however the lack of demand to such expensive places keeps technology prices higher. Additionally, the technology and services seem to be lacking focus on the social infrastructures and needs of the communities. Therefore, further efforts are needed to create a market for better utilisation of the technology and building the partnership with society to establish required social infrastructures. Public participation can support these cities to be shaped by a mix of technological, social, cultural, economic, political and organisational processes. Moreover, planners and designers should give due diligence to develop an environment that best matches their image about prospective users, and shape a socio-technical environment in which social and technological aspects are intimately related to, and define and redefine, each other. Additionally, retrofitting of the u-eco-city concept should also be considered, as it is not always possible to construct such cities from scratch everywhere.

Thirdly, Korean u-eco-city projects are perceived as national growth engines. Especially when national governments and large technology corporations partnership in the development of these projects in Korea is considered, this perception can be easily comprehended. The development and application of ubiquitous technologies by these large corporations help them to keep the innovative cutting edge and contribute to the competitiveness of the national economy. However, in the

glocalised—global & local—world of the 21st century, local economies have become as important as the national economies. Therefore, the ability of new ubiquitous technologies and projects to regenerate local economies from the bottom-up are definitely has a great importance. However, so far this has been completely absent in the investigated Korean cases.

Lastly, current ambitious initiatives from Korea somehow provide a positive outlook and progress in forming smart and sustainable cities of the 21st century. Particularly the success in high-tech use in the planning, development, monitoring and management of various urban services gives us hope in the formation of a truly smart and sustainable urban form. In its infancy, it is very early to refer to u-eco-cities as a smart and sustainable urban form. However, investigated initiatives are determining a new development path for—at least for Korean cities—and setting the benchmark high for the next generation cities of the century. This is surely giving us some hope for future developments—while still keeping all of the criticism and scepticism in mind—and some day realisation of the idea of living in harmony with each other and the environment.

5. Conclusions

In this paper, we first explored u-eco-cities considering their potentialities to become an ideal city model for achieving smart and sustainable urban development. Findings of the literature review show that ubiquitous computing is already more than a mere technology vision, especially when considered the RFID technology being currently reached to a high degree of maturity and entering application areas of complex u-eco-cities[78]. Besides, smart phones and their mobile applications have already paved the way and are seriously overcoming the paradigm of the general-purpose personal computer in favour of small, specialised information appliances becoming an integrated part of our lifestyles and shaping the space around us—i.e., cities. Coupled with urban infrastructures such ubiquitous technology approach enables a great number of new infrastructures and services that contributes to the social well-being and environmental sustainability. It has a considerable economic potential to increase efficiency and thus competitiveness of our cities. On the contrary to the countless opportunities they provide, there are also many challenges and barriers associated with ubiquitous technologies, infrastructures and services—and so as u-eco-cities. Thus, the rather limited but growing literature motivates us to keep our hopes up on that one day, current emerging trends on the utilisation of ubiquitous technology, service, infrastructure and management systems to become a panacea for the urbanisation problems—although this still seems to be just a wishful thinking.

We, then, focused on addressing the question of whether the u-eco-city model really is a dazzling urban form to achieve smart and sustainable urban development or just a city-branding hoax, and also whether it constitutes a role model for the 21st century cities. The analysis framework adopted looked at this matter from a multidimensional and balanced angle of the quadruple bottom-line sustainability view. The analysis results show that—due to the fact that u-eco-city concept has not reached to maturation and not produced any comprehensive u-eco-spaces yet—at this stage it is not possible to prove or disprove either of the claims. However, all these attempts—particularly taking place in South-East Asia in large scales—within the next few years will help us to clearly understand whether smart and sustainable urban development can be produced via ambitious u-eco-city projects or whether they will come to the verge of bankruptcy as in the cases of Middle-Eastern development fantasies—i.e., Dubai. If the u-eco-city model proves successful, this may change the reserved attitude towards u-eco-city development in the Western countries—particularly due to large investment risks, not knowing how to deal with this new kind of urban formation, and limited understanding of their social implications.

Lastly, this paper brought up additional new questions while addressing its own. As the South-East Asian u-eco-city model is a masterminded infrastructure-oriented and developmentalist approach, thus, the most important question here is: How a balanced development with strong emphasis on local economic development priority, social concerns, environmental sustainability and a bottom-up democratic perspective can be adopted in this new city formation model? We conclude by speculating that unless this question is addressed clearly, perhaps beyond some limited successful Korean u-eco-city cases, current initiatives are destined to result in disappointment. However, this will most likely

to help us understand the failure factors in such ambitious development approach, learn from the mistakes, and much better plan and develop the next generation cities—e.g., u-eco2-city or u-eco-city 2.0—by adopting a more balanced development approach. Perhaps, a future u-eco-city model would hold a better chance to become a true role model for the cities of the 21st century that are seeking balance and sustainability in all fronts.

References

[1] S. Van der Ryn, P. Calthorpe, Sustainable communities, Sierra Club Books, San Francisco, CA, 1986.
[2] United Nations Environment Programme, Global environment outlook, Earthscan, London, 2000.
[3] R. Wang, T. Zhou, D. Hu, F. Li, J. Liu, Cultivating eco-sustainability, Ecological Complexity 8 (1) (2011) 273-283.
[4] R.Wang, Y. Ye, Eco-city development in China, Ambio 33 (6) (2004) 341-342.
[5] X. Kunbao, Development of low-carbon economy and achieve sustainable development of cities, Journal of Environmental Protection 2 (2) (2008) 33-35.
[6] S. Lee, T. Yigitcanlar, H. Hoon, L. Taik, Ubiquitous urban infrastructure, Innovation, Management, Policy and Practice 10 (2/3) (2008) 282-292.
[7] L. Blassingame, Sustainable cities, Social Science Journal 35 (1) (1998) 1-13.
[8] F. Vanclay, The triple bottom line and impact assessment: how do TBL, EIA, SIA, SEA and EMS relate to each other? J. Environmental Assessment Policy and Management, 6(1) (2004) 265-288.
[9] J. Jaeger, R. Bertiller, C. Schwick, F. Kienast, Suitability criteria for measures of urban sprawl, Ecological Indicators 10 (2) (2010) 397-406.
[10] P. Jacobs, J. Gardner, D. Munro, Sustainable and equitable development, in: P. Jacobs, D. Munro (Eds.), Conservation with equity, IUCNNR Press, Cambridge, 1987, pp. 69-87.
[11] T. Yigitcanlar, Sustainable urban and regional infrastructure development, IGI Global, Hersey, PA, 2010.
[12] D. Godschalk, Land-use planning challenges, Journal of the American Planning Association 70 (1) (2004) 5-13.
[13] D. Stead, Relationships between land-use, socioeconomic factors, and travel patterns in Britain, Environment and Planning B 28 (4) (2001) 499-528.
[14] P. Naess, Urban planning and sustainable development, European Planning Studies 9 (4) (2001) 503-524.
[15] G. Mitchell, A. May, A. McDonald, PICABUE, International Journal of Sustainable Development and World Ecology 2 (2) (1995) 104-123.
[16] R. Register, Eco-cities: rebuilding cities in balance with nature, New Society, New Gabriola, BC, 2006.
[17] S. Joss, Eco-cities: the mainstreaming of urban sustainability; key characteristics and driving factors, Int. J. Sustainable Development and Planning, 6(3) (2011) 268-285.
[18] M. Low, Eco-cities in Japan: past and future, Journal of Urban Technology, 20(1) (2013) 7-22.
[19] F. Cugurullo, How to build a sandcastle: an analysis of the genesis and development of Masdar city, Journal of Urban Technology, 20(1) (2013) 23-37.
[20] S. Joss , R. Kargon A. Molella, From the guest editors: eco-cities in Pan-Asia international discourses, local practices, Journal of Urban Technology, 20(1) (2013) 1-5.
[21] M. Jong , D. Wang C. Yu, Exploring the relevance of the eco-city concept in china: the case of Shenzhen Sino-Dutch low carbon city, Journal of Urban Technology, 20(1) (2013) 95-113.
[22] D. Prytherch, Selling the eco-entrepreneurial city: natural wonders and urban stratagems in Tucson, Arizona, Urban Geography, 23(8) (2002) 771–793.
[23] C. Chang, E. Sheppard, China's eco-cities as variegated urban sustainability: Dongtan eco-city and Chongming eco-island, Journal of Urban Technology, 20(1) (2013) 57-75.
[24] H. Suzuki, A. Dastur, S. Moffatt, N. Yabuki, H. Maruyama, Eco2cities: ecological cities as economic cities, The World Bank, Washington, DC, 2010.
[25] S. Joss, A. Molella, The eco-city as urban technology: perspectives on Caofeidian international eco-city (China), Journal of Urban Technology, 20(1) (2013) 115-137.
[26] E. Schumacher, Small is beautiful, Harper and Row, New York, 1973.
[27] M. Friedewald, O. Raabe, Ubiquitous computing, Telematics and Informatics 28 (1) (2011) 55-65.
[28] P. Gabriel, M. Bovenschulte, E. Hartmann, W. Gross, H. Strese, K. Bayarou, M. Haisch, M. Matthess, C. Brune, H. Strauss, H. Kelter, R. Oberweis, Pervasive computing, SecuMedia, Ingelheim, 2006.

[29] E. Aarts, J. Encarnaçao, Into ambient intelligence, in: E. Aarts, J. Encarnaçao (Eds.), True visions: the emergence of ambient intelligence. Springer, Berlin, 2005, pp. 1-16.
[30] S. Lee, Internet-based planning methodology, Journal of Korea Planners Association 34 (3) (1999) 49-60.
[31] S. Lee, T. Yigitcanlar, J. Wong, Ubiquitous and smart system approaches to infrastructure planning, in: T. Yigitcanlar (Ed.), Sustainable urban and regional infrastructure development, IGI Global, Hersey, PA, 2010, pp. 165-182.
[32] C. Leem, B. Kim, Taxonomy of ubiquitous computing services for city development, Personal and Ubiquitous Computing 6 (1) (2012) 1-9.
[33] P. Arseni, G. Boggia, P. Camarda, Modeling telecommunication infrastructures integrating wideband wireless and wired networks, Simulation 78 (3) (2001) 173-184.
[34] G. Cohen-Blankshtain, Modelling ICT perceptions and views of urban front-liners, Urban Studies 41 (13) (2004) 2647-2667.
[35] R. Klosterman, Planning support systems, in: R. Brail, R. Klosterman (Eds.), Planning support systems, ESRI Press, Redlands, CA, 2001, pp. 31-43.
[36] S. Lee, Y. Leem, Understanding u-city, Urban Affairs, 41 (1) (2006) 36-51.
[37] Yigitcanlar, T., Managing ubiquitous eco cities, Eco-humanity 10 (3) (2010), 25-59.
[38] United Nations Development Programme, Participatory local governance, UNDP Publications, New York, 1997.
[39] M. Stubbs, M. Lemon, P. Longhurst, Intelligent urban management, Urban Studies 37 (10) (2000) 1801-1811.
[40] J. Borja, M. Castells, Local and global, Earthscan, London, 1997.
[41] L. Neilson, Instruments of governance in urban management, Australian Planner 39 (2) (2002) 97-102.
[42] A. Giddens, The constitution of society, Polity Press, Cambridge, 1984.
[43] P. Jones, T. Taule'elo, J. Kohlhase, Growing pacific town and cities, Australian Planner 39 (4) (2002) 186-193.
[44] W. Dutton, K. Kraemer, Technology and urban management, Administration and Society 9(3) (1977) 305-340.
[45] T. Yigitcanlar, Rethinking sustainable development, IGI Global, Hersey, PA, 2010.
[46] O. Kwon, K. Yoo, E. Suh, UbiDSS, Expert Systems with Applications 28 (1) (2005) 149-161.
[47] E. Allen, INDEX, in: R. Brail, R. Klosterman (Eds.), Planning support systems, ESRI Press, Redlands, CA, 2001. pp. 229-261.
[48] J. Spangenberg, S. Pfah, K. Deller, Toward indicators for institutional sustainability, Ecological Indicators 2 (1) (2002) 61-77.
[49] A. Repetti, G. Desthieux, A relational indicator-set model for urban land-use planning and management, Landscape and Urban Planning 77 (1) (2006) 196-215.
[50] B. Hu, B. Hu, J. Wana , H. Nie, C. Zhai, Safe river water, Pervasive and Mobile Computing 5 (1) (2009) 419-431.
[51] A. Tuominen, T. Ahlqvist, Is the transport system becoming ubiquitous? Technological Forecasting and Social Change 77 (1) (2010) 120-134.
[52] E. Lupu, N. Dulay, M. Sloman, J. Sventek, Autonomic management of ubiquitous e-health systems, Concurrency and Computation: Practice and Experience 20 (1) (2008) 277-295.
[53] S. Geertman, J. Stillwell, Planning support systems, in: S. Geertman, J. Stillwell (Eds.), Planning support systems in practice, Springer, Berlin, 2003, pp. 3-22.
[54] M. Carmona, R. Burgess, Strategic planning and urban projects, Delft University Press, Delft, 2001.
[55] J. Lee, S. Baik, C. Lee, Building an integrated service management platform for ubiquitous ecological cities, Computer 44 (6) (2011) 56-63.
[56] D. Shin, Ubiquitous city, Journal of Information Science 35 (5) (2009) 515-526.
[57] S. Joss, A. Molella, The eco-city as urban technology, Journal of Urban Technology 20 (1) (2013) 115-137.
[58] S. Lee, Introduction to ubiquitous city, in S. Lee ed., Ubiquitous city: future of city, city of future (Daejeon, Korea: Hanbat National University Press, 2009).
[59] S. Joss, "Eco-cities—a global survey 2009," WIT Transactions on Ecology and The Environment, 129, (2010), 239-250
[60] M. Weiser, The computer for the twenty-first century, Scientific American, 13 (1991) 94-100.
[61] S. Lee and Y. Leem, "U-city planning characteristics," Journal of Korea Planners Association, 43:5(2008) 179-190.
[62] W. Ha, A study on action plan and strategies for building u-Korea, Telecommunications Review 13 (1) (2003) 4-15.

[63] S. Lee, Ubiquitous city: concept, ®e-megatrend, and u-strategies, International Symposium on Ubiquitous City, 28-29 Nov. (2011), Sydney.
[64] I. Audirac, Information technology and urban form, International Regional Science Review 28 (2) (2005) 119-145.
[65] T. Kim, M. Claus, J. Rank, Y. Xiao, Technologies and cities, Journal of Urban Technology16 (1) (2009) 63-89.
[66] H. Kim, Y. Jin, Y. Lee, and H. Kang, Changing urban structure and policy issues in information society, Korea Research Institute for Human Settlements Report Series, 2002.
[67] D. Shin, K. Wang, Y. Jeong, J. Lee, Urban space changes and the direction of urban planning in the age of u-city, Korea Research Institute for Human Settlements Report Series, 2011.
[68] S. Lee, Introduction to ubiquitous city, in: S. Lee (Ed.), Ubiquitous city, Hanbat National University Press, Daejeon, Korea, 2009, pp. 10-29.
[69] D. Washburn, U. Sindhu, Helping CIOs understand "smart city" initiatives: defining the smart city, its drivers, and the role of the CIO, itworldcanada.com, 2010
[70] S. Jo, Y. Leem, S.H. Lee, The structure path analysis on ubiquitous city, Korea Planners Association Conference, (2012), pp. 199-200.
[71] S. Shwayri, A model Korean ubiquitous eco-city? Journal of Urban Technology 20 (1) (2013) 39-55.
[72] A. Anttiroiko, U-cities reshaping our future, AI & Society 28 (1) (2013) 131-148.
[73] J. Bohn, V. Coroama, M. Langheinrich, F. Mattern, M. Rohs, Social, economic and ethical implications of ambient intelligence and ubiquitous computing, in: W., Weber, J., Rabaey, E. Aarts (Eds.), Ambient intelligence, Springer, Berlin, 2005, pp. 5-29.
[74] F. Rotondo, The u-city-paradigm, Future Internet 4 (1) (2012) 563-574.
[75] S. Shwayri, A model Korean ubiquitous eco-city? Journal of Urban Technology 20 (1) (2013) 39-55.
[76] MLTM, Current status and prospect of U-city policy in Korea, ULI Seoul Seminar, "Smart connected cities: how to start and sustain," March 28th, Seoul Square, Seoul Korea, 2013.
[77] J. Hwang, U-city, in: M. Foth (Ed.), Urban informatics, IGI Global, Hersey, PA, 2008, pp. 367-378.
[78] G. Wolfram, B. Gampl, P. Gabriel, The RFID roadmap, Springer, Berlin, 2008.

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